

Input Output Reference

The Encyclopedic Reference to EnergyPlus Input
and Output

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Input-Output Reference

This document is intended to be an encyclopedic reference for the EnergyPlus Input Data Dictionary (IDD), Input Data File (IDF) and potential resultant outputs (various output files).

The following descriptions are “grouped” by the elements in the IDD (ref: Getting Started Document and the IDD Conventions). In some cases, the descriptions of reporting will be done for an object (e.g. Lighting electrical consumption or thermal comfort value for a group of people) and in some cases for the entire group (e.g., ambient condition reports).

What's different about EnergyPlus Input and Output?

The usual procedure for non-interactive programs is to process all the input necessary to “do the job”, perform the actions required by the input, and somewhere along the way produce reports on the actions. Usually, there will be error messages on incorrect input statements and/or incorrect conditions detected during processing. Usually, the input is echoed in its entirety so that the context of errors is shown clearly.

Results are typically output into reports as well as a compilation of various inputs reformatted into different groupings than were originally entered (defaults filled in, etc.)

EnergyPlus does all the above. However, some nuances are different from the usual actions.

EnergyPlus Input Processing

- 1) EnergyPlus reads the data dictionary (Energy+.idd) and the input data file (in.idf) prior to doing anything else. Only after this is done does processing start. HOWEVER, the input processor only knows as much as the data dictionary has told it. It knows which fields should be alpha and which should be numeric. All of this information (including the IDD) is echoed to the audit file (audit.out) in case errors occur. Most of the errors show up (out of context) in the standard error file (eplusout.err) – there might be enough information to decipher where the error is or you may have to look at the more inclusive audit file. Invalid numeric fields are detected during this processing and default numeric fields are filled. For more information on the IDD, its structure and implications, please see the IDD Conventions discussion below.
- 2) The biggest difference between EnergyPlus and more traditional input processing is that EnergyPlus is modular in its actual filling in the details for the simulation. Because of the modular structure of EnergyPlus, each module is responsible for “getting” its own input. It receives this input from the input processor in the form of alpha and numeric fields. Each module typically gets all its input the first time it is called. The implication for the user is that error messages may show up in somewhat peculiar places. A further implication is that no order is needed in the input data file! Data that is not needed by a particular simulation is not processed.
- 3) The data dictionary has the capability to do “automatic” range checking on numeric fields as well as fill in numeric defaults. Both filling in defaults and “automatic” range checking are done when the data is read. Other checks may need a combination of fields and won't be done until the data is “processed” (after the simulation starts).
- 4) A couple of other differences that might not be true in other programs: Blanks are significant in alpha fields **SO** DesignDay is not the same as Design Day (1 space between Design and Day) nor Design Day (2 spaces between Design and Day). Alpha objects, however, *are* case insensitive SO DesignDay is the same as 'designday' or 'SizingPeriod:DesignDay'.

EnergyPlus Output Processing

- 1) Unlike the usual formatted output text formatted reports, EnergyPlus usual output is either at the summary or at the detailed (variable) level. Summary reports exist for many inputs as well as sizing results. The more detailed variable level reporting is produced as “stream of consciousness” (as the simulation happens) and must be post-processed for more sensible viewing.
- 2) Most EnergyPlus reporting can be readily viewed in current spreadsheet programs – or other software that can process “delimited variable” reports. In these kind of reports, each “column” is separated from the next by a “delimiter”. Typical delimiters are “comma” and “tab”. Gradually, EnergyPlus reporting is moving from all comma separated reports to allow the user to select the delimiter via “style” objects.
- 3) Styled reports allow for more selectable output reporting but also increase the number of output files as we have chosen to create the report names with extensions that typify the actual reporting. Depending on the reporting, these can be:
 - ✓ Tab – reports with a .tab extension have tabs as the delimiter. These report files (directly from EnergyPlus) will be named something like “eplus<xxx>.tab” where the <xxx> is a short name of the kind of report (e.g. Zsz for Zone Sizing, Map for Daylighting Map)
 - ✓ Csv – reports with a .csv extension have commas as the delimiter. These are also specially formatted for use in spreadsheets (such as the compilation of results from the eplusout.eso file into the eplusout.csv file using the default post-processor program).
 - ✓ Txt – reports with a .txt extension have spaces as the “delimiter” but only certain of these are really formatted the way you might expect: where multiple spaces make printing with a non-proportional font would produce readable output.
 - ✓ Html – reports with a .html extension are “web-browser” ready.

IDD Conventions

The following is a basic description of the structure of the IDD (it’s actually taken directly from the IDD file). As noted within, ! signifies a comment character as does the \. \ has also been adopted as a convention for including more specific comments about each field in an object. These have been used with success in the IDFEditor and it is hoped the flexibility will provide other interface developers with useful information.

```
!IDD_Version VERSION NUMBER
! *****
! This file is the Input Data Dictionary (IDD) for EnergyPlus.
! The IDD defines the syntax and data model for each type of input "Object."
!
! Object Description
! -----
! To define an object (a record with data), develop a key word that is unique
! Each data item to the object can be A (Alphanumeric string) or N (numeric)
! Number each A and N. This will show how the data items will be put into the
! arrays that are passed to the Input Processor "Get" (GetObjectItem) routines.
! All alpha fields are limited to 100 characters. Numeric fields should be
! valid numerics (can include such as 1.0E+05) and are placed into double
! precision variables.
!
! NOTE: Even though a field may be optional, a comma representing that field
! must be included (unless it is the last field in the object). Since the
! entire input is "field-oriented" and not "keyword-oriented", the EnergyPlus
! Input Processor must have some representation (even if blank) for each
! field.
!
```

```

! Object Documentation
! -----
! In addition, the following special comments appear one per line and
! most are followed by a value. Comments may apply to a field or the object
! or a group of objects.
!
! Field-level comments:
!
! \field      Name of field
!              (should be succinct and readable, blanks are encouraged)
!
! \note      Note describing the field and its valid values
!
! \required-field To flag fields which may not be left blank
!              (this comment has no "value")
!
! \units      Units (must be from EnergyPlus standard units list)
!              EnergyPlus units are standard SI units
!
! \ip-units   IP-Units (for use by input processors with IP units)
!              This is only used if the default conversion is not
!              appropriate.
!
! \minimum    Minimum that includes the following value
!
! \minimum>   Minimum that must be > than the following value
!
! \maximum    Maximum that includes the following value
!
! \maximum<   Maximum that must be < than the following value
!
! \default    Default for the field (if N/A then omit entire line)
!
! \deprecated This field is not really used and will be deleted from the object.
!              The information is gotten internally within the program.
!
! \autosizable Flag to indicate that this field can be used with the Auto
!              Sizing routines to produce calculated results for the
!              field. If a value follows this, then that will be used
!              when the "Autosize" feature is flagged. To trigger
!              autosizing for a field, enter Autosize as the field's
!              value. Only applicable to numeric fields.
!
! \autocalculatable Flag to indicate that this field can be automatically
!              calculated. To trigger auto calculation for a field, enter
!              Autocalculate as the field's value. Only applicable to
!              numeric fields.
!
! \type       Type of data for the field -
!              integer
!              real
!              alpha      (arbitrary string),
!              choice      (alpha with specific list of choices, see
!                          \key)
!              object-list (link to a list of objects defined elsewhere,
!                          see \object-list and \reference)
!
! \retaincase Retains the alphabetic case for alpha type fields
!
! \key        Possible value for "\type choice" (blanks are significant)
!              use multiple \key lines to indicate all valid choices
!
!

```

```

! \object-list      Name of a list of user-provided object names that are valid
entries
!                  for this field (used with "\reference")
!                  see Zone and BuildingSurface:Detailed objects below for
!                  examples.
!                  ** Note that a field may have only one \object-list reference.
!                  ** If it must reference more than one object-list, then a
!                  composite object-list should be created which contains all
!                  valid references.
!
! \reference        Name of a list of names to which this object belongs
!                  used with "\type object-list" and with "\object-list"
!                  see Zone and BuildingSurface:Detailed objects below for
!                  examples:
!
!                  Zone,
!                  A1 , \field Name
!                  \type alpha
!                  \reference ZoneNames
!
!                  BuildingSurface:Detailed,
!                  A4 , \field Zone Name
!                  \note Zone the surface is a part of
!                  \type object-list
!                  \object-list ZoneNames
!
!                  For each zone, the field "Name" may be referenced
!                  by other objects, such as BuildingSurface:Detailed, so it is
!                  commented with "\reference ZoneNames"
!                  Fields that reference a zone name, such as BuildingSurface:Detailed's
!                  "Zone Name", are commented as
!                  "\type object-list" and "\object-list ZoneNames"
!                  ** Note that a field may have multiple \reference commands.
!                  ** This is useful if the object belongs to a small specific
!                  object-list as well as a larger more general object-list.
!
! Object-level comments:
!
! \memo             Memo describing the object
!
! \unique-object    To flag objects which should appear only once in an idf
!                  (this comment has no "value")
!
! \required-object  To flag objects which are required in every idf
!                  (this comment has no "value")
!
! \min-fields       Minimum number of fields that should be included in the
!                  object.  If appropriate, the Input Processor will fill
!                  any missing fields with defaults (for numeric fields).
!                  It will also supply that number of fields to the "get"
!                  routines using blanks for alpha fields (note -- blanks
!                  may not be allowable for some alpha fields).
!
! \obsolete         This object has been replaced though is kept (and is read)
!                  in the current version.  Please refer to documentation as
!                  to the dispersal of the object.  If this object is
!                  encountered in an IDF, the InputProcessor will post an
!                  appropriate message to the error file.
!                  usage: \obsolete New=>[New object name]
!
! \extensible:<#>  This object is dynamically extensible -- meaning, if you
!                  change the IDD appropriately (if the object has a simple list
!                  structure -- just add items to the list arguments (i.e. BRANCH

```

```

! LIST). These will be automatically redimensioned and used during
! the simulation. <#> should be entered by the developer to signify
! how many of the last fields are needed to be extended (and EnergyPlus
! will attempt to auto-extend the object).
!
! \format          The object should have a special format when saved in
!                  the IDF Editor with the special format option enabled.
!                  The options include SingleLine, Vertices, CompactSchedule,
!                  FluidProperties, ViewFactors, and Spectral.
!                  The SingleLine option puts all the fields for the object
!                  on a single line. The Vertices option is used in objects
!                  that use X, Y and Z fields to format those three fields
!                  on a single line.
!                  The CompactSchedule formats that specific object.
!                  The FluidProperty option formats long lists of fluid
!                  properties to ten values per line.
!                  The ViewFactor option formats three fields related to
!                  view factors per line.
!                  The Spectral option formats the four fields related to
!                  window glass spectral data per line.
!
! Group-level comments:
!
! \group          Name for a group of related objects
!
!
! Notes on comments
! -----
!
! 1. If a particular comment is not applicable (such as units, or default)
! then simply omit the comment rather than indicating N/A.
!
! 2. Memos and notes should be brief (recommend 5 lines or less per block).
! More extensive explanations are expected to be in the user documentation

```

IDD – IP Units

In addition, the IDD contains indications of IP (inch-pound) units for the EnergyPlus standard SI (Systems International) units. These may be used by input and output interfaces to display values in the IP system. As noted, if the IP units are “standard” (first block below), then no \ip-units is expected in the field. Note that for some fields – due to their multiple use (for example, schedule values) – there cannot be a ip-unit designation.

```

! Default IP conversions (no \ip-units necessary)
! m => ft 3.281
! W => Btu/h 3.412
! m3/s => ft3/min 2118.6438
! C => F 1.8 (plus 32)
! kg/J => lb/Btu 2325.83774250441
! Pa => psi 0.0001450377
! W/m-K => Btu-in/h-ft2-F 6.93481276005548
! W/K => Btu/h-F 1.8987
! deltaC => deltaF 1.8
! m2 => ft2 10.764961
! K => R 1.8
! 1/K => 1/R 0.555555556
! (kg/s)/W => (lbm/sec)/(Btu/hr) 0.646078115385742
! J/kg => Btu/lb 0.00042956 (plus
7.6736)
! kg-H2O/kg-air => lb-H2O/lb-air 1
! kJ/kg => Btu/lb 0.429925
! lux => foot-candles 0.092902267
! kg/m3 => lb/ft3 0.062428

```

!	kg/s	=>	lb/s	2.2046
!	kg/s-m	=>	lb/s-ft	0.67194
!	m3	=>	ft3	35.319837041
!	m3	=>	gal	264.172
!	W/m2-K	=>	Btu/h-ft2-F	0.176110194261872
!	l/m	=>	l/ft	0.304785126485827
!	J/kg-K	=>	Btu/lb-F	0.000239005736137667
!	J/m3-K	=>	Btu/ft3-F	1.49237004739337E-05
!	m/s	=>	ft/min	196.86
!	m/s	=>	miles/hr	2.2369
!	m2-K/W	=>	ft2-F-hr/Btu	5.678263
!	W/m2	=>	Btu/h-ft2	0.316957210776545
!	A/K	=>	A/F	0.555555555555556
!	g/kg	=>	grains/lb	7.00000
!	g/m-s	=>	lb/ft-s	0.000671968949659
!	g/m-s-K	=>	lb/ft-s-F	0.000373574867724868
!	J/K	=>	Btu/F	0.000526917584820558
!	J/kg-K2	=>	Btu/lb-F2	0.000132889924714692
!	J/m3	=>	Btu/ft3	2.68096514745308E-05
!	kg/kg-K	=>	lb/lb-F	0.555555555555556
!	kPa	=>	psi	0.145038
!	kPa	=>	inHg	0.29523
!	m2/s	=>	ft2/s	10.764961
!	m3/kg	=>	ft3/lb	16.018
!	m3/m3	=>	ft3/ft3	1
!	N-s/m2	=>	lbf-s/ft2	0.0208857913669065
!	V/K	=>	V/F	0.555555555555556
!	W/m-K2	=>	Btu/h-F2-ft	0.321418310071648
!	m3/s-m	=>	ft3/min-ft	645.89
!	J/m2-K	=>	Btu/ft2-F	4.89224766847393E-05
!	cycles/hr	=>	cycles/hr	1
!	kg/kg	=>	lb/lb	1
!	J/J	=>	Btu/Btu	1
!	g/GJ	=>	lb/MWh	0.00793664091373665
!	L/GJ	=>	gal/kWh	0.000951022349025202
!	m3/GJ	=>	ft3/MWh	127.13292
!	m3/s-m2	=>	ft3/min-ft2	196.85
!	m3/s-person	=>	ft3/min-person	2118.6438
!	W/m2-K2	=>	Btu/h-ft2-F2	0.097826
!	g/MJ	=>	lb/MWh	7.93664091373665
!	L/MJ	=>	gal/kWh	0.951022349025202
!	m3/MJ	=>	ft3/kWh	127.13292
!	W/W	=>	Btuh/Btuh	1
!	\$/m2	=>	\$/ft2	0.0928939733269818
!	\$	=>	\$	1
!	\$/kW	=>	\$/ (kBtuh/h)	0.293083235638921
!	\$/m3	=>	\$/ft3	0.0283127014102352
!	years	=>	years	1
!	\$/ (W/K)	=>	\$/ (Btu/h-F)	0.52667614683731
!	\$/ (m3/s)	=>	\$/ (ft3/min)	0.000472000059660808
!	W/m	=>	Btu/h-ft	1.04072
!	K/m	=>	F/ft	0.54861322767449
!	W/s	=>	W/s	1
!	kmol	=>	kmol	1
!	J	=>	Wh	0.000277777777777778
!	GJ	=>	ton-hrs	78.9889415481832
!	kg/m2	=>	lb/ft2	0.204794053596664
!	kg	=>	lb	2.2046
!	percent/K	=>	percent/F	0.555555555555556
!	kg/s2	=>	lb/s2	2.2046
!	g/mol	=>	lb/mol	0.0022046
!	deltaJ/kg	=>	deltaBtu/lb	0.0004299
!	person/m2	=>	person/ft2	0.0928939733269818

```

!      m2/person          =>  ft2/person          10.764961
!      W/person           =>  Btu/h-person         3.412
!      m3/person          =>  ft3/person          35.319837041
!      m3/hr-person       =>  ft3/hr-person       35.319837041
!      m3/m2              =>  ft3/ft2             3.281
!      m3/hr-m2          =>  ft3/hr-ft2         3.281
!      m3/hr              =>  ft3/hr             35.319837041
!      s/m                =>  s/ft                0.304785126485827
!
! Other conversions supported (needs the \ip-units code)
!
!      m                  =>  in                  39.37
!      W                  =>  W                    1
!      m3/s               =>  gal/min             15852
!      Pa                 =>  inHg              0.00029613
!      Pa                 =>  inH2O             0.00401463
!      Pa                 =>  ftH2O            0.00033455
!      W/person           =>  W/person          1
!      W/m2               =>  W/m2             1
!      W/m2               =>  W/ft2            0.0928939733269818
!
! Units fields that are not translated
!      deg
!      hr
!      A
!      dimensionless
!      V
!      ohms
!      A/V
!      eV
!      percent
!      s
!      W/m2 or deg C
!      W/m2, W or deg C
!      minutes
! *****

```

In the descriptions below, you will see IDD snippets for each input object. The Site:Location object will serve as an example.

```

Site:Location,
  \unique-object
  \min-fields 5
A1 , \field Name
  \required-field
  \type alpha
N1 , \field Latitude
  \units deg
  \type real
N2 , \field Longitude
  \units deg
  \type real
N3 , \field Time Zone
  \units hr
  \type real
N4 ; \field Elevation
  \units m
  \type real

```

For the purposes of this example, the IDD snippet above is somewhat abbreviated from the true definition that you will find in the IDD file and below in the more complete description of the Location object.

First, the object name is given. (Site:Location) This is followed by a comma in both the definition (IDD) and in an input file (IDF). In fact, all fields except the terminating field of an

IDD class object and IDF object are followed by commas. The final field in an IDD class object or in an IDF object is terminated by a semi-colon.

Next is an alpha field, the location name. As noted above, for input, spaces are significant in this field. The main inputs for Site:Location are numeric fields. These are numbered (as is the alpha field) for convenience. The \ designations will show various information about the objects as described above in the IDD conventions discussion. Of importance for reading this document are the units and possible minimum and maximum values for a field.

There is automatic processing of the \minimum, \maximum and \default data for numeric fields. Any infractions of the \minimum, \maximum fields are automatically detected and messages will appear in the standard error file. After all the input is checked, infractions will cause program termination (before the bulk of the simulation is completed). Defaults are also enforced if you leave the numeric field blank.

Some objects need all the parameters listed by the definition; some do not. In the descriptions that follow, we will try to indicate which parts are optional. Usually, these will be the last fields in the object input or definition. Even if items are not used for a particular object (e.g. Multiplier in the FenestrationSurface:Detailed and type=Door), the field must be included unless it is the *last field in the object*. So, for this instance, one must include a multiplier field (must be numeric and would need to obey any \minimum, \maximum rules) for doors.

Group – Simulation Parameters

This group of objects influences the simulation in various ways.

Version

Field: Version Identifier

The Version object allows you to enter the proper version that your IDF was created for. This is checked against the current version of EnergyPlus and a Severe error issued (non-terminating) if it does not match the current version string.

```
Version,
  \unique-object
  \format singleLine
A1 ; \field Version Identifier
  \required-field
```

Timestep

Field: Number of Timesteps per Hour

The Timestep object specifies the "basic" timestep for the simulation. The value entered here is usually known as the Zone Timestep. This is used in the Zone Heat Balance Model calculation as the driving timestep for heat transfer and load calculations. The value entered here is the number of timesteps to use within an hour. Longer length timesteps have lower values for Number of Timesteps per Hour. For example a value of 6 entered here directs the program to use a zone timestep of 10 minutes and a value of 60 means a 1 minute timestep. The user's choice for Number of Timesteps per Hour must be evenly divisible into 60; the allowable choices are 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, and 60.

The choice made for this field has important implications for modeling accuracy and the overall time it takes to run a simulation. Here are some considerations when choosing a value:

- The solution technique used in EnergyPlus has been designed to be stable with zone timesteps of up to sixty minutes (Number Timesteps in Hour = 1). However, 60 minutes is considered a "long" timestep and it should only be used in rare occasions where there is no HVAC system, accuracy is not a concern, and short run times are critical. Such long timesteps are not recommended to use because simulation results are more accurate for shorter timesteps, of say 10 minutes or less (Number of

Timesteps per Hour of 6 or more). Shorter zone timesteps improve the numerical solution of the Zone Heat Balance Model because they improve how models for surface temperature and zone air temperature are coupled together. Longer timesteps introduce more lag and lead to more a dampened dynamic response.

- Simulation run time increases with shorter timesteps or larger values for Number of Timesteps per Hour. The effect varies with the nature of the model. The user can test out different values on their particular model to understand the implications for his or her particular case. Sometimes large models with multizone HVAC and Plant systems execute nearly as fast with 15 minute timesteps as with 60 minute timesteps because fewer iterations are required in the system modeling since the prior timestep's results are close to the final outcome of next timestep.
- The weather data files usually have 60-minute data. However, it does not follow that this should be used as the basis for choosing the zone timestep because:
 - EnergyPlus carefully interpolates the weather data between data points for use at shorter timesteps. This is discussed in a later section: Weather Data Hourly Interpolation
 - Many aspects of a model have time scales that differ from the that of the weather data. A goal of the modeling is to predict how the building will respond to the weather. However, the building's response is not *governed* by the time scale that the weather data are available at, but rather the time scales of the dynamic performance of the thermal envelope as well as things like schedules for internal gains, thermostats, and equipment availability.
- If the model will include calculating the cost of electricity, then the user should be aware that many electric utility tariffs base charges on demand windows of a specified length of time. If the choice of Number of Timesteps per Hour is not consistent with the demand window, then unexpected results may be obtained. For reasonable prediction of the maximum rates for electricity use for in calculating demand charges, the length of the zone timestep needs to be consistent with the tariff's demand window. The following table lists what values are consistent with various demand windows.

Demand Window	Applicable Number of Timesteps per Hour
QuarterHour	4, 12, 20, or 60
HalfHour	2, 4, 6, 10, 12, 20, 30, or 60
FullHour, Day, Week	Any

There is also second type of timestep inside EnergyPlus that is known as the System Timestep. This is a variable-length timestep that governs the driving timestep for HVAC and Plant system modeling. The user cannot directly control the system timestep (except by use of the ConvergenceLimits object). When the HVAC portion of the simulation begins it's solution for the current zone timestep, it uses the zone timestep as its maximum length but then can reduce the timestep, as necessary, to improve the solution. The technical details of the approach are explained in the Engineering Documentation under "Integrated Solution Manager".

Users can see the system timestep used if they select the "detailed" frequency option on an HVAC report variable (e.g. Zone/Sys Air Temperature). To contrast, the "Zone" variables will only be reported on the zone timestep (e.g. Zone Mean Air Temperature).

```

Timestep,
  \unique-object
  \format singleLine
N1 ; \field Number of Timesteps per Hour
  \required-field
  \note Number in hour: normal validity 4 to 60: 6 suggested
  \note Must be evenly divisible into 60
  \note Allowable values include 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, and 60
  \note Normal 6 is minimum as lower values may cause inaccuracies
  \note A minimum value of 20 is suggested for both ConductionFiniteDifference
  \note and CombinedHeatAndMoistureFiniteElement surface heat balance algorithms
  \note
  \default 6
  \type integer
  \minimum 1
  \maximum 60

```

And, the IDF example:

```
Timestep, 6; !Suggested default for most system simulations
```

Suggested defaults are 4 for non-HVAC simulations, 6 for simulations with HVAC, 20 is the minimum for ConductionFiniteDifference and HeatAndMoistureFiniteElement simulations.

Note that hourly data (such as outdoor conditions expressed by Design Days or Weather data) are interpolated to the Zone Timestep. This is discussed in a later section: Weather Data Hourly Interpolation

ConvergenceLimits

This item is an “advanced” feature that should be used only with caution. It is specifically included to assist some users “speed up” calculations while not overly compromising accuracy. The user must judge for him/herself whether the reduced run time is useful.

Field: Minimum System Timestep

Usually the minimum system timestep is allowed to vary from the zone timestep (as maximum) to a minimum timestep of 1 minute during certain system calculations. This might be when the system turns on or off, for example. Entering 0 in this field sets the minimum system timestep to be the same as the zone timestep. Otherwise the units of the field are minutes. It’s probably a good idea to have any minimum entered be a divisor of the zone timestep.

Field: Maximum HVAC Iterations

The HVAC Manager will iterate to a solution or up to a set number of iterations. If not “converged”, then a warning error appears:

```
** Warning ** SimHVAC: Maximum iterations (20) exceeded for all HVAC loops, at CHICAGO IL USA TMY2-94846 WMO#=725300, 10/07 14:06 - 14:08
```

In order to reduce time used in simulating your building, you may choose to enter a lesser number than the default of 20 for the maximum number of iterations to be used. Or, you may wish to enter a bigger number for certain buildings. To get more information printed with a “max iteration” message, you need to enter a “Diagnostics, DisplayExtraWarnings;” command (which may also generate other warnings than just this one).

The IDD for the object:

```

ConvergenceLimits,
  \unique-object
N1 , \field Minimum System Timestep
     \units minutes
     \type integer
     \note 0 sets the minimum to the zone timestep (ref: Timestep)
     \note 1 is normal (ratchet down to 1 minute)
     \note setting greater than zone timestep (in minutes) will effectively set to zone timestep
     \minimum 0
     \maximum 60
N2 ; \field Maximum HVAC Iterations
     \type integer
     \default 20
     \minimum 1

```

and in use in an IDF:

```

ConvergenceLimits,
0;           ! Minimum System Timestep (0=same as zone timestep)

```

Building

The Building object describes parameters that are used during the simulation of the building. There are necessary correlations between the entries for this object and some entries in the Site:WeatherStation and Site:HeightVariation objects, specifically the Terrain field.

Field: Building Name

Building name is specified for output convenience.

Field: North Axis

The Building North Axis is specified **relative to true North**. Buildings frequently do not line up with true north. For convenience, one may enter surfaces in a “regular” coordinate system and then shift them via the use of the North Axis. The value is specified in degrees from “true north” (clockwise is positive).

The figure below shows how the building north axis can be rotated to correspond with one of the major axes of an actual building. The relevance of this field is described more completely under “GlobalGeometryRules”; in particular, the value of “North Axis” is *ignored* if a coordinate system other than “relative” is used.

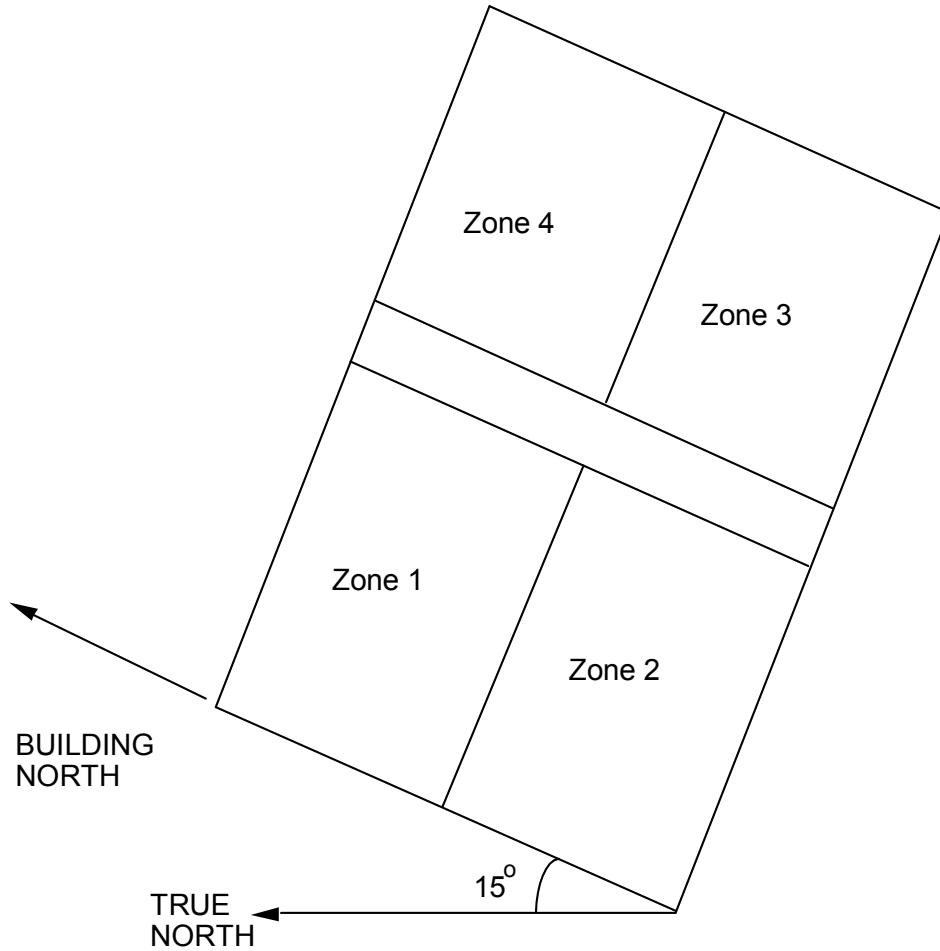


Figure 1. Illustration of Building North Axis

Field: Terrain

The site’s terrain affects how the wind hits the building – as does the building height. In addition, the external conduction method usually has its own parameters for the calculation. Please see the Engineering Documentation, External Conduction section for particulars. The legal values for this field are shown in the following table.

Table 1. Values for "Terrain"

Terrain Type Value	Terrain Description
Country	Flat, Open Country
Suburbs	Rough, Wooded Country, Suburbs
City	Towns, city outskirts, center of large cities
Ocean	Ocean, Bayou flat country
Urban	Urban, Industrial, Forest

Field: Loads Convergence Tolerance Value

This value represents the number at which the loads values must agree before “convergence” is reached. Loads tolerance value is a fraction of the load.

Field: Temperature Convergence Tolerance Value

This value represents the number at which the zone temperatures must agree (from previous iteration) before "convergence" is reached. (Units for this field is delta C).

Convergence of the simultaneous heat balance/HVAC solution is reached when either the loads or temperature criterion is satisfied.

All tolerances have units so the temperature tolerance is in degrees C (or degrees K) and the loads tolerance is in Watts. Both tolerances work the same way, just one looks at temperatures and one looks at heating and cooling loads. After the second warm-up day, the program compares the maximum temperature experienced in a space with the maximum temperature from the previous day. If those two temperatures are within the tolerance, then it has passed the first warm-up check.

It does a similar comparison with lowest temperatures experience within all the zones. If the current simulation day and the previous day values are within the tolerance, then it has passed the second warm-up check. Similar things are done with the loads tolerance and the maximum heating and cooling loads that are experienced within the spaces. Those are compared individually to the values for the previous day. If they are both in tolerance, then the simulation has passed the third and fourth warm-up check. The simulation stays in the warm-up period until ALL FOUR checks have been passed.

Please note--other "convergence tolerance" inputs are required for certain HVAC equipment (unit ventilator, unit heater, window AC, etc.). The purpose and units of these parameters are different from "load convergence tolerance" and "temperature convergence tolerance" in the BUILDING object.

Field: Solar Distribution

Setting this value determines how EnergyPlus treats beam solar radiation and reflectances from exterior surfaces that strike the building and, ultimately, enter the zone. There are five choices: **MinimalShadowing**, **FullExterior** and **FullInteriorAndExterior**, **FullExteriorWithReflections**, **FullInteriorAndExteriorWithReflections**.

MinimalShadowing

In this case, there is no exterior shadowing except from window and door reveals. All beam solar radiation entering the zone is assumed to fall on the floor, where it is absorbed according to the floor's solar absorptance. Any reflected by the floor is added to the transmitted diffuse radiation, which is assumed to be uniformly distributed on all interior surfaces. If no floor is present in the zone, the incident beam solar radiation is absorbed on all interior surfaces according to their absorptances. The zone heat balance is then applied at each surface and on the zone's air with the absorbed radiation being treated as a flux on the surface.

FullExterior, FullExteriorWithReflections

In this case, shadow patterns on exterior surfaces caused by detached shading, wings, overhangs, and exterior surfaces of all zones are computed. As for MinimalShadowing, shadowing by window and door reveals is also calculated. Beam solar radiation entering the zone is treated as for MinimalShadowing -- All beam solar radiation entering the zone is assumed to fall on the floor, where it is absorbed according to the floor's solar absorptance. Any reflected by the floor is added to the transmitted diffuse radiation, which is assumed to be uniformly distributed on all interior surfaces. If no floor is present in the zone, the incident beam solar radiation is absorbed on all interior surfaces according to their absorptances. The zone heat balance is then applied at each surface and on the zone's air with the absorbed radiation being treated as a flux on the surface.

FullInteriorAndExterior, FullInteriorAndExteriorWithReflections

This is the same as FullExterior except that instead of assuming all transmitted beam solar falls on the floor the program calculates the amount of beam radiation falling on each surface in the zone, including floor, walls and windows, by projecting the sun's rays through the

exterior windows, taking into account the effect of exterior shadowing surfaces and window shading devices.

If this option is used, you should be sure that the surfaces of the zone totally enclose a space. This can be determined by viewing the **epplusout.dxf** file with a program like AutoDesk's Volo View Express. You should also be sure that the zone is **convex**. Examples of convex and non-convex zones are shown in Figure 2. The most common non-convex zone is an L-shaped zone. (A formal definition of convex is that any straight line passing through the zone intercepts at most two surfaces.) If the zone's surfaces do not enclose a space or if the zone is not convex you should use Solar Distribution = **FullExterior** instead of **FullInteriorAndExterior**.

If you use **FullInteriorAndExterior** the program will also calculate how much beam radiation falling on the inside of an exterior window (from other windows in the zone) is absorbed by the window, how much is reflected back into the zone, and how much is transmitted to the outside. In this calculation the effect of a shading device, if present, is accounted for.

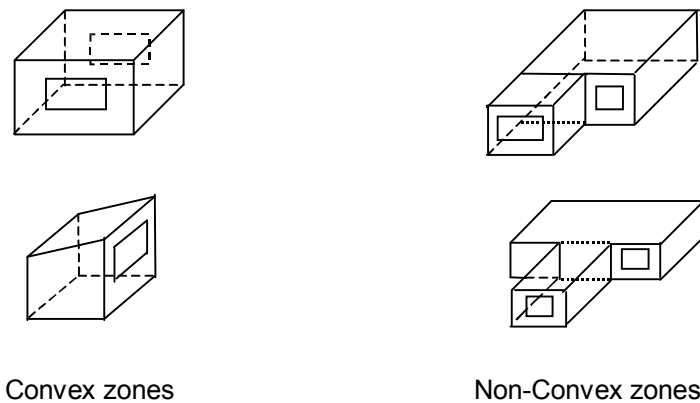


Figure 2. Illustration of Convex and Non-convex Zones

Reflection calculations

Note: Using the reflection calculations can be very time-consuming. Even error-prone. As a possible alleviation, you can use the Output:Diagnostics,DoNotMirrorDetachedShading; in many cases to get past a fatal error.

If using reflections, the program calculates beam and sky solar radiation that is reflected from exterior surfaces and then strikes the building. These reflecting surfaces fall into three categories:

- (1) **Shadowing surfaces.** These are surfaces like overhangs or neighboring buildings entered with Surface Shading:Site:Detailed, Shading:Building:Detailed, or Shading:Zone:Detailed. See Figure 3.
- (2) These surfaces can have diffuse and/or specular (beam-to-beam) reflectance values that are specified with the Shading Surface Reflectance object (ref: ShadingProperty:Reflectance).
- (3) **Exterior building surfaces.** In this case one section of the building reflects solar radiation onto another section (and vice-versa). See Figure 4.
- (4) The building surfaces are assumed to be diffusely reflecting if they are opaque (walls, for example) and specularly reflecting if they are windows or glass doors. The reflectance values for opaque surfaces are calculated by the program from the Solar Absorptance and Visible Absorptance values of the outer material layer of the surface's

construction (ref: Material properties). The reflectance values for windows and glass doors are calculated by the program from the reflectance properties of the individual glass layers that make up surface's construction assuming no shading device is present and taking into account inter-reflections among the layers (ref: Window Properties).

- (5) **The ground surface.** Reflection from the ground is calculated even if reflections option is not used. But in this case the ground plane is considered unobstructed, i.e., the shadowing of the ground by the building itself or by obstructions such as neighboring buildings is ignored. This shadowing is taken into account if the reflections option is used.¹ This is shown in Figure 5.

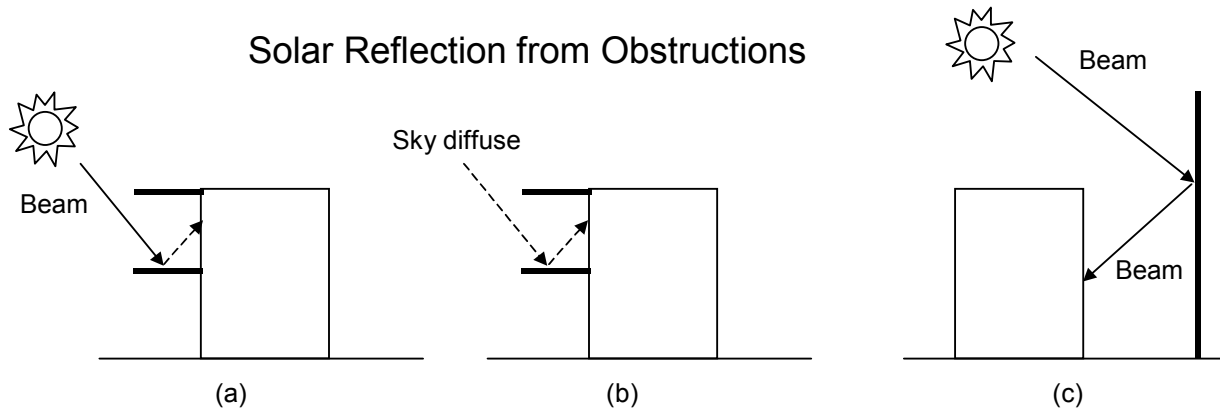


Figure 3. Solar reflection from shadowing surfaces. Solid arrows are beam solar radiation; dashed arrows are diffuse solar radiation. (a) Diffuse reflection of beam solar radiation from the top of an overhang. (b) Diffuse reflection of sky solar radiation from the top of an overhang. (c) Beam-to-beam (specular) reflection from the façade of an adjacent highly-glazed building represented by a vertical shadowing surface.

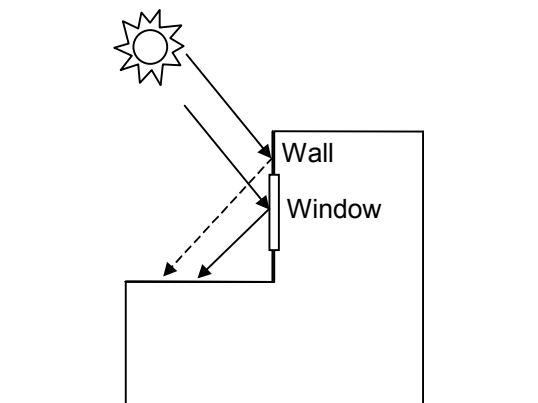


Figure 4. Solar reflection from building surfaces onto other building surfaces. In this example beam solar reflects from a vertical section of the building onto a roof section. The reflection from the window is specular. The reflection from the wall is diffuse.

¹ If reflections option is used for the ground surface then the ground view factor is NOT used.

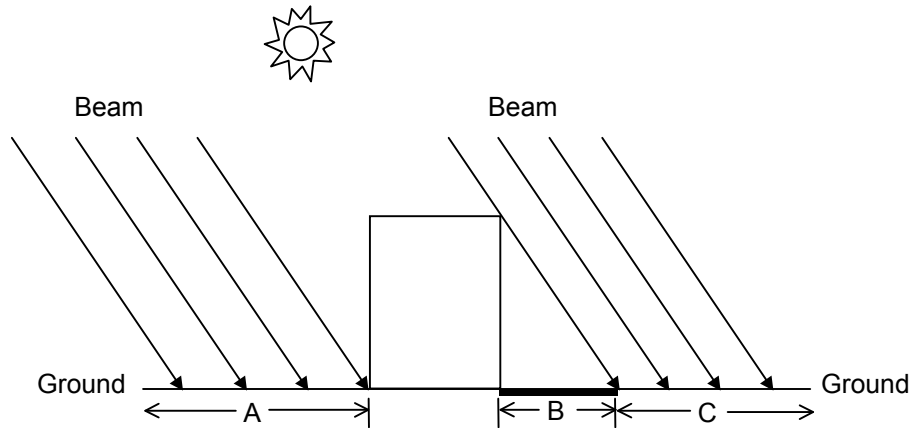


Figure 5. Shadowing from building affects beam solar reflection from the ground. Beam-to-diffuse reflection from the ground onto the building occurs only for sunlit areas, A and C, not from shaded area, B.

Field: Maximum Number of Warmup Days

This field specifies the number of “warmup” days that might be used in the simulation before “convergence” is achieved. The default number, 25, is usually more than sufficient for this task; however, some complex buildings (with complex constructions) may require more days. A warning message will occur when the simulation “runs” out of days:

```
Loads Initialization did not Converge (CheckWarmupConvergence)
```

You may be able to increase the Maximum Number of Warmup Days and get convergence, but some anomalous buildings may still not converge. Simulation proceeds for x warmup days until “convergence” is reached (see the discussion under the Temperature Convergence Tolerance Value field in this object, just above).

```

Building,
  \unique-object
  \required-object
  \min-fields 7
A1 , \field Name
  \required-field
  \retaincase
  \default NONE
N1 , \field North Axis
  \note degrees from true North
  \units deg
  \type real
  \default 0.0
A2 , \field Terrain
  \note Country=FlatOpenCountry | Suburbs=CountryTownsSuburbs | City=CityCenter | Ocean=body of
water (5km) | Urban=Urban-Industrial-Forest
  \type choice
  \key Country
  \key Suburbs
  \key City
  \key Ocean
  \key Urban
  \default Suburbs
N2 , \field Loads Convergence Tolerance Value
  \note Load tolerance value is a fraction of load
  \type real
  \minimum> 0.0
  \maximum .5
  \default .04
N3 , \field Temperature Convergence Tolerance Value
  \units deltaC
  \type real
  \minimum> 0.0
  \maximum .5
  \default .4
A3 , \field Solar Distribution
  \note MinimalShadowing | FullExterior | FullInteriorAndExterior | FullExteriorWithReflections |
FullInteriorAndExteriorWithReflections
  \type choice
  \key MinimalShadowing
  \key FullExterior
  \key FullInteriorAndExterior
  \key FullExteriorWithReflections
  \key FullInteriorAndExteriorWithReflections
  \default FullExterior
N4 ; \field Maximum Number of Warmup Days
  \note EnergyPlus will only use as many warmup days as needed to reach convergence tolerance.
  \note This field's value should NOT be set less than 25.
  \type integer
  \minimum> 0
  \default 25

```

And example from an IDF:

```

Building,
PSI HOUSE DORM AND OFFICES, ! Building Name
36.87000, ! Building Azimuth
Suburbs, ! Building Terrain
4.0E-02, ! Loads Convergence Tolerance
0.4, ! Temperature Convergence Tolerance
FullInteriorAndExterior, ! Solar Distribution
25; ! Maximum Number of Warmup Days

```

SurfaceConvectionAlgorithm:Inside

Three interior convection models may be selected for global use. The simple natural convection model applies constant heat transfer coefficients depending on the surface orientation. The detailed natural convection model correlates the heat transfer coefficient to the temperature difference for various orientations. This model is based on flat plate experiments. The third model is a mixed and forced convection model for ceiling diffuser

configurations. The model correlates the heat transfer coefficient to the air change rate for ceilings, walls and floors. These correlations are based on experiments performed in an isothermal room with a cold ceiling jet.

To avoid discontinuities in surface heat transfer rate calculations, all of correlations have been extrapolated beyond the lower limit of the data set (3 ACH) to a natural convection limit that is applied during the hours when the system is off. These models are explained in detail in the EnergyPlus Engineering Reference Document.

Field: Algorithm

The model specified in this field is the default algorithm for all zones. The optional Zone Inside Convection Algorithm field in the Zone object may be used to selectively override this value on a zone-by-zone basis.

```
SurfaceConvectionAlgorithm:Inside,
  \memo Default indoor surface heat transfer convection algorithm to be used for all zones
  \unique-object
  \format singleLine
A1 ; \field Algorithm
  \required-field
  \type choice
  \key Simple
  \key Detailed
  \key CeilingDiffuser
  \default Detailed
  \note Simple = constant natural convection (ASHRAE)
  \note Detailed = variable natural convection based on temperature difference (ASHRAE)
  \note CeilingDiffuser = ACH based forced and mixed convection correlations
  \note for ceiling diffuser configuration with simple natural convection limit
```

IDF Example:

```
SurfaceConvectionAlgorithm:Inside,Detailed;
```

SurfaceConvectionAlgorithm:Outside

Field: Algorithm

Six exterior convection models may be selected in EnergyPlus. The simple convection model applies heat transfer coefficients depending on the roughness and windspeed. This is a combined heat transfer coefficient that includes radiation to sky, ground, and air. The correlation is based on Figure 1, Page 25.1 (Thermal and Water Vapor Transmission Data), 2001 ASHRAE Handbook of Fundamentals.

All other convection models apply heat transfer coefficients depending on the roughness, windspeed, and terrain of the building's location. These are *convection only* heat transfer coefficients; radiation heat transfer coefficients are calculated automatically by the program. All algorithms are described more fully in the Engineering Reference.

Note that when the surface is wet (i.e. it is raining and the surface is exposed to wind) then the convection coefficient appears as a very large number (1000) and the surface is exposed to the Outdoor Wet-bulb Temperature rather than the Outdoor Dry-bulb Temperature.

```

SurfaceConvectionAlgorithm:Outside,
  \memo Default outside convection algorithm to be used for all zones
  \unique-object
  \format singleLine
A1 ; \field Algorithm
  \required-field
  \type choice
  \key Simple
  \key Detailed
  \key BLAST
  \key TARP
  \key DOE-2
  \key MoWiTT
  \default Detailed
  \note Simple = ASHRAE Simple
  \note Detailed = ASHRAE Detailed
  \note BLAST is identical to Detailed as of version 1.2.1
  \note TARP is identical to Detailed as of version 1.3.0

```

IDF Example:

```
SurfaceConvectionAlgorithm:Outside,Detailed;
```

HeatBalanceAlgorithm

The HeatBalanceAlgorithm object provides a way to select what type of heat and moisture transfer algorithm will be used across the building construction calculations.

Field: Algorithm

Four values are allowed to select which solution will be used. The **ConductionTransferFunction** selection is a sensible heat only solution and does not take into account moisture storage or diffusion in the construction elements. The **MoisturePenetrationDepthConductionTransferFunction** selection is a sensible heat diffusion and an inside surface moisture storage algorithm that also needs additional moisture material property information. See the appropriate moisture material property objects for additional information. **Advanced/Research usage: The ConductionFiniteDifference selection is a sensible heat only solution and does not take into account moisture storage or diffusion in the construction elements. This solution technique uses a 1-D finite difference solution in the construction elements.**

Advanced/Research usage: The CombinedHeatAndMoistureFiniteElement is a coupled heat and moisture transfer and storage solution. The solution technique uses a one dimensional finite difference solution in the construction elements and requires further material properties described in the Heat and Moisture Transfer material properties objects.

Field: Surface Temperature Upper Limit

This field is a bit “advanced”. It should only be used when the simulation fails AND you cannot determine a cause for the failure. That is, you receive an error similar to:

```

** Severe  ** Temperature out of bounds (202.91) for surface=Wall11
**   ~~~  ** in Zone=Zone01
**   ~~~  ** Occurrence info=NEW YORK CITY NY SUMMER, 07/21 16:00 - 16:01
**   ~~~  ** A temperature out of bounds problem can be caused by several things. The user
**   ~~~  ** should check the weather environment, the level of internal gains with respect
**   ~~~  ** to the zone, and the thermal properties of their materials among other things.
**   ~~~  ** A common cause is a building with no thermal mass -- all materials with
**   ~~~  ** Regular-R definitions.

```

And, after careful perusal, you cannot find a solution as suggested in the error description. You may then want to enter a higher number than the default for this field.

```
HeatBalanceAlgorithm,
    \memo Determines which Heat Balance Algorithm will be used ie. CTF (Conduction Transfer Functions),
    \memo EMPD (Effective Moisture Penetration Depth with Conduction Transfer Functions).
    \memo Advanced/Research Usage: CondFD (Conduction Finite Difference)
    \memo Advanced/Research Usage: HAMT (Combined Heat And Moisture Finite Element)
    \unique-object
    \format singleLine
A1 , \field Algorithm
    \required-field
    \type choice
    \key ConductionTransferFunction
    \key MoisturePenetrationDepthConductionTransferFunction
    \key ConductionFiniteDifference
    \key CombinedHeatAndMoistureFiniteElement
    \default ConductionTransferFunction
N1; \field Surface Temperature Upper Limit
    \minimum 200
    \default 200
```

And, a default IDF example

```
HeatBalanceAlgorithm,ConductionTransferFunction; ! Solution Algorithm
```

ShadowCalculation

In order to speed up the calculations, shadowing calculations (sun position, etc) are performed over a period of days. Note that this value may be very important for determining the amount of sun entering your building and by inference the amount of cooling or heating load needed for maintaining the building. Though termed “shadowing” calculations, it in affect determines the sun position for a particular day in a weather file period simulation. (Each design day will use the date of the design day object). Even though weather file data contains the amount of solar radiation, the internal calculation of sun position will govern how that affect various parts of the building. By default, this is every 20 days throughout a weather run period.

Field: Calculation Frequency

This numeric field will cause the shadowing calculations to be done periodically using the number in the field as the number of days in each period. Using this field will allow you to synchronize the shadowing calculations with changes in shading devices. Using the default of 20 days in each period is the average number of days between significant changes in solar position angles.

Field: Maximum Figures in Shadow Overlap Calculations

This numeric field will allow you to increase the number of figures in shadow overlaps. Due to the shadowing algorithm, the number of shadows in a figure may grow quite large even with fairly reasonable looking structures. Of course, the inclusion of more allowed figures will increase calculation time. Likewise, too few figures may not result in as accurate calculations as you desire.

```
ShadowCalculation,
  \unique-object
  N1 , \field Calculation Frequency
      \required-field
      \type integer
      \minimum 1
      \default 20
      \note 0=Use Default Periodic Calculation|<else> calculate every <value> day
      \note only really applicable to RunPeriods
  N2 ; \field Maximum Figures in Shadow Overlap Calculations
      \note Number of allowable figures in shadow overlap calculations
      \type integer
      \minimum 200
      \default 15000
```

If shadowing surfaces are used with the transmittance property, the user should be careful to synchronize this calculation with the scheduled occurrence of the transmittance (if any) (or use 1, which will be the most accurate but will cause more time in the calculations). Example:

```
ShadowCalculation,1;
```

Output:Diagnostics

Sometimes, messages only confuse users – especially new users. Likewise, sometimes certain report variables exist for only a certain condition but some take them at face value/name. Some features may be very important but under certain instances cause problems. Thus, we have added the **diagnostic output** object to be able to turn on or off certain messages, variables, and features depending on conditions.

Both fields of the Output:Diagnostics command can accept all the applicable keys. More than one object may be entered.

Field: *key1*, *key2*

Allowable choices are:

DisplayAllWarnings – use this to get all warnings (except the developer warnings “DisplayZoneAirHeatBalanceOffBalance”). This key sets all other display warning values to on.

DisplayExtraWarnings – use this to get all extra warnings. An example of an extra warning is when a user enters a ceiling height or volume with the Zone object and EnergyPlus calculates something significantly different based on the entered zone geometry.

DisplayUnusedSchedules – use this to have the unused schedules (by name) listed at the end of the simulation.

DisplayUnusedObjects – use this to have unused (orphan) objects (by name) listed at the end of the simulation.

DisplayAdvancedReportVariables – use this to be able to use the “Opaque Surface Inside Face Conduction” – the name may be misleading to some. If you put in this field, then you will be able to report on this variable.

DisplayZoneAirHeatBalanceOffBalance – this is a developer diagnostic which you can turn on, if you desire.

DoNotMirrorDetachedShading – use this to turn off the automatic mirroring of detached shading surfaces. These surfaces are automatically mirrored so that the user does not need to worry about facing direction of the surface and the shading surface will shade the building as appropriate. Note that Shading:Zone:Detailed surfaces are also mirrored and there is no way to turn that “off”.

ReportDuringWarmup – use this to allow reporting during warmup days. This can show you exactly how your facility is converging (or not) during the initial “warmup” days of the simulation. Generally, only developers or expert simulation users would need this kind of detail.

The IDD for the object follows:

```

Output:Diagnostics,
  A1 , \field Key 1
      \type choice
      \key DisplayAllWarnings
      \key DisplayExtraWarnings
      \key DisplayUnusedSchedules
      \key DisplayUnusedObjects
      \key DisplayZoneAirHeatBalanceOffBalance
      \key DisplayAdvancedReportVariables
      \key DoNotMirrorDetachedShading
  A2 ; \field Key 2
      \type choice
      \key DisplayAllWarnings
      \key DisplayExtraWarnings
      \key DisplayUnusedSchedules
      \key DisplayUnusedObjects
      \key DisplayZoneAirHeatBalanceOffBalance
      \key DisplayAdvancedReportVariables
      \key DoNotMirrorDetachedShading

```

In IDF use:

```

Output:Diagnostics,
  DisplayExtraWarnings;

```

Output:PreprocessorMessage

The Output:PreprocessorMessage object can be used by preprocessor programs to EnergyPlus for passing certain conditions/errors that might not be detected by scripts executing the EnergyPlus system of programs. This allows EnergyPlus to intercept problems and terminate gracefully rather than the user having to track down the exact conditions.

There is no reason for a user to enter a Output:PreprocessorMessage object but you should encourage interface developers to use this feature. More than one Output:PreprocessorMessage objects may be entered. Of course, no preprocessor message objects are necessary if there is no error information to be passed.

```

P Output:PreprocessorMessage,
  \memo This object does not come from a user input. This is generated by a pre-processor
  \memo so that various conditions can be gracefully passed on by the InputProcessor.
  A1, \field Preprocessor Name
      \retaincase
  A2, \field Error Severity
      \note Depending on type, InputProcessor may terminate the program.
      \type choice
      \key Information
      \key Warning
      \key Severe
      \key Fatal
      \retaincase
  A3, \field Message Line 1
      \retaincase
<reduced for brevity - 10 lines currently allowed>

```

Field: Preprocessor Name

The preprocessor name (e.g. EPMacro, ExpandObjects) is entered here. Case is retained so that messages from EnergyPlus look very similar to what a preprocessor would produce.

Field: Error Severity

This is the error severity. If Fatal, EnergyPlus will terminate after showing all preprocessor messages.

Fields: Message Line 1 through Message Line 10

Each line is limited to 100 characters and an appropriate message can be composed.

An IDF Example:

```
Output:PreprocessorMessage,
  No Preprocessor Used,      !- preprocessor name
  Information,               !- error severity
  Illustrative Message,     !- message line 1
  No problems for processing; !- message line 2
```

And would appear in output:

```
***** Preprocessor="No Preprocessor Used" has the following Information messages:
**   ~~~   ** Illustrative Message
**   ~~~   ** No problems for processing
```

ZoneCapacitanceMultiplier

ZoneCapacitanceMultiplier = 1.0 is the capacitance of the air in the volume of the specified zone. This multiplier can be increased if the zone air capacitance needs to be increased for stability of the simulation.

```
ZoneCapacitanceMultiplier,
  \unique-object
  \format singleLine
  N1 ; \field Multiplier
  \type real
  \default 1.0
  \minimum 0.0
  \note Used for stability in predictor-corrector step by increasing air heat capacity of the zone air.
```

One of the few EnergyPlus defaulted items. If not defined, ZoneCapacitanceMultiplier defaults to 1.0.

SimulationControl

The input for SimulationControl allows the user to specify what kind of calculations a given EnergyPlus simulation will perform. For instance the user may want to perform one or more of the sizing calculations but not proceed to a annual weather file simulation. Or the user might have all flow rates and equipment sizes already specified and desire an annual weather without any preceding sizing calculations. The SimulationControl input allows all permutations of run selection by means of 5 yes/no inputs.

Only one SimulationControl object is permitted for each EnergyPlus input file. While a SimulationControl is needed to trigger sizing calculations, it is optional for other runs (design days, run periods). The actions will still be shown in the eplusout.eio file (see Output Details and Examples Document).

Field: Do Zone Sizing Calculation

Input is Yes or No. The default is No.

Field: Do System Sizing Calculation

Input is Yes or No. The default is No.

Field: Do Plant Sizing Calculation

Input is Yes or No. The default is No.

Field: Run Simulation for Sizing Periods

Input is Yes or No. The default is Yes. Yes implies that the simulation will be run on all the included SizingPeriod objects (i.e., SizingPeriod:DesignDay, SizingPeriod:WeatherFileDays, and SizingPeriod:WeatherFileConditionType)

Field: Run Simulation for Weather File Run Periods

Input is Yes or No. The default is Yes. Yes implies the simulation will be run on all the included RunPeriod objects.

The full IDD specification follows:

```
SimulationControl,
  \unique-object
  A1, \field Do Zone Sizing Calculation
      \type choice
      \key Yes
      \key No
      \default No
  A2, \field Do System Sizing Calculation
      \type choice
      \key Yes
      \key No
      \default No
  A3, \field Do Plant Sizing Calculation
      \type choice
      \key Yes
      \key No
      \default No
  A4, \field Run Simulation for Sizing Periods
      \type choice
      \key Yes
      \key No
      \default Yes
  A5; \field Run Simulation for Weather File Run Periods
      \type choice
      \key Yes
      \key No
      \default Yes
```

An IDF example:

```
SimulationControl,
  Yes, !zone sizing
  No, ! system sizing
  No, ! plant sizing
  No, ! design day full simulation
  No; ! weather file full simulation
```

MeterCustom

A custom meter allows the user to group variables or meters onto a virtual meter that can be used just like a normal meter created by EnergyPlus. For consistency, the items being grouped must all be similar.

Field: Name

This is a user defined name for the custom meter.

Field: Fuel Type

A fuel type should be specified for the meter. All assignments to this meter will be checked to assure that the same fuel type is used. Additionally, this may be used in other objects (such as the Demand Limiting). Valid choices for this field are:

- Electricity
- NaturalGas
- PropaneGas
- FuelOil#1
- FuelOil#2
- Coal
- Diesel
- Gasoline
- Water

- Generic

Fuel types are generally self-explanatory. Generic is included for convenience when a custom meter is defined that doesn't quite fit the "fuel" categories. See the examples below.

Field: group(s) Key Name-Report Variable/Meter Name

The rest of the object is filled with parameters of the key name/report variable or meter names. When a meter name is used, the key name field is left blank.

Field: Key Name #

A key name field is used when the following field specifies a report variable. If the field is left blank, then all the report variables in the following field are assigned to the meter.

Field: Report Variable or Meter Name #

This field must be a valid report variable name or a valid meter name.

The full IDD specification is:

```

Meter:Custom,
  \extensible:2 - repeat last two fields, remembering to remove ; from "inner" fields.
  \memo Used to allow users to combine specific variables and/or meters into
  \memo "custom" meter configurations.
  A1, \field Name
      \required-field
      \reference CustomMeterNames
  A2, \field Fuel Type
      \type choice
      \key Electricity
      \key NaturalGas
      \key PropaneGas
      \key FuelOil#1
      \key FuelOil#2
      \key Coal
      \key Diesel
      \key Gasoline
      \key Water
      \key Generic
  A3, \field Key Name 1
  A4, \field Report Variable or Meter Name 1
  A5, \field Key Name 2
  A6, \field Report Variable or Meter Name 2
  A7, \field Key Name 3
  A8, \field Report Variable or Meter Name 3
  <reduced for brevity>

```

Meter:CustomDecrement

The decrement custom meter is very similar to the custom meter specification but additionally allows a predefined meter to be used as the "source" meter and the remaining items subtract from that predefined meter.

Field: Name

This is a user defined name for the custom meter.

Field: Fuel Type

A fuel type should be specified for the meter. All assignments to this meter will be checked to assure that the same fuel type is used. Additionally, this may be used in other objects (such as the Demand Limiting). Valid choices for this field are:

- Electricity
- NaturalGas
- PropaneGas
- FuelOil#1

- FuelOil#2
- Coal
- Diesel
- Gasoline
- Water
- Generic

Field: Source Meter Name

This name specifies the meter that will be used as the main source for the decrement custom meter. The remainder of the fields are subtracted from the value of this meter to create the meter value named above. The Source Meter is not changed in any way by including this custom meter.

Field: group(s) Key Name-Report Variable/Meter Name

The rest of the object is filled with parameters of the key name/report variable or meter names. When a meter name is used, the key name field is left blank.

Field: Key Name #

A key name field is used when the following field specifies a report variable. If the field is left blank, then all the report variables in the following field are assigned to the meter.

Field: Report Variable or Meter Name #

This field must be a valid report variable name or a valid meter name. Additionally, it must be contained on the Source Meter. Note that, if an error occurs, only the Variable in error will show – confusing things if what was entered was a meter name.

The full IDD specification is:

```
Meter:CustomDecrement,
  \extensible:2 - repeat last two fields, remembering to remove ; from "inner" fields.
  \memo Used to allow users to combine specific variables and/or meters into
  \memo "custom" meter configurations.
A1, \field Name
    \required-field
    \reference CustomMeterNames
A2, \field Fuel Type
    \type choice
    \key Electricity
    \key NaturalGas
    \key PropaneGas
    \key FuelOil#1
    \key FuelOil#2
    \key Coal
    \key Diesel
    \key Gasoline
    \key Water
    \key Generic
A3, \field Source Meter Name
A4, \field Key Name 1
A5, \field Report Variable or Meter Name 1
A6, \field Key Name 2
A7, \field Report Variable or Meter Name 2
A8, \field Key Name 3
A9, \field Report Variable or Meter Name 3
<reduced for brevity>
```

Details of the Custom Meter/Custom Meter:Decrement are shown on the Meter Details file.
Examples of Custom Meter/Custom Meter:Decrement:

```

! The following custom meters are set up to illustrate the capabilities
! of custom meters.
! Custom Meter "MyGeneralLights" duplicates the InteriorLights:Electricity meter.
! Custom Meter "MyBuildingElectric" duplicates the Electricity:Building meter (by specifying that meter).
! Custom Meter (Decrement) "MyBuildingOther" uses Electricity:Building as its source meter
! and subtracts out the values for MyGeneralLights (aka InteriorLights:Electricity). The
! resultant value for MyBuildingOther should be equal to the value for the meters
! Electricity:Building - InteriorLights:Electricity (aka MyGeneralLights)
Meter:Custom,
  MyGeneralLights,      !- Name
  Electricity,          !- Fuel Type
  SPACE1-1,            !- Key Name 1
  Lights Electric Consumption, !- Report Variable or Meter Name 1
  SPACE2-1,            !- Key Name 2
  Lights Electric Consumption, !- Report Variable or Meter Name 2
  SPACE3-1,            !- Key Name 3
  Lights Electric Consumption, !- Report Variable or Meter Name 3
  SPACE4-1,            !- Key Name 4
  Lights Electric Consumption, !- Report Variable or Meter Name 4
  SPACE5-1,            !- Key Name 5
  Lights Electric Consumption; !- Report Variable or Meter Name 5

```

```

Meter:Custom,
  MyBuildingElectric,  !- Name
  Electricity,         !- Fuel Type
  ,                   !- Key Name #1
  Electricity:Building; !- Report Variable or Meter Name #1

Meter:CustomDecrement,
  MyBuildingOther,    !- Name
  Electricity,         !- Fuel Type
  Electricity:Building, !- Source Meter Name
  ,                   !- Key Name #1
  MyGeneralLights;    !- Report Variable or Meter Name #1

```

For an example of “generic” fuel type, one might put the Building Infiltration Heat Loss & Heat Gain on a set of custom meters:

```

Meter:Custom,
  Building Infiltration Heat Loss, !- Name
  Generic,                        !- Fuel Type
  *,                              !- Key Name 1
  Zone Infiltration Total Heat Loss; !- Report Variable or Meter Name 1

Meter:Custom,
  Building Infiltration Heat Gain, !- Name
  Generic,                        !- Fuel Type
  *,                              !- Key Name 1
  Zone Infiltration Total Heat Gain; !- Report Variable or Meter Name 1

```

One can then report these values the same way one reports other standard meters.

Simulation Parameter Outputs

These appear in the **eplusout.eio** file. For details of the reporting, please see the Output Details and Examples document.

Group – Compliance Objects

Not perhaps related directly to simulation, the Compliance Object group provides a repository for a group of objects that can be used directly or indirectly in reporting compliance (such as ASHRAE 90.1) to building standards.

Compliance:Building

The Compliance:Building object describes parameters related to compliance to building standards, building codes, and beyond energy code programs.

Field: Building Rotation for Appendix G

Building Rotation for Appendix G allows for the building model to be rotated for use with compliance such as ASHRAE 90.1 Appendix G. Appendix G requires the building to be rotated 0, 90, 180 and 270 degrees and the values averaged to establish baseline energy use. This input works with relative or world coordinate systems.

```
Compliance:Building,
    \memo Building level inputs related to compliance to building standards, building codes, and beyond
energy code programs.
    \unique-object
    \min-fields 1
N1; \field Building Rotation for Appendix G
    \note Additional degrees of rotation to be used with the requirement in ASHRAE Standard 90.1
Appendix G
    \note that states that the baseline building should be rotated in four directions.
    \units deg
    \type real
    \default 0.0
```

And example from an IDF:

```
Compliance:Building,
90;          Building Rotation for Appendix G
```

Group – Location – Climate – Weather File Access

This group of objects describes the ambient conditions for the simulation.

Site:Location

The location class describes the parameters for the building's location. Only one location is allowed. Weather data file location, if it exists, will override any location data in the IDF. Thus, for an annual simulation, a Location does not need to be entered.

Field: Name

This alpha field is used as an identifying field in output reports.

Field: Latitude

This field represents the latitude (in degrees) of the facility. By convention, North Latitude is represented as positive; South Latitude as negative. Minutes should be represented in decimal fractions of 60. (15' is 15/60 or .25)

Field: Longitude

This field represents the longitude (in degrees) of the facility. By convention, East Longitude is represented as positive; West Longitude as negative. Minutes should be represented in decimal fractions of 60. (15' is 15/60 or .25)

Field: Time Zone

This field represents the time zone of the facility (relative to Greenwich Mean Time or the 0th meridian). Time zones west of GMT (e.g. North America) are represented as negative; east of GMT as positive. Non-whole hours can be represented in decimal (e.g. 6:30 is 6.5).

Field: Elevation

This field represents the elevation of the facility in meters (relative to sea level).

```

Site:Location,
  \unique-object
  \min-fields 5
  A1 , \field Name
      \required-field
      \type alpha
  N1 , \field Latitude
      \units deg
      \minimum -90.0
      \maximum +90.0
      \default 0.0
      \note + is North, - is South, degree minutes represented in decimal (i.e. 30 minutes is .5)
      \type real
  N2 , \field Longitude
      \units deg
      \minimum -180.0
      \maximum +180.0
      \default 0.0
      \note - is West, + is East, degree minutes represented in decimal (i.e. 30 minutes is .5)
      \type real
  N3 , \field Time Zone
      \note basic these limits on the WorldTimeZone Map (2003)
      \units hr
      \minimum -12.0
      \maximum +14.0
      \default 0.0
      \note Time relative to GMT. Decimal hours.
      \type real
  N4 ; \field Elevation
      \units m
      \minimum -300.0
      \maximum< 6096.0
      \default 0.0
      \type real

```

Units with their abbreviations are shown in Appendix A. And, as shown in an IDF:

```

Site:Location, DENVER COLORADO,      ! Name
  39.75000      ,      ! Latitude {N+ S-}
 -104.8700     ,      ! Longitude {W- E+}
 -7.000000    ,      ! TimeZoneNumber {GMT+/-}
 1610.26;     ! Elevation {m}

```

Most examples in this document include the comment lines that illustrate each data field's value. However, this is not necessary (though it makes the IDF more readable). The previous example could also be:

```

Site:Location, DENVER COLORADO,39.75,-104.87,-7,1610.26;

```

Site:WeatherStation

The **Site:WeatherStation** object is used to specify the measurement conditions for the climatic data listed in the weather file. These conditions indicate the height above ground of the air temperature sensor, the height above ground of the wind speed sensor, as well as coefficients that describe the wind speed profile due to the terrain surrounding the weather station. There are necessary correlations between the entries for this object and some entries in the Building object, specifically the Terrain field.

Weather stations throughout the world (ref: WMO – World Meteorological Organization) take their measurements at standard conditions:

- Air temperature is measured at approximately 1.5 m above ground
- Wind speed is measured at 10 m above ground
- Weather station is in a flat, open field with little protection from the wind.

When using weather data from standard sources (e.g., TMY2, IWEC, TMY, or ASHRAE design day data), it is not necessary to use the **Site:WeatherStation** object. However, if you

are using custom weather data or real-time weather data, you may need to read and understand the concepts in the **Site:WeatherStation** object.

The measurement conditions at the weather station (i.e., the weather file) are used by EnergyPlus in conjunction with the *Terrain* field of the **Building** object, or optionally with the **Site:HeightVariation** object (see below), to calculate the local variation in atmospheric properties as a function of height above ground. Outdoor air temperature decreases with height, while wind speed increases with height. The algorithms for this calculation are in the Engineering Reference.

The **Site:WeatherStation** object is useful when working with a custom weather file that includes data that were not measured at the WMO standard conditions. For example, the weather data could be measured on site, or on the roof top of a nearby building. The wind speed profile coefficients can be estimated from the table below or calculated beforehand using more sophisticated techniques such as CFD modeling of the weather station terrain.

Table 2. Wind Speed Profile Coefficients (ASHRAE Fundamentals 2005).

Terrain Description	Exponent	Boundary Layer Thickness (m)
Flat, open country	0.14	270
Rough, wooded country	0.22	370
Towns and cities	0.33	460
Ocean	0.10	210
Urban, industrial, forest	0.22	370

If the **Site:WeatherStation** object is omitted from the input file, the WMO standard measurement conditions are assumed.

Field: Wind Sensor Height Above Ground

The height [m] above ground for the wind speed sensor.

Field: Wind Speed Profile Exponent

The wind speed profile exponent for the terrain surrounding the weather station. The exponent can be estimated from the table above or calculated beforehand using more sophisticated techniques, such as CFD modeling of the weather station terrain.

Field: Wind Speed Profile Boundary Layer Thickness

The wind speed profile boundary layer thickness [m] for the terrain surrounding the weather station. The boundary layer can be estimated from the table above or calculated beforehand using more sophisticated techniques, such as CFD modeling of the weather station terrain.

Field: Air Temperature Sensor Height Above Ground

The height [m] above ground for the air temperature sensor.

For example, if you are using weather data measured on the top of your building, you should set the *Wind Sensor Height Above Ground* and the *Air Temperature Sensor Height Above Ground* to equal the height of your building (say 30 m). The *Wind Speed Profile Exponent* and *Wind Speed Profile Boundary Layer Thickness* should be set to match the values associated with the *Terrain* field of the **Building** object, or the equivalent fields of the **Site:HeightVariation** object.

Or, in IDF terms, with a building in a town or city:

```
Site:WeatherStation,
  30,  !- Wind Sensor Height Above Ground {m}
  0.33,  !- Wind Speed Profile Exponent {}
  460,  !- Wind Speed Profile Boundary Layer Thickness {m}
  30;  !- Air Temperature Sensor Height Above Ground {m}
```

This would change if you had a different wind speed profile exponent or wind speed profile boundary layer thickness at your site.

The complete IDD definition:

```
Site:WeatherStation,
  \unique-object
  \memo This object is only used for non-standard weather data. Standard weather data
  \memo such as TMY2, IWEC, and ASHRAE design day data are all measured at the
  \memo default conditions and do not require this object to be used.
  N1 , \field Wind Sensor Height Above Ground
    \type real
    \units m
    \default 10.0
    \minimum > 0.0
  N2 , \field Wind Speed Profile Exponent
    \type real
    \default 0.14
    \minimum 0.0
  N3 , \field Wind Speed Profile Boundary Layer Thickness
    \type real
    \units m
    \default 270.0
    \minimum 0.0
  N4 ; \field Air Temperature Sensor Height Above Ground
    \type real
    \units m
    \default 1.5
    \minimum 0.0
```

Site:HeightVariation

The **Site:HeightVariation** object is used to specify the local variation in atmospheric properties at the site and should be used only if you require advanced control over the height-dependent variations for wind speed and temperature. The coefficients set by this object are used by EnergyPlus, in conjunction with the **Site:WeatherStation** object (see above), to calculate the local variation in atmospheric properties as a function of height above ground. Outdoor air temperature decreases with height, while wind speed increases with height. The local outdoor air temperature and wind speed are calculated separately for all zones and surfaces, and optionally for outdoor air nodes for which a height has been specified (see **OutdoorAir:Node** object). With the default inputs, wind speed falls significantly at heights lower than the weather station measurement height, and temperature increases slightly. The algorithms for this calculation are in the Engineering Reference. There are necessary correlations between the entries for this object and some entries in the Building object, specifically the Terrain field.

Table 3. Atmospheric Variables at Two Different Heights Above Ground Level.

Variable	1.5 m	284 m	Absolute Diff	Percent Diff
Air Temperature	15°C	13.15°C	1.85°C	12.3%
Barometric Pressure	101,325 Pa	97,960 Pa	3,365 Pa	3.3%
Wind Speed	2.46 m/s	7.75 m/s	5.29 m/s	215%

Note that using this object overrides the wind speed profile coefficients implied by the *Terrain* field of the **Building** object even if the wind speed profile fields are left blank. The wind speed profile coefficients can be estimated from the table above (see **Site:WeatherStation**) or

calculated beforehand using more sophisticated techniques such as CFD modeling of the site terrain.

```

Site:HeightVariation,
  \unique-object
  \memo This object is used if the user requires advanced control over height-dependent
  \memo variations in wind speed and temperature. When this object is not present, the default model
  \memo for temperature dependence on height is used, and the wind speed is modeled according
  \memo to the Terrain field of the BUILDING object.
N1 , \field Wind Speed Profile Exponent
  \note Set to zero for no wind speed dependence on height.
  \type real
  \default 0.22
  \minimum 0.0
N2 , \field Wind Speed Profile Boundary Layer Thickness
  \type real
  \units m
  \default 370.0
  \minimum> 0.0
N3 ; \field Air Temperature Gradient Coefficient
  \note Set to zero for no air temperature dependence on height.
  \type real
  \units K/m
  \default 0.0065
  \minimum 0.0

```

Field: Wind Speed Profile Exponent

The wind speed profile exponent for the terrain surrounding the site. The exponent can be estimated from the table above (see **Site:WeatherStation**) or calculated beforehand using more sophisticated techniques, such as CFD modeling of the site terrain. Note that using this object overrides the wind speed profile coefficients implied by the *Terrain* field of the **Building** object even if this field is left blank.

Field: Wind Speed Profile Boundary Layer Thickness

The wind speed profile boundary layer thickness [m] for the terrain surrounding the site. The boundary layer can be estimated from the table above (see **Site:WeatherStation**) or calculated beforehand using more sophisticated techniques, such as CFD modeling of the site terrain. Note that using this object overrides the wind speed profile coefficients implied by the *Terrain* field of the **Building** object even if this field is left blank. This field can be set to zero to turn off all wind dependence on height.

Field: Air Temperature Gradient Coefficient

The air temperature gradient coefficient [K/m] is a research option that allows the user to control the variation in outdoor air temperature as a function of height above ground. The real physical value is 0.0065 K/m. This field can be set to zero to turn off all temperature dependence on height. Note that the *Air Temperature Sensor Height* in the **Site:WeatherStation** object should also be set to zero in order to force the local outdoor air temperatures to match the weather file outdoor air temperature. This change is required because the **Site:WeatherStation** object assumes an air temperature gradient of 0.0065 K/m.

```

Site:HeightVariation,
  0.22, !- Wind Speed Profile Exponent
  370, !- Wind Speed Profile Boundary Layer Thickness {m}
  0.0065; !- Air Temperature Gradient Coefficient {deltaC/m}

```

RunPeriod

The RunPeriod object describes the elements necessary to create a weather file simulation. Multiple run periods may be input. EnergyPlus accepts weather files in the special EnergyPlus weather format (described below in this document). These files can describe Daylight Saving Time periods as well as holidays within their definitions. The RunPeriod object allows the user to override the use of both the Daylight Saving Period (i.e. use or

ignore) and holidays that are embedded within the weather file. Note that the weather file also may contain design condition information, typical and extreme period information, ground temperatures based on air temperature calculations.

Field: Begin Month

This numeric field should contain the starting month number (1=January, 2=February, etc.) for the annual run period desired.

Field: Begin Day of Month

This numeric field should contain the starting day of the starting month (must be valid for month) for the annual run period desired.

Field: End Month

This numeric field should contain the ending month number (1=January, 2=February, etc.) for the annual run period desired.

Field: End Day of Month

This numeric field should contain the ending day of the ending month (must be valid for month) for the annual run period desired.

Field: Day of Week for Start Day

For flexibility, the day of week indicated on the weather file can be overridden by this field's value. Valid days of the week (Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday) must be entered in this field.

Field: Use Weather File Holidays and Special Days

Weather files can contain holiday designations or other kinds of special days. These day types cause a corresponding day's schedule (see SCHEDULE definitions below) to be used during that day. This field should contain the word **Yes** if holidays or other special days indicated directly on the weather file should retain their "day type" or **No** if holidays or other special days on the weather file should be ignored. Reference SpecialDayPeriod below to enter your own special days and holidays.

Note that a blank or null field in this field will indicate **Yes**.

Field: Use Weather File Daylight Saving Period

Weather files can contain indicators of Daylight Saving period days. For flexibility, you may want to ignore these designations on the weather file. This field should contain the word **Yes** if you will accept daylight saving period days as contained on the weather file (note: not all weather files may actually have this period) or **No** if you wish to ignore Daylight Saving period days that may be on the weather file.

Note that a blank or null field in this field will indicate **Yes**.

Field: Apply Weekend Holiday Rule

In some countries (notably the US), when holidays fall on weekends, they are often observed on a weekday close to the holiday day. (Usually if the specific day falls on a Saturday, the observed day is Friday; if on a Sunday, the observed day is Monday). EnergyPlus will represent this custom using the value in this field. If the field is **Yes**, then specific date holidays that have a duration of one day, will be "observed" on the Monday after the day. (Specific day holidays are such as January 1 – a day-month combination). If the field is blank or **No**, then the holiday will be shown on the day-month as entered. As this option is listed at the RunPeriod, all applicable special days for the run will use the rule – there is no override for individual special days.

Note that a blank or null field in this field will indicate **No**.

Note: EnergyPlus processed weather files available on the EnergyPlus web site: http://www.energyplus.gov/cfm/weather_data.cfm have neither special days specified nor daylight saving period. However, DDY (Design Day) files produced from the ASHRAE Design Conditions that accompany the EPW files may include a DaylightSavingPeriod object for certain locations.

Field: Use Weather File Rain Indicators

Weather files can contain “rain” indicators. (EPW field “Present Weather Codes” – described in the AuxiliaryPrograms document). In turn, rain indicates wet surfaces which changes the film convection coefficient for the surface. Other models may use rain as well (Ground Heat Exchangers). Entering “**Yes**” in this field allows the weather file conditions to represent “Rain”; entering “**No**” in the field “turns off” the rain indicator for this period. You might use this to be able to compare two “same location” weather files of different years, origins, etc.

Field: Use Weather File Snow Indicators

Weather files can contain “snow” indicators. (EPW field “Snow Depth” > 0 indicates “Snow on the ground”). In turn, snow changes the reflectivity of the ground and cascades changes of this reflectivity. Entering “**Yes**” in this field allows the weather file conditions to represent “Snow”; entering “**No**” in the field “turns off” the snow indicator for this period. You might use this to be able to compare two “same location” weather files of different years, origins, etc.

Field: Number of Times Runperiod to be Repeated

This numeric field represents the number of times (usually years) the simulation has to be carried out in a multi runperiod simulation. The default value is set to 1. The number of years of simulation, in case of a Ground Loop Heat Exchanger (GLHE) simulation, should be equal to the length of simulation field in GLHE object. Note that you can specify a number of simulation years with a shorter run period (e.g. 1 week) and EnergyPlus will repeat the simulation of the shorter run period for that many times.

The IDD for object RunPeriod is shown below:

```

RunPeriod,
  \min-fields 10
N1 , \field Begin Month
     \required-field
     \minimum 1
     \maximum 12
     \type integer
N2 , \field Begin Day of Month
     \required-field
     \minimum 1
     \maximum 31
     \type integer
N3 , \field End Month
     \required-field
     \minimum 1
     \maximum 12
     \type integer
N4 , \field End Day of Month
     \required-field
     \minimum 1
     \maximum 31
     \type integer
A1 , \field Day of Week for Start Day
     \note =<blank - use WeatherFile>|Sunday|Monday|Tuesday|Wednesday|Thursday|Friday|Saturday|;
     \default UseWeatherFile
     \type choice
     \key Sunday
     \key Monday
     \key Tuesday
     \key Wednesday
     \key Thursday
     \key Friday
     \key Saturday
     \key UseWeatherFile
A2, \field Use Weather File Holidays and Special Days
     \note If yes or blank, use holidays as specified on Weatherfile.
     \note If no, do not use the holidays specified on the Weatherfile.
     \note Note: You can still specify holidays/special days using the SpecialDayPeriod object(s).
     \type choice
     \default Yes
     \key Yes
     \key No
A3, \field Use Weather File Daylight Saving Period
     \note If yes or blank, use daylight saving period as specified on Weatherfile.
     \note If no, do not use the daylight saving period as specified on the Weatherfile.
     \type choice
     \default Yes
     \key Yes
     \key No
A4, \field Apply Weekend Holiday Rule
     \note if yes and single day holiday falls on weekend, "holiday" occurs on following Monday
     \type choice
     \key Yes
     \key No
     \default No
A5, \field Use Weather File Rain Indicators
     \type choice
     \key Yes
     \key No
     \default Yes
A6, \field Use Weather File Snow Indicators
     \type choice
     \key Yes
     \key No
     \default Yes
N5; \field Number of Times Runperiod to be Repeated
     \type integer
     \minimum 1
     \default 1

```

And, as shown in an IDF:

```

RunPeriod, ! Winter Simulation
  12, !- Begin Month
  1, !- Begin Day of Month
  3, !- End Month
  31, !- End Day of Month
UseWeatherFile, !- Day of Week for Start Day
Yes, !- Use Weather File Holidays and Special Days
Yes, !- Use Weather File Daylight Saving Period
No, !- Apply Weekend Holiday Rule
Yes, !- Use Weather File Rain Indicators
Yes; !- Use Weather File Snow Indicators

```

```

! Multiple year simulation example
RunPeriod,
  1, !- Begin Month
  1, !- Begin Day of Month
  12, !- End Month
  31, !- End Day of Month
UseWeatherFile, !- Day of Week for Start Day
Yes, !- Use Weather File Holidays and Special Days
Yes, !- Use Weather File Daylight Saving Period
No, !- Apply Weekend Holiday Rule
Yes, !- Use Weather File Rain Indicators
Yes, !- Use Weather File Snow Indicators
  3; !- Number of Times Runperiod to be Repeated

```

SizingPeriod:WeatherFileDays

The SizingPeriod:WeatherFileDays object describes using a selected period from the “attached” weather file to be used in load calculations or sizing equipment. The period selected can be as small as a single day or larger. Multiple periods may be input.

Field: Name

This field allows for an assigned name for this run period so it can be tracked easily in sizing and other outputs.

Field: Begin Month

This numeric field should contain the starting month number (1=January, 2=February, etc.) for the annual run period desired.

Field: Begin Day of Month

This numeric field should contain the starting day of the starting month (must be valid for month) for the annual run period desired.

Field: End Month

This numeric field should contain the ending month number (1=January, 2=February, etc.) for the annual run period desired.

Field: End Day of Month

This numeric field should contain the ending day of the ending month (must be valid for month) for the annual run period desired.

Field: Day of Week for Start Day

For flexibility, the day of week indicated on the weather file can be overridden by this field’s value. Valid days of the week (Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday) can be entered. When weekdays are used, each subsequent day in the period will

be incremented. Also valid values are SummerDesignDay, WinterDesignDay, CustomDay1, CustomDay2 – if these days are used, however, they will be applied for the entire period.

Field: Use Weather File Daylight Saving Period

Weather files can contain indicators of Daylight Saving Period days. For flexibility, you may want to ignore these designations on the weather file. This field should contain the word **Yes** if you will accept daylight saving period days as contained on the weather file (note: not all weather files may actually have this period) or **No** if you wish to ignore Daylight Saving Period days that may be on the weather file.

Note that a blank or null field in this field will indicate **Yes**.

Field: Use Weather File Rain and Snow Indicators

Weather files can contain “rain” and “snow” indicators. (EPW field “Present Weather Codes” – described in the AuxiliaryPrograms document). In turn, rain indicates wet surfaces which changes the film convection coefficient for the surface. Other models may use rain as well (Ground Heat Exchangers). Snow indicators can change the ground reflectance if there is snow on the ground. Entering “**Yes**” in this field allows the weather file conditions to represent “Rain” and “Snow”; entering “**No**” in the field “turns off” the rain/snow indicators for this period. You might use this to be able to compare two “same location” weather files of different years, origins, etc.

The IDD for the object follows:

```
SizingPeriod:WeatherFileDays,
  \memo Use a weather file period for design sizing calculations.
A1 , \field Name
  \reference DesignDays
  \note user supplied name for reporting
N1 , \field Begin Month
  \required-field
  \minimum 1
  \maximum 12
  \type integer
N2 , \field Begin Day of Month
  \required-field
  \minimum 1
  \maximum 31
  \type integer
N3 , \field End Month
  \required-field
  \minimum 1
  \maximum 12
  \type integer
N4 , \field End Day of Month
  \required-field
  \minimum 1
  \maximum 31
  \type integer
```

```

A2 , \field Day of Week for Start Day
      \note = [|Sunday|Monday|Tuesday|Wednesday|Thursday|Friday|Saturday|SummerDesignDay|WinterDesignDay|
      \note |CustomDay1|CustomDay2];
      \note if you use SummerDesignDay or WinterDesignDay or the CustomDays then this will apply
      \note to the whole period; other days (i.e., Monday) will signify a start day and
      \note normal sequence of subsequent days
      \default Monday
      \type choice
      \key Sunday
      \key Monday
      \key Tuesday
      \key Wednesday
      \key Thursday
      \key Friday
      \key Saturday
      \key SummerDesignDay
      \key WinterDesignDay
      \key CustomDay1
      \key CustomDay2
A3, \field Use Weather File Daylight Saving Period
      \note If yes or blank, use daylight saving period as specified on Weatherfile.
      \note If no, do not use the daylight saving period as specified on the Weatherfile.
      \type choice
      \default Yes
      \key Yes
      \key No
A4; \field Use Weather File Rain and Snow Indicators
      \type choice
      \key Yes
      \key No
      \default Yes

```

IDF Example:

```

SizingPeriod:WeatherFileDays,
  Summer including Extreme Summer days,  !- Name
  7,18,7,25,                             !- Begin/end Day/Month
  SummerDesignDay,                       !- Day type
  No,                                     !- Use Weather File Daylight Saving Period
  No;                                     !- Use Weather File Rain and Snow Indicators

SizingPeriod:WeatherFileDays,
  Winter including Extreme Winter days,  !- Name
  1,25,2,1,                             !- Begin/end Day/Month
  WinterDesignDay,                       !- Day type
  No,                                     !- Use Weather File Daylight Saving Period
  No;                                     !- Use Weather File Rain and Snow Indicators

```

SizingPeriod:WeatherFileConditionType

When the EPW files are created, a heuristic procedure identifies extreme and typical periods in the actual weather file. This object will allow one of those periods to be selected for sizing or load calculations (typically).

Field: Name

This field allows for an assigned name for this run period so it can be tracked easily in sizing and other outputs.

Field: Period Selection

This field allows the generic period calculated from the weather file to be selected for this run period. It is not completely generic as there may be extreme cold periods in some weather files but extreme wet periods (tropical) in others. Not all weather files have all of the valid choices. The choices for this field are:

- SummerExtreme
- SummerTypical
- WinterExtreme

- WinterTypical
- AutumnTypical
- SpringTypical
- WetSeason
- DrySeason
- NoDrySeason
- NoWetSeason
- TropicalHot
- TropicalCold

Field: Day of Week for Start Day

For flexibility, the day of week indicated on the weather file can be overridden by this field's value. Valid days of the week (Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday) can be entered. When weekdays are used, each subsequent day in the period will be incremented. Also valid values are SummerDesignDay, WinterDesignDay, CustomDay1, CustomDay2 – if these days are used, however, they will be applied for the entire period.

Field: Use Weather File Daylight Saving Period

Weather files can contain indicators of Daylight Saving Period days. For flexibility, you may want to ignore these designations on the weather file. This field should contain the word **Yes** if you will accept daylight saving period days as contained on the weather file (note: not all weather files may actually have this period) or **No** if you wish to ignore Daylight Saving Period days that may be on the weather file.

Note that a blank or null field in this field will indicate **Yes**.

Field: Use Weather File Rain and Snow Indicators

Weather files can contain “rain” and “snow” indicators. (EPW field “Present Weather Codes” – described in the AuxiliaryPrograms document). In turn, rain indicates wet surfaces which changes the film convection coefficient for the surface. Other models may use rain as well (Ground Heat Exchangers). Snow indicators can change the ground reflectance if there is snow on the ground. Entering “**Yes**” in this field allows the weather file conditions to represent “Rain” and “Snow”; entering “**No**” in the field “turns off” the rain/snow indicators for this period. You might use this to be able to compare two “same location” weather files of different years, origins, etc.

```
RSizingPeriod:WeatherFileConditionType,
  \memo Use a weather file period for design sizing calculations.
  \memo EPW weather files are created with typical and extreme periods
  \memo created heuristically from the weather file data. For more
  \memo details on these periods, see AuxiliaryPrograms document.
A1 , \field Name
  \reference DesignDays
  \note user supplied name for reporting
```



```

A2 , \field Period Selection
    \retaincase
    \note Following is a list of all possible types of Extreme and Typical periods that
    \note might be identified in the Weather File. Not all possible types are available
    \note for all weather files.
    \type choice
    \key SummerExtreme
    \key SummerTypical
    \key WinterExtreme
    \key WinterTypical
    \key AutumnTypical
    \key SpringTypical
    \key WetSeason
    \key DrySeason
    \key NoDrySeason
    \key NoWetSeason
    \key TropicalHot
    \key TropicalCold
A3 , \field Day of Week for Start Day
    \note =[|Sunday|Monday|Tuesday|Wednesday|Thursday|Friday|Saturday|SummerDesignDay|WinterDesignDay|
    \note |CustomDay1|CustomDay2];
    \note if you use SummerDesignDay or WinterDesignDay or the CustomDays then this will apply
    \note to the whole period; other days (i.e., Monday) will signify a start day and
    \note normal sequence of subsequent days
    \default Monday
    \type choice
    \key Sunday
    \key Monday
    \key Tuesday
    \key Wednesday
    \key Thursday
    \key Friday
    \key Saturday
    \key SummerDesignDay
    \key WinterDesignDay
    \key CustomDay1
    \key CustomDay2
A4, \field Use Weather File Daylight Saving Period
    \note If yes or blank, use daylight saving period as specified on Weatherfile.
    \note If no, do not use the daylight saving period as specified on the Weatherfile.
    \type choice
    \default Yes
    \key Yes
    \key No
A5; \field Use Weather File Rain and Snow Indicators
    \type choice
    \key Yes
    \key No
    \default Yes

```

IDF Example:

```

SizingPeriod:WeatherFileConditionType,
    Extreme Summer Weather Period for Design,    !- Name
    SummerExtreme,                               !- Period Selection
    SummerDesignDay,                             !- Day Type
    No,                                           !- Use Weather File Daylight Saving Period
    No;                                           !- Use Weather File Rain and Snow Indicators

SizingPeriod:WeatherFileConditionType,
    Extreme Winter Weather Period for Design,    !- Name
    WinterExtreme,                               !- Period Selection
    WinterDesignDay,                             !- Day Type
    No,                                           !- Use Weather File Daylight Saving Period
    No;                                           !- Use Weather File Rain and Snow Indicators

```

SizingPeriod:DesignDay

The design day input describes the parameters to effect a “design day” simulation, often used for load calculations or sizing equipment. Using the values in these fields, EnergyPlus “creates” a complete day’s worth of weather data (air temperatures, solar radiation, etc.)

Normal operation uses the default range multipliers as shown in Figure 6 though users may choose to input their own multiplier schedule. Likewise, normal operation specifies one “humidity indicating temperature” which is used to calculate the humidity ratio at maximum temperature – this is used as the constant humidity ratio for the entire day. Again, this can be overridden by specifying a relative humidity schedule. Multiple design days may be specified.

In the install, the “design day files” are included for the weather file locations that are included (weatherdata folder). All the design day definitions from the ASHRAE 2005 design conditions are included, grouped by WMO region, on the main web site with the weather data. http://www.energyplus.gov/cfm/weather_data.cfm These files are in “macro” form but it is easy to cut and paste the appropriate definition segments. These files include the location information as well as some locations have **RunPeriodControl:DaylightSavingTime** objects.

Field: Name

This field, like the location name, is used simply for reporting and identification. This name must be unique among the SizingPeriod names entered.

Field: Maximum Dry-Bulb Temperature

This numeric field should contain the day’s maximum dry-bulb temperature in degrees Celsius. (Reference Appendix A of this document for EnergyPlus standard units and abbreviations). The MacroDataSets design day files show extreme temperature for locations as indicated in the ASHRAE HOF design condition tables.

Field: Daily Temperature Range

A design day can have a “high” temperature and a “low” temperature (or can be a constant temperature for each hour of the day). If there is a difference between high and low temperatures, this field should contain the difference from the high to the low. EnergyPlus, by default, distributes this range over the 24 hours in the day as shown in the figure below:

Daily Range Multiplier

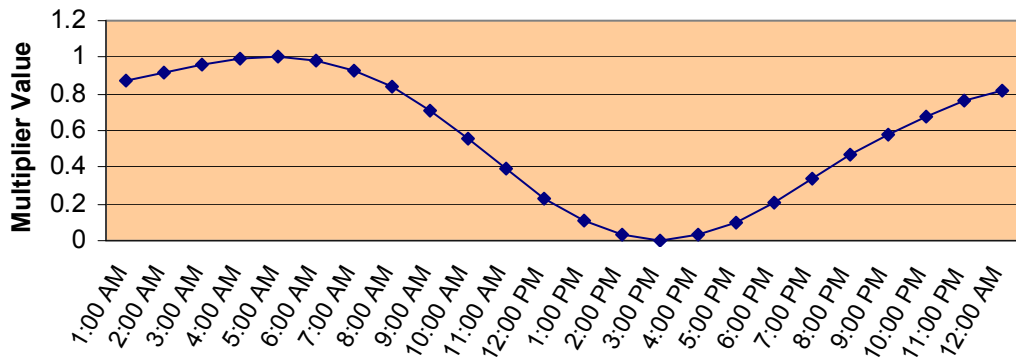


Figure 6. Default Daily range Multiplier for Design Days

More explicitly, EnergyPlus creates an air temperature for each timestep by using the entered maximum dry-bulb temperature in conjunction with the entered daily range and the above multiplier values. The actual equation used is shown below:

$$T_{current} = T_{Max} - T_{range} \cdot T_{Multiplier}$$

where

T_{current} = Air temperature of current Hour of Day

T_{Max} = User supplied Max Dry-bulb Temperature

T_{range} = User supplied Daily Temperature Range

$T_{\text{Multiplier}}$ = Range multiplier as shown on the above graph

The range multiplier values represent typical conditions of diurnal temperatures (i.e. the low temperature for the day occurring about 5:00 AM and the maximum temperature for the day occurring about 3:00 PM).

Field: Humidity Indicating Conditions at Maximum Dry-Bulb

This numeric field represents the “humidity indicating” conditions that are coincident with the maximum temperature for the day. The value in this field is indicated by the key value in the field **Humidity Indicating Type**. This numeric value, along with the Maximum Dry-bulb Temperature and Barometric Pressure, is used to determine a humidity ratio and then used to calculate relative humidity, wet-bulb and dewpoint temperatures at each timestep. Note that this field is unnecessary when you put in a relative humidity day schedule (described later in this section).

Field: Barometric Pressure

This numeric field is the constant barometric pressure (Pascals) for the entire day.

Field: Wind Speed

This numeric field is the wind speed in meters/second (constant throughout the day) for the day. The MacroDataSets design day files includes wind speed values (99.6% - heating, 1% cooling) as indicated in ASHRAE HOF design condition tables. But, you should be aware that traditional values for these are 6.7056 m/s (15 mph) for heating and 3.3528 m/s (7 mph) for cooling. A reminder is shown in the comments for the wind speed values. The comments also note the extreme wind speeds from the ASHRAE tables.

Field: Wind Direction

This numeric field is the source wind direction in degrees. By convention, winds from the North would have a value of 0., from the East a value of 90.

Field: Sky Clearness

This value represents the “clearness” value for the day. This value, along with the solar position as defined by the Location information and the date entered for the design day, help define the solar radiation values for each hour of the day. Traditionally, one uses 0.0 clearness for Winter Design Days.

Field: Rain Indicator

This numeric field indicates whether or not the building surfaces are wet. If the value is 1, then it is assumed that the building surfaces are wet. Wet surfaces may change the conduction of heat through the surface.

Field: Snow Indicator

This numeric field indicates whether or not there is snow on the ground. If the value is 1, then it is assumed there is snow on the ground. Snow on the ground changes the ground reflectance properties.

Field: Day of Month

This numeric field specifies the day of the month. That, in conjunction with the month and location information, determines the current solar position and solar radiation values for each hour of the day.

Field: Month

This numeric field specifies the month. That, in conjunction with the day of the month and location information, determines the current solar position and solar radiation values for each hour of the day.

Field: Day Type

This alpha field specifies the day type for the design day. This value indicates which day profile to use in schedules. For further information, see the Schedule discussion later in this document {Group -- Schedules}. Note that two of the possible day types are SummerDesignDay and WinterDesignDay – allowing the user to customize schedules for the design conditions.

Field: Daylight Saving Time Indicator

This numeric field specifies whether to consider this day to be a Daylight Saving Day. This essentially adds 1 hour to the scheduling times used in items with schedules.

Field: Humidity Indicating Type

Valid choices here are: **WetBulb**, **DewPoint**, **HumidityRatio**, **Enthalpy**, **Schedule**. Units for the first four choices are Celsius, Celsius, ratio of kg wet air/kg dry air (no units), and kJ/kg. Using one of these choices means that you then put an appropriate value in the Humidity Indicating Conditions at Maximum Dry-Bulb field. The **Schedule** choice uses the day schedule indicated in the next field. That is, if you want to specify your own relative humidity to occur throughout the day, you put schedule in here and put in the name of your day schedule that specifies the relative humidity in the Relative Humidity Day Schedule Name.

Field: Relative Humidity Day Schedule Name

If you want to specify your own relative humidity for the day, put in schedule in the Humidity Indicating Type field and put in the name of a day schedule with relative humidity values (0 to 100 percent) in this field.

Field: Dry-Bulb Temperature Range Modifier Type

If you are happy with lows at 5am and highs at 3pm, you can ignore this field. If you want to specify your own temperature range multipliers (see earlier discussion at the Temperature Range field description), you can specify a type here and create a day schedule which you reference in the next field.

If you specify **MultiplierSchedule** in this field, then you need to create a day schedule that specifies a multiplier applied to the temperature range field (above) to create the proper dry-bulb temperature range profile for your design day.

If you specify **DifferenceSchedule** in this field, then you need to create a day schedule that specifies a number to be **subtracted** from dry-bulb maximum temperature for each timestep in the day. Note that numbers in the delta schedules cannot be negative as that would result in a higher maximum than the maximum previously specified.

If you leave this field blank or enter **DefaultMultipliers**, then the default multipliers will be used as shown in the “temperature range” field above.

Field: Dry-Bulb Temperature Range Modifier Schedule Name

This field is the name of a day schedule with the values as specified in the Dry-Bulb Temperature Range Modifier Type field above.

Field: Solar Model Indicator

This field allows the user to select ASHRAEClearSky, ZhangHuang or Schedule for solar modeling in the calculation of the solar radiation in the design day. Both named models use the Clearness value as part of their calculations. More details on the two models are

described in the Engineering Reference. The Schedule choice allows you to enter schedule values for the day's profile (use the next two fields for the names).

Field: Beam Solar Day Schedule Name

This field allows the option for you to put in your own day profile of beam solar values (wh/m²). These values will replace the calculated values during design day processing.

Field: Diffuse Solar Day Schedule Name

This field allows the option for you to put in your own day profile of diffuse solar values (wh/m²). These values will replace the calculated values during design day processing.

The IDD definition for the object:

```
SizingPeriod:DesignDay,
  \min-fields 15
  A1, \field Name
    \type alpha
    \required-field
    \reference DesignDays
  N1 , \field Maximum Dry-Bulb Temperature
    \required-field
    \units C
    \minimum -70
    \maximum 70
    \type real
  N2 , \field Daily Temperature Range
    \note Must still produce appropriate maximum dry bulb (within range)
    \note This field is not needed if Dry-Bulb Temperature Range Modifier Type
    \note is "delta".
    \units deltaC
    \minimum 0
    \default 0
    \type real
  N3 , \field Humidity Indicating Conditions at Maximum Dry-Bulb
    \note this will be a wet-bulb or dewpoint temperature coincident with the
    \note maximum temperature depending on the value of the field
    \note Humidity Indicating Temperature Type
    \note required-field if Relative Humidity Day Schedule is not used
    \type real
  N4 , \field Barometric Pressure
    \note This field's value is also checked against the calculated "standard barometric pressure"
    \note for the location. If out of range (>10%), then is replaced by standard value.
    \required-field
    \units Pa
    \minimum 31000
    \maximum 120000
    \type real
    \ip-units inHg
  N5 , \field Wind Speed
    \required-field
    \units m/s
    \minimum 0
    \maximum 40
    \ip-units miles/hr
    \type real
  N6 , \field Wind Direction
    \required-field
    \units deg
    \minimum 0
    \maximum 360
    \note North=0.0 East=90.0
    \note 0 and 360 are the same direction.
    \type real
```

```

N7 , \field Sky Clearness
    \required-field
    \minimum 0.0
    \maximum 1.2
    \default 0.0
    \note 0.0 is totally unclear, 1.0 is totally clear
    \type real
N8 , \field Rain Indicator
    \minimum 0
    \maximum 1
    \default 0
    \note 1 is raining, 0 is not
    \type integer
N9 , \field Snow Indicator
    \minimum 0
    \maximum 1
    \default 0
    \note 1 is Snow on Ground, 0 is no Snow on Ground
    \type integer
N10, \field Day of Month
    \required-field
    \minimum 1
    \maximum 31
    \type integer
    \note must be valid for Month field
N11, \field Month
    \required-field
    \minimum 1
    \maximum 12
    \type integer
A2 , \field Day Type
    \required-field
    \note Day Type selects the schedules appropriate for this design day
    \type choice
    \key Sunday
    \key Monday
    \key Tuesday
    \key Wednesday
    \key Thursday
    \key Friday
    \key Saturday
    \key Holiday
    \key SummerDesignDay
    \key WinterDesignDay
    \key CustomDay1
    \key CustomDay2
N12, \field Daylight Saving Time Indicator
    \minimum 0
    \maximum 1
    \default 0
    \note 1=Yes, 0=No
    \type integer
A3 , \field Humidity Indicating Type
    \note What Field "Humidity Indicating Conditions at Maximum Dry-Bulb" is.
    \note Units for Wet-Bulb, Dewpoint [C]
    \note Units for Humidity-Ratio []
    \note Units for Enthalpy [kJ/kg]
    \type choice
    \key WetBulb
    \key DewPoint
    \key HumidityRatio
    \key Enthalpy
    \key Schedule
    \default WetBulb
A4 , \field Relative Humidity Day Schedule Name
    \type object-list
    \object-list DayScheduleNames
    \note only used when previous field is "Schedule"
    \note the hour/time interval values should specify relative humidity (percent) from 0.0 to 100.0

```

```

A5 , \field Dry-Bulb Temperature Range Modifier Type
     \note Type of modifier to the dry-bulb temperature calculated for the timestep
     \type choice
     \key MultiplierSchedule
     \key DifferenceSchedule
     \key DefaultMultipliers
     \default DefaultMultipliers
A6 , \field Dry-Bulb Temperature Range Modifier Schedule Name
     \type object-list
     \object-list DayScheduleNames
     \note Only used when previous field is "MultiplierSchedule" or "DifferenceSchedule".
     \note For type "MultiplierSchedule" the hour/time interval values should specify
     \note range from 0.0 to 1.0 of the maximum temperature.
     \note For type "DifferenceSchedule" the values should specify a number to be subtracted
     \note from dry bulb maximum temperature for each timestep in the day.
     \note Note that numbers in the delta schedules cannot be negative as that
     \note would result in a higher maximum than the maximum previously specified.
A7 , \field Solar Model Indicator
     \type choice
     \key ASHRAEClearSky
     \key ZhangHuang
     \key Schedule
     \default ASHRAEClearSky
A8 , \field Beam Solar Day Schedule Name
     \note if Solar Model Indicator = Schedule, then beam schedule name (for day)
     \type object-list
     \object-list DayScheduleNames
A9 ; \field Diffuse Solar Day Schedule Name
     \note if Solar Model Indicator = Schedule, then diffuse schedule name (for day)
     \type object-list
     \object-list DayScheduleNames

```

IDF examples of design day specifications. Note that usual Winter design conditions are for very cloudy days (clearness = 0), and low temperatures (temperature range=0).

```

! DENVER STAPLETON CO USA Annual Heating Design Conditions Wind Speed=2.3m/s Wind Dir=180
! Coldest Month=December
! DENVER STAPLETON CO USA Annual Heating 99%, MaxDB=-16°C
SizingPeriod:DesignDay,
DENVER STAPLETON Ann Htg 99% Condns DB,      !- Name
  -16,      !- Maximum Dry-Bulb Temperature {C}
  0.0,      !- Daily Temperature Range {C}
  -16,      !- Humidity Indicating Condition at Maximum Dry-Bulb
  83411.,   !- Barometric Pressure {Pa}
  2.3,      !- Wind Speed {m/s} design conditions vs. traditional 6.71 m/s (15 mph)
  180,      !- Wind Direction {Degrees; N=0, S=180}
  0.00,     !- Sky Clearness {0.0 to 1.1}
  0,        !- Rain {0-no,1-yes}
  0,        !- Snow on ground {0-no,1-yes}
  21,      !- Day of Month
  12,      !- Month
WinterDesignDay, !- Day Type
  0,        !- Daylight Saving Time Indicator
WetBulb;     !- Humidity Indicating Type

```

```

! DENVER_STAPLETON Annual Cooling Design Conditions Wind Speed=4m/s Wind Dir=120
! Hottest Month=July
! DENVER_STAPLETON CO USA Annual Cooling (DB=>MWB) 1%, MaxDB=32.6°C MWB=15.5°C
SizingPeriod:DesignDay,
DENVER_STAPLETON Ann Clg 1% Condns DB=>MWB,      !- Name
  32.6,      !- Maximum Dry-Bulb Temperature {C}
  15.2,      !- Daily Temperature Range {C}
  15.5,      !- Humidity Indicating Condition at Maximum Dry-Bulb
  83411.,    !- Barometric Pressure {Pa}
  4,         !- Wind Speed {m/s} design conditions vs. traditional 3.35 m/s (7mph)
  120,      !- Wind Direction {Degrees; N=0, S=180}
  1.00,     !- Sky Clearness {0.0 to 1.1}
  0,        !- Rain {0=no,1=yes}
  0,        !- Snow on ground {0=no,1=yes}
  21,      !- Day of Month
  7,       !- Month
SummerDesignDay, !- Day Type
  0,      !- Daylight Saving Time Indicator
Wet-Bulb;  !- Humidity Indicating Type

```

```

SizingPeriod:DesignDay,
DENVER_STAPLETON Ann Htg 99% Condns DB - sched solar, !- DesignDayName
-16,          !- Maximum Dry-Bulb Temperature {C}
0.0,         !- Daily Temperature Range {deltaC}
-16,         !- Humidity Indicating Conditions at Max Dry-Bulb
83411.,      !- Barometric Pressure {Pa}
2.3,        !- Wind Speed {m/s}
180,        !- Wind Direction {deg}
0.00,       !- Sky Clearness
0,          !- Rain Indicator
0,          !- Snow Indicator
13,        !- Day Of Month
1,         !- Month
WinterDesignDay, !- Day Type
0,        !- Daylight Saving Time Indicator
Wet-Bulb,  !- Humidity Indicating Type
,         !- Relative Humidity Day Schedule
,         !- Dry-Bulb Temperature Range Modifier Type
,         !- Dry-Bulb Temperature Range Modifier Schedule
Schedule,  !- Solar Model Indicator
Winter (1/13) Beam Solar, !- Beam Solar Day Schedule Name
Winter (1/13) Diffuse Solar; !- Diffuse Solar Day Schedule Name

Schedule:Day:Hourly,
Winter (1/13) Beam Solar,
Any Number,
0,0,0,0,0,0,0,190,698,852,892,919,957,953,856,700,213,0,0,0,0,0,0,0;

Schedule:Day:Hourly,
Winter (1/13) Diffuse Solar,
Any Number,
0,0,0,0,0,0,0,35,118,116,92,65,40,14,0,0,5,0,0,0,0,0,0,0;

```

Look at the example file 1ZoneUncontrolled_DDChanges.idf for several examples of specifying Design Day inputs.

Longer Design Periods

Some features may benefit by using a longer design weather period for sizing or loads calculations. Longer design periods may be created by using the **SizingPeriod:WeatherFileDays** or **SizingPeriod:WeatherFileType** objects. These two objects allow for selections from an attached weather file to be used in the sizing calculations.

RunPeriodControl:SpecialDays

For weather file run periods, special day run periods can be described. These will always be in effect for the selected days in the run period. Depending on the Use Special Days value in the RunPeriod object, these can augment any special days included on the weather file.

Note: EnergyPlus processed weather files available on the EnergyPlus web site: http://www.energyplus.gov/cfm/weather_data.cfm have neither special days specified nor daylight saving period. However, DDY (Design Day) files produced from the ASHRAE Design Conditions that accompany the EPW files may include a DaylightSavingPeriod object for certain locations.

Field: Name

This alpha field is the title for the special day period. It must be unique among all the special day period objects entered.

Field: Start Date

This field is the starting date for the special day period. Dates in this field can be entered in several ways as shown in the accompanying table:

Table 4. Date Field Interpretation

Field Contents	Interpretation
<number> / <number>	Month / Day
<number> Month	Day and Month
Month <number>	Day and Month
<number> Weekday in Month	Numbered weekday of month
Last Weekday In Month	Last weekday of month

In the table, Month can be one of (January, February, March, April, May, June, July, August, September, October, November, December). Abbreviations of the first three characters are also valid.

In the table, Weekday can be one of (Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday). Abbreviations of the first three characters are also valid.

Field: Duration

This numeric field specifies how long (number of days) the special day period lasts.

Field: Special Day Type

This alpha field designates the “day type” for schedule use during the special period. It must be one of (Holiday, SummerDesignDay, WinterDesignDay, CustomDay1, CustomDay2).

```
RunPeriodControl:SpecialDays,
  \min-fields 4
  \memo This object sets up holidays/special days to be used during weather file
  \memo run periods. (These are not used with DesignDay objects.)
  \memo Depending on the value in the run period, days on the weather file may also
  \memo be used. However, the weather file specification will take precedence over
  \memo any specification shown here. (No error message on duplicate days or overlapping
  \memo days).
A1, \field Name
  \required-field
```

```

A2, \field Start Date
  \required-field
  \note Dates can be several formats:
  \note <number>/<number> (month/day)
  \note <number> <Month>
  \note <Month> <number>
  \note <Nth> <Weekday> in <Month>
  \note Last <WeekDay> in <Month>
  \note <Month> can be January, February, March, April, May, June, July, August, September, October,
November, December
  \note Months can be the first 3 letters of the month
  \note <Weekday> can be Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday
  \note <Nth> can be 1 or 1st, 2 or 2nd, etc. up to 5(?)
N1, \field Duration
  \units days
  \minimum 1
  \maximum 366
  \default 1
A3; \field Special Day Type
  \required-field
  \note Special Day Type selects the schedules appropriate for each day so labeled
  \type choice
  \key Holiday
  \key SummerDesignDay
  \key WinterDesignDay
  \key CustomDay1
  \key CustomDay2
  \default Holiday

```

An example in the IDF would be:

```

RunPeriodControl:SpecialDays, President's Day, 3rd Monday in
February,1,Holiday;
RunPeriodControl:SpecialDays, Thanksgiving, 4th Thursday in November,
1,Holiday;
RunPeriodControl:SpecialDays, Halloween, 10/31, 1, Holiday;
RunPeriodControl:SpecialDays, Vacation, 5/1, 14, CustomDay1;

```

RunPeriodControl:DaylightSavingTime

Similar to a special day period, a daylight saving period may be entered to be applied to weather file run periods. These will always be in effect, regardless of the value entered on the RunPeriod object. Note that this period will always override any daylight saving period specified in a weather file.

Note: EnergyPlus processed weather files available on the EnergyPlus web site: http://www.energyplus.gov/cfm/weather_data.cfm have neither special days specified nor daylight saving period.

Field: Start Date

This is the starting date of the daylight saving period. Note that it can be entered in several formats as shown in Table 4. Date Field Interpretation.

Field: End Date

This is the ending date of the daylight saving period. Note that it can be entered in several formats as shown in Table 4. Date Field Interpretation.

```

RunPeriodControl:DaylightSavingTime,
  \unique-object
  \min-fields 2
  \memo This object sets up the daylight saving time period for any RunPeriod.
  \memo Ignores any daylight saving time period on the weather file and uses this definition.
  \memo These are not used with SizingPeriod:DesignDay objects.
  \memo Use with SizingPeriod:WeatherFileDays object can be controlled in that object.
A1, \field Start Date
  \required-field
A2; \field End Date
  \required-field
  \note Dates can be several formats:
  \note <number>/<number> (month/day)
  \note <number> <Month>
  \note <Month> <number>
  \note <Nth> <Weekday> in <Month>
  \note Last <WeekDay> in <Month>
  \note <Month> can be January, February, March, April, May, June, July, August, September, October,
November, December
  \note Months can be the first 3 letters of the month
  \note <Weekday> can be Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday
  \note <Nth> can be 1 or 1st, 2 or 2nd, etc. up to 5(?)

```

And in the IDF:

```

! U.S. Standard for Daylight Saving
RunPeriodControl:DaylightSavingTime,2nd Sunday in March, 1st Sunday in
November; !2007
! Brazil standard
RunPeriodControl:DaylightSavingTime,1st Sunday in October, Last Sunday in
February;
! European Standard
RunPeriodControl:DaylightSavingTime, Last Sunday in March, Last Sunday in
October;
! Syria Standard
RunPeriodControl:DaylightSavingTime, 4/1, 10/1;

```

Of course, these could not all appear in the same IDF as only one DaylightSavingPeriod object per input file is allowed. More information on Daylight Saving Periods can be seen on the web at: <http://www.webexhibits.org/daylightsaving/> The ASHRAE Handbook of Fundamentals [ASHRAE 2005] also contains information about daylight saving periods and their climatic information now includes start and end dates for many locations.

Site:GroundTemperature:BuildingSurface

Ground temperatures are used for the ground heat transfer model. There can be only one ground temperature object included, and it is used as the outside surface temperature for all surfaces with Outside Boundary Condition=Ground. The outside surface temperature for individual surfaces can be specified using the OtherSideCoefficients (ref: SurfaceProperty:OtherSideCoefficients) object that allows Toutside to be set with a schedule. This permits using any number of different outside face temperatures in addition to the ground temperature.

Caution: The “undisturbed” ground temperatures calculated by the weather converter should not be used in building losses but are appropriate to be used in the Site:GroundTemperature:Shallow and Site:GroundTemperature:Deep objects. The reasoning (for building losses) is that these values are too extreme for the soil under a conditioned building. For best results, use the Slab or Basement program described in this document to calculate custom monthly average ground temperatures (see the Ground Heat Transfer section). This is especially important for residential applications and very small buildings. If one of these ground temperature preprocessors is not used, for typical commercial buildings in the USA, a reasonable default value is 2C less than the average indoor space temperature.

More information about determining appropriate ground temperatures is given in the Auxiliary Programs document.

Field: Month Temperature(s) – 12 fields in all

Each numeric field is the monthly ground temperature (degrees Celsius) used for the indicated month (January=1st field, February=2nd field, etc.)

```
Site:GroundTemperature:BuildingSurface,
  \memo These temperatures are specifically for those surfaces that have the outside environment
  \memo of "Ground". Documentation about what values these should be is located in the
  \memo Auxiliary programs document (Ground Heat Transfer) as well as the InputOutput Reference.
  \memo CAUTION - Do not use the "undisturbed" ground temperatures from the weather data.
  \memo These values are too extreme for the soil under a conditioned building.
  \memo For best results, use the Slab or Basement program to calculate custom monthly
  \memo average ground temperatures (see Auxiliary Programs). For typical commercial
  \memo buildings in the USA, a reasonable default value is 2C less than the average indoor space
temperature.
  \unique-object
  \min-fields 12
  \format singleLine
N1 , \field January Ground Temperature
  \required-field
  \units C
  \type real
  \default 18
---reduced for brevity ---
N12; \field December Ground Temperature
  \required-field
  \units C
  \type real
  \default 18
```

And, the IDF example:

```
Site:GroundTemperature:BuildingSurface, 1.22222233E+01, 1.27777786E+01, 1.44444447E+01,
1.66666679E+01, 1.94444447E+01, 2.33333340E+01, 2.2222233E+01, 2.00000000E+01, 1.77777786E+01,
1.66666679E+01, 1.44444447E+01, 1.27777786E+01;
```

Site:GroundTemperature:Shallow

Site:GroundTemperature:Shallow are used by the Surface Ground Heat Exchanger (i.e. object: GroundHeatExchanger:Surface). Only one surface ground temperature object can be included.

Note that the ground temperatures included in full year weather files may be suitable of being used for the values in these fields – namely, the .5 m depth temperatures that are calculated for “undisturbed” soil of “typical” conditions. However, you may wish to use some other change effect – based on the weather conditions of the building location.

Field: Month Temperature(s) – 12 fields in all

Each numeric field is the monthly surface ground temperature (degrees Celsius) used for the indicated month (January=1st field, February=2nd field, etc.)

```

Site:GroundTemperature:Shallow,
    \memo These temperatures are specifically for the Surface Ground Heat Exchanger and
    \memo should probably be close to the average outdoor air temperature for the location.
    \unique-object
    \min-fields 12
    \format singleLine
N1 , \field January Surface Ground Temperature
    \required-field
    \units C
    \type real
    \default 13
---reduced for brevity ---
N12; \field December Surface Ground Temperature
    \required-field
    \units C
    \type real
    \default 13

```

And, the IDF example:

```
Site:GroundTemperature:Shallow, 4,4,6,6,10,10,15,15,14,14,8,8;
```

Site:GroundTemperature:Deep

Site:GroundTemperature:Deep are used by the Pond Ground Heat Exchanger and Vertical Ground Heat Exchanger objects (i.e. objects: GroundHeatExchanger:Pond and GroundHeatExchanger:Vertical). Only one deep ground temperature object can be included.

Note that the ground temperatures included in full year weather files may be suitable of being used for the values in these fields – namely, the 4 m depth temperatures that are calculated for “undisturbed” soil of “typical” conditions. However, you may wish to use some other change effect – based on the weather conditions or special knowledge of the building location.

Field: Month Temperature(s) – 12 fields in all

Each numeric field is the monthly deep ground temperature (degrees Celsius) used for the indicated month (January=1st field, February=2nd field, etc.)

```

Site:GroundTemperature:Deep,
    \memo These temperatures are specifically for the ground heat exchangers that would use
    \memo "deep" (3-4 m depth) ground temperatures for their heat source.
    \unique-object
    \min-fields 12
    \format singleLine
N1 , \field January Deep Ground Temperature
    \required-field
    \units C
    \type real
    \default 16
---reduced for brevity ---
N12; \field December Deep Ground Temperature
    \required-field
    \units C
    \type real
    \default 16

```

And, the IDF example:

```
Site:GroundTemperature:Deep, 16,16,16,16,16,16,16,16,16,16,16,16;
```

Site:GroundReflectance

Ground reflectance values are used to calculate the ground reflected solar amount. This fractional amount (entered monthly) is used in this equation:

$\text{GroundReflectedSolar} = (\text{BeamSolar} \cdot \text{COS}(\text{SunZenithAngle}) + \text{DiffuseSolar}) \cdot \text{GroundReflectance}$

Of course, the Ground Reflected Solar is never allowed to be negative. The ground reflectance can be further modified when snow is on the ground by the Snow Ground Reflectance Modifier. To use no ground reflected solar in your simulation, enter 0.0 for each month.

Field: Month Average Ground Reflectance(s) – 12 fields in all

Each numeric field is the monthly average reflectivity of the ground used for the indicated month (January=1st field, February=2nd field, etc.)

The IDD Definition:

```
Site:GroundReflectance,
\unique-object
\min-fields 12
\format singleLine
N1 , \field January Ground Reflectance
    \default 0.2
    \type real
    \minimum 0.0
    \maximum 1.0
    \units dimensionless
---reduced for brevity ---
N12 ; \field December Ground Reflectance
    \default 0.2
    \type real
    \minimum 0.0
    \maximum 1.0
    \units dimensionless
```

And use in an IDF:

```
Site:GroundReflectance,
0.600, !January Ground Reflectance
0.600, !February Ground Reflectance
0.400, !March Ground Reflectance
0.300, !April Ground Reflectance
0.200, !May Ground Reflectance
0.200, !June Ground Reflectance
0.200, !July Ground Reflectance
0.200, !August Ground Reflectance
0.200, !September Ground Reflectance
0.200, !October Ground Reflectance
0.300, !November Ground Reflectance
0.400, !December Ground Reflectance
```

Site:GroundReflectance:SnowModifier

It is generally accepted that snow resident on the ground increases the basic ground reflectance. EnergyPlus allows the user control over the snow ground reflectance for both “normal ground reflected solar” calculations (see above) and snow ground reflected solar modified for daylighting. These are entered under this object and both default to 1 (same as normal ground reflectance – no special case for snow which is a conservative approach).

Field: Ground Reflected Solar Modifier

This field is a decimal number which is used to modified the basic monthly ground reflectance when snow is on the ground (from design day input or weather data values).

$$\text{GroundReflectance}_{\text{used}} = \text{GroundReflectance} \cdot \text{Modifier}_{\text{Snow}}$$

The actual Ground Reflectance is limited to [0.0,1.0].

Field: Daylighting Ground Reflected Solar Modifier

This field is a decimal number which is used to modified the basic monthly ground reflectance when snow is on the ground (from design day input or weather data values).

$$\text{DaylightingGroundReflectance}_{\text{used}} = \text{GroundReflectance} \bullet \text{Modifier}_{\text{Snow}}$$

The actual Ground Reflectance is limited to [0.0,1.0].

```
Site:GroundReflectance:SnowModifier,
N1, \field Ground Reflected Solar Modifier
\minimum 0.0
\default 1.0
\note Value for modifying the "normal" ground reflectance when Snow is on ground
\note when calculating the "Ground Reflected Solar Radiation Value"
\note a value of 1.0 here uses the "normal" ground reflectance
\note Ground Reflected Solar = (BeamSolar*CosSunZenith + DiffuseSolar)*GroundReflectance
\note This would be further modified by the Snow Ground Reflectance Modifier when Snow was on the
ground
\note When Snow on ground, effective GroundReflectance is normal GroundReflectance*"Ground
Reflectance Snow Modifier"
\note Ground Reflectance achieved in this manner will be restricted to [0.0,1.0]
N2; \field Daylighting Ground Reflected Solar Modifier
\minimum 0.0
\default 1.0
\note Value for modifying the "normal" daylighting ground reflectance when Snow is on ground
\note when calculating the "Ground Reflected Solar Radiation Value"
\note a value of 1.0 here uses the "normal" ground reflectance
\note Ground Reflected Solar = (BeamSolar*CosSunZenith + DiffuseSolar)*GroundReflectance
\note This would be further modified by the Snow Ground Reflectance Modifier when Snow was on the
ground
\note When Snow on ground, effective GroundReflectance is normal GroundReflectance*"Daylighting
Ground Reflectance Snow Modifier"
\note Ground Reflectance achieved in this manner will be restricted to [0.0,1.0]
```

Outputs will show both the inputs from the above object as well as monthly values for both Snow Ground Reflectance and Snow Ground Reflectance for Daylighting.

Site:WaterMainsTemperature

The Site:WaterMainsTemperature object is used to calculate water temperatures delivered by underground water main pipes. The mains temperatures are used as default, make-up water temperature inputs for several plant objects, including: **WaterUse:Equipment**, **WaterUse:Connections**, **WaterHeater:Mixed** and **WaterHeater:Stratified**. The mains temperatures are also used in the water systems objects to model the temperature of cold water supplies.

Water mains temperatures are a function of outdoor climate conditions and vary with time of year. A correlation has been formulated to predict water mains temperatures based on two weather inputs:

- average annual outdoor air temperature (dry-bulb)
- maximum difference in monthly average outdoor air temperatures

These values can be easily calculated from annual weather data using a spreadsheet or from the ".stat" file available with the EnergyPlus weather files at www.energyplus.gov. Monthly statistics for dry-bulb temperatures are shown with daily averages. The daily averages are averaged to obtain the annual average. The maximum and minimum daily average are subtracted to obtain the maximum difference. For more information on the water mains temperatures correlation, see the *EnergyPlus Engineering Document*.

Alternatively, the Site:WaterMainsTemperature object can read values from a schedule. This is useful for measured data or when water comes from a source other than buried pipes, e.g., a river or lake.

If there is no Site:WaterMainsTemperature object in the input file, a default constant value of 10 C is assumed.

```
Site:WaterMainsTemperature,
A1 , \field Calculation Method
    \required-field
    \type choice
    \key Schedule
    \key Correlation
A2 , \field Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
N1 , \field Annual Average Outdoor Air Temperature
    \type real
    \units C
N2 ; \field Maximum Difference In Monthly Average Outdoor Air Temperatures
    \type real
    \units deltaC
    \minimum 0
```

Field: Calculation Method

This field selects the calculation method and must have the keyword Schedule or Correlation.

Field: Schedule Name

If the calculation method is Schedule, the water mains temperatures are read from the schedule referenced by this field. If the calculation method is Correlation, this field is ignored.

Field: Annual Average Outdoor Air Temperature

If the calculation method is Correlation, this field is used in the calculation as the annual average outdoor air temperature (dry-bulb) [C]. If the calculation method is Schedule, this field is ignored.

Field: Maximum Difference In Monthly Average Outdoor Air Temperatures

If the calculation method is Correlation, this field is used in the calculation as the maximum difference in monthly average outdoor air temperatures [Δ C]. If the calculation method is Schedule, this field is ignored.

```
Site:WaterMainsTemperature,
Correlation, !- Calculation Method {SCHEDULE | CORRELATION}
, !- Schedule Name
9.69, !- Annual Average Outdoor Air Temperature {C}
28.1; !- Maximum Difference In Monthly Average Outdoor Air Temperatures {deltaC}
```

Site:Precipitation

The Site:Precipitation object is used to describe the amount of water precipitation at the building site over the course of the simulation run period. Precipitation includes both rain and the equivalent water content of snow. Precipitation is not yet described well enough in the usual building weather data file. So this object is used to provide the data using Schedule objects that define rates of precipitation in meters per hour.

A set of schedules for site precipitation have been developed for USA weather locations and are provided with EnergyPlus in the data set called PrecipitationSchedulesUSA.idf. The user can develop schedules however they want. The schedules in the data set were developed using EnergyPlus' weather file (EPW) observations and the average monthly precipitation for the closest weather site provided by NOAA. EPW files for the USA that were based on TMY or TMY2 include weather observations for Light/Moderate/Heavy rainfall, however most international locations do not include these observations. The values were modeled by taking

the middle of the ranges quoted in the EPW data dictionary. The assumed piecewise function is shown below.

$$Amount (m / hour) = \begin{cases} Light = 0.0125 \\ Moderate = 0.052 \\ Heavy = 0.1 \end{cases}$$

The values were inserted on hour by hour basis for the month based on the observations. Then each month was rescaled to meet the average precipitation for the month based on the 30-year average (1971-2000) provided by the NOAA/NCDC. Therefore, the flags in the EPW file match the precipitation schedules for the USA. Note that summing the average monthly precipitation values will not give you the average yearly precipitation. The resulting value may be lower or higher than the average yearly value.

Once the typical rainfall pattern and rates are scheduled, the Site Precipitation object provides a method of shifting the total rainfall up or down for design purposes. Wetter or drier conditions can be modeled by changing the Design Annual Precipitation although the timing of precipitation throughout the year will not be changed.

IDD specification:

```
Site:Precipitation,
  A1, \field Precipitation Model Type
      \type choice
      \key ScheduleAndDesignLevel
  N1, \field Design Level for Total Annual Precipitation
      \note meters of water per year used for design level
  A2, \field Precipitation Rates Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Schedule values in meters of water per hour
      \note values should be non-negative
  N2; \field Average Total Annual Precipitation
      \note meters of water per year from average weather statistics
      \minimum 0
```

Field: Precipitation Model Type

Choose rainfall modeling options. Only available option is ScheduleAndDesignLevel.

Field: Design Level for Total Annual Precipitation

Magnitude of total precipitation for an annual period to be used in the model. Value selected by the user to correspond with the amount of precipitation expected or being assumed for design purposes. The units are in meters. This field works with the following two fields to allow easily shifting the amounts without having to generate new schedules.

Field: Precipitation Rate Schedule Name

Name of a schedule defined elsewhere that describes the rate of precipitation. The precipitation rate schedule is analogous to weather file data. However, weather files for building simulation do not currently contain adequate data for such calculations. Therefore, EnergyPlus schedules are used to enter the pattern of precipitation events. The values in this schedule are the average rate of precipitation in meters per hour. The integration of these values over an annual schedule should equal the nominal annual precipitation.

Field: Average Total Annual Precipitation

Magnitude of annual precipitation associated with the rate schedule. This value is used to normalize the precipitation.

IDF example:

```

Site:Precipitation,
  ScheduledAndDesignLevel, !- Precipitation Model Type
  0.75,                    !- Design Level Total Annual Precipitation
  PrecipitationSchd,      !- Schedule Name for Precipitation Rates
  0.80771;                !- Average Total Annual Precipitation

```

RoofIrrigation

The RoofIrrigation object is used to describe the amount of irrigation on the ecoroof surface over the course of the simulation runperiod. This object is used to provide irrigation data using Schedule objects that define rates of irrigation in meters per hour. These schedules can be one of two types: Schedule, or SmartSchedule. The Schedule type is used to force an irrigation schedule regardless of the current moisture state of the soil. The SmartSchedule type allows the precipitation schedule to be overridden if the current moisture state of the soil is greater than 30% saturated.

Field: Irrigation Model Type

Choose irrigation modeling options. Available options are Schedule and SmartSchedule.

Field: Irrigation Rate Schedule Name

Name of a schedule defined elsewhere that describes the rate of irrigation. The values in this schedule are the average rate of irrigation in meters per hour.

IDD specification:

```

RoofIrrigation,
  A1, \field Irrigation Model Type
      \type choice
      \key Schedule
      \key SmartSchedule
      \note SmartSchedule will not allow irrigation when soil is already moist.
      \note Current threshold set at 30% of saturation.
  A2; \field Irrigation Rate Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Schedule values in meters of water per hour
      \note values should be non-negative

```

IDF example:

```

RoofIrrigation,
  Schedule, !- Irrigation Model Type
  IrrigationSchd, !- Schedule Name for Irrigation Rates

```

Climate Group Outputs

Climate related variables appear in two places for EnergyPlus outputs. Certain objects that are invariant throughout a simulation period have lines appear in the eplusout.eio file. For descriptions of this reporting, please see the Output Details and Examples document.

Weather Data Related Outputs

Variables related to ambient environment data are available at timestep and higher resolutions. Below is a variable dictionary of these variables and subsequent definitions:

```

Zone,Average,Outdoor Dry Bulb [C]
Zone,Average,Outdoor Dew Point [C]
Zone,Average,Outdoor Wet Bulb [C]
Zone,Average,Outdoor Barometric Pressure [Pa]
Zone,Average,Outdoor Relative Humidity [%]
Zone,Average,Outdoor Humidity Ratio [kgWater/kgAir]
Zone,Average,Wind Speed [m/s]
Zone,Average,Wind Direction [degree]
Zone,Average,Sky Temperature [C]
Zone,Average,Diffuse Solar [W/m2]

```

```

Zone,Average,Direct Solar [W/m2]
Zone,Average,Ground Reflected Solar [W/m2]
Zone,Average,Ground Temperature [C]
Zone,Average,Outdoor Enthalpy [J/kg]
Zone,Average,Outdoor Air Density [kg/m3]
Zone,Average,Solar Azimuth Angle [degree]
Zone,Average,Solar Altitude Angle [degree]
Zone,Average,Solar Hour Angle [degree]
Zone,Average,Fraction of Time Raining
Zone,Average,Fraction of Time Snow On Ground
Zone,Average,Daylight Saving Time Indicator []
Zone,Average,DayType Index []
Zone,Average,Water Mains Temperature [C]
HVAC,Average,Site Precipitation Rate [m/s]
HVAC,Sum,Site Precipitation [m]
HVAC,Sum,Roof Irrigation Scheduled Amount [m]
HVAC,Sum,Roof Irrigation Actual Amount [m]

```

Note that these data values may be interpolated from “hour” points (ref: Weather Data Hourly Interpolation). The data values represent the “average” over the reporting resolution period.

Outdoor Dry Bulb [C]

This is the outdoor dry-bulb temperature in degrees C.

Outdoor Dew Point [C]

This is the outdoor dewpoint temperature in degrees C.

Outdoor Wet Bulb [C]

The outdoor wet-bulb temperature is derived (at the timestep) from the values for dry-bulb temperature, humidity ratio and barometric pressure.

Outdoor Barometric Pressure [Pa]

This is the atmospheric/barometric pressure in Pa.

Outdoor Relative Humidity [%]

This is the outdoor relative humidity expressed in percent.

Outdoor Humidity Ratio [kgWater/kgAir]

The outdoor humidity ratio is derived (at the timestep) from the dry-bulb temperature, relative humidity and barometric pressure.

Wind Speed [m/s]

This is the outdoor wind speed in m/s.

Wind Direction [degree]

This is the wind direction (N=0, E=90, S=180, W=270).

Sky Temperature [C]

The sky temperature is derived from horizontal IR. It is expressed in degrees C. Note that Sigma is the Stefan-Boltzmann constant in the following equation:

$$Sky\ Temperature = \left(\frac{Horizontal\ IR}{Sigma} \right)^{\frac{1}{4}} - 273.15_{Conversion\ from\ Kelvin\ to\ Centigrade}$$

Diffuse Solar [W/m2]

Diffuse solar is the amount of solar radiation in W/m² received from the sky (excluding the solar disk) on a horizontal surface.

Direct Solar [W/m2]

Direct solar is amount of solar radiation in W/m² received within a 5.7° field of view centered on the sun. This is also known as Beam Solar.

Ground Reflected Solar [W/m2]

The ground reflected solar amount (W/m²) is derived from the Beam Solar, Diffuse Solar, User specified Ground Reflectance (for month) and Solar Altitude Angle:

$$\text{Groundreflectedsolar} = (\text{Beamsolar} \cdot \text{COS}(\text{SolarAltitudeAngle}) + \text{Diffusesolar}) \cdot \text{Groundreflectance}_{\text{month}}$$

where if the calculation returns a value < 0.0, then 0.0 will be reported.

Ground Temperature [C]

The ground temperature is reported in degrees C – this is a user-specified input by month.

Outdoor Enthalpy [J/kg]

Outdoor enthalpy is derived at each timestep from the Outdoor Dry-bulb and the Outdoor Humidity Ratio. It is reported in J/kg.

Outdoor Air Density [kg/m3]

Outdoor air density is derived at each timestep from the Outdoor Barometric Pressure, the Outdoor Dry-bulb temperature and the Outdoor Humidity Ratio. It is reported in units kg/m³.

Solar Altitude Angle [degree]

The Solar Altitude Angle (β) is the angle of the sun above the horizontal (degrees).

Solar Azimuth Angle [degree]

The Solar Azimuth Angle (ϕ) is measured from the North (clockwise) and is expressed in degrees. This is shown more clearly in the following figure.

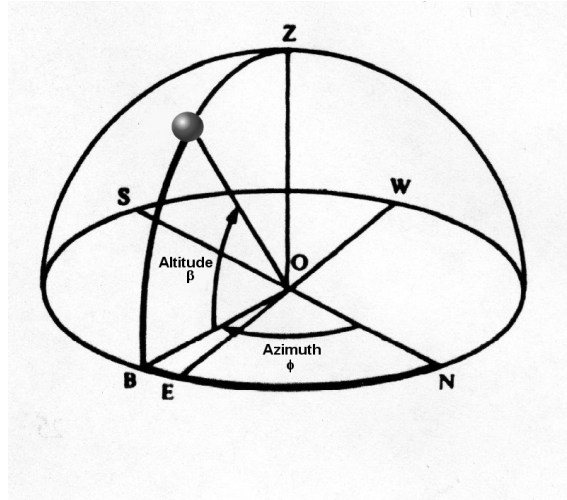


Figure 7. Solar Position Illustration

Solar Hour Angle [degree]

The Solar Hour Angle (H) gives the apparent solar time for the current time period (degrees). It is common astronomical practice to express the hour angle in hours, minutes and seconds of time rather than in degrees. You can convert the hour angle displayed from EnergyPlus to time by dividing by 15. (Note that 1 hour is equivalent to 15 degrees; 360° of the Earth’s rotation takes place every 24 hours.) The relationship of angles in degrees to time is shown in the following table:

Table 5. Relationship of Angles (degrees) to Time

Unit of Angle	Equivalent time
1 radian	3.819719 hours
1 degree	4 minutes
1 arcmin	4 seconds
1 arcsec	0.066667 seconds

Solar Position

The sun’s position in the sky is expressed in terms of the solar altitude and the solar azimuth. Further, these angles depend on the local latitude, the solar declination (which is a function of the date) and the apparent solar time (solar hour angle).

Fraction of Time Raining

This field shows whether or not (1=yes, 0=no) the weather shows “raining”. For a Design Day, one can denote rain for the entire day but not timestep by timestep. Weather files may indicate rain for a single time interval. This is an “averaged” field – thus a 1 shown for a time period (e.g. daily reporting) means that it was raining during each timestep of that period.

Fraction of Time Snow On Ground

This field shows whether or not (1=yes, 0=no) the weather shows “snow on the ground”. For a Design Day, one can denote snow for the entire day but not timestep by timestep. Weather files may indicate snow (snow depth) for a single time interval. This is an “averaged” field – thus a 1 shown for a time period (e.g. daily reporting) means that there was snow on the ground during each timestep of that period.

Daylight Saving Time Indicator

This field shows when daylight saving time (1=yes, 0=no) is in effect. Though shown as an average variable, this value is only set on a daily basis.

DayType Index

This field shows what "day type" the current day is. Daytypes are (1=Sunday, 2=Monday, etc.) with Holiday=8, SummerDesignDay=9, WinterDesignDay=10, CustomDay1=11, CustomDay2=12. Though shown as an average variable, this value is only set on a daily basis.

Water Mains Temperature

The value of the Water Mains Temperature is reported in C following the calculation shown in the Water Mains Temperature object.

Site Precipitation Rate [m/s]**Site Precipitation [m]**

The rate and quantity of precipitation at the site. These outputs are only available if a Site Precipitation object is used. Precipitation is measured in meters.

Roof Irrigation Scheduled Amount[m]

This is the scheduled amount of irrigation for the green roof (ecorooft) based on the user input. Amount is measured in meters.

Roof Irrigation Actual Amount[m]

This is the actual amount of irrigation for the green roof (ecorooft) based on the scheduled user input and moisture state/saturation of the soil. Amount is measured in meters.

Outputs for local temperature/wind speed calculations

Local atmospheric properties for outdoor air temperature and wind speed are separately calculated and reported for all zones, surfaces, and outdoor air nodes. The report variables are associated with their respective objects:

```
Zone,Average,Zone Outdoor Dry Bulb [C]
Zone,Average,Zone Outdoor Wet Bulb [C]
Zone,Average,Zone Outdoor Wind Speed [m/s]
Zone,Average,Surface Ext Outdoor Dry Bulb [C]
Zone,Average,Surface Ext Outdoor Wet Bulb [C]
Zone,Average,Surface Ext Wind Speed [m/s]
HVAC,Average,System Node Temp[C]           (for OUTDOOR AIR NODE object)
```

Zone Outdoor Dry Bulb [C]

The outdoor air dry-bulb temperature calculated at the height above ground of the zone centroid.

Zone Outdoor Wet Bulb [C]

The outdoor air wet-bulb temperature calculated at the height above ground of the zone centroid.

Zone Outdoor Wind Speed [m/s]

The outdoor wind speed calculated at the height above ground of the zone centroid.

Surface Ext Outdoor Dry Bulb [C]

The outdoor air dry-bulb temperature calculated at the height above ground of the surface centroid.

Surface Ext Outdoor Wet Bulb [C]

The outdoor air wet-bulb temperature calculated at the height above ground of the surface centroid.

Surface Ext Wind Speed [m/s]

The outdoor wind speed calculated at the height above ground of the surface centroid.

System Node Temp [C]

When reporting for the **OutdoorAir:Node** object, this is the outdoor air dry-bulb temperature calculated at the height above ground of the node, if height is specified in the input.

Group – Schedules

This group of objects allows the user to influence scheduling of many items (such as occupancy density, lighting, thermostatic controls, occupancy activity). In addition, schedules are used to control shading element density on the building.

EnergyPlus schedules consist of three pieces: a day description, a week description, and an annual description. An optional element is the schedule type. Each description level builds off the previous sub-level. The day description is simply a name and the values that span the 24 hours in a day to be associated with that name. The week description also has an identifier (name) and twelve additional names corresponding to previously defined day descriptions. There are names for each individual day of the week plus holiday, summer design day, winter design day and two more custom day designations. Finally, the annual schedule contains an identifier and the names and FROM-THROUGH dates of the week schedules associate with this annual schedule. The annual schedule can have several FROM-THROUGH date pairs. One type of schedule reads the values from an external file to facilitate the incorporation of monitored data or factors that change throughout the year.

Schedules are processed by the EnergyPlus Schedule Manager, stored within the Schedule Manager and are accessed through module routines to get the basic values (timestep, hourly, etc). Values are resolved at the Zone Timestep frequency and carry through any HVAC timesteps.

Day Type

A brief description of “Day Type” which is used in the SizingPeriod objects, RunPeriodControl:SpecialDays object, the Sizing objects and also used by reference in the Schedule:Week:Daily object (discussed later in this section).

Schedules work on days of the week as well as certain specially designated days. Days of the week are the normal – Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. Special day types that can be designated are: Holiday, SummerDesignDay, WinterDesignDay, CustomDay1, CustomDay2. These day types can be used at the user’s convenience to designate special scheduling (e.g. lights, electric equipment, set point temperatures) using these days as reference.

For example, a normal office building may have normal “occupancy” rules during the weekdays but significantly different use on weekend. For this, you would set up rules/schedules based on the weekdays (Monday through Friday, in the US) and different rules/schedules for the weekend (Saturday and Sunday, in the US). However, you could also specially designate SummerDesignDay and WinterDesignDay schedules for sizing calculations. These schedules can be activated by setting the Day Type field in the Design Day object to the appropriate season (**SummerDesignDay** for cooling design calculations; **WinterDesignDay** for heating design calculations).

In a different building, such as a theater/playhouse, the building may only have occupancy during certain weeks of the year and/or certain hours of certain days. If it was every week, you could designate the appropriate values during the “regular” days (Sunday through

Saturday). But this would also be an ideal application for the “CustomDay1” and/or “CustomDay2”. Here you would set the significant occupancy, lighting, and other schedules for the custom days and use unoccupied values for the normal weekdays. Then, using a weather file and setting special day periods as appropriate, you will get the “picture” of the building usage during the appropriate periods.

ScheduleTypeLimits

Schedule types can be used to validate portions of the other schedules. Hourly day schedules, for example, are validated by range -- minimum/maximum (if entered) -- as well as numeric type (continuous or discrete). Annual schedules, on the other hand, are only validated for range – as the numeric type validation has already been done.

Field: Name

This alpha field should contain a unique (within the schedule types) designator. It is referenced wherever Schedule Type Limits Names can be referenced.

Field: Range

Since schedule values, in their base descriptions, are all numeric, this field will represent the min and max range for the values. If this field is left blank, then the schedule type is not limited to a minimum/maximum value range.

Field: Numeric Type

This field designates how the range values are validated. Using **Continuous** in this field allows for all numbers, including fractional amounts, within the range to be valid. Using **Discrete** in this field allows only integer values between the minimum and maximum range values to be valid.

```
ScheduleTypeLimits,
  \memo ScheduleTypeLimits specifies the data types and limits for the values contained in schedules
  A1, \field Name
     \required-field
     \reference ScheduleTypeLimitsNames
     \note used to validate schedule types in various schedule objects
  A2, \field Range
     \note put in minimum:maximum here or blank if not a limited value, e.g. 0.0:1.0 for fraction
  A3: \field Numeric Type
     \note Numeric type is either Continuous (all numbers within the min and
     \note max are valid or Discrete (only integer numbers between min and
     \note max are valid. (Could also allow REAL and INTEGER to mean the
     \note same things)
     \type choice
     \key Continuous
     \key Discrete
```

Several IDF Examples will illustrate the use:

```
ScheduleTypeLimits,Any Number; ! Not limited
ScheduleTypeLimits,Fraction, 0.0 : 1.0 ,CONTINUOUS;
ScheduleTypeLimits,Temperature,-60:200,CONTINUOUS;
ScheduleTypeLimits,Control Type,0:4,DISCRETE;
ScheduleTypeLimits,On/Off,0:1,DISCRETE;
```

Day Schedules

The day schedules perform the assignment of pieces of information across a 24 hour day. This can occur in various fashions including a 1-per hour assignment, a user specified interval scheme or a list of values that represent an hour or portion of an hour.

Schedule:Day:Hourly

The Schedule:Day:Hourly contains an hour-by-hour profile for a single simulation day.

Field: Name

This field should contain a unique (within all DaySchedules) designation for this schedule. It is referenced by WeekSchedules to define the appropriate schedule values.

Field: Schedule Type Limits Name

This field contains a reference to the Schedule Type Limits object. If found in a list of Schedule Type Limits (see above), then the restrictions from the referenced object will be used to validate the hourly field values (below).

Field: Hour Values (1-24)

These fields contain the hourly values for each of the 24 hours in a day. (Hour field 1 represents clock time 00:00:01 AM to 1:00:00 AM, hour field 2 is 1:00:01 AM to 2:00:00 AM, etc.) The values in these fields will be passed to the simulation as indicated for “scheduled” items.

```
Schedule:Day:Hourly,
  \min-fields 26
  \memo A Schedule:Day:Hourly contains 24 values for each hour of the day.
A1 , \field Name
  \required-field
  \type alpha
  \reference DayScheduleNames
A2 , \field Schedule Type Limits Name
  \type object-list
  \object-list ScheduleTypeLimitsNames
N1 , \field Hour 1
  \type real
  \default 0
N2 , \field Hour 2
  \type real
  \default 0
-- etc to 24 hour values
```

For brevity each of the hour fields is not listed here – see the IDD for complete definition. An IDF example:

```
Schedule:Day:Hourly, Day On Peak, Fraction,
  0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,1.,1.,1.,1.,1.,1.,1.,1.,0.,0.,0.,0.,0.,0.;
```

Schedule:Day:Interval

The Schedule:Day:Interval introduces a slightly different way of entering the schedule values for a day. Using the intervals, you can shorten the “hourly” input of the “Schedule:Day:Hourly” object to 2 fields. And, more importantly, you can enter an interval that represents only a portion of an hour. Schedule values are “given” to the simulation at the zone timestep, so there is also a possibility of “interpolation” from the entries used in this object to the value used in the simulation.

Field: Name

This field should contain a unique (within all DaySchedules) designation for this schedule. It is referenced by WeekSchedules to define the appropriate schedule values.

Field: Schedule Type Limits Name

This field contains a reference to the Schedule Type Limits object. If found in a list of Schedule Type Limits (see above), then the restrictions from the referenced object will be used to validate the hourly field values (below).

Field: Interpolate to Timestep

The value contained in this field directs how to apply values that aren't coincident with the given timestep (ref: Timestep) intervals. If "Yes" is entered, then any intervals entered here will be interpolated/averaged and that value will be used at the appropriate minute in the hour. If "No" is entered, then the value that occurs on the appropriate minute in the hour will be used as the schedule value.

For example, if "yes" is entered and the interval is every 15 minutes (say a value of 0 for the first 15 minutes, then .5 for the second 15 minutes) AND there is a 10 minute timestep for the simulation: the value at 10 minutes will be 0 and the value at 20 minutes will be .25. For the same input entries but "no" for this field, the value at 10 minutes will be 0 and the value at 20 minutes will be .5.

Field-Set: Time and Value (extensible object)

To specify each interval, both an "until" time (which includes the designated time) and the value must be given.

Field: Time

The value of each field should represent clock time (standard) in the format "Until: HH:MM". 24 hour clock format (i.e. 1PM is 13:00) is used. Note that Until: 7:00 includes all times up through 07:00 or 7am.

Field: Value

This represents the actual value to be passed to the simulation at the appropriate timestep. (Using interpolation value as shown above). Limits on the values are indicated by the Schedule Type Limits Name field of this object.

The IDD representation for the Schedule:Day:Interval object:

```
Schedule:Day:Interval,
  \extensible:2 - repeat last two fields, remembering to remove ; from "inner" fields.
  \memo A Schedule:Day:Interval contains a full day of values with specified end times for each value
  \memo Currently, is set up to allow for 10 minute intervals for an entire day.
  A1 , \field Name
      \required-field
      \type alpha
      \reference DayScheduleNames
  A2 , \field Schedule Type Limits Name
      \type object-list
      \object-list ScheduleTypeLimitsNames
  A3 , \field Interpolate to Timestep
      \note when the interval does not match the user specified timestep a Yes choice will average
between the intervals request (to
      \note timestep resolution. a No choice will use the interval value at the simulation timestep
without regard to if it matches
      \note the boundary or not.
      \type choice
      \key Yes
      \key No
      \default No
  A4 , \field Time 1
      \note "until" includes the time entered.
      \units hh:mm
  N1 , \field Value Until Time 1
  A5 , \field Time 2
      \note "until" includes the time entered.
      \units hh:mm
  N2 , \field Value Until Time 2
  A6 , \field Time 3
      \note "until" includes the time entered.
      \units hh:mm
  N3 , \field Value Until Time 3
<reduced for brevity - can have up to 24 intervals>
```

And an example of use:

```

Schedule:Day:Interval,
  dd winter rel humidity,  !- Name
  Percent,                 !- Schedule Type Limits Name
  No,                      !- Interpolate to Timestep
  until: 24:00,           !- Time 1
  74;                     !- Value Until Time 1

```

Schedule:Day:List

To facilitate possible matches to externally generated data intervals, this object has been included. In similar fashion to the Schedule:Day:Interval object, this object can also include “sub-hourly” values but must represent a complete day in its list of values.

Field: Name

This field should contain a unique (within all day schedules) designation for this schedule. It is referenced by week schedules to define the appropriate schedule values.

Field: Schedule Type Limits Name

This field contains a reference to the Schedule Type Limits object. If found in a list of Schedule Type Limits (see above), then the restrictions from the referenced object will be used to validate the hourly field values (below).

Field: Interpolate to Timestep

The value contained in this field directs how to apply values that aren’t coincident with the given timestep (ref: Timestep) intervals. If “Yes” is entered, then any intervals entered here will be interpolated/averaged and that value will be used at the appropriate minute in the hour. If “No” is entered, then the value that occurs on the appropriate minute in the hour will be used as the schedule value.

For example, if “yes” is entered and the minutes per item is 15 minutes (say a value of 0 for the first 15 minutes, then .5 for the second 15 minutes) AND there is a 10 minute timestep for the simulation: the value at 10 minutes will be 0 and the value at 20 minutes will be .25. For the same input entries but “no” for this field, the value at 10 minutes will be 0 and the value at 20 minutes will be .5.

Field: Minutes Per Item

This field allows the “list” interval to be specified in the number of minutes for each item. The value here must be ≤ 60 and evenly divisible into 60 (same as the timestep limits).

Field Value 1 (same definition for each value – up to 1440 (24*60) allowed)

This is the value to be used for the specified number of minutes.

```

Schedule:Day:List,
  \memo Schedule:Day:List will allow the user to list 24 hours worth of values, which can be sub-
  hourly in nature.
  A1 , \field Name
      \required-field
      \type alpha
      \reference DayScheduleNames
  A2 , \field Schedule Type Limits Name
      \type object-list
      \object-list ScheduleTypeLimitsNames
  A3 , \field Interpolate to Timestep
      \note when the interval does not match the user specified timestep a "Yes" choice will average
      between the intervals request (to
      \note timestep resolution. a "No" choice will use the interval value at the simulation timestep
      without regard to if it matches
      \note the boundary or not.
      \type choice
      \key Yes
      \key No
      \default No
  N1 , \field Minutes Per Item
      \note Must be evenly divisible into 60
      \type integer
      \minimum 1
      \maximum 60
  N2, \field Value 1
<reduced for brevity, up to 1440 (24*60) values may be entered>

```

For example:

```

Schedule:Day:List,
  Myschedule, ! name
  Fraction, ! Schedule type
  No, ! Interpolate value
  30, ! Minutes per item
  0.0, ! from 00:01 to 00:30
  0.5, ! from 00:31 to 01:00
  <etc>

```

Week Schedule(s)

The week schedule object(s) perform the task of assigning the day schedule to day types in the simulation. The basic week schedule is shown next.

Schedule:Week:Daily

Field: Name

This field should contain a unique (within all WeekSchedules) designation for this schedule. It is referenced by Schedules to define the appropriate schedule values.

Field: Schedule Day Name Fields (12 day types – Sunday, Monday, ...)

These fields contain day schedule names for the appropriate day types. Days of the week (or special days as described earlier) will then use the indicated hourly profile as the actual schedule value.

```

Schedule:Week:Daily,
  \min-fields 13
  \memo A Schedule:Week:Daily contains 12 Schedule:Day:Hourly objects, one for each day type.
A1 , \field Name
  \required-field
  \reference WeekScheduleNames
  \type alpha
A2 , \field Sunday Schedule:Day Name
  \required-field
  \type object-list
  \object-list DayScheduleNames
A3 , \field Monday Schedule:Day Name
  \required-field
  \type object-list
  \object-list DayScheduleNames
A4 , \field Tuesday Schedule:Day Name
  \required-field
  \type object-list
  \object-list DayScheduleNames
A5 , \field Wednesday Schedule:Day Name
  \required-field
  \type object-list
  \object-list DayScheduleNames
A6 , \field Thursday Schedule:Day Name
  \required-field
  \type object-list
  \object-list DayScheduleNames
A7 , \field Friday Schedule:Day Name
  \required-field
  \type object-list
  \object-list DayScheduleNames
A8 , \field Saturday Schedule:Day Name
  \required-field
  \type object-list
  \object-list DayScheduleNames
A9 , \field Holiday Schedule:Day Name
  \required-field
  \type object-list
  \object-list DayScheduleNames
A10, \field SummerDesignDay Schedule:Day Name
  \required-field
  \type object-list
  \object-list DayScheduleNames
A11, \field WinterDesignDay Schedule:Day Name
  \required-field
  \type object-list
  \object-list DayScheduleNames
A12, \field CustomDay1 Schedule:Day Name
  \required-field
  \type object-list
  \object-list DayScheduleNames
A13; \field CustomDay2 Schedule:Day Name
  \required-field
  \type object-list
  \object-list DayScheduleNames

```

An IDF example:

```

Schedule:Week:Daily, Week on Peak,
  Day On Peak,Day On Peak,Day On Peak,
  Day On Peak,Day On Peak,Day On Peak,
  Day On Peak,Day On Peak,Day On Peak,
  Day On Peak,Day On Peak,Day On Peak;

```

Schedule:Week:Compact

Further flexibility can be realized by using the Schedule:Week:Compact object. In this the fields, after the name is given, a “for” field is given for the days to be assigned and then a dayschedule name is used.

Field:Name

This field should contain a unique (within all WeekSchedules) designation for this schedule. It is referenced by Schedules to define the appropriate schedule values.

Field-Set – DayType List#, Schedule:Day Name #

Each assignment is made in a pair-wise fashion. First the “days” assignment and then the dayschedule name to be assigned. The entire set of day types must be assigned or an error will result.

Field: DayType List #

This field can optionally contain the prefix “For” for clarity. Multiple choices may then be combined on the line. Choices are: Weekdays, Weekends, Holidays, Alldays, SummerDesignDay, WinterDesignDay, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, CustomDay1, CustomDay2. In fields after the first “for”, AllOtherDays may also be used.

Field: Schedule:Day Name #

This field contains the name of the day schedule (any of the Schedule:Day object names) that is to be applied for the days referenced in the prior field.

```
Schedule:Week:Compact,
  \extendible:2 - repeat last two fields, remembering to remove ; from "inner" fields.
  \memo Compact definition for Schedule:Day:List
  \min-fields 3
A1 , \field Name
    \required-field
    \reference WeekScheduleNames
    \type alpha
A2 , \field DayType List 1
    \note "For" is an optional prefix/start of the For fields. Choices can be combined on single line
    \note if sepaRated by spaces. i.e. "Holiday Weekends"
    \note Should have a space after For, if it is included. i.e. "For Alldays"
    \required-field
    \type choice
    \key AllDays
    \key Weekdays
    \key Weekends
    \key Sunday
    \key Monday
    \key Tuesday
    \key Wednesday
    \key Thursday
    \key Friday
    \key Saturday
    \key Holiday
    \key SummerDesignDay
    \key WinterDesignDay
    \key CustomDay1
    \key CustomDay2
A3 , \field Schedule:Day Name 1
    \required-field
    \type object-list
    \object-list DayScheduleNames
- reduced for brevity --
```

Some IDF examples:

```
Schedule:Week:Compact, Week on Peak,
    For AllDays,
    Day On Peak;
Schedule:Week:Compact, WeekDays on Peak,
    WeekDays,
    Day On Peak,
    AllOtherDays
    Day Off Peak;
```

Schedule:Year

The yearly schedule is used to cover the entire year using references to week schedules (which in turn reference day schedules). If the entered schedule does not cover the entire year, a fatal error will result.

Field: Name

This field should contain a unique (between Schedule:Year, Schedule:Compact, and Schedule:File) designation for the schedule. It is referenced by various "scheduled" items (e.g. Lights, People, Infiltration) to define the appropriate schedule values.

Field: Schedule Type Limits Name

This field contains a reference to the Schedule Type Limits object. If found in a list of Schedule Type Limits (see above), then the restrictions from the referenced object will be used to validate the hourly field values (below).

Field Set (WeekSchedule, Start Month and Day, End Month and Day)

Each of the designated fields is used to fully define the schedule values for the indicated time period). Up to 53 sets can be used. An error will be noted and EnergyPlus will be terminated if an incomplete set is entered. Missing time periods will also be noted as warning errors; for these time periods a zero (0.0) value will be returned when a schedule value is requested. Each of the sets has the following 5 fields:

Field: Schedule Week Name #

This field contains the appropriate WeekSchedule name for the designated time period.

Field: Start Month #

This numeric field is the starting month for the schedule time period.

Field: Start Day #

This numeric field is the starting day for the schedule time period.

Field: End Month #

This numeric field is the ending month for the schedule time period.

Field: End Day #

This numeric field is the ending day for the schedule time period.

```

Schedule:Year,
\min-fields 7
  \memo A Schedule:Year contains from 1 to 52 week schedules
  A1 , \field Name
      \required-field
      \type alpha
      \reference ScheduleNames
  A2 , \field Schedule Type Limits Name
      \type object-list
      \object-list ScheduleTypeLimitsNames
  A3 , \field Schedule:Week Name 1
      \required-field
      \type object-list
      \object-list WeekScheduleNames
  N1 , \field Start Month 1
      \required-field
      \type integer
      \minimum 1
      \maximum 12
  N2 , \field Start Day 1
      \required-field
      \type integer
      \minimum 1
      \maximum 31
  N3 , \field End Month 1
      \required-field
      \type integer
      \minimum 1
      \maximum 12
  N4 , \field End Day 1
      \required-field
      \type integer
      \minimum 1
      \maximum 31
  A4 , \field Schedule:Week Name 2
      \type object-list
      \object-list WeekScheduleNames
  N5 , \field Start Month 2
      \type integer
      \minimum 1
      \maximum 12
  N6 , \field Start Day 2
      \type integer
      \minimum 1
      \maximum 31
  N7 , \field End Month 2
      \type integer
      \minimum 1
      \maximum 12
  N8 , \field End Day 2
      \type integer
      \minimum 1
      \maximum 31
-- etc to 53 weekschedule "field sets"

```

For brevity, the entire definition of week schedules is not included here. See the actual IDD for full definition.

Note that there are many possible periods to be described. An IDF example with a single period:

```

Schedule:Year, On Peak, Fraction,
  Week On Peak, 1,1, 12,31;

```

And a multiple period illustration:


```
Schedule:Year,CoolingCoilAvailSched,Fraction,
FanAndCoilAllOffWeekSched, 1,1, 3,31,
FanAndCoilSummerWeekSched, 4,1, 9,30,
FanAndCoilAllOffWeekSched, 10,1, 12,31;
```

The following definition will generate an error (if any scheduled items are used in the simulation):

```
Schedule:Year,MySchedule,Fraction,4,1,9,30;
```

Schedule:Compact

For flexibility, a schedule can be entered in “one fell swoop”. Using the Schedule:Compact object, all the features of the schedule components are accessed in a single command. Like the “regular” schedule object, each schedule:compact entry must cover all the days for a year. Additionally, the validations for DaySchedule (i.e. must have values for all 24 hours) and WeekSchedule (i.e. must have values for all day types) will apply. Schedule values are “given” to the simulation at the zone timestep, so there is also a possibility of “interpolation” from the entries used in this object to the value used in the simulation.

This object is an unusual object for description. For the data the number of fields and position are not set, they cannot really be described in the usual Field # manner. Thus, the following description will list the fields and order in which they must be used in the object. The name and schedule type are the exceptions:

Field: Name

This field should contain a unique (between Schedule:Year, Schedule:Compact, and Schedule:File) designation for the schedule. It is referenced by various “scheduled” items (e.g. Lights, People, Infiltration) to define the appropriate schedule values.

Field: Schedule Type Limits Name

This field contains a reference to the Schedule Type Limits object. If found in a list of Schedule Type Limits (see above), then the restrictions from the referenced object will be used to validate the hourly field values (below).

Field-Set (Through, For, Interpolate, Until, Value)

Each compact schedule must contain the elements Through (date), For (days), Interpolate (optional), Until (time of day) and Value. In general, each of the “titled” fields must include the “title”.

Field: Through

This field starts with “Through:” and contains the ending date for the schedule period (may be more than one). Refer to Table 4. Date Field Interpretation for information on date entry – note that only Month-Day combinations are allowed for this field. Each “through” field generates a new WeekSchedule named “Schedule Name”_wk_# where # is the sequential number for this compact schedule.

Field: For

This field starts with “For:” and contains the applicable days (reference the compact week schedule object above for complete description) for the 24 hour period that must be described. Each “for” field generates a new DaySchedule named “Schedule Name”_dy_# where # is the sequential number for this compact schedule.

Field: Interpolate (optional)

This field, if used, starts with “Interpolate:” and contains the word “Yes” or “No”. If this field is not used, it should not be blank – rather just have the following field appear in this slot. The definition of “Interpolate” in this context is shown in the interval day schedule above.

Field: Until

This field contains the ending time (again, reference the interval day schedule discussion above) for the current days and day schedule being defined.

Field: Value

Finally, the value field is the schedule value for the specified time interval.

The complete IDD definition:

```
Schedule:Compact,
  \extensible:1 - repeat last field, remembering to remove ; from "inner" fields.
  \memo Irregular object. Does not follow the usual definition for fields. Fields A3... are:
  \memo Through: Date
  \memo For: Applicable days (ref: Schedule:Week:Compact)
  \memo Interpolate: Yes/No (ref: Schedule:Day:Interval) -- optional, if not used will be "No"
  \memo Until: <Time> (ref: Schedule:Day:Interval)
  \memo <numeric value>
  \memo words "Through","For","Interpolate","Until" must be included.
  \format compactSchedule
A1 , \field Name
  \required-field
  \type alpha
  \reference ScheduleNames
A2 , \field Schedule Type Limits Name
  \type object-list
  \object-list ScheduleTypeLimitsNames
A3 , \field Field 1
A4 , \field Field 2
A5 , \field Field 3
A6 , \field Field 4
A7 , \field Field 5
A8 , \field Field 6
A9 , \field Field 7
A10, \field Field 8
-- reduced for brevity --
```

And, some IDF examples:

```
Schedule:Compact,
POFF,    !- Name
Fraction, !- Schedule Type Limits Name
Through: 4/30,
For: AllDays,
Until: 24:00, 1.0,
Through: 12/31,
For: Weekdays,
  Until: 7:00, .1,
  Until: 17:00, 1.0,
  Until: 24:00, .1,
For: Weekends Holidays,
  Until: 24:00, .1,
For: AllOtherDays,
  Until: 24:00, .1;
! Schedule Continuous
Schedule:Compact,
Continuous,
on/off,
Through: 12/31,
For: AllDays,
Until: 24:00, 1.0;
```

```
! Schedule Daytime Ventilation
Schedule:Compact,
  Daytime Ventilation,
  Fraction,
  Through: 12/31,
  For: Weekdays SummerDesignDay,
  Until: 08:00, 0.0,
  Until: 18:00, 1.0,
  Until: 24:00, 0.0,
  For: Weekends WinterDesignDay,
  Until: 10:00, 0.0,
  Until: 16:00, 1.0,
  Until: 24:00, 0.0,
  For: Holidays AllOtherDays,
  Until: 24:00, 0.0;
```

Schedule:File

At times, data is available from a building being monitored or for factors that change throughout the year. The Schedule:File object allows this type of data to be used in EnergyPlus as a schedule.

The format for the data file referenced is a text file with values separated by commas with one line per hour. The file may contain header lines that are skipped. The file should contain values for an entire year (8760 lines with data) or a warning message will be issued. Multiple schedules may be created using a single external data file or multiple external data files may be used. The file must be located in the same directory as the EnergyPlus application.

The use of Schedule:File along with the FuelFactors object and TDV files in the DataSets directory to compute Time Dependent Valuation based source energy as used by the California Energy Commission's Title 24 Energy Code. See Fuel Factor for more discussion on Time Dependent Valuation.

Field: Name

This field should contain a unique (between Schedule:Year, Schedule:Compact, and Schedule:File) designation for the schedule. It is referenced by various "scheduled" items (e.g. Lights, People, Infiltration, FuelFactors) to define the appropriate schedule values.

Field: Schedule Type Limits Name

This field contains a reference to the Schedule Type Limits object. If found in a list of Schedule Type Limits (see above), then the restrictions from the referenced object will be used to validate the hourly field values (below).

Field: File Name

This field contains the name of the file that contains the data for the schedule. The field may include just the simple file name, a full path with file name or a relational path with file name. The field must be <= 100 characters. If just a simple file name, the file must be located in the "run" folder (same folder as the EnergyPlus.exe). If a relational path with file name, the file must be placed in relation to the "run" folder. The file name must not include commas or an exclamation point.

Field: Column Number

The column that contains the value to be used in the schedule. The column can be more easily viewed if the comma delimited file is opened in a spreadsheet program that parses commas. The first column is column one. If no data for a row appears for a referenced column the value of zero is used for the schedule value for that hour.

Field: Rows to Skip at Top

Many times the data in a file contains rows (lines) that are describing the files or contain the names of each column. These rows need to be skipped and the number of skipped rows should be entered for this field.

Field: Number of Hours of Data

The value entered in this field should be either 8760 or 8784 as the number of hours of data. 8760 does not include a leap year (if existant). 8784 will include the possibility of leap year data which can be processed according to leap year indicators in the weather file or elsewhere specified.

```
Schedule:File,
\min-fields 5
  \memo A Schedule:File points to a text computer file that has 8760 hours of data.
A1 , \field Name
  \required-field
  \type alpha
  \reference ScheduleNames
A2 , \field Schedule Type Limits Name
  \type object-list
  \object-list ScheduleTypeLimitsNames
A3 , \field File Name
  \required-field
  \retaincase
N1 , \field Column Number
  \required-field
  \type integer
  \minimum 1
N2 , \field Rows to Skip at Top
  \required-field
  \type integer
  \minimum 0
N3 ; \field Number of Hours of Data
  \note 8760 hours does not account for leap years, 8784 does.
  \note should be either 8760 or 8784
  \default 8760
  \minimum 8760
  \maximum 8784
```

Here is an IDF example:

```
Schedule:File,
  elecTDVfromCZ01res,    !- Name
  Any Number,           !- ScheduleType
  TDV_kBtu_CTZ01.csv,   !- Name of File
  2,                    !- Column Number
  4;                    !- Rows to Skip at Top
```

or with a relational path:

```
Schedule:File,
  elecTDVfromCZ01res,    !- Name
  Any Number,           !- ScheduleType
  DataSets\TDV\TDV_kBtu_CTZ01.csv, !- Name of File
  2,                    !- Column Number
  4;                    !- Rows to Skip at Top
```

Schedule Outputs

An optional report can be used to gain the values described in the previous Schedule objects. This is a condensed reporting that illustrates the full range of schedule values – in the style of input: DaySchedule, WeekSchedule, Annual Schedule.

```
Output:Reports, Schedules, Hourly; ! will give them on hourly increments (day schedule
resolution)
Output:Reports, Schedules, Timestep; ! will give them at the timestep of the simulation
```

This report is placed on the eplusout.eio file. Details of this reporting are shown in the Output Details and Examples document.

Schedule Value Output

```
Zone, Average, Schedule Value []
```

Schedule Value

This is the schedule value (as given to whatever entity that uses it). It has no units in this context because values may be many different units (i.e. temperatures, fractions, watts). For best results, you may want to apply the schedule name when you use this report variable to avoid output proliferation. For example, the following reporting should yield the values shown above, depending on day of week and day type:

```
Output:Variable, People_Shopping_Sch, Schedule Value, hourly;
Output:Variable, Activity_Shopping_Sch, Schedule Value, hourly;
```

Group – Surface Construction Elements

This group of objects describes the physical properties and configuration for the building envelope and interior elements. That is, the walls, roofs, floors, windows, doors for the building.

Specifying the Building Envelope

Building element constructions in EnergyPlus are built from the basic thermal and other material property parameters in physical constructions. Materials are specified by types and named. Constructions are defined by the composition of materials. Finally, surfaces are specified for the building with geometric coordinates as well as referenced constructions.

Material and Material Properties

There are several material “types” which may be used to describe layers within opaque construction elements. The choice of which of these types to use is left up to the user. However, some guidance as to which material type to use is appropriate before describing each in detail. The opaque types are:

- Material
- Material:NoMass
- Material:AirGap
- Material:RoofVegetation
- Material:InfraredTransparent

Material is the “preferred” type of material. This requires knowledge of many of the thermal properties of the material, but it allows EnergyPlus to take into account the thermal mass of the material and thus allows the evaluation of transient conduction effects. Material:NoMass is similar in nature but only requires the thermal resistance (R-value) rather than the thickness, thermal conductivity, density, and specific heat. Note that using a simple R-value only material forces EnergyPlus to assume steady state heat conduction through this material layer. Finally, Material:AirGap should only be used for an air gap between other layers in a construction. This type assumes that air is sufficiently lightweight to require only an R-value. In addition, since it is not exposed to any external environment, surface properties such as absorptance are not necessary. Material:RoofVegetation is used to help model “green roofs”. Material:InfraredTransparent is used similarly to the NoMass materials. Each of these materials is described in more detail below.

There are several material additions that can be made to the basic material properties. These additional material types are:

- MaterialProperty:MoisturePenetrationDepth:Settings
- MaterialProperty:HeatAndMoistureTransfer:SorptionIsotherm

- MaterialProperty:HeatAndMoistureTransfer:Diffusion
- MaterialProperty:HeatAndMoistureTransfer:Settings
- MaterialProperty:HeatAndMoistureTransfer:Redistribution
- MaterialProperty:HeatAndMoistureTransfer:Suction
- MaterialProperty:HeatAndMoistureTransfer:ThermalConductivity
- MaterialProperty:PhaseChange

These material property objects are used in conjunction with the basic material specification and reference back to the name of the basic material type. Without the basic material type specified the program, will give a severe error and terminate. For example, specifying the moisture materials and changing the HeatBalanceAlgorithm to a moisture simulation will allow the moisture simulation to take place.

Material

This definition should be used when the four main thermal properties (thickness, conductivity, density, and specific heat) of the material are known. This syntax is used to describe opaque construction elements only.

Field: Name

This field is a unique reference name that the user assigns to a particular material. This name can then be referred to by other input data (ref: Construction).

Field: Roughness

This alpha field defines the relative roughness of a particular material layer. This parameter only influences the convection coefficients, more specifically the exterior convection coefficient. A special keyword is expected in this field with the options being “VeryRough”, “Rough”, “MediumRough”, “MediumSmooth”, “Smooth”, and “VerySmooth” in order of roughest to smoothest options.

Field: Thickness

This field characterizes the thickness of the material layer in meters. This should be the dimension of the layer in the direction perpendicular to the main path of heat conduction. This value must be a positive.

Field: Conductivity

This field is used to enter the thermal conductivity of the material layer. Units for this parameter are W/(m-K). Thermal conductivity must be greater than zero.

Field: Density

This field is used to enter the density of the material layer in units of kg/m³. Density must be a positive quantity.

Field: Specific Heat

This field represents the specific heat of the material layer in units of J/(kg-K). Note that these units are most likely different than those reported in textbooks and references which tend to use kJ/(kg-K) or J/(g-K). They were chosen for internal consistency within EnergyPlus. Only positive values of specific heat are allowed.

Field: Thermal Absorptance

The thermal absorptance field in the Material input syntax represents the fraction of incident long wavelength radiation that is absorbed by the material. This parameter is used when calculating the long wavelength radiant exchange between various surfaces and affects the surface heat balances (both inside and outside as appropriate). Values for this field must be between 0.0 and 1.0 (with 1.0 representing “black body” conditions).

Field: Solar Absorptance

The solar absorptance field in the Material input syntax represents the fraction of incident solar radiation that is absorbed by the material. Solar radiation includes the visible spectrum as well as infrared and ultraviolet wavelengths. This parameter is used when calculating the amount of incident solar radiation absorbed by various surfaces and affects the surface heat balances (both inside and outside as appropriate). Values for this field must be between 0.0 and 1.0.

Field: Visible Absorptance

The visible absorptance field in the Material input syntax represents the fraction of incident visible wavelength radiation that is absorbed by the material. Visible wavelength radiation is slightly different than solar radiation in that the visible band of wavelengths is much more narrow while solar radiation includes the visible spectrum as well as infrared and ultraviolet wavelengths. This parameter is used when calculating the amount of incident visible radiation absorbed by various surfaces and affects the surface heat balances (both inside and outside as appropriate) as well as the daylighting calculations. Values for this field must be between 0.0 and 1.0.

```
Material,
  \memo Regular materials described with full set of thermal properties
  \min-fields 6
  A1 , \field Name
        \required-field
        \type alpha
        \reference MaterialName
  A2 , \field Roughness
        \required-field
        \type choice
        \key VeryRough
        \key Rough
        \key MediumRough
        \key MediumSmooth
        \key Smooth
        \key VerySmooth
  N1 , \field Thickness
        \required-field
        \units m
        \type real
        \minimum> 0
        \maximum 3.0
        \ip-units in
  N2 , \field Conductivity
        \required-field
        \units W/m-K
        \type real
        \minimum> 0
  N3 , \field Density
        \required-field
        \units kg/m3
        \type real
        \minimum> 0
  N4 , \field Specific Heat
        \required-field
        \units J/kg-K
        \type real
        \minimum> 0
```

```

N5 , \field Thermal Absorptance
     \type real
     \minimum > 0
     \default .9
     \maximum 0.99999
N6 , \field Solar Absorptance
     \type real
     \default .7
     \minimum 0
     \maximum 1
N7 ; \field Visible Absorptance
     \type real
     \minimum 0
     \default .7
     \maximum 1

```

An IDF example:

```

Material,A2 - 4 IN DENSE FACE BRICK, ! Material Name
Rough, ! Roughness
0.1014984 , ! Thickness {m}
1.245296 , ! Conductivity {W/M*K}
2082.400 , ! Density {Kg/M**3}
920.4800 , ! Specific Heat {J/Kg*K}
0.9000000 , ! Thermal Absorptance
0.9300000 , ! Solar Absorptance
0.9300000 ; ! Visible Absorptance

```

Material:NoMass

Use this definition when only the thermal resistance (R value) of the material is known. This object is used to describe opaque construction elements.

Field: Name

This field is a unique reference name that the user assigns to a particular material. This name can then be referred to by other input data (ref: Construction, SurfaceControl:MoveableInsulation).

Field: Roughness

This alpha field defines the relative roughness of a particular material layer. This parameter only influences the convection coefficients, more specifically the exterior convection coefficient. A special keyword is expected in this field with the options being “VeryRough”, “Rough”, “MediumRough”, “MediumSmooth”, “Smooth”, and “VerySmooth” in order of roughest to smoothest options.

Field: Thermal Resistance

This field is used to enter the thermal resistance (R-value) of the material layer. Units for this parameter are (m²-K)/W. Thermal resistance must be greater than zero. Note that most R-values in the USA are calculated in Inch-Pound units and must be converted to the SI equivalent.

Field: Thermal Absorptance

The thermal absorptance field in the Material input syntax represents the fraction of incident long wavelength radiation that is absorbed by the material. This parameter is used when calculating the long wavelength radiant exchange between various surfaces and affects the surface heat balances (both inside and outside as appropriate). Values for this field must be between 0.0 and 1.0 (with 1.0 representing “black body” conditions).

Field: Solar Absorptance

The solar absorptance field in the Material input syntax represents the fraction of incident solar radiation that is absorbed by the material. Solar radiation includes the visible spectrum as well as infrared and ultraviolet wavelengths. This parameter is used when calculating the

amount of incident solar radiation absorbed by various surfaces and affects the surface heat balances (both inside and outside as appropriate). Values for this field must be between 0.0 and 1.0.

Field: Visible Absorptance

The visible absorptance field in the Material input syntax represents the fraction of incident visible wavelength radiation that is absorbed by the material. Visible wavelength radiation is slightly different than solar radiation in that the visible band of wavelengths is much more narrow while solar radiation includes the visible spectrum as well as infrared and ultraviolet wavelengths. This parameter is used when calculating the amount of incident visible radiation absorbed by various surfaces and affects the surface heat balances (both inside and outside as appropriate) as well as the daylighting calculations. Values for this field must be between 0.0 and 1.0.

```
Material:NoMass,
  \memo Regular materials properties described whose principal description is R (Thermal Resistance)
  \min-fields 3
  A1 , \field Name
      \required-field
      \type alpha
      \reference MaterialName
  A2 , \field Roughness
      \required-field
      \type choice
      \key VeryRough
      \key Rough
      \key MediumRough
      \key MediumSmooth
      \key Smooth
      \key VerySmooth
  N1 , \field Thermal Resistance
      \required-field
      \units m2-K/W
      \type real
      \minimum> 0
  N2 , \field Thermal Absorptance
      \type real
      \minimum> 0
      \default .9
      \maximum 0.99999
  N3 , \field Solar Absorptance
      \type real
      \minimum 0
      \default .7
      \maximum 1
  N4 ; \field Visible Absorptance
      \type real
      \minimum 0
      \default .7
      \maximum 1
```

An IDF example:

```
Material:NoMass,R13LAYER, ! Material Name
Rough, ! Roughness
2.290965 , ! Resistance {M**2K/W}
0.9000000 , ! Thermal Absorptance
0.7500000 , ! Solar Absorptance
0.7500000 ; ! Visible Absorptance
```

Material:InfraredTransparent

A Infrared Transparent surface is similar to a resistance-only surface. The idd object for this type of surface is shown below. The surface will actually participate in the transfer of visible and solar radiation by doing a wavelength transformation and making all short wave length radiation that is incident on the surface into long wave length radiation and having it

participate in the long wavelength radiant exchange. **Note the ConvectionCoefficient instructions that follow the Infrared Transparent construction object below.**

```
Material:InfraredTransparent,
  \memo Special infrared transparent material. Similar to a Material:Nomass with low thermal
  resistance.
  \memo High absorptance in both wavelengths.
  \memo Area will be doubled internally to make internal radiant exchange accurate.
  \memo Should be only material in single layer surface construction.
  \memo All thermal properties are set internally. User needs only to supply name.
  \min-fields 1
A1 ; \field Name
  \required-field
  \type alpha
  \reference MaterialName
```

Field: Name

This field contains the unique name (across all Material objects) for the Infrared Transparent material.

A Infrared Transparent surface should not participate in a convective/conductive exchange between the zones it separates. In order to minimize this effect, the ConvectionCoefficients object must be used for the surfaces referencing the Infrared Transparent (IRT) construction.

An example idf object specification for use with the IRT surface is shown below:

```
Material:InfraredTransparent,
  IRTMaterial1;           !- Name

Construction,
  IRTSurface,           !- Name
  IRTMaterial1;       !- Outside Layer
```

Surfaces are not described in this example.

```
SurfaceProperty:ConvectionCoefficients,
  Bottom:Top,           !- SurfaceName
  Outside,             !- Convection Type 1
  value,              !- Convection Value Type 1
  0.1,                !- Convection value 1 {W/m2-K}
  ,                  !- Convection Schedule 1
  Inside,             !- Convection Type 2
  value,              !- Convection Value Type 2
  0.1;                !- Convection value 2 {W/m2-K}

SurfaceProperty:ConvectionCoefficients,
  SecondLevel:Bottom, !- SurfaceName
  Outside,           !- Convection Type 1
  value,            !- Convection Value Type 1
  0.1,              !- Convection value 1 {W/m2-K}
  ,                !- Convection Schedule 1
  Inside,          !- Convection Type 2
  value,          !- Convection Value Type 2
  0.1;            !- Convection value 2 {W/m2-K}
```

```

SurfaceProperty:ConvectionCoefficients,
  SecondLevel:Top,      !- SurfaceName
  Outside,              !- Convection Type 1
  value,                !- Convection Value Type 1
  0.1,                  !- Convection value 1 {W/m2-K}
  ,                     !- Convection Schedule 1
  Inside,               !- Convection Type 2
  value,                !- Convection Value Type 2
  0.1;                  !- Convection value 2 {W/m2-K}

SurfaceProperty:ConvectionCoefficients,
  ThirdLevel:Bottom,   !- SurfaceName
  Outside,              !- Convection Type 1
  value,                !- Convection Value Type 1
  0.1,                  !- Convection value 1 {W/m2-K}
  ,                     !- Convection Schedule 1
  Inside,               !- Convection Type 2
  value,                !- Convection Value Type 2
  0.1;                  !- Convection value 2 {W/m2-K}

```

Material:AirGap

This material is used to describe the air gap in an opaque construction element. Glass elements use a different property (WindowGas) to describe the air between two glass layers.

Field: Name

This field is a unique reference name that the user assigns to a particular material. This name can then be referred to by other input data (ref: Construction).

Field: Thermal Resistance

This field is used to enter the thermal resistance (R-value) of the material layer. Units for this parameter are (m²-K)/W. Thermal resistance must be greater than zero. Note that most R-values in the USA are calculated in Inch-Pound units and must be converted to the SI equivalent.

```

Material:AirGap,
  \min-fields 2
  \memo Air Space in Opaque Construction
  A1 , \field Name
  \required-field
  \type alpha
  \reference MaterialName
  N1 ; \field Thermal Resistance
  \units m2-K/W
  \type real
  \minimum> 0

```

And, an IDF example:

```

Material:AirGap,B1 - AIRSPACE RESISTANCE, ! Material Name
0.1603675 ; ! Resistance {M**2K/W}

```

MaterialProperty:MoisturePenetrationDepth:Settings

This material is used to describe the five moisture material properties that are used in the EMPD (Effective Moisture Penetration Depth) heat balance solution algorithm (known there as MoisturePenetrationDepthConductionTransferFunction). The EMPD algorithm is a simplified, lumped moisture model that simulates moisture storage and release from interior surfaces. The model uses "actual" convective mass transfer coefficients that are determined by existing heat and mass transfer relationships, e.g. the Lewis relation. An effective moisture penetration depth may be determined from either experimental or detailed simulation data by using actual surface areas and moisture sorption isotherms.

This moisture model will be used when the appropriate EMPD moisture materials are specified and the Solution Algorithm parameter is set to EMPD.

Field: Name

This field is a unique reference name that the user assigns to a particular material. This name can then be referred to by other input data (ref: Construction).

Field: Moisture Penetration Depth

This field is used to enter the effective moisture penetration depth of the material layer. Units for this parameter are (m).

Field: Constants to Define Moisture Equilibrium Equation

The next four fields, coefficients “a”, “b”, “c”, and “d”, help define the sorption isotherm curve used for building materials under equilibrium conditions. They are used to define the relationship between the material’s moisture content and the surface air relative humidity (ref: Effective Moisture Penetration Depth (EMPD) Model in the Engineering Reference):

$$U = a\varphi^b + c\varphi^d$$

where

a,b,c,d = Coefficients to define the relationship between the material’s moisture content and the surface air relative humidity

U = Moisture content defined as the mass fraction of [water](#) contained in a material [kg/kg]

φ = Surface air relative humidity [0 to 1]

These four fields are dimensionless coefficients.

Field: Moisture Equation Coefficient a

Field: Moisture Equation Coefficient b

Field: Moisture Equation Coefficient c

Field: Moisture Equation Coefficient d

```
MaterialProperty:MoisturePenetrationDepth:Settings,
  \memo Additional properties for moisture using EMPD procedure
  \memo HeatBalanceAlgorithm choice=MoisturePenetrationDepthConductionTransferFunction
A1 , \field Name
  \required-field
  \type object-list
  \object-list MaterialName
  \note Material Name that the moisture properties will be added to.
  \note Additional material properties required to perform the EMPD model.
  \note Effective Mean Penetration Depth (EMPD)
N1 , \field Moisture Penetration Depth
  \required-field
  \note This is the penetration depth
  \units m
  \minimum 0.0
  \type real
```

```

N2 , \field Moisture Equation Coefficient a
    \required-field
    \units dimensionless
    \type real
N3 , \field Moisture Equation Coefficient b
    \required-field
    \units dimensionless
    \type real
N4 , \field Moisture Equation Coefficient c
    \required-field
    \units dimensionless
    \type real
N5 ; \field Moisture Equation Coefficient d
    \required-field
    \units dimensionless
    \type real

```

And, an IDF example showing how it is used in conjunction with Material in synchronous pairs:

```

Material,
E1 - 3 / 4 IN PLASTER OR GYP BOARD,  !- Name
Smooth,                               !- Roughness
1.9050000E-02,                        !- Thickness {m}
0.7264224,                            !- Conductivity {W/m-K}
1601.846,                             !- Density {kg/m3}
836.8000,                             !- Specific Heat {J/kg-K}
0.9000000,                             !- Thermal Absorptance
0.9200000,                             !- Solar Absorptance
0.9200000;                             !- Visible Absorptance

MaterialProperty:MoisturePenetrationDepth:Settings,
E1 - 3 / 4 IN PLASTER OR GYP BOARD,  !- Name
0.004,                                !- Effective Moisture Penetration Depth {m}
0.072549,                             !- Moisture Equation Coefficient a {dimensionless}
0.397173,                             !- Moisture Equation Coefficient b {dimensionless}
0.007774,                             !- Moisture Equation Coefficient c {dimensionless}
11.7057;                               !- Moisture Equation Coefficient d {dimensionless}

Material,
C10 - 8 IN HW CONCRETE,              !- Name
MediumRough,                          !- Roughness
0.2033016,                             !- Thickness {m}
1.729577,                             !- Conductivity {W/m-K}
2242.585,                             !- Density {kg/m3}
836.8000,                             !- Specific Heat {J/kg-K}
0.9000000,                             !- Thermal Absorptance
0.6500000,                             !- Solar Absorptance
0.6500000;                             !- Visible Absorptance

MaterialProperty:MoisturePenetrationDepth:Settings,
C10 - 8 IN HW CONCRETE,              !- Name
0.004,                                !- Effective Moisture Penetration Depth {m}
0.018062,                             !- Moisture Equation Coefficient a {dimensionless}
0.451879,                             !- Moisture Equation Coefficient b {dimensionless}
0.026178,                             !- Moisture Equation Coefficient c {dimensionless}
10.8356;                               !- Moisture Equation Coefficient d {dimensionless}

```

MaterialProperty:PhaseChange

Advanced/Research Usage: This material is used to describe the temperature dependent material properties that are used in the Conduction Finite Difference solution algorithm. This conduction model is done when the appropriate materials are specified and the Solution Algorithm parameter is set to ConductionFiniteDifference. This permits simulating temperature dependent thermal conductivity and phase change materials (PCM) in EnergyPlus.

Field: Name

This field is a regular material name specifying the material with which this additional temperature dependent property information will be associated.

Field: Temperature Coefficient for Thermal Conductivity

This field is used to enter the temperature dependent coefficient for thermal conductivity of the material. Units for this parameter are $(W/(m \cdot K^2))$. This is the thermal conductivity change per unit temperature excursion from 20 C. The conductivity value at 20 C is the one specified with the basic material properties of the regular material specified in the name field. The thermal conductivity is obtained from:

$$k = k_o + k_1(T_i - 20)$$

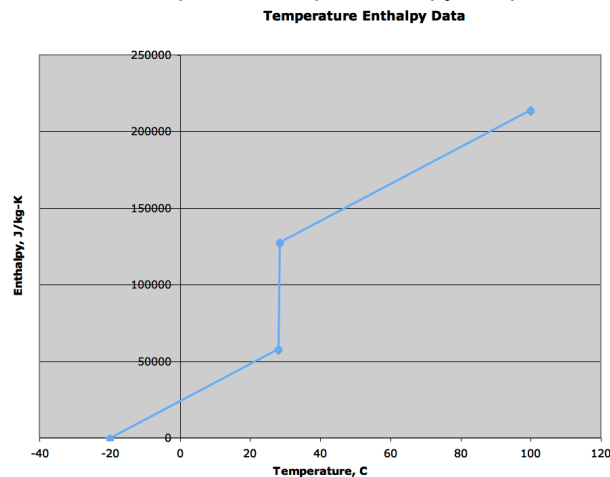
where:

k_o is the 20C value of thermal conductivity(normal idf input)

k_1 is the change in conductivity per degree temperature difference from 20C (this field).

Field Set: Temperature-Enthalpy

The temperature – enthalpy set of inputs specify a two column tabular temperature-enthalpy function for the basic material. Sixteen pairs can be specified. Specify only the number of pairs necessary. The tabular function must cover the entire temperature range that will be seen by the material in the simulation. It is suggested that the function start at a low temperature, and extend to 100C. Note that the function has no negative slopes and the lowest slope that will occur is the base material specific heat. Enthalpy contributions of the phase change are always added to the enthalpy that would result from a constant specific heat base material. An example of a simple enthalpy temperature function is shown below.

**Field: Temperature x**

This field is used to specify the temperature of the temperature-enthalpy function for the basic material. Units are C.

Field: Enthalpy x

This field specifies the enthalpy that corresponds to the previous temperature of the temperature-enthalpy function. Units are J/kg.

The IDD object for these values is shown below.

```

MaterialProperty:PhaseChange,
  \memo Additional properties for temperature dependent thermal conductivity
  \memo and enthalpy for Phase Change Materials (PCM)
A1 , \field Name
  \required-field
  \type object-list
  \object-list MaterialName
  \note Regular Material Name to which the additional properties will be added.
  \note this the material name for the basic material properties.
N1 , \field Temperature Coefficient for Thermal Conductivity
  \note The base temperature is 20C.
  \note This is the thermal conductivity change per degree excursion from 20C.
  \units W/m-K2
  \type real
  \default 0.0
N2 , \field Temperature 1
  \note for Temperature-enthalpy function
  \units C
  \type real
  \default 0.0
N3, \field Enthalpy 1
  \note for Temperature-enthalpy function corresponding to temperature 1
  \units J/kg
  \default 0.0
<reduced for brevity>

```

And, an IDF example showing how it is used in conjunction with the Material:

Note, the following Heat Balance Algorithm is necessary (only specified once). Also, when using ConductionFiniteDifference, it is more efficient to set the zone timestep shorter than those used for the ConductionTransferFunction solution algorithm. It should be set to 12 timesteps per hour or greater, and can range up to 60.

```

HeatBalanceAlgorithm,
ConductionFiniteDifference;

Timestep,
12;

```

```

Material,
E1 - 3 / 4 IN PLASTER OR GYP BOARD,  !- Name
Smooth,                               !- Roughness
1.9050000E-02,                         !- Thickness {m}
0.7264224,                             !- Conductivity {W/m-K}
1601.846,                              !- Density {kg/m3}
836.8000,                              !- Specific Heat {J/kg-K}
0.9000000,                             !- Thermal Absorptance
0.9200000,                             !- Solar Absorptance
0.9200000;                             !- Visible Absorptance

```

```

MaterialProperty:PhaseChange,
E1 - 3 / 4 IN PLASTER OR GYP BOARD,  !- Name
0.0,                                  !- Temperature coefficient,thermal conductivity(W/m K2)
-20.,                                  !- Temperature 1, C
0.01,                                  !- Enthalpy 1 at -20C, (J/kg)
20.,                                   !- Temperature 2, C
33400,                                 !- Enthalpy 2, (J/kg)
20.5,                                  !- temperature 3, C
70000,                                 !- Ethalpy 3, (J/kg)
100.,                                  !- Temperature 4, C
137000;                                !- Enthalpy 4, (J/kg)

```

MaterialProperty:HeatAndMoistureTransfer:Settings

Advanced/Research Usage. This object is used to describe two of the seven additional material properties needed for the CombinedHeatAndMoistureFiniteElement heat balance solution algorithm. The settings object is used when the solutions algorithm is set to CombinedHeatAndMoistureFiniteElement and the appropriate material properties are

assigned to each material. This permits the simulation of the moisture dependant thermal properties of the material as well as the transfer of moisture through, into and out of the material into the zone or exterior.

In addition to the Porosity and Initial Water content properties described here, five additional properties, described by tabulated relationships between variables, are required. These properties are;

- MaterialProperty:HeatAndMoistureTransfer:SorptionIsotherm
- MaterialProperty:HeatAndMoistureTransfer:Suction
- MaterialProperty:HeatAndMoistureTransfer:Redistribution
- MaterialProperty:HeatAndMoistureTransfer:Diffusion
- MaterialProperty:HeatAndMoistureTransfer:ThermalConductivity

All materials in a construction are required to have all material properties defined for HAMT to work.

Within the MaterialProperty:MoisturePenetrationDepth:Settings object the following fields are defined.

Field: Material Name

This field is a unique reference name that the user assigns to a particular material. This name can then be referred to by other input data.

Field: Porosity

The porosity of a material is the maximum fraction, by volume, of a material that can be taken up with water. The units are [m³/m³].

Field: Initial Water Content Ratio

For this solution algorithm, the initial water content is assumed to be distributed evenly through the depth of the material. The units are [kg/kg].

```
MaterialProperty:HeatAndMoistureTransfer:Settings,
  \memo Additional material properties for CombinedHeatAndMoistureFiniteElement algorithm for surfaces.
A1, \field Material Name
  \required-field
  \type object-list
  \object-list MaterialName
  \note Material Name that the moisture properties will be added to.
  \note This augments material properties needed for combined heat and moisture transfer for surfaces.
N1, \field Porosity
  \required-field
  \units m3/m3
  \minimum 0.0
  \maximum 1.0
  \type real
N2; \field Initial Water Content Ratio
  \memo units are the water/material density ratio at the begining of each run period.
  \required-field
  \units kg/kg
  \minimum 0.0
  \default 0.2
  \type real
```

Below is an example input for the porosity and initial water content of a material.

```
MaterialProperty:HeatAndMoistureTransfer:Settings,
  Concrete,      !- Name
  0.76,         !- Porosity
  0.2;         !- Initial (or typical) Water content
```

MaterialProperty:HeatAndMoistureTransfer:SorptionIsotherm

Advanced/Research Usage. This material property is used in conjunction with the CombinedHeatAndMoistureFiniteElement heat balance solution algorithm.

The Isotherm data relates the moisture, or water content [kg/m³] of a material with the relative humidity (RH). The water content is expected to increase as relative humidity increases, starting at zero content at 0%RH and reaching a maximum, defined by the porosity, at 100% relative humidity. These two extremes are automatically set by the HAMT solution. However, if they are entered they will be used as extra data points. Data should be provided with increasing RH and moisture content up to as high an RH as possible to provide a stable solution. One possible reason for the following error message may be that a material has a very rapid increase in water content for a small change in RH, which can happen if the last entered water content point is at a low RH and the material has a very high porosity.

```
** Warning ** HeatAndMoistureTransfer: Large Latent Heat for Surface ROOF
```

Another potential reason for this error being generated is the use of inappropriate values for Vapor Transfer Coefficients. See the SurfaceProperties:VaporCoefficients object in the Advanced Surface Concepts group.

Field: Material Name

This field is a unique reference name that the user assigns to a particular material. This name can then be referred to by other input data.

Field: Number of data Coordinates

A maximum of 25 coordinates can be specified.

Field Set: Relative Humidity-Moisture Content

Field: Relative Humidity x

The relative humidity of the xth coordinate.

Field: Moisture Content x

The Moisture Content of the xth coordinate. The units are [kg/m³]

The following shows the Input Data Dictionary description of the object.

```
MaterialProperty:HeatAndMoistureTransfer:SorptionIsotherm,
  \memo Additional properties for CombinedHeatAndMoistureFiniteElement algorithm for surfaces.
A1 , \field Material Name
  \required-field
  \type object-list
  \object-list MaterialName
  \note The Material Name that the moisture sorption isotherm will be added to.
N1, \field Number of Isotherm Coordinates
  \required-field
  \note Number of data Coordinates
  \minimum 1
  \maximum 25
  \type integer
N2, \field Relative Humidity 1
N3, \field Moisture Content 1
  \units kg/m3
N4, \field Relative Humidity 2
N5, \field Moisture Content 2
  \units kg/m3
N6, \field Relative Humidity 3
N7, \field Moisture Content 3
  \units kg/m3
N8, \field Relative Humidity 4
N9, \field Moisture Content 4
  \units kg/m3
<reduced for brevity>
N50,\field Relative Humidity 25
N51;\field Moisture content 25
  \units kg/m3
```

Below is an example input for a material isotherm

```

MaterialProperty:HeatAndMoistureTransfer:SORPTIONISOOTHERM,
Concrete,      !- Name
10,           !- Number of data Coordinates
0.2205,       !- Relative Humidity #1
22.31,        !- Moisture content #1
0.202,        !- Relative Humidity #2
19.665,       !- Moisture content #2
0.449,        !- Relative Humidity #3
40.02,        !- Moisture content #3
0.454,        !- Relative Humidity #4
36.915,       !- Moisture content #4
0.6506,       !- Relative Humidity #5
56.005,       !- Moisture content #5
0.655,        !- Relative Humidity #6
52.325,       !- Moisture content #6
0.824,        !- Relative Humidity #7
72.565,       !- Moisture content #7
0.8725,       !- Relative Humidity #8
85.1,         !- Moisture content #8
0.924,        !- Relative Humidity #9
91.08,        !- Moisture content #9
0.964,        !- Relative Humidity #10
100.28;       !- Moisture content #10

```

MaterialProperty:HeatAndMoistureTransfer:Suction

Advanced/Research Usage. This material property is used in conjunction with the CombinedHeatAndMoistureFiniteElement heat balance solution algorithm.

The suction data relates the liquid transport coefficient, under suction, to the water content of a material. A data point at zero water content is required. The liquid transport coefficient at the highest entered water content value is used for all liquid transport coefficient values above this water content. These coefficients are used by HAMT when the rain flag is set in the weather file.

Field: Material Name

This field is a unique reference name that the user assigns to a particular material. This name can then be referred to by other input data.

Field: Number of Suction points

A maximum of 25 points can be specified.

Field Set: Moisture Content-Liquid Transport Coefficient

Field: Moisture Content x

The moisture content of the x^{th} point. The units are [kg/m³].

Field: Liquid Transport Coefficient x

The Liquid Transport Coefficient of the x^{th} point. The units are [m²/s].

The following shows the Input Data Dictionary description of the HAMT-SUCTION input.

```

MaterialProperty:HeatAndMoistureTransfer:Suction,
  \memo Additional properties for CombinedHeatAndMoistureFiniteElement algorithm for surfaces.
  \memo Relationship between liquid suction transport coefficient and moisture content
A1 , \field Material Name
  \required-field
  \type object-list
  \object-list MaterialName
  \note Material Name that the moisture properties will be added to.
N1, \field Number of Suction points
  \required-field
  \note Number of Suction Liquid Transport Coefficient coordinates
  \minimum 1
  \maximum 25
  \type integer
N2,\field Moisture Content 1
  \units kg/m3
N3,\field Liquid Transport Coefficient 1
  \units m2/s
N4,\field Moisture Content 2
  \units kg/m3
N5,\field Liquid Transport Coefficient 2
  \units m2/s
N6,\field Moisture Content 3
  \units kg/m3
N7,\field Liquid Transport Coefficient 3
  \units m2/s
N8,\field Moisture Content 4
  \units kg/m3
N9,\field Liquid Transport Coefficient 4
  \units m2/s
<reduced for brevity>
N50,\field Moisture content 25
  \units kg/m3
N51;\field Liquid Transport Coefficient 25
  \units m2/s

```

Below is an example input for a material liquid transport coefficient under suction.

```

MaterialProperty:HeatAndMoistureTransfer:Suction,
Concrete,      !- Name
5,            !- Number of Suction points
0,           !- Moisture content 1
0,           !- Liquid Transport Coefficient 1
72,          !- Moisture content 2
0.000000000741, !- Liquid Transport Coefficient 2
85,          !- Moisture content 3
0.000000000253, !- Liquid Transport Coefficient 3
100,         !- Moisture content 4
0.00000000101, !- Liquid Transport Coefficient 4
118,         !- Moisture content 5
0.00000000128; !- Liquid Transport Coefficient 5

```

MaterialProperty:HeatAndMoistureTransfer:Redistribution

Advanced/Research Usage. This material property is used in conjunction with the CombinedHeatAndMoistureFiniteElement heat balance solution algorithm.

The redistribution data relates the liquid transport coefficient to the water content of a material under normal conditions. A data point at zero water content is required. The liquid transport coefficient at the highest entered water content value is used for all liquid transport coefficient values above this water content. These coefficients are used by the Heat and Moisture Transfer algorithm when the rain flag is NOT set in the weather file.

Field: Material Name

This field is a unique reference name that the user assigns to a particular material. This name can then be referred to by other input data.

Field: Number of Redistribution points

A maximum of 25 points can be specified.

Field Set: Moisture Content-- Liquid Transport Coefficient**Field: Moisture Content x**

The moisture content of the x^{th} point. The units are [kg/m3].

Field: Liquid Transport Coefficient x

The Liquid Transport Coefficient of the x^{th} point. The units are [m2/s].

The following shows the Input Data Dictionary description of the HAMT-REDISTRIBUTION input.

```
MaterialProperty:HeatAndMoistureTransfer:Redistribution,
  \memo Additional properties for CombinedHeatAndMoistureFiniteElement algorithm for surfaces.
  \memo Relationship between liquid transport coefficient and moisture content
A1 , \field Material Name
    \required-field
    \type object-list
    \object-list MaterialName
    \note Moisture Material Name that the moisture properties will be added to.
N1, \field Number of Redistribution points
    \required-field
    \note number of data points
    \minimum 1
    \maximum 25
    \type integer
N2,\field Moisture Content 1
    \units kg/m3
N3,\field Liquid Transport Coefficient 1
    \units m2/s
N4,\field Moisture Content 2
    \units kg/m3
N5,\field Liquid Transport Coefficient 2
    \units m2/s
N6,\field Moisture Content 3
    \units kg/m3
N7,\field Liquid Transport Coefficient 3
    \units m2/s
N8,\field Moisture Content 4
    \units kg/m3
N9,\field Liquid Transport Coefficient 4
    \units m2/s
<reduced for brevity>
N50,\field Moisture content 25
    \units kg/m3
N51;\field Liquid Transport Coefficient 25
    \units m2/s
```

Below is an example input for the object.

```

MaterialProperty:HeatAndMoistureTransfer:Redistribution,
Concrete,      !- Name
5,            !- Number of Redistribution points
0,            !- Moisture content 1
0,            !- Liquid Transport Coefficient 1
72,          !- Moisture content 2
0.0000000000741, !- Liquid Transport Coefficient 2
85,          !- Moisture content 3
0.0000000000253, !- Liquid Transport Coefficient 3
100,         !- Moisture content 4
0.000000000101, !- Liquid Transport Coefficient 4
118,         !- Moisture content 5
0.000000000128; !- Liquid Transport Coefficient 5

```

MaterialProperty:HeatAndMoistureTransfer:Diffusion

Advanced/Research Usage. This material property is used in conjunction with the CombinedHeatAndMoistureFiniteElement heat balance solution algorithm.

The MU data relates the vapor diffusion resistance factor to the relative humidity (RH). A data point at zero RH is required. The vapor diffusion resistance factor at the highest entered RH value is used for all vapor diffusion resistance factor values above this RH.

Field: Material Name

This field is a unique reference name that the user assigns to a particular material. This name can then be referred to by other input data.

Field: Number of Data Pairs

A maximum of 25 pairs can be specified.

Field Set: Relative Humidity-Vapor Diffusion Resistance Factor

Field: Relative Humidity #x

The moisture content of the xth pair.

Field: Vapor Diffusion Resistance Factor #x

The Liquid Transport Coefficient of the xth pair.

The following shows the Input Data Dictionary description of the object.

```

MaterialProperty:HeatAndMoistureTransfer:Diffusion,
  \memo Additional properties for CombinedHeatAndMoistureFiniteElement algorithm for surfaces.
  \memo Relationship between water vapor diffusion and relative humidity
A1 , \field Material Name
  \required-field
  \type object-list
  \object-list MaterialName
  \note Moisture Material Name that the moisture properties will be added to.
N1, \field Number of Data Pairs
  \required-field
  \note Water Vapor Diffusion Resistance Factor
  \minimum 0
  \maximum 25
  \type integer
N2, \field Relative Humidity 1
N3, \field Water Vapor Diffusion Resistance Factor 1
N4, \field Relative Humidity 2
N5, \field Water Vapor Diffusion Resistance Factor 2
N6, \field Relative Humidity 3
N7, \field Water Vapor Diffusion Resistance Factor 3
N8, \field Relative Humidity 4
N9, \field Water Vapor Diffusion Resistance Factor 4
<reduced for brevity>
N50, \field Relative Humidity 25
N51, \field Water Vapor Diffusion Resistance Factor 25

```

Below are some examples of the values for materials.

```

MaterialProperty:HeatAndMoistureTransfer:Diffusion,
  Plywood,      !- Name
  3,            !- Number of data Points
  0,            !- Relative Humidity 1
  700,         !- Water Vapor Diffusion Resistance Factor 1
  0.5,         !- Relative Humidity 2
  200,         !- Water Vapor Diffusion Resistance Factor 2
  1,           !- Relative Humidity 3
  20;          !- Water Vapor Diffusion Resistance Factor 3
MaterialProperty:HeatAndMoistureTransfer:Diffusion,
  Concrete,     !- Name
  1,           !- Number of Mu Points
  0,           !- Relative Humidity 1
  180;        !- Water Vapor Diffusion Resistance Factor 1

```

MaterialProperty:HeatAndMoistureTransfer:ThermalConductivity

Advanced/Research Usage. This material property is used in conjunction with the CombinedHeatAndMoistureFiniteElement heat balance solution algorithm.

The thermal data relates the thermal conductivity [W/m-K] of a material to the moisture or water content [kg/m3]. A data point at zero water content is required. The thermal conductivity at the highest entered water content value is used for all thermal conductivity values above this water content. If this object is not defined for a material then the algorithm will use a constant value entered in the Material object for all water contents.

Field: Material Name

This field is a unique reference name that the user assigns to a particular material. This name can then be referred to by other input data.

Field: Number of Thermal Coordinates

A maximum of 25 coordinates can be specified.

Field Set: Moisture Content- Thermal Conductivity

Field: Moisture Content x

The moisture content of the x^{th} coordinate. The units are [kg/m3]

Field: Thermal Conductivity x

The Thermal Conductivity of the x^{th} coordinate. The units are [W/m-K]

The following shows the Input Data Dictionary description of the HAMT-THERMAL input.

```

MaterialProperty:HeatAndMoistureTransfer:ThermalConductivity,
  \memo Additional properties for CombinedHeatAndMoistureFiniteElement algorithm for surfaces.
  \memo Relationship between thermal conductivity and moisture content
  A1 , \field Material Name
      \required-field
      \type object-list
      \object-list MaterialName
      \note Moisture Material Name that the Thermal Conductivity will be added to.
  N1, \field Number of Thermal Coordinates
      \required-field
      \note number of data coordinates
      \minimum 0
      \maximum 25
      \type integer

```

```

N2, \field Moisture Content 1
    \units kg/m3
N3, \field Thermal Conductivity 1
    \units W/m-K
N4, \field Moisture Content 2
    \units kg/m3
N5, \field Thermal Conductivity 2
    \units W/m-K
N6, \field Moisture Content 3
    \units kg/m3
N7, \field Thermal Conductivity 3
    \units W/m-K
N8, \field Moisture Content 4
    \units kg/m3
N9, \field Thermal Conductivity 4
    \units W/m-K
<reduced for brevity>
N50, \field Moisture content 25
    \units kg/m3
N51; \field Thermal Conductivity 25
    \units W/m-K

```

Below is an example of values for a material.

```

MaterialProperty:HeatAndMoistureTransfer:ThermalConductivity
Concrete,      !- Name
2,            !- Number of Thermal Coordinates
0,           !- Moisture content #1
1.6,         !- Thermal Conductivity #1
180,         !- Moisture content #2
2.602;       !- Thermal Conductivity #2

```

Materials for Glass Windows and Doors

All the materials for glass windows and doors have the prefix “WindowMaterial”. The following WindowMaterial descriptions (Glazing, Glazing:RefractionExtinctionMethod, Gas, GasMixture, Shade, Screen and Blind) apply to glass windows and doors. The property definitions described herein for Glazing, Gas and GasMixture are supported by the National Fenestration Rating Council as standard.

“Front side” is the side of the layer opposite the zone in which the window is defined. “Back side” is the side closest to the zone in which the window is defined. Therefore, for exterior windows, “front side” is the side closest to the outdoors. For interior windows, “front side” is the side closest to the zone adjacent to the zone in which the window is defined.

The solar radiation transmitted by the window layers enters the zone and is a component of the zone load. The solar radiation absorbed in each solid layer (glass, shade, screen or blind) participates in the window layer heat balance calculation. The visible transmittance and reflectance properties of the window are used in the daylighting calculation.

WindowMaterial:Glazing

In the following, for exterior windows, “front side” is the side of the glass closest to the outside air and “back side” is the side closest to the zone the window is defined in. For interzone windows, “front side” is the side closest to the zone adjacent to the zone the window is defined in and “back side” is the side closest to the zone the window is defined in.

Field: Name

The name of the glass layer. It corresponds to a layer in a window construction.

Field: Optical Data Type

If Optical Data Type = SpectralAverage, the values you enter for solar transmittance and reflectance are assumed to be averaged over the solar spectrum, and the values you enter for visible transmittance and reflectance are assumed to be averaged over the solar spectrum and weighted by the response of the human eye. There is an EnergyPlus Reference Data

Set for WindowMaterial:Glazing that contains spectral average properties for many different types of glass.

If Optical Data Type = Spectral, then, in the following field, you must enter the name of a spectral data set defined with the WindowGlassSpectralData object. In this case, the values of solar and visible transmittance and reflectance in the fields below should be blank.

Field: Window Glass Spectral Data Set Name

If Optical Data Type = Spectral, this is the name of a spectral data set defined with a WindowGlassSpectralData object.

Field: Thickness

The surface-to-surface thickness of the glass (m).

Field: Solar Transmittance at Normal Incidence

Transmittance at normal incidence averaged over the solar spectrum. Used only when Optical Data Type = SpectralAverage.

For uncoated glass, when alternative optical properties are available—such as thickness, solar index of refraction, and solar extinction coefficient—they can be converted to equivalent solar transmittance and reflectance values using the equations given in “Conversion from Alternative Specification of Glass Optical Properties.”)

Field: Front Side Solar Reflectance at Normal Incidence

Front-side reflectance at normal incidence averaged over the solar spectrum. Used only when Optical Data Type = SpectralAverage.

Field: Back Side Solar Reflectance at Normal Incidence

Back-side reflectance at normal incidence averaged over the solar spectrum. Used only when Optical Data Type = SpectralAverage.

Field: Visible Transmittance at Normal Incidence

Transmittance at normal incidence averaged over the solar spectrum and weighted by the response of the human eye. Used only when Optical Data Type = SpectralAverage.

For uncoated glass, when alternative optical properties are available—such as thickness, visible index of refraction, and visible extinction coefficient—they can be converted to equivalent visible transmittance and reflectance values using the equations given in “Conversion from Alternative Specification of Glass Optical Properties.”)

Field: Front Side Visible Reflectance at Normal Incidence

Front-side reflectance at normal incidence averaged over the solar spectrum and weighted by the response of the human eye. Used only when Optical Data Type = SpectralAverage.

Field: Back Side Visible Reflectance at Normal Incidence

Back-side reflectance at normal incidence averaged over the solar spectrum and weighted by the response of the human eye. Used only when Optical Data Type = SpectralAverage.

Field: Infrared Transmittance at Normal Incidence

Long-wave transmittance at normal incidence.

Field: Front Side Infrared Hemispherical Emissivity

Front-side long-wave emissivity.

Field: Back Side Infrared Hemispherical Emissivity

Back-side long-wave emissivity.

Field: Conductivity

Thermal conductivity (W/m-K).

Field: Dirt Correction Factor for Solar and Visible Transmittance

This is a factor that corrects for the presence of dirt on the glass. The program multiplies the fields “Solar Transmittance at Normal Incidence” and “Visible Transmittance at Normal Incidence” by this factor if the material is used as the outer glass layer of an exterior window or glass door.² If the material is used as an inner glass layer (in double glazing, for example), the dirt correction factor is not applied because inner glass layers are assumed to be clean. Using a material with dirt correction factor < 1.0 in the construction for an interior window will result in an error message.

Representative values of the dirt correction factor are shown in Table 6.

Table 6. Dirt Correction Factors

Type of Location	Angle of Glazing		
	Vertical	45 ^o	Horizontal
Non-industrial	0.9	0.8	0.7
Industrial	0.7	0.6	0.5
Very Dirty	0.6	0.5	0.4

From Appendix A, “Daylighting in Sports Halls, Report 2,” SportScotland, Nov. 2002
(www.sportscotland.org.uk)

The default value of the dirt correction factor is 1.0, which means the glass is clean.

It is assumed that dirt, if present, has no effect on the IR properties of the glass.

Field: Solar Diffusing

Takes values No (the default) and Yes. If No, the glass is transparent and beam solar radiation incident on the glass is transmitted as beam radiation with no diffuse component. If Yes, the glass is translucent and beam solar radiation incident on the glass is transmitted as hemispherically diffuse radiation with no beam component.³ See Figure 8. Solar Diffusing = Yes should only be used on the *innermost* pane of glass in an exterior window; it does not apply to interior windows.

For both Solar Diffusing = No and Yes, beam is reflected as beam with no diffuse component (see Figure 8)

If, in the Building object, Solar Distribution = FullInteriorAndExterior, use of Solar Diffusing = Yes for glass in an exterior window will change the distribution of interior solar radiation from the window. The result is that beam solar radiation that would be transmitted by a transparent window and get absorbed by particular interior surfaces will be diffused by a translucent window and be spread over more interior surfaces. This can change the time dependence of heating and cooling loads in the zone.

In a zone with Daylighting:Detailed, translucent glazing---which is often used in skylights---will provide a more uniform daylight illuminance over the zone and will avoid patches of sunlight on the floor.

² If Optical Data Type = Spectral, the program multiplies the solar and visible transmittance *at each wavelength* by the dirt correction factor.

³ EnergyPlus does not model the “partially translucent” case in which beam solar radiation incident on the glass is transmitted as a combination of beam and diffuse.

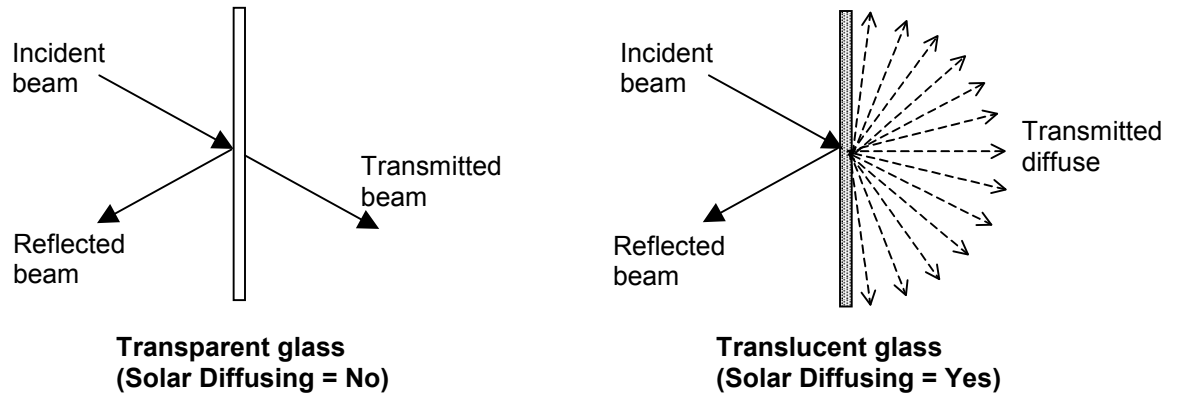


Figure 8. Comparison between transmittance properties of transparent glass (Solar Diffusing = No) and translucent glass (Solar Diffusing = Yes).

```

WindowMaterial:Glazing,
  \min-fields 14
  \memo Glass material properties for Windows or Glass Doors
  \memo Transmittance/Reflectance input method.
A1 , \field Name
  \required-field
  \type alpha
  \reference MaterialName
  \reference GlazingMaterialName
A2 , \field Optical Data Type
  \required-field
  \type choice
  \key SpectralAverage
  \key Spectral
A3 , \field Window Glass Spectral Data Set Name
  \note Used only when Optical Data Type = Spectral
N1 , \field Thickness
  \required-field
  \units m
  \type real
  \minimum > 0.0
  \ip-units in
N2 , \field Solar Transmittance at Normal Incidence
  \note Used only when Optical Data Type = SpectralAverage
  \type real
  \minimum 0.0
  \maximum < 1.0
N3 , \field Front Side Solar Reflectance at Normal Incidence
  \note Used only when Optical Data Type = SpectralAverage
  \note Front Side is side closest to outdoor air
  \note minimum must be >0.0 for SpectralAverage
  \type real
  \minimum 0.0
  \maximum < 1.0
N4 , \field Back Side Solar Reflectance at Normal Incidence
  \note Used only when Optical Data Type = SpectralAverage
  \note Back Side is side closest to zone air
  \note minimum must be >0.0 for SpectralAverage
  \type real
  \minimum 0.0
  \maximum < 1.0

```

```

N5 , \field Visible Transmittance at Normal Incidence
     \note Used only when Optical Data Type = SpectralAverage
     \type real
     \minimum 0.0
     \maximum< 1.0
N6 , \field Front Side Visible Reflectance at Normal Incidence
     \note Used only when Optical Data Type = SpectralAverage
     \type real
     \note minimum must be >0.0 for SpectralAverage
     \minimum 0.0
     \maximum< 1.0
N7 , \field Back Side Visible Reflectance at Normal Incidence
     \note Used only when Optical Data Type = SpectralAverage
     \note minimum must be >0.0 for SpectralAverage
     \type real
     \minimum 0.0
     \maximum< 1.0
N8 , \field Infrared Transmittance at Normal Incidence
     \type real
     \minimum 0.0
     \maximum< 1.0
     \default 0.0
N9 , \field Front Side Infrared Hemispherical Emissivity
     \type real
     \minimum> 0.0
     \maximum< 1.0
     \default 0.84
N10, \field Back Side Infrared Hemispherical Emissivity
     \type real
     \minimum> 0.0
     \maximum< 1.0
     \default 0.84
N11, \field Conductivity
     \units W/m-K
     \type real
     \minimum> 0.0
     \default 0.9
N12, \field Dirt Correction Factor for Solar and Visible Transmittance
     \type real
     \minimum> 0.0
     \maximum 1.0
     \default 1.0
A4;  \field Solar Diffusing
     \type choice
     \key No
     \key Yes
     \default No

```

IDF examples of Spectral average and using a Spectral data set:

```

MATERIAL:WINDOWGLASS, GLASS - CLEAR SHEET 1 / 8 IN,
SpectralAverage, ! Optical data type
0.003, ! Thickness {m} 1/8"
0.850, ! Solar transmittance at normal incidence
0.075, ! Solar reflectance at normal incidence: front side
0.075, ! Solar reflectance at normal incidence: back side
0.901, ! Visible transmittance at normal incidence
0.081, ! Visible reflectance at normal incidence: front side
0.081, ! Visible reflectance at normal incidence: back side
0.0,   ! IR transmittance at normal incidence
0.84,  ! IR hemispherical emissivity: front side
0.84,  ! IR hemispherical emissivity: back side
0.9;   ! Conductivity {W/m-K}

```

```

WindowMaterial:Glazing ,SPECTRAL GLASS INNER PANE, ! Material name
Spectral, ! Optical data type {SpectralAverage or Spectral}
TestSpectralDataSet, ! Name of spectral data set when Optical Data Type = Spectral
0.0099, ! Thickness {m}
, ! Solar transmittance at normal incidence
, ! Solar reflectance at normal incidence: front side
, ! Solar reflectance at normal incidence: back side
, ! Visible transmittance at normal incidence
, ! Visible reflectance at normal incidence: front side
, ! Visible reflectance at normal incidence: back side
0.0, ! IR transmittance at normal incidence
0.84, ! IR emissivity: front side
0.84, ! IR emissivity: back side
0.798; ! Conductivity {W/m-K}

```

WindowMaterial:Glazing:RefractionExtinctionMethod

This is an alternative way of specifying glass properties. [Index of refraction](#) and [extinction coefficient](#) are given instead of the transmittance and reflectance values used in WindowMaterial:Glazing. However, unlike WindowMaterial:Glazing, WindowMaterial:Glazing:RefractionExtinctionMethod is restricted to cases where the front and back optical properties of the glass are the same. This means it cannot be used for glass with a coating on one side. In that case WindowMaterial:Glazing should be used. Also, unlike WindowMaterial:Glazing, WindowMaterial:Glazing:RefractionExtinctionMethod does not allow input of glass wavelength-by-wavelength (spectral) properties.

Field: Name

The name of the glass layer. It corresponds to a layer in a window construction.

Field: Thickness

The surface-to-surface thickness of the glass (m).

Field: Solar Index of Refraction

Index of refraction averaged over the solar spectrum.

Field: Solar Extinction Coefficient

Extinction coefficient averaged over the solar spectrum (m^{-1}).

Field: Visible Index of Refraction

Index of refraction averaged over the solar spectrum and weighted by the response of the human eye.

Field: Visible Extinction Coefficient

Extinction coefficient averaged over the solar spectrum and weighted by the response of the human eye (m^{-1}).

Field: Infrared Transmittance at Normal Incidence

Long-wave transmittance at normal incidence.

Field: Infrared Hemispherical Emissivity

Long-wave hemispherical emissivity, assumed the same on both sides of the glass.

Field: Conductivity

Thermal conductivity (W/m-K).

Field: Dirt Correction Factor for Solar and Visible Transmittance

This is a factor that corrects for the presence of dirt on the glass. It multiplies the solar and visible transmittance at normal Incidence (which the program calculates from the input values

of thickness, solar index of refraction, solar extinction coefficient, etc.) if the material is used as the outer glass layer of an exterior window or glass door. If the material is used as an inner glass layer (in double glazing, for example), the dirt correction factor is not applied because inner glass layers are assumed to be clean. Using a material with dirt correction factor < 1.0 in the construction for an interior window will result in an error message.

Representative values of the direct correction factor are shown in Table 6.

The default value of the dirt correction factor is 1.0, which means the glass is clean. It is assumed that dirt, if present, has no effect on the IR properties of the glass.

Field: Solar Diffusing

Takes values No (the default) and Yes. If No, the glass is transparent. If Yes, the glass is translucent and beam solar radiation incident on the glass is transmitted as hemispherically diffuse radiation with no beam component. Solar Diffusing = Yes should only be used on the innermost pane of glass in an exterior window; it does not apply to interior windows.

If, in the Building object, Solar Distribution = FullInteriorAndExterior, use of Solar Diffusing = Yes for glass in an exterior window will change the distribution of interior solar radiation from the window. The result is that beam solar radiation that would be transmitted by a transparent window and get absorbed by particular interior surfaces will be diffused by a translucent window and be spread over more interior surfaces. This can change the time dependence of heating and cooling loads in the zone.

In a zone with Daylighting:Detailed, translucent glazing, which is often used in skylights, will provide a more uniform daylight illuminance over the zone and will avoid patches of sunlight on the floor.

```
WindowMaterial:Glazing:RefractionExtinctionMethod,
  \memo Glass material properties for Windows or Glass Doors
  \memo Index of Refraction/Extinction Coefficient input method
  \memo Not to be used for coated glass
A1 , \field Name
    \required-field
    \type alpha
    \reference MaterialName
    \reference GlazingMaterialName
N1 , \field Thickness
    \required-field
    \units m
    \type real
    \minimum> 0.0
    \ip-units in
N2 , \field Solar Index of Refraction
    \required-field
    \type real
    \minimum> 1.0
N3 , \field Solar Extinction Coefficient
    \required-field
    \units 1/m
    \type real
    \minimum> 0.0
N4 , \field Visible Index of Refraction
    \required-field
    \type real
    \minimum> 1.0
```

```

N5 , \field Visible Extinction Coefficient
    \required-field
    \units 1/m
    \type real
    \minimum> 0.0
N6 , \field Infrared Transmittance at Normal Incidence
    \type real
    \maximum< 1.0
    \minimum 0.0
    \default 0.0
N7 , \field Infrared Hemispherical Emissivity
    \note Emissivity of front and back side assumed equal
    \type real
    \maximum< 1.0
    \minimum> 0.0
    \default 0.84
N8 , \field Conductivity
    \units W/m-K
    \type real
    \minimum> 0.0
    \default 0.9
N9 , \field Dirt Correction Factor for Solar and Visible Transmittance
    \type real
    \minimum> 0.0
    \maximum 1.0
    \default 1.0
A2 ; \field Solar Diffusing
    \type choice
    \key No
    \key Yes
    \default No

```

An IDF example:

```

WindowMaterial:Glazing:RefractionExtinctionMethod,4MM CLEAR GLASS, ! Material name
0.004, ! Thickness {m}
1.526, ! Solar index of refraction
30.0 , ! Solar extinction coefficient (1/m)
1.526, ! Visible index of refraction
30.0 , ! Visible extinction coefficient (1/m)
0.0, ! IR transmittance at normal incidence
0.84, ! IR emissivity
0.9; ! Conductivity {W/m-K}

```

Glass Optical Properties Conversion

Conversion from Glass Optical Properties Specified as Index of Refraction and Transmittance at Normal Incidence

The optical properties of uncoated glass are sometimes specified by index of refraction, n , and transmittance at normal incidence, T .

The following equations show how to convert from this set of values to the transmittance and reflectance values required by WindowMaterial:Glazing. These equations apply only to uncoated glass, and can be used to convert either spectral-average solar properties or spectral-average visible properties (in general, n and T are different for the solar and visible). Note that since the glass is uncoated, the front and back reflectances are the same and equal to the R that is solved for in the following equations.

Given n and T , find R :

$$r = \left(\frac{n-1}{n+1} \right)^2$$

$$\tau = \frac{\left[(1-r)^4 + 4r^2 T^2 \right]^{1/2} - (1-r)^2}{2r^2 T}$$

$$R = r + \frac{(1-r)^2 r \tau^2}{1-r^2 \tau^2}$$

Example:

$$T = 0.86156$$

$$n = 1.526$$

$$r = \left(\frac{1.526-1}{1.526+1} \right)^2$$

$$\tau = 0.93974$$

$$R = 0.07846$$

WindowMaterial:GlazingGroup:Thermochromic

Thermochromic (TC) materials have active, reversible optical properties that vary with temperature. Thermochromic windows are adaptive window systems for incorporation into building envelopes. Thermochromic windows respond by absorbing sunlight and turning the sunlight energy into heat. As the thermochromic film warms it changes its light transmission level from less absorbing to more absorbing. The more sunlight it absorbs the lower the light level going through it. By using the sun's own energy the window adapts based solely on the directness and amount of sunlight. Thermochromic materials will normally reduce optical transparency by absorption and/or reflection, and are specular (maintaining vision).

A thermochromic window is defined with a Construction object which references a special layer defined with a WindowMaterial:GlazingGroup:Thermochromic object. The WindowMaterial:GlazingGroup:Thermochromic object further references a series of WindowMaterial:Glazing objects corresponding to each specification temperature of the TC layer.

This object specifies a layer of thermochromic glass, part of a thermochromic window. An example file ThermochromicWindow.idf is included in the EnergyPlus installation.

Field: Name

A unique user assigned name for a particular thermochromic glass material.

Field Set (Optical Data Temperature, Window Material Glazing Name) is extensible.

Field: Optical Data Temperature <N>

The temperature of the TC glass layer corresponding to the optical data of the TC layer. Unit is °C.

Field: Window Material Glazing Name <N>

The window glazing (defined with WindowMaterial:Glazing) name that provides the TC glass layer performance at the above specified temperature.

The IDD definition for the object follows:

```

WindowMaterial:GlazingGroup:Thermochromic,
  \min-fields 3
  \extensible:2 - repeat last two fields remembering to remove ; from "inner" fields.
  \memo thermochromic glass at different temperatures
A1 , \field Name
  \required-field
  \type alpha
N1 , \field Optical Data Temperature 1
  \required-field
  \units C
  \ip-units F
  \type real
A2 , \field Window Material Glazing Name 1
  \required-field
  \type object-list
  \object-list GlazingMaterialName
N2 , \field Optical Data Temperature 2
  \units C
  \ip-units F
  \type real
A3 ; \field Window Material Glazing Name 2
  \type object-list
  \object-list GlazingMaterialName

```

IDF Examples

```

Construction,
  window_const,          !- Name
  Usual Glass,           !- Layer 1
  AIR 6MM,               !- Layer 2
  TCGlazings,           !- Layer 3
  AIR 6MM,               !- Layer 4
  Usual Glass;          !- Layer 5

```

```

WindowMaterial:Gas,
  AIR 6MM,               !- Name
  Air,                   !- Gas Type
  0.0063;                !- Thickness {m}

```

```

! Added for thermochromic glazings
WindowMaterial:GlazingGroup:Thermochromic,
  TCGlazings,
  0 , TCGlazing0,
  20, TCGlazing20,
  25, TCGlazing25,
  30, TCGlazing30,
  35, TCGlazing35,
  40, TCGlazing40,
  45, TCGlazing45,
  50, TCGlazing50,
  55, TCGlazing55,
  60, TCGlazing60,
  65, TCGlazing65,
  75, TCGlazing75,
  85, TCGlazing85;

```



```

WindowMaterial:Glazing,
TCGlazing0,  !- Name
SpectralAverage,  !- Optical Data Type
,            !- Window Glass Spectral Data Set Name
0.0030,    !- Thickness
0.2442,    !- Solar Transmittance at Normal Incidence
0.7058,    !- Front Side Solar Reflectance at Normal Incidence
0.7058,    !- Back Side Solar Reflectance at Normal Incidence
0.3192,    !- Visible Transmittance at Normal Incidence
0.6308,    !- Front Side Visible Reflectance at Normal Incidence
0.6308,    !- Back Side Visible Reflectance at Normal Incidence
0.0000,    !- Infrared Transmittance at Normal Incidence
0.9000,    !- Front Side Infrared Hemispherical Emissivity
0.9000,    !- Back Side Infrared Hemispherical Emissivity
0.0199,    !- Conductivity
1.0000,    !- Dirt Correction Factor for Solar and Visible Transmittance
No;        !- Solar Diffusing

```

```

WindowMaterial:Glazing,
TCGlazing20,  !- Name
SpectralAverage,  !- Optical Data Type
,            !- Window Glass Spectral Data Set Name
0.0030,    !- Thickness
0.2442,    !- Solar Transmittance at Normal Incidence
0.7058,    !- Front Side Solar Reflectance at Normal Incidence
0.7058,    !- Back Side Solar Reflectance at Normal Incidence
0.3192,    !- Visible Transmittance at Normal Incidence
0.6308,    !- Front Side Visible Reflectance at Normal Incidence
0.6308,    !- Back Side Visible Reflectance at Normal Incidence
0.0000,    !- Infrared Transmittance at Normal Incidence
0.9000,    !- Front Side Infrared Hemispherical Emissivity
0.9000,    !- Back Side Infrared Hemispherical Emissivity
0.0199,    !- Conductivity
1.0000,    !- Dirt Correction Factor for Solar and Visible Transmittance
No;        !- Solar Diffusing

```

```

WindowMaterial:Glazing,
TCGlazing25,  !- Name
SpectralAverage,  !- Optical Data Type
,            !- Window Glass Spectral Data Set Name
0.0030,    !- Thickness
0.2442,    !- Solar Transmittance at Normal Incidence
0.7058,    !- Front Side Solar Reflectance at Normal Incidence
0.7058,    !- Back Side Solar Reflectance at Normal Incidence
0.3192,    !- Visible Transmittance at Normal Incidence
0.6308,    !- Front Side Visible Reflectance at Normal Incidence
0.6308,    !- Back Side Visible Reflectance at Normal Incidence
0.0000,    !- Infrared Transmittance at Normal Incidence
0.9000,    !- Front Side Infrared Hemispherical Emissivity
0.9000,    !- Back Side Infrared Hemispherical Emissivity
0.0199,    !- Conductivity
1.0000,    !- Dirt Correction Factor for Solar and Visible Transmittance
No;        !- Solar Diffusing

```

```

WindowMaterial:Glazing,
TCGlazing30,  !- Name
SpectralAverage,  !- Optical Data Type
,            !- Window Glass Spectral Data Set Name
0.0030,    !- Thickness
0.2442,    !- Solar Transmittance at Normal Incidence
0.7058,    !- Front Side Solar Reflectance at Normal Incidence
0.7058,    !- Back Side Solar Reflectance at Normal Incidence
0.3192,    !- Visible Transmittance at Normal Incidence
0.6308,    !- Front Side Visible Reflectance at Normal Incidence
0.6308,    !- Back Side Visible Reflectance at Normal Incidence
0.0000,    !- Infrared Transmittance at Normal Incidence
0.9000,    !- Front Side Infrared Hemispherical Emissivity
0.9000,    !- Back Side Infrared Hemispherical Emissivity
0.0199,    !- Conductivity
1.0000,    !- Dirt Correction Factor for Solar and Visible Transmittance
No;        !- Solar Diffusing

```

```

WindowMaterial:Glazing,
TCGlazing35, !- Name
SpectralAverage, !- Optical Data Type
, !- Window Glass Spectral Data Set Name
0.0030, !- Thickness
0.2442, !- Solar Transmittance at Normal Incidence
0.7058, !- Front Side Solar Reflectance at Normal Incidence
0.7058, !- Back Side Solar Reflectance at Normal Incidence
0.3192, !- Visible Transmittance at Normal Incidence
0.6308, !- Front Side Visible Reflectance at Normal Incidence
0.6308, !- Back Side Visible Reflectance at Normal Incidence
0.0000, !- Infrared Transmittance at Normal Incidence
0.9000, !- Front Side Infrared Hemispherical Emissivity
0.9000, !- Back Side Infrared Hemispherical Emissivity
0.0199, !- Conductivity
1.0000, !- Dirt Correction Factor for Solar and Visible Transmittance
No; !- Solar Diffusing

```

```

WindowMaterial:Glazing,
TCGlazing40, !- Name
SpectralAverage, !- Optical Data Type
, !- Window Glass Spectral Data Set Name
0.0030, !- Thickness
0.2442, !- Solar Transmittance at Normal Incidence
0.7058, !- Front Side Solar Reflectance at Normal Incidence
0.7058, !- Back Side Solar Reflectance at Normal Incidence
0.3192, !- Visible Transmittance at Normal Incidence
0.6308, !- Front Side Visible Reflectance at Normal Incidence
0.6308, !- Back Side Visible Reflectance at Normal Incidence
0.0000, !- Infrared Transmittance at Normal Incidence
0.9000, !- Front Side Infrared Hemispherical Emissivity
0.9000, !- Back Side Infrared Hemispherical Emissivity
0.0199, !- Conductivity
1.0000, !- Dirt Correction Factor for Solar and Visible Transmittance
No; !- Solar Diffusing

```

```

WindowMaterial:Glazing,
TCGlazing45, !- Name
SpectralAverage, !- Optical Data Type
, !- Window Glass Spectral Data Set Name
0.0030, !- Thickness
0.2442, !- Solar Transmittance at Normal Incidence
0.7058, !- Front Side Solar Reflectance at Normal Incidence
0.7058, !- Back Side Solar Reflectance at Normal Incidence
0.3192, !- Visible Transmittance at Normal Incidence
0.6308, !- Front Side Visible Reflectance at Normal Incidence
0.6308, !- Back Side Visible Reflectance at Normal Incidence
0.0000, !- Infrared Transmittance at Normal Incidence
0.9000, !- Front Side Infrared Hemispherical Emissivity
0.9000, !- Back Side Infrared Hemispherical Emissivity
0.0199, !- Conductivity
1.0000, !- Dirt Correction Factor for Solar and Visible Transmittance
No; !- Solar Diffusing

```

```

WindowMaterial:Glazing,
TCGlazing50, !- Name
SpectralAverage, !- Optical Data Type
, !- Window Glass Spectral Data Set Name
0.0030, !- Thickness
0.2442, !- Solar Transmittance at Normal Incidence
0.7058, !- Front Side Solar Reflectance at Normal Incidence
0.7058, !- Back Side Solar Reflectance at Normal Incidence
0.3192, !- Visible Transmittance at Normal Incidence
0.6308, !- Front Side Visible Reflectance at Normal Incidence
0.6308, !- Back Side Visible Reflectance at Normal Incidence
0.0000, !- Infrared Transmittance at Normal Incidence
0.9000, !- Front Side Infrared Hemispherical Emissivity
0.9000, !- Back Side Infrared Hemispherical Emissivity
0.0199, !- Conductivity
1.0000, !- Dirt Correction Factor for Solar and Visible Transmittance

```

```
No;      !- Solar Diffusing

WindowMaterial:Glazing,
TCGlazing55, !- Name
SpectralAverage, !- Optical Data Type
,          !- Window Glass Spectral Data Set Name
0.0030,    !- Thickness
0.2442,    !- Solar Transmittance at Normal Incidence
0.7058,    !- Front Side Solar Reflectance at Normal Incidence
0.7058,    !- Back Side Solar Reflectance at Normal Incidence
0.3192,    !- Visible Transmittance at Normal Incidence
0.6308,    !- Front Side Visible Reflectance at Normal Incidence
0.6308,    !- Back Side Visible Reflectance at Normal Incidence
0.0000,    !- Infrared Transmittance at Normal Incidence
0.9000,    !- Front Side Infrared Hemispherical Emissivity
0.9000,    !- Back Side Infrared Hemispherical Emissivity
0.0199,    !- Conductivity
1.0000,    !- Dirt Correction Factor for Solar and Visible Transmittance
No;      !- Solar Diffusing

WindowMaterial:Glazing,
TCGlazing60, !- Name
SpectralAverage, !- Optical Data Type
,          !- Window Glass Spectral Data Set Name
0.0030,    !- Thickness
0.2442,    !- Solar Transmittance at Normal Incidence
0.7058,    !- Front Side Solar Reflectance at Normal Incidence
0.7058,    !- Back Side Solar Reflectance at Normal Incidence
0.3192,    !- Visible Transmittance at Normal Incidence
0.6308,    !- Front Side Visible Reflectance at Normal Incidence
0.6308,    !- Back Side Visible Reflectance at Normal Incidence
0.0000,    !- Infrared Transmittance at Normal Incidence
0.9000,    !- Front Side Infrared Hemispherical Emissivity
0.9000,    !- Back Side Infrared Hemispherical Emissivity
0.0199,    !- Conductivity
1.0000,    !- Dirt Correction Factor for Solar and Visible Transmittance
No;      !- Solar Diffusing

WindowMaterial:Glazing,
TCGlazing65, !- Name
SpectralAverage, !- Optical Data Type
,          !- Window Glass Spectral Data Set Name
0.0030,    !- Thickness
0.2442,    !- Solar Transmittance at Normal Incidence
0.7058,    !- Front Side Solar Reflectance at Normal Incidence
0.7058,    !- Back Side Solar Reflectance at Normal Incidence
0.3192,    !- Visible Transmittance at Normal Incidence
0.6308,    !- Front Side Visible Reflectance at Normal Incidence
0.6308,    !- Back Side Visible Reflectance at Normal Incidence
0.0000,    !- Infrared Transmittance at Normal Incidence
0.9000,    !- Front Side Infrared Hemispherical Emissivity
0.9000,    !- Back Side Infrared Hemispherical Emissivity
0.0199,    !- Conductivity
1.0000,    !- Dirt Correction Factor for Solar and Visible Transmittance
No;      !- Solar Diffusing

WindowMaterial:Glazing,
TCGlazing75, !- Name
SpectralAverage, !- Optical Data Type
,          !- Window Glass Spectral Data Set Name
0.0030,    !- Thickness
0.2442,    !- Solar Transmittance at Normal Incidence
0.7058,    !- Front Side Solar Reflectance at Normal Incidence
0.7058,    !- Back Side Solar Reflectance at Normal Incidence
0.3192,    !- Visible Transmittance at Normal Incidence
0.6308,    !- Front Side Visible Reflectance at Normal Incidence
0.6308,    !- Back Side Visible Reflectance at Normal Incidence
0.0000,    !- Infrared Transmittance at Normal Incidence
0.9000,    !- Front Side Infrared Hemispherical Emissivity
0.9000,    !- Back Side Infrared Hemispherical Emissivity
0.0199,    !- Conductivity
```

```

1.0000,  !- Dirt Correction Factor for Solar and Visible Transmittance
No;      !- Solar Diffusing

WindowMaterial:Glazing,
TCGlazing85,  !- Name
SpectralAverage,  !- Optical Data Type
,           !- Window Glass Spectral Data Set Name
0.0030,  !- Thickness
0.2442,  !- Solar Transmittance at Normal Incidence
0.7058,  !- Front Side Solar Reflectance at Normal Incidence
0.7058,  !- Back Side Solar Reflectance at Normal Incidence
0.3192,  !- Visible Transmittance at Normal Incidence
0.6308,  !- Front Side Visible Reflectance at Normal Incidence
0.6308,  !- Back Side Visible Reflectance at Normal Incidence
0.0000,  !- Infrared Transmittance at Normal Incidence
0.9000,  !- Front Side Infrared Hemispherical Emissivity
0.9000,  !- Back Side Infrared Hemispherical Emissivity
0.0199,  !- Conductivity
1.0000,  !- Dirt Correction Factor for Solar and Visible Transmittance
No;      !- Solar Diffusing

```

Thermochromic Window Outputs

Window Thermochromic Layer Temperature [C]

The temperature of the TC glass layer of a TC window at each time step.

Window Thermochromic Layer Specification Temperature [C]

The temperature under which the optical data of the TC glass layer are specified.

The overall properties (U-factor/SHGC/VT) of the thermochromic windows at different specification temperatures are reported in the EIO file. These window constructions are created by EnergyPlus during run time. They have similar names with suffix “_TC_XX” where XX represents a specification temperature.

WindowMaterial:Gas

This object specifies the properties of the gas between the panes of a multi-pane window. Gas Type = Custom allows you to specify the properties of gases other than air, Argon, Krypton or Xenon. There is an EnergyPlus Reference Data Set for Material:WindowGas that contains several types of gas of different thicknesses. See Material:WindowGasMixture for the case that the gas fill is a mixture of different gases.

Field: Name

The name of the gas fill. It refers to a layer in a window construction.

Field: Gas Type

The type of gas. The choices are Air, Argon, Krypton, or Xenon. If Gas Type = Custom you can use Conductivity Coefficient A, etc. to specify the properties of a different type of gas.

Field: Thickness

The thickness (m) of the gas layer.

Properties for Custom Gas Types

The following entries are used only if Gas Type = Custom. The A and B coefficients are those in the following expression that gives a property value as a function of temperature in degrees K:

$$Property = Coefficient_A + Coefficient_B * Temperature_K$$

Field: Conductivity Coefficient A

The A coefficient for gas conductivity (W/m-K). Used only if Gas Type = Custom.

Field: Conductivity Coefficient B

The B coefficient for gas conductivity (W/m-K²). Used only if Gas Type = Custom.

Field: Viscosity Coefficient A

The A coefficient for gas viscosity (kg/m-s). Used only if Gas Type = Custom.

Field: Viscosity Coefficient B

The B coefficient for gas viscosity (kg/m-s-K). Used only if Gas Type = Custom.

Field: Specific Heat Coefficient A

The A coefficient for gas specific heat (J/kg-K). Used only if Gas Type = Custom.

Field: Specific Heat Coefficient B

The B coefficient for gas specific heat (J/kg-K²). Used only if Gas Type = Custom.

```

WindowMaterial:Gas,
  \memo Gas material properties that are used in Windows or Glass Doors
  \min-fields 3
A1 , \field Name
  \required-field
  \type alpha
  \reference MaterialName
A2 , \field Gas Type
  \required-field
  \type choice
  \key Air
  \key Argon
  \key Krypton
  \key Xenon
  \key Custom
N1 , \field Thickness
  \required-field
  \units m
  \type real
  \minimum> 0.0
  \ip-units in
N2 , \field Conductivity Coefficient A
  \units W/m-K
  \type real
  \note Used only if Gas Type = Custom
N3 , \field Conductivity Coefficient B
  \units W/m-K2
  \type real
  \note Used only if Gas Type = Custom
N4 , \field Viscosity Coefficient A
  \units g/m-s
  \type real
  \note Used only if Gas Type = Custom
  \minimum> 0.0
N5 , \field Viscosity Coefficient B
  \units g/m-s-K
  \type real
  \note Used only if Gas Type = Custom
N6 , \field Specific Heat Coefficient A
  \units J/kg-K
  \type real
  \note Used only if Gas Type = Custom
  \minimum> 0.0
N7 , \field Specific Heat Coefficient B
  \units J/kg-K2
  \type real
  \note Used only if Gas Type = Custom
N8 ; \field Molecular Weight
  \type real
  \note Used only if Gas Type = Custom
  \minimum 20.0
  \maximum 200.0

```

An IDF example:

```

WindowMaterial:Gas,AIRGAP,
AIR,      ! Gas type (Air - Argon - Krypton - Xenon - Custom)]
0.0125;  ! Thickness {m} 1/2 inch

```

WindowMaterial:GasMixture

This object allows you to specify the fill between the panes of a multi-pane window to be a mixture of two, three or four different gases chosen from air, argon, krypton and xenon. It can also be used if only one type of gas in the fill. In this case you can also use WindowMaterial:Gas. Note that the fractions of gas types in the mixture should add up to 1.0.

Field: Name

The name of the gas mixture. It refers to a layer in a window construction.

Field: Thickness

The thickness (m) of the gas mixture layer.

Field: Number of Gases in Mixture

The number of different types of gas in the mixture (a value from 1 to 4)

Set: Gas Type-Fraction (up to 4)**Field: Gas 1 Type**

The type of the first gas in the mixture. Choices are Air, Argon, Krypton and Xenon.

Field: Gas 1 Fraction

The fraction of the first gas in the mixture.

```
WindowMaterial:GasMixture,
  \memo Gas mixtures that are used in Windows or Glass Doors
  \min-fields 7
  A1 , \field Name
      \required-field
      \type alpha
      \reference MaterialName
  N1 , \field Thickness
      \required-field
      \units m
      \type real
      \minimum> 0.0
  N2 , \field Number of Gases in Mixture
      \required-field
      \type integer
      \minimum 1
      \maximum 4
  A2 , \field Gas 1 Type
      \required-field
      \type choice
      \key Air
      \key Argon
      \key Krypton
      \key Xenon
  N3 , \field Gas 1 Fraction
      \required-field
      \type real
      \minimum> 0.0
      \maximum 1.0
<reduced for brevity>
```

An IDF example:

```
WindowMaterial:GasMixture,ArgonKryptonMix,
0.0125, ! Thickness {m} 1/2 inch
2,      ! Number of Gases in Mixture
Argon,  ! Gas 1 Type
0.6,    ! Gas 1 Fraction
Krypton, ! Gas 2 Type
0.4;    ! Gas 2 Fraction
```

WindowMaterial:Shade

This object specifies the properties of window shade materials. Reflectance and emissivity properties are assumed to be the same on both sides of the shade. Shades are considered to be perfect diffusers (all transmitted and reflected radiation is hemispherically-diffuse) with transmittance and reflectance independent of angle of incidence. There is an EnergyPlus Reference Data Set for WindowMaterial:Shade that contains properties of generic window shades.

Window shades can be on the inside of the window (“interior shades”), on the outside of the window (“exterior shades”), or between glass layers (“between-glass shades”). When in place, the shade is assumed to cover all of the glazed part of the window, including dividers; it does not cover any of the window frame, if present. The plane of the shade is assumed to be parallel to the glazing.

Note that when locating a window shade between glass layers, the WindowMaterial:Glazing layers in the window construction must all use an Optical Data Type of SpectralAverage. Spectral data for glazing layers is not currently supported for between glass shades.

WindowMaterial:Shade can be used for diffusing materials such as drapery and translucent roller shades. For slat-type shading devices, like Venetian blinds, that have a strong angular dependence of transmission, absorption and reflection, it is better to use WindowMaterial:Blind. WindowMaterial:Screen should be used to model wire mesh insect screens where the solar and visible transmission and reflection properties vary with the angle of incidence of solar radiation.

Transmittance and reflectance values for drapery material with different color and openness of weave can be obtained from manufacturers or determined from 2001 ASHRAE Fundamentals, Chapter 30, Fig. 31.

There are two methods of assigning a shade to a window:

Method 1:

- 1) Define the construction of the window without the shade, the so-called “bare” construction.
- 2) Reference the bare construction in the FenestrationSurface:Detailed for the window.
- 3) Define the WindowMaterial:Shade.
- 4) Define a WindowProperty:ShadingControl for the window in which you (a) specify that this WindowMaterial:Shade is the window’s shading device and (b) specify how the shade is controlled.

Method 2:

- 1) Define the Construction of the window without the shade, the so-called “bare” construction.
- 2) Reference the bare construction in the FenestrationSurface:Detailed for the window.
- 3) Define the WindowMaterial:Shade.
- 4) Define another Construction, called the “shaded construction,” that includes the WindowMaterial:Shade.
- 5) Define a WindowProperty:ShadingControl for the window in which you (a) reference the shaded construction and (b) specify how the shade is controlled.

Note that WindowProperty:ShadingControl has to be used with either method, even if the shade is in place at all times. You will get an error message if you try to reference a shaded construction directly from FenestrationSurface:Detailed.

Field: Name

Name of the shade. It is referenced as an inside or outside layer in a window construction.

Field: Solar Transmittance

Transmittance averaged over the solar spectrum. Assumed independent of incidence angle.

Field: Solar Reflectance

Reflectance averaged over the solar spectrum. Assumed same on both sides of shade and independent of incidence angle.

Field: Visible Transmittance

Transmittance averaged over the solar spectrum and weighted by the response of the human eye. Assumed independent of incidence angle.

Field: Visible Reflectance

Reflectance averaged over the solar spectrum and weighted by the response of the human eye. Assumed same on both side of shade and independent of incidence angle.

Field: Thermal Hemispherical Emissivity

Effective long-wave emissivity. Assumed same on both sides of shade. We can approximate this effective emissivity, ϵ_{eff} , as follows. Let η be the “openness” the shade, i.e., the ratio of the area of openings in the shade to the overall shade area (see Field: Air-Flow Permeability, below). Let the emissivity of the shade material be ϵ . Then

$$\epsilon_{eff} \approx \epsilon(1 - \eta)$$

For most non-metallic materials ϵ is about 0.9.

Field: Thermal Transmittance

Effective long-wave transmittance. Assumed independent of incidence angle. We can approximate this effective long-wave transmittance, T_{eff} , as follows. Let η be the “openness” the shade, i.e., the ratio of the area of openings in the shade to the overall shade area. Let the long-wave transmittance of the shade material be T . Then

$$T_{eff} \approx \eta + T(1 - \eta)$$

For most materials T is very close to zero, which gives

$$T_{eff} \approx \eta$$

Field: Thickness

Thickness of the shade material (m). If the shade is not flat, such as for pleated pull-down shades or folded drapery, the average thickness normal to the plane of the shade should be used.

Field: Conductivity

Shade material conductivity (W/m-K).

Field: Shade to Glass Distance

Distance from shade to adjacent glass (m). This is denoted by s in Figure 9 and Figure 10, below. If the shade is not flat, such as for pleated pull-down shades or folded drapery, the average shade-to-glass distance should be used. (The shade-to-glass distance is used in calculating the natural convective air flow between glass and shade produced by buoyancy effects.). Note used for between-glass shades.

In the following, H is the glazing height and W is the glazing width.

Field: Top Opening Multiplier

Effective area for air flow at the top of the shade divided by sW , the horizontal area between glass and shade (see Figures below).

Field: Bottom Opening Multiplier

Effective area for air flow at the bottom of the shade divided by sW , the horizontal area between glass and shade (see Figures below).

Field: Left-Side Opening Multiplier

Effective area for air flow at the left side of the shade divided by sH , the vertical area between glass and shade (see Figures below).

Field: Right-Side Opening Multiplier

Effective area for air flow at the right side of the shade divided by sH , the vertical area between glass and shade (see Figures below).

Field: Air-Flow Permeability

The fraction of the shade surface that is open to air flow, i.e., the total area of openings (“holes”) in the shade surface divided by the shade area, HW . If air cannot pass through the shade material, Air-Flow Permeability = 0. For drapery fabric and screens the Air-Flow Permeability can be taken as the “openness” of the fabric (see 2001 ASHRAE Fundamentals, Chapter 30, Fig. 31), which is 0.0 to 0.07 for closed weave, 0.07 to 0.25 for semi-open weave, and 0.25 and higher for open weave.

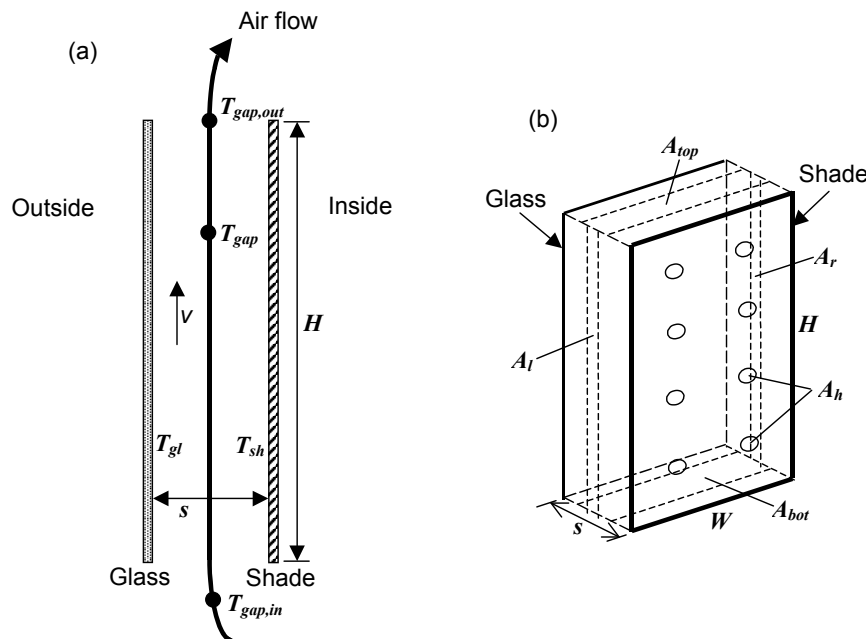


Figure 9. Vertical section (a) and perspective view (b) of glass and interior shade layers showing variables used in the gap air flow analysis. In (b), the air-flow opening areas A_{bot} , A_{top} , A_l , A_r and A_h are shown schematically. See *Engineering Manual* for definition of thermal variables.

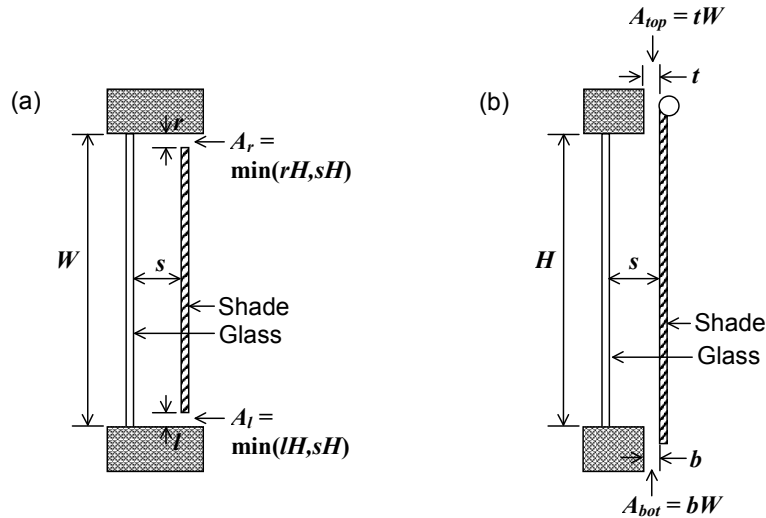


Figure 10. Examples of air-flow openings for an interior shade covering glass of height H and width W . Not to scale. (a) Horizontal section through shade with openings on the left and right sides (top view). (b) Vertical section through shade with openings at the top and bottom (side view). In (a) Left-Side Opening Multiplier = $A_l/sH = \min(l/s, 1)$ and Right-Side Opening Multiplier = $A_r/sH = \min(r/s, 1)$. In (b) Top Opening Multiplier = $A_{top}/sW = t/s$ and Bottom Opening Multiplier = $A_{bot}/sW = b/s$.

```

WindowMaterial:Shade,
  \memo Window shade thermal properties
  \min-fields 15
  A1 , \field Name
        \required-field
        \type alpha
        \reference MaterialName
        \reference WindowShadesScreensAndBlinds
  N1 , \field Solar Transmittance
        \required-field
        \note Assumed independent of incidence angle
        \type real
        \minimum 0
        \maximum< 1
  N2 , \field Solar Reflectance
        \required-field
        \note Assumed same for both sides
        \note Assumed independent of incidence angle
        \type real
        \minimum 0
        \maximum< 1
  N3 , \field Visible Transmittance
        \required-field
        \note Assumed independent of incidence angle
        \type real
        \minimum 0
        \maximum< 1
  N4 , \field Visible Reflectance
        \required-field
        \note Assumed same for both sides
        \note Assumed independent of incidence angle
        \type real
        \minimum 0
        \maximum< 1

```

```
N5 , \field Thermal Hemispherical Emissivity
    \required-field
    \type real
    \maximum< 1
    \minimum> 0
N6 , \field Thermal Transmittance
    \required-field
    \type real
    \maximum< 1
    \minimum 0
N7 , \field Thickness
    \required-field
    \type real
    \units m
    \minimum> 0
    \ip-units in
N8 , \field Conductivity
    \required-field
    \units W/m-K
    \type real
    \minimum> 0
N9 , \field Shade to Glass Distance
    \type real
    \units m
    \minimum 0.001
    \maximum 1.0
    \default 0.050
    \ip-units in
N10, \field Top Opening Multiplier
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0.5
N11, \field Bottom Opening Multiplier
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0.5
N12, \field Left-Side Opening Multiplier
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0.5
N13, \field Right-Side Opening Multiplier
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0.5
N14; \field Airflow Permeability
    \type real
    \minimum 0.0
    \maximum 0.8
    \default 0.0
```

An IDF example:

```

WindowMaterial:Shade,
  DRAPES - CLOSE WEAVE MEDIUM,  !- Name
  0.05,                          !- Solar transmittance
  0.3000000,                    !- Solar Reflectance
  .05,                          !- Visible transmittance
  0.3000000,                    !- Visible reflectance
  0.9000000,                    !- Thermal Hemispherical Emissivity
  0.0,                          !- Thermal Transmittance
  0.003,                        !- Thickness {m}
  0.1,                          !- Conductivity {W/m-K}
  0.050,                        !- Shade to glass distance {m}
  1.0,                          !- Top opening multiplier
  1.0,                          !- Bottom opening multiplier
  0.0,                          !- Left-side opening multiplier
  0.0,                          !- Right-side opening multiplier
  0.0;                          !- Air flow permeability

```

WindowMaterial:Blind

This object specifies the properties of a window blind consisting of flat, equally-spaced slats. Unlike window shades, which are modeled as perfect diffusers, window blinds have solar and visible transmission and reflection properties that strongly depend on slat angle and angle of incidence of solar radiation. There is an EnergyPlus Reference Data Set for WindowMaterial:Blind that contains properties of generic window blinds.

Blinds can be located on the inside of the window (“interior blinds”), on the outside of the window (“exterior blinds”), or between two layers of glass (“between-glass blinds”). When in place, the blind is assumed to cover all of the glazed part of the window, including dividers; it does not cover any of the window frame, if present. The plane of the blind is assumed to be parallel to the glazing. When the blind is retracted it is assumed to cover none of the window. The solar and thermal effects of the blind’s support strings, tapes or rods are ignored. Slat curvature, if present, is ignored.

Note that when locating a window blind between glass layers, the WindowMaterial:Glazing layers in the window construction must all use an Optical Data Type of SpectralAverage. Spectral data for glazing layers is not currently supported for between glass blinds.

There are two methods of assigning a blind to a window:

Method 1:

1. Define the construction of the window without the blind, the so-called “bare” construction.
2. Reference the bare construction in the FenestrationSurface:Detailed for the window.
3. Define the WindowMaterial:Blind.
4. Define a WindowProperty:ShadingControl for the window in which you (a) specify that this WindowMaterial:Blind is the window’s shading device and (b) specify how the blind is controlled.

Method 2:

1. Define the Construction of the window without the blind, the so-called “bare” construction.
2. Reference the bare construction in the FenestrationSurface:Detailed for the window.
3. Define the WindowMaterial:Blind.
4. Define another Construction, called the “shaded construction,” that includes the WindowMaterial:Blind.
5. Define a WindowProperty:ShadingControl for the window in which you (a) reference the shaded construction and (b) specify how the blind is controlled.

Note that WindowProperty:ShadingControl has to be used with either method, even if the blind is in place at all times. You will get an error message if you try to reference a construction with a blind directly from Surface:HeatTransfer:Sub.

Note also that WindowProperty:ShadingControl is used to determine not only when the blind is in place, but how its slat angle is controlled.

Field: Name

Name of the blind. It is referenced as a layer in a window construction (ref: Construction) or as a “Material Name of Shading Device” in a WindowProperty:ShadingControl object.

Field: Slat Orientation

The choices are Horizontal and Vertical. “Horizontal” means the slats are parallel to the bottom of the window; this is the same as saying that the slats are parallel to the X-axis of the window. “Vertical” means the slats are parallel to Y-axis of the window.

Field: Slat Width

The width of the slat measured from edge to edge (m). See Figure 11.

Field: Slat Separation

The distance between the front of a slat and the back of the adjacent slat (m). See Figure 11.

Field: Slat Thickness

The distance between the faces of a slat (m). See Figure 11.

Field: Slat Angle

The angle (degrees) between the glazing outward normal and the slat outward normal, where the outward normal points away from the front face of the slat (degrees). See Figure 11.

If the WindowProperty:ShadingControl for the blind has Type of Slat Angle Control for Blinds = FixedSlatAngle, the slat angle is fixed at “Slat Angle.”

If Type of Slat Angle Control for Blinds = BlockBeamSolar, the program automatically adjusts the slat angle so as just block beam solar radiation. In this case the value of “Slat Angle” is used only when the blind is in place and there is no beam solar radiation incident on the blind.

If Type of Slat Angle Control for Blinds = ScheduledSlatAngle, the slat angle is variable. In this case “Slat Angle” is not applicable and the field should be blank.

If Type of Slat Angle Control for Blinds = FixedSlatAngle and “Slat Angle” is less than the minimum or greater than the maximum allowed by Slat Width, Slat Separation and Slat Thickness, the slat angle will be reset to the corresponding minimum or maximum and a warning will be issued.

Field: Slat Conductivity

The thermal conductivity of the slat (W/m-K).

Field: Slat Beam Solar Transmittance

The beam solar transmittance of the slat, assumed to be independent of angle of incidence on the slat. Any transmitted beam radiation is assumed to be 100% diffuse (i.e., slats are translucent).

Field: Front Side Slat Beam Solar Reflectance

The beam solar reflectance of the front side of the slat, assumed to be independent of angle of incidence (matte finish). This means that slats with a large specularly-reflective component (shiny slats) are not well modeled.

Field: Back Side Slat Beam Solar Reflectance

The beam solar reflectance of the back side of the slat, assumed to be independent of angle of incidence (matte finish). This means that slats with a large specularly-reflective component (shiny slats) are not well modeled.

Field: Slat Diffuse Solar Transmittance

The slat transmittance for hemispherically diffuse solar radiation. This value should equal "Slat Beam Solar Transmittance."

Field: Front Side Slat Diffuse Solar Reflectance

The front-side slat reflectance for hemispherically diffuse solar radiation. This value should equal "Front Side Slat Beam Solar Reflectance."

Field: Back Side Slat Diffuse Solar Reflectance

The back-side slat reflectance for hemispherically diffuse solar radiation. This value should equal "Back Side Slat Beam Solar Reflectance."

Field: Slat Beam Visible Transmittance

The beam visible transmittance of the slat, assumed to be independent of angle of incidence on the slat. Any transmitted visible radiation is assumed to be 100% diffuse (i.e., slats are translucent).

Field: Front Side Slat Beam Visible Reflectance

The beam visible reflectance on the front side of the slat, assumed to be independent of angle of incidence (matte finish). This means that slats with a large specularly-reflective component (shiny slats) are not well modeled.

Field: Back Side Slat Beam Visible Reflectance

The beam visible reflectance on the front side of the slat, assumed to be independent of angle of incidence (matte finish). This means that slats with a large specularly-reflective component (shiny slats) are not well modeled.

Field: Slat Diffuse Visible Transmittance

The slat transmittance for hemispherically diffuse visible radiation. This value should equal "Slat Beam Visible Transmittance."

Field: Front Side Slat Diffuse Visible Reflectance

The front-side slat reflectance for hemispherically diffuse visible radiation. This value should equal "Front Side Slat Beam Visible Reflectance."

Field: Back Side Slat Diffuse Visible Reflectance

The back-side slat reflectance for hemispherically diffuse visible radiation. This value should equal "Back Side Slat Beam Visible Reflectance.."

Field: Slat Infrared Hemispherical Transmittance

The slat Infrared transmittance. It is zero for solid metallic, wooden or glass slats, but may be non-zero in some cases (e.g., thin plastic slats).

Field: Front Side Slat Infrared Hemispherical Emissivity

Front-side hemispherical emissivity of the slat. Approximately 0.9 for most materials. The most common exception is bare (unpainted) metal slats or slats finished with a metallic paint.

Field: Back Side Slat Infrared Hemispherical Emissivity

Back-side hemispherical emissivity of the slat. Approximately 0.9 for most materials. The most common exception is bare (unpainted) metal slats or slats finished with a metallic paint.

Field: Blind to Glass Distance

For interior and exterior blinds, the distance from the mid-plane of the blind to the adjacent glass (m). See Figure 11. Not used for between-glass blinds. As for window shades (ref: WindowMaterial:Shade) this distance is used in calculating the natural convective air flow between glass and blind that is produced by buoyancy effects.

Opening Multipliers

The following opening multipliers are defined in the same way as for window shades (see WindowMaterial:Shade, Figure 9 and Figure 10). Note that, unlike window shades, there is no input for Air-Flow Permeability; this is automatically calculated by the program from slat angle, width and separation.

Field: Blind Top Opening Multiplier

Defined as for Material:WindowShade.

Field: Blind Bottom Opening Multiplier

Defined as for Material:WindowShade.

Field: Blind Left-Side Opening Multiplier

Defined as for Material:WindowShade.

Field: Blind Right-Side Opening Multiplier

Defined as for Material:WindowShade.

Field: Minimum Slat Angle

The minimum allowed slat angle (degrees). Used only if WindowProperty:ShadingControl (for the window that incorporates this blind) varies the slat angle (i.e., the WindowProperty:ShadingControl has Type of Slat Angle Control for Blinds = ScheduledSlatAngle or BlockBeamSolar). In this case, if the program tries to select a slat angle less than Minimum Slat Angle it will be reset to Minimum Slat Angle. (Note that if the Minimum Slat Angle itself is less than the minimum allowed by Slat Width, Slat Separation and Slat Thickness, it will be reset to that minimum.)

Field: Maximum Slat Angle

The maximum allowed slat angle (degrees). Used only if WindowProperty:ShadingControl (for the window that incorporates this blind) varies the slat angle (i.e., the WindowProperty:ShadingControl has Type of Slat Angle Control for Blinds = ScheduledSlatAngle or BlockBeamSolar). In this case, if the program tries to select a slat angle greater than Maximum Slat Angle the slat angle will be reset to Maximum Slat Angle. (Note that if the Maximum Slat Angle itself is greater than the maximum allowed by Slat Width, Slat Separation and Slat Thickness, it will be reset to that maximum.)


```

WindowMaterial:Blind,
  \memo Window blind thermal properties
  \min-fields 29
A1 , \field Name
  \required-field
  \type alpha
  \reference MaterialName
  \reference WindowShadesScreensAndBlinds
A2 , \field Slat Orientation
  \type choice
  \key Horizontal
  \key Vertical
  \default Horizontal
N1 , \field Slat Width
  \required-field
  \units m
  \type real
  \minimum> 0
  \maximum 1
  \ip-units in
N2 , \field Slat Separation
  \required-field
  \note Distance between adjacent slat faces
  \units m
  \type real
  \minimum> 0
  \maximum 1
  \ip-units in
N3 , \field Slat Thickness
  \note Distance between top and bottom surfaces of slat
  \note Slat is assumed to be rectangular in cross section and flat
  \type real
  \units m
  \minimum> 0
  \maximum 0.1
  \default 0.00025
  \ip-units in
N4 , \field Slat Angle
  \note If WindowProperty:ShadingControl for the window that incorporates this blind
  \note has Type of Slat Angle Control for Blinds = FixedSlatAngle,
  \note then this is the fixed value of the slat angle;
  \note If WindowProperty:ShadingControl for the window that incorporates this blind
  \note has Type of Slat Angle Control for Blinds = BlockBeamSolar,
  \note then this is the slat angle when slat angle control
  \note is not in effect (e.g., when there is no beam solar on the blind);
  \note Not used if WindowProperty:ShadingControl for the window that incorporates this blind
  \note has Type of Slat Angle Control for Blinds = ScheduledSlatAngle.
  \type real
  \units deg
  \default 45
  \minimum 0
  \maximum 180
N5 , \field Slat Conductivity
  \type real
  \units W/m-K
  \minimum> 0
  \default 221.0
  \note default is for aluminum
N6 , \field Slat Beam Solar Transmittance
  \type real
  \maximum< 1
  \minimum 0
  \default 0
N7 , \field Front Side Slat Beam Solar Reflectance
  \required-field
  \type real
  \maximum< 1
  \minimum 0

```

```
N8 , \field Back Side Slat Beam Solar Reflectance
    \required-field
    \type real
    \maximum< 1
    \minimum 0
N9 , \field Slat Diffuse Solar Transmittance
    \note Must equal "Slat beam solar transmittance"
    \type real
    \maximum< 1
    \minimum 0
    \default 0
N10, \field Front Side Slat Diffuse Solar Reflectance
    \note Must equal "Front Side Slat Beam Solar Reflectance"
    \required-field
    \type real
    \maximum< 1
    \minimum 0
N11, \field Back Side Slat Diffuse Solar Reflectance
    \note Must equal "Back Side Slat Beam Solar Reflectance"
    \required-field
    \type real
    \maximum< 1
    \minimum 0
N12, \field Slat Beam Visible Transmittance
    \note Required for detailed daylighting calculation
    \type real
    \maximum< 1
    \minimum 0
    \required-field
N13, \field Front Side Slat Beam Visible Reflectance
    \note Required for detailed daylighting calculation
    \type real
    \maximum< 1
    \minimum 0
N14, \field Back Side Slat Beam Visible Reflectance
    \note Required for detailed daylighting calculation
    \type real
    \maximum< 1
    \minimum 0
N15, \field Slat Diffuse Visible Transmittance
    \note Used only for detailed daylighting calculation
    \note Must equal "Slat Beam Visible Transmittance"
    \type real
    \maximum< 1
    \minimum 0
    \default 0
N16, \field Front Side Slat Diffuse Visible Reflectance
    \note Required for detailed daylighting calculation
    \note Must equal "Front Side Slat Beam Visible Reflectance"
    \type real
    \maximum< 1
    \minimum 0
N17, \field Back Side Slat Diffuse Visible Reflectance
    \note Required for detailed daylighting calculation
    \note Must equal "Back Side Slat Beam Visible Reflectance"
    \type real
    \maximum< 1
    \minimum 0
N18, \field Slat Infrared Hemispherical Transmittance
    \type real
    \maximum< 1
    \minimum 0
    \default 0
N19, \field Front Side Slat Infrared Hemispherical Emissivity
    \type real
    \maximum< 1
    \minimum 0
    \default 0.9
```

```
N20, \field Back Side Slat Infrared Hemispherical Emissivity
      \type real
      \maximum< 1
      \minimum 0
      \default 0.9
N21, \field Blind to Glass Distance
      \type real
      \units m
      \minimum 0.01
      \maximum 1.0
      \default 0.050
      \ip-units in
N22, \field Blind Top Opening Multiplier
      \type real
      \minimum 0.0
      \maximum 1.0
      \default 0.5
N23, \field Blind Bottom Opening Multiplier
      \type real
      \minimum 0.0
      \maximum 1.0
      \default 0.0
N24, \field Blind Left Side Opening Multiplier
      \type real
      \minimum 0.0
      \maximum 1.0
      \default 0.5
N25, \field Blind Right Side Opening Multiplier
      \type real
      \minimum 0.0
      \maximum 1.0
      \default 0.5
N26, \field Minimum Slat Angle
      \note Used only if WindowProperty:ShadingControl for the window that incorporates
      \note this blind varies the slat angle (i.e., WindowProperty:ShadingControl with
      \note Type of Slat Angle Control for Blinds = ScheduledSlatAngle
      \note or BlockBeamSolar)
      \type real
      \units deg
      \default 0
      \minimum 0
      \maximum 180
N27; \field Maximum Slat Angle
      \note Used only if WindowProperty:ShadingControl for the window that incorporates
      \note this blind varies the slat angle (i.e., WindowProperty:ShadingControl with
      \note Type of Slat Angle Control for Blinds = ScheduledSlatAngle
      \note or BlockBeamSolar)
      \type real
      \units deg
      \default 180
      \minimum 0
      \maximum 180
```

An IDF example:

```

WindowMaterial:Blind,
White Painted Metal Blind,  !- Name
HORIZONTAL, !- Slat orientation
0.025 , !- Slat width (m)
0.01875 , !- Slat separation (m)
0.001 , !- Slat thickness (m)
45.0 , !- Slat angle (deg)
44.9 , !- Slat conductivity (W/m-K)
0.0 , !- Slat beam solar transmittance
0.8 , !- Front Side Slat beam solar reflectance
0.8 , !- Back Side Slat beam solar reflectance
0.0 , !- Slat diffuse solar transmittance
0.8 , !- Front Side Slat diffuse solar reflectance
0.8 , !- Back Side Slat diffuse solar reflectance
0.0 , !- Slat beam visible transmittance
0.7 , !- Front Side Slat beam visible reflectance
0.7 , !- Back Side Slat beam visible reflectance
0.0 , !- Slat diffuse visible transmittance
0.7 , !- Front Side Slat diffuse visible reflectance
0.7 , !- Back Side Slat diffuse visible reflectance
0.0 , !- Slat Infrared hemispherical transmittance
0.9 , !- Front Side Slat Infrared hemispherical emissivity
0.9 , !- Back Side Slat Infrared hemispherical emissivity
0.050 , !- Blind-to-glass distance
0.0 , !- Blind top opening multiplier
0.0 , !- Blind bottom opening multiplier
0.5 , !- Blind left-side opening multiplier
0.5 , !- Blind right-side opening multiplier
, !- Minimum slat angle (deg)
; !- Maximum slat angle (deg)
    
```

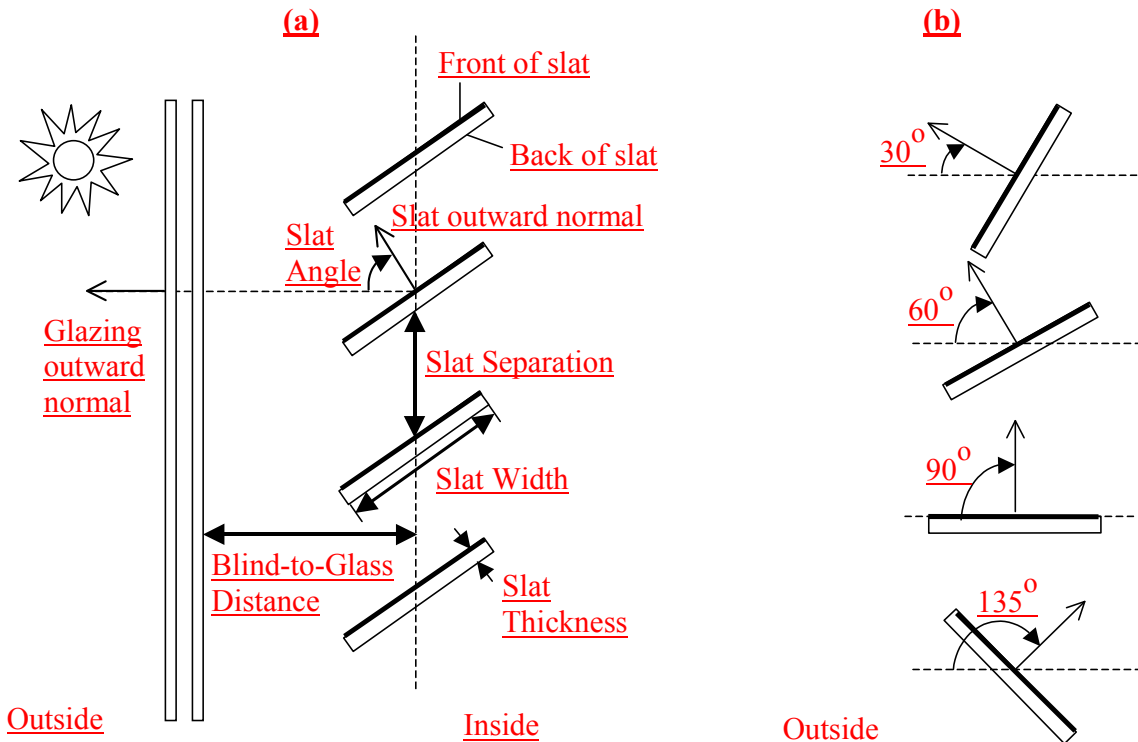


Figure 11. (a) Side view of a window blind with horizontal slats (or top view of blind with vertical slats) showing slat geometry. The front face of a slat is shown by a heavy line. The slat angle is defined as the angle between the glazing outward normal and the slat outward normal, where the outward normal points away from the front face of the slat. (b) Slat orientations for representative slat angles. The slat angle varies from 0°, when the front of the slat is parallel to the glazing and faces toward the outdoors, to 90°,

when the slat is perpendicular to the glazing, to 180° , when the front of the slat is parallel to the glazing and faces toward the indoors. The minimum and maximum slat angles are determined by the slat thickness, width and separation.

WindowMaterial:Screen

This object specifies the properties of exterior window screen materials. The window screen model assumes the screen is made up of intersecting orthogonally-crossed cylinders. The surface of the cylinders is assumed to be diffusely reflecting, having the optical properties of a Lambertian surface.

The beam solar radiation transmitted through a window screen varies with sun angle and is made up of two distinct elements: a direct beam component and a reflected beam component. The direct beam transmittance component is modeled using the geometry of the screen material and the incident angle of the sun to account for shadowing of the window by the screen material. The reflected beam component is an empirical model that accounts for the inward reflection of solar beam off the screen material surface. This component is both highly directional and small in magnitude compared to the direct beam transmittance component (except at higher incident angles, for which case the magnitude of the direct beam component is small or zero and the reflected beam component, though small in absolute terms can be many times larger than the direct beam component). For this reason, the reflected beam transmittance component calculated by the model can be a. disregarded, b. treated as an additive component to direct beam transmittance (and in the same direction), or c. treated as hemispherically-diffuse transmittance based on a user input to the model.

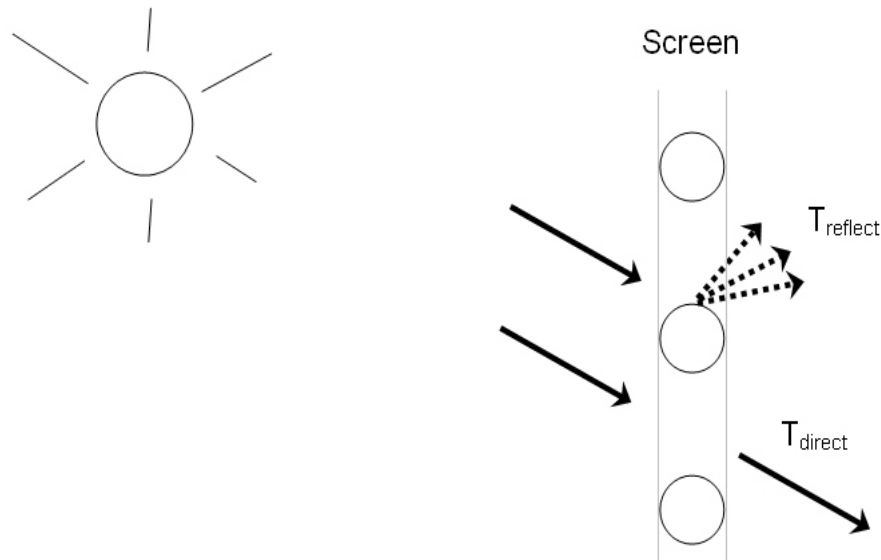


Figure 12. Direct beam and reflected beam transmittance components

The window screen “assembly” properties of overall beam solar reflectance and absorptance (including the screen material ‘cylinders’ and open area) also change with sun angle and are calculated based on the values of the beam solar transmittance components (direct and reflected components described above) and the physical properties of the screen material (i.e., screen material diameter, spacing, and reflectance).

Transmittance, reflectance, and absorptance of diffuse solar radiation are considered constant values and apply to both the front and back surfaces of the screen. These properties are calculated by the model as an average value by integrating the screen’s beam solar properties over a quarter hemisphere of incident radiation. Long-wave emissivity is also assumed to be the same for both sides of the screen.

There is an EnergyPlus Reference Data Set for WindowMaterial:Screen that contains properties for generic window screens. Window screens of this type can only be used on the outside surface of the window (“exterior screens”). When in place, the screen is assumed to cover all of the glazed part of the window, including dividers; it does not cover any of the window frame, if present. The plane of the screen is assumed to be parallel to the glazing.

WindowMaterial:Screen can be used to model wire mesh insect screens where the solar and visible transmission and reflection properties vary with the angle of incidence of solar radiation. For diffusing materials such as drapery and translucent roller shades it is better to use the WindowMaterial:Shade object. For slat-type shading devices like Venetian blinds, which have solar and visible transmission and reflection properties that strongly depend on slat angle and angle of incidence of solar radiation, it is better to use WindowMaterial:Blind.

There are two methods of assigning a screen to a window:

Method 1:

- 1) Define the construction of the window without the screen, the so-called “bare” construction.
- 2) Reference the bare construction in the FenestrationSurface:Detailed for the window.
- 3) Define the WindowMaterial:Screen object.
- 4) Define a WindowProperty:ShadingControl for the window in which you (a) specify that this Material:WindowScreen is the window’s shading device, and (b) specify how the screen is controlled.

Method 2:

1. Define the Construction of the window without the screen, the so-called “bare” construction.
2. Reference the bare construction in the FenestrationSurface:Detailed for the window.
3. Define the WindowMaterial:Screen object.
4. Define another Construction, called the “shaded construction,” that includes the WindowMaterial:Screen.
5. Define a WindowProperty:ShadingControl for the window in which you (a) reference the shaded construction, and (b) specify how the screen is controlled.

Note that WindowProperty:ShadingControl has to be used with either method, even if the screen is in place at all times. You will get an error message if you try to reference a shaded construction directly from a FenestrationSurface:Detailed object.

Field: Name

Enter a unique name for the screen. This name is referenced as an outside layer in a window construction.

Field: Reflected Beam Transmittance Accounting Method

This input specifies the method used to account for screen-reflected beam solar radiation that is transmitted through the window screen (as opposed to being reflected back outside the building). Since this inward reflecting beam solar is highly directional and is not modeled in the direction of the actual reflection, the user is given the option of how to account for the directionality of this component of beam solar transmittance. Valid choices are DoNotModel, ModelAsDirectBeam (i.e., model as an additive component to direct solar beam and in the same direction), or ModelAsDiffuse (i.e., model as hemispherically-diffuse radiation). The default value is ModelAsDiffuse.

Field: Diffuse Solar Reflectance

This input specifies the solar reflectance (beam-to-diffuse) of the screen material itself (not the effective value for the overall screen “assembly” including open spaces between the screen material). The outgoing diffuse radiation is assumed to be Lambertian (distributed

angularly according to Lambert's cosine law). The solar reflectance is assumed to be the same for both sides of the screen. This value must be from 0 to less than 1.0. In the absence of better information, the input value for diffuse solar reflectance should match the input value for diffuse visible reflectance.

Field: Diffuse Visible Reflectance

This input specifies the visible reflectance (beam-to-diffuse) of the screen material itself (not the effective value for the overall screen “assembly” including open spaces between the screen material) averaged over the solar spectrum and weighted by the response of the human eye. The outgoing diffuse radiation is assumed to be Lambertian (distributed angularly according to Lambert's cosine law). The visible reflectance is assumed to be the same for both sides of the screen. This value must be from 0 to less than 1.0.

If diffuse visible reflectance for the screen material is not available, then the following guidelines can be used to estimate this value:

Dark-colored screen (e.g., charcoal):	0.08 – 0.10
Medium-colored screen (e.g., gray):	0.20 – 0.25
Light-colored screen (e.g., bright aluminum):	0.60 – 0.65

Commercially-available gray scale or grayscale reflecting chart references can be purchased for improved accuracy in estimating visible reflectance (by visual comparison of screen reflected brightness with that of various known-reflectance portions of the grayscale).

Field: Thermal Hemispherical Emissivity

Long-wave emissivity ϵ of the screen material itself (not the effective value for the overall screen “assembly” including open spaces between the screen material). The emissivity is assumed to be the same for both sides of the screen.

For most non-metallic materials, ϵ is about 0.9. For metallic materials, ϵ is dependent on material, its surface condition, and temperature. Typical values for metallic materials range from 0.05 – 0.1 with lower values representing a more finished surface (e.g. low oxidation, polished surface). Material emissivities may be found in Table 5 from the 2005 ASHRAE Handbook of Fundamentals, page 3.9. The value for this input field must be between 0 and 1, with a default value of 0.9 if this field is left blank.

Field: Conductivity

Screen material conductivity (W/m-K). This input value must be greater than 0. The default value is 221 W/m-K (aluminum).

Field: Screen Material Spacing

The spacing, S , of the screen material (m) is the distance from the center of one strand of screen to the center of the adjacent one. The spacing of the screen material is assumed to be the same in both directions (e.g., vertical and horizontal). This input value must be greater than the non-zero screen material diameter. If the spacing is different in the two directions, use the average of the two values.

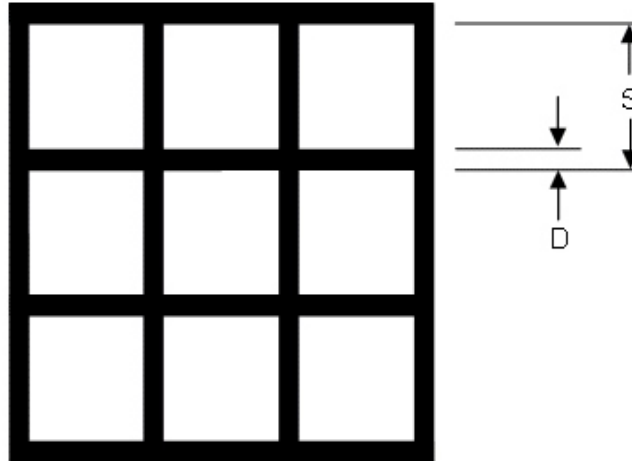


Figure 13. Screen Material Spacing and Diameter

Field: Screen Material Diameter

The diameter, D , of individual strands or wires of the screen material (m). The screen material diameter is assumed to be the same in both directions (e.g., vertical and horizontal). This input value must be greater than 0 and less than the screen material spacing. If the diameter is different in the two directions, use the average of the two values.

Field: Screen to Glass Distance

Distance from the window screen to the adjacent glass surface (m). If the screen is not flat, the average screen to glass distance should be used. The screen-to-glass distance is used in calculating the natural convective air flow between the glass and the screen produced by buoyancy effects. This input value must be from 0.001 m to 1 m, with a default value of 0.025 m if this field is left blank.

Field: Top Opening Multiplier

Effective area for air flow at the top of the screen divided by the horizontal area between the glass and screen (see the same field for the Material:WindowShade object for additional description). The opening multiplier fields can be used to simulate a shading material that is offset from the window frame. Since window screens are typically installed against the window frame, the default value is equal to 0. This input value can range from 0 to 1.

Field: Bottom Opening Multiplier

Effective area for air flow at the bottom of the screen divided the horizontal area between the glass and screen (see the same field for the Material:WindowShade object for additional description). The opening multiplier fields can be used to simulate a shading material that is offset from the window frame. Since window screens are typically installed against the window frame, the default value is equal to 0. This input value can range from 0 to 1.

Field: Left-Side Opening Multiplier

Effective area for air flow at the left side of the screen divided the vertical area between the glass and screen (see the same field for the Material:WindowShade object for additional description). The opening multiplier fields can be used to simulate a shading material that is offset from the window frame. Since window screens are typically installed against the window frame, the default value is equal to 0. This input value can range from 0 to 1.

Field: Right-Side Opening Multiplier

Effective area for air flow at the right side of the screen divided the vertical area between the glass and screen (see the same field for the Material:WindowShade object for additional

description). The opening multiplier fields can be used to simulate a shading material that is offset from the window frame. Since window screens are typically installed against the window frame, the default value is equal to 0. This input value can range from 0 to 1.

Field: Angle of Resolution for Screen Transmittance Output Map

Angle of resolution, in degrees, for the overall screen beam transmittance (direct and reflected) output map. The comma-separated variable file `eplusscreen.csv` (Ref. `OutputDetailsandExamples.pdf`) will contain the direct beam and reflected beam solar radiation that is transmitted through the window screen as a function of incident sun angle (0 to 90 degrees relative solar azimuth and 0 to 90 degrees relative solar altitude) in sun angle increments specified by this input field. The default value is 0, which means no transmittance map is generated. Other valid choice inputs are 1, 2, 3 and 5 degrees.

The input data dictionary (IDD) definition for this object is shown below:

```
WindowMaterial:Screen,
    \memo Window screen physical properties. Can only be located on the exterior side of a window
construction.
    \min-fields 9
A1 , \field Name
    \note Enter a unique name for this window screen material.
    \required-field
    \type alpha
    \reference MaterialName
    \reference WindowShadesScreensAndBlinds
A2 , \field Reflected Beam Transmittance Accounting Method
    \note Select the method used to account for the beam solar reflected off the material surface.
    \type choice
    \key DoNotModel
    \key ModelAsDirectBeam
    \key ModelAsDiffuse
    \default ModelAsDiffuse
```

```

N1 , \field Diffuse Solar Reflectance
    \note Diffuse reflectance of the screen material over the entire solar radiation spectrum.
    \note Assumed to be the same for both sides of the screen.
    \required-field
    \type real
    \units dimensionless
    \minimum 0
    \maximum< 1
N2 , \field Diffuse Visible Reflectance
    \note Diffuse visible reflectance of the screen material averaged over the solar spectrum
    \note and weighted by the response of the human eye.
    \note Assumed to be the same for both sides of the screen.
    \required-field
    \type real
    \units dimensionless
    \minimum 0
    \maximum< 1
N3 , \field Thermal Hemispherical Emissivity
    \note Long-wave emissivity of the screen material.
    \note Assumed to be the same for both sides of the screen.
    \type real
    \units dimensionless
    \maximum< 1
    \minimum> 0
    \default 0.9
N4 , \field Conductivity
    \note Thermal conductivity of the screen material.
    \type real
    \units W/m-K
    \minimum> 0
    \default 221.0
    \note Default is for aluminum.
N5 , \field Screen Material Spacing
    \note Spacing assumed to be the same in both directions.
    \required-field
    \type real
    \units m
    \minimum> 0
    \ip-units in
N6 , \field Screen Material Diameter
    \note Diameter assumed to be the same in both directions.
    \required-field
    \type real
    \units m
    \minimum> 0
    \ip-units in
N7 , \field Screen to Glass Distance
    \note Distance from the window screen to the adjacent glass surface.
    \type real
    \units m
    \minimum 0.001
    \maximum 1.0
    \default 0.025
    \ip-units in
N8 , \field Top Opening Multiplier
    \note Effective area for air flow at the top of the screen divided by the perpendicular
    \note area between the glass and the top of the screen.
    \type real
    \units dimensionless
    \minimum 0.0
    \maximum 1.0
    \default 0.0
N9 , \field Bottom Opening Multiplier
    \note Effective area for air flow at the bottom of the screen divided by the perpendicular
    \note area between the glass and the bottom of the screen.
    \type real
    \units dimensionless
    \minimum 0.0
    \maximum 1.0
    \default 0.0

```

```

N10, \field Left Side Opening Multiplier
      \note Effective area for air flow at the left side of the screen divided by the perpendicular
      \note area between the glass and the left side of the screen.
      \type real
      \units dimensionless
      \minimum 0.0
      \maximum 1.0
      \default 0.0
N11, \field Right Side Opening Multiplier
      \note Effective area for air flow at the right side of the screen divided by the perpendicular
      \note area between the glass and the right side of the screen.
      \type real
      \units dimensionless
      \minimum 0.0
      \maximum 1.0
      \default 0.0
N12; \field Angle of Resolution for Screen Transmittance Output Map
      \note Select the resolution of azimuth and altitude angles for the screen transmittance map.
      \note A value of 0 means no transmittance map will be generated.
      \note Valid values for this field are 0, 1, 2, 3 and 5.
      \type choice
      \units deg
      \key 0
      \key 1
      \key 2
      \key 3
      \key 5
      \default 0

```

An IDF example for this object, along with Construction and WindowProperty:ShadingControl objects, is shown below:

```

WindowMaterial:Screen,
  EXTERIOR SCREEN,           !- Name
  ModelAsDiffuse,           !- Reflected Beam Transmittance Accounting Method
  0.6,                       !- Diffuse Solar Reflectance
  0.6,                       !- Diffuse Visible Reflectance
  0.9,                       !- Thermal Hemispherical Emissivity
  221.0,                     !- Conductivity {W/m-K}
  0.00154,                   !- Screen Material Spacing (m)
  0.000254,                  !- Screen Material Diameter (m)
  0.025,                     !- Screen-to-Glass Distance {m}
  0.0,                       !- Top Opening Multiplier
  0.0,                       !- Bottom Opening Multiplier
  0.0,                       !- Left-Side Opening Multiplier
  0.0,                       !- Right-Side Opening Multiplier
  0;                          !- Angle of Resolution for Screen Transmittance Output Map {deg}

Construction,
  DOUBLE PANE WITHOUT SCREEN, !- Name
  GLASS - CLEAR SHEET 1 / 8 IN, !- Outside Layer
  WinAirB1 - AIRSPACE RESISTANCE, !- Layer #2
  GLASS - CLEAR SHEET 1 / 8 IN; !- Layer #3

```

```

WindowProperty:ShadingControl,
DOUBLE PANE WITH SCREEN, !- User Supplied Shading Control Name
ExteriorScreen,          !- Shading Type
,                          !- Name of construction with shading
AlwaysOn,                !- Shading Control Type
ScreenSchedule,          !- Schedule Name
20.0,                    !- SetPoint {W/m2, W or deg C}
YES,                      !- Shading Control Is Scheduled
NO,                       !- Glare Control Is Active
EXTERIOR SCREEN,         !- Material Name of Shading Device
,                          !- Type of Slat Angle Control for Blinds
;                          !- Slat Angle Schedule Name

```

Material:RoofVegetation

This definition must be used in order to simulate the green roof (ecorooft) model. The material becomes the outside layer in a green roof construction (see example below). In the initial release of the green roof model, only one material may be used as a green roof layer though, of course, several constructions using that material may be used. In addition, the model has only been tested with the ConductionTransferFunction solution algorithm – a warning will be issued for other solution algorithm choices.

Field: Name

This field is a unique reference name that the user assigns to a particular ecorooft material. This name can then be referred to by other input data.

Field: Height of Plants

This field defines the height of plants in units of meters. This field is limited to values in the range $0.01 < \text{Height} < 1.00$ m.

Field: Leaf Area Index

This is the projected leaf area per unit area of soil surface. This field is dimensionless and is limited to values in the range of $0.001 < \text{LAI} < 5.0$.

Field: Leaf Reflectivity

This field represents the fraction of incident solar radiation that is reflected by the individual leaf surfaces. Solar radiation includes the visible spectrum as well as infrared and ultraviolet wavelengths. Values for this field must be between 0.1 and 0.4.

Field: Leaf Emissivity

This field is the ratio of thermal radiation emitted from leaf surfaces to that emitted by an ideal black body at the same temperature. This parameter is used when calculating the long wavelength radiant exchange at the leaf surfaces. Values for this field must be between 0.8 and 1.0 (with 1.0 representing “black body” conditions).

Field: Minimum Stomatal Resistance

This field represents the resistance of the plants to moisture transport. It has units of s/m. Plants with low values of stomatal resistance will result in higher evapotranspiration rates than plants with high resistance. Values for this field must be in the range of 50.0 to 300.0.

Field: Soil Layer Name

This field is a unique reference name that the user assigns to the soil layer for a particular ecorooft. This name can then be referred to by other input data.

Field: Roughness

This alpha field defines the relative roughness of a particular material layer. This parameter only influences the convection coefficients, more specifically the exterior convection coefficient. A special keyword is expected in this field with the options being “VeryRough”,

“Rough”, “MediumRough”, “MediumSmooth”, “Smooth”, and “VerySmooth” in order of roughest to smoothest options.

Field: Thickness

This field characterizes the thickness of the material layer in meters. This should be the dimension of the layer in the direction perpendicular to the main path of heat conduction. This value must be a positive.

Field: Conductivity of Dry Soil

This field is used to enter the thermal conductivity of the material layer. Units for this parameter are W/(m-K). Thermal conductivity must be greater than zero.

Field: Density of Dry Soil

This field is used to enter the density of the material layer in units of kg/m³. Density must be a positive quantity.

Field: Specific Heat of Dry Soil

This field represents the specific heat of the material layer in units of J/(kg-K). Note that these units are most likely different than those reported in textbooks and references which tend to use kJ/(kg-K) or J/(g-K). They were chosen for internal consistency within EnergyPlus. Only positive values of specific heat are allowed.

Field: Thermal Absorptance

The thermal absorptance field in the Material input syntax represents the fraction of incident long wavelength radiation that is absorbed by the material. This parameter is used when calculating the long wavelength radiant exchange between various surfaces and affects the surface heat balances (both inside and outside as appropriate). Values for this field must be between 0.0 and 1.0 (with 1.0 representing “black body” conditions).

Field: Solar Absorptance

The solar absorptance field in the Material input syntax represents the fraction of incident solar radiation that is absorbed by the material. Solar radiation includes the visible spectrum as well as infrared and ultraviolet wavelengths. This parameter is used when calculating the amount of incident solar radiation absorbed by various surfaces and affects the surface heat balances (both inside and outside as appropriate). Values for this field must be between 0.0 and 1.0.

Field: Visible Absorptance

The visible absorptance field in the Material input syntax represents the fraction of incident visible wavelength radiation that is absorbed by the material. Visible wavelength radiation is slightly different than solar radiation in that the visible band of wavelengths is much more narrow while solar radiation includes the visible spectrum as well as infrared and ultraviolet wavelengths. This parameter is used when calculating the amount of incident visible radiation absorbed by various surfaces and affects the surface heat balances (both inside and outside as appropriate) as well as the daylighting calculations. Values for this field must be between 0.0 and 1.0.

```

Material:RoofVegetation,
  \memo EcoRoof model, plant layer plus soil layer
  \memo Implemented by Portland State University
  \memo (Sailor et al., January, 2007)
  \memo only one material must be used per simulation though the same EcoRoof material could be
  \memo used in multiple constructoins.
  \min-fields 18
A1 ,\field Name
  \required-field
  \type alpha
  \reference MaterialName
N1 ,\field Height of Plants
  \type real
  \note The ecoroof module is designed for short plants and shrubs.
  \minimum> 0.01
  \maximum 1.0
  \units m
  \default .2
N2 ,\field Leaf Area Index
  \required-field
  \units dimensionless
  \note Entire surface is assumed covered, so decrease LAI accordingly.
  \minimum> 0.001
  \maximum 5.0
  \default 1.0
  \type real
N3 ,\field Leaf Reflectivity
  \required-field
  \type real
  \units dimensionless
  \note Leaf reflectivity (albedo) is typically 0.18-0.25
  \maximum 0.4
  \minimum 0.1
  \default 0.22
N4 ,\field Leaf Emissivity
  \required-field
  \type real
  \minimum 0.8
  \maximum 1.0
  \default 0.95
N5 ,\field Minimum Stomatal Resistance
  \units s/m
  \default 180.0
  \note This depends upon plant type
  \minimum 50.0
  \maximum 300.
  \type real
A2 ,\field Soil Layer Name
  \type alpha
  \default Ecoroof Soil
A3 ,\field Roughness
  \note multiple choices
  \required-field
  \type choice
  \key VeryRough
  \key MediumRough
  \key Rough
  \key Smooth
  \key MediumSmooth
  \key VerySmooth
  \default MediumRough
N6 ,\field Thickness
  \note thickness of the soil layer of the EcoRoof
  \required-field
  \units m
  \type real
  \note Soil depths of 0.15m (6in) and 0.30m (12in) are common.
  \default 0.15
  \minimum> 0.05
  \maximum 0.5
  \ip-units in

```

```
N7 ,\field Conductivity of Dry Soil
  \required-field
  \units W/m-K
  \type real
  \note Thermal conductivity of dry soil.
  \note Typical ecoroof soils range from 0.3 to 0.5
  \default 0.4
  \minimum 0.2
  \maximum 1.0
N8 ,\field Density of Dry Soil
  \required-field
  \units kg/m3
  \note Density of dry soil (the code modifies this as the soil becomes moist)
  \note Typical ecoroof soils range from 400 to 1000 (dry to wet)
  \type real
  \minimum 300
  \maximum 2000
  \default 500
N9 ,\field Specific Heat of Dry Soil
  \required-field
  \units J/kg-K
  \type real
  \note Specific heat of dry soil
  \minimum> 500
  \maximum 2000
  \default 1000
N10,\field Thermal Absorptance
  \type real
  \note Soil emissivity is typically in range of 0.90 to 0.98
  \minimum> 0.8
  \default .9
  \maximum 1.0
N11,\field Solar Absorptance
  \type real
  \note Solar absorptance of dry soil (1-albedo) is typically 0.60 to 0.85
  \note corresponding to a dry albedo of 0.15 to 0.40
  \default .70
  \minimum 0.40
  \maximum 0.9
N12,\field Visible Absorptance
  \type real
  \minimum> 0.5
  \default .75
  \maximum 1.0
N13,\field Saturation Volumetric Moisture Content of the Soil Layer
  \type real
  \note Maximum moisture content is typically less than 0.5
  \minimum> 0.1
  \maximum 1.0
  \default 0.5
N14,\field Residual Volumetric Moisture Content of the Soil Layer
  \type real
  \minimum 0.01
  \maximum 0.1
  \default 0.01
N15;\field Initial Volumetric Moisture Content of the Soil Layer
  \type real
  \minimum> 0.1
  \maximum 1.0
  \default 0.15
```

An IDF example:

```

Material:RoofVegetation,
  BaseEco,           !- Name
  0.5,              !- Height of Plants {m}
  5,                !- Leaf Area Index {dimensionless}
  0.2,              !- Leaf Reflectivity {dimensionless}
  0.95,             !- Leaf Emissivity
  180,              !- Minimum Stomatal Resistance (s/m)
  EcoRoofSoil,      !- Soil Layer Name
  MediumSmooth,     !- Roughness
  0.18,             !- Thickness {m}
  0.4,              !- Conductivity (dry soil) {W/m-K}
  641,              !- Density (dry soil) {kg/m3}
  1100,             !- Specific Heat (dry soil) {J/kg-K}
  0.95,             !- Thermal Absorptance
  0.8,              !- Solar Absorptance
  0.7,              !- Visible Absorptance
  0.4,              !- Max volumetric moisture content of the soil layer (saturation)
  0.01,             !- Min (residual) volumetric moisture content of the soil layer
  0.2;              !- Initial volumetric moisture content of the soil layer

```

And construction using the ecoroof material:

```

Construction,
  ASHRAE 90.1-2004_Sec 5.5-2_Roof, !- Name
  BaseEco,           !- Outside Layer
  ASHRAE 90.1-2004_Sec 5.5-2_Roof Insulation_1, !- Layer #2
  ASHRAE 90.1-2004_Sec 5.5-2_MAT-METAL; !- Layer #3

```

MaterialProperty:GlazingSpectralData

With the MaterialProperty:GlazingSpectralData object, you can specify the wavelength-by-wavelength transmittance and reflectance properties of a glass material. To determine the overall optical properties of a glazing system (solar and visible transmittance and solar absorptance vs. angle of incidence) EnergyPlus first calculates transmittance and absorptance vs. angle of incidence for each wavelength. This is then weighted by a standard solar spectrum to get the solar transmittance and absorptance vs. angle of incidence (for use in the solar heat gain calculations), and further weighted by the response of the human eye to get the visible transmittance vs. angle of incidence (for use in the daylighting calculation).

MaterialProperty:GlazingSpectralData should be used for multi-pane windows when one or more of the glass layers is *spectrally selective*, i.e., the transmittance depends strongly on wavelength. An example is glass with a coating that gives high transmittance in the daylight part of the solar spectrum (roughly 0.4 to 0.7 microns) and low transmittance at longer wavelengths, thus providing better solar heat gain control than uncoated glass. If spectral data is not used in case, the overall optical properties of the glazing system that EnergyPlus calculates will not be correct.

You can input up to 450 sets of values for wavelengths covering the solar spectrum. Each set consists of {wavelength (microns), transmittance, front reflectance, back reflectance}

Spectral data of this kind are routinely measured by glass manufacturers. Data sets for over 800 commercially available products are contained in an Optical Data Library maintained by the Windows Group at Lawrence Berkeley National Laboratory. This library can be downloaded from <http://windows.lbl.gov/>. You will have to edit entries from this library to put them in the format required by the EnergyPlus WindowGlassSpectralData object.

An alternative to using the MaterialProperty:GlazingSpectralData object is to run the WINDOW 5 window analysis program. This program has built-in access to the Optical Data Library and let's you easily create customized, multi-layer glazing systems that can be exported for use in EnergyPlus. For more details, see "StormWindow".

Field: Name

The name of the spectral data set. It is referenced by WindowMaterial:Glazing when Optical Data Type = Spectral.

Fields 1-4 (repeated up to 450 times)

Sets of values for wavelengths covering the solar spectrum (from about 0.25 to 2.5 microns [10^{-6} m]). Each set consists of

{wavelength (microns), transmittance, front reflectance, back reflectance}

The wavelength values must be in ascending order. The transmittance and reflectance values are at normal incidence. “Front reflectance” is the reflectance for radiation striking the glass from the outside, i.e., from the side opposite the zone in which the window is defined. “Back reflectance” is the reflectance for radiation striking the glass from the inside, i.e., from the zone in which the window is defined. Therefore, for exterior windows, “front” is the side closest to the outdoors and “back” is the side closest to the zone in which the window is defined. For interior windows, “front” is the side closest to the adjacent zone and “back” is the side closest to the zone in which the window is defined.

```
MaterialProperty:GlazingSpectralData,
  \memo Name is followed by up to 450 sets of normal-incidence measured values of
  \memo [wavelength, transmittance, front reflectance, back reflectance] for wavelengths
  \memo covering the solar spectrum (from about 0.25 to 2.5 microns)
A1, \field Name
N1,N2,N3,N4,      N5,N6,N7,N8,      N9,N10,N11,N12,  N13,N14,N15,N16, N17,N18,N19,N20,
N21,N22,N23,N24, N25,N26,N27,N28, N29,N30,N31,N32, N33,N34,N35,N36, N37,N38,N39,N40,
N41,N42,N43,N44,  N45,N46,N47,N48,  N49,N50,N51,N52, N53,N54,N55,N56, N57,N58,N59,N60,
N61,N62,N63,N64,  N65,N66,N67,N68,  N69,N70,N71,N72, N73,N74,N75,N76, N77,N78,N79,N80,
N81,N82,N83,N84,  N85,N86,N87,N88,  N89,N90,N91,N92, N93,N94,N95,N96, N97,N98,N99,N100,
.
.
.
N1701,N1702,N1703,N1704, N1705,N1706,N1707,N1708, N1709,N1710,N1711,N1712,N1713,N1714,N1715,N1716,
N1717,N1718,N1719,N1720, N1721,N1722,N1723,N1724, N1725,N1726,N1727,N1728, N1729,N1730,N1731,N1732,
N1733,N1734,N1735,N1736, N1737,N1738,N1739,N1740, N1741,N1742,N1743,N1744, N1745,N1746,N1747,N1748,
N1749,N1750,N1751,N1752, N1753,N1754,N1755,N1756, N1757,N1758,N1759,N1760, N1761,N1762,N1763,N1764,
N1765,N1766,N1767,N1768, N1769,N1770,N1771,N1772, N1773,N1774,N1775,N1776, N1777,N1778,N1779,N1780,
N1781,N1782,N1783,N1784, N1785,N1786,N1787,N1788, N1789,N1790,N1791,N1792, N1793,N1794,N1795,N1796,
N1797,N1798,N1799,N1800;
```

An IDF example:

```
MaterialProperty:GlazingSpectralData,
  TestSpectralDataSet,
  ! { from WINDOW 4 library }
  ! { actual 9.91mm clear laminate: 15_mil PVB, ID:37966/50032-39-9 } 10.38
  ! { conductivity PVB adjusted, W/M/K } 0.798
  ! { thermal IR transmittance, assumed } tir=0.00
  ! { thermal IR hemispherical emittance, assumed } emis= 0.84 0.84

  ! WL   T      Rfront Rback
  .300, 0.000, 0.045, 0.045,
  .310, 0.000, 0.044, 0.044,
  .320, 0.000, 0.044, 0.044,
  .330, 0.000, 0.042, 0.042,
  .340, 0.000, 0.041, 0.041,
  .350, 0.000, 0.040, 0.040,
  <reduced for brevity>
  2.450, 0.200, 0.040, 0.040,
  2.500, 0.214, 0.039, 0.039;
```

Construction

For walls, roofs, floors, windows, and doors, constructions are “built” from the included materials. Each layer of the construction is a material name listed in order from “outside” to “inside”. Up to ten layers (eight for windows) may be specified (one of the few limitations in EnergyPlus!). “Outside” is the layer furthest away from the Zone air (not necessarily the outside environment). “Inside” is the layer next to the Zone air. In the example floor below, for

example, the outside layer is the acoustic tile below the floor, the next layer is the air space above the tile, and the inside layer is the concrete floor deck.

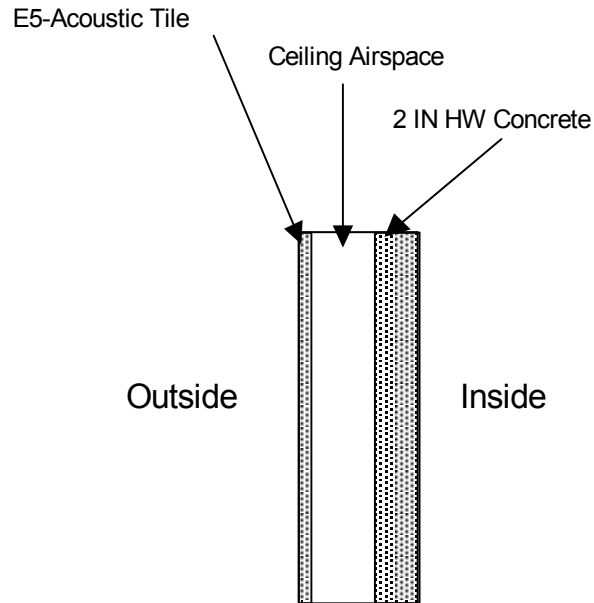


Figure 14. Example Floor Construction illustration.

Window constructions are similarly built up from items in the Window Materials set using similar layers.. See Figure 15. Illustration for material ordering in windows, which shows the case where an interior shading layer such as a blind is present. The gap between the inside glass layer (layer #3) and the interior shading layer is not entered. Similarly, for an exterior shading layer, the gap between the outside glass layer and the shading layer is not entered.

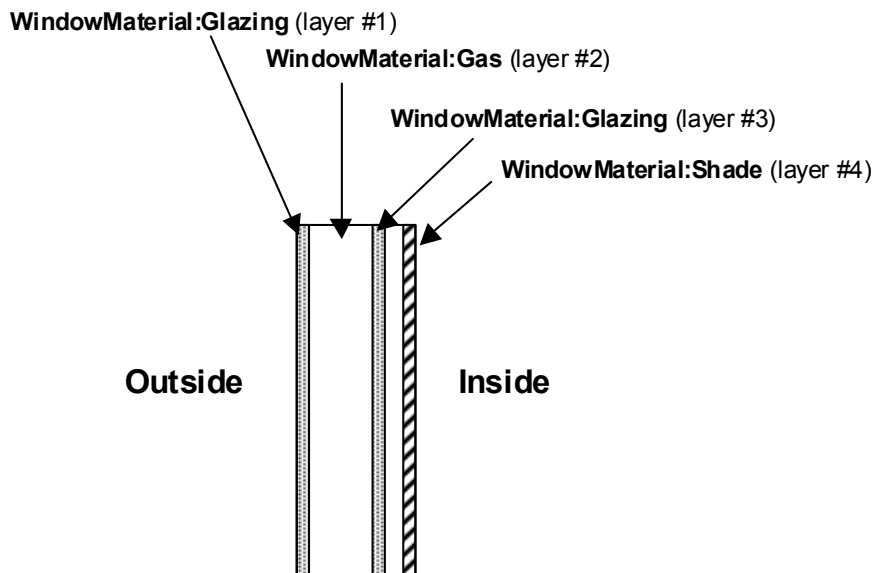


Figure 15. Illustration for material ordering in windows.

However, for a between-glass shading device the gaps on either side of the shading layer must be entered and they must have the same gas type. In addition, the gap widths with and without the between-glass shading layer must be consistent (see Figure 16).

A maximum of four glass layers and one shading layer is allowed. A gas layer must always separate adjacent glass layers in a multi-pane glazing without a between-glass shading layer.

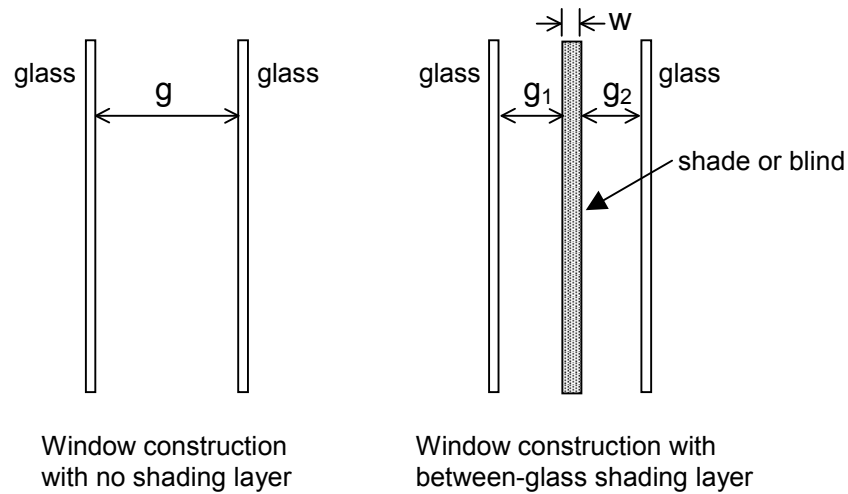


Figure 16. Window construction with and without a between-glass shading layer. Shown are gap widths g , g_1 and g_2 , and shading layer width, w . An error will result if $g_1 + g_2 + w$ is not equal to g , where w is zero for a blind and greater than zero for a shade.

Outside and inside air film resistances are never given as part of a construction definitions since they are calculated during the EnergyPlus simulation. Note also that constructions are assumed to be one-dimensional in a direction perpendicular to the surface.

Field: Name

This field is a user specified name that will be used as a reference by other input syntax. For example, a heat transfer surface (ref: Building Surfaces) requires a construction name to define what the make-up of the wall is. This name must be identical to one of the Construction definitions in the input data file.

Field: Outside Layer

Each construction must have at least one layer. This field defines the material name associated with the layer on the outside of the construction—outside referring to the side that is not exposed to the zone but rather the opposite side environment, whether this is the outdoor environment or another zone. Material layers are defined based on their thermal properties elsewhere in the input file (ref: Material and Material Properties and Materials for Glass Windows and Doors). As noted above, the outside layer should NOT be a film coefficient since EnergyPlus will calculate outside convection and radiation heat transfer more precisely.

Field(s) 2-10: Layers

The next fields are optional and the number of them showing up in a particular Construction definition depends solely on the number of material layers present in that construction. The data expected is identical to the outside layer field (see previous field description). The order of the remaining layers is important and should be listed in order of occurrence from the one just inside the outside layer until the inside layer is reached. As noted above, the inside layer should NOT be a film coefficient since EnergyPlus will calculate inside convection and radiation heat transfer more precisely.

```

Construction,
  \memo Start with outside layer and work your way to the inside layer
  \memo Up to 10 layers total, 8 for windows
  \memo Enter the material name for each layer
A1 , \field Name
  \required-field
  \type alpha
  \reference ConstructionNames
A2 , \field Outside Layer
  \required-field
  \type object-list
  \object-list MaterialName
A3 , \field Layer 2
  \type object-list
  \object-list MaterialName
<reduced for brevity>
A11; \field Layer 10
  \type object-list
  \object-list MaterialName

```

IDF Example (floor construction):

```

Construction, FLOOR38, ! Material layer names follow:
E5 - ACOUSTIC TILE,
E4 - CEILING AIRSPACE,
C12 - 2 IN HW CONCRETE;

```

IDF Example (window construction, no shade):

```

Construction, DOUBLE PANE WINDOW, !- Material layer names follow:
GLASS - CLEAR SHEET 1 / 8 IN,
WinAirB1 - AIRSPACE RESISTANCE,
GLASS - CLEAR SHEET 1 / 8 IN;

```

IDF Example (window construction, with interior shade):

```

Construction, DOUBLE PANE WITH ROLL SHADE, !- Material layer names follow:
GLASS - CLEAR SHEET 1 / 8 IN,
WinAirB1 - AIRSPACE RESISTANCE,
GLASS - CLEAR SHEET 1 / 8 IN,
ROLL SHADE - LIGHT

```

Construction:InternalSource

In some cases such as radiant systems, a construction will actually have resistance wires or hydronic tubing embedded within the construction. Heat is then either added or removed from this building element to provide heating or cooling to the zone in question. In the case of building-integrated photovoltaics, the energy removed in the form of electricity will form a sink. It is possible to enter such constructions into EnergyPlus with the syntax described below. The definition is similar to the Construction definition with a few additions related to radiant or other systems that will lead to source/sink terms.

Field: Name

This field is a user specified name that will be used as a reference by other input syntax. For example, a heat transfer surface (ref: Building Surfaces) requires a construction name to define what the make-up of the wall is.

Field: Source Present After Layer Number

This field is an integer that relates the location of the heat source or sink. The integer refers to the list of material layers that follow later in the syntax and determines the layer after which the source is present. If a source is embedded within a single homogenous layer (such as concrete), that layer should be split into two layers and the source added between them. For example, a value of “2” in this field tells EnergyPlus that the source is located between the second and third material layers listed later in the construction description (see layer fields below).

Field: Temperature Calculation Requested After Layer Number

The nature of this field is similar to the source interface parameter (see previous field) in that it is an integer, refers to the list of material layers that follow, and defines a location after the layer number identified by the user-defined number. In this case, the user is specifying the location for a separate temperature calculation rather than the location of the heat source/sink. This feature is intended to allow users to calculate a temperature within the construction. This might be important in a radiant cooling system where condensation could be a problem. This temperature calculation can assist users in making that determination in absence of a full heat and mass balance calculation.

Field: Dimensions for the CTF Calculation

This field is also an integer and refers to the detail level of the calculation. A value of “1” states that the user is only interested in a one-dimensional calculation. This is appropriate for electric resistance heating and for hydronic heating (when boiler/hot water heater performance is not affected by return and supply water temperatures). A value of “2” will trigger a two-dimensional solution for this surface only. This may be necessary for hydronic radiant cooling situations since chiller performance is affected by the water temperatures provided.

A few things should be noted about requesting two-dimensional solutions. First, the calculation of the conduction transfer functions (CTF) is fairly intensive and will require a significant amount of computing time. Second, the solution regime is two-dimensional internally but it has a one-dimensional boundary condition imposed at the inside and outside surface (i.e., surface temperatures are still isothermal as if the surface was one-dimensional).

Field: Tube Spacing

This field defines how far apart in meters the hydronic tubing or electrical resistance wires are spaced in the direction perpendicular to the main direction of heat transfer. Note that this parameter is only used for two-dimensional solutions (see previous field).

Field: Outside Layer

Each construction must have at least one layer. This field defines the material name associated with the layer on the outside of this construction—outside referring to the side that is not exposed to the zone but rather the opposite side environment, whether this is the outdoor environment or another zone. Material layers are defined based on their thermal properties elsewhere in the input file (ref: Material and Material Properties and Materials for Glass Windows and Doors). As noted above, the outside layer should NOT be a film coefficient since EnergyPlus will calculate convection and radiation heat transfer more precisely.

Field(s) 2-10: Layers

The next fields are optional and the number of them showing up in a particular Construction definition depends solely on the number of material layers present in that particular construction. The data expected is identical to the outside layer field (see previous field description). The order of the remaining layers is important and should be listed in order of occurrence from the one just inside the outside layer until the inside layer is reached. As noted above, the inside layer should NOT be a film coefficient since EnergyPlus will calculate convection and radiation heat transfer more precisely.

```

Construction:InternalSource,
    \memo Start with outside layer and work your way to the inside Layer
    \memo Up to 10 layers total, 8 for windows
    \memo Enter the material name for each layer
A1 , \field Name
    \required-field
    \type alpha
    \reference ConstructionNames
N1 , \field Source Present After Layer Number
    \required-field
    \type integer
    \minimum 1
    \note refers to the list of materials which follows
N2 , \field Temperature Calculation Requested After Layer Number
    \required-field
    \type integer
    \note refers to the list of materials which follows
N3 , \field Dimensions for the CTF Calculation
    \required-field
    \type integer
    \minimum 1
    \maximum 2
    \note 1 = 1-dimensional calculation, 2 = 2-dimensional calculation
N4 , \field Tube Spacing
    \required-field
    \type real
    \units m
    \note uniform spacing between tubes or resistance wires in direction
    \note perpendicular to main intended direction of heat transfer
A2 , \field Outside Layer
    \required-field
    \type object-list
    \object-list MaterialName
A3 , \field Layer 2
    \type object-list
    \object-list MaterialName
<reduced for brevity>
A11; \field Layer 10
    \type object-list
    \object-list MaterialName

```

Composite Wall Constructions

Standard constructions in EnergyPlus are built with the materials and layers described earlier. However, some configurations will not be adequately represented by using this approach. The Reference Data Set CompositeWallConstructions.idf contains constructions and associated materials for a set of **composite** walls. These are walls—such as stud walls—that have complicated heat-flow paths so that the conduction is two- or three-dimensional.

The materials here are **not** real materials but are “equivalent” materials obtained from finite-difference modeling.⁴ EnergyPlus will calculate conduction transfer functions using these materials. The heat transfer based on these conduction transfer functions will then be very close to what would be calculated with a two- or three-dimensional heat transfer calculation.

For stud walls, using these composite constructions will give more accurate heat flow than you would get by manually dividing the wall into a stud section and a non-stud section.

If your wall’s exterior or interior roughness or thermal, solar or visible absorptances are different from those in the data set, you can make the appropriate changes to the first

⁴ The thickness, conductivity, density and specific heat values of the material layers for the different constructions have been taken from the ASHRAE report “Modeling Two- and Three-Dimensional Heat Transfer through Composite Wall and Roof Assemblies in Hourly Energy Simulation Programs (1145-TRP),” by Enermodal Engineering Limited, Oak Ridge National Laboratory, and the Polish Academy of Sciences, January 2001.

material (the outside layer) or the third material (the inside layer). **None of the other values should be changed.**

Complete description of the CompositeWallConstructions data set are found in the OutputDetailsAndExamples document.

Construction:WindowDataFile

The WINDOW 5 program, which does a thermal and optical analysis of a window under different design conditions, writes a data file (“Window5 data file”) containing a description of the window that was analyzed. The Construction:WindowDataFile object allows a window to be read in from the Window5 data file—see “Importing Windows from WINDOW 5.” For information on adding a shading device to the window see “WindowProperty:ShadingControl.”

Field: Name

This is the name of a window on the Window5 data file. An error will result if EnergyPlus cannot find a window of this name on the file, or if the file, called Window5DataFile.dat, is not present. By default, the file Window5DataFile.dat is expected to be in the same folder as the EnergyPlus.exe file (the “run” folder). For details on what is done with the data if a matching window is found on the file see “Importing Windows from WINDOW 5.”

Field: File Name

This is the file name of the Window5 data file that contains the Window referenced in the previous field. You may specify this file name completely, including path, but it must be 60 characters or less. You may also specify it using relative path but that path must be relative to the “run” folder.

The IDD of the object:

```
Construction:WindowDataFile,
    \memo Initiates search of the Window5 data file for a window called Name.
A1 , \field Name
    \required-field
    \type alpha
    \reference ConstructionNames
A2 ; \field File Name
    \retaincase
    \note default file name is "Window5DataFile.dat"
    \note limit on this field is 100 characters.
```

Input Example

```
Construction:WindowDataFile,
DoubleClear;           !- Name of a Window on the Window5 Data File
! Note - Window5DataFile.dat is presumed to be in the "run" folder where EnergyPlus.exe is

FenestrationSurface:Detailed,
Zn001:Wall1001:Win001, !- Name
Window,                !- Class
DoubleClear,         !- Construction Name
Zn001:Wall1001,,       !- Base Surface Name, and Target (if applicable)
0.5,                   !- View Factor to Ground
,                      !- Window Shading Control name
,                      !- Frame/Divider name
1.0,                   !- Multiplier
4,                     !- Number of vertices
0.548, 0.0, 2.5000,    !- X,Y,Z of Vertices
0.548, 0.0, 0.5000,
5.548, 0.0, 0.5000,
5.548, 0.0, 2.5000;
```

An example showing use of specific data file name and relative path location follows:

```
Construction:WindowDataFile,  
  DoubleClear,      !- Name of a Window on the Window5 Data File  
  DataSets\MyWindow5.dat; !- Filename is "MyWindow5.dat" and is in the DataSets folder relative to  
                        !- the "run" folder where EnergyPlus.exe is.
```

Construction Element Outputs

An optional report (contained in **eplusout.eio**) gives calculational elements for the materials and constructions used in the input. These reports are explained fully in the Output Details and Examples document.

Group – Thermal Zone Description/Geometry

Without thermal zones and surfaces, the building can't be simulated. This group of objects (Zone, BuildingSurface) describes the thermal zone characteristics as well as the details of each surface to be modeled. Included here are shading surfaces.

Zone

This element sets up the parameters to simulate each thermal zone of the building.

Field: Direction of Relative North

The Zone North Axis is specified **relative to the Building North Axis**. This value is specified in degrees (clockwise is positive). For more information, see the figure below as well as the description under "GlobalGeometryRules".

Field(s): (X,Y,Z) Origin

The X,Y,Z coordinates of a zone origin can be specified, for convenience in vertice entry. Depending on the values in "GlobalGeometryRules" (see description later in this section), these will be used to completely specify the building coordinates in "world coordinate" or not. Zone Origin coordinates are specified **relative to the Building Origin (which always 0,0,0)**. The following figure illustrates the use of Zone North Axis as well as Zone Origin values.

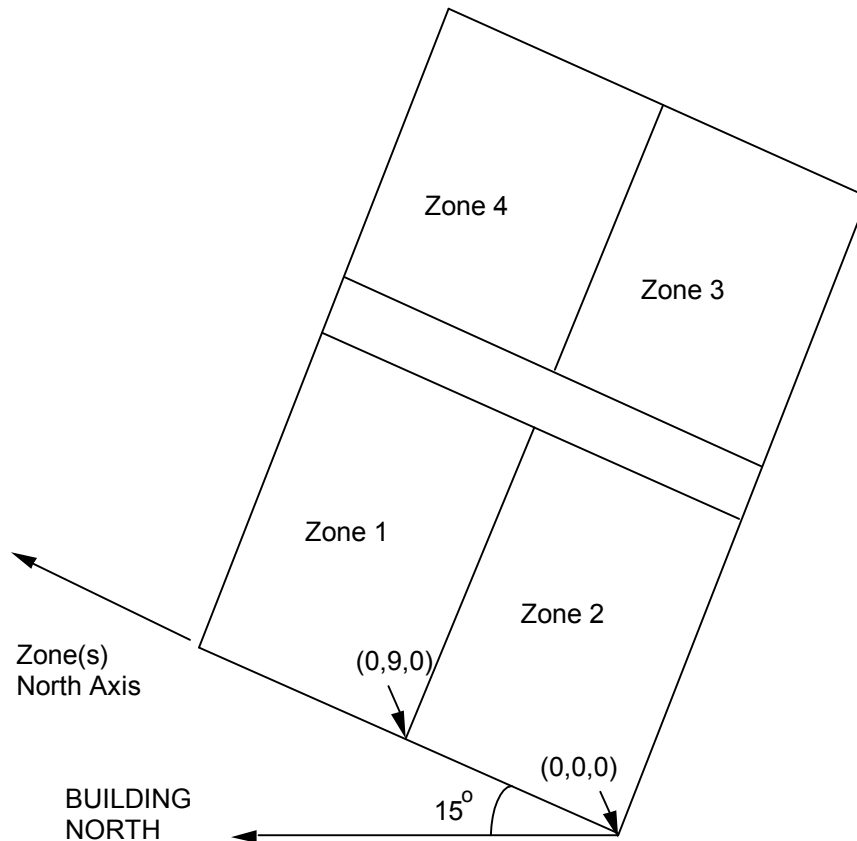


Figure 17. Illustration of Zone North Axis and Origins

Field: Type

Zone type is currently unused.

Field: Multiplier

Zone Multiplier is designed as a “multiplier” for zone loads. It takes the calculated load for the inputted zone and multiplies it and sends the multiplied load to the attached system to meet the demand. The system will have to be specified to meet the entire multiplied zone load and will report the amount of the load it can meet in the Zone/Sys Sensible Heating or Cooling Energy/Rate report variable. The default is 1.

Field: Ceiling Height

Zone ceiling height is used in several areas within EnergyPlus. Energyplus automatically calculates the zone ceiling height (m) from the average height of the zone. If this field is 0.0, negative or **autocalculate**, then the calculated zone ceiling height will be used in subsequent calculations. If this field is positive, then the calculated zone ceiling height will not be used -- the number entered here will be used as the zone ceiling height. If this number differs significantly from the calculated ceiling height, then a warning message will be issued. If a zone ceiling height is entered, but no Volume is entered, then the floor area (if there is one) times the zone ceiling height will be used as the volume.

Note that the Zone Ceiling Height is the distance from the Floor to the Ceiling in the Zone, not an absolute height from the ground.

Field: Volume

Zone volume is used in several areas within EnergyPlus. EnergyPlus automatically calculates the zone volume (m³) from the zone geometry given by the surfaces that belong to the zone. If this field is 0.0, negative or **autocalculate**, then the calculated zone volume will be used in subsequent calculations. If this field is positive, then it will be used as the zone volume. If this number differs significantly from the calculated zone volume a warning message will be issued. For autocalculate to work properly, the zone must be enclosed by the entered walls. Note that indicating the volume to be calculated but entering a positive ceiling height in the previous field will cause the volume to be calculated as the floor area (if > 0) times the entered ceiling height; else the volume will be calculated from the described surfaces. If this field is positive, any ceiling height positive value will not be used in volume calculations.

Field: Zone Inside Convection Algorithm

The Zone Inside Convection Algorithm field is optional. This field specifies the convection model to be used in the zone. The choices are: **Simple** (constant natural convection - ASHRAE), **Detailed** (variable natural convection based on temperature difference - ASHRAE), **CeilingDiffuser** (ACH based forced and mixed convection correlations for ceiling diffuser configuration with simple natural convection limit), and **TrombeWall** (variable natural convection in an enclosed rectangular cavity). See the Inside Convection Algorithm object for further descriptions of the available models.

If omitted or blank, the algorithm specified in the Inside Convection Algorithm object is the default.

Field: Zone Outside Convection Algorithm

The Zone Outside Convection Algorithm field is optional. This field specifies the convection model to be used in the zone. The choices are: **Simple**, **Detailed**, **BLAST**, **TARP**, **DOE-2**, and **MoWITT**. The simple convection model applies heat transfer coefficients depending on the roughness and windspeed. This is a combined heat transfer coefficient that includes radiation to sky, ground, and air. The correlation is based on Figure 1, Page 25.1 (Thermal and Water Vapor Transmission Data), 2001 ASHRAE Handbook of Fundamentals.

The other convection models apply heat transfer coefficients depending on the roughness, windspeed, and terrain of the building's location. These are *convection only* heat transfer coefficients; radiation heat transfer coefficients are calculated automatically by the program. All algorithms are described more fully in the Engineering Reference.

If omitted or blank, the algorithm specified in the Inside Convection Algorithm object is the default.

Field: Part of Total Floor Area

This optional field defaults to Yes if not specified. The field is used to show when a zone is not part of the Total Floor Area as shown in the Annual Building Utility Performance Summary tables. Specifically, when No is specified, the area is excluded from both the conditioned floor area and the total floor area in the Building Area sub table and the Normalized Metrics sub tables.

```
Zone,  
  \format vertices  
  A1 , \field Name  
      \required-field  
      \type alpha  
      \reference ZoneNames  
      \reference OutFaceEnvNames  
      \reference ZoneAndZoneListNames  
  N1 , \field Direction of Relative North  
      \units deg  
      \type real  
      \default 0  
  N2 , \field X Origin  
      \units m  
      \type real  
      \default 0  
  N3 , \field Y Origin  
      \units m  
      \type real  
      \default 0  
  N4 , \field Z Origin  
      \units m  
      \type real  
      \default 0
```

```

N5 , \field Type
    \type integer
    \maximum 1
    \minimum 1
    \default 1
N6 , \field Multiplier
    \type integer
    \minimum 1
    \default 1
N7 , \field Ceiling Height
    \note If this field is 0.0, negative or autocalculate, then the average height
    \note of the zone is automatically calculated and used in subsequent calculations.
    \note If this field is positive, then the number entered here will be used.
    \note Note that the Zone Ceiling Height is the distance from the Floor to
    \note the Ceiling in the Zone, not an absolute height from the ground.
    \units m
    \type real
    \autocalculatable
    \default autocalculate
N8 , \field Volume
    \note If this field is 0.0, negative or autocalculate, then the volume of the zone
    \note is automatically calculated and used in subsequent calculations.
    \note If this field is positive, then the number entered here will be used.
    \units m3
    \type real
    \autocalculatable
    \default autocalculate
A2 , \field Zone Inside Convection Algorithm
    \type choice
    \key Simple
    \key Detailed
    \key CeilingDiffuser
    \key TrombeWall
    \note Will default to same value as SurfaceConvectionAlgorithm:Inside object
    \note setting this field overrides the default SurfaceConvectionAlgorithm:Inside for this zone
    \note Simple = constant natural convection (ASHRAE)
    \note Detailed = variable natural convection based on temperature difference (ASHRAE)
    \note CeilingDiffuser = ACH based forced and mixed convection correlations
    \note for ceiling diffuser configuration with simple natural convection limit
    \note TrombeWall = variable natural convection in an enclosed rectangular cavity
A3, \field Zone Outside Convection Algorithm
    \note Will default to same value as SurfaceConvectionAlgorithm:Outside object
    \note setting this field overrides the default SurfaceConvectionAlgorithm:Outside for this zone
    \type choice
    \key Simple
    \key Detailed
    \key BLAST
    \key TARP
    \key DOE-2
    \key MoWiTT
A4; \field Part of Total Floor Area
    \type choice
    \key Yes
    \key No
    \default Yes

```

And, an IDF example:

```

Zone, DORM ROOMS AND COMMON AREAS, ! Zone Name
0.0000000E+00, ! Direction of Relative North
0.0000000E+00, ! X Origin {m}
6.096000 , ! Y Origin {m}
0.0000000E+00, ! Z Origin {m}
1, ! Type
1, ! Multiplier
-100.0000 , ! Ceiling Height {m}
0.0000000E+00; ! Volume {m**3}

```

Zone Outputs

Each zone command produces zone outputs that echo the input fields above. However, the values to be used for the Zone Ceiling Height and Volume will be displayed if the entered fields are negative or zero. Details on this report are shown in the Output Details and Examples document.

In addition to the invariant outputs for the zone, atmospheric temperature and wind speed due to zone centroid heights are calculated. Rationale and further details on these values is shown in the Weather Station and Site Atmospheric Variation objects. These are described in the Group -- Location – Climate – Weather File Access.

```

Zone,Average,Zone Outdoor Dry Bulb [C]
Zone,Average,Zone Outdoor Wet Bulb [C]
Zone,Average,Zone Outdoor Wind Speed [m/s]

```

Zone Outdoor Dry Bulb [C]

The outdoor air dry-bulb temperature calculated at the height above ground of the zone centroid.

Zone Outdoor Wet Bulb [C]

The outdoor air wet-bulb temperature calculated at the height above ground of the zone centroid.

Zone Outdoor Wind Speed [m/s]

The outdoor wind speed calculated at the height above ground of the zone centroid.

Zone Thermal Output(s)

In addition to the canned Surface reports (view the Reports section later in this document) and surface variables (above), the following variables are available for all zones:

```

Zone,Sum,Zone Total Internal Radiant Heat Gain [J]
Zone,Sum,Zone Total Internal Visible Heat Gain [J]
Zone,Sum,Zone Total Internal Convective Heat Gain [J]
Zone,Sum,Zone Total Internal Latent Gain [J]
Zone,Sum,Zone Total Internal Total Heat Gain [J]
Zone,Average,Zone Mean Air Temperature [C]
HVAC,Average,Zone/Sys Air Temperature[C]
Zone,Average,Zone Mean Radiant Temperature [C]
Zone,Average,Zone Operative Temperature [C]
HVAC,Average,Zone Air Balance Internal Convective Gains Rate [W]
HVAC,Average,Zone Air Balance Surface Convection Rate [W]
HVAC,Average,Zone Air Balance Interzone Air Transfer Rate [W]
HVAC,Average,Zone Air Balance Outdoor Air Transfer Rate [W]
HVAC,Average,Zone Air Balance System Air Transfer Rate [W]
HVAC,Average,Zone Air Balance Air Energy Storage Rate [W]
HVAC,Average,Zone Air Balance Deviation Rate [W]
HVAC,Sum,Zone/Sys Sensible Heating Energy[J]
HVAC,Sum,Zone/Sys Sensible Cooling Energy[J]
HVAC,Average,Zone/Sys Sensible Heating Rate[W]
HVAC,Average,Zone/Sys Sensible Cooling Rate[W]
HVAC,Average,Zone Air Humidity Ratio[]
HVAC,Average,Zone Air Relative Humidity[%]

```

Two of these are of particular interest:

Zone, Average, Zone Mean Air Temperature [C] HVAC, Average, Zone/Sys Air Temperature [C]

These two variable outputs are/should be identical. However, note that they can be reported at different time intervals. “Zone Mean Air Temperature” is only available on the Zone/HB timestep (Number of Timesteps per Hour) whereas “Zone/Sys Air Temperature” can be reported at the HVAC timestep (which can vary).

Zone Mean Air Temperature [C]

From the code definition, the zone mean air temperature is the average temperature of the air temperatures at the system timestep. Remember that the zone heat balance represents a “well stirred” model for a zone, therefore there is only one mean air temperature to represent the air temperature for the zone.

Zone/Sys Air Temperature [C]

This is very similar to the mean air temperature in the last field. The “well stirred” model for the zone is the basis, but this temperature is also available at the “detailed” system timestep.

Zone Mean Radiant Temperature [C]

The Mean Radiant Temperature (MRT) in degrees Celsius of a space is really the measure of the combined effects of temperatures of surfaces within that space. The larger the surface area and the closer one is to it, the more effect the surface temperature of that surface has on each other. The MRT is the measure of all these surface areas and temperatures.

Zone Operative Temperature [C]

Zone Operative Temperature (OT) is the average of the Zone Mean Air Temperature (MAT) and Zone Mean Radiant Temperature (MRT), $OT = 0.5 \cdot MAT + 0.5 \cdot MRT$. This report variable is not affected by the type of thermostat controls in the zone, and does not include the direct effect of high temperature radiant systems. See also Zone Thermostat Operative Temperature.

Zone Air Balance Internal Convective Gains Rate [W]

The Zone Air Balance Internal Convective Gains Rate is the sum, in watts, of heat transferred to the zone air from all types of internal gains, including people, lights, equipment etc. This and the following provide results on the load components of the zone air heat balance. This field is not multiplied by zone or group multipliers.

Zone Air Balance Surface Convection Rate [W]

The Zone Air Balance Surface Convection Rate is the sum, in watts, of heat transferred to the zone air from all the surfaces. This field is not multiplied by zone or group multipliers.

Zone Air Balance Interzone Air Transfer Rate [W]

The Zone Air Balance Interzone Air Transfer Rate is the sum, in watts, of heat transferred to the zone air from all the transfers of air from other thermal zones. This field is not multiplied by zone or group multipliers.

Zone Air Balance Outdoor Air Transfer Rate [W]

The Zone Air Balance Outdoor Air Transfer Rate is the sum, in watts, of heat transferred to the zone air from all the transfers of air from the out side, such as infiltration. This field is not multiplied by zone or group multipliers.

Zone Air Balance System Air Transfer Rate [W]

The Zone Air Balance System Air Transfer Rate is the sum, in watts, of heat transferred to the zone air by HVAC air systems. This field is not multiplied by zone or group multipliers.

Zone Air Balance Air Energy Storage Rate [W]

The Zone Air Balance Air Energy Storage Rate is the heat stored, in watts, in the zone air as result of zone air temperature changing from one timestep to the next. This field is not multiplied by zone or group multipliers.

Zone Air Balance Deviation Rate [W]

The Zone Air Balance Deviation Rate is the imbalance, in watts, in the energy balance for zone air. The value should be near zero but will become non-zero if zone conditions are changing rapidly or erratically. This field is not multiplied by zone or group multipliers. (This report variable is only generated if the user has set a computer system environment variable DisplayAdvancedReportVariables equal to "yes".)

Zone/Sys Sensible Heating Energy [J]

This report variable represents the sensible heating energy in Joules that is actually supplied by the system to that zone for the timestep reported. This is the sensible heating rate multiplied by the simulation timestep. This is calculated and reported from the Correct step in the Zone Predictor-Corrector module. This field is not multiplied by zone or group multipliers.

Zone/Sys Sensible Heating (and Cooling) Energy (and Rate) all report the heating or cooling delivered by the HVAC system to a zone. These values are calculated by multiplying the supply air mass flow rate by the difference between the supply air temperature and the zone air temperature. This does not always indicate the operation of heating or cooling coils. For example, cooling will be reported if the supply air is cooled due to the introduction of outside air, even if all coils are off.

Note that these variables are calculated at the system timestep. When reported at the "detailed" reporting frequency, these variable will never show heating and cooling both in the same system timestep. If reported at a frequency less than "Detailed" (for example, Hourly) values may appear in both the heating and cooling variable for the same hour if the system cooled the zone for part of the reporting period and heated the zone for another part of the reporting period.

Zone/Sys Sensible Cooling Energy [J]

This report variable represents the sensible cooling energy in Joules that is actually supplied by the system to that zone for the timestep reported. This is the sensible cooling rate multiplied by the simulation timestep. This is calculated and reported from the Correct step in the Zone Predictor-Corrector module. This field is not multiplied by zone or group multipliers.

Zone/Sys Sensible Heating Rate [W]

This report variable represents the sensible heating rate in Watts that is actually supplied by the system to that zone for the timestep reported. This is calculated and reported from the Correct step in the Zone Predictor-Corrector module. This field is not multiplied by zone or group multipliers.

Zone/Sys Sensible Cooling Rate [W]

This report variable represents the sensible cooling rate in Watts that is actually supplied by the system to that zone for the timestep reported. This is calculated and reported from the Correct step in the Zone Predictor-Corrector module. This field is not multiplied by zone or group multipliers.

Zone Air Humidity Ratio []

This report variable represents the air humidity ratio after the correct step for each zone. The humidity ratio is the mass of water vapor to the mass of dry air contained in the zone in (kg water/kg air) and is unitless.

Zone Air Relative Humidity [%]

This report variable represents the air relative humidity after the correct step for each zone. The relative humidity is in percent and uses the Zone Air Temperature, the Zone Air Humidity Ratio and the Outside Barometric Pressure for calculation.

Zone Total Internal Radiant Heat Gain [J]

This report variable represents the sum of radiant gains from specific internal sources (e.g. equipment) throughout the zone in joules. This includes radiant gain from People, Lights, Electric Equipment, Gas Equipment, Other Equipment, Hot Water Equipment, and Steam Equipment.

Zone-Total Internal Visible Heat Gain [J]

This report variable expresses the sum of heat gain in joules that is the calculated short wavelength radiation gain from lights in the zones. This calculation uses the total energy from lights and the fraction visible to realize this value, summed over the zones in the simulation.

Zone Total Internal Convective Heat Gain [J]

This report variable represents the sum of convective gains from specific sources (e.g. equipment) throughout the zone in joules. This includes convective gain from People, Lights, Electric Equipment, Gas Equipment, Other Equipment, Hot Water Equipment, and Steam Equipment.

Zone Total Internal Latent Gain [J]

This report variable represents the sum of latent gains from specific internal sources (e.g. equipment) throughout the zone in joules. This includes latent gain from People, Electric Equipment, Gas Equipment, Other Equipment, Hot Water Equipment, and Steam Equipment.

Zone Total Internal Total Heat Gain [J]

This report variable represents the sum of all heat gains throughout the zone in joules. This includes all heat gains from People, Lights, Electric Equipment, Gas Equipment, Other Equipment, Hot Water Equipment, and Steam Equipment.

ZoneList

The ZoneList object defines a list of Zone objects. It is primarily used with the ZoneGroup object to provide a generalized way for doing "Floor Multipliers". (See the ZoneGroup description below.) The associated ZoneList output variables also provide a way to aggregate and organize zone loads.

Zone lists are not exclusive. A zone can be referenced by more than one ZoneList object.


```

ZoneList,
  \min-fields 2
  \extensible:1 - repeat last field, remembering to remove ; from "inner" fields.
A1 , \field Zone List Name
  \required-field
  \type alpha
  \reference ZoneListNames
  \reference ZoneAndZoneListNames
A2 , \field Zone 1 Name
  \required-field
  \type object-list
  \object-list ZoneNames
A3 , \field Zone 2 Name
  \type object-list
  \object-list ZoneNames
--reduced for brevity --
A21; \field Zone 20 Name
  \type object-list
  \object-list ZoneNames

```

Field: Zone List Name

The name of the ZoneList object. Must be unique across ZoneLists.

Field: Zone 1 – 20 Name

Reference to a Zone object. This field is extensible; for greater than 20 zones, edit the IDD to add more *Zone Name* fields.

```

ZoneList,
Mid Floor List,  !- Name
Mid West Zone,  !- Zone 1 Name
Mid Center Zone, !- Zone 2 Name
Mid East Zone;  !- Zone 3 Name

```

ZoneList Outputs

The following output variables are reported by the ZoneList object:

```

HVAC,Average,Zone List Sensible Heating Rate[W]
HVAC,Average,Zone List Sensible Cooling Rate[W]
HVAC,Sum,Zone List Sensible Heating Energy[J]
HVAC,Sum,Zone List Sensible Cooling Energy[J]

```

All ZoneList variables are the sum of the corresponding Zone variables. *Zone Multiplier* fields in the Zone objects are also taken into account.

ZoneGroup

The ZoneGroup object adds a multiplier to a ZoneList. This can be used to reduce the amount of input necessary for simulating repetitive structures, such as the identical floors of a multi-story building. To create a "Floor Multiplier", use the ZoneList object to organize several zones into a typical floor. Then use the *Zone List Multiplier* field in the ZoneGroup object to multiply the system load for the zones in the list will also be multiplied. Zones with a *Multiplier* field greater than one in the Zone object are effectively double-multiplied.

NOTE: Although ZoneLists are not exclusive by themselves, ZoneLists used to form a ZoneGroup are exclusive; the ZoneLists used with a ZoneGroup must not have any zones in common.

Tips for Multi-Story Simulations:

- For floors that are multiplied, connect exterior boundary conditions of the floor to the ceiling and vice versa.
- Since exterior convection coefficients vary with elevation, locate the typical middle floor zones midheight between the lowest and highest middle floors to be modeled.

- Shading must be identical for all multiplied floors or less accurate results may be obtained by using the zone list multiplier.

ZoneGroup and ZoneList can also be used to simulate other repetitive cases, such as clusters of zones on the ground.

```
ZoneGroup,
  \min-fields 2
A1 , \field Zone Group Name
  \required-field
  \type alpha
A2, \field Zone List Name
  \required-field
  \type object-list
  \object-list ZoneListNames
N1; \field Zone List Multiplier
  \type integer
  \default 1
  \minimum 1
```

Field: Zone Group Name

The name of the ZoneGroup object. This must be unique across ZoneGroups.

Field: Zone List Name

Reference to a ZoneList object. The zones in the list constitute the zones in the group.

Field: Zone List Multiplier

An integer multiplier.

```
ZONE GROUP,
Mid Floor,  !- Zone Group Name
Mid Floor List,  !- Zone List Name
8;  !- Zone List Multiplier
```

ZoneGroup Outputs

The following output variables are reported by the ZoneGroup object:

```
HVAC,Average,Zone Group Sensible Heating Rate[W]
HVAC,Average,Zone Group Sensible Cooling Rate[W]
HVAC,Sum,Zone Group Sensible Heating Energy[J]
HVAC,Sum,Zone Group Sensible Cooling Energy[J]
```

All ZoneGroup variables report the associated ZoneList value multiplied by the *Zone List Multiplier*.

Surface(s)

What's a building without surfaces?

EnergyPlus allows for several surface types:

- **BuildingSurface:Detailed**
- **FenestrationSurface:Detailed**
- **Shading:Site:Detailed**
- **Shading:Building:Detailed**
- **Shading:Zone:Detailed**

Each of the preceding surfaces has “correct” geometry specifications. BuildingSurface and Fenestration surfaces (heat transfer surfaces) are used to describe the important elements of the building (walls, roofs, floors, windows, doors) that will determine the interactions of the building surfaces with the outside environment parameters and the internal space requirements. These surfaces are also used to represent “interzone” heat transfer. During specification of surfaces, several “outside” environments may be chosen:

- **Ground** – when the surface is in touch with the ground (e.g. slab floors)

- **Outdoors** – when the surface is an external surface (e.g. walls, roofs, windows directly exposed to the outdoor conditions)
- **Surface** – when the surface is
 - An adiabatic internal zone surface
 - A interzone surface
- **Zone** – when the surface is
 - A interzone surface in which the other surface is not put in the input file.
- **OtherSideCoefficients** – when using a custom profile to describe the external conditions of the surface (advanced concept – covered in subject: SurfaceProperty:OtherSideCoefficients)
- **OtherSideConditionsModel** – when using specially modeled components, such as active solar systems, that cover the outside surface and modify the conditions it experiences.

Surface items must also specify an “outside face object”. This is

- Current surface name – for adiabatic internal surfaces.
- A surface name in another zone – for interzone heat transfer.
- An “opposing” surface name (in the current zone) – for representing “middle” zones.

Zone items must also specify an “outside face object”. This is

- The zone that contains the other surface that is adjacent to this surface but is not entered in input.

Note that heat transfer surfaces are fully represented with each description. As stated earlier in the Construction description, materials in the construction (outside to inside) are included but film coefficients neither inside nor outside are used in the description – these are automatically calculated during the EnergyPlus run. Interzone surfaces which do not have a symmetrical construction (such as a ceiling/floor) require two Construction objects with the layers in reverse order. For example, CEILING with carpet, concrete, ceiling tile and FLOOR with ceiling tile, concrete, carpet. If interzone surfaces have a symmetrical construction, the specification for the two surfaces can reference the same Construction.

Shading surfaces are used to describe aspects of the site which do not directly impact the physical interactions of the environmental parameters but may significantly shade the building during specific hours of the day or time so the year (e.g. trees, bushes, mountains, nearby buildings which aren't being simulated as part of this facility, etc.)

Note that surfaces which are part of the simulated building automatically shade other parts of the building as geometry and time of day dictate – there is no need on the user's part to include surfaces that might be in other zones for shading.

Another surface type:

- **InternalMass**

is used to specify the construction/material parameters and area of items within the space that are important to heat transfer calculations but not necessarily important geometrically. (For example, furniture within the space – particularly for large spaces). Internal mass can also be used for internal walls that are not needed (when FullInteriorAndExterior Solar Distribution is in effect) for solar distribution or to represent many, if not all, interior walls when solar is distributed to the floors only.

Interzone Surfaces

EnergyPlus can quite accurately simulate the surface heat exchange between two zones. However, this accuracy is not always required and using interzonal heat transfer does add to the complexity of the calculations – thus requiring more CPU time to simulate. More information about interzonal heat transfer calculations is contained in the Engineering Reference. Some simple guidelines are presented here – for three cases: adiabatic surfaces, surfaces in “middle” zones, and surfaces where heat transfer is “expected” (e.g. between a residence and an unheated, attached garage).

- **Adiabatic Surfaces** – These surfaces would be represented as common surfaces (between two zones) where both zones are typically the same temperature. Thus, no transfer is expected in the surface from one zone to the next. These surfaces should be described as simply internal surfaces for the zone referencing as their Outside Boundary Condition Object (see later description in individual surface objects) their own surface names.
- **Surfaces in Middle Zones** – Middle zones in a building can be simulated using a judicious use of surfaces and zone multipliers to effect the correct “loads” for the building. Thus, middle zone behavior can be simulated without modeling the adjacent zones. This is done by specifying a surface within the zone. For example, a middle floor zone can be modeled by making the floor the Outside Boundary Condition Object for the ceiling, and the ceiling the Outside Boundary Condition Object for the floor.
- **Surfaces between Zones with differing temperatures** – These zones represent the true use of interzone surfaces. In a residence that has an attached garage, the garage may be unheated/uncooled or at least not conditioned to the same degree as the residence interior. In this case, EnergyPlus can be used to accurately calculate the effects of the differently conditioned space to the other spaces.

Surface View Factors

EnergyPlus uses an area weighted approximation to calculate “view factors” between surfaces within a thermal zone. Each surface uses the total area that it can “see” among the other surfaces. The approximate view factor from this surface to each other surface is then the area of the receiving surface over the sum of areas that is visible to the sending surface.

In order to account in some limited way for the fact that certain surfaces will not see each other, several assumptions have been built into this simple view factor approximation. First, a surface cannot see itself. Second, surfaces with approximately the same azimuth (facing direction) and tilt (“same” being within a built in limit) will not see each other. This means that a window will not see the wall that it is placed on, for example. Third, floors cannot see each other. Fourth, if the surface is a floor, ceiling, roof, or internal mass, the rule for the same azimuth and tilt eliminating radiant exchange between surface is waived when the receiving surface is floor, roof, ceiling, or internal mass as long as both surfaces are not floors.

Note that this does not take into account that surfaces may be “around the corner” from each other and in reality not see each other at all. Rooms are assumed to be convex rather than concave in this method.

To summarize, using the Surface “Class”, the approximate view factors have:

1. No surface sees itself.
2. No Floor sees another floor.
3. All other surface types see Internal Mass.
4. All other surface types see floors.
5. Floors always see ceilings.
6. Floors always see roofs.
7. All other surfaces whose tilt or facing angle differences are greater than 10 degrees see each other.

If geometry is correct, conditions 1,3, and 7 should take care of all surfaces, but the other conditions supply common sense when the geometry is incorrect. More information about the EnergyPlus view factor calculation is contained in the Engineering Reference document.

GlobalGeometryRules

Before the surface objects are explained in detail, a description of geometric parameters used in EnergyPlus will be given. Since the input of surface vertices is common to most of the surface types, it will also be given a separate discussion.

Some flexibility is allowed in specifying surface vertices. This flexibility is embodied in the GlobalGeometryRules class/object in the input file. Note that the parameters specified in this statement are used for all surface vertex inputs – there is no further “flexibility” allowed.

In order to perform shadowing calculations, the building surfaces must be specified. EnergyPlus uses a three dimensional (3D) Cartesian coordinate system for surface vertex specification. This Right Hand coordinate system has the X-axis pointing east, the Y-axis pointing north, and the Z-axis pointing up. See figure below.

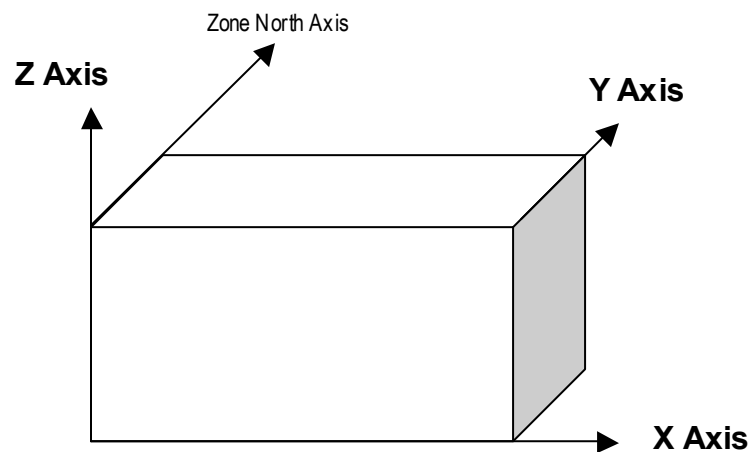


Figure 18. EnergyPlus Coordinate System

```
GlobalGeometryRules,
  \required-object
  \unique-object
  A1, \field Starting Vertex Position
  \required-field
  \note Specified as entry for a 4 sided surface/rectangle
  \note Surfaces are specified as viewed from outside the surface
  \note Shading surfaces as viewed from behind. (towards what they are shading)
  \type choice
  \key UpperLeftCorner
  \key LowerLeftCorner
  \key UpperRightCorner
  \key LowerRightCorner
```

```

A2, \field Vertex Entry Direction
    \required-field
    \type choice
    \key Counterclockwise
    \key Clockwise
A3, \field Coordinate System
    \required-field
    \note relative -- coordinates are entered relative to zone origin
    \note world -- all coordinates entered are "absolute" for this facility
    \note absolute -- same as world
    \type choice
    \key Relative
    \key World
    \key Absolute
A4, \field Daylighting Reference Point Coordinate System
    \type choice
    \key Relative
    \default Relative
    \note Relative -- coordinates are entered relative to zone origin
    \key World
    \note World -- all coordinates entered are "absolute" for this facility
    \key Absolute
    \note absolute -- same as world
A5; \field Rectangular Surface Coordinate System
    \type choice
    \key Relative
    \default Relative
    \note Relative -- Starting corner is entered relative to zone origin
    \key World
    \note World -- Starting corner is entered in "absolute"
    \key Absolute
    \note absolute -- same as world

```

Field: Starting Vertex Position

The shadowing algorithms in EnergyPlus rely on surfaces having vertices in a certain order and positional structure. Thus, the surface translator needs to know the starting point for each surface entry. The choices are: UpperLeftCorner, LowerLeftCorner, UpperRightCorner, or LowerRightCorner. Since most surfaces will be 4 sided, the convention will specify this position as though each surface were 4 sided. Extrapolate 3 sided figures to this convention. For 5 and more sided figures, again, try to extrapolate the best “corner” starting position.

Field: Vertex Entry Direction

Surfaces are always specified as being viewed from the outside of the zone to which they belong. (Shading surfaces are specified slightly differently and are discussed under the particular types). EnergyPlus needs to know whether the surfaces are being specified in counterclockwise or clockwise order (from the Starting Vertex Position). EnergyPlus uses this to determine the outward facing normal for the surface (which is the *facing angle* of the surface – very important in shading and shadowing calculations).

Field: Coordinate System

Vertices can be specified in two ways: using “Absolute”/“World” coordinates, or a **relative** coordinate specification. Relative coordinates allow flexibility of rapid change to observe changes in building results due to orientation and position. “World” coordinates will facilitate use within a CADD system structure.

Relative coordinates make use of both Building and Zone North Axis values as well as Zone Origin values to locate the surface in 3D coordinate space. **World** coordinates do not use these values.

Typically, all zone origin values for “World” coordinates will be (0,0,0) but Building and Zone North Axis values may be used in certain instances (namely the Daylighting Coordinate Location entries).

Field: Daylighting Reference Point Coordinate System

Daylighting reference points need to be specified as well. Again, there can be two flavors; **relative** and **world**. Daylighting reference points must fit within the zone boundaries.

Relative coordinates make use of both Building and Zone North Axis values as well as Zone Origin values to locate the reference point in 3D coordinate space. **World** coordinates do not use these values.

Field: Rectangular Surface Coordinate System

Simple, rectangular surfaces (Wall:Exterior, Wall:Adiabatic, Wall:Underground, Wall:Interzone, Roof, Ceiling:Adiabatic, Ceiling:Interzone, Floor:GroundContact, Floor:Adiabatic, Floor:Interzone) can be specified with their Lower Left Corner as **relative** or **world**.

Relative (default) corners are specified relative to the Zone Origin for each surface. **World** corners would specify the absolute/world coordinate for this corner.

Surfaces

Surfaces make up the buildings and the elements that shade buildings. There are several methods to inputting surfaces, ranging from simple rectangular surfaces to detailed descriptions that describe each vertex in the order specified in the GlobalGeometryRules object. The simple, rectangular surface objects are described first with the more detailed descriptions following.

Walls

Walls are usually vertical (tilt = 90 degrees). These objects are used to describe exterior walls, interior walls (adiabatic), underground walls, and walls adjacent to other zones.

Wall:Exterior

The Wall:Exterior object is used to describe walls that are exposed to the external environment. They receive sun, wind – all the characteristics of the external world. The IDD definition is shown below:

```

Wall:Exterior,
    \memo Used for exterior walls
    \memo View Factor to Ground is automatically calculated.
A1 , \field Name
    \required-field
    \type alpha
    \reference SurfaceNames
    \reference SurfAndSubSurfNames
    \reference AllHeatTranSurfNames
    \reference HeatTranBaseSurfNames
    \reference OutFaceEnvNames
    \reference AllHeatTranAngFacNames
    \reference RadGroupAndSurfNames
    \reference SurfGroupAndHTSurfNames
    \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
    \required-field
    \note To be matched with a construction in this input file
    \type object-list
    \object-list ConstructionNames
A4 , \field Zone Name
    \required-field
    \note Zone the surface is a part of
    \type object-list
    \object-list ZoneNames
N1, \field Azimuth Angle
    \note Facing direction of outside of wall (S=180,N=0,E=90,W=270)
    \minimum 0
    \maximum 360
    \units deg
N2, \field Tilt Angle
    \note Walls are usually tilted 90 degrees
    \default 90
    \minimum 0
    \maximum 180
    \units deg
N3, \field Starting X Coordinate
    \note Starting (x,y,z) coordinate is the Lower Left Corner of the Wall
    \units m
N4, \field Starting Y Coordinate
    \units m
N5, \field Starting Z Coordinate
    \units m
N6. \field Length
    \units m
N7; \field Height
    \units m

```

Field: Name

This is a unique name associated with the exterior wall. It is used in several other places as a reference (e.g. as the base surface name for a Window or Door).

Field: Construction Name

This is the name of the construction (ref: Construction) used in the surface. Regardless of location in the building, the “full” construction (all layers) is used. For example, for an interior wall separating two zones, zone x would have the outside layer (e.g. drywall) as the material that shows in zone y and then the layers to the inside layer – the material that shows in zone x. For symmetric constructions, the same construction can be used in the surfaces described in both zones.

Field: Zone Name

This is the zone name to which the surface belongs.

Field: Azimuth Angle

The Azimuth Angle indicates the direction that the wall faces (outward normal). The angle is specified in degrees where East=90, South=180, West=270, North=0.

Field: Tilt Angle

The tilt angle is the angle (in degrees) that the wall is tilted from horizontal (or the ground). Normally, walls are tilted 90 degrees and that is the default for this field.

Starting Corner for the surface

The rectangular surfaces specify the lower left corner of the surface for their starting coordinate. This is specified with (x,y,z) and can be relative to the zone origin or in world coordinates, depending on the value for rectangular surfaces specified in the GlobalGeometryRules object.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Y Coordinate

This field is the Y coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the wall in meters.

Field: Height

This field is the height of the wall in meters.

Wall:Adiabatic

The Wall:Adiabatic object is used to describe interior walls and partitions. Adiabatic walls are used to describe walls next to zones that have the same thermal conditions (thus, no heat transfer). The IDD definition is shown below:

```

Wall:Adiabatic, \memo used for interior walls
A1 , \field Name
    \required-field
    \type alpha
    \reference SurfaceNames
    \reference SurfAndSubSurfNames
    \reference AllHeatTranSurfNames
    \reference HeatTranBaseSurfNames
    \reference AllHeatTranAngFacNames
    \reference RadGroupAndSurfNames
    \reference SurfGroupAndHTSurfNames
    \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
    \required-field
    \note To be matched with a construction in this input file
    \type object-list
    \object-list ConstructionNames
A3 , \field Zone Name
    \required-field
    \note Zone the surface is a part of
    \type object-list
    \object-list ZoneNames
N1, \field Azimuth Angle
    \note Facing direction of outside of wall (S=180,N=0,E=90,W=270)
    \minimum 0
    \maximum 360
    \units deg
N2, \field Tilt Angle
    \note Walls are usually tilted 90 degrees
    \default 90
    \minimum 0
    \maximum 180
    \units deg
N3, \field Starting X Coordinate
    \note Starting (x,y,z) coordinate is the Lower Left Corner of the Wall
    \units m
N4, \field Starting Y Coordinate
    \units m
N5, \field Starting Z Coordinate
    \units m
N6. \field Length
    \units m
N7; \field Height
    \units m

```

Field: Name

This is a unique name associated with the interior wall. It is used in several other places as a reference (e.g. as the base surface name for a Window or Door).

Field: Construction Name

This is the name of the construction (ref: Construction) used in the surface. Regardless of location in the building, the “full” construction (all layers) is used. For example, for an interior wall separating two zones, zone x would have the outside layer (e.g. drywall) as the material that shows in zone y and then the layers to the inside layer – the material that shows in zone x. For symmetric constructions, the same construction can be used in the surfaces described in both zones.

Field: Zone Name

This is the zone name to which the surface belongs.

Field: Azimuth Angle

The Azimuth Angle indicates the direction that the wall faces (outward normal). The angle is specified in degrees where East=90, South=180, West=270, North=0.

Field: Tilt Angle

The tilt angle is the angle (in degrees) that the wall is tilted from horizontal (or the ground). Normally, walls are tilted 90 degrees and that is the default for this field.

Starting Corner for the surface

The rectangular surfaces specify the lower left corner of the surface for their starting coordinate. This is specified with (x,y,z) and can be relative to the zone origin or in world coordinates, depending on the value for rectangular surfaces specified in the GlobalGeometryRules object.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Y Coordinate

This field is the Y coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the wall in meters.

Field: Height

This field is the height of the wall in meters.

Wall:Underground

The Wall:Underground object is used to describe walls with ground contact. The temperature at the outside of the wall is the temperature in the GroundTemperature:BuildingSurface object. The IDD definition is shown below:

```

Wall:Underground, \memo used for interior walls
A1 , \field Name
    \required-field
    \type alpha
    \reference SurfaceNames
    \reference SurfAndSubSurfNames
    \reference AllHeatTranSurfNames
    \reference HeatTranBaseSurfNames
    \reference AllHeatTranAngFacNames
    \reference RadGroupAndSurfNames
    \reference SurfGroupAndHTSurfNames
    \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
    \required-field
    \note To be matched with a construction in this input file
    \type object-list
    \object-list ConstructionNames
A3 , \field Zone Name
    \required-field
    \note Zone the surface is a part of
    \type object-list
    \object-list ZoneNames
N1, \field Azimuth Angle
    \note Facing direction of outside of wall (S=180,N=0,E=90,W=270)
    \minimum 0
    \maximum 360
    \units deg
N2, \field Tilt Angle
    \note Walls are usually tilted 90 degrees
    \default 90
    \minimum 0
    \maximum 180
    \units deg
N3, \field Starting X Coordinate
    \note Starting (x,y,z) coordinate is the Lower Left Corner of the Wall
    \units m
N4, \field Starting Y Coordinate
    \units m
N5, \field Starting Z Coordinate
    \units m
N6. \field Length
    \units m
N7; \field Height
    \units m

```

Field: Name

This is a unique name associated with the underground wall. It is used in several other places as a reference (e.g. as the base surface name for a Window or Door).

Field: Construction Name

This is the name of the construction (ref: Construction) used in the surface. Regardless of location in the building, the “full” construction (all layers) is used. For example, for an interior wall separating two zones, zone x would have the outside layer (e.g. drywall) as the material that shows in zone y and then the layers to the inside layer – the material that shows in zone x. For symmetric constructions, the same construction can be used in the surfaces described in both zones.

Field: Zone Name

This is the zone name to which the surface belongs.

Field: Azimuth Angle

The Azimuth Angle indicates the direction that the wall faces (outward normal). The angle is specified in degrees where East=90, South=180, West=270, North=0.

Field: Tilt Angle

The tilt angle is the angle (in degrees) that the wall is tilted from horizontal (or the ground). Normally, walls are tilted 90 degrees and that is the default for this field.

Starting Corner for the surface

The rectangular surfaces specify the lower left corner of the surface for their starting coordinate. This is specified with (x,y,z) and can be relative to the zone origin or in world coordinates, depending on the value for rectangular surfaces specified in the GlobalGeometryRules object.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Y Coordinate

This field is the Y coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the wall in meters.

Field: Height

This field is the height of the wall in meters.

Wall:Interzone

The Wall:Interzone object is used to describe walls adjacent to zones that are significantly different conditions than the zone with this wall.. The IDD definition is shown below:

```

Wall: Interzone, \memo used for interzone walls (walls between zones)
A1 , \field Name
    \required-field
    \type alpha
    \reference SurfaceNames
    \reference SurfAndSubSurfNames
    \reference AllHeatTranSurfNames
    \reference HeatTranBaseSurfNames
    \reference AllHeatTranAngFacNames
    \reference RadGroupAndSurfNames
    \reference SurfGroupAndHTSurfNames
    \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
    \required-field
    \note To be matched with a construction in this input file
    \type object-list
    \object-list ConstructionNames
A3 , \field Zone Name
    \required-field
    \note Zone for the inside of the surface
    \type object-list
    \object-list ZoneNames
A4 , \field Outside Boundary Condition Object
    \required-field
    \note Specify a surface name in an adjacent zone for known interior walls.
    \note Specify a zone name of an adjacent zone to automatically generate the interior wall in the
adjacent zone.
    \type object-list
    \object-list OutFaceEnvNames
N1, \field Azimuth Angle
    \note Facing direction of outside of wall (S=180,N=0,E=90,W=270)
    \minimum 0
    \maximum 360
    \units deg
N2, \field Tilt Angle
    \note Walls are usually tilted 90 degrees
    \default 90
    \minimum 0
    \maximum 180
    \units deg
N3, \field Starting X Coordinate
    \note Starting (x,y,z) coordinate is the Lower Left Corner of the Wall
    \units m
N4, \field Starting Y Coordinate
    \units m
N5, \field Starting Z Coordinate
    \units m
N6. \field Length
    \units m
N7; \field Height
    \units m

```

Field: Name

This is a unique name associated with the interzone wall. It is used in several other places as a reference (e.g. as the base surface name for a Window or Door).

Field: Construction Name

This is the name of the construction (ref: Construction) used in the surface. Regardless of location in the building, the “full” construction (all layers) is used. For example, for an interior wall separating two zones, zone x would have the outside layer (e.g. drywall) as the material that shows in zone y and then the layers to the inside layer – the material that shows in zone x. For symmetric constructions, the same construction can be used in the surfaces described in both zones.

Field: Zone Name

This is the zone name to which the surface belongs.

Field: Outside Boundary Condition Object

The Outside Boundary Condition Object field is the name of a wall in an adjacent zone or the name of the adjacent zone. If the adjacent zone option is used, the adjacent wall is automatically generated in the adjacent zone. If the surface name is used, it must be in the adjacent zone.

Field: Azimuth Angle

The Azimuth Angle indicates the direction that the wall faces (outward normal). The angle is specified in degrees where East=90, South=180, West=270, North=0.

Field: Tilt Angle

The tilt angle is the angle (in degrees) that the wall is tilted from horizontal (or the ground). Normally, walls are tilted 90 degrees and that is the default for this field.

Starting Corner for the surface

The rectangular surfaces specify the lower left corner of the surface for their starting coordinate. This is specified with (x,y,z) and can be relative to the zone origin or in world coordinates, depending on the value for rectangular surfaces specified in the GlobalGeometryRules object.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Y Coordinate

This field is the Y coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the wall in meters.

Field: Height

This field is the height of the wall in meters.

Roofs/Ceilings

Roofs and ceilings are, by default, flat (tilt = 0 degrees). These objects are used to describe roofs, interior ceilings (adiabatic) and ceilings adjacent to other zones.

Roof

The Roof object is used to describe roofs that are exposed to the external environment. The IDD definition is shown below:

```

Roof,
  \memo Used for exterior roofs
  \memo View Factor to Ground is automatically calculated.
A1 , \field Name
  \required-field
  \type alpha
  \reference SurfaceNames
  \reference SurfAndSubSurfNames
  \reference AllHeatTranSurfNames
  \reference HeatTranBaseSurfNames
  \reference OutFaceEnvNames
  \reference AllHeatTranAngFacNames
  \reference RadGroupAndSurfNames
  \reference SurfGroupAndHTSurfNames
  \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
  \required-field
  \note To be matched with a construction in this input file
  \type object-list
  \object-list ConstructionNames
A3 , \field Zone Name
  \required-field
  \note Zone the surface is a part of
  \type object-list
  \object-list ZoneNames
N1, \field Azimuth Angle (would like to do away with this)
  \note Facing direction of outside of Roof
  \minimum 0
  \maximum 360
  \units deg
N2, \field Tilt Angle
  \note Flat Roofs are tilted 0 degrees
  \minimum 0
  \maximum 180
  \default 0
  \units deg
N3, \field Starting X Coordinate
  \note If not Flat, Starting coordinate is the Lower Left Corner of the Roof
  \units m
N4, \field Starting Y Coordinate
  \units m
N5, \field Starting Z Coordinate
  \units m
N6. \field Length
  \note Along X Axis
  \units m
N7; \field Width
  \note Along Y Axis
  \units m

```

Field: Name

This is a unique name associated with the roof. It is used in several other places as a reference (e.g. as the base surface name for a Window or Door).

Field: Construction Name

This is the name of the construction (ref: Construction) used in the surface. Regardless of location in the building, the “full” construction (all layers) is used. For example, for an interior wall separating two zones, zone x would have the outside layer (e.g. drywall) as the material that shows in zone y and then the layers to the inside layer – the material that shows in zone x. For symmetric constructions, the same construction can be used in the surfaces described in both zones.

Field: Zone Name

This is the zone name to which the surface belongs.

Field: Azimuth Angle

The Azimuth Angle indicates the direction of the outward normal for the roof. The angle is specified in degrees where East=90, South=180, West=270, North=0.

Field: Tilt Angle

The tilt angle is the angle (in degrees) that the wall is tilted from horizontal (or the ground). Flat roofs are tilted 0 degrees and that is the default for this field.

Starting Corner for the surface

The rectangular surfaces specify the lower left corner of the surface for their starting coordinate. This is specified with (x,y,z) and can be relative to the zone origin or in world coordinates, depending on the value for rectangular surfaces specified in the GlobalGeometryRules object.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Y Coordinate

This field is the Y coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the roof in meters.

Field: Width

This field is the width of the roof in meters.

Ceiling:Adiabatic

The Ceiling:Adiabatic object is used to describe interior ceilings that separate zones of like conditions. The IDD definition is shown below:

```

Ceiling:Adiabatic,
  \memo used for interior ceilings
A1 , \field Name
     \required-field
     \type alpha
     \reference SurfaceNames
     \reference SurfAndSubSurfNames
     \reference AllHeatTranSurfNames
     \reference HeatTranBaseSurfNames
     \reference AllHeatTranAngFacNames
     \reference RadGroupAndSurfNames
     \reference SurfGroupAndHTSurfNames
     \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
     \required-field
     \note To be matched with a construction in this input file
     \type object-list
     \object-list ConstructionNames
A3 , \field Zone Name
     \required-field
     \note Zone the surface is a part of
     \type object-list
     \object-list ZoneNames
N1,  \field Azimuth Angle
     \note Facing direction of outside of Ceiling
     \minimum 0
     \maximum 360
     \units deg
N2,  \field Tilt Angle
     \note Ceilings are usually tilted 0 degrees
     \minimum 0
     \maximum 180
     \default 0
     \units deg
N3,  \field Starting X Coordinate
     \note If not Flat, Starting coordinate is the Lower Left Corner of the Ceiling
     \units m
N4,  \field Starting Y Coordinate
     \units m
N5,  \field Starting Z Coordinate
     \units m
N6.  \field Length
     \note Along X Axis
     \units m
N7;  \field Width
     \note Along Y Axis
     \units m

```

Field: Name

This is a unique name associated with the ceiling. It is used in several other places as a reference (e.g. as the base surface name for a Window or Door).

Field: Construction Name

This is the name of the construction (ref: Construction) used in the surface. Regardless of location in the building, the “full” construction (all layers) is used. For example, for an interior wall separating two zones, zone x would have the outside layer (e.g. drywall) as the material that shows in zone y and then the layers to the inside layer – the material that shows in zone x. For symmetric constructions, the same construction can be used in the surfaces described in both zones.

Field: Zone Name

This is the zone name to which the surface belongs.

Field: Azimuth Angle

The Azimuth Angle indicates the direction of the outward normal for the roof. The angle is specified in degrees where East=90, South=180, West=270, North=0.

Field: Tilt Angle

The tilt angle is the angle (in degrees) that the wall is tilted from horizontal (or the ground). Flat ceilings are tilted 0 degrees and that is the default for this field.

Starting Corner for the surface

The rectangular surfaces specify the lower left corner of the surface for their starting coordinate. This is specified with (x,y,z) and can be relative to the zone origin or in world coordinates, depending on the value for rectangular surfaces specified in the GlobalGeometryRules object.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Y Coordinate

This field is the Y coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the ceiling in meters.

Field: Width

This field is the width of the ceiling in meters.

Ceiling:Interzone

The Ceiling:Interzone object is used to describe interior ceilings that separate zones of differing conditions (and expect heat transfer through the ceiling from the adjacent zone). The IDD definition is shown below:

```

Ceiling: Interzone,
  \memo used for ceilings using adjacent zone (interzone) heat transfer
  \memo adjacent surface should be a floor
A1 , \field Name
    \required-field
    \type alpha
    \reference SurfaceNames
    \reference SurfAndSubSurfNames
    \reference AllHeatTranSurfNames
    \reference HeatTranBaseSurfNames
    \reference AllHeatTranAngFacNames
    \reference RadGroupAndSurfNames
    \reference SurfGroupAndHTSurfNames
    \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
    \required-field
    \note To be matched with a construction in this input file
    \type object-list
    \object-list ConstructionNames
A3 , \field Zone Name
    \required-field
    \note Zone for the inside of the surface
    \type object-list
    \object-list ZoneNames
A4 , \field Outside Boundary Condition Object
    \required-field
    \note Specify a surface name in an adjacent zone for known interior walls.
    \note Specify a zone name of an adjacent zone to automatically generate the interior wall in the
adjacent zone.
    \type object-list
    \object-list OutFaceEnvNames
N1, \field Azimuth Angle
    \note Facing direction of outside of wall (S=180,N=0,E=90,W=270)
    \minimum 0
    \maximum 360
    \units deg
N2, \field Tilt Angle
    \note Ceilings are usually tilted 0 degrees
    \minimum 0
    \maximum 180
    \default 0
    \units deg
N3, \field Starting X Coordinate
    \note If not Flat, should be Lower Left Corner (from outside)
    \units m
N4, \field Starting Y Coordinate
    \units m
N5, \field Starting Z Coordinate
    \units m
N6. \field Length
    \note Along X Axis
    \units m
N7; \field Width
    \note Along Y Axis
    \units m

```

Field: Name

This is a unique name associated with the interzone ceiling. It is used in several other places as a reference (e.g. as the base surface name for a Window or Door).

Field: Construction Name

This is the name of the construction (ref: Construction) used in the surface. Regardless of location in the building, the “full” construction (all layers) is used. For example, for an interior wall separating two zones, zone x would have the outside layer (e.g. drywall) as the material that shows in zone y and then the layers to the inside layer – the material that shows in zone x. For symmetric constructions, the same construction can be used in the surfaces described in both zones.

Field: Zone Name

This is the zone name to which the surface belongs.

Field: Outside Boundary Condition Object

The Outside Boundary Condition Object field is the name of a floor in an adjacent zone or the name of the adjacent zone. If the adjacent zone option is used, the adjacent floor is automatically generated in the adjacent zone. If the surface name is used, it must be in the adjacent zone.

Field: Azimuth Angle

The Azimuth Angle indicates the direction of the outward normal for the roof. The angle is specified in degrees where East=90, South=180, West=270, North=0.

Field: Tilt Angle

The tilt angle is the angle (in degrees) that the wall is tilted from horizontal (or the ground). Flat ceilings are tilted 0 degrees and that is the default for this field.

Starting Corner for the surface

The rectangular surfaces specify the lower left corner of the surface for their starting coordinate. This is specified with (x,y,z) and can be relative to the zone origin or in world coordinates, depending on the value for rectangular surfaces specified in the GlobalGeometryRules object.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Y Coordinate

This field is the Y coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the ceiling in meters.

Field: Width

This field is the width of the ceiling in meters.

Floors

Floors are, by default, flat (tilt = 180 degrees). These objects are used to describe floors on the ground, interior floors (adiabatic) and floors adjacent to other zones.

Floor:GroundContact

The Floor:GroundContact object is used to describe floors that have ground contact (usually called slabs). The temperature at the outside of the floor is the temperature in the GroundTemperature:BuildingSurface object. The IDD definition is shown below:

```

Floor:GroundContact,
    \memo Used for exterior floors with ground contact
    \memo View Factors to Ground is automatically calculated.
A1 , \field Name
    \required-field
    \type alpha
    \reference SurfaceNames
    \reference SurfAndSubSurfNames
    \reference AllHeatTranSurfNames
    \reference HeatTranBaseSurfNames
    \reference OutFaceEnvNames
    \reference AllHeatTranAngFacNames
    \reference RadGroupAndSurfNames
    \reference SurfGroupAndHTSurfNames
    \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
    \required-field
    \note To be matched with a construction in this input file
    \type object-list
    \object-list ConstructionNames
A3 , \field Zone Name
    \required-field
    \note Zone the surface is a part of
    \type object-list
    \object-list ZoneNames
N1, \field Azimuth Angle
    \minimum 0
    \maximum 360
N2, \field Tilt Angle
    \note Floors are usually tilted 180 degrees
    \minimum 0
    \maximum 180
    \default 180
N3, \field Starting X Coordinate
    \note if not flat, should be lower left corner (from outside)
    \units m
N4, \field Starting Y Coordinate
    \units m
N5, \field Starting Z Coordinate
    \units m
N6. \field Length
    \note Along X Axis
    \units m
N7; \field Width
    \note Along Y Axis
    \units m

```

Field: Name

This is a unique name associated with the floor.

Field: Construction Name

This is the name of the construction (ref: Construction) used in the surface. Regardless of location in the building, the “full” construction (all layers) is used. For example, for an interior wall separating two zones, zone x would have the outside layer (e.g. drywall) as the material that shows in zone y and then the layers to the inside layer – the material that shows in zone x. For symmetric constructions, the same construction can be used in the surfaces described in both zones.

Field: Zone Name

This is the zone name to which the surface belongs.

Field: Azimuth Angle

The Azimuth Angle indicates the direction of the outward normal for the roof. The angle is specified in degrees where East=90, South=180, West=270, North=0.

Field: Tilt Angle

The tilt angle is the angle (in degrees) that the wall is tilted from horizontal (or the ground). Flat floors are tilted 180 degrees and that is the default for this field.

Starting Corner for the surface

The rectangular surfaces specify the lower left corner of the surface for their starting coordinate. This is specified with (x,y,z) and can be relative to the zone origin or in world coordinates, depending on the value for rectangular surfaces specified in the GlobalGeometryRules object.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Y Coordinate

This field is the Y coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the floor in meters.

Field: Width

This field is the width of the floor in meters.

Floor:Adiabatic

The Floor:Adiabatic object is used to describe interior floors or floors that you wish to model with no heat transfer from the exterior to the floor. The IDD definition is shown below:

```

Floor:Adiabatic,
  \memo Used for exterior floors ignoring ground contact or interior floors
  \memo View Factor to Ground is automatically calculated.
A1 , \field Name
  \required-field
  \type alpha
  \reference SurfaceNames
  \reference SurfAndSubSurfNames
  \reference AllHeatTranSurfNames
  \reference HeatTranBaseSurfNames
  \reference AllHeatTranAngFacNames
  \reference RadGroupAndSurfNames
  \reference SurfGroupAndHTSurfNames
  \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
  \required-field
  \note To be matched with a construction in this input file
  \type object-list
  \object-list ConstructionNames
A3 , \field Zone Name
  \required-field
  \note Zone the surface is a part of
  \type object-list
  \object-list ZoneNames
N1, \field Azimuth Angle
  \minimum 0
  \maximum 360
N2, \field Tilt Angle
  \note Floors are usually tilted 180 degrees
  \minimum 0
  \maximum 180
  \default 180
N3, \field Starting X Coordinate
  \note if not flat, should be lower left corner (from outside)
  \units m
N4, \field Starting Y Coordinate
  \units m
N5, \field Starting Z Coordinate
  \units m
N6. \field Length
  \note Along X Axis
  \units m
N7; \field Width
  \note Along Y Axis
  \units m

```

Field: Name

This is a unique name associated with the floor.

Field: Construction Name

This is the name of the construction (ref: Construction) used in the surface. Regardless of location in the building, the “full” construction (all layers) is used. For example, for an interior wall separating two zones, zone x would have the outside layer (e.g. drywall) as the material that shows in zone y and then the layers to the inside layer – the material that shows in zone x. For symmetric constructions, the same construction can be used in the surfaces described in both zones.

Field: Zone Name

This is the zone name to which the surface belongs.

Field: Azimuth Angle

The Azimuth Angle indicates the direction of the outward normal for the roof. The angle is specified in degrees where East=90, South=180, West=270, North=0.

Field: Tilt Angle

The tilt angle is the angle (in degrees) that the wall is tilted from horizontal (or the ground). Flat floors are tilted 180 degrees and that is the default for this field.

Starting Corner for the surface

The rectangular surfaces specify the lower left corner of the surface for their starting coordinate. This is specified with (x,y,z) and can be relative to the zone origin or in world coordinates, depending on the value for rectangular surfaces specified in the GlobalGeometryRules object.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Y Coordinate

This field is the Y coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the floor in meters.

Field: Width

This field is the width of the floor in meters.

Floor:Interzone

The Floor:Interzone object is used to describe floors that are adjacent to other zones that have differing conditions and you wish to model the heat transfer through the floor. The IDD definition is shown below:

```

Floor:Interzone,
    \memo used for floors using adjacent zone (interzone) heat transfer
    \memo adjacent surface should be a ceiling
A1 , \field Name
    \required-field
    \type alpha
    \reference SurfaceNames
    \reference SurfAndSubSurfNames
    \reference AllHeatTranSurfNames
    \reference HeatTranBaseSurfNames
    \reference AllHeatTranAngFacNames
    \reference RadGroupAndSurfNames
    \reference SurfGroupAndHTSurfNames
    \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
    \required-field
    \note To be matched with a construction in this input file
    \type object-list
    \object-list ConstructionNames
A3 , \field Zone Name
    \required-field
    \note Zone for the inside of the surface
    \type object-list
    \object-list ZoneNames
A4 , \field Outside Boundary Condition Object
    \required-field
    \note Specify a surface name in an adjacent zone for known interior walls.
    \note Specify a zone name of an adjacent zone to automatically generate the interior wall in the
adjacent zone.
    \type object-list
    \object-list OutFaceEnvNames
N1, \field Azimuth Angle
    \minimum 0
    \maximum 360
    \units deg
N2, \field Tilt Angle
    \note Floors are usually tilted 180 degrees
    \minimum 0
    \maximum 180
    \default 180
    \units deg
N3, \field Starting X Coordinate
    \note If not Flat, should be Lower Left Corner (from outside)
    \units m
N4, \field Starting Y Coordinate
    \units m
N5, \field Starting Z Coordinate
    \units m
N3, \field Starting X Coordinate
    \note if not flat, should be lower left corner (from outside)
    \units m
N4, \field Starting Y Coordinate
    \units m
N5, \field Starting Z Coordinate
    \units m
N6. \field Length
    \note Along X Axis
    \units m
N7; \field Width
    \note Along Y Axis
    \units m

```

Field: Name

This is a unique name associated with the floor.

Field: Construction Name

This is the name of the construction (ref: Construction) used in the surface. Regardless of location in the building, the “full” construction (all layers) is used. For example, for an interior

wall separating two zones, zone x would have the outside layer (e.g. drywall) as the material that shows in zone y and then the layers to the inside layer – the material that shows in zone x. For symmetric constructions, the same construction can be used in the surfaces described in both zones.

Field: Zone Name

This is the zone name to which the surface belongs.

Field: Outside Boundary Condition Object

The Outside Boundary Condition Object field is the name of a ceiling in an adjacent zone or the name of the adjacent zone. If the adjacent zone option is used, the adjacent ceiling is automatically generated in the adjacent zone. If the surface name is used, it must be in the adjacent zone.

Field: Azimuth Angle

The Azimuth Angle indicates the direction of the outward normal for the roof. The angle is specified in degrees where East=90, South=180, West=270, North=0.

Field: Tilt Angle

The tilt angle is the angle (in degrees) that the wall is tilted from horizontal (or the ground). Flat floors are tilted 180 degrees and that is the default for this field.

Starting Corner for the surface

The rectangular surfaces specify the lower left corner of the surface for their starting coordinate. This is specified with (x,y,z) and can be relative to the zone origin or in world coordinates, depending on the value for rectangular surfaces specified in the GlobalGeometryRules object.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Y Coordinate

This field is the Y coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the floor in meters.

Field: Width

This field is the width of the floor in meters.

Windows/Doors

The following window and door objects can be used to specify simple, rectangular doors and windows. In each case, the lower left corner (locator coordinate) of the window or door is specified **relative** to the surface it is on. Viewing the base surface as a planar surface, base the relative location from the lower left corner of the base surface. Vertex entry description as well as provisions for a few other surface types can be entered with the FenestrationSurface:Detailed object.

Window

The Window object is used to place windows on surfaces that can have windows, including exterior walls, interior walls, interzone walls, roofs, floors that are exposed to outdoor

conditions, interzone ceiling/floors. These, of course, can be entered using the simple rectangular objects or the more detailed vertex entry objects. The IDD for the object follows:

```
Window,
A1 , \field Name
    \required-field
    \type alpha
    \reference SubSurfNames
    \reference SurfAndSubSurfNames
    \reference AllHeatTranSurfNames
    \reference HeatTranBaseSurfNames
    \reference AllHeatTranAngFacNames
    \reference RadGroupAndSurfNames
    \reference SurfGroupAndHTSurfNames
    \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
    \required-field
    \note To be matched with a construction in this input file
    \type object-list
    \object-list ConstructionNames
A3 , \field Building Surface Name
    \note Name of Surface (Wall, usually) the Window is on (i.e., Base Surface)
    \note Window assumes the azimuth and tilt angles of the surface it is on.
    \required-field
    \type object-list
    \object-list SurfaceNames
A4, \field Shading Control Name
    \note enter the name of a WindowProperty:ShadingControl object
    \type object-list
    \object-list WindowShadeControlNames
    \note used for windows and glass doors only
    \note If not specified, window or glass door has no shading (blind, roller shade, etc.)
A5, \field Frame and Divider Name
    \note Enter the name of a WindowProperty:FrameAndDivider object
    \type object-list
    \object-list WindowFrameAndDividerNames
    \note Used only for exterior windows (rectangular) and glass doors.
    \note Unused for triangular windows.
    \note If not specified (blank), window or glass door has no frame or divider
    \note and no beam solar reflection from reveal surfaces.
N1 , \field Multiplier
    \note Used only for Surface Type = WINDOW, GLASSDOOR or DOOR
    \note Non-integer values will be truncated to integer
    \default 1.0
    \minimum 1.0
N2, \field Starting X Coordinate
    \note Window starting coordinate is specified relative to the Base Surface origin.
    \units m
N3, \field Starting Z Coordinate
    \note How far up the wall the Window starts. (in 2-d, this would be a Y Coordinate)
    \units m
N4. \field Length
    \units m
N5; \field Height
    \units m
```

Field: Name

This is a unique name associated with the window.

Field: Construction Name

This is the name of the subsurface's construction (ref: Construction and Construction:WindowDataFile).

For windows, if Construction Name is not found among the constructions on the input (.idf) file, the Window5 Data File (default Window5DataFile.dat) will be searched for that Construction Name (see "Importing Windows from WINDOW 5"). If that file is not present or if the Construction Name does not match the name of an entry on the file, an error will result. If

there is a match, a window construction and its corresponding glass and gas materials will be created from the information read from the file.

Field: Building Surface Name

This is the name of a surface that contains this subsurface. Certain kinds of surfaces may not be allowed to have subsurfaces. For example, a surface in contact with the ground (Outside Boundary Condition = Ground) cannot contain a window. The window assumes the outward facing angle as well as the tilt angle of the base surface.

Field: Shading Control Name

This field, if not blank, is the name of the window shading control (ref: WindowProperty:ShadingControl) for this subsurface. It is used for Surface Type = Window and GlassDoor. To assign a shade to a window or glass door, see WindowMaterial:Shade. To assign a screen, see WindowMaterial:Screen. To assign a blind, see WindowMaterial:Blind. To assign switchable glazing, such as electrochromic glazing, see WindowProperty:ShadingControl.

Field: Frame and Divider Name

This field, if not blank, can be used to specify window frame, divider and reveal-surface data (ref: WindowProperty:FrameAndDivider). It is used only for exterior GlassDoors and rectangular exterior Windows, i.e., those with OutsideFaceEnvironment = Outdoors.

This field should be blank for triangular windows.

Field: Multiplier

This field is the number of identical items on the base surface. Using Multiplier can save input effort and calculation time. In the calculation the area (and area of frame and divider, if present and surface type is a window) is multiplied by Multiplier. The calculation of shadowing on the subsurfaces (and the calculation of the interior distribution of beam solar radiation transmitted by windows and glass doors) are done for the specified subsurface position and dimensions.

Multiplier should be used with caution. Multiplier > 1 can give inaccurate or nonsensical results in situations where the results are sensitive to window or glass door position. This includes shadowing on the window/glass door, daylighting from the window/glass door, and interior distribution of solar radiation from the window/glass door. In these cases, the results for the single input window/glass door, after multiplication, may not be representative of the results you would get if you entered each of the multiple subsurfaces separately.

If Multiplier > 1, you will get

--a *warning* if Solar Distribution = FullExterior or FullInteriorAndExterior (ref: Building - Field: Solar Distribution), indicating that the shadowing on the input window or the interior solar radiation distribution from the input window may not be representative of the actual group of windows. No warning is issued if Solar Distribution = MinimalShadowing.

--an *error* if the window is an exterior window/glass door in a zone that has a detailed daylighting calculation (Daylighting:Detailed specified for the zone). Since a single window with a multiplier can never give the same daylight illuminance as the actual set of windows, you are not allowed to use Multiplier in this situation.

Starting Corner for the surface

The rectangular subsurfaces specify the lower left corner of the surface for their starting coordinate. This corner is specified relative to the lower left corner of the base surface by specifying the X and Z values from that corner.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the window in meters.

Field: Height

This field is the height of the window in meters.

Door

The Door object is used to place opaque doors on surfaces that can have doors, including exterior walls, interior walls, interzone walls, roofs, floors that are exposed to outdoor conditions, interzone ceiling/floors. These, of course, can be entered using the simple rectangular objects or the more detailed vertex entry objects. The IDD for the object follows:

```
Door, \memo used to specify opaque doors
A1 , \field Name
    \required-field
    \type alpha
    \reference SubSurfNames
    \reference SurfAndSubSurfNames
    \reference AllHeatTranSurfNames
    \reference HeatTranBaseSurfNames
    \reference AllHeatTranAngFacNames
    \reference RadGroupAndSurfNames
    \reference SurfGroupAndHTSurfNames
    \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
    \required-field
    \note To be matched with a construction in this input file
    \type object-list
    \object-list ConstructionNames
A3 , \field Building Surface Name
    \note Name of Surface (Wall, usually) the Door is on (i.e., Base Surface)
    \note Door assumes the azimuth and tilt angles of the surface it is on.
    \required-field
    \type object-list
    \object-list SurfaceNames
N1 , \field Multiplier
    \note Used only for Surface Type = WINDOW, GLASSDOOR or DOOR
    \note Non-integer values will be truncated to integer
    \default 1.0
    \minimum 1.0
N2, \field Starting X Coordinate
    \note Door starting coordinate is specified relative to the Base Surface origin.
    \units m
N3, \field Starting Z Coordinate
    \note How far up the wall the Door starts. (in 2-d, this would be a Y Coordinate)
    \units m
N4. \field Length
    \units m
N5; \field Height
    \units m
```

Field: Name

This is a unique name associated with the door.

Field: Construction Name

This is the name of the subsurface's construction (ref: Construction)

Field: Building Surface Name

This is the name of a surface that contains this subsurface. Certain kinds of surfaces may not be allowed to have subsurfaces. The door assumes the outward facing angle as well as the tilt angle of the base surface.

Field: Multiplier

This field is the number of identical items on the base surface. Using Multiplier can save input effort and calculation time. In the calculation the area (and area of frame and divider, if present and surface type is a window) is multiplied by Multiplier. The calculation of shadowing on the subsurfaces (and the calculation of the interior distribution of beam solar radiation transmitted by windows and glass doors) are done for the specified subsurface position and dimensions.

Multiplier should be used with caution. Multiplier > 1 can give inaccurate or nonsensical results in situations where the results are sensitive to window or glass door position. This includes shadowing on the window/glass door, daylighting from the window/glass door, and interior distribution of solar radiation from the window/glass door. In these cases, the results for the single input window/glass door, after multiplication, may not be representative of the results you would get if you entered each of the multiple subsurfaces separately.

If Multiplier > 1, you will get

--a *warning* if Solar Distribution = FullExterior or FullInteriorAndExterior (ref: Building - Field: Solar Distribution), indicating that the shadowing on the input window or the interior solar radiation distribution from the input window may not be representative of the actual group of windows. No warning is issued if Solar Distribution = MinimalShadowing.

--an *error* if the window is an exterior window/glass door in a zone that has a detailed daylighting calculation (Daylighting:Detailed specified for the zone). Since a single window with a multiplier can never give the same daylight illuminance as the actual set of windows, you are not allowed to use Multiplier in this situation.

Starting Corner for the surface

The rectangular subsurfaces specify the lower left corner of the surface for their starting coordinate. This corner is specified relative to the lower left corner of the base surface by specifying the X and Z values from that corner.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the door in meters.

Field: Height

This field is the height of the door in meters.

GlazedDoor

The GlazedDoor object is used to place doors on surfaces that can have doors, including exterior walls, interior walls, interzone walls, roofs, floors that are exposed to outdoor conditions, interzone ceiling/floors. These, of course, can be entered using the simple rectangular objects or the more detailed vertex entry objects. The IDD for the object follows:

```

GlazedDoor, \memo used to specify glass doors
A1 , \field Name
    \required-field
    \type alpha
    \reference SubSurfNames
    \reference SurfAndSubSurfNames
    \reference AllHeatTranSurfNames
    \reference HeatTranBaseSurfNames
    \reference AllHeatTranAngFacNames
    \reference RadGroupAndSurfNames
    \reference SurfGroupAndHTSurfNames
    \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
    \required-field
    \note To be matched with a construction in this input file
    \type object-list
    \object-list ConstructionNames
A3 , \field Building Surface Name
    \note Name of Surface (Wall, usually) the Door is on (i.e., Base Surface)
    \note Door assumes the azimuth and tilt angles of the surface it is on.
    \required-field
    \type object-list
    \object-list SurfaceNames
A4, \field Shading Control Name
    \note enter the name of a WindowProperty:ShadingControl object
    \type object-list
    \object-list WindowShadeControlNames
    \note used for windows and glass doors only
    \note If not specified, window or glass door has no shading (blind, roller shade, etc.)
A5, \field Frame and Divider Name
    \note Enter the name of a WindowProperty:FrameAndDivider object
    \type object-list
    \object-list WindowFrameAndDividerNames
    \note Used only for exterior windows (rectangular) and glass doors.
    \note Unused for triangular windows.
    \note If not specified (blank), window or glass door has no frame or divider
    \note and no beam solar reflection from reveal surfaces.
N1 , \field Multiplier
    \note Used only for Surface Type = WINDOW, GLASSDOOR or DOOR
    \note Non-integer values will be truncated to integer
    \default 1.0
    \minimum 1.0
N2, \field Starting X Coordinate
    \note Door starting coordinate is specified relative to the Base Surface origin.
    \units m
N3, \field Starting Z Coordinate
    \note How far up the wall the Door starts. (in 2-d, this would be a Y Coordinate)
    \units m
N4. \field Length
    \units m
N5; \field Height
    \units m

```

Field: Name

This is a unique name associated with the glass door.

Field: Construction Name

This is the name of the subsurface's construction (ref: Construction and Construction:WindowDataFile).

For windows, if Construction Name is not found among the constructions on the input (.idf) file, the Window5 Data File (default Window5DataFile.dat) will be searched for that Construction Name (see "Importing Windows from WINDOW 5"). If that file is not present or if the Construction Name does not match the name of an entry on the file, an error will result. If there is a match, a window construction and its corresponding glass and gas materials will be created from the information read from the file.

Field: Building Surface Name

This is the name of a surface that contains this subsurface. Certain kinds of surfaces may not be allowed to have subsurfaces. For example, a surface in contact with the ground (Outside Boundary Condition = Ground) cannot contain a window. The door assumes the outward facing angle as well as the tilt angle of the base surface.

Field: Shading Control Name

This field, if not blank, is the name of the window shading control (ref: WindowProperty:ShadingControl) for this subsurface. It is used for Surface Type = Window and GlassDoor. To assign a shade to a window or glass door, see WindowMaterial:Shade. To assign a screen, see WindowMaterial:Screen. To assign a blind, see WindowMaterial:Blind. To assign switchable glazing, such as electrochromic glazing, see WindowProperty:ShadingControl.

Field: Frame and Divider Name

This field, if not blank, can be used to specify window frame, divider and reveal-surface data (ref: WindowProperty:FrameAndDivider). It is used only for exterior GlassDoors and rectangular exterior Windows, i.e., those with OutsideFaceEnvironment = Outdoors.

This field should be blank for triangular windows.

Field: Multiplier

This field is the number of identical items on the base surface. Using Multiplier can save input effort and calculation time. In the calculation the area (and area of frame and divider, if present and surface type is a window) is multiplied by Multiplier. The calculation of shadowing on the subsurfaces (and the calculation of the interior distribution of beam solar radiation transmitted by windows and glass doors) are done for the specified subsurface position and dimensions.

Multiplier should be used with caution. Multiplier > 1 can give inaccurate or nonsensical results in situations where the results are sensitive to window or glass door position. This includes shadowing on the window/glass door, daylighting from the window/glass door, and interior distribution of solar radiation from the window/glass door. In these cases, the results for the single input window/glass door, after multiplication, may not be representative of the results you would get if you entered each of the multiple subsurfaces separately.

If Multiplier > 1, you will get

--a *warning* if Solar Distribution = FullExterior or FullInteriorAndExterior (ref: Building - Field: Solar Distribution), indicating that the shadowing on the input window or the interior solar radiation distribution from the input window may not be representative of the actual group of windows. No warning is issued if Solar Distribution = MinimalShadowing.

--an *error* if the window is an exterior window/glass door in a zone that has a detailed daylighting calculation (Daylighting:Detailed specified for the zone). Since a single window with a multiplier can never give the same daylight illuminance as the actual set of windows, you are not allowed to use Multiplier in this situation.

Starting Corner for the surface

The rectangular subsurfaces specify the lower left corner of the surface for their starting coordinate. This corner is specified relative to the lower left corner of the base surface by specifying the X and Z values from that corner.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the door in meters.

Field: Height

This field is the height of the door in meters.

Window:Interzone

The Window:Interzone object is used to place windows on surfaces that can have windows, including interzone walls, interzone ceiling/floors. These, of course, can be entered using the simple rectangular objects or the more detailed vertex entry objects. The IDD for the object follows:

```

Window:Interzone,
  \memo used to specify interior windows adjacent to other zones
A1 , \field Name
  \required-field
  \type alpha
  \reference SubSurfNames
  \reference SurfAndSubSurfNames
  \reference AllHeatTranSurfNames
  \reference HeatTranBaseSurfNames
  \reference AllHeatTranAngFacNames
  \reference RadGroupAndSurfNames
  \reference SurfGroupAndHTSurfNames
  \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
  \required-field
  \note To be matched with a construction in this input file
  \type object-list
  \object-list ConstructionNames
A3 , \field Building Surface Name
  \note Name of Surface (Wall, usually) the Window is on (i.e., Base Surface)
  \note Window assumes the azimuth and tilt angles of the surface it is on.
  \required-field
  \type object-list
  \object-list SurfaceNames
A4, \field Outside Boundary Condition Object
  \type object-list
  \object-list OutFaceEnvNames
  \note Specify a surface name in an adjacent zone for known interior windows.
  \note Specify a zone name of an adjacent zone to automatically generate the interior window in the
adjacent zone.
  \note a blank field will set up a Window in an adjacent zone (same zone as adjacent to base
surface)
N1 , \field Multiplier
  \note Used only for Surface Type = WINDOW, GLASSDOOR or DOOR
  \note Non-integer values will be truncated to integer
  \default 1.0
  \minimum 1.0
N2, \field Starting X Coordinate
  \note Window starting coordinate is specified relative to the Base Surface origin.
  \units m
N3, \field Starting Z Coordinate
  \note How far up the wall the Window starts. (in 2-d, this would be a Y Coordinate)
  \units m
N4. \field Length
  \units m
N5; \field Height
  \units m

```

Field: Name

This is a unique name associated with the window.

Field: Construction Name

This is the name of the subsurface's construction (ref: Construction and Construction:WindowDataFile).

For windows, if Construction Name is not found among the constructions on the input (.idf) file, the Window5 Data File (default Window5DataFile.dat) will be searched for that Construction Name (see "Importing Windows from WINDOW 5"). If that file is not present or if the Construction Name does not match the name of an entry on the file, an error will result. If there is a match, a window construction and its corresponding glass and gas materials will be created from the information read from the file.

Field: Building Surface Name

This is the name of a surface that contains this subsurface. Certain kinds of surfaces may not be allowed to have subsurfaces. For example, a surface in contact with the ground (Outside Boundary Condition = Ground) cannot contain a window. The window assumes the outward facing angle as well as the tilt angle of the base surface.

Field: Outside Boundary Condition Object

The Outside Boundary Condition Object field is the name of a window in an adjacent zone or the name of the adjacent zone. If the adjacent zone option is used, the adjacent ceiling is automatically generated in the adjacent zone. If the surface name is used, it must be in the adjacent zone.

Field: Multiplier

This field is the number of identical items on the base surface. Using Multiplier can save input effort and calculation time. In the calculation the area (and area of frame and divider, if present and surface type is a window) is multiplied by Multiplier. The calculation of shadowing on the subsurfaces (and the calculation of the interior distribution of beam solar radiation transmitted by windows and glass doors) are done for the specified subsurface position and dimensions.

Multiplier should be used with caution. Multiplier > 1 can give inaccurate or nonsensical results in situations where the results are sensitive to window or glass door position. This includes shadowing on the window/glass door, daylighting from the window/glass door, and interior distribution of solar radiation from the window/glass door. In these cases, the results for the single input window/glass door, after multiplication, may not be representative of the results you would get if you entered each of the multiple subsurfaces separately.

If Multiplier > 1, you will get

--a *warning* if Solar Distribution = FullExterior or FullInteriorAndExterior (ref: Building - Field: Solar Distribution), indicating that the shadowing on the input window or the interior solar radiation distribution from the input window may not be representative of the actual group of windows. No warning is issued if Solar Distribution = MinimalShadowing.

--an *error* if the window is an exterior window/glass door in a zone that has a detailed daylighting calculation (Daylighting:Detailed specified for the zone). Since a single window with a multiplier can never give the same daylight illuminance as the actual set of windows, you are not allowed to use Multiplier in this situation.

Starting Corner for the surface

The rectangular subsurfaces specify the lower left corner of the surface for their starting coordinate. This corner is specified relative to the lower left corner of the base surface by specifying the X and Z values from that corner.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the window in meters.

Field: Height

This field is the height of the window in meters.

Door:Interzone

The Door:Interzone object is used to place opaque doors on surfaces that can have doors, including interzone walls, interzone ceiling/floors. These, of course, can be entered using the simple rectangular objects or the more detailed vertex entry objects. The IDD for the object follows:

```

Door: Interzone,
  \memo used to specify opaque interior doors adjacent to other zones
A1 , \field Name
    \required-field
    \type alpha
    \reference SubSurfNames
    \reference SurfAndSubSurfNames
    \reference AllHeatTranSurfNames
    \reference HeatTranBaseSurfNames
    \reference AllHeatTranAngFacNames
    \reference RadGroupAndSurfNames
    \reference SurfGroupAndHTSurfNames
    \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
    \required-field
    \note To be matched with a construction in this input file
    \type object-list
    \object-list ConstructionNames
A3 , \field Building Surface Name
    \note Name of Surface (Wall, usually) the Door is on (i.e., Base Surface)
    \note Door assumes the azimuth and tilt angles of the surface it is on.
    \required-field
    \type object-list
    \object-list SurfaceNames
A4,  \field Outside Boundary Condition Object
    \type object-list
    \object-list OutFaceEnvNames
    \note Specify a surface name in an adjacent zone for known interior doors.
    \note Specify a zone name of an adjacent zone to automatically generate interior door in the
adjacent zone.
    \note a blank field will set up a Window in an adjacent zone (same zone as adjacent to base
surface)
N1 , \field Multiplier
    \note Used only for Surface Type = WINDOW, GLASSDOOR or DOOR
    \note Non-integer values will be truncated to integer
    \default 1.0
    \minimum 1.0
N2,  \field Starting X Coordinate
    \note Door starting coordinate is specified relative to the Base Surface origin.
    \units m
N3,  \field Starting Z Coordinate
    \note How far up the wall the Door starts. (in 2-d, this would be a Y Coordinate)
    \units m
N4.  \field Length
    \units m
N5;  \field Height
    \units m

```

Field: Name

This is a unique name associated with the door.

Field: Construction Name

This is the name of the subsurface's construction (ref: Construction)

Field: Building Surface Name

This is the name of a surface that contains this subsurface. Certain kinds of surfaces may not be allowed to have subsurfaces. The door assumes the outward facing angle as well as the tilt angle of the base surface.

Field: Outside Boundary Condition Object

The Outside Boundary Condition Object field is the name of a door in an adjacent zone or the name of the adjacent zone. If the adjacent zone option is used, the adjacent ceiling is automatically generated in the adjacent zone. If the surface name is used, it must be in the adjacent zone.

Field: Multiplier

This field is the number of identical items on the base surface. Using Multiplier can save input effort and calculation time. In the calculation the area (and area of frame and divider, if present and surface type is a window) is multiplied by Multiplier. The calculation of shadowing on the subsurfaces (and the calculation of the interior distribution of beam solar radiation transmitted by windows and glass doors) are done for the specified subsurface position and dimensions.

Multiplier should be used with caution. Multiplier > 1 can give inaccurate or nonsensical results in situations where the results are sensitive to window or glass door position. This includes shadowing on the window/glass door, daylighting from the window/glass door, and interior distribution of solar radiation from the window/glass door. In these cases, the results for the single input window/glass door, after multiplication, may not be representative of the results you would get if you entered each of the multiple subsurfaces separately.

If Multiplier > 1, you will get

--a *warning* if Solar Distribution = FullExterior or FullInteriorAndExterior (ref: Building - Field: Solar Distribution), indicating that the shadowing on the input window or the interior solar radiation distribution from the input window may not be representative of the actual group of windows. No warning is issued if Solar Distribution = MinimalShadowing.

--an *error* if the window is an exterior window/glass door in a zone that has a detailed daylighting calculation (Daylighting:Detailed specified for the zone). Since a single window with a multiplier can never give the same daylight illuminance as the actual set of windows, you are not allowed to use Multiplier in this situation.

Starting Corner for the surface

The rectangular subsurfaces specify the lower left corner of the surface for their starting coordinate. This corner is specified relative to the lower left corner of the base surface by specifying the X and Z values from that corner.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the door in meters.

Field: Height

This field is the height of the door in meters.

GlazedDoor:Interzone

The GlazedDoor:Interzone object is used to place doors on surfaces that can have doors, including interzone walls, interzone ceiling/floors. These, of course, can be entered using the simple rectangular objects or the more detailed vertex entry objects. The IDD for the object follows:

```

GlazedDoor:Interzone,
  \memo used to specify glass interior doors adjacent to other zones
  A1 , \field Name
      \required-field
      \type alpha
      \reference SubSurfNames
      \reference SurfAndSubSurfNames
      \reference AllHeatTranSurfNames
      \reference HeatTranBaseSurfNames
      \reference AllHeatTranAngFacNames
      \reference RadGroupAndSurfNames
      \reference SurfGroupAndHTSurfNames
      \reference AllShadingAndHTSurfNames
  A2 , \field Construction Name
      \required-field
      \note To be matched with a construction in this input file
      \type object-list
      \object-list ConstructionNames
  A3 , \field Building Surface Name
      \note Name of Surface (Wall, usually) the Door is on (i.e., Base Surface)
      \note Door assumes the azimuth and tilt angles of the surface it is on.
      \required-field
      \type object-list
      \object-list SurfaceNames
  A4,  \field Outside Boundary Condition Object
      \type object-list
      \object-list OutFaceEnvNames
      \note Specify a surface name in an adjacent zone for known interior doors.
      \note Specify a zone name of an adjacent zone to automatically generate the interior glazed door in
the adjacent zone.
      \note a blank field will set up a Window in an adjacent zone (same zone as adjacent to base
surface)
  N1 , \field Multiplier
      \note Used only for Surface Type = WINDOW, GLASSDOOR or DOOR
      \note Non-integer values will be truncated to integer
      \default 1.0
      \minimum 1.0
  N2,  \field Starting X Coordinate
      \note Door starting coordinate is specified relative to the Base Surface origin.
      \units m
  N3,  \field Starting Z Coordinate
      \note How far up the wall the Door starts. (in 2-d, this would be a Y Coordinate)
      \units m
  N4.  \field Length
      \units m
  N5;  \field Height
      \units m

```

Field: Name

This is a unique name associated with the glass door.

Field: Construction Name

This is the name of the subsurface's construction (ref: Construction and Construction:WindowDataFile).

For windows, if Construction Name is not found among the constructions on the input (.idf) file, the Window5 Data File (default Window5DataFile.dat) will be searched for that Construction Name (see "Importing Windows from WINDOW 5"). If that file is not present or if the Construction Name does not match the name of an entry on the file, an error will result. If

there is a match, a window construction and its corresponding glass and gas materials will be created from the information read from the file.

Field: Building Surface Name

This is the name of a surface that contains this subsurface. Certain kinds of surfaces may not be allowed to have subsurfaces. For example, a surface in contact with the ground (Outside Boundary Condition = Ground) cannot contain a window. The door assumes the outward facing angle as well as the tilt angle of the base surface.

Field: Outside Boundary Condition Object

The Outside Boundary Condition Object field is the name of a glazed (glass) door in an adjacent zone or the name of the adjacent zone. If the adjacent zone option is used, the adjacent ceiling is automatically generated in the adjacent zone. If the surface name is used, it must be in the adjacent zone.

Field: Multiplier

This field is the number of identical items on the base surface. Using Multiplier can save input effort and calculation time. In the calculation the area (and area of frame and divider, if present and surface type is a window) is multiplied by Multiplier. The calculation of shadowing on the subsurfaces (and the calculation of the interior distribution of beam solar radiation transmitted by windows and glass doors) are done for the specified subsurface position and dimensions.

Multiplier should be used with caution. Multiplier > 1 can give inaccurate or nonsensical results in situations where the results are sensitive to window or glass door position. This includes shadowing on the window/glass door, daylighting from the window/glass door, and interior distribution of solar radiation from the window/glass door. In these cases, the results for the single input window/glass door, after multiplication, may not be representative of the results you would get if you entered each of the multiple subsurfaces separately.

If Multiplier > 1, you will get

--a *warning* if Solar Distribution = FullExterior or FullInteriorAndExterior (ref: Building - Field: Solar Distribution), indicating that the shadowing on the input window or the interior solar radiation distribution from the input window may not be representative of the actual group of windows. No warning is issued if Solar Distribution = MinimalShadowing.

--an *error* if the window is an exterior window/glass door in a zone that has a detailed daylighting calculation (Daylighting:Detailed specified for the zone). Since a single window with a multiplier can never give the same daylight illuminance as the actual set of windows, you are not allowed to use Multiplier in this situation.

Starting Corner for the surface

The rectangular subsurfaces specify the lower left corner of the surface for their starting coordinate. This corner is specified relative to the lower left corner of the base surface by specifying the X and Z values from that corner.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the door in meters.

Field: Height

This field is the height of the door in meters.

Surface Vertices

Each of the following surfaces:

BuildingSurface:Detailed

Wall:Detailed

RoofCeiling:Detailed

Floor:Detailed

FenestrationSurface:Detailed

Shading:Site:Detailed

Shading:Building:Detailed

Shading:Zone:Detailed

use the same vertex input. The numeric parameters indicated below are taken from the BuildingSurface:Detailed definition; the others may not be exactly the same but are identical in configuration. They are also “extensible” – so, if you want more vertices for these surfaces, you may add to the IDD definition as indicated in the “extensible” comment or, as EnergyPlus is “auto-extensible” just add the number of vertices into your input file.. Note that FenestrationSurface:Detailed is not extensible and is limited to 4 (max) vertices. If you leave the Number of Surface Vertex groups blank or enter **autocalculate**, EnergyPlus looks at the number of groups entered and figures out how many coordinate groups are entered.

Note that the resolution on the surface vertex input is 1 millimeter (.001 meter). Therefore, using vertices that are very close together (<1 mm) may result in invalid dot product and fatal errors during shading calculations.

```
N2 , \field Number of Vertices
    \note shown with 120 vertex coordinates -- extensible object
    \note "extensible" -- duplicate last set of x,y,z coordinates, renumbering please
    \note (and changing z terminator to a comma "," for all but last one which needs a semi-colon ";")
    \autocalculatable
    \minimum 3
    \default autocalculate
    \note vertices are given in GlobalGeometryRules coordinates -- if relative, all surface coordinates
    \note are "relative" to the Zone Origin.  If world, then building and zone origins are used
    \note for some internal calculations, but all coordinates are given in an "absolute" system.
N3, \field Vertex 1 X-coordinate
    \units m
    \type real
N4 , \field Vertex 1 Y-coordinate
    \units m
    \type real
N5 , \field Vertex 1 Z-coordinate
    \units m
    \type real
< repeated for Vertex 2 through 120 (Surface:Heat Transfer)>, same order as above
< repeated for Vertex 2 through 6 (Shading surfaces)>, same order as above
```

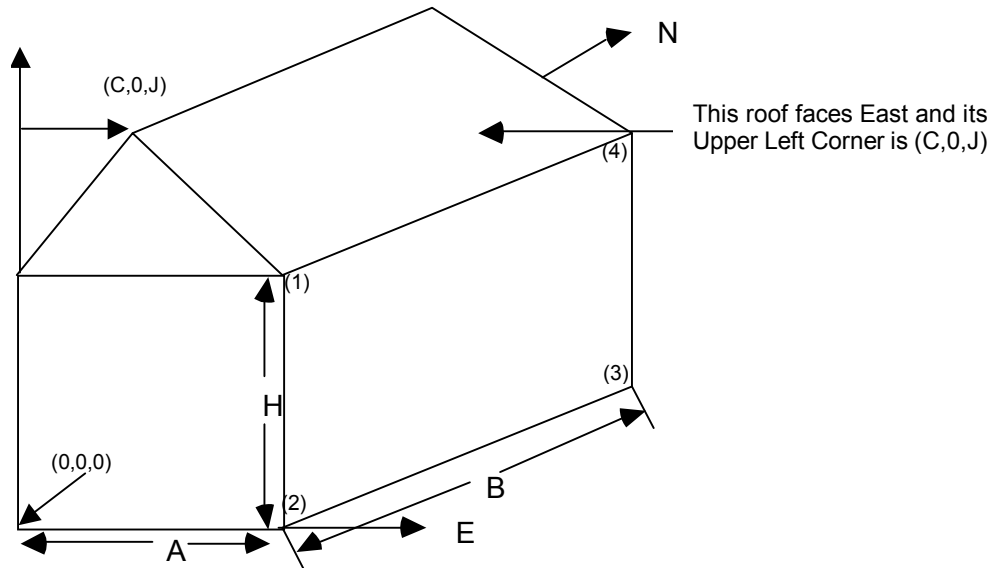



Figure 19. Illustration for Surface Vertices

The figure above will help illustrate Surface Vertex entry. The convention used in “GlobalGeometryRules” dictates the order of the vertices (ref: GlobalGeometryRules). In this example, the conventions used are Starting Vertex Position = UpperLeftCorner and Vertex Entry Direction= CounterClockwise. The surfaces for this single zone are:

```

4,0,0,H, 0,0,0, A,0,0, A,0,H; ! (4 vertices, South Wall)
4,A,0,H,A,0,0,A,B,0,A,B,H; ! (4 vertices, East Wall)
  ignore other walls that are not shown in this figure
4,C,0,J,A,0,H,A,B,H,C,B,J; ! (4 vertices, roof)
3,C,0,J,0,0,H,A,0,H; ! (3 vertices, gable end)
4,0,0,H, 0,0,0, A,0,0, A,0,H; ! (4 vertices, South Wall)

```

Note that in this example, point 1 of the entry is the Upper Left Corner of the rectangular surfaces and the point of the triangle for the 3 sided surface. The east wall shows the order of vertex entry. For horizontal surfaces, any vertex may be chosen as the starting position, but the Vertex Entry Direction convention must be followed. The surface details report (Output: Surfaces:List, Details;) is very useful for reviewing the accuracy of surface geometry inputs (ref: Surface Output Variables/Reports and Variable Dictionary Reports).

Building Surfaces - Detailed

A building surface is necessary for all calculations. There must be at least one building surface per zone. You can use the detailed descriptions as shown below or the simpler, rectangular surface descriptions shown earlier.

Wall:Detailed

The Wall:Detailed object is used to describe walls. The IDD definition, up to the number of surface sides, is shown below:

```

Wall:Detailed,
  \extensible:3 -- duplicate last set of x,y,z coordinates, renumbering please
  \format vertices
  A1 , \field Name
        \required-field
        \type alpha
        \reference SurfaceNames
        \reference SurfAndSubSurfNames
        \reference AllHeatTranSurfNames
        \reference HeatTranBaseSurfNames
        \reference OutFaceEnvNames
        \reference AllHeatTranAngFacNames
        \reference RadGroupAndSurfNames
        \reference SurfGroupAndHTSurfNames
        \reference AllShadingAndHTSurfNames
  A2 , \field Construction Name
        \required-field
        \note To be matched with a construction in this input file
        \type object-list
        \object-list ConstructionNames
  A3 , \field Zone Name
        \required-field
        \note Zone the surface is a part of
        \type object-list
        \object-list ZoneNames
  A4 , \field Outside Boundary Condition
        \required-field
        \type choice
        \key Surface
        \key Zone
        \key Outdoors
        \key Ground
        \key OtherSideCoefficients
        \key OtherSideConditionsModel
        \key Adiabatic
  A5, \field Outside Boundary Condition Object
        \type object-list
        \object-list OutFaceEnvNames
        \note Non-blank only if the field Outside Boundary Condition is Surface, Zone,
OtherSideCoefficients,
        \note or OtherSideConditionsModel
        \note If Surface, specify name of corresponding surface in adjacent zone or
        \note specify current surface name for internal partition separating like zones
        \note If Zone, specify the name of the corresponding zone and
        \note the program will generate the corresponding interzone surface
        \note If OtherSideCoefficients, specify name of SurfaceProperty:OtherSideCoefficients
        \note If OtherSideConditionsModel, specify name of SurfaceProperty:OtherSideConditionsModel
  A6 , \field Sun Exposure
        \required-field
        \type choice
        \key SunExposed
        \key NoSun
        \default SunExposed
  A7, \field Wind Exposure
        \required-field
        \type choice
        \key WindExposed
        \key NoWind
        \default WindExposed
  N1, \field View Factor to Ground
        \type real
        \note From the exterior of the surface
        \note Unused if one uses the "reflections" options in Solar Distribution in Building input
        \note unless a DaylightingDevice:Shelf or DaylightingDevice:Tubular object has been specified.
        \note autocalculate will automatically calculate this value from the tilt of the surface
        \autocalculatable
        \minimum 0.0
        \maximum 1.0
        \default autocalculate
  N2 , \field Number of Vertices
        \note shown with 120 vertex coordinates -- extensible object

```

```

\note "extensible" -- duplicate last set of x,y,z coordinates, renumbering please
\note (and changing z terminator to a comma "," for all but last one which needs a semi-colon ";")
\autocalculatable
\minimum 3
\default autocalculate
\note vertices are given in GlobalGeometryRules coordinates -- if relative, all surface coordinates
\note are "relative" to the Zone Origin.  If world, then building and zone origins are used
\note for some internal calculations, but all coordinates are given in an "absolute" system.
N3, \field Vertex 1 X-coordinate
\units m
\type real
N4 , \field Vertex 1 Y-coordinate
\units m
\type real
N5 , \field Vertex 1 Z-coordinate
\units m
\type real
N6, \field Vertex 2 X-coordinate
\units m
\type real
N7, \field Vertex 2 Y-coordinate
\units m
\type real
N8, \field Vertex 2 Z-coordinate
\units m
\type real
N9, \field Vertex 3 X-coordinate
\units m
\type real
N10, \field Vertex 3 Y-coordinate
\units m
\type real
N11, \field Vertex 3 Z-coordinate
\units m
\type real
N12, \field Vertex 4 X-coordinate
\units m
\type real
N13, \field Vertex 4 Y-coordinate
\units m
\type real
N14, \field Vertex 4 Z-coordinate
\units m
\type real
N15, \field Vertex 5 X-coordinate
\units m
\type real
N16, \field Vertex 5 Y-coordinate
\units m
\type real
N17, \field Vertex 5 Z-coordinate
\units m
\type real
N18, \field Vertex 6 X-coordinate
\units m
\type real
N19, \field Vertex 6 Y-coordinate
\units m
\type real
N20, \field Vertex 6 Z-coordinate
\units m
\type real
N21, \field Vertex 7 X-coordinate
\units m
\type real
N22, \field Vertex 7 Y-coordinate
\units m
\type real
N23, \field Vertex 7 Z-coordinate
\units m
\type real

```

```

N24, \field Vertex 8 X-coordinate
      \units m
      \type real
N25, \field Vertex 8 Y-coordinate
      \type real
      \units m
N26, \field Vertex 8 Z-coordinate
      \units m
      \type real
N27, \field Vertex 9 X-coordinate
      \units m
      \type real
N28, \field Vertex 9 Y-coordinate
      \type real
      \units m
N29, \field Vertex 9 Z-coordinate
      \units m
      \type real
N30, \field Vertex 10 X-coordinate
      \units m
      \type real
N31, \field Vertex 10 Y-coordinate
      \type real
      \units m
N32, \field Vertex 10 Z-coordinate
      \units m
      \type real

```

Field: Name

This is a unique name associated with each building surface. It is used in several other places as a reference (e.g. as the base surface name for a Window or Door).

Field: Construction Name

This is the name of the construction (ref: Construction) used in the surface. Regardless of location in the building, the “full” construction (all layers) is used. For example, for an interior wall separating two zones, zone x would have the outside layer (e.g. drywall) as the material that shows in zone y and then the layers to the inside layer – the material that shows in zone x. For symmetric constructions, the same construction can be used in the surfaces described in both zones.

Field: Zone Name

This is the zone name to which the surface belongs.

Field: Outside Boundary Condition

This value can be one of several things depending on the actual kind of surface.

- 1) **Surface** – if this surface is an internal surface, then this is the choice. The value will either be a surface in the base zone or a surface in another zone. The heat balance between two zones can be accurately simulated by specifying a surface in an adjacent zone. EnergyPlus will simulate a group of zones simultaneously and will include the heat transfer between zones. However, as this increases the complexity of the calculations, it is not necessary to specify the other zone unless the two zones will have a significant temperature difference. If the two zones will not be very different (temperature wise), then the surface should use itself as the outside environment. In either case, the surface name on the “outside” of this surface (adjacent to) is placed in the next field.
- 2) **Adiabatic** – an internal surface in the same Zone. The Outside Boundary Condition Object can be left blank.
- 3) **Zone** – this is similar to Surface but EnergyPlus will automatically create the required surface in the adjacent zone when this is entered for the surface. If there are windows or doors on the surface, EnergyPlus automatically creates appropriate sub-surfaces as well.

- 4) **Outdoors** – if this surface is exposed to outside temperature conditions, then this is the choice. See Sun Exposure and Wind Exposure below for further specifications on this kind of surface.
- 5) **Ground** – if this surface is exposed to the ground, then this is the choice. The temperature on the outside of this surface will be the Ground Temperature.
- 6) **OtherSideCoefficients** – if this surface has a custom, user specified temperature or other parameters (See SurfaceProperty:OtherSideCoefficients specification), then this is the choice. The outside boundary condition will be the name of the SurfaceProperty:OtherSideCoefficients specification.
- 7) **OtherSideConditionsModel** – if this surface has a specially-modeled multi-skin component, such as a transpired collector or vented photovoltaic panel, attached to the outside (See SurfaceProperty:OtherSideConditionsModel specification), then this the choice. The outside face environment will be the name of the SurfaceProperty:OtherSideConditionsModels specification.

Field: Outside Boundary Condition Object

If neither Surface, OtherSideCoefficients, or OtherSideConditionsModel are specified for the Outside Boundary Condition (previous field), then this field should be left blank.

As stated above, if the Outside Boundary Condition is “Surface”, then this field’s value must be the surface name whose inside face temperature will be forced on the outside face of the base surface. This permits heat exchange between adjacent zones (interzone heat transfer) when multiple zones are simulated, but can also be used to simulate middle zone behavior without modeling the adjacent zones. This is done by specifying a surface within the zone. For example, a middle floor zone can be modeled by making the floor the Outside Boundary Condition Object for the ceiling, and the ceiling the Outside Boundary Condition Object for the floor.

If the Outside Boundary Condition is Zone, then this field should contain the zone name of the adjacent zone for the surface.

Note: Zones with interzone heat transfer are not adiabatic and the internal surfaces contribute to gains or losses. Adiabatic surfaces are modeled by specifying the base surface itself in this field. Also, for interzone heat transfer, both surfaces must be represented – for example, if you want interzone heat transfer to an attic space, the ceiling in the lower zone must have a surface object with the outside face environment as the floor in the attic and, likewise, there must be a floor surface object in the attic that references the ceiling surface name in the lower zone.

Equally, if the Outside Boundary Condition is “OtherSideCoefficients”, then this field’s value must be the SurfaceProperty:OtherSideCoefficients name. Or if the Outside Boundary Condition is “OtherSideConditionsModel” then this field’s value must be the SurfaceProperty:OtherSideConditionsModel name.

Field: Sun Exposure

If the surface is exposed to the sun, then “SunExposed” should be entered in this field. Otherwise, “NoSun” should be entered.

Note, a cantilevered floor could have “Outdoors” but “NoSun” exposure.

Field: Wind Exposure

If the surface is exposed to the Wind, then “WindExposed” should be entered in this field. Otherwise, “NoWind” should be entered.

Note: When a surface is specified with “NoWind”, this has several implications. Within the heat balance code, this surface will default to using the simple ASHRAE exterior convection coefficient correlation with a zero wind speed. In addition, since the ASHRAE simple method

does not have a separate value for equivalent long wavelength radiation to the sky and ground, using “NoWind” also eliminates long wavelength radiant exchange from the exterior of the surface to both the sky and the ground. Thus, only simple convection takes place at the exterior face of a surface specified with “NoWind”.

Field: View Factor to Ground

The fraction of the ground plane (assumed horizontal) that is visible from a heat-transfer surface. It is used to calculate the diffuse solar radiation from the ground that is incident on the surface.

For example, if there are no obstructions, a vertical surface sees half of the ground plane and so View Factor to Ground = 0.5. A horizontal downward-facing surface sees the entire ground plane, so View Factor to Ground = 1.0. A horizontal upward-facing surface (horizontal roof) does not see the ground at all, so View Factor to Ground = 0.0.

Unused if reflections option in Solar Distribution field in Building object input unless a DaylightingDevice:Shelf or DaylightingDevice:Tubular has been specified.

If you do not use the reflections option in the Solar Distribution field in your Building object input, you are responsible for entering the View Factor to Ground for each heat-transfer surface. Typical values for a surface that is not shadowed are obtained by the simple equation:

$$\text{View Factor to Ground} = (1 - \cos(\text{SurfTilt})) / 2$$

For example, this gives 0.5 for a wall of tilt 90°. If the tilt of the wall changes, then the View Factor to Ground must also change.

If you enter **autocalculate** in this field, EnergyPlus will automatically calculate the view factor to ground based on the tilt of the surface.

If **you do use the reflections option in the Solar Distribution field** in your Building object input, you do **not** have to enter View Factor to Ground values. In this case the program will automatically calculate the value to use for each exterior surface taking into account solar shadowing (including shadowing of the ground by the building) and reflections from obstructions (ref: Building, Field: Solar Distribution).

However, if you do use the reflections option AND you are modeling a DaylightingDevice:Shelf or DaylightingDevice:Tubular, then you still need to enter some values of View Factor to Ground. For DaylightingDevice:Shelf you need to enter View Factor to Ground for the window associated with the shelf. And for DaylightingDevice:Tubular you need to enter the View Factor to Ground for the FenestrationSurface:Detailed corresponding to the dome of the tubular device.

Note 1: The corresponding view factor to the sky for diffuse solar radiation is not a user input; it is calculated within EnergyPlus based on surface orientation, sky solar radiance distribution, and shadowing surfaces.

Note 2: The view factors to the sky and ground for thermal infrared (long-wave) radiation are not user inputs; they are calculated within EnergyPlus based on surface tilt and shadowing surfaces. Shadowing surfaces are considered to have the same emissivity and temperature as the ground, so they are lumped together with the ground in calculating the ground IR view factor.

Field: Number of Vertices

This field specifies the number of sides in the surface (number of X,Y,Z vertex groups). For further information, see the discussion on “Surface Vertices” above.

RoofCeiling:Detailed

The RoofCeiling:Detailed object is used to describe walls. The IDD definition, up to the number of surface sides, is shown below:

```

RoofCeiling:Detailed,
\extensible:3 -- duplicate last set of x,y,z coordinates, renumbering please
\format vertices
A1 , \field Name
    \required-field
    \type alpha
    \reference SurfaceNames
    \reference SurfAndSubSurfNames
    \reference AllHeatTranSurfNames
    \reference HeatTranBaseSurfNames
    \reference OutFaceEnvNames
    \reference AllHeatTranAngFacNames
    \reference RadGroupAndSurfNames
    \reference SurfGroupAndHTSurfNames
    \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
    \required-field
    \note To be matched with a construction in this input file
    \type object-list
    \object-list ConstructionNames
A3 , \field Zone Name
    \required-field
    \note Zone the surface is a part of
    \type object-list
    \object-list ZoneNames
A4 , \field Outside Boundary Condition
    \required-field
    \type choice
    \key Surface
    \key Zone
    \key Outdoors
    \key Ground
    \key OtherSideCoefficients
    \key OtherSideConditionsModel
    \key Adiabatic
A5, \field Outside Boundary Condition Object
    \type object-list
    \object-list OutFaceEnvNames
    \note Non-blank only if the field Outside Boundary Condition is Surface, Zone,
OtherSideCoefficients,
    \note or OtherSideConditionsModel
    \note If Surface, specify name of corresponding surface in adjacent zone or
    \note specify current surface name for internal partition separating like zones
    \note If Zone, specify the name of the corresponding zone and
    \note the program will generate the corresponding interzone surface
    \note If OtherSideCoefficients, specify name of SurfaceProperty:OtherSideCoefficients
    \note If OtherSideConditionsModel, specify name of SurfaceProperty:OtherSideConditionsModel
A6 , \field Sun Exposure
    \required-field
    \type choice
    \key SunExposed
    \key NoSun
    \default SunExposed
A7, \field Wind Exposure
    \required-field
    \type choice
    \key WindExposed
    \key NoWind
    \default WindExposed
N1, \field View Factor to Ground
    \type real
    \note From the exterior of the surface
    \note Unused if one uses the "reflections" options in Solar Distribution in Building input
    \note unless a DaylightingDevice:Shelf or DaylightingDevice:Tubular object has been specified.
    \note autocalculate will automatically calculate this value from the tilt of the surface
    \autocalculatable
    \minimum 0.0
    \maximum 1.0
    \default autocalculate
N2 , \field Number of Vertices
    \note shown with 120 vertex coordinates -- extensible object

```

```

\note "extensible" -- duplicate last set of x,y,z coordinates, renumbering please
\note (and changing z terminator to a comma "," for all but last one which needs a semi-colon ";")
\autocalculatable
\minimum 3
\default autocalculate
\note vertices are given in GlobalGeometryRules coordinates -- if relative, all surface coordinates
\note are "relative" to the Zone Origin.  If world, then building and zone origins are used
\note for some internal calculations, but all coordinates are given in an "absolute" system.
N3, \field Vertex 1 X-coordinate
\units m
\type real
N4 , \field Vertex 1 Y-coordinate
\units m
\type real
N5 , \field Vertex 1 Z-coordinate
\units m
\type real
N6, \field Vertex 2 X-coordinate
\units m
\type real
N7, \field Vertex 2 Y-coordinate
\units m
\type real
N8, \field Vertex 2 Z-coordinate
\units m
\type real
N9, \field Vertex 3 X-coordinate
\units m
\type real
N10, \field Vertex 3 Y-coordinate
\units m
\type real
N11, \field Vertex 3 Z-coordinate
\units m
\type real
N12, \field Vertex 4 X-coordinate
\units m
\type real
N13, \field Vertex 4 Y-coordinate
\type real
\units m
N14, \field Vertex 4 Z-coordinate
\units m
\type real
N15, \field Vertex 5 X-coordinate
\units m
\type real
N16, \field Vertex 5 Y-coordinate
\type real
\units m
N17, \field Vertex 5 Z-coordinate
\units m
\type real
N18, \field Vertex 6 X-coordinate
\units m
\type real
N19, \field Vertex 6 Y-coordinate
\type real
\units m
N20, \field Vertex 6 Z-coordinate
\units m
\type real
N21, \field Vertex 7 X-coordinate
\units m
\type real
N22, \field Vertex 7 Y-coordinate
\type real
\units m
N23, \field Vertex 7 Z-coordinate
\units m
\type real

```



```

N24, \field Vertex 8 X-coordinate
      \units m
      \type real
N25, \field Vertex 8 Y-coordinate
      \type real
      \units m
N26, \field Vertex 8 Z-coordinate
      \units m
      \type real
N27, \field Vertex 9 X-coordinate
      \units m
      \type real
N28, \field Vertex 9 Y-coordinate
      \type real
      \units m
N29, \field Vertex 9 Z-coordinate
      \units m
      \type real
N30, \field Vertex 10 X-coordinate
      \units m
      \type real
N31, \field Vertex 10 Y-coordinate
      \type real
      \units m
N32, \field Vertex 10 Z-coordinate
      \units m
      \type real

```

Field: Name

This is a unique name associated with each building surface. It is used in several other places as a reference (e.g. as the base surface name for a Window or Door).

Field: Construction Name

This is the name of the construction (ref: Construction) used in the surface. Regardless of location in the building, the “full” construction (all layers) is used. For example, for an interior wall separating two zones, zone x would have the outside layer (e.g. drywall) as the material that shows in zone y and then the layers to the inside layer – the material that shows in zone x. For symmetric constructions, the same construction can be used in the surfaces described in both zones.

Field: Zone Name

This is the zone name to which the surface belongs.

Field: Outside Boundary Condition

This value can be one of several things depending on the actual kind of surface.

- 1) **Surface** – if this surface is an internal surface, then this is the choice. The value will either be a surface in the base zone or a surface in another zone. The heat balance between two zones can be accurately simulated by specifying a surface in an adjacent zone. EnergyPlus will simulate a group of zones simultaneously and will include the heat transfer between zones. However, as this increases the complexity of the calculations, it is not necessary to specify the other zone unless the two zones will have a significant temperature difference. If the two zones will not be very different (temperature wise), then the surface should use itself as the outside environment. In either case, the surface name on the “outside” of this surface (adjacent to) is placed in the next field.
- 2) **Adiabatic** – an internal surface in the same Zone. The Outside Boundary Condition Object can be left blank.
- 3) **Zone** – this is similar to Surface but EnergyPlus will automatically create the required surface in the adjacent zone when this is entered for the surface. If there are windows or doors on the surface, EnergyPlus automatically creates appropriate sub-surfaces as well.

- 4) **Outdoors** – if this surface is exposed to outside temperature conditions, then this is the choice. See Sun Exposure and Wind Exposure below for further specifications on this kind of surface.
- 5) **Ground** – if this surface is exposed to the ground, then this is the choice. The temperature on the outside of this surface will be the Ground Temperature.
- 6) **OtherSideCoefficients** – if this surface has a custom, user specified temperature or other parameters (See SurfaceProperty:OtherSideCoefficients specification), then this is the choice. The outside boundary condition will be the name of the SurfaceProperty:OtherSideCoefficients specification.
- 7) **OtherSideConditionsModel** – if this surface has a specially-modeled multi-skin component, such as a transpired collector or vented photovoltaic panel, attached to the outside (See SurfaceProperty:OtherSideConditionsModel specification), then this the choice. The outside face environment will be the name of the SurfaceProperty:OtherSideConditionsModels specification.

Field: Outside Boundary Condition Object

If neither Surface, OtherSideCoefficients, or OtherSideConditionsModel are specified for the Outside Boundary Condition (previous field), then this field should be left blank.

As stated above, if the Outside Boundary Condition is “Surface”, then this field’s value must be the surface name whose inside face temperature will be forced on the outside face of the base surface. This permits heat exchange between adjacent zones (interzone heat transfer) when multiple zones are simulated, but can also be used to simulate middle zone behavior without modeling the adjacent zones. This is done by specifying a surface within the zone. For example, a middle floor zone can be modeled by making the floor the Outside Boundary Condition Object for the ceiling, and the ceiling the Outside Boundary Condition Object for the floor.

If the Outside Boundary Condition is Zone, then this field should contain the zone name of the adjacent zone for the surface.

Note: Zones with interzone heat transfer are not adiabatic and the internal surfaces contribute to gains or losses. Adiabatic surfaces are modeled by specifying the base surface itself in this field. Also, for interzone heat transfer, both surfaces must be represented – for example, if you want interzone heat transfer to an attic space, the ceiling in the lower zone must have a surface object with the outside face environment as the floor in the attic and, likewise, there must be a floor surface object in the attic that references the ceiling surface name in the lower zone.

Equally, if the Outside Boundary Condition is “OtherSideCoefficients”, then this field’s value must be the SurfaceProperty:OtherSideCoefficients name. Or if the Outside Boundary Condition is “OtherSideConditionsModel” then this field’s value must be the SurfaceProperty:OtherSideConditionsModel name.

Field: Sun Exposure

If the surface is exposed to the sun, then “SunExposed” should be entered in this field. Otherwise, “NoSun” should be entered.

Note, a cantilevered floor could have “Outdoors” but “NoSun” exposure.

Field: Wind Exposure

If the surface is exposed to the Wind, then “WindExposed” should be entered in this field. Otherwise, “NoWind” should be entered.

Note: When a surface is specified with “NoWind”, this has several implications. Within the heat balance code, this surface will default to using the simple ASHRAE exterior convection coefficient correlation with a zero wind speed. In addition, since the ASHRAE simple method

does not have a separate value for equivalent long wavelength radiation to the sky and ground, using “NoWind” also eliminates long wavelength radiant exchange from the exterior of the surface to both the sky and the ground. Thus, only simple convection takes place at the exterior face of a surface specified with “NoWind”.

Field: View Factor to Ground

The fraction of the ground plane (assumed horizontal) that is visible from a heat-transfer surface. It is used to calculate the diffuse solar radiation from the ground that is incident on the surface.

For example, if there are no obstructions, a vertical surface sees half of the ground plane and so View Factor to Ground = 0.5. A horizontal downward-facing surface sees the entire ground plane, so View Factor to Ground = 1.0. A horizontal upward-facing surface (horizontal roof) does not see the ground at all, so View Factor to Ground = 0.0.

Unused if reflections option in Solar Distribution field in Building object input unless a DaylightingDevice:Shelf or DaylightingDevice:Tubular has been specified.

If you do not use the reflections option in the Solar Distribution field in your Building object input, you are responsible for entering the View Factor to Ground for each heat-transfer surface. Typical values for a surface that is not shadowed are obtained by the simple equation:

$$\text{View Factor to Ground} = (1 - \cos(\text{SurfTilt})) / 2$$

For example, this gives 0.5 for a wall of tilt 90°. If the tilt of the wall changes, then the View Factor to Ground must also change.

If you enter **autocalculate** in this field, EnergyPlus will automatically calculate the view factor to ground based on the tilt of the surface.

If **you do use the reflections option in the Solar Distribution field** in your Building object input, you do **not** have to enter View Factor to Ground values. In this case the program will automatically calculate the value to use for each exterior surface taking into account solar shadowing (including shadowing of the ground by the building) and reflections from obstructions (ref: Building, Field: Solar Distribution).

However, if you do use the reflections option AND you are modeling a DaylightingDevice:Shelf or DaylightingDevice:Tubular, then you still need to enter some values of View Factor to Ground. For DaylightingDevice:Shelf you need to enter View Factor to Ground for the window associated with the shelf. And for DaylightingDevice:Tubular you need to enter the View Factor to Ground for the FenestrationSurface:Detailed corresponding to the dome of the tubular device.

Note 1: The corresponding view factor to the sky for diffuse solar radiation is not a user input; it is calculated within EnergyPlus based on surface orientation, sky solar radiance distribution, and shadowing surfaces.

Note 2: The view factors to the sky and ground for thermal infrared (long-wave) radiation are not user inputs; they are calculated within EnergyPlus based on surface tilt and shadowing surfaces. Shadowing surfaces are considered to have the same emissivity and temperature as the ground, so they are lumped together with the ground in calculating the ground IR view factor.

Field: Number of Vertices

This field specifies the number of sides in the surface (number of X,Y,Z vertex groups). For further information, see the discussion on “Surface Vertices” above.

Floor:Detailed

The Floor:Detailed object is used to describe walls. The IDD definition, up to the number of surface sides, is shown below:

```

Floor:Detailed,
\extensible:3 -- duplicate last set of x,y,z coordinates, renumbering please
\format vertices
A1 , \field Name
    \required-field
    \type alpha
    \reference SurfaceNames
    \reference SurfAndSubSurfNames
    \reference AllHeatTranSurfNames
    \reference HeatTranBaseSurfNames
    \reference OutFaceEnvNames
    \reference AllHeatTranAngFacNames
    \reference RadGroupAndSurfNames
    \reference SurfGroupAndHTSurfNames
    \reference AllShadingAndHTSurfNames
A2 , \field Construction Name
    \required-field
    \note To be matched with a construction in this input file
    \type object-list
    \object-list ConstructionNames
A3 , \field Zone Name
    \required-field
    \note Zone the surface is a part of
    \type object-list
    \object-list ZoneNames
A4 , \field Outside Boundary Condition
    \required-field
    \type choice
    \key Surface
    \key Zone
    \key Outdoors
    \key Ground
    \key OtherSideCoefficients
    \key OtherSideConditionsModel
    \key Adiabatic
A5, \field Outside Boundary Condition Object
    \type object-list
    \object-list OutFaceEnvNames
    \note Non-blank only if the field Outside Boundary Condition is Surface, Zone,
OtherSideCoefficients,
    \note or OtherSideConditionsModel
    \note If Surface, specify name of corresponding surface in adjacent zone or
    \note specify current surface name for internal partition separating like zones
    \note If Zone, specify the name of the corresponding zone and
    \note the program will generate the corresponding interzone surface
    \note If OtherSideCoefficients, specify name of SurfaceProperty:OtherSideCoefficients
    \note If OtherSideConditionsModel, specify name of SurfaceProperty:OtherSideConditionsModel
A6 , \field Sun Exposure
    \required-field
    \type choice
    \key SunExposed
    \key NoSun
    \default SunExposed
A7, \field Wind Exposure
    \required-field
    \type choice
    \key WindExposed
    \key NoWind
    \default WindExposed
N1, \field View Factor to Ground
    \type real
    \note From the exterior of the surface
    \note Unused if one uses the "reflections" options in Solar Distribution in Building input
    \note unless a DaylightingDevice:Shelf or DaylightingDevice:Tubular object has been specified.
    \note autocalculate will automatically calculate this value from the tilt of the surface
    \autocalculatable
    \minimum 0.0
    \maximum 1.0
    \default autocalculate
N2 , \field Number of Vertices
    \note shown with 120 vertex coordinates -- extensible object

```

```

\note "extensible" -- duplicate last set of x,y,z coordinates, renumbering please
\note (and changing z terminator to a comma "," for all but last one which needs a semi-colon ";")
\autocalculatable
\minimum 3
\default autocalculate
\note vertices are given in GlobalGeometryRules coordinates -- if relative, all surface coordinates
\note are "relative" to the Zone Origin.  If world, then building and zone origins are used
\note for some internal calculations, but all coordinates are given in an "absolute" system.
N3, \field Vertex 1 X-coordinate
\units m
\type real
N4 , \field Vertex 1 Y-coordinate
\units m
\type real
N5 , \field Vertex 1 Z-coordinate
\units m
\type real
N6, \field Vertex 2 X-coordinate
\units m
\type real
N7, \field Vertex 2 Y-coordinate
\units m
\type real
N8, \field Vertex 2 Z-coordinate
\units m
\type real
N9, \field Vertex 3 X-coordinate
\units m
\type real
N10, \field Vertex 3 Y-coordinate
\units m
\type real
N11, \field Vertex 3 Z-coordinate
\units m
\type real
N12, \field Vertex 4 X-coordinate
\units m
\type real
N13, \field Vertex 4 Y-coordinate
\units m
\type real
N14, \field Vertex 4 Z-coordinate
\units m
\type real
N15, \field Vertex 5 X-coordinate
\units m
\type real
N16, \field Vertex 5 Y-coordinate
\units m
\type real
N17, \field Vertex 5 Z-coordinate
\units m
\type real
N18, \field Vertex 6 X-coordinate
\units m
\type real
N19, \field Vertex 6 Y-coordinate
\units m
\type real
N20, \field Vertex 6 Z-coordinate
\units m
\type real
N21, \field Vertex 7 X-coordinate
\units m
\type real
N22, \field Vertex 7 Y-coordinate
\units m
\type real
N23, \field Vertex 7 Z-coordinate
\units m
\type real

```

```

N24, \field Vertex 8 X-coordinate
      \units m
      \type real
N25, \field Vertex 8 Y-coordinate
      \type real
      \units m
N26, \field Vertex 8 Z-coordinate
      \units m
      \type real
N27, \field Vertex 9 X-coordinate
      \units m
      \type real
N28, \field Vertex 9 Y-coordinate
      \type real
      \units m
N29, \field Vertex 9 Z-coordinate
      \units m
      \type real
N30, \field Vertex 10 X-coordinate
      \units m
      \type real
N31, \field Vertex 10 Y-coordinate
      \type real
      \units m
N32, \field Vertex 10 Z-coordinate
      \units m
      \type real

```

Field: Name

This is a unique name associated with each building surface. It is used in several other places as a reference (e.g. as the base surface name for a Window or Door).

Field: Construction Name

This is the name of the construction (ref: Construction) used in the surface. Regardless of location in the building, the “full” construction (all layers) is used. For example, for an interior wall separating two zones, zone x would have the outside layer (e.g. drywall) as the material that shows in zone y and then the layers to the inside layer – the material that shows in zone x. For symmetric constructions, the same construction can be used in the surfaces described in both zones.

Field: Zone Name

This is the zone name to which the surface belongs.

Field: Outside Boundary Condition

This value can be one of several things depending on the actual kind of surface.

- 1) **Surface** – if this surface is an internal surface, then this is the choice. The value will either be a surface in the base zone or a surface in another zone. The heat balance between two zones can be accurately simulated by specifying a surface in an adjacent zone. EnergyPlus will simulate a group of zones simultaneously and will include the heat transfer between zones. However, as this increases the complexity of the calculations, it is not necessary to specify the other zone unless the two zones will have a significant temperature difference. If the two zones will not be very different (temperature wise), then the surface should use itself as the outside environment. In either case, the surface name on the “outside” of this surface (adjacent to) is placed in the next field.
- 2) **Adiabatic** – an internal surface in the same Zone. The Outside Boundary Condition Object can be left blank.
- 3) **Zone** – this is similar to Surface but EnergyPlus will automatically create the required surface in the adjacent zone when this is entered for the surface. If there are windows or doors on the surface, EnergyPlus automatically creates appropriate sub-surfaces as well.

- 4) **Outdoors** – if this surface is exposed to outside temperature conditions, then this is the choice. See Sun Exposure and Wind Exposure below for further specifications on this kind of surface.
- 5) **Ground** – if this surface is exposed to the ground, then this is the choice. The temperature on the outside of this surface will be the Ground Temperature.
- 6) **OtherSideCoefficients** – if this surface has a custom, user specified temperature or other parameters (See SurfaceProperty:OtherSideCoefficients specification), then this is the choice. The outside boundary condition will be the name of the SurfaceProperty:OtherSideCoefficients specification.
- 7) **OtherSideConditionsModel** – if this surface has a specially-modeled multi-skin component, such as a transpired collector or vented photovoltaic panel, attached to the outside (See SurfaceProperty:OtherSideConditionsModel specification), then this the choice. The outside face environment will be the name of the SurfaceProperty:OtherSideConditionsModels specification.

Field: Outside Boundary Condition Object

If neither Surface, OtherSideCoefficients, or OtherSideConditionsModel are specified for the Outside Boundary Condition (previous field), then this field should be left blank.

As stated above, if the Outside Boundary Condition is “Surface”, then this field’s value must be the surface name whose inside face temperature will be forced on the outside face of the base surface. This permits heat exchange between adjacent zones (interzone heat transfer) when multiple zones are simulated, but can also be used to simulate middle zone behavior without modeling the adjacent zones. This is done by specifying a surface within the zone. For example, a middle floor zone can be modeled by making the floor the Outside Boundary Condition Object for the ceiling, and the ceiling the Outside Boundary Condition Object for the floor.

If the Outside Boundary Condition is Zone, then this field should contain the zone name of the adjacent zone for the surface.

Note: Zones with interzone heat transfer are not adiabatic and the internal surfaces contribute to gains or losses. Adiabatic surfaces are modeled by specifying the base surface itself in this field. Also, for interzone heat transfer, both surfaces must be represented – for example, if you want interzone heat transfer to an attic space, the ceiling in the lower zone must have a surface object with the outside face environment as the floor in the attic and, likewise, there must be a floor surface object in the attic that references the ceiling surface name in the lower zone.

Equally, if the Outside Boundary Condition is “OtherSideCoefficients”, then this field’s value must be the SurfaceProperty:OtherSideCoefficients name. Or if the Outside Boundary Condition is “OtherSideConditionsModel” then this field’s value must be the SurfaceProperty:OtherSideConditionsModel name.

Field: Sun Exposure

If the surface is exposed to the sun, then “SunExposed” should be entered in this field. Otherwise, “NoSun” should be entered.

Note, a cantilevered floor could have “Outdoors” but “NoSun” exposure.

Field: Wind Exposure

If the surface is exposed to the Wind, then “WindExposed” should be entered in this field. Otherwise, “NoWind” should be entered.

Note: When a surface is specified with “NoWind”, this has several implications. Within the heat balance code, this surface will default to using the simple ASHRAE exterior convection coefficient correlation with a zero wind speed. In addition, since the ASHRAE simple method

does not have a separate value for equivalent long wavelength radiation to the sky and ground, using “NoWind” also eliminates long wavelength radiant exchange from the exterior of the surface to both the sky and the ground. Thus, only simple convection takes place at the exterior face of a surface specified with “NoWind”.

Field: View Factor to Ground

The fraction of the ground plane (assumed horizontal) that is visible from a heat-transfer surface. It is used to calculate the diffuse solar radiation from the ground that is incident on the surface.

For example, if there are no obstructions, a vertical surface sees half of the ground plane and so View Factor to Ground = 0.5. A horizontal downward-facing surface sees the entire ground plane, so View Factor to Ground = 1.0. A horizontal upward-facing surface (horizontal roof) does not see the ground at all, so View Factor to Ground = 0.0.

Unused if reflections option in Solar Distribution field in Building object input unless a DaylightingDevice:Shelf or DaylightingDevice:Tubular has been specified.

If you do not use the reflections option in the Solar Distribution field in your Building object input, you are responsible for entering the View Factor to Ground for each heat-transfer surface. Typical values for a surface that is not shadowed are obtained by the simple equation:

$$\text{View Factor to Ground} = (1 - \cos(\text{SurfTilt})) / 2$$

For example, this gives 0.5 for a wall of tilt 90°. If the tilt of the wall changes, then the View Factor to Ground must also change.

If you enter **autocalculate** in this field, EnergyPlus will automatically calculate the view factor to ground based on the tilt of the surface.

If **you do use the reflections option in the Solar Distribution field** in your Building object input, you do **not** have to enter View Factor to Ground values. In this case the program will automatically calculate the value to use for each exterior surface taking into account solar shadowing (including shadowing of the ground by the building) and reflections from obstructions (ref: Building, Field: Solar Distribution).

However, if you do use the reflections option AND you are modeling a DaylightingDevice:Shelf or DaylightingDevice:Tubular, then you still need to enter some values of View Factor to Ground. For DaylightingDevice:Shelf you need to enter View Factor to Ground for the window associated with the shelf. And for DaylightingDevice:Tubular you need to enter the View Factor to Ground for the FenestrationSurface:Detailed corresponding to the dome of the tubular device.

Note 1: The corresponding view factor to the sky for diffuse solar radiation is not a user input; it is calculated within EnergyPlus based on surface orientation, sky solar radiance distribution, and shadowing surfaces.

Note 2: The view factors to the sky and ground for thermal infrared (long-wave) radiation are not user inputs; they are calculated within EnergyPlus based on surface tilt and shadowing surfaces. Shadowing surfaces are considered to have the same emissivity and temperature as the ground, so they are lumped together with the ground in calculating the ground IR view factor.

Field: Number of Vertices

This field specifies the number of sides in the surface (number of X,Y,Z vertex groups). For further information, see the discussion on “Surface Vertices” above.

BuildingSurface:Detailed

The BuildingSurface:Detailed object can more generally describe each of the surfaces. The IDD definition, up to the number of surface sides, is shown below:

BuildingSurface:Detailed,

```

\extensible:3 -- duplicate last set of x,y,z coordinates, renumbering please
\format vertices
A1 , \field Name
    \required-field
    \type alpha
    \reference SurfaceNames
    \reference SurfAndSubSurfNames
    \reference AllHeatTranSurfNames
    \reference HeatTranBaseSurfNames
    \reference OutFaceEnvNames
    \reference AllHeatTranAngFacNames
    \reference RadGroupAndSurfNames
    \reference SurfGroupAndHTSurfNames
    \reference AllShadingAndHTSurfNames
A2 , \field Surface Type
    \required-field
    \type choice
    \key Floor
    \key Wall
    \key Ceiling
    \key Roof
A3 , \field Construction Name
    \required-field
    \note To be matched with a construction in this input file
    \type object-list
    \object-list ConstructionNames
A4 , \field Zone Name
    \required-field
    \note Zone the surface is a part of
    \type object-list
    \object-list ZoneNames
A5 , \field Outside Boundary Condition
    \required-field
    \type choice
    \key Surface
    \key Zone
    \key Outdoors
    \key Ground
    \key OtherSideCoefficients
    \key OtherSideConditionsModel
A6, \field Outside Boundary Condition Object
    \type object-list
    \object-list OutFaceEnvNames
    \note Non-blank only if the field Outside Boundary Condition is Surface, Zone,
OtherSideCoefficients,
    \note or OtherSideConditionsModel
    \note If Surface, specify name of corresponding surface in adjacent zone or
    \note specify current surface name for internal partition separating like zones
    \note If Zone, specify the name of the corresponding zone and
    \note the program will generate the corresponding interzone surface
    \note If OtherSideCoefficients, specify name of SurfaceProperty:OtherSideCoefficients
    \note If OtherSideConditionsModel, specify name of SurfaceProperty:OtherSideConditionsModel

```

```

A7 , \field Sun Exposure
    \required-field
    \type choice
    \key SunExposed
    \key NoSun
    \default SunExposed
A8, \field Wind Exposure
    \required-field
    \type choice
    \key WindExposed
    \key NoWind
    \default WindExposed
N1, \field View Factor to Ground
    \type real
    \note From the exterior of the surface
    \note Unused if one uses the "reflections" options in Solar Distribution in Building input
    \note unless a DaylightingDevice:Shelf or DaylightingDevice:Tubular object has been specified.
    \note autocalculate will automatically calculate this value from the tilt of the surface
    \autocalculatable
    \minimum 0.0
    \maximum 1.0
    \default autocalculate
N2 , \field Number of Vertices
    \note shown with 120 vertex coordinates -- extensible object
    \note "extensible" -- duplicate last set of x,y,z coordinates, renumbering please
    \note (and changing z terminator to a comma "," for all but last one which needs a semi-colon ";")
    \autocalculatable
    \minimum 3
    \default autocalculate
    \note vertices are given in GlobalGeometryRules coordinates -- if relative, all surface coordinates
    \note are "relative" to the Zone Origin.  If world, then building and zone origins are used
    \note for some internal calculations, but all coordinates are given in an "absolute" system.

```

Field: Name

This is a unique name associated with each building surface. It is used in several other places as a reference (e.g. as the base surface name for a Window or Door).

Field: Surface Type

Used primarily for convenience, the surface type can be one of the choices illustrated above – Wall, Floor, Ceiling, Roof. Azimuth (facing) and Tilt are determined from the vertex coordinates. Note that “normal” floors will be tilted 180° whereas flat roofs/ceilings will be tilted 0°. EnergyPlus uses this field’s designation, along with the calculated tilt of the surface, to issue warning messages when tilts are “out of range”. Calculations in EnergyPlus use the actual calculated tilt values for the actual heat balance calculations. Note, however, that a floor tilted 0° is really facing “into” the zone and is not what you will desire for the calculations even though the coordinate may appear correct in the viewed DXF display.

“Normal” tilt for walls is 90° -- here you may use the calculated Azimuth to make sure your walls are facing away from the zone’s interior.

Field: Construction Name

This is the name of the construction (ref: Construction) used in the surface. Regardless of location in the building, the “full” construction (all layers) is used. For example, for an interior wall separating two zones, zone x would have the outside layer (e.g. drywall) as the material that shows in zone y and then the layers to the inside layer – the material that shows in zone x. For symmetric constructions, the same construction can be used in the surfaces described in both zones.

Field: Zone Name

This is the zone name to which the surface belongs.

Field: Outside Boundary Condition

This value can be one of several things depending on the actual kind of surface.

- 1) **Surface** – if this surface is an internal surface, then this is the choice. The value will either be a surface in the base zone or a surface in another zone. The heat balance between two zones can be accurately simulated by specifying a surface in an adjacent zone. EnergyPlus will simulate a group of zones simultaneously and will include the heat transfer between zones. However, as this increases the complexity of the calculations, it is not necessary to specify the other zone unless the two zones will have a significant temperature difference. If the two zones will not be very different (temperature wise), then the surface should use itself as the outside environment. In either case, the surface name on the “outside” of this surface (adjacent to) is placed in the next field.
- 2) **Adiabatic** – an internal surface in the same Zone. The Outside Boundary Condition Object can be left blank.
- 3) **Zone** – this is similar to Surface but EnergyPlus will automatically create the required surface in the adjacent zone when this is entered for the surface. If there are windows or doors on the surface, EnergyPlus automatically creates appropriate sub-surfaces as well.
- 4) **Outdoors** – if this surface is exposed to outside temperature conditions, then this is the choice. See Sun Exposure and Wind Exposure below for further specifications on this kind of surface.
- 5) **Ground** – if this surface is exposed to the ground, then this is the choice. The temperature on the outside of this surface will be the Ground Temperature.
- 6) **OtherSideCoefficients** – if this surface has a custom, user specified temperature or other parameters (See SurfaceProperty:OtherSideCoefficients specification), then this is the choice. The outside boundary condition will be the name of the SurfaceProperty:OtherSideCoefficients specification.
- 7) **OtherSideConditionsModel** – if this surface has a specially-modeled multi-skin component, such as a transpired collector or vented photovoltaic panel, attached to the outside (See SurfaceProperty:OtherSideConditionsModel specification), then this the choice. The outside face environment will be the name of the SurfaceProperty:OtherSideConditionsModelspecification.

Field: Outside Boundary Condition Object

If neither Surface, OtherSideCoefficients, or OtherSideConditionsModel are specified for the Outside Boundary Condition (previous field), then this field should be left blank.

As stated above, if the Outside Boundary Condition is “Surface”, then this field’s value must be the surface name whose inside face temperature will be forced on the outside face of the base surface. This permits heat exchange between adjacent zones (interzone heat transfer) when multiple zones are simulated, but can also be used to simulate middle zone behavior without modeling the adjacent zones. This is done by specifying a surface within the zone. For example, a middle floor zone can be modeled by making the floor the Outside Boundary Condition Object for the ceiling, and the ceiling the Outside Boundary Condition Object for the floor.

If the Outside Boundary Condition is Zone, then this field should contain the zone name of the adjacent zone for the surface.

Note: Zones with interzone heat transfer are not adiabatic and the internal surfaces contribute to gains or losses. Adiabatic surfaces are modeled by specifying the base surface itself in this field. Also, for interzone heat transfer, both surfaces must be represented – for example, if you want interzone heat transfer to an attic space, the ceiling in the lower zone must have a surface object with the outside face environment as the floor in the attic and, likewise, there must be a floor surface object in the attic that references the ceiling surface name in the lower zone.

Equally, if the Outside Boundary Condition is “OtherSideCoefficients”, then this field’s value must be the SurfaceProperty:OtherSideCoefficients name. Or if the Outside Boundary Condition is “OtherSideConditionsModel” then this field’s value must be the SurfaceProperty:OtherSideConditionsModel name.

Field: Sun Exposure

If the surface is exposed to the sun, then “SunExposed” should be entered in this field. Otherwise, “NoSun” should be entered.

Note, a cantilevered floor could have “Outdoors” but “NoSun” exposure.

Field: Wind Exposure

If the surface is exposed to the Wind, then “WindExposed” should be entered in this field. Otherwise, “NoWind” should be entered.

Note: When a surface is specified with “NoWind”, this has several implications. Within the heat balance code, this surface will default to using the simple ASHRAE exterior convection coefficient correlation with a zero wind speed. In addition, since the ASHRAE simple method does not have a separate value for equivalent long wavelength radiation to the sky and ground, using “NoWind” also eliminates long wavelength radiant exchange from the exterior of the surface to both the sky and the ground. Thus, only simple convection takes place at the exterior face of a surface specified with “NoWind”.

Field: View Factor to Ground

The fraction of the ground plane (assumed horizontal) that is visible from a heat-transfer surface. It is used to calculate the diffuse solar radiation from the ground that is incident on the surface.

For example, if there are no obstructions, a vertical surface sees half of the ground plane and so View Factor to Ground = 0.5. A horizontal downward-facing surface sees the entire ground plane, so View Factor to Ground = 1.0. A horizontal upward-facing surface (horizontal roof) does not see the ground at all, so View Factor to Ground = 0.0.

Unused if reflections option in Solar Distribution field in Building object input unless a DaylightingDevice:Shelf or DaylightingDevice:Tubular has been specified.

If you do not use the reflections option in the Solar Distribution field in your Building object input, you are responsible for entering the View Factor to Ground for each heat-transfer surface. Typical values for a surface that is not shadowed are obtained by the simple equation:

$$\text{View Factor to Ground} = (1 - \cos(\text{SurfTilt})) / 2$$

For example, this gives 0.5 for a wall of tilt 90°. If the tilt of the wall changes, then the View Factor to Ground must also change.

If you enter **autocalculate** in this field, EnergyPlus will automatically calculate the view factor to ground based on the tilt of the surface.

If **you do use the reflections option in the Solar Distribution field** in your Building object input, you do **not** have to enter View Factor to Ground values. In this case the program will automatically calculate the value to use for each exterior surface taking into account solar shadowing (including shadowing of the ground by the building) and reflections from obstructions (ref: Building, Field: Solar Distribution).

However, if you do use the reflections option AND you are modeling a DaylightingDevice:Shelf or DaylightingDevice:Tubular, then you still need to enter some values of View Factor to Ground. For DaylightingDevice:Shelf you need to enter View Factor to Ground for the window associated with the shelf. And for DaylightingDevice:Tubular you need to enter the View Factor to Ground for the FenestrationSurface:Detailed corresponding to the dome of the tubular device.

Note 1: The corresponding view factor to the sky for diffuse solar radiation is not a user input; it is calculated within EnergyPlus based on surface orientation, sky solar radiance distribution, and shadowing surfaces.

Note 2: The view factors to the sky and ground for thermal infrared (long-wave) radiation are not user inputs; they are calculated within EnergyPlus based on surface tilt and shadowing surfaces. Shadowing surfaces are considered to have the same emissivity and temperature as the ground, so they are lumped together with the ground in calculating the ground IR view factor.

Field: Number of Vertices

This field specifies the number of sides in the surface (number of X,Y,Z vertex groups). For further information, see the discussion on “Surface Vertices” above.

An IDF example of three walls (first is an exterior wall, second and third are interzone partitions):

```
BuildingSurface:Detailed,Zn001:Wall001, !- Base Surface Name
Wall,EXTERIOR, !- Class and Construction Name
ZONE 1 @ 200 601 0 T, !- Zone
Outdoors,, !- Outside Boundary Condition and Target (if applicable)
SunExposed, !- Solar Exposure
WindExposed, !- Wind Exposure
0.5000000, !- VF to Ground
4, !-Rectangle
0.0000000E+00, 0.0000000E+00, 3.048000,
0.0000000E+00, 0.0000000E+00, 0.0000000E+00,
6.096000, 0.0000000E+00, 0.0000000E+00,
6.096000, 0.0000000E+00, 3.048000 ;
```

```
BuildingSurface:Detailed,Zn001:Wall006, !- Base Surface Name
Wall,INTERIOR, !- Class and Construction Name
HEARTLAND AREA, !- Zone
Surface,Zn004:Wall1005, !- Outside Boundary Conditions and Target (if applicable)
NoSun, !- Solar Exposure
NoWind, !- Wind Exposure
0.5000000, !- VF to Ground
4, !-Rectangle
38.01000, 28.25000, 10.00000,
38.01000, 28.25000, 0.0000000E+00,
38.01000, 18.25000, 0.0000000E+00,
38.01000, 18.25000, 10.00000 ;
```

```
BuildingSurface:Detailed,Zn001:Wall007, !- Base Surface Name
Wall,INTERIOR, !- Class and Construction Name
HEARTLAND AREA, !- Zone
Surface,Zn003:Wall1006, !- Outside Boundary Conditions and Target (if applicable)
NoSun, !- Solar Exposure
NoWind, !- Wind Exposure
0.5000000, !- VF to Ground
4, !-Rectangle
58.01000, 18.25000, 10.00000,
58.01000, 18.25000, 0.0000000E+00,
58.01000, 28.25000, 0.0000000E+00,
58.01000, 28.25000, 10.00000 ;
```

FenestrationSurface:Detailed

This surface class is used for subsurfaces, which can be of five different types: Windows, Doors, GlassDoors, TubularDaylightDomes, and TubularDaylightDiffusers. A subsurface (such as a window) of a base surface (such as a wall) inherits several of the properties (such as Outside Boundary Condition, Sun Exposure, etc.) of the base surface. Windows, GlassDoors, TubularDaylightDomes, and TubularDaylightDiffusers are considered to have one or more glass layers and so transmit solar radiation. Doors are considered to be opaque.

```

FenestrationSurface:Detailed,
  \min-fields 19
  \memo Used for windows, doors
  \format vertices
A1 , \field Name
  \type alpha
  \reference SubSurfNames
  \reference SurfAndSubSurfNames
  \reference AllHeatTranSurfNames
  \reference OutFaceEnvNames
  \reference AllHeatTranAngFacNames
  \reference SurfGroupAndHTSurfNames
  \reference AllShadingAndHTSurfNames
A2 , \field Surface Type
  \required-field
  \type choice
  \key Window
  \key Door
  \key GlassDoor
  \key TubularDaylightDome
  \key TubularDaylightDiffuser
A3 , \field Construction Name
  \required-field
  \note To be matched with a construction in this input file
  \type object-list
  \object-list ConstructionNames
A4 , \field Building Surface Name
  \required-field
  \type object-list
  \object-list SurfaceNames
A5, \field Outside Boundary Condition Object
  \type object-list
  \object-list OutFaceEnvNames
  \note Non-blank only if base surface field Outside Boundary Condition is Surface or
OtherSideCoefficients
  \note If Surface, specify name of corresponding subsurface in adjacent zone or
  \note specify current subsurface name for internal partition separating like zones
  \note If OtherSideCoefficients, specify name of SurfaceProperty:OtherSideCoefficients or leave
blank to inherit
  \note Base Surface's OtherSide Coefficients
N1, \field View Factor to Ground
  \type real
  \note From the exterior of the surface
  \note Unused if one uses the "reflections" options in Solar Distribution in Building input
  \note unless a DaylightingDevice:Shelf or DaylightingDevice:Tubular object has been specified.
  \note autocalculate will automatically calculate this value from the tilt of the surface
  \autocalculatable
  \minimum 0.0
  \maximum 1.0
  \default autocalculate
A6, \field Shading Control Name
  \note enter the name of a WindowProperty:ShadingControl object
  \type object-list
  \object-list WindowShadeControlNames
  \note used for windows and glass doors only
  \note If not specified, window or glass door has no shading (blind, roller shade, etc.)
A7, \field Frame and Divider Name
  \note Enter the name of a WindowProperty:FrameAndDivider object
  \type object-list
  \object-list WindowFrameAndDividerNames
  \note Used only for exterior windows (rectangular) and glass doors.
  \note Unused for triangular windows.
  \note If not specified (blank), window or glass door has no frame or divider
  \note and no beam solar reflection from reveal surfaces.
N2 , \field Multiplier
  \note Used only for Surface Type = WINDOW, GLASSDOOR or DOOR
  \note Non-integer values will be truncated to integer
  \default 1.0
  \minimum 1.0

```

```

N3 , \field Number of Vertices
    \minimum 3
    \maximum 4
    \autocalculatable
    \default autocalculate
    \note vertices are given in GlobalGeometryRules coordinates -- if relative, all surface coordinates
    \note are "relative" to the Zone Origin.  If world, then building and zone origins are used
    \note for some internal calculations, but all coordinates are given in an "absolute" system.
N4, \field Vertex 1 X-coordinate
    \units m
    \type real
N5 , \field Vertex 1 Y-coordinate
    \units m
    \type real
N6 , \field Vertex 1 Z-coordinate
    \units m
    \type real
N7, \field Vertex 2 X-coordinate
    \units m
    \type real
N8, \field Vertex 2 Y-coordinate
    \units m
    \type real
N9, \field Vertex 2 Z-coordinate
    \units m
    \type real
N10, \field Vertex 3 X-coordinate
    \units m
    \type real
N11, \field Vertex 3 Y-coordinate
    \units m
    \type real
N12, \field Vertex 3 Z-coordinate
    \units m
    \type real
N13, \field Vertex 4 X-coordinate
    \units m
    \type real
    \note Not used for triangles
N14, \field Vertex 4 Y-coordinate
    \type real
    \units m
    \note Not used for triangles
N15; \field Vertex 4 Z-coordinate
    \units m
    \type real
    \note Not used for triangles

```

Field: Name

This is a unique name associated with the heat transfer subsurface. It may be used in other places as a reference (e.g. as the opposing subsurface of an interzone window or door).

Field: Surface Type

The choices for Surface Type are Window, Door, GlassDoor, TubularDaylightDome, and TubularDaylightDiffuser. Doors are assumed to be opaque (do not transmit solar radiation) whereas the other surface types do transmit solar radiation. Windows and Glass Doors are treated identically in the calculation of conduction heat transfer, solar gain, daylighting, etc. A Window or GlassDoor, but not a Door, can have a movable interior, exterior or between-glass shading device, such as blinds (ref: WindowMaterial:Blind), and can have a frame and/or a divider (ref: WindowProperty:FrameAndDivider). TubularDaylightDomes and TubularDaylightDomes are specialized subsurfaces for use with the DaylightingDevice:Tubular object to simulate Tubular Daylighting Devices (TDDs). TubularDaylightDomes and TubularDaylightDomes cannot have shades, screens or blinds. In the following, the term "window" applies to Window, GlassDoor, TubularDaylightDome, and TubularDaylightDome, if not otherwise explicitly mentioned.

As noted in the description of the BuildingSurface:Detailed, Azimuth (facing angle) and Tilt are calculated from the entered vertices. Tilts of subsurfaces will normally be the same as their base surface. If these are significantly beyond the “normals” for the base surface, warning messages may be issued. If the facing angles are not correct, you may have a window pointing “into” the zone rather than out of it – this would cause problems in the calculations. Note, too, that a “reveal” (inset or outset) may occur if the plane of the subsurface is not coincident with the base surface; the reveal has an effect on shading of the subsurface.

Field: Construction Name

This is the name of the subsurface’s construction (ref: Construction [for Window, GlassDoor and Door] and Construction:WindowDataFile [for Window and GlassDoor]).

For windows, if Construction Name is not found among the constructions on the input (.idf) file, the Window5 Data File (Window5DataFile.dat) will be searched for that Construction Name (see “Importing Windows from WINDOW 5”). If that file is not present or if the Construction Name does not match the name of an entry on the file, an error will result. If there is a match, a window construction and its corresponding glass and gas materials will be created from the information read from the file.

Field: Building Surface Name

This is the name of a surface that contains this subsurface. Certain kinds of surfaces may not be allowed to have subsurfaces. For example, a surface in contact with the ground (Outside Boundary Condition = Ground) cannot contain a window.

Field: Outside Boundary Condition Object

If the base surface has Outside Boundary Condition = Surface or OtherSideCoefficients, then this field must also be specified for the subsurface. Otherwise, it can be left blank.

If the base surface has Outside Boundary Condition = Zone, then this surface retains that characteristic and uses the same zone of the base surface. It can be entered here for clarity or it can be left blank.

If Outside Boundary Condition for the base surface is Surface, this field should specify the subsurface in the opposing zone that is the counterpart to this subsurface. The constructions of the subsurface and opposing subsurface must match, except that, for multi-layer constructions, the layer order of the opposing subsurface’s construction must be the reverse of that of the subsurface.

If Outside Boundary Condition for the base surface is OtherSideCoefficients, this field could specify the set of SurfaceProperty:OtherSideCoefficients for this subsurface. If this is left blank, then the Other Side Coefficients of the base surface will be used for this subsurface. *Windows and GlassDoors are not allowed to have Other Side Coefficients.*

Field: View Factor to Ground

The fraction of the ground plane (assumed horizontal) that is visible from a heat-transfer surface. It is used to calculate the diffuse solar radiation from the ground that is incident on the surface.

For example, if there are no obstructions, a vertical surface sees half of the ground plane and so View Factor to Ground = 0.5. A horizontal downward-facing surface sees the entire ground plane, so View Factor to Ground = 1.0. A horizontal upward-facing surface (horizontal roof) does not see the ground at all, so View Factor to Ground = 0.0.

Unused if reflections option in Solar Distribution field in Building object input unless a Daylighting Device:Shelf or Daylighting Device:Tubular has been specified.

If you do not use the reflections option in the Solar Distribution field in your Building object input, you are responsible for entering the View Factor to Ground for each heat-transfer surface. Typical values for a surface that is not shadowed are obtained by the simple equation:

$$\text{View Factor to Ground} = (1 - \cos(\text{SurfTilt})) / 2$$

For example, this gives 0.5 for a wall of tilt 90°. If the tilt of the wall changes, then the View Factor to Ground must also change.

If you enter **autocalculate** in this field, EnergyPlus will automatically calculate the view factor to ground based on the tilt of the surface.

If **you do use the reflections option in the Solar Distribution field** in your BUILDING object input, you do **not** have to enter View Factor to Ground values. In this case the program will automatically calculate the value to use for each exterior surface taking into account solar shadowing (including shadowing of the ground by the building) and reflections from obstructions (ref: Building, Field: Solar Distribution).

However, if you do use the reflections option AND you are modeling a DaylightingDevice:Shelf or DaylightingDevice:Tubular, then you still need to enter some values of View Factor to Ground. For DaylightingDevice:Shelf you need to enter View Factor to Ground for the window associated with the shelf. And for DaylightingDevice:Tubular you need to enter the View Factor to Ground for the FenestrationSurface:Detailed corresponding to the dome of the tubular device (ref: NEED CROSS REFERENCE HERE).

Note 1: The corresponding view factor to the sky for diffuse solar radiation is not a user input; it is calculated within EnergyPlus based on surface orientation, sky solar radiance distribution, and shadowing surfaces.

Note 2: The view factors to the sky and ground for thermal infrared (long-wave) radiation are not user inputs; they are calculated within EnergyPlus based on surface tilt and shadowing surfaces. Shadowing surfaces are considered to have the same emissivity and temperature as the ground, so they are lumped together with the ground in calculating the ground infrared view factor.

Field: Shading Control Name

This field, if not blank, is the name of the window shading control (ref: WindowProperty:ShadingControl) for this subsurface. It is used for Surface Type = Window and GlassDoor. To assign a shade to a window or glass door, see WindowMaterial:Shade. To assign a screen, see WindowMaterial:Screen. To assign a blind, see WindowMaterial:Blind. To assign switchable glazing, such as electrochromic glazing, see WindowProperty:ShadingControl.

Field: Frame and Divider Name

This field, if not blank, can be used to specify window frame, divider and reveal-surface data (ref: WindowProperty:FrameAndDivider). It is used only for exterior GlassDoors and rectangular exterior Windows, i.e., those with OutsideFaceEnvironment = Outdoors.

This field should be blank for triangular windows.

Field: Multiplier

Used only for Surface Type = Window, Door or Glass Door. It is the number of identical items on the base surface. Using Multiplier can save input effort and calculation time. In the calculation the area (and area of frame and divider, if present and surface type is a window) is multiplied by Multiplier. The calculation of shadowing on the subsurfaces (and the calculation of the interior distribution of beam solar radiation transmitted by windows and glass doors) are done for the specified subsurface position and dimensions.

Multiplier should be used with caution. Multiplier > 1 can give inaccurate or nonsensical results in situations where the results are sensitive to window or glass door position. This includes shadowing on the window/glass door, daylighting from the window/glass door, and interior distribution of solar radiation from the window/glass door. In these cases, the results for the single input window/glass door, after multiplication, may not be representative of the results you would get if you entered each of the multiple subsurfaces separately.

If Multiplier > 1, you will get

--a *warning* if Solar Distribution = FullExterior or FullInteriorAndExterior (ref: Building - Field: Solar Distribution), indicating that the shadowing on the input window or the interior solar radiation distribution from the input window may not be representative of the actual group of windows. No warning is issued if Solar Distribution = MinimalShadowing.

--an *error* if the window is an exterior window/glass door in a zone that has a detailed daylighting calculation (Daylighting:Detailed specified for the zone). Since a single window with a multiplier can never give the same daylight illuminance as the actual set of windows, you are not allowed to use Multiplier in this situation.

Field: Number of Vertices

The number of sides the surface has (number of X,Y,Z vertex groups). For further information, see the discussion on “Surface Vertices” above. Door and GlassDoor subsurfaces are rectangular and therefore have four vertices. Window subsurfaces can be rectangular or triangular and therefore have four or three vertices, respectively.

Fields: Vertex Coordinates

This is a total of twelve fields giving the x,y,z coordinate values of the four vertices of rectangular subsurfaces [m], or a total of nine fields giving the x,y,z coordinate values of the three vertices of triangular windows.

For triangular windows the first vertex listed can be any of the three vertices, but the order of the vertices should be counter-clockwise if VertexEntry is CounterClockWise and clockwise if VertexEntry is ClockWise (ref: GlobalGeometryRules).

An IDF example of a rectangular subsurface (Window):

```

FenestrationSurface:Detailed,Zn001:Wall001:Win001,  !- SubSurface Name
Window,SINGLE PANE HW WINDOW,  !- Class and Construction Name
Zn001:Wall001,,  !- Base Surface Name and Target (if applicable)
0.5000000 ,  !- VF to Ground
WINDOW-CONTROL-DRAPES,  !- Window Shading Control
TestFrameAndDivider,  !- Frame/Divider name
5,  !- Multiplier
4,  !- Rectangle (number of sides)
1.524000 , 0.1520000 , 2.743000 ,
1.524000 , 0.1520000 , 0.3050000 ,
4.572000 , 0.1520000 , 0.3050000 ,
4.572000 , 0.1520000 , 2.743000 ;
    
```

Window Modeling Options

The following table shows what input objects/fields to use to model different window options. It also gives the name of an example input, if available, that demonstrates the option.

Table 7. Window Modeling Options

Option	Object/Field or Output Variable	Input File (distributed with install)
Build up a window from layers	WindowMaterial:Glazing, WindowMaterial:Gas, WindowMaterial:Shade, WindowMaterial:Screen, WindowMaterial:Blind, Construction	WindowTests.idf
Add an overhang	Shading:Zone:Detailed	5ZoneAirCooled.idf
Add a shading device	WindowMaterial:Shade, WindowMaterial:Screen or WindowMaterial:Blind;	WindowTests.idf, PurchAirWindowBlind.idf

	WindowProperty:ShadingControl	
Control a shading device	WindowProperty:ShadingControl	PurchAirWindowBlind.idf
Determine when a shading device is on in a particular timestep	Print the variable “Fraction of Time Shading Device is On”	PurchAirWindowBlind.idf
Control the slat angle of a blind	WindowProperty:ShadingControl	PurchAirWindowBlind.idf
Add a frame	WindowProperty:FrameAndDivider	PurchAirWithDaylighting.idf
Add a divider	WindowProperty:FrameAndDivider	PurchAirWithDaylighting.idf
Allow window to daylight a zone	Daylighting:Controls, Daylighting:DELight:Controls	PurchAirWithDaylighting.idf, DELight-Detailed-Comparison.idf
Find solar reflected onto window from neighboring buildings	Building/SolarDistribution field – uses “WithReflections”	ReflectiveAdjacentBuilding.idf
Model switchable glazing (e.g., electrochromic glass)	WindowProperty:ShadingControl	PurchAirWithDaylighting.idf
Add an interior window	Define two FenestrationSurface:Detailed’s, one for each associated interior wall	PurchAirWithDoubleFacadeDaylighting.idf
Track how beam solar falls on interior surfaces	Building/Solar Distribution = FullInteriorAndExterior	PurchAirWithDoubleFacadeDaylighting.idf
Track beam solar transmitted through interior windows	Building/Solar Distribution = FullInteriorAndExterior	PurchAirWithDoubleFacadeDaylighting.idf
Add a shading device on an interior window	<i>Not allowed</i>	
Model an airflow window (aka, heat extract window)	WindowProperty:AirflowControl	AirflowWindowsAndBetweenGlassBlinds.idf
Add a storm window glass layer	WindowProperty:StormWindow	StormWindow.idf
Add natural ventilation through an open window	Ventilation or AirflowNetwork objects (AirflowNetwork:MultiZone:Surface, AirflowNetwork:MultiZone:Component:DetailedOpening, etc.)	AirflowNetwork3zvent.idf
Add diffusing glass	WindowMaterial:Glazing/Solar Diffusing = Yes	
Add dirt on window	WindowMaterial:Glazing/Dirt Correction Factor for Solar and Visible Transmittance	
Import window (and frame/divider if present) from WINDOW 5 program	See “Importing Windows from WINDOW 5”	
Find daylighting through interior windows	See “Double Facades: Daylighting through Interior Windows”	PurchAirWithDoubleFacadeDaylighting.idf
Determine when condensation	Print the variables “Inside	

occurs	Glass Condensation Flag," "Inside Frame Condensation Flag," "Inside Divider Condensation Flag"	
--------	---	--

InternalMass

Any surface that would logically be described as an interior wall, floor or ceiling can just as easily be described as Internal Mass. Internal Mass surface types only exchange energy with the zone in which they are described; they do not see any other zones. There are two approaches to using internal mass. The first approach is to have several pieces of internal mass with each piece having a different construction type. The other approach is to choose an average construction type and combine all of the interior surfaces into a single internal mass. Note that furniture and other large objects within a zone can be described using internal mass. However, simplifying calculations using internal mass must be used with caution when the "FullInteriorAndExterior" or "FullInteriorAndExteriorWithReflections" Solar Distribution model (see Building parameters) is chosen.

Example

When zoning an office building, five west-facing offices have been combined into one zone. All of the offices have interior walls made of the same materials. As shown in the figure below, this zone may be described with 5 exterior walls and 11 internal walls or 1 exterior wall and 1 internal mass. Note that fewer surfaces will speed up the EnergyPlus calculations.

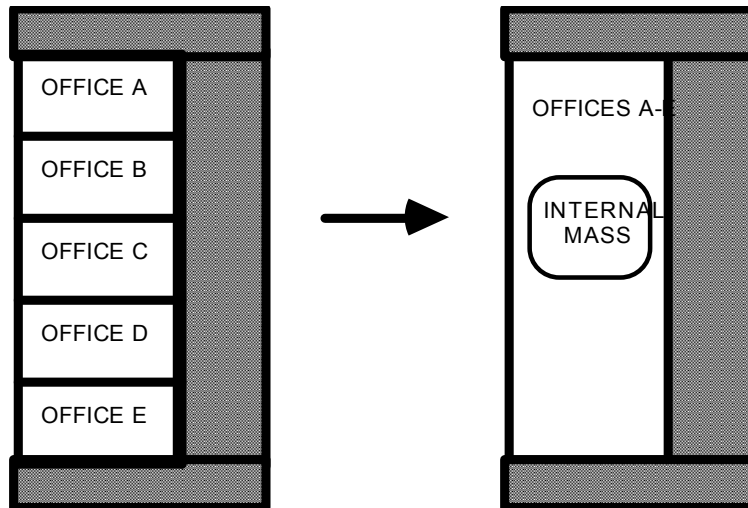


Figure 20. Representing 11 internal walls as internal mass

Example

A five-story building has the same ceiling/floor construction separating each of the levels. Zones that are on floors 2 through 4 may be described using a single piece of internal mass to represent both the floor and ceiling. The construction for this internal mass would be identical to the ceiling/floor construction that would be used to describe separate surfaces.

```

InternalMass,
  \memo Used to describe internal zone surface area that does not need to be part of geometric
  \memo representation. This should be the total surface area exposed to the zone air.
A1 , \field Name
  \required-field
  \type alpha
  \reference AllHeatTranSurfNames
  \reference AllHeatTranAngFacNames
  \reference SurfGroupAndHTSurfNames
A2 , \field Construction Name
  \required-field
  \note To be matched with a construction in this input file
  \type object-list
  \object-list ConstructionNames
A3 , \field Zone Name
  \required-field
  \note Zone the surface is a part of
  \note used to be Interior Environment
  \type object-list
  \object-list ZoneNames
N1 ; \field Surface Area
  \required-field
  \units m2
  \minimum> 0

```

Field: Name

This is a unique character string associated with the internal mass surface. Though it must be unique from other surface names, it is used primarily for convenience with internal mass surfaces.

Field: Construction Name

This is the name of the construction (ref: Construction) used in the surface.

Field: Zone Name

This is the name of the zone in which the internal mass is represented.

Field: Surface Area

This field is the surface area of the internal mass. The area that is specified must be the entire surface area that is exposed to the zone. If both sides of a wall are completely within the same zone, then the area of both sides must be included when describing that internal wall.

IDF examples of Internal Mass surfaces:

```

InternalMass,Zn002:IntM001, !- Surface Name
INTERIOR, !- Construction Name
DORM ROOMS AND COMMON AREAS, !- Zone
408.7734 ; !- Total area exposed to Zone {m2}
InternalMass,Zn002:IntM002, !- Surface Name
PARTITION02, !- Construction Name
DORM ROOMS AND COMMON AREAS, !- Zone
371.6122 ; !- Total area exposed to Zone {m2}

```

Surface Output Variables/Reports

Output variables applicable to all heat transfer surfaces:

```

Zone,Average,Surface Inside Temperature[C]
Zone,Average,Surface Outside Temperature[C]
Zone,Average,Surface Int Adjacent Air Temperature [C]
Zone,Average,Surface Int Convection Coeff[W/m2-K]
Zone,Average,Surface Ext Convection Coeff[W/m2-K]
Zone,Average,Surface Ext Rad To Air Coeff[W/m2-K]
Zone,Average,Surface Ext Rad To Sky Coeff[W/m2-K]

```

Zone,Average,Surface Ext Rad To Ground Coeff[W/m2-K]Zone,Average,Beam Sol Amount from Ext Windows on Inside of Surface[W]
 Zone,Average,Beam Sol Intensity from Ext Windows on Inside of Surface[W/m2]
 Zone,Average,Beam Sol Amount from Int Windows on Inside of Surface[W]
 Zone,Average,Beam Sol Intensity from Int Windows on Inside of Surface[W/m2]
 Zone,Average,Initial Transmitted Diffuse Solar Absorbed on Inside of Surface[W]
 Zone,Average,Initial Transmitted Diffuse Solar Transmitted Out Through Inside of Window Surface[W]
 Zone,Average,Total Shortwave Radiation Absorbed on Inside of Surface[W]

Output variables applicable to all exterior heat transfer surfaces:

Zone,Average,Surface Ext Outdoor Dry Bulb [C]
 Zone,Average,Surface Ext Outdoor Wet Bulb [C]
 Zone,Average,Surface Ext Wind Speed [m/s]
 Zone,Average,Surface Ext Sunlit Area [m2]
 Zone,Average,Surface Ext Sunlit Fraction []
 Zone,Average,Surface Ext Solar Incident[W/m2]
 Zone,Average,Surface Ext Solar Beam Incident[W/m2]
 Zone,Average,Surface Ext Solar Sky Diffuse Incident[W/m2]
 Zone,Average,Surface Ext Solar Ground Diffuse Incident[W/m2]
 Zone,Average,Surface Ext Diff Sol From Bm-To-Diff Refl From Ground[W/m2]
 Zone,Average,Surface Ext Solar From Sky Diffuse Refl From Ground[W/m2]
 Zone,Average,Surface Ext Solar From Sky Diffuse Refl From Obstructions[W/m2]
 Zone,Average,Surface Ext Beam Sol From Bm-To-Bm Refl From Obstructions[W/m2]
 Zone,Average,Surface Ext Diff Sol From Bm-To-Diff Refl FromObstructions[W/m2]
 Zone,Average,Surface Ext Solar Beam Cosine Of Incidence Angle[]

Output variables applicable to opaque heat transfer surfaces (FLOOR, WALL, ROOF, DOOR). Note – these are advanced variables – you must read the descriptions and understand before use – then you must use the Diagnostics object to allow reporting.

Zone,Average,Opaque Surface Inside Face Conduction[W]
 Zone,Average,Opaque Surface Inside Face Conduction Gain[W]
 Zone,Average,Opaque Surface Inside Face Conduction Loss[W]
 Zone,Average,Zone Opaque Surface Inside Face Conduction Gain[W]
 Zone,Average,Zone Opaque Surface Inside Face Conduction Loss[W]
 Zone,Average,Opaque Surface Inside Face Beam Solar Absorbed[W]

Output variables applicable only to exterior windows and glass doors:

Zone,Average,Zone Transmitted Solar[W]
 Zone,Sum,Zone Transmitted Solar Energy[J]
 Zone,Average,Zone Window Heat Gain[W]
 Zone,Sum,Zone Window Heat Gain Energy[J]
 Zone,Average,Zone Window Heat Loss[W]
 Zone,Sum,Zone Window Heat Loss Energy[J]
 Zone,Average,Zone Beam Solar from Exterior Windows[W]
 Zone,Sum,Zone Beam Solar from Exterior Windows Energy[J]
 Zone,Average,Zone Diff Solar from Exterior Windows[W]
 Zone,Sum,Zone Diff Solar from Exterior Windows Energy[J]
 Zone,Average,Window Solar Absorbed:All Glass Layers[W]
 Zone,Average,Total Shortwave Absorbed:All Glass Layers[W]
 Zone,Sum,Window Solar Absorbed:All Glass Layers Energy[J]
 Zone,Average,Window Solar Absorbed:Shading Device[W]
 Zone,Average,Window Transmitted Solar[W]
 Zone,Sum,Window Transmitted Solar Energy[J]
 Zone,Average,Window Transmitted Beam Solar[W]
 Zone,Sum,Window Transmitted Beam Solar Energy[J]
 Zone,Average,Window Transmitted Diffuse Solar[W]
 Zone,Sum,Window Transmitted Diffuse Solar Energy[J]
 Zone,Average,Window System Solar Transmittance[]
 Zone,Average,Window System Solar Absorptance[]
 Zone,Average,Window System Solar Reflectance[]
 Zone,Average,Window Gap Convective Heat Flow[W]

```

Zone,Sum,Window Gap Convective Heat Flow Energy[J]
Zone,Average,Window Heat Gain[W]
Zone,Sum,Window Heat Gain Energy[J]
Zone,Average,Window Heat Loss[W]
Zone,Sum,Window Heat Loss Energy[J]
Zone,Average,Glass Beam-Beam Solar Transmittance[]
Zone,Average,Glass Diffuse-Diffuse Solar Transmittance[]
Zone,Average,Window Calculation Iterations[]
Zone,Average,Solar Horizontal Profile Angle[degree]
Zone,Average,Solar Vertical Profile Angle[degree]
Zone,Average,Beam Solar Reflected by Outside Reveal Surfaces[W]
Zone,Average,Beam Solar Reflected by Inside Reveal Surfaces[W]
Zone,Average,Inside Glass Condensation Flag[]
Zone,Average,Inside Frame Condensation Flag[]
Zone,Average,Inside Divider Condensation Flag[]
Zone,Average,Fraction of Time Shading Device Is On[]
Zone,Average,Window Blind Slat Angle [deg]
Zone,Average,Blind Beam-Beam Solar Transmittance[]
Zone,Average,Blind Beam-Diffuse Solar Transmittance[]
Zone,Average,Blind Diffuse-Diffuse Solar Transmittance[]
Zone,Average,Blind/Glass System Beam-Beam Solar Transmittance[]
Zone,Average,Blind/Glass System Diffuse-Diffuse Solar Transmittance[]
Zone,State,Storm Window On/Off Flag[]
HVAC,Average,System Node Temp[C]           (for OUTDOOR AIR NODE object)

```

If the user requests to display advanced report variables (e.g. see Output:Diagnostics keyword DisplayAdvancedReportVariables) the the following additional output variables are available for exterior windows and glass doors

```

Zone,Average,Window Convection Heat Gain from Glazing to Zone [W]
Zone,Average,Window Net Infrared Heat Gain from Glazing to Zone [W]
Zone,Average,Window Shortwave Heat Loss from Zone Back Out Window [W]
Zone,Average,Window Heat Gain from Frame and Divider to Zone [W]
Zone,Average,Window Convection Heat Gain from Gap between Shade and Glazing
to Zone [W]
Zone,Average,Window Convection Heat Gain from Shade to Zone [W]
Zone,Average,Window Net Infrared Heat Gain from Shade to Zone [W]

```

Output variable applicable only to interior windows and glass doors:

```

Zone,Average, Beam Solar Transmitted Through Interior Window [W]

```

Surface Output Variables (all heat transfer surfaces)

Surface Inside Temperature [C]

The inside surface temperature of a heat transfer surface.

Surface Outside Temperature [C]

The outside surface temperature of a heat transfer surface.

Surface Int Adjacent Air Temperature [C]

The effective bulk air temperature used for modeling the inside surface convection heat transfer. This is the same as the zone mean air temperature when using the mixing model for roomair. However, if more advanced roomair models are used, this variable will report the air temperature predicted by the roomair model as it was used in the surface heat balance model calculations.

Surface Int Convection Coeff [W/m2-K]

The inside air film convective conductance for a heat transfer surface.

Surface Ext Convection Coeff [W/m2-K]

The outside air film convective conductance for a heat transfer surface.

Surface Ext Rad To Air Coeff [W/m2-K]

The outside heat transfer coefficient for radiation exchange with the air mass.

Surface Ext Rad To Sky Coeff [W/m2-K]

The outside heat transfer coefficient for radiation exchange with the sky.

Surface Ext Rad To Ground Coeff [W/m2-K]

The outside heat transfer coefficient for radiation exchange with the ground.

Beam Sol Amount from Ext Windows on Inside of Surface [W]

Beam solar radiation from the exterior windows in a zone incident on the inside face of a surface in the zone. If Solar Distribution in the BUILDING object is equal to MinimalShadowing or FullExterior, it is assumed that all beam solar from exterior windows falls on the floor. In this case the value of this report variable can be greater than zero only for floor surfaces. If Solar Distribution equals FullInteriorExterior the program tracks where beam solar from exterior windows falls inside the zone, in which case the value of this variable can be greater than zero for floor as well as wall surfaces.

Beam Sol Intensity from Ext Windows on Inside of Surface [W/m2]

The previous variable divided by the surface's area.

Diff Sol Amount from Ext Windows on Inside of Surface [W]

Diffuse solar radiation from the exterior windows in a zone incident on the inside face of a surface in the zone. It is assumed that this diffuse radiation is uniformly distributed in the inside of the zone.

Diff Sol Intensity from Ext Windows on Inside of Surface [W/m2]

The previous variable divided by the surface's area. Since this diffuse radiation is assumed to be uniformly distributed, the value of this report variable will be the same for all of the heat transfer surfaces in a zone.

Beam Sol Amount from Int Windows on Inside of Surface [W]

Beam solar radiation from the interior (i.e., interzone) windows in a zone incident on the inside face of a surface in the zone. This value is calculated only if Solar Distribution in the BUILDING object is equal to FullInteriorExterior. However, the program does not track where this radiation falls. Instead, it is treated by the program as though it were diffuse radiation uniformly distributed over all of the zone surfaces. See **Figure 21**.

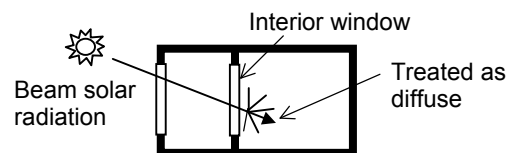


Figure 21. Beam solar radiation entering a zone through an interior window is distributed inside the zone as though it were diffuse radiation.

Beam Sol Intensity from Int Windows on Inside of Surface [W/m2]

The previous variable divided by the surface's area. Since this diffuse radiation is assumed to be uniformly distributed, the value of this report variable will be the same for all of the heat transfer surfaces in a zone.

Initial Transmitted Diffuse Solar Absorbed on Inside of Surface [W]

As of Version 2.1, diffuse solar transmitted through exterior and interior windows is no longer uniformly distributed. Instead, it is distributed according to the approximate view factors between the transmitting window and all other heat transfer surfaces in the zone. This variable is the amount of transmitted diffuse solar that is initially absorbed on the inside of each heat transfer surface. The portion of this diffuse solar that is reflected by all surfaces in the zone is subsequently redistributed uniformly to all heat transfer surfaces in the zone, along with interior reflected beam solar and shortwave radiation from lights. The total absorbed shortwave radiation is given by the next variable.

Total Shortwave Radiation Absorbed on Inside of Surface [W]

As of Version 2.1, the previous variable plus absorbed shortwave radiation from uniformly distributed initially-reflected diffuse solar, reflected beam solar, and shortwave radiation from lights.

Surface Output Variables (exterior heat transfer surfaces)***Surface Ext Outdoor Dry Bulb [C]***

The outdoor air dry-bulb temperature calculated at the height above ground of the surface centroid.

Surface Ext Outdoor Wet Bulb [C]

The outdoor air wet-bulb temperature calculated at the height above ground of the surface centroid.

Surface Ext Wind Speed [m/s]

The outdoor wind speed calculated at the height above ground of the surface centroid.

Surface Ext Sunlit Area [m²]

The outside area of an exterior surface that is illuminated by (unreflected) beam solar radiation.

Surface Ext Sunlit Fraction []

The fraction of the outside area of an exterior surface that is illuminated by (unreflected) beam solar radiation. Equals Surface Ext Sunlit Area divided by total surface area.

Surface Ext Solar Incident [W/m²]

The total solar radiation incident on the outside of an exterior surface. It is the sum of:

- Surface Ext Solar Beam Incident
- Surface Ext Solar Sky Diffuse Incident
- Surface Ext Solar Ground Diffuse Incident
- Surface Ext Solar From Sky Diffuse Refl From Obstructions
- Surface Ext Beam Sol From Bm-To-Bm Refl From Obstructions
- Surface Ext Diff Sol From Bm-To-Diff Refl From Obstructions

Surface Ext Solar Beam Incident [W/m²]

The solar beam radiation incident on the outside of an exterior surface, including the effects of shadowing, if present. The beam here is that directly from the sun; it excludes beam specularly reflected from obstructions.

Surface Ext Solar Sky Diffuse Incident [W/m²]

The solar diffuse radiation from the sky incident on the outside of an exterior surface, including the effects of shadowing, if present.

Surface Ext Solar Ground Diffuse Incident [W/m²]

The solar diffuse radiation incident on the outside of an exterior surface that arises from reflection of beam solar and sky diffuse solar from the ground. This is the sum of the next two output variables, “Surface Ext Diff Sol From Bm-To-Diff Refl From Ground” and “Surface Ext Solar From Sky Diffuse Refl From Ground.” The reflected solar radiation from the ground is assumed to be diffuse and isotropic (there is no specular component).

If “Reflections” option is not chosen in the Solar Distribution Field in the BUILDING object, the effects of shadowing are accounted for by the user-specified value of View Factor to Ground for the surface. If “Reflections” option is chosen, the program determines the effects of shadowing, including time-varying shadowing of the ground plane by the building itself.

Surface Ext Solar From Bm-To-Diff Refl From Ground [W/m²]

The solar diffuse radiation incident on the outside of an exterior surface that arises from beam-to-diffuse reflection from the ground. It is assumed that there is no beam-to-beam (specular) component. The beam here is that directly from the sun; it excludes beam specularly reflected from obstructions.

Surface Ext Solar From Sky Diffuse Refl From Ground [W/m²]

The solar diffuse radiation incident on the outside of an exterior surface that arises from sky diffuse solar reflection from the ground. The sky diffuse here is that directly from the sky; it excludes reflection of sky diffuse from obstructions.

Surface Ext Solar From Sky Diffuse Refl From Obstructions [W/m²]

The solar diffuse radiation incident on the outside of an exterior surface that arises from sky diffuse reflection from one or more obstructions. This value will be non-zero only if “Reflections” option is chosen in the BUILDING object.

Surface Ext Beam Sol From Bm-To-Bm Refl From Obstructions [W/m²]

The solar beam radiation incident on the outside of an exterior surface that arises from beam-to-beam (specular) reflection from one or more obstructions. This value will be non-zero only if “Reflections” option is chosen in the BUILDING object. For windows, the program treats this beam radiation as diffuse radiation in calculating its transmission and absorption.

Surface Ext Diff Sol From Bm-To-Diff Refl From Obstructions [W/m²]

The solar diffuse radiation incident on the outside of an exterior surface that arises from beam-to-diffuse reflection from building shades or building surfaces. This value will be non-zero only if “Reflections” option is chosen in the BUILDING object.

Surface Ext Solar Beam Cosine Of Incidence Angle []

The cosine of the angle of incidence of (unreflected) beam solar radiation on the outside of an exterior surface. The value varies from 0.0 for beam parallel to the surface (incidence angle = 90°) to 1.0 for beam perpendicular to the surface (incidence angle = 0°).

Surface Inside Temperature [C]

The inside surface temperature of a heat transfer surface.

Surface Outside Temperature [C]

The outside surface temperature of a heat transfer surface.

Surface Int Convection Coeff [W/m²-K]

The inside air film convective conductance for a heat transfer surface.

Surface Ext Convection Coeff [W/m²-K]

The outside air film convective conductance for a heat transfer surface.

Opaque Surface Output Variables

The following variables apply only to opaque surfaces, where an opaque surface is considered here to be an exterior or interzone heat transfer surface of class FLOOR, WALL, ROOF or DOOR. **Note – these are advanced variables – you must read the descriptions and understand before use – then you must use the Output:Diagnostics object to allow reporting.**

Opaque Surface Inside Face Conduction [W]

The heat flow by conduction at the inside face of an opaque heat transfer surface. A positive value means that the conduction is from just inside the inside face to the inside face. A negative value means that the conduction is from the inside face into the surface.

Note that Inside Face Conduction, when positive, does **not** indicate the heat flow from the surface to the zone air, which is governed by the inside face convection coefficient and the difference in temperature between the inside face and the zone air.

Opaque Surface Inside Face Conduction Gain [W]

The Opaque Surface Inside Face Conduction when that conduction is positive (see definition of Opaque Surface Inside Face Conduction).

Opaque Surface Inside Face Conduction Loss [W]

The absolute value of the Opaque Surface Inside Face Conduction when that conduction is negative (see definition of Opaque Surface Inside Face Conduction).

Zone Opaque Surface Inside Face Conduction Gain [W]

The sum of the Opaque Surface Inside Face Conduction values for all opaque surfaces in a zone when that sum is positive. For example, assume a zone has six opaque surfaces with Opaque Surface Inside Face Conduction values of 100, -200, 400, 50, 150 and -300 W. Then Zone Opaque Surface Inside Face Conduction Gain = 700 - 500 = 200 W.

Zone Opaque Surface Inside Face Conduction Loss [W]

The absolute value of the sum of the Opaque Surface Inside Face Conduction values for all opaque surfaces in a zone when that sum is negative. For example, assume a zone has six opaque surfaces with Opaque Surface Inside Face Conduction values of -100, -200, 400, -50, 150 and -300W. Then Zone Opaque Surface Inside Face Conduction Loss = $|550 - 650| = |-100| = 100$ W.

Opaque Surface Inside Face Beam Solar Absorbed [W]

Beam solar radiation from exterior windows absorbed on the inside face of an opaque heat transfer surface. For Solar Distribution = FullInteriorAndExterior, this quantity can be non-zero for both floor and wall surfaces. Otherwise, for Solar Distribution = FullExterior or MinimalShadowing, it can be non-zero only for floor surfaces since in this case all entering beam solar is assumed to fall on the floor. Note that this variable will not be operational (have a real value) unless there are exterior windows in the zone.

Window Output Variables

The following output variables apply to subsurfaces that are windows or glass doors. These two subsurface types are called “window” here. “Exterior window” means that the base surface of the window is an exterior wall, floor, roof or ceiling (i.e., the base surface is a BuildingSurface:Detailed with OutsideFaceEnvironment = ExteriorEnvironment). “Interior window” means that the base surface of the window is an inter-zone wall, floor or ceiling. “Glass” means a transparent solid layer, usually glass, but possibly plastic or other transparent material. “Shading device” means an interior, exterior or between-glass shade or blind, or an exterior screen (only exterior windows can have a shading device).

Zone Transmitted Solar [W]**Zone Transmitted Solar Energy [J]**

The total Window Transmitted Solar of all the exterior windows in a zone.

Zone Window Heat Gain [W]**Zone Window Heat Gain Energy [J]**

The sum of the heat flow from all of the exterior windows in a zone when that sum is positive. (See definition of “heat flow” under “Window Heat Gain,” below.)

Zone Window Heat Loss [W]**Zone Window Heat Loss Energy [J]**

The absolute value of the sum of the heat flow from all of the exterior windows in a zone when that sum is negative.

Window Solar Absorbed: All Glass Layers [W]**Window Solar Absorbed: All Glass Layers Energy [J]**

The total exterior beam and diffuse solar radiation absorbed in all of the glass layers of an exterior window.

Window Solar Absorbed: Shading Device [W] and Window Solar Absorbed: Shading Device Energy [J] The exterior beam and diffuse solar radiation absorbed in the shading device, if present, of an exterior window.

Window Transmitted Solar [W] and Window Transmitted Solar Energy [J]

The amount of beam and diffuse solar radiation entering a zone through an exterior window. It is the sum of the following two variables, “Window Transmitted Beam Solar” and “Window Transmitted Diffuse Solar.”

Window Transmitted Beam Solar [W]**Window Transmitted Beam Solar Energy [J]**

The solar radiation transmitted by an exterior window whose source is beam solar incident on the outside of the window. For a bare window, this transmitted radiation consists of beam radiation passing through the glass (assumed transparent) and diffuse radiation from beam reflected from the outside window reveal, if present. For a window with a shade, this transmitted radiation is totally diffuse (shades are assumed to be perfect diffusers). For a window with a blind, this transmitted radiation consists of beam radiation that passes between the slats and diffuse radiation from beam-to-diffuse reflection from the slats. For a window with a screen, this value consists of direct beam radiation that is transmitted through the screen (gaps between the screen material) and diffuse radiation from beam-to-diffuse reflection from the screen material.

Zone Beam Solar from Exterior Windows [W]**Zone Beam Solar from Exterior Windows Energy [J]**

The sum of the Window Transmitted Beam Solar (see definition above) from all exterior windows in a zone.

Zone Beam Solar from Interior Windows [W]**Zone Beam Solar from Interior Windows Energy [J]**

The sum of the Window Transmitted Beam Solar (see definition above) from all interior windows in a zone.

Window Transmitted Diffuse Solar [W]**Window Transmitted Diffuse Solar Energy[J]**

The solar radiation transmitted by an exterior window whose source is diffuse solar incident on the outside of the window. For a bare window, this transmitted radiation consists of diffuse radiation passing through the glass. For a window with a shade, this transmitted radiation is totally diffuse (shades are assumed to be perfect diffusers). For a window with a blind, this transmitted radiation consists of diffuse radiation that passes between the slats and diffuse radiation from diffuse-to-diffuse reflection from the slats. For a window with a screen, this value consists of diffuse radiation transmitted through the screen (gaps between the screen material) and diffuse radiation from diffuse-to-diffuse reflection from the screen material.

Zone Diff Solar from Exterior Windows [W]**Zone Diff Solar from Exterior Windows Energy[J]**

The combined beam and diffuse solar that first entered adjacent zones through exterior windows in the adjacent zones, was subsequently reflected from interior surfaces in those zones (becoming diffuse through that reflection), and was then transmitted through interior windows into the current zone.

Zone Diffuse Solar from Interior Windows [W]**Zone Diffuse Solar from Interior Windows Energy[J]**

The sum of the Window Transmitted Diffuse Solar (see definition above) from all interior windows in a zone.

Window System Solar Transmittance []

Effective solar transmittance of an exterior window, including effect of shading device, if present. Equal to “Window Transmitted Solar” divided by total exterior beam plus diffuse solar radiation incident on the window (excluding frame, if present).

Window System Solar Absorptance []

Effective solar absorptance of an exterior window, including effect of shading device, if present. Equal to “Window Solar Absorbed: All Glass Layers” plus “Window Solar Absorbed: Shading Device” divided by total exterior beam plus diffuse solar radiation incident on window (excluding frame, if present)

Window System Solar Reflectance []

Effective solar reflectance of an exterior window, including effect of shading device, if present. Equal to: $[1.0 - \text{“Window System Solar Transmittance”} - \text{“Window System Solar Absorptance”}]$.

Window Gap Convective Heat Flow [W]**Window Gap Convective Heat Flow Energy[J]**

For an airflow window, the forced convective heat flow from the gap through which airflow occurs. This is the heat gained (or lost) by the air from the glass surfaces (and between-glass shading device surfaces, if present) that the air comes in contact with as it flows through the gap. If the gap airflow goes to the zone indoor air, the gap convective heat flow is added to the zone load. Applicable to exterior windows only.

Window Heat Gain [W]**Window Heat Gain Energy[J]**

The total heat flow to the zone from the glazing, frame and divider of an exterior window when the total heat flow is positive.

For a window *without an interior shading device*, this heat flow is equal to:

- [Window transmitted solar (see definition, above)]
- + [Convective heat flow to the zone from the zone side of the glazing]
- + [Net IR heat flow to the zone from zone side of the glazing]
- [Short-wave radiation from zone transmitted back out the window]
- + [Conduction to zone from window frame and divider, if present]

Here, short-wave radiation is that from lights and diffuse interior solar radiation.

For a window *with an interior shading device*, this heat flow is equal to:

- [Window transmitted solar]
- + [Convective heat flow to the zone from the air flowing through the gap between glazing and shading device]
- + [Convective heat flow to the zone from the zone side of the shading device]
- + [Net IR heat flow to the zone from the zone side of the glazing]
- + [Net IR heat flow to the zone from the zone side of the shading device]
- [Short-wave radiation from zone transmitted back out the window]
- + [Conduction to zone from window frame and divider, if present]

The total window heat flow can also be thought of as the sum of the solar and conductive gain from the window glazing.

Window Heat Loss [W]

Window Heat Loss Energy[J]

The absolute value of the total heat flow through an exterior window when the total heat flow is negative. (See definition of “total heat flow” under “Window Heat Gain,” above.)

Glass Beam-Beam Solar Transmittance []

The fraction of exterior beam solar radiation incident on the glass of an exterior window that is transmitted through the glass assuming that the window has no shading device. Takes into account the angle of incidence of beam solar radiation on the glass. Currently, all glass is considered to be transparent, so that incident beam solar is transmitted only as beam solar with no diffuse solar component.

Glass Diffuse-Diffuse Solar Transmittance []

The fraction of exterior diffuse solar radiation incident on the glass of an exterior window that is transmitted through the glass assuming that the window has no shading device. It is assumed that incident diffuse solar is transmitted only as diffuse with no beam component.

Window Calculation Iterations []

The number of iterations needed by the window-layer heat balance solution to converge.

Solar Horizontal Profile Angle [degrees]

For a vertical exterior window, this is an angle appropriate for calculating beam solar quantities appropriate to horizontal window elements such as horizontal reveal surfaces, horizontal frame and divider elements and horizontal slats of window blinds. It is defined as the angle between the window outward normal and the projection of the sun’s ray on the vertical plane containing the outward normal. See Figure 22.

For an exterior window of arbitrary tilt, it is defined as the angle between the window outward normal the projection of the sun’s ray on the plane that contains the outward normal and is perpendicular to the ground.

If the sun is behind the window, the horizontal profile angle is not defined and is reported as 0.0.

Note that in most texts what we call “horizontal profile angle” is called “vertical profile angle.”

Solar Vertical Profile Angle [degrees]

For a vertical exterior window, this is an angle appropriate for calculating beam solar quantities appropriate to vertical window elements such as vertical reveal surfaces, vertical frame and divider elements and vertical slats of window blinds. It is defined as the angle between the window outward normal and the projection of the sun's ray on the horizontal plane containing the outward normal. See **Figure 22**.

For an exterior window of arbitrary tilt, it is defined as the angle between the window outward normal the projection of the sun's ray on the plane that contains the outward normal and is perpendicular to the plane defined above for Solar Horizontal Profile Angle for a window of arbitrary tilt.

If the sun is behind the window, the vertical profile angle is not defined and is reported as 0.0. Note that in most texts what we call "vertical profile angle" is called "horizontal profile angle."

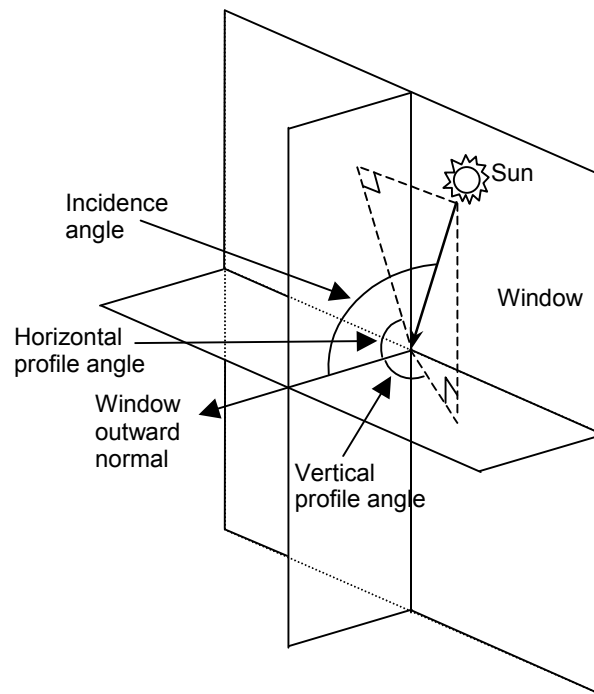


Figure 22. Vertical exterior window showing solar horizontal profile angle, solar vertical profile angle and solar incidence angle.

Beam Solar Reflected by Outside Reveal Surfaces [W]

Beam solar radiation reflected from the outside reveal surfaces of an exterior window (ref: Reveal Surfaces under WindowProperty:FrameAndDivider).

Beam Solar Reflected by Inside Reveal Surfaces [W]

Beam solar radiation reflected from the inside reveal surfaces of an exterior window (ref: Reveal Surfaces under WindowProperty:FrameAndDivider).

Inside Glass Condensation Flag []

A value of 1 means that moisture condensation will occur on the innermost glass face of an exterior window (i.e., on the glass face in contact with the zone air). Otherwise the value is 0. The condition for condensation is glass inside face temperature < zone air dewpoint temperature.

For airflow exterior windows, in which forced air passes between adjacent glass faces in double- and triple-pane windows, a value of 1 means that condensation will occur on one or both of the glass faces in contact with the airflow. In this case the condition for condensation is:

- For *airflow source = indoorair*, temperature of either face in contact with airflow < zone air dewpoint temperature.
- For *airflow source = outdoorair*, temperature of either face in contact with airflow < outside air dewpoint temperature.

As for regular windows, the value will also be 1 if condensation occurs on the innermost glass face.

Inside Frame Condensation Flag []

If an exterior window has a frame and the value of this flag is 1, condensation will occur on the inside surface of the frame. The condition for condensation is frame inside surface temperature < zone air dewpoint temperature.

Inside Divider Condensation Flag []

If an exterior window has a divider and the value of this flag is 1, condensation will occur on the inside surface of the divider. The condition for condensation is divider inside surface temperature < zone air dewpoint temperature.

Fraction of Time Shading Device Is On []

The fraction of time that a shading device is on an exterior window. For a particular simulation timestep, the value is 0.0 if the shading device is off (or there is no shading device) and the value is 1.0 if the shading device is on. (It is assumed that the shading device, if present, is either on or off for the entire timestep.) If the shading device is switchable glazing, a value of 0.0 means that the glazing is in the unswitched (light colored) state, and a value of 1.0 means that the glazing is in the switched (dark colored) state.

For a time interval longer a timestep, this is the fraction of the time interval that the shading device is on. For example, take the case where the time interval is one hour and the timestep is 10 minutes. Then if the shading device is on for two timesteps in the hour and off for the other four timesteps, then the fraction of time that the shading device is on = $2/6 = 0.3333$.

Window Blind Slat Angle [deg]

For an exterior window with a blind, this is the angle in degrees between the glazing outward normal and the blind slat angle outward normal, where the outward normal points away from the front face of the slat. The slat angle varies from 0 to 180 deg. If the slat angle is 0 deg or 180 deg, the slats are parallel to the glazing and the slats are said to be “closed”. If the slat angle is 90 deg, the slats are perpendicular to the glazing and the slats are said to be “fully open”. See illustrations under WindowMaterial:Blind. For blinds with a fixed slat angle, the value reported here will be constant.

Blind Beam-Beam Solar Transmittance []

For an exterior window with a blind, this is the fraction of exterior beam solar radiation incident on the blind that is transmitted through the blind as beam solar radiation when the blind is isolated (i.e., as though the window glass were not present). Depends on various factors, including slat angle, width, separation, and thickness, and horizontal solar profile angle (for blinds with horizontal slats) or vertical solar profile angle (for blinds with vertical slats). The transmittance value reported here will be non-zero only when some beam solar can pass through the blind without hitting the slats.

Blind Beam-Diffuse Solar Transmittance []

For an exterior window with a blind, the fraction of exterior beam solar radiation incident on the blind that is transmitted through the blind as diffuse solar radiation when the blind is

isolated (i.e., as though the window glass were not present). Depends on various factors, including slat angle, width, separation, thickness and reflectance, and horizontal solar profile angle (for blinds with horizontal slats) or vertical solar profile angle (for blinds with vertical slats).

Blind Diffuse-Diffuse Solar Transmittance []

For an exterior window with a blind, the fraction of exterior diffuse solar radiation incident on the blind that is transmitted through the blind as diffuse solar radiation when the blind is isolated (i.e., as though the window glass were not present). Depends on various factors, including slat angle, width, separation, thickness and reflectance. For blinds with a fixed slat angle the transmittance value reported here will be constant.

Blind/Glass System Beam-Beam Solar Transmittance []

The fraction of exterior beam solar radiation incident on an exterior window with a blind (excluding window frame, if present) that is transmitted through the blind/glass system as beam solar radiation. Depends on various factors, including type of glass; solar incidence angle; slat angle, width, separation, and thickness; and horizontal solar profile angle (for blinds with horizontal slats) or vertical solar profile angle (for blinds with vertical slats).

Blind/Glass System Diffuse-Diffuse Solar Transmittance []

The fraction of exterior diffuse solar radiation incident on an exterior window with a blind (excluding window frame, if present) that is transmitted through the blind/glass system as diffuse solar radiation. Depends on various factors, including type of glass and slat angle, width, separation, thickness and reflectance. For blinds with a fixed slat angle the transmittance value reported here will be constant.

Screen Beam-Beam Solar Transmittance[]

For an exterior window with a screen, this is the fraction of exterior beam solar radiation incident on the screen that is transmitted through the screen as beam solar radiation when the screen is isolated (i.e., as though the window glass were not present). Depends on various factors, including the screen reflectance and the relative angle of the incident beam with respect to the screen. This value will include the amount of inward reflection of solar beam off the screen material surface if the user specifies this modeling option (i.e., Material: WindowScreen, field Reflected Beam Transmittance Accounting Method = Model as Direct Beam).

Screen Beam-Diffuse Solar Transmittance[]

For an exterior window with a screen, the fraction of exterior beam solar radiation incident on the screen that is transmitted through the screen as diffuse solar radiation when the screen is isolated (i.e., as though the window glass were not present). Depends on various factors, including the screen reflectance and the relative angle of the incident beam with respect to the screen. This value is the amount of inward reflection of solar beam off the screen material surface if the user specifies this modeling option (i.e., Material: WindowScreen, field Reflected Beam Transmittance Accounting Method = Model as Diffuse); otherwise, this value will be zero.

Screen Diffuse-Diffuse Solar Transmittance[]

For an exterior window with a screen, the fraction of exterior diffuse solar radiation incident on the screen that is transmitted through the screen as diffuse solar radiation when the screen is isolated (i.e., as though the window glass were not present). Depends on various factors including screen material geometry and reflectance. This value is calculated as an average, constant For a window with a screen, this value consists of diffuse radiation transmitted through the screen (gaps between the screen material) and diffuse radiation from diffuse-to-diffuse reflection from the screen material. For a window with a screen, this value

consists of diffuse radiation transmitted through the screen (gaps between the screen material) and diffuse radiation from diffuse-to-diffuse reflection from the screen material.

Screen/Glass System Beam-Beam Solar Transmittance[]

The fraction of exterior beam solar radiation incident on an exterior window with a screen (excluding window frame, if present) that is transmitted through the screen/glass system as beam solar radiation. Depends on various factors, including the screen reflectance and the relative angle of the incident beam with respect to the screen. This value will include the amount of inward reflection of solar beam off the screen material surface if the user specifies this modeling option (i.e., Material: WindowScreen, field Reflected Beam Transmittance Accounting Method = Model as Direct Beam).

Screen/Glass System Diffuse-Diffuse Solar Transmittance []

The fraction of exterior diffuse solar radiation incident on an exterior window with a screen (excluding window frame, if present) that is transmitted through the screen/glass system as diffuse solar radiation. Depends on various factors including screen material geometry and reflectance.

Beam Solar Transmitted Through Interior Window [W]

The beam solar radiation transmitted through an interior window. Calculated only if Solar Distribution = FullInteriorAndExterior in your Building input. The origin of this radiation is beam solar that enters through an exterior window in a zone and then passes through an interior window into the adjacent zone. The amount of this radiation depends on several factors, including sun position, intensity of beam solar incident on the exterior window (including effects of shadowing, if present), relative position of the exterior and interior window, and the size and transmittance of the windows. Note that if there are two or more exterior windows in a zone, then beam solar from one or more of them may pass through the same interior window. Likewise, if there are more than two or more interior windows in a zone then beam solar from a single exterior window may pass through one or more of the interior windows.

Storm Window On/Off Flag []

Indicates whether a storm window glass layer is present (ref: StormWindow). The value is **0** if the storm window glass layer is off, **1** if it is on, and **-1** if the window does not have an associated storm window. Applicable only to exterior windows and glass doors.

Initial Transmitted Diffuse Solar Transmitted out through Inside of Window Surface [W]

As of Version 2.1, the diffuse solar transmitted through exterior windows that is initially distributed to another window in the zone and transmitted out of the zone through that window. For exterior windows, this transmitted diffuse solar is “lost” to the exterior environment. For interior windows, this transmitted diffuse solar is distributed to heat transfer surfaces in the adjacent zone, and is part of the Initial Transmitted Diffuse Solar Absorbed on Inside of Surface for these adjacent zone surfaces.

Additional Window Outputs (Advanced)

The following output variables for windows or glass doors are available when the user requests to display advanced report variables. These seven reports show the individual components that are combined to determine overall Window Heat Gain and/or Window Heat Loss (described above).

Window Convection Heat Gain from Glazing to Zone [W]

The surface convection heat transfer from the glazing to the zone in watts. This report variable is the term called “[Convective heat flow to the zone from the zone side of the glazing]” under the description above for Window Heat Gain report variable. If the window

has an interior shade or blind, then this is zero and the glazing's convection is included in the report called "Window Convection Heat Gain from Gap between Shade and Glazing to Zone".

Window Net Infrared Heat Gain from Glazing to Zone [W]

The net exchange of infrared radiation heat transfer from the glazing to the zone in watts. This report variable is the term called "[Net IR heat flow to the zone from zone side of the glazing]" under the description above for Window Heat Gain report variable.

Window Shortwave Heat Loss from Zone Back Out Window [W]

This is the short-wave radiation heat transfer from the zone back out the window in watts. This is a measure of the diffuse short-wave light (from reflected solar and electric lighting) that leave the zone through the window. This report variable is the term called "[Short-wave radiation from zone transmitted back out the window]" under the description above for Window Heat Gain report variable.

Window Heat Gain from Frame and Divider to Zone [W]

This is the heat transfer from any frames and/or dividers to the zone in watts. This report variable is the term called "[Conduction to zone from window frame and divider, if present]" under the description above for Window Heat Gain report variable. (The word "conduction" here is used because the models is simplified compared to the complexities of surface convection and radiation.)

Window Convection Heat Gain from Gap between Shade and Glazing to Zone [W]

This is the convection surface heat transfer from the both the glazing and the shade's back face to the zone in Watts. This report variable is the term called "[Convective heat flow to the zone from the air flowing through the gap between glazing and shading device]" under the description above for Window Heat Gain report variable.

Window Convection Heat Gain from Shade to Zone [W]

This is the convection surface heat transfer from the front side of any interior shade or blind to the zone in Watts. This report variable is the term called "[Convective heat flow to the zone from the zone side of the shading device]" under the description above for Window Heat Gain report variable.

Window Net Infrared Heat Gain from Shade to Zone [W]

The net exchange of infrared radiation heat transfer from the shade or blind to the zone in watts. This report variable is the term called "[Net IR heat flow to the zone from the zone side of the shading device]" under the description above for Window Heat Gain report variable.

Thermochromic Window Outputs

Window Thermochromic Layer Temperature [C]

The temperature of the TC glass layer of a TC window at each time step.

Window Thermochromic Layer Specification Temperature [C]

The temperature under which the optical data of the TC glass layer are specified.

The overall properties (U-factor/SHGC/VT) of the thermochromic windows at different specification temperatures are reported in the EIO file. These window constructions are created by EnergyPlus during run time. They have similar names with suffix "_TC_XX" where XX represents a specification temperature.

Other Surface Outputs/Reports

Several reports can be selected for Surfaces. (See Group – Report for details on how to specify). Examples are:

DXF

This report produces a special file (**eplusout.dxf**) in the industry standard DXF (Drawing Interchange Format) for drawings. It is produced and accepted by many popular, commercial CAD programs. Detailed reference can be found on the AutoCAD™ website at: <http://www.autodesk.com/techpubs/autocad/acadr14/dxf/index.htm>

EnergyPlus produces this file from the Report command:

```
Output:Reports, Surfaces, DXF;
```

Details, Vertices, DetailsWithVertices

This version of the report creates lines in the eplusout.eio file for each surface (except internal mass surfaces). Details of this reporting is shown in the Output Details and Examples document.

Shading Surfaces

Shading surfaces are entities outside of the building that may cast shadows on the building's heat transfer surfaces. These entities do not typically have enough thermal mass to be described as part of the building's thermal makeup.

The most important effect of shading surfaces is to reduce solar gain in windows that are shadowed. (However, in some cases, shading surfaces can reflect solar onto a wall or window and increase solar gain.)

There are two kinds of shading surfaces in EnergyPlus: **detached** and **attached**. A **detached** shading surface, such as a tree or neighboring building, is not connected to the building. An **attached** shading surface is typically an overhang or fin that is attached to a particular base surface of the building, usually a wall; attached shading surfaces are usually designed to shade specific windows.

Objects for detached shading surfaces:

Shading:Site

Shading:Building

Shading:Site:Detailed

Shading:Building:Detailed

Similarly to the surfaces, the detailed objects use vertex entry whereas the other objects are limited to rectangular representation.

Objects for attached shading surfaces:

Shading:Overhang

Shading:Overhang:Projection

Shading:Fin

Shading:Fin:Projection

Shading:Zone:Detailed

EnergyPlus creates “bi-directional” shades from each shading surface entered. This means that the shade you input will cast a shadow no matter which side of the shade the sun is on. For example, a vertical fin will cast a shadow whether the sun is on the left side or right side of the fin.⁵

It is important to note that EnergyPlus will automatically account for “self-shading” effects—such as in L-shaped buildings—in which some of the building's wall and roof surfaces shade

⁵ Prior to V1.0.2, a shading surface cast a shadow only in the hemisphere toward which the surface faced. This hemisphere is the one pointed to by the shading surface's outward normal vector, which is the cross product $V23 \times V21$, where $V23$ is the vector from vertex 2 to vertex 3 of the shading surface and $V21$ is the vector from vertex 2 to vertex 1. Beginning with V1.0.2, the shades in EnergyPlus are “bi-directional” so that they can cast shadows in both hemispheres depending on the time-varying position of the sun relative to the shading surface.

other parts of the building, especially windows. This means that you only need to describe shading elements that aren't building heat-transfer surfaces.

Shading surfaces can also **reflect** solar radiation onto the building. This feature is simulated if you choose FullExteriorWithReflections or FullInteriorAndExteriorWithReflections in the Building object (ref: Building - Field: Solar Distribution). In this case, you specify the reflectance properties of a shading surface with the ShadingProperty:Reflectance object .

Shading surfaces also automatically shade diffuse solar radiation (and long-wave radiation) from the sky. And they will automatically shade diffuse solar radiation from the ground if Solar Distribution Field = FullExteriorWithReflections or FullInteriorAndExteriorWithReflections in the Building object.⁶ Otherwise, shading surfaces will not shade diffuse radiation from the ground unless you enter a reduced value for View Factor to Ground for those building surfaces that are shaded (ref: BuildingSurface:Detailed - Field: View Factor to Ground and FenestrationSurface:Detailed - Field: View Factor to Ground).

Detached Shading Surfaces

Shading:Site, Shading:Building

These objects are used to describe rectangular shading elements that are external to the building. Examples are trees, high fences, near-by hills, and neighboring buildings.

If relative coordinates are used (ref: Field: Coordinate System in GlobalGeometryRules), shading surfaces entered with Shading:Site remain stationary if the building is rotated, whereas those entered with Shading:Building rotate with the building. If world coordinates are used Shading:Site and Shading:Building are equivalent.

These shading elements are always opaque. The IDD's for both objects follows:

```

Shading:Site,
  \memo used for shading elements such as trees
  \memo these items are fixed in space and would not move with relative geometry
A1 , \field Name
    \required-field
    \type alpha
    \reference AllShadingAndHTSurfNames
    \reference AllShadingSurfNames
N1, \field Azimuth Angle
    \note Facing direction of outside of shading device (S=180,N=0,E=90,W=270)
    \minimum 0
    \maximum 360
    \units deg
N2, \field Tilt Angle
    \default 90
    \minimum 0
    \maximum 180
    \units deg
N3, \field Starting X Coordinate
    \note Starting coordinate is the Lower Left Corner of the Shade
    \units m
N4, \field Starting Y Coordinate
    \units m
N5, \field Starting Z Coordinate
    \units m
N6. \field Length
    \units m
N7; \field Height
    \units m

```

⁶ If the reflections option for Solar Distribution is used, the program also takes into account the reduction of solar radiation reflected from the ground due to shading of the ground by shading surfaces and by the building itself.

```

Shading:Building,
  \memo used for shading elements such as trees, other buildings, parts of this building not being
modeled
  \memo these items are relative to the current building and would move with relative geometry
A1 , \field Name
  \required-field
  \type alpha
  \reference AllShadingAndHTSurfNames
  \reference AllShadingSurfNames
N1, \field Azimuth Angle
  \note Facing direction of outside of shading device (S=180,N=0,E=90,W=270)
  \minimum 0
  \maximum 360
  \units deg
N2, \field Tilt Angle
  \default 90
  \minimum 0
  \maximum 180
  \units deg
N3, \field Starting X Coordinate
  \note Starting coordinate is the Lower Left Corner of the Shade
  \units m
N4, \field Starting Y Coordinate
  \units m
N5, \field Starting Z Coordinate
  \units m
N6. \field Length
  \units m
N7; \field Height
  \units m

```

Field: Name

This is a unique character string associated with the detached shading surface. Though it must be unique from other surface names, it is used primarily for convenience with detached shading surfaces.

Field: Azimuth Angle

Theoretically, this should face to the surface it is shading (i.e. if a south wall, this should be a north facing shade) but since EnergyPlus automatically generates the mirror image, the facing angle per se' is not so important.

Field: Tilt Angle

The tilt angle is the angle (in degrees) that the shade is tilted from horizontal (or the ground). Default for this field is 90 degrees.

Starting Corner for the surface

The rectangular surfaces specify the lower left corner of the surface for their starting coordinate. See the introductory paragraph for rules on this entry.

Field: Starting X Coordinate

This field is the X coordinate (in meters).

Field: Starting Y Coordinate

This field is the Y coordinate (in meters).

Field: Starting Z Coordinate

This field is the Z coordinate (in meters).

Field: Length

This field is the length of the shade in meters.

Field: Height

This field is the width of the shade in meters.

Shading:Site:Detailed, Shading:Building:Detailed

These objects are used to describe shading elements that are external to the building. Examples are trees, high fences, near-by hills, and neighboring buildings.

If relative coordinates are used (ref: Field: Coordinate System in GlobalGeometryRules), shading surfaces entered with Shading:Site:Detailed remain stationary if the building is rotated, whereas those entered with Shading:Building:Detailed rotate with the building. If world coordinates are used Shading:Site:Detailed and Shading:Building:Detailed are equivalent.

While "detached" implies that shading surfaces are not part of the building, the detached shading sequence can be used to describe attached shading surfaces that may shade heat transfer surfaces in more than one zone. For example, wing A of a building might shade several zones of wing B but wing A (for whatever reason) is not described in the geometry for the simulation so it is represented by a detached shade to get its shadowing effect. The IDD for both objects follows:

```

Shading:Site:Detailed,
  \extensible:3 -- duplicate last set of x,y,z coordinates, renumbering please (and changing z terminator
to , for all but last)
    \memo used for shading elements such as trees
    \memo these items are fixed in space and would not move with relative geometry
    \format vertices
A1 , \field Name
    \required-field
    \type alpha
    \reference AllShadingAndHTSurfNames
    \reference AllShadingSurfNames
A2, \field Transmittance Schedule Name
    \note Transmittance schedule for the shading device, defaults to zero (always opaque)
    \type object-list
    \object-list ScheduleNames
N1 , \field Number of Vertices
    \required-field
    \note shown with 6 vertex coordinates -- extensible object
    \autocalculatable
    \default autocalculate
    \minimum 3
    \note Rules for vertices are given in GlobalGeometryRules coordinates --
    \note For this object all surface coordinates are in world coordinates.

```

```

Shading:Building:Detailed,
  \extensible:3 -- duplicate last set of x,y,z coordinates, renumbering please (and changing z terminator
to , for all but last)
  \memo used for shading elements such as trees, other buildings, parts of this building not being
modeled
  \memo these items are relative to the current building and would move with relative geometry
  \format vertices
A1 , \field Name
  \required-field
  \type alpha
  \reference AllShadingAndHTSurfNames
  \reference AllShadingSurfNames
A2, \field Transmittance Schedule Name
  \note Transmittance schedule for the shading device, defaults to zero (always opaque)
  \type object-list
  \object-list ScheduleNames
N1 , \field Number of Vertices
  \required-field
  \note shown with 6 vertex coordinates -- extensible object
  \autocalculatable
  \default autocalculate
  \minimum 3
  \note Rules for vertices are given in GlobalGeometryRules coordinates --
  \note For this object all surface coordinates are relative to the building origin (0,0,0)
  \note and will rotate with the BUILDING north axis.

```

Field: Name

This is a unique character string associated with the detached shading surface. Though it must be unique from other surface names, it is used primarily for convenience with detached shading surfaces.

Field: Transmittance Schedule Name

The name of a schedule of solar transmittance values from 0.0 to 1.0 for the shading surface. If a blank is entered in this field, the transmittance value defaults to 0.0, i.e., the shading surface is opaque at all times. This scheduling can be used to allow for seasonal transmittance change, such as for deciduous trees that have a higher transmittance in winter than in summer. Transmittance based on time of day can also be used—a movable awning, for example, where the transmittance is some value less than 1.0 when the awning is in place and is 1.0 when the awning is retracted.

The following assumptions are made in the shading surface transmittance calculation:

- Both sides of the shading surface have the same transmittance properties.
- The transmittance is the same for both beam and diffuse solar radiation.
- Beam solar transmittance is independent of angle of incidence on the shading surface.
- Beam radiation incident on a shading surface is transmitted as beam radiation with no change in direction, i.e., there is no beam-to-diffuse component.
- If two shading surfaces with non-zero transmittance overlap, the net transmittance is the product of the individual transmittances. Inter-reflection between the shading surfaces (and between the shading surfaces and the building) is ignored.
- For the daylighting calculation (ref: Group – Daylighting) the shading surface's visible transmittance is assumed to be the same as its solar transmittance.
- Shading devices are assumed to be opaque to long-wave radiation no matter what the solar transmittance value is.

Note that shading devices only shade solar radiation when the sun is up, which is automatically determined by EnergyPlus from latitude, time of year, etc. The user need only account for the time-varying transmittance of the shading device in the transmittance schedule, not whether the sun is up or not.

Field: Number Vertices

The number of sides in the surface (number of X,Y,Z vertex groups). For further information, see the discussion on “Surface Vertices” above.

IDF example of Detached Shading Surfaces:

```
Shading:Building:Detailed,
EAST SIDE TREE, !- Detached Shading
ShadingTransmittance:0002, !- Shadowing Transmittance & Schedule
3, !-Triangle
33.52800 , 10.66800 , 10.05800 ,
33.52800 , 13.71600 , 0.9140000 ,
33.52800 , 4.572000 , 0.9140000 ;
Shading:Building:Detailed,
WEST SIDE TREE, !- Detached Shading
ShadingTransmittance:0002, !- Shadowing Transmittance & Schedule
3, !-Triangle
-3.048000 , 7.620000 , 10.05800 ,
-3.048000 , 4.572000 , 0.9140000 ,
-3.048000 , 13.71600 , 0.9140000 ;
```

Attached Shading Surfaces

Overhangs are usually horizontal devices that are used to shade windows. Fins are usually vertical devices that similarly shade windows.

Shading:Overhang

An overhang typically is used to shade a window in a building. The IDD for the object is:

```
Shading:Overhang,
\memo Overhangs are usually flat shading surfaces that reference a window or door.
A1 , \field Name
\required-field
\type alpha
\reference AttachedShadingSurfNames
\reference AllShadingAndHTSurfNames
\reference AllShadingSurfNames
A2 , \field Window or Door Name
\required-field
\type object-list
\reference SubSurfNames
\reference SurfAndSubSurfNames
N1, \field Height above Window or Door
\units m
N2, \field Tilt Angle from Window/Door
\units deg
\default 90
\minimum 0
\maximum 180
N3, \field Left extension from Window/Door Width
\units m
N4, \field Right extension from Window/Door Width
\note N3 + N4 + Window/Door Width is Overhang Length
\units m
N5; \field Depth
\units m
```

Field: Name

This is the name of the overhang. It must be different from other surface names.

Field: Window or Door Name

The name of a window or door that this overhang shades.

Field: Height above Window or Door

This field is the height (meters) above the top of the door for the overhang.

Field Tilt Angle from Window/Door

This field is the tilt angle from the Window/Door. For a flat overhang, this would be 90 (degrees).

Field: Left Extension from Window/Door Width

This field is the width from the left edge of the window/door to the start of the overhang (meters).

Field: Right Extension from Window/Door Width

This field is the width from the right edge of the window/door to the start of the overhang (meters).

Field: Depth

This field is the depth of the overhang (meters) projecting out from the wall.

Shading:Overhang:Projection

An overhang typically is used to shade a window in a building. This object allows for specifying the depth of the overhang as a fraction of the window or door's height. The IDD for the object is:

```
Shading:Overhang:Projection,
  \memo Overhangs are typically flat shading surfaces that reference a window or door.
  A1 , \field Name
      \required-field
      \type alpha
      \reference AttachedShadingSurfNames
      \reference AllShadingAndHTSurfNames
      \reference AllShadingSurfNames
  A2 , \field Window or Door Name
      \required-field
      \type object-list
      \reference SubSurfNames
      \reference SurfAndSubSurfNames
  N1, \field Height above Window or Door
      \units m
  N2, \field Tilt Angle from Window/Door
      \units deg
      \default 90
      \minimum 0
      \maximum 180
  N3, \field Left extension from Window/Door Width
      \units m
  N4, \field Right extension from Window/Door Width
      \units m
      \note N3 + N4 + Window/Door Width is Overhang Length
  N5; \field Depth as Fraction of Window/Door Height
      \units m
```

Field: Name

This is the name of the overhang. It must be different from other surface names.

Field: Window or Door Name

The name of a window or door that this overhang shades.

Field: Height above Window or Door

This field is the height (meters) above the top of the door for the overhang.

Field Tilt Angle from Window/Door

This field is the tilt angle from the Window/Door. For a flat overhang, this would be 90 (degrees).

Field: Left Extension from Window/Door Width

This field is the width from the left edge of the window/door to the start of the overhang (meters).

Field: Right Extension from Window/Door Width

This field is the width from the right edge of the window/door to the start of the overhang (meters).

Field: Depth as Fraction of Window/Door Height

This field is the fraction of the window/door height to specify as the depth of the overhang (meters) projecting out from the wall.

Shading:Fin

Fins shade either side of windows/doors in a building. This object allows for specification of both fins for the window. The IDD for the object is:

```

Shading:Fin,
\memo Fins are usually shading surfaces that are perpendicular to a window or door.
A1 , \field Name
    \required-field
    \type alpha
    \reference AttachedShadingSurfNames
    \reference AllShadingAndHTSurfNames
    \reference AllShadingSurfNames
A2 , \field Window or Door Name
    \required-field
    \type object-list
    \reference SubSurfNames
    \reference SurfAndSubSurfNames
N1, \field Left Extension from Window/Door
    \units m
N2, \field Left Distance Above Top of Window
    \units m
N3, \field Left Distance Below Bottom of Window
    \units m
    \note N2 + N3 + height of Window/Door is height of Fin
N4, \field Tilt Angle from Window/Door
    \units deg
    \default 90
    \minimum 0
    \maximum 180
N5, \field Depth
    \units m
N6, \field Right Extension from Window/Door
    \units m
N7, \field Right Distance Above Top of Window
    \units m
N8, \field Right Distance Below Bottom of Window
    \note N7 + N8 + height of Window/Door is height of Fin
    \units m
N9, \field Tilt Angle from Window/Door
    \units deg
    \default 90
    \minimum 0
    \maximum 180
N10; \field Depth
    \units m

```

Field: Name

This is the name of the overhang. It must be different from other surface names.

Field: Window or Door Name

The name of a window or door that this overhang shades.

Field: Left Extension from Window/Door

This field is the width from the left edge of the window/door to the plane of the left fin (meters).

Field: Left Distance Above Top of Window

This field is the distance from the top of the window to the top of the left fin (meters).

Field: Left Distance Below Bottom of Window

This field is the distance from the bottom of the window to the bottom of the left fin (meters).

Field: Left Tilt Angle from Window/Door

This field is the tilt angle from the window / door for the left fin. Typically, a fin is 90 degrees (default) from its associated window/door.

Field: Left Depth

This field is the depth (meters) of the left fin (projecting out from the wall).

Field: Right Extension from Window/Door

This field is the width from the right edge of the window/door to the plane of the right fin (meters).

Field: Right Distance Above Top of Window

This field is the distance from the top of the window to the top of the right fin (meters).

Field: Right Distance Below Bottom of Window

This field is the distance from the bottom of the window to the bottom of the right fin (meters).

Field: Right Tilt Angle from Window/Door

This field is the tilt angle from the window / door for the right fin.. Typically, a fin is 90 degrees (default) from its associated window/door.

Field: Right Depth

This field is the depth (meters) of the right fin (projecting out from the wall).

Shading:Fin:Projection

Fins shade either side of windows/doors in a building. This object allows for specification of both fins for the window. This object allows for specifying the depth of the overhang as a fraction of the window or door's width. The IDD for the object is:

```

Shading:Fin:Projection,
  \memo Fins are usually shading surfaces that are perpendicular to a window or door.
A1 , \field Name
     \required-field
     \type alpha
     \reference AttachedShadingSurfNames
     \reference AllShadingAndHTSurfNames
     \reference AllShadingSurfNames
A2 , \field Window or Door Name
     \required-field
     \type object-list
     \reference SubSurfNames
     \reference SurfAndSubSurfNames
N1, \field Left Extension from Window/Door
     \units m
N2, \field Left Distance Above Top of Window
     \units m
N3, \field Left Distance Below Bottom of Window
     \units m
     \note N2 + N3 + height of Window/Door is height of Fin
N4, \field Left Tilt Angle from Window/Door
     \units deg
     \default 90
     \minimum 0
     \maximum 180
N5, \field Left Depth as Fraction of Window/Door Width
     \units m
N6, \field Right Extension from Window/Door
     \units m
N7, \field Right Distance Above Top of Window
     \units m
N8, \field Right Distance Below Bottom of Window
     \note N7 + N8 + height of Window/Door is height of Fin
     \units m
N9, \field Right Tilt Angle from Window/Door
     \units deg
     \default 90
     \minimum 0
     \maximum 180
N10; \field Right Depth as Fraction of Window/Door Width
     \units m

```

Field: Name

This is the name of the overhang. It must be different from other surface names.

Field: Window or Door Name

The name of a window or door that this overhang shades.

Field: Left Extension from Window/Door

This field is the width from the left edge of the window/door to the plane of the left fin (meters).

Field: Left Distance Above Top of Window

This field is the distance from the top of the window to the top of the left fin (meters).

Field: Left Distance Below Bottom of Window

This field is the distance from the bottom of the window to the bottom of the left fin (meters).

Field: Left Tilt Angle from Window/Door

This field is the tilt angle from the window / door for the left fin. Typically, a fin is 90 degrees (default) from its associated window/door.

Field: Left Depth as Fraction of Window/Door Width

This field is the fraction of the window/door width to specify as the depth of the left fin (meters) projecting out from the wall.

Field: Right Extension from Window/Door

This field is the width from the right edge of the window/door to the plane of the right fin (meters).

Field: Right Distance Above Top of Window

This field is the distance from the top of the window to the top of the right fin (meters).

Field: Right Distance Below Bottom of Window

This field is the distance from the bottom of the window to the bottom of the right fin (meters).

Field: Right Tilt Angle from Window/Door

This field is the tilt angle from the window / door for the right fin.. Typically, a fin is 90 degrees (default) from its associated window/door.

Field: Right Depth as Fraction of Window/Door Width

This field is the fraction of the window/door width to specify as the depth of the right fin (meters) projecting out from the wall.

Shading:Zone:Detailed

This object is used to describe attached “subsurfaces” such as overhangs, wings or fins that project outward from a base surface. This classification is used for convenience; actually, a device of this type can cast shadows on the surface to which it is attached as well as on adjacent surfaces. For example, a fin may shade its parent wall as well as adjacent walls.

Note that a zone surface can cast shadows on other zone surfaces. However, you don’t have to worry about such effects—for example, one wall of an L-shaped building shading another wall--because EnergyPlus will automatically check for this kind of “self shadowing” and do the proper calculations.

Unlike attached (or detached) shading surfaces, building surfaces can only cast shadows in the hemisphere towards which they face. This means, for example, that a roof that faces *upward* will not cast a shadow *downward*. (Thus, specifying an oversized roof in an attempt to account for the shading effects of overhangs will *not* work). Interior surfaces do not cast shadows of any kind.

```

Shading:Zone:Detailed,
  \extensible:3 -- duplicate last set of x,y,z coordinates, renumbering please (and changing z terminator
to , for all but last)
    \memo used For fins, overhangs, elements that shade the building, are attached to the building
    \memo but are not part of the heat transfer calculations
    \format vertices
A1 , \field Name
    \required-field
    \type alpha
    \reference AttachedShadingSurfNames
    \reference AllShadingAndHTSurfNames
    \reference AllShadingSurfNames
A2 , \field Base Surface Name
    \required-field
    \type object-list
    \object-list SurfaceNames
A3, \field Transmittance Schedule Name
    \note Transmittance schedule for the shading device, defaults to zero (always opaque)
    \type object-list
    \object-list ScheduleNames
N1 , \field Number of Vertices
    \required-field
    \note shown with 6 vertex coordinates -- extensible object
    \autocalculatable
    \default autocalculate
    \minimum 3
    \note vertices are given in GlobalGeometryRules coordinates -- if relative, all surface coordinates
    \note are "relative" to the Zone Origin.  if world, then building and zone origins are used
    \note for some internal calculations, but all coordinates are given in an "absolute" system.

```

Field: Name

This is the name of the attached shading surface. It must be different from other surface names.

Field: Base Surface Name

This is the name of the surface to which this shading device is attached. This surface can be a wall (or roof) but not a window or door.

Field: Transmittance Schedule Name

The name of a schedule of solar transmittance values from 0.0 to 1.0 for the shading surface. If a blank is entered in this field, the transmittance value defaults to 0.0, i.e., the shading surface is opaque at all times. This scheduling can be used to allow for seasonal transmittance change, such as for deciduous trees that have a higher transmittance in winter than in summer. Transmittance based on time of day can also be used—a movable awning, for example, where the transmittance is some value less than 1.0 when the awning is in place and is 1.0 when the awning is retracted.

The following assumptions are made in the shading surface transmittance calculation:

- Both sides of the shading surface have the same transmittance properties.
- The transmittance is the same for both beam and diffuse solar radiation.
- Beam solar transmittance is independent of angle of incidence on the shading surface.
- Beam radiation incident on a shading surface is transmitted as beam radiation with no change in direction, i.e., there is no beam-to-diffuse component.
- If two shading surfaces with non-zero transmittance overlap, the net transmittance is the product of the individual transmittances. Inter-reflection between the shading surfaces (and between the shading surfaces and the building) is ignored.
- For the daylighting calculation (ref: Group – Daylighting) the shading surface's visible transmittance is assumed to be the same as its solar transmittance.

- Shading devices are assumed to be opaque to long-wave radiation no matter what the solar transmittance value is.

Note that shading devices only shade solar radiation when the sun is up, which is automatically determined by EnergyPlus from latitude, time of year, etc. The user need only account for the time-varying transmittance of the shading device in the transmittance schedule, not whether the sun is up or not.

Field: Number Vertices

The number of sides in the surface (number of X,Y,Z vertex groups). For further information, see the discussion on “Surface Vertices” above. The example below shows the correct input for an overhang (to shade the appropriate portion of the base wall and window).

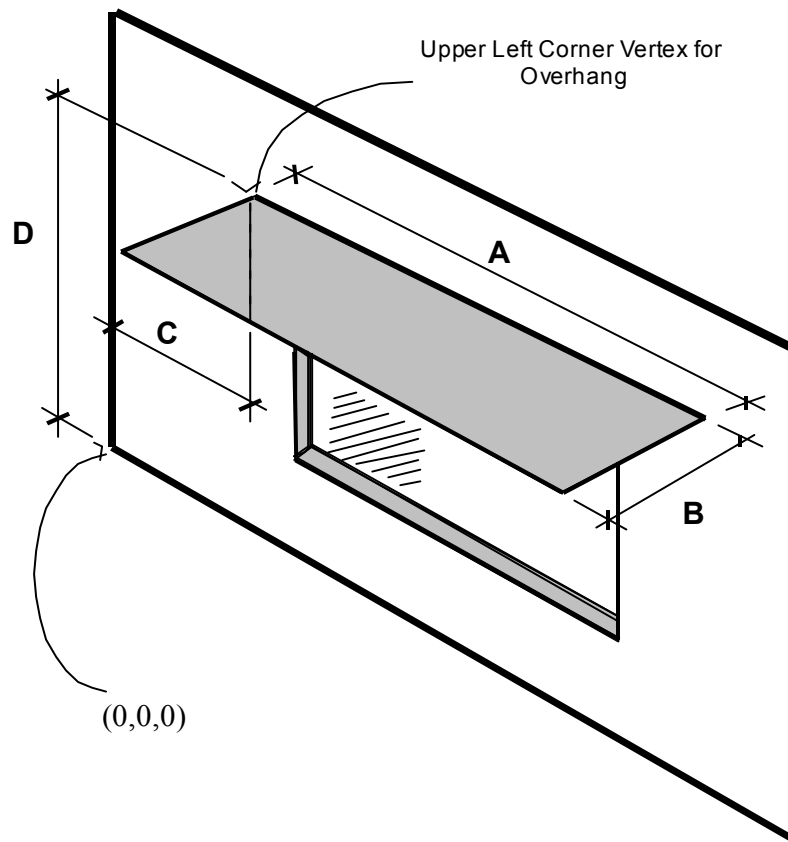


Figure 23. Illustration for Attached Shading Surface

Proper specification for this overhang (facing up) is:

4,(C,0,D),(C,-B,D),(C+A,-B,D),(C+A,0,D); () used to illustrate each vertex.

Note that for horizontal surfaces, any corner may be chosen as the starting corner. The order of vertices determines whether the surface is facing up or down. Shading surfaces are mirrored automatically unless the user specifies "DoNotMirrorDetachedShading", so each shading surface need only be described once.

Thus, another shading surface will be created (facing down):

4,(C+A,-B,D),(C+A,0,D),(C,0,D),(C,-B,D);

IDF example of attached shading surfaces (overhang, fin):


```

Shading:Zone:Detailed,
Zn001:Wall001:Shade001,  !- Surface Name
Zn001:Wall001,  !- Base Surface Name
ShadingTransmittance:0001,  !- Shading Transmittance Schedule
4,  !-RectangularOverhang
1.524000      , -0.3050000      , 2.865000      ,
1.524000      , 0.0000000E+00, 2.865000      ,
4.572000      , 0.0000000E+00, 2.865000      ,
4.572000      , -0.3050000      , 2.865000      ;
Shading:Zone:Detailed,
Zn003:Wall001:Shade001,  !- Surface Name
Zn003:Wall001,  !- Base Surface Name
ShadingTransmittance:0001,  !- Shading Transmittance Schedule
4,  !-RectangularLeftFin
57.97000      , 8.450000      , 10.00000      ,
57.97000      , 8.450000      , 0.0000000E+00,
57.97000      , 6.450000      , 0.0000000E+00,
57.97000      , 6.450000      , 10.00000      ;
Shading:Zone:Detailed,Zn003:Wall001:Shade002,  !- Surface Name
Zn003:Wall001,  !- Base Surface Name
ShadingTransmittance:0003,  !- Shading Transmittance Schedule
4,  !-RectangularRightFin
77.97000      , 6.450000      , 10.00000      ,
77.97000      , 6.450000      , 0.0000000E+00,
77.97000      , 8.450000      , 0.0000000E+00,
77.97000      , 8.450000      , 10.00000      ;

```

ShadingProperty:Reflectance

Specifies the reflectance properties of a shading surface when the solar reflection calculation has requested, i.e., when if “Reflections” option is chosen in the Building object (ref: Building - Field: Solar Distribution). It is assumed that shading surfaces are divided into an unglazed, diffusely reflecting portion and a glazed, specularly-reflecting portion, either of which may be zero. The reflectance properties are assumed to be the same on both sides of the shading surface.

Note that a shading transmittance schedule (ref: Shading Surfaces, Field: Transmittance Schedule Name) can be used with a reflective shading surface. However, EnergyPlus assumes that the reflectance properties of the shading surface are constant even if the transmittance varies.

```

ShadingProperty:Reflectance,
  \min-fields 3
  \memo If this object is not defined for a shading surface the default values
  \memo listed in following fields will be used in the solar reflection calculation.
A1,  \field Shading Surface Name
     \required-field
     \type object-list
     \object-list AllShadingSurfNames
N1,  \field Diffuse Solar Reflectance of Unglazed Part of Shading Surface
     \minimum 0.0
     \maximum 1.0
     \default 0.2
N2,  \field Diffuse Visible Reflectance of Unglazed Part of Shading Surface
     \minimum 0.0
     \maximum 1.0
     \default 0.2
N3,  \field Fraction of Shading Surface That Is Glazed
     \minimum 0.0
     \maximum 1.0
     \default 0.0
A2;  \field Glazing Construction Name
     \note Required if Fraction of Shading Surface That Is Glazed > 0.0

```

Field: Shading Surface Name

The name of the Shading:Site:Detailed, Shading:Building:Detailed, or Shading:Zone:Detailed object to which the following fields apply.

If this ShadingProperty:Reflectance object is not defined for a shading surface the default values listed in each of the following fields will be used in the solar reflection calculation.

Field: Diffuse Solar Reflectance of Unglazed Part of Shading Surface

The diffuse solar reflectance of the unglazed part of the shading surface (default = 0.2). This reflectance is assumed to be the same for beam-to-diffuse and diffuse-to-diffuse reflection. Beam-to-diffuse reflection is assumed to be independent of angle of incidence of beam radiation. Diffuse-to-diffuse reflection is assumed to be independent of angular distribution of the incident of diffuse radiation. The outgoing diffuse radiation is assumed to be isotropic (hemispherically uniform).

The sum of this reflectance and the shading surface transmittance should be less than or equal to 1.0.

Field: Diffuse Visible Reflectance of Unglazed Part of Shading Surface

The diffuse visible reflectance of the unglazed part of the shading surface (default = 0.2). This reflectance is assumed to be the same for beam-to-diffuse and diffuse-to-diffuse reflection. Beam-to-diffuse reflection is assumed to be independent of angle of incidence of beam radiation. Diffuse-to-diffuse reflection is assumed to be independent of angular distribution of the incident of diffuse radiation. The outgoing diffuse radiation is assumed to be isotropic (hemispherically uniform).

This value if used only for the daylighting calculation (ref: Daylighting:Controls). The sum of this reflectance and the shading surface transmittance should be less than or equal to 1.0.

Field: Fraction of Shading Surface That Is Glazed

The fraction of the area of the shading surface that consists of windows (default = 0.0). It is assumed that the windows are evenly distributed over the surface and have the same glazing construction (see following "Name of Glazing Construction"). This might be the case, for example, for reflection from the façade of a neighboring, highly-glazed building. For the reflection calculation the possible presence of shades, screens or blinds on the windows of the shading surface is ignored. Beam-to-beam (specular) reflection is assumed to occur only from the glazed portion of the shading surface. This reflection depends on angle of incidence as determined by the program from the glazing construction. Beam-to-diffuse reflection from the glazed portion is assumed to be zero. The diffuse-to-diffuse reflectance of the glazed portion is determined by the program from the glazing construction.

Field: Glazing Construction Name

The name of the construction of the windows on the shading surface. Required if Fraction of Shading Surface That Is Glazed is greater than 0.0.

IDF example of Shading Surface Reflectance for shading surface with specular reflection

```
Shading:Site:Detailed,
Adjacent Glazed Facade,  !- User Supplied Surface Name
,      !- Shadowing Transmittance Schedule
4,    !- Number of Surface Vertex Groups -- Number of (X,Y,Z) groups
0,-24,30, !- Vertex 1 X,Y,Z coordinates
0,-24,0,  !- Vertex 2 X,Y,Z coordinates
0,0,0,    !- Vertex 3 X,Y,Z coordinates
0,0,30;   !- Vertex 3 X,Y,Z coordinates

ShadingProperty:Reflectance,
Adjacent Glazed Facade, !- Name of Surface:Shading Object
0.3,  !- Diffuse Solar Reflectance of Unglazed Part of Shading Surface
```

```
0.3,  !- Diffuse Visible Reflectance of Unglazed Part of Shading Surface
0.7,  !- Fraction of Shading Surface That Is Glazed
GlassCon-1; !- Name of Glazing Construction
```

IDF example of Shading Surface Reflectance for shading surface without specular reflection

```
Shading:Site:Detailed,
Adjacent Blank Facade,  !- User Supplied Surface Name
,  !- Shadowing Transmittance Schedule
4,  !- Number of Surface Vertex Groups -- Number of (X,Y,Z) groups
0,-24,30,
0,-24,0,
0,0,0,
0,0,30;

ShadingProperty:Reflectance,
Adjacent Blank Facade,  !- Name of Surface:Shading Object
0.4,  !- Diffuse Solar Reflectance of Unglazed Part of Shading Surface
0.4,  !- Diffuse Visible Reflectance of Unglazed Part of Shading Surface
0.0,  !- Fraction of Shading Surface That Is Glazed
;  !- Name of glazing construction
```

WindowProperty:ShadingControl

Window shading with coverings like drapes, blinds, screens or pull-down shades can be used to reduce the amount of solar radiation entering the window or reduce daylighting glare. It can also be used to reduce heat loss through the window (movable insulation). Leaving the window covering open in the winter can maximize solar heat gain and thereby reduce heating loads.

With WindowProperty:ShadingControl—which is referenced by windows and glass doors (ref: FenestrationSurface:Detailed with Type = Window or GlassDoor)—you specify the type and location of the shading device, what variable or combination of variables controls deployment of the shading device, and what the control setpoint is. If the shading device is a blind, you also specify how the slat angle is controlled.

As shown in Figure 24, a shading device can be inside the window (Shading Type = InteriorShade or InteriorBlind), outside the window (Shading Type = ExteriorShade or ExteriorBlind), or between panes of glass (Shading Type = BetweenGlassShade or BetweenGlassBlind). The exception is window screens which can only be outside the window (Shading Type = ExteriorScreen).

Note that when locating a window shade or blind between glass layers, the WindowMaterial:Glazing layers in the window construction must all use an Optical Data Type of SpectralAverage. Spectral data for glazing layers is not currently supported for between glass shades or blinds.

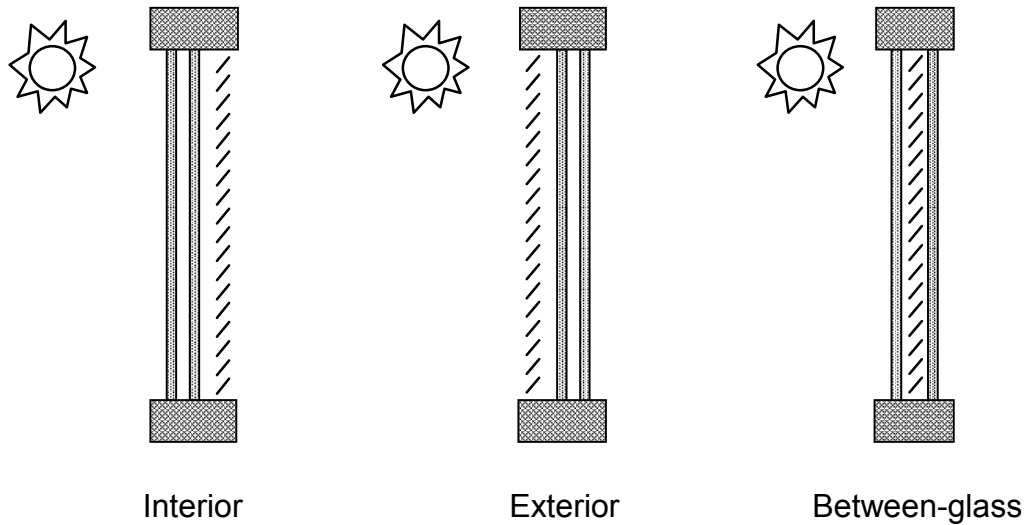


Figure 24. Allowed locations of a window shading device.

When a shading device is present it is either retracted or activated. When it is retracted it covers none of the window. When it is activated it covers the entire glazed part of the window (but not the frame). Whether the shading device is retracted or activated in a particular timestep depends on the control mechanism: see “Shading Control Type,” below. To model a case in which the shading device, when activated, covers only **part** of the window you will have to divide the window into two separate windows, one with the shading device and one without the shading device.

A shading device can also be of a kind in which the optical properties of the glazing switch from one set of values to another in order to increase or decrease solar or visible transmittance (Shading Type = SwitchableGlazing).

There are two ways of specifying the actual shading device:

Specify “Name of Construction with Shading”

This is the name of a window Construction that has the shading device as one of its layers. The thermal and solar-optical properties of the shading device are given by the shading material referenced in that Construction (ref: Construction, WindowMaterial:Shade, WindowMaterial:Screen and WindowMaterial:Blind). To use this method you have to define two Constructions for the window, one without the shading device and one with it. See Example 1, below.

The Construction without the shading device is referenced in the FenestrationSurface:Detailed input for the window (see IDF example, below). The Construction with the shading device is referenced by the window’s WindowProperty:ShadingControl.

For Shading Type = InteriorShade, InteriorBlind, ExteriorShade, ExteriorScreen and ExteriorBlind these two Constructions must be identical except for the presence of the shading layer in the shaded Construction, otherwise you will get an error message. You will also get an error message if the Construction referenced by the window has a shading layer.

Specify the “Material Name of the Shading Device”

This is the name of a WindowMaterial:Shade, WindowMaterial:Screen or WindowMaterial:Blind. This method can be used with Shading Type = InteriorShade, InteriorBlind, ExteriorShade and ExteriorBlind. It cannot be used with Shading Type = BetweenGlassShade, BetweenGlassBlind, or SwitchableGlazing. If Shading Type = InteriorShade or ExteriorShade, then you specify the name of a WindowMaterial:Shade. If Shading Type = InteriorBlind or ExteriorBlind, then you specify the name of a

WindowMaterial:Blind. If Shading Type = ExteriorScreen, then you specify the name of a WindowMaterial:Screen. See Example 2, below. This method is simpler to use since you don't have to specify two Constructions that differ only by the shading layer.

When this method is used, the program will automatically create a shaded window construction by adding a shading layer to the outside or inside of the construction corresponding to the window referencing the WindowProperty:ShadingControl. The name, created by the program, of this shaded construction is composed as follows: if the name of the window construction is CCC and the material name of the shading device is DDD, then the shaded construction name is CCC:DDD:INT for an interior shading device and CCC:DDD:EXT for an exterior shading device.

This method is the required if you want to add a shading device to a construction brought in from a WINDOW5 Data File (ref: Construction:WindowDataFile).

Note that if both "Name of Construction with Shading" and "Material Name of Shading Device" are specified, the former takes precedence.

Most Shading Control Types allow you to specify a schedule that determines when the control is active. One example is a control that is active seasonally. For example, to deploy shading only in the summer when the incident solar is high enough, use Shading Control Type = OnIfHighSolarOnWindow with a schedule that is 1 during the summer months and 0 otherwise and specify Shading Control Is Scheduled = YES.

In addition, most Shading Control Types also allow you to specify that glare control is active in addition to the specified Control Type. For example, you might want to deploy shading when the solar incident on a window is too high OR the glare from the window is too high. This type of joint control requires that the window be in a daylit zone, that the maximum allowed glare be specified in the Daylighting object for the zone, and that Glare Control Is Active = YES in WindowProperty:ShadingControl.

If Shading Type = InteriorBlind, ExteriorBlind or BetweenGlassBlind you can use WindowProperty:ShadingControl to specify how the slat angle of the blind is controlled when the blind is in place.

A special type of WindowProperty:ShadingControl is SwitchableGlazing. An example is electrochromic glazing in which the transmittance and reflectance of the glass is controlled electronically. For example, you could have electrochromic glazing switch from clear (high transmittance) to dark (low transmittance) to control solar gain. If you choose the Shading Type = SwitchableGlazing option for WindowProperty:ShadingControl, the unswitched (clear) state is specified by the Construction referenced by the window and the switched (dark) state is specified by the Construction referenced by WindowProperty:ShadingControl for that window. For example, if you specify Shading Type = SwitchableGlazing and Shading Control Type = OnIfHighSolarOnWindow, then the glazing will switch to the dark state whenever the solar radiation striking the window exceeds the Setpoint value.

For Shading Type = SwitchableGlazing the state of the window is either clear (unswitched) or dark (fully switched) for all Shading Control Types except MeetDaylightIlluminanceSetpoint. In this case, the transmittance of the glazing is adjusted to just meet the daylight illuminance set point at the first daylighting reference point (see Daylighting). This type of control assures that there is just enough solar gain to meet the daylighting requirements in a zone, and no more, thus reducing the cooling load.

Field: Name

Name of the window shading control. It is referenced by a window (ref: Field: Shading Control Name).

Field: Shading Type

The type of shading device. The choices are:

InteriorShade: A diffusing shade is on the inside of the window. (In the shaded Construction the shading layer must be a WindowMaterial:Shade.)

ExteriorShade: A diffusing shade is on the outside of the window. (In the shaded Construction the shading layer must be a WindowMaterial:Shade.)

BetweenGlassShade: A diffusing shade is between two glass layers. (In the shaded Construction the shading layer must be a WindowMaterial:Shade.) This shading type is allowed only for double- and triple-glazing. For triple-glazing the shade must be between the two inner glass layers.

ExteriorScreen: An insect screen is on the outside of the window. (In the shaded Construction the shading layer must be a WindowMaterial:Screen.)

InteriorBlind: A slat-type shading device, such as a Venetian blind, is on the inside of the window. (In the shaded Construction the shading layer must be a WindowMaterial:Blind.)

ExteriorBlind: A slat-type shading device is on the outside of the window. (In the shaded Construction the shading layer must be a WindowMaterial:Blind.)

BetweenGlassBlind: A slat-type shading device is between two glass layers. (In the shaded Construction the shading layer must be a WindowMaterial:Blind.) This shading type is allowed only for double- and triple-glazing. For triple-glazing the blind must be between the two inner glass layers.

SwitchableGlazing: Shading is achieved by changing the characteristics of the window glass, such as by darkening it.

Field: Construction with Shading Name

Name of the window Construction that has the shading in place. The properties of the shading device are given by the shading material referenced in that Construction (ref: Construction, WindowMaterial:Shade, WindowMaterial:Screen and WindowMaterial:Blind). For Shading Type = SwitchableGlazing, this is the name of the Construction that corresponds to the window in its fully-switched (darkest) state.

Specifying “Name of Construction with Shading” is required if Shading Type = BetweenGlassShade, BetweenGlassBlind, or SwitchableGlazing. For other Shading Types, you may alternatively specify “Material Name of Shading Device” (see below).

Field: Shading Control Type

Specifies how the shading device is controlled, i.e., it determines whether the shading device is “on” or “off.” For blinds, screens and shades, when the device is “on” it is assumed to cover all of the window except its frame; when the device is “off” it is assumed to cover none of the window (whether “on” or “off” the shading device is assumed to cover none of the wall that the window is on).

For switchable glazing, “on” means that the glazing is in the fully-switched state and “off” means that it is in the unswitched state; for example, for electrochromic glazing, “on” means the glazing is in its darkest state and “off” means it is in its lightest state.

The choices for Shading Control Type are the following. If SetPoint is applicable its units are shown in parentheses.

AlwaysOn: Shading is always on.

AlwaysOff: Shading is always off.

The following six control types are used primarily to reduce zone cooling load due to window solar gain.

OnIfScheduleAllows: Shading is on if schedule value is non-zero. Requires that Schedule Name be specified and Shading Control Is Scheduled = Yes.

Note: For exterior window screens *AlwaysOn*, *AlwaysOff*, and *OnIfScheduleAllows* are the only valid shading control types.

OnIfHighSolarOnWindow: Shading is on if beam plus diffuse solar radiation incident on the window exceeds SetPoint (W/m^2) and schedule, if specified, allows shading.

OnIfHighHorizontalSolar: Shading is on if total (beam plus diffuse) horizontal solar irradiance exceeds SetPoint (W/m^2) and schedule, if specified, allows shading.

OnIfHighOutdoorAirTemperature: Shading is on if outside air temperature exceeds SetPoint (C) and schedule, if specified, allows shading.

OnIfHighZoneAirTemperature: Shading is on if zone air temperature in the previous timestep exceeds SetPoint (C) and schedule, if specified, allows shading.

OnIfHighZoneCooling: Shading is on if zone cooling rate in the previous timestep exceeds SetPoint (W) and schedule, if specified, allows shading.

OnIfHighGlare: Shading is on if the total daylight glare index at the zone's first daylighting reference point from all of the exterior windows in the zone exceeds the maximum glare index specified in the daylighting input for zone (ref: Group – Daylighting). Applicable only to windows in zones with daylighting.

Note: Unlike other Shading Control Types, glare control is active whether or not a schedule is specified.

MeetDaylightIlluminanceSetpoint: Used only with ShadingType = SwitchableGlazing in zones with daylighting controls. In this case the transmittance of the glazing is adjusted to just meet the daylight illuminance set point at the first daylighting reference point. Note that the daylight illuminance set point is specified in the zone's Daylighting object; it is not specified as a WindowProperty:ShadingControl SetPoint.

The following three control types can be used to reduce zone heating load during the winter by reducing window conductive heat loss at night and leaving the window unshaded during the day to maximize solar gain. They are applicable to any Shading Type except ExteriorScreen but are most appropriate for interior or exterior shades with high insulating value ("movable insulation"). "Night" means the sun is down and "day" means the sun is up.

OnNightIfLowOutdoorTempAndOffDay: Shading is on at night if the outside air temperature is less than SetPoint (C) and schedule, if specified, allows shading. Shading is off during the day.

OnNightIfLowInsideTempAndOffDay: Shading is on at night if the zone air temperature in the previous timestep is less than SetPoint (C) and schedule, if specified, allows shading. Shading is off during the day.

OnNightIfHeatingAndOffDay: Shading is on at night if the zone heating rate in the previous timestep exceeds SetPoint (W) and schedule, if specified, allows shading. Shading is off during the day.

The following two control types can be used to reduce zone heating and cooling load. They are applicable to any Shading Type except ExteriorScreen but are most appropriate for translucent interior or exterior shades with high insulating value ("translucent movable insulation").

OnNightIfLowOutdoorTempAndOnDayIfCooling: Shading is on at night if the outside air temperature is less than SetPoint (C). Shading is on during the day if the zone cooling rate in the previous timestep is non-zero. Night and day shading is subject to schedule, if specified.

OnNightIfHeatingAndOnDayIfCooling: Shading is on at night if the zone heating rate in the previous timestep exceeds SetPoint (W). Shading is on during the day if the zone cooling rate in the previous timestep is non-zero. Night and day shading is subject to schedule, if specified.

The following control types can be used to reduce zone cooling load. They are applicable to any Shading Type except ExteriorScreen but are most appropriate for interior or exterior blinds, interior or exterior shades with low insulating value, or switchable glazing.

OffNightAndOnDayIfCoolingAndHighSolarOnWindow: Shading is off at night. Shading is on during the day if the solar radiation incident on the window exceeds SetPoint (W/m^2) and if the zone cooling rate in the previous timestep is non-zero. Daytime shading is subject to schedule, if specified.

OnNightAndOnDayIfCoolingAndHighSolarOnWindow: Shading is on at night. Shading is on during the day if the solar radiation incident on the window exceeds SetPoint (W/m^2) and if

the zone cooling rate in the previous timestep is non-zero. Day and night shading is subject to schedule, if specified. (This Shading Control Type is the same as the previous one, except the shading is on at night rather than off.)

OnIfHighOutdoorAirTempAndHighSolarOnWindow: Shading is on if the outside air temperature exceeds the Setpoint (C) and if the solar radiation incident on the window exceeds SetPoint 2 (W/m²).

OnIfHighOutdoorAirTempAndHighHorizontalSolar: Shading is on if the outside air temperature exceeds the Setpoint (C) and if the horizontal solar radiation on the window exceeds SetPoint 2 (W/m²).

Field: Schedule Name

Required if Shading Control Is Scheduled = Yes. If schedule value > 0, shading control is active, i.e., shading can be on only if the shading control test passes. If schedule value = 0, shading is off whether or not the control test passes. If Schedule Name is not specified, shading control is assumed to be active at all times.

Field: Setpoint

The setpoint for activating window shading. The units depend on the type of trigger:

- W/m² for solar-based controls
- W for cooling- or heating-based controls
- Degrees C for temperature-based controls

SetPoint is unused for Shading Control Type = OnIfScheduleAllows, OnIfHighGlare and DaylightIlluminance.

Field: Shading Control Is Scheduled

Accepts values YES and NO. The default is NO. Not applicable for Shading Control Type = OnIfHighGlare and should be blank in that case.

If YES, Schedule Name is required and that schedule determines whether the shading control specified by Shading Control Type is active or inactive (see Schedule Name, above).

If NO, Schedule Name is not applicable (should be blank) and the shading control is unscheduled.

Shading Control Is Scheduled = YES is required if Shading Control Type = OnIfScheduleAllows.

Field: Glare Control Is Active

Accepts values YES and NO. The default is NO.

If YES and the window is in a daylit zone, shading is on if the zone's discomfort glare index exceeds the maximum discomfort glare index specified in the Daylighting object referenced by the zone.

The glare test is OR'ed with the test specified by Shading Control Type. For example, if Glare Control Is Active = YES and Shading Control Type = OnIfHighZoneAirTemp, then shading is on if glare is too high OR if the zone air temperature is too high.

Glare Control Is Active = YES is required if Shading Control Type = OnIfHighGlare.

Field: Shading Device Material Name

The name of a WindowMaterial:Shade, WindowMaterial:Screen or WindowMaterial:Blind. Required if "Name of Construction with Shading" is not specified. Not applicable if Shading Type = BetweenGlassShade, BetweenGlassBlind or SwitchableGlazing and should be blank in this case. If both "Name of Construction with Shading" and "Material Name of Shading Device" are entered the former takes precedence.

Field: Type of Slat Angle Control for Blinds

Applies only to Shading Type = InteriorBlind, ExteriorBlind or BetweenGlassBlind. Specifies how the slat angle is controlled. The choices are FixedSlatAngle, ScheduledSlatAngle and BlockBeamSolar.

If FixedSlatAngle (the default), the angle of the slat is fixed at the value input for the WindowMaterial:Blind that is contained in the construction specified by Name of Construction with Shading or is specified by Material Name of Shading Device.

If ScheduledSlatAngle, the slat angle varies according to the schedule specified by Slat Angle Schedule Name, below.

If BlockBeamSolar, the slat angle is set each timestep to just block beam solar radiation. If there is no beam solar on the window the slat angle is set to the value input for the WindowMaterial:Blind that is contained in the construction specified by Name of Construction with Shading or is specified by Material Name of Shading Device. The BlockBeamSolar option prevents beam solar from entering the window and causing possible unwanted glare if the beam falls on work surfaces while at the same time allowing near-optimal indirect radiation for daylighting.

Field: Slat Angle Schedule Name

This is the name of a schedule of slat angles that is used when Type of Slat Angle Control for Blinds = ScheduledSlatAngle. You should be sure that the schedule values fall within the range given by the Minimum Slat Angle and Maximum Slat Angle values entered in the corresponding WindowMaterial:Blind. If not, the program will force them into this range.

Field: Setpoint 2

Used only as the second setpoint for the following two-setpoint control types:
OnIfHighOutdoorAirTempAndHighSolarOnWindow,
OnIfHighOutdoorAirTempAndHighHorizontalSolar,
OnIfHighZoneAirTempAndHighSolarOnWindow,
and OnIfHighZoneAirTempAndHighHorizontalSolar

```

WindowProperty:ShadingControl,
  \min-fields 11
  A1 , \field Name
        \required-field
        \type alpha
        \reference WindowShadeControlNames
        \note Referenced by surfaces that are exterior windows
        \note Not used by interzone windows
  A2 , \field Shading Type
        \required-field
        \type choice
        \key InteriorShade
        \key ExteriorShade
        \key ExteriorScreen
        \key InteriorBlind
        \key ExteriorBlind
        \key BetweenGlassShade
        \key BetweenGlassBlind
        \key SwitchableGlazing
  A3 , \field Construction with Shading Name
        \type object-list
        \object-list ConstructionNames
        \note Required if Shading Type = SwitchableGlazing
        \note Required if Shading Type = interior or exterior shade or blind, or exterior screen, and
        \note "Shading Device Material Name" is not specified.
        \note If both "Construction with Shading Name" and "Shading Device Material Name" are entered,
        \note the former takes precedence.
  A4 , \field Shading Control Type
        \required-field
        \type choice
        \key AlwaysOn
        \key AlwaysOff
        \key OnIfScheduleAllows
        \note OnIfScheduleAllows requires that Schedule Name be specified and
        \note Shading Control Is Scheduled = Yes.
        \note AlwaysOn, AlwaysOff and OnIfScheduleAllows are the only valid control types for
ExteriorScreen.
        \note The following six control types are used primarily to reduce
        \note zone cooling load due to window solar gain
        \key OnIfHighSolarOnWindow
        \key OnIfHighHorizontalSolar
        \key OnIfHighOutdoorAirTemperature
        \key OnIfHighZoneAirTemperature
        \key OnIfHighZoneCooling
        \key OnIfHighGlare
        \note Following entry should be used only if Shading Type = SwitchableGlazing
        \note and window is in a daylight zone
        \key MeetDaylightIlluminanceSetpoint
        \note The following three control types are used to reduce zone Heating load. They can be
        \note used with any Shading Type but are most appropriate for opaque interior or exterior
        \note shades with high insulating value ("opaque movable insulation")
        \key OnNightIfLowOutdoorTempAndOffDay
        \key OnNightIfLowInsideTempAndOffDay
        \key OnNightIfHeatingAndOffDay
        \note The following two control types are used to reduce zone heating and cooling load.
        \note They can be used with any Shading Type but are most appropriate for translucent interior
        \note or exterior shades with high insulating value ("translucent movable insulation")
        \key OnNightIfLowOutdoorTempAndOnDayIfCooling
        \key OnNightIfHeatingAndOnDayIfCooling
        \note The following two control types are used to reduce zone Cooling load.
        \note They can be used with any Shading Type but are most appropriate for interior
        \note or exterior blinds, interior or exterior shades with low insulating value, or
        \note switchable glazing
        \key OffNightAndOnDayIfCoolingAndHighSolarOnWindow
        \key OnNightAndOnDayIfCoolingAndHighSolarOnWindow
        \note The following four control types require that both Setpoint and Setpoint2 be specified
        \note Setpoint will correspond to outdoor air temp or zone air temp (deg C)
        \note Setpoint2 will correspond to solar on window or horizontal solar (W/m2)
        \key OnIfHighOutdoorAirTempAndHighSolarOnWindow
        \key OnIfHighOutdoorAirTempAndHighHorizontalSolar
        \key OnIfHighZoneAirTempAndHighSolarOnWindow

```

```

\key OnIfHighZoneAirTempAndHighHorizontalSolar
A5 , \field Schedule Name
\type object-list
\object-list ScheduleNames
\note Required if Shading Control Is Scheduled = Yes.
\note If schedule value = 1, shading control is active, i.e., shading can take place only
\note if the control test passes. If schedule value = 0, shading is off whether or not
\note the control test passes. Schedule Name is required if Shading Control Is Scheduled = Yes.
\note If Schedule Name is not specified, shading control is assumed to be active at all times.
N1 , \field Setpoint
\units W/m2, W or deg C
\note W/m2 for solar-based controls, W for cooling- or heating-based controls,
\note deg C for temperature-based controls.
\note Unused for Shading Control Type = AlwaysOn, AlwaysOff, OnIfScheduleAllows,
\note OnIfHighGlare, Glare, and DaylightIlluminance
\type real
A6 , \field Shading Control Is Scheduled
\type choice
\key No
\key Yes
\default No
\note If Yes, Schedule Name is required; if No, Schedule Name is not used.
\note Shading Control Is Scheduled = Yes is required if Shading Control Type = OnIfScheduleAllows.
A7 , \field Glare Control Is Active
\type choice
\key No
\key Yes
\default No
\note If Yes and window is in a daylit zone, shading is on if zone's discomfort glare index exceeds
\note the maximum discomfort glare index specified in the Daylighting object referenced by the
zone.
\note The glare test is OR'ed with the test specified by Shading Control Type.
\note Glare Control Is Active = Yes is required if Shading Control Type = OnIfHighGlare.
A8, \field Shading Device Material Name
\type object-list
\object-list WindowShadesScreensAndBlinds
\note Enter then name of a WindowMaterial:Shade, WindowMaterial:Screen or WindowMaterial:Blind
object.
\note Required if "Construction with Shading Name" is not specified.
\note Not used if Shading Control Type = SwitchableGlazing, BetweenGlassShade, or
BetweenGlassBlind.
\note If both "Construction with Shading Name" and "Shading Device Material Name" are entered,
\note the former takes precedence.
A9 , \field Type of Slat Angle Control for Blinds
\type choice
\key FixedSlatAngle
\key ScheduledSlatAngle
\key BlockBeamSolar
\default FixedSlatAngle
\note Used only if Shading Type = InteriorBlind, ExteriorBlind or BetweenGlassBlind.
\note If choice is ScheduledSlatAngle then Slat Angle Schedule Name is required.
A10, \field Slat Angle Schedule Name
\type object-list
\object-list ScheduleNames
\note Used only if Shading Type = InteriorBlind, ExteriorBlind or BetweenGlassBlind.
\note Required if Type of Slat Angle Control for Blinds = ScheduledSlatAngle
\note Schedule values should be degrees (0 minimum, 180 maximum)
N2 ; \field Setpoint 2
\units W/m2 or deg C
\note W/m2 for solar-based controls, deg C for temperature-based controls.
\note Used only as the second setpoint for the following two-setpoint control types:
\note OnIfHighOutdoorAirTempAndHighSolarOnWindow, OnIfHighOutdoorAirTempAndHighHorizontalSolar,
\note OnIfHighZoneAirTempAndHighSolarOnWindow, and OnIfHighZoneAirTempAndHighHorizontalSolar
\type real
\ip-units unknown

```

An IDF example: window with interior roll shade that is deployed when solar incident on the window exceeds 50 W/m².

**! Example 1: Interior movable shade specified by giving name of shaded construction
! in WindowProperty:ShadingControl**

```

WindowMaterial:Glazing, GLASS - CLEAR SHEET 1 / 8 IN,  !- Material Name
  SpectralAverage,! Optical data type {SpectralAverage or Spectral}
  ,                ! Name of spectral data set when Optical Data Type = Spectral
  0.003           ,  !- Thickness {m}
  0.837           ,  !- Solar Transmittance at Normal Incidence
  0.075           ,  !- Solar Reflectance at Normal Incidence: Front Side
  0.075           ,  !- Solar Reflectance at Normal Incidence: Back Side
  0.898           ,  !- Visible Transmittance at Normal Incidence
  0.081           ,  !- Visible Reflectance at Normal Incidence: Front Side
  0.081           ,  !- Visible Reflectance at Normal Incidence: Back Side
  0.0             ,  !- IR Transmittance
  0.8400000      ,  !- IR Emissivity: Front Side
  0.8400000      ,  !- IR Emissivity: Back Side
  0.9000000      ;  !- Conductivity {W/m-K}

WindowMaterial:Shade, ROLL SHADE,  !- Material Name
  0.3             ,  !- Solar Transmittance at normal incidence
  0.5000000      ,  !- Solar Reflectance (same for front and back side)
  0.3             ,  !- Visible Transmittance at normal incidence
  0.5000000      ,  !- Visible reflectance (same for front and back side)
  0.9000000      ,  !- IR Emissivity (same for front and back side)
  0.05           ,  !- IR Transmittance
  0.003          ,  !- Thickness
  0.1             ,  !- Conductivity {W/m-K}
  0.0             ,  !- Top Opening Multiplier
  0.0             ,  !- Bottom Opening Multiplier
  0.5             ,  !- Left-Side Opening Multiplier
  0.5             ,  !- Right-Side Opening Multiplier
  0.0             ;  !- Air-Flow Permeability

Construction, SINGLE PANE WITH NO SHADE,  ! Name of construction without shade
  GLASS - CLEAR SHEET 1 / 8 IN;  !- First material layer

Construction, SINGLE PANE WITH INT SHADE, ! Name of construction with shade
  GLASS - CLEAR SHEET 1 / 8 IN,  !- First material layer
  ROLL SHADE                ;  !- Second material layer

WindowProperty:ShadingControl, CONTROL ON INCIDENT SOLAR,  !- Name of Shading Control
  InteriorShade,                !- Shading Type
  SINGLE PANE WITH INT SHADE,  !- Name of construction with shading device
  OnIfHighSolarOnWindow,       !- Shading Control Type
  ,                              !- Schedule name
  50.0,                          !- Setpoint {W/m2}
  NO,                             !- Shading Control Is Scheduled
  NO,                             !- Glare Control Is Active
  ,                              !- Material Name of Shading Device
  ,                              !- Type of Slat Angle Control for Blinds
  ;                              !- Slat Angle Schedule Name

FenestrationSurface:Detailed, Zn001:Wall001:Win001,  !- SubSurface Name
  Window                        ,  !- Class
  SINGLE PANE WITH NO SHADE,  !- Name of construction without shading device
  Zn001:Wall001                ,  !- Base Surface Name
  ,                              !- Target
  0.5000000                    ,  !- VF to Ground
  CONTROL ON INCIDENT SOLAR,    !- Window Shading Control name
  ,                              !- Frame/Divider name
  1.0                           ,  !- Multiplier
  4                              ,  !- Number of vertices (assumed rectangular)
  0.548 , 0.0 , 2.5            ,  !- x,y,z of vertices {m}
  0.548 , 0.0 , 0.5            ,
  5.548 , 0.0 , 0.5            ,
  5.548 , 0.0 , 2.5            ;

```

! Example 2: Interior movable shade specified by giving name of shading device in WindowProperty:ShadingControl

```

WindowMaterial:Glazing, GLASS - CLEAR SHEET 1 / 8 IN,  !- Material Name
  SpectralAverage,! Optical data type {SpectralAverage or Spectral}
  ,              ! Name of spectral data set when Optical Data Type = Spectral
  0.003         ,  !- Thickness {m}
  0.837         ,  !- Solar Transmittance at Normal Incidence
  0.075         ,  !- Solar Reflectance at Normal Incidence: Front Side
  0.075         ,  !- Solar Reflectance at Normal Incidence: Back Side
  0.898         ,  !- Visible Transmittance at Normal Incidence
  0.081         ,  !- Visible Reflectance at Normal Incidence: Front Side
  0.081         ,  !- Visible Reflectance at Normal Incidence: Back Side
  0.0           ,  !- IR Transmittance
  0.8400000    ,  !- IR Emissivity: Front Side
  0.8400000    ,  !- IR Emissivity: Back Side
  0.9000000    ;  !- Conductivity {W/m-K}

WindowMaterial:Shade, ROLL SHADE,  !- Material Name
  0.3           ,  !- Solar Transmittance at normal incidence
  0.5000000    ,  !- Solar Reflectance (same for front and back side)
  0.3           ,  !- Visible Transmittance at normal incidence
  0.5000000    ,  !- Visible reflectance (same for front and back side)
  0.9000000    ,  !- IR Emissivity (same for front and back side)
  0.05         ,  !- IR Transmittance
  0.003        ,  !- Thickness
  0.1           ,  !- Conductivity {W/m-K}
  0.0           ,  !- Top Opening Multiplier
  0.0           ,  !- Bottom Opening Multiplier
  0.5           ,  !- Left-Side Opening Multiplier
  0.5           ,  !- Right-Side Opening Multiplier
  0.0           ;  !- Air-Flow Permeability

Construction, SINGLE PANE WITH NO SHADE,  ! Name of construction without shade
  GLASS - CLEAR SHEET 1 / 8 IN;  !- First material layer

WINDOWPROPERTY:SHADINGCONTROL, CONTROL ON INCIDENT SOLAR,  !- Name of Shading Control
  InteriorShade,  !- Shading Type
  ,              !- Name of shaded construction
  OnIfHighSolarOnWindow,  !- Shading Control Type
  ,              !- Schedule name
  50.0,          !- Setpoint {W/m2}
  NO,            !- Shading Control Is Scheduled
  NO,            !- Glare Control Is Active
  ROLL SHADE,  !- Material Name of Shading Device
  ,              !- Type of Slat Angle Control for Blinds
  ;              !- Slat Angle Schedule Name

FenestrationSurface:Detailed, Zn001:Wall001:Win001,  !- SubSurface Name
  Window        ,  !- Class
  SINGLE PANE WITH NO SHADE,  !- Name of construction without shade
  Zn001:Wall001 ,  !- Base Surface Name
  ,              !- Target
  0.5000000    ,  !- VF to Ground
  CONTROL ON INCIDENT SOLAR,  !- Window Shading Control name
  ,              !- Frame/Divider name
  1.0           ,  !- Multiplier
  4             ,  !- Number of vertices (assumed rectangular)
  0.548 ,  0.0 ,  2.5 ,  !- x,y,z of vertices {m}
  0.548 ,  0.0 ,  0.5 ,
  5.548 ,  0.0 ,  0.5 ,
  5.548 ,  0.0 ,  2.5 ;

```

WindowProperty:FrameAndDivider

The WindowProperty:FrameAndDivider object is referenced by exterior windows that have

- a frame, and/or
- a divider, and/or
- reveal surfaces that reflect beam solar radiation.

A **frame** surrounds the glazing in a window (see Figure 25 and Figure 26). It is assumed that all frame characteristics—such as width, conductance and solar absorptance—are the same for the top, bottom and side elements of the frame. If the frame elements are not the same then you should enter area-weighted average values for the frame characteristics.

The window vertices that you specify in the FenestrationSurface:Detailed object are those of the glazed part of the window, not the frame. EnergyPlus automatically subtracts the area of the frame—determined from the glazing dimensions and the frame width—from the area of the wall containing the window.

A **divider**, as shown in Figure 25, Figure 26 and Figure 27, divides the glazing up into separate lites. It is assumed that all divider elements have the same characteristics. If not, area-weighted average values should be used. EnergyPlus automatically subtracts the divider area from the glazed area of the window.

Reveal surfaces, as shown in Figure 28, are associated with the setback of the glazing from the outside and/or inside surface of the parent wall. If the depth and solar absorptance of these surfaces are specified, the program will calculate the reflection of beam solar radiation from these surfaces. The program also calculates the shadowing (onto the window) of beam and diffuse solar radiation by outside reveal surfaces.

In EnergyPlus, a window can have any combination of frame, divider and reveal surfaces, or none of these.

The best source of frame and divider characteristics is the WINDOW 5 program, which will calculate the values required by EnergyPlus for different frame and divider types. In particular, the THERM program within WINDOW 5 will calculate the effective conductance of frames and dividers; this is the conductance taking 2-D heat transfer effects into account.

Note that a window's frame and divider characteristics, along with other window information, can be read in from the Window 5 Data File (see "Importing Windows from WINDOW 5" and "Construction from Window5 Data File"). In this case the WindowProperty:FrameAndDivider referenced by the window is not applicable and should be blank unless you want to specify reveal surfaces for beam solar reflection.

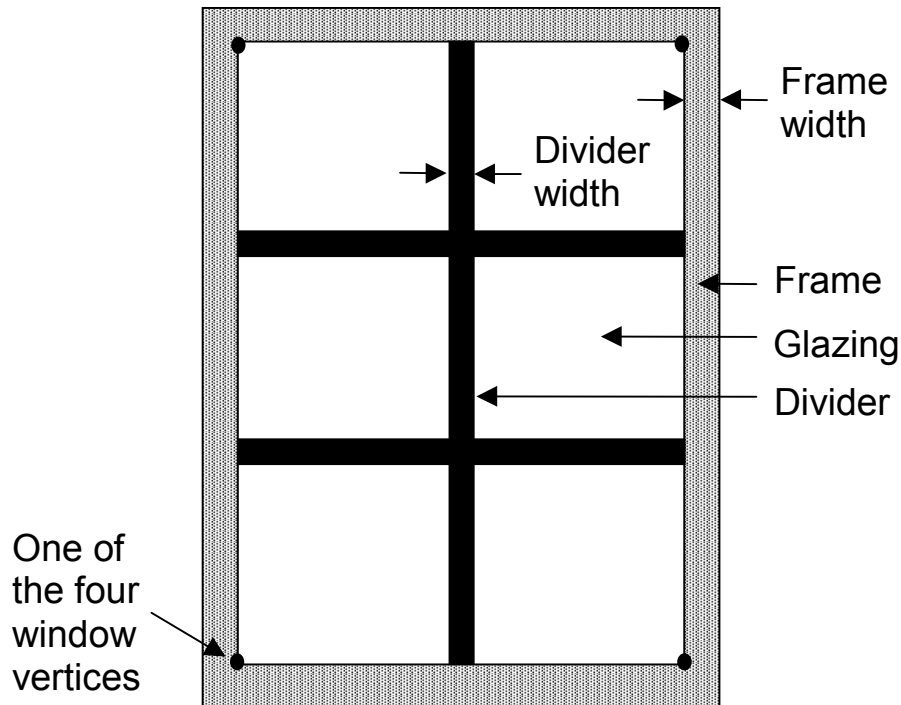


Figure 25. A window with a frame and divider.

In the illustration above, the divider has two horizontal elements and one vertical element.

Field: Name

The name of the frame/divider object. It is referenced by WindowProperty:FrameAndDivider Name in FenestrationSurface:Detailed.

Frame Fields

Field: Frame Width

The width of the frame elements when projected onto the plane of the window. It is assumed that the top, bottom and side elements of the frame have the same width. If not, an average frame width should be entered such that the projected frame area calculated using the average value equals the sum of the areas of the frame elements.

Field: Frame Outside Projection

The amount by which the frame projects outward from the outside surface of the window glazing. If the outer surface of the frame is flush with the glazing, Frame Outside Projection = 0.0. Used to calculate shadowing of frame onto glass, solar absorbed by frame, IR emitted and absorbed by frame, and convection from frame.

Field: Frame Inside Projection

The amount by which the frame projects inward from the inside surface of the window glazing. If the inner surface of the frame is flush with the glazing, Frame Inside Projection = 0.0. Used to calculate solar absorbed by frame, IR emitted and absorbed by frame, and convection from frame.

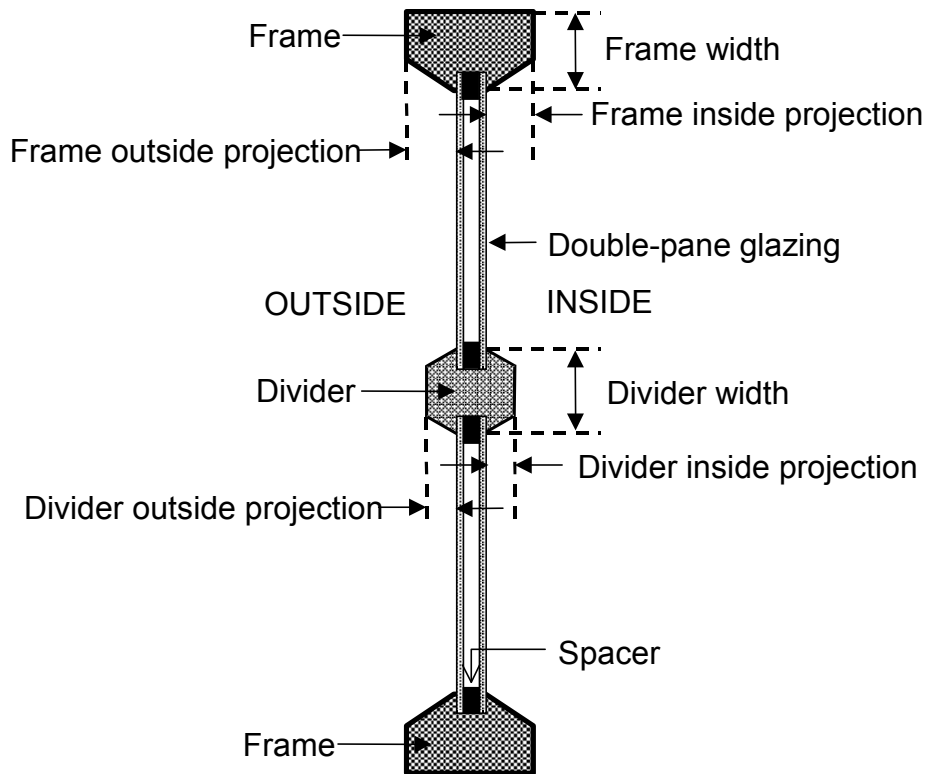


Figure 26. Illustration showing frame and divider dimensioning.

Field: Frame Conductance

The effective thermal conductance of the frame measured from inside to outside frame surface (no air films) and taking 2-D conduction effects into account. Obtained from WINDOW 5 or other 2-D calculation.

Field: Ratio of Frame-Edge Glass Conductance to Center-Of-Glass Conductance

The glass conductance near the frame (excluding air films) divided by the glass conductance at the center of the glazing (excluding air films). Used only for multi-pane glazing constructions. This ratio is greater than 1.0 because of thermal bridging from the glazing across the frame and across the spacer that separates the glass panes. Values can be obtained from WINDOW 5 for the user-selected glazing construction and frame characteristics.

Field: Frame Solar Absorptance

The solar absorptance of the frame. The value is assumed to be the same on the inside and outside of the frame and to be independent of angle of incidence of solar radiation.

Field: Frame Visible Absorptance

The visible absorptance of the frame. The value is assumed to be the same on the inside and outside of the frame and to be independent of angle of incidence of solar radiation.

Field: Frame Thermal Hemispherical Emissivity

The thermal emissivity of the frame, assumed the same on the inside and outside.

Divider Fields

Field: Divider Type

The type of divider (see figure below). Divider Type = Suspended is applicable only to multi-pane glazing. It means that the divider is suspended between the panes. (If there are more than two glass layers, the divider is assumed to be placed between the two outermost layers.)

Divider Type = DividedLite means that the divider elements project out from the outside and inside surfaces of the glazing and divide the glazing into individual lites. For multi-pane glazing, this type of divider also has between-glass elements that separate the panes.

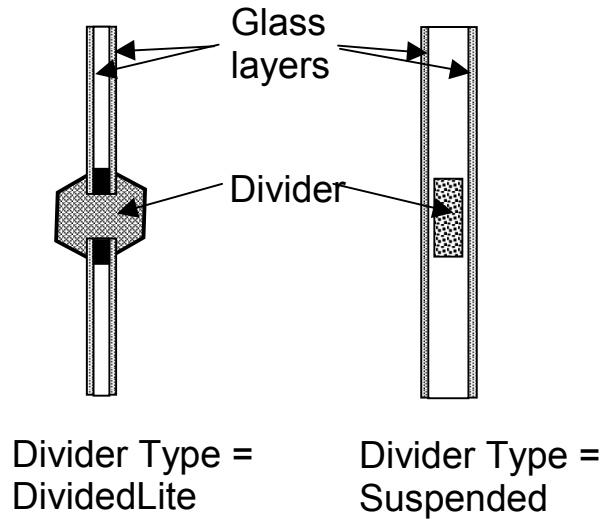


Figure 27. Illustration showing divider types.

Field: Divider Width

The width of the divider elements when projected onto the plane of the window. It is assumed that the horizontal and vertical divider elements have the same width. If not, an average divider width should be entered such that the projected divider area calculated using the average value equals the sum of the areas of the divider elements.

Field: Number of Horizontal Dividers

The number of divider elements parallel to the top and bottom of the window.

Field: Number of Vertical Dividers

The number of divider elements parallel to the sides of the window.

Field: Divider Outside Projection

The amount by which the divider projects out from the outside surface of the window glazing. For Divider Type = Suspended, Divider Projection = 0.0. Used to calculate shadowing of divider onto glass, solar absorbed by divider, IR emitted and absorbed by divider, and convection from divider.

Field: Divider Inside Projection

The amount by which the divider projects inward from the inside surface of the window glazing. If the inner surface of the divider is flush with the glazing, Divider Inside Projection = 0.0. Used to calculate solar absorbed by divider, IR emitted and absorbed by divider, and convection from divider.

Field: Divider Conductance

The effective thermal conductance of the divider measured from inside to outside divider surface (no air films) and taking 2-D conduction effects into account. Obtained from WINDOW 5 or other 2-D calculation.

Field: Ratio of Divider-Edge Glass Conductance to Center-Of-Glass Conductance

The glass conductance near the divider (excluding air films) divided by the glass conductance at the center of the glazing (excluding air films). Used only for multi-pane glazing constructions. This ratio is greater than 1.0 because of thermal bridging from the glazing across the divider and across the spacer that separates the glass panes. Values can be obtained from WINDOW 5 for the user-selected glazing construction and divider characteristics.

Field: Divider Solar Absorptance

The solar absorptance of the divider. The value is assumed to be the same on the inside and outside of the divider and to be independent of angle of incidence of solar radiation.

Field: Divider Visible Absorptance

The visible absorptance of the divider. The value is assumed to be the same on the inside and outside of the divider and to be independent of angle of incidence of solar radiation.

Field: Divider Thermal Hemispherical Emissivity

The thermal emissivity of the divider, assumed the same on the inside and outside.

Reveal Surface Fields

The following fields specify the properties of the window reveal surfaces (reveals occur when the window is not in the same plane as the base surface). From this information and from the geometry of the window and the sun position, the program calculates beam solar radiation absorbed and reflected by the top, bottom, right and left sides of outside and inside window reveal surfaces. In doing this calculation, the shadowing on a reveal surface by other reveal surfaces is determined using the orientation of the reveal surfaces and the sun position.

It is assumed that:

- The window is an exterior window and is rectangular.
- The reveal surfaces are perpendicular to the window plane.
- If an exterior shade, screen or blind is in place it shades exterior and interior reveal surfaces so that in this case there is no beam solar on these surfaces.
- If an interior shade or blind is in place it shades the interior reveal surfaces so that in this case there is no beam solar on these surfaces.
- The possible shadowing on inside reveal surfaces by a window divider is ignored.
- The outside reveal surfaces (top, bottom, left, right) have the same solar absorptance and depth. This depth is not input here but is automatically determined by the program— from window and wall vertices—as the distance between the plane of the outside face of the glazing and plane of the outside face of the parent wall.
- The inside reveal surfaces are divided into two categories: (1) the bottom reveal surface, called here the "inside sill;" and (2) the other reveal surfaces (left, right and top).
- The left, right and top inside reveal surfaces have the same depth and solar absorptance. The inside sill is allowed to have depth and solar absorptance values that are different from the corresponding values for the other inside reveal surfaces.
- The inside sill depth is required to be greater than or equal to the depth of the other inside reveal surfaces. If the inside sill depth is greater than zero the depth of the other inside reveal surfaces is required to be greater than zero.

- The reflection of beam solar radiation from all reveal surfaces is assumed to be isotropic diffuse; there is no specular component.
- Half of the beam solar reflected from outside reveal surfaces is goes towards the window; the other half goes back to the exterior environment (i.e., reflection of this outward-going component from other outside reveal surfaces is not considered).
- The half that goes towards the window is added to the other solar radiation incident on the window. Correspondingly, half of the beam solar reflected from inside reveal surfaces goes towards the window, with the other half going into the zone. The portion going towards the window that is not reflected is absorbed in the glazing or is transmitted back out into the exterior environment.
- The beam solar that is absorbed by outside reveal surfaces is added to the solar absorbed by the outside surface of the window's parent wall; similarly, the beam solar absorbed by the inside reveal surfaces is added to the solar absorbed by the inside surface of the parent wall.

The net effect of beam solar reflected from outside reveal surfaces is to increase the heat gain to the zone, whereas the effect of beam solar reflected from inside reveal surfaces is to decrease the heat gain to the zone since part of this reflected solar is transmitted back out the window.

If the window has a frame, the absorption of reflected beam solar by the inside and outside surfaces of the frame is considered. The shadowing of the frame onto interior reveal surfaces is also considered.

Field: Outside Reveal Solar Absorptance

The solar absorptance of outside reveal surfaces.

Field: Inside Sill Depth

The depth of the inside sill, measured from the inside surface of the glazing to the edge of the sill (see Figure 28).

Field: Inside Sill Solar Absorptance

The solar absorptance of the inside sill.

Field: Inside Reveal Depth

The depth of the inside reveal surfaces other than the sill, measured from the inside surface of the glazing to the edge of the reveal surface (see Figure 28).

Field: Inside Reveal Solar Absorptance

The solar absorptance of the inside reveal surfaces other than the sill.

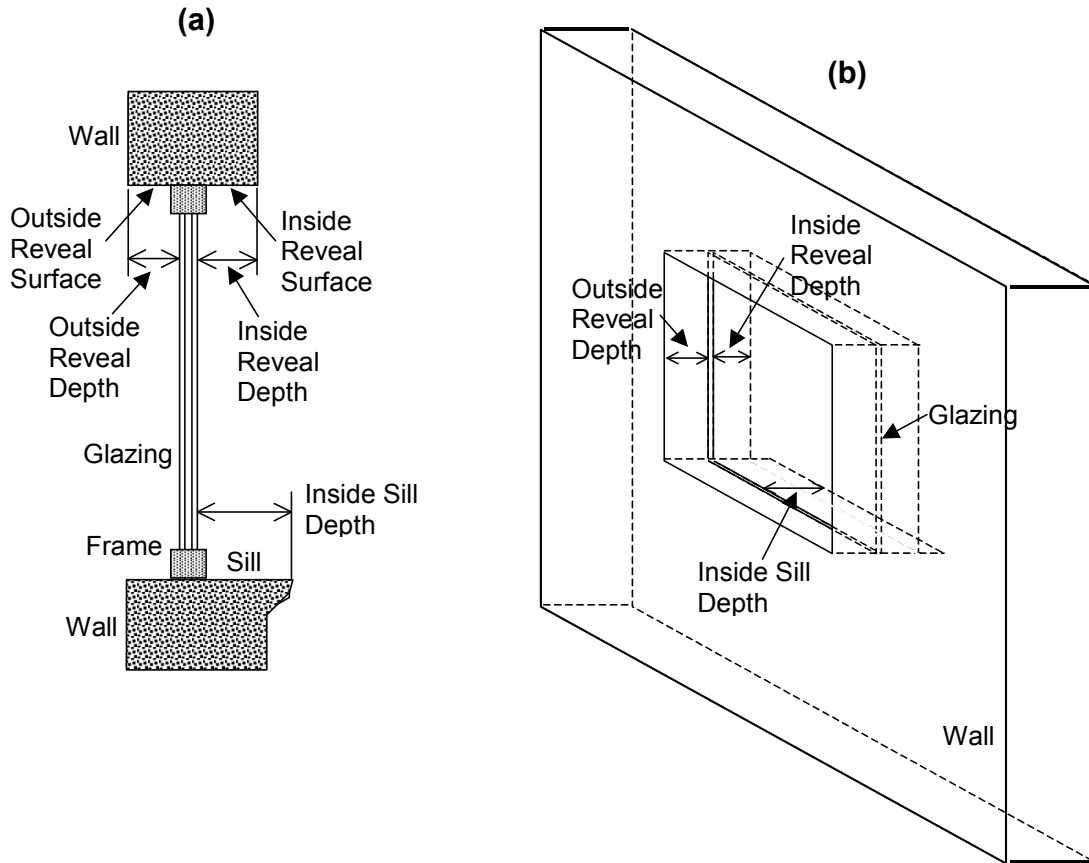


Figure 28. (a) Vertical section through a window (with frame) showing outside and inside reveal surfaces and inside sill. (b) Perspective view looking from the outside of a window (without frame) showing reveal surfaces. Note that “Outside Reveal Depth” is not a user input; it is calculated by the program from the window and wall vertices.

```

WindowProperty:FrameAndDivider,
  \min-fields 20
A1 , \field Name
  \required-field
  \type alpha
  \reference WindowFrameAndDividerNames
  \note Referenced by surfaces that are exterior windows
  \note Not used by interzone windows
N1 , \field Frame Width
  \units m
  \type real
  \minimum 0.0
  \maximum 1.0
  \default 0.0
  \note Width of frame in plane of window
  \note Frame width assumed the same on all sides of window
N2 , \field Frame Outside Projection
  \units m
  \type real
  \minimum 0.0
  \maximum 0.5
  \default 0.0
  \note Amount that frame projects outward from the outside face of the glazing

```

```

N3 , \field Frame Inside Projection
    \units m
    \type real
    \minimum 0.0
    \maximum 0.5
    \default 0.0
    \note Amount that frame projects inward from the inside face of the glazing
N4 , \field Frame Conductance
    \units W/m2-K
    \type real
    \minimum 0.0
    \note Effective conductance of frame
    \note Excludes air films
    \note Obtained from WINDOW 5 or other 2-D calculation
N5 , \field Ratio of Frame-Edge Glass Conductance to Center-Of-Glass Conductance
    \type real
    \minimum 1.0
    \maximum 4.0
    \default 1.0
    \note Excludes air films; applies only to multipane windows
    \note Obtained from WINDOW 5 or other 2-D calculation
N6 , \field Frame Solar Absorptance
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0.7
    \note Assumed same on outside and inside of frame
N7 , \field Frame Visible Absorptance
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0.7
    \note Assumed same on outside and inside of frame
N8 , \field Frame Thermal Hemispherical Emissivity
    \type real
    \minimum> 0.0
    \default 0.9
    \note Assumed same on outside and inside of frame
A2 , \field Divider Type
    \required-field
    \type choice
    \key DividedLite
    \key Suspended
    \default DividedLite
N9 , \field Divider Width
    \units m
    \type real
    \minimum 0.0
    \maximum 0.5
    \default 0.0
    \note Width of dividers in plane of window
    \note Width assumed the same for all dividers
N10, \field Number of Horizontal Dividers
    \type real
    \minimum 0
    \default 0
    \note "Horizontal" means parallel to local window X-axis
N11, \field Number of Vertical Dividers
    \type real
    \minimum 0
    \default 0
    \note "Vertical" means parallel to local window Y-axis
N12, \field Divider Outside Projection
    \units m
    \type real
    \minimum 0.0
    \maximum 0.5
    \default 0.0
    \note Amount that divider projects outward from the outside face of the glazing
    \note Outside projection assumed the same for all divider elements

```

```
N13, \field Divider Inside Projection
      \units m
      \type real
      \minimum 0.0
      \maximum 0.5
      \default 0.0
      \note Amount that divider projects inward from the inside face of the glazing
      \note Inside projection assumed the same for all divider elements
N14, \field Divider Conductance
      \units W/m2-K
      \type real
      \minimum 0.0
      \default 0.0
      \note Effective conductance of divider
      \note Excludes air films
      \note Obtained from WINDOW 5 or other 2-D calculation
N15, \field Ratio of Divider-Edge Glass Conductance to Center-Of-Glass Conductance
      \type real
      \minimum 1.0
      \maximum 4.0
      \default 1.0
      \note Excludes air films
      \note Obtained from WINDOW 5 or other 2-D calculation
N16, \field Divider Solar Absorptance
      \type real
      \minimum 0.0
      \maximum 1.0
      \default 0.0
      \note Assumed same on outside and inside of divider
N17, \field Divider Visible Absorptance
      \type real
      \minimum 0.0
      \maximum 1.0
      \default 0.0
      \note Assumed same on outside and inside of divider
N18, \field Divider Thermal Hemispherical Emissivity
      \type real
      \minimum> 0.0
      \maximum< 1.0
      \default 0.9
      \note Assumed same on outside and inside of divider
N19, \field Outside Reveal Solar Absorptance
      \type real
      \minimum 0.0
      \maximum 1.0
      \default 0.0
N20, \field Inside Sill Depth
      \units m
      \type real
      \minimum 0.0
      \maximum 2.0
      \default 0.0
N21, \field Inside Sill Solar Absorptance
      \type real
      \minimum 0.0
      \maximum 1.0
      \default 0.0
```

```

N22, \field Inside Reveal Depth
      \note Distance from plane of inside surface of glazing
      \note to plane of inside surface of wall.
      \note Outside reveal depth is determined from the geometry
      \note of the window and the wall it is on; it is non-zero if the plane of
      \note the outside surface of the glazing is set back from the plane of the
      \note outside surface of the wall.
      \units m
      \minimum 0.0
      \maximum 2.0
      \default 0.0
N23; \field Inside Reveal Solar Absorptance
      \type real
      \minimum 0.0
      \maximum 1.0
      \default 0.0

```

An IDF example:

```

WindowProperty:FrameAndDivider,
  TestFrameAndDivider, ! Frame/Divider Name
  0.05, ! Frame Width
  0.04, ! Frame Outside Projection
  0.03, ! Frame Inside Projection
  5.0, ! Frame Conductance
  1.3, ! Ratio of Frame-Edge Glass Conductance to Center-Of-Glass Conductance
  0.8, ! Frame Solar Absorptance
  0.8, ! Frame Visible Absorptance
  0.9, ! Frame Thermal Emissivity
  DividedLite, ! Divider Type
  0.03, ! Divider Width
  2, ! Number of Horizontal Dividers
  2, ! Number of Vertical Dividers
  0.03, ! Divider Outside Projection
  0.03, ! Divider Inside Projection
  5.0, ! Divider Conductance
  1.3, ! Ratio of Divider-Edge Glass Conductance to Center-Of-Glass Conductance
  0.8, ! Divider Solar Absorptance
  0.8, ! Divider Visible Absorptance
  0.9, ! Divider Thermal Emissivity
  0.7, ! Outside Reveal Solar Absorptance
  0.25, ! Inside Sill Depth (m)
  0.6, ! Inside Sill Solar Absorptance
  0.2, ! Inside Reveal Depth (m)
  0.5; ! Inside Reveal Solar Absorptance

```

WindowProperty:AirflowControl

This object is used to specify the control mechanism for windows in which forced air flows in the gap between adjacent layers of glass. Such windows are called “airflow windows.” They are also known as “heat-extract windows” or “climate windows.”

A common application is to reduce the zone load by exhausting indoor air through the window. In the cooling season this picks up and expels some of the solar heat absorbed by the window glass (and by the between-glass shade or blind, if present). In the heating season this warms the window, reducing the heat loss from the window. A side benefit is increased thermal comfort. This is because the inside surface of the window will generally be cooler in summer and warmer in winter.

The surface report variable “Window Gap Convective Heat Flow [W]” gives the heat picked up (or lost) by the gap airflow.

Field: Name

Name of the window that this WindowProperty:AirflowControl refers to. It must be a window with two or three glass layers, i.e., double- or triple-glazing. For triple-glazing the airflow is assumed to be between the two inner glass layers.

An error will result if the gas in the airflow gap is other than air (ref: WindowMaterial:GlazingGroup:Thermochromic

Thermochromic (TC) materials have active, reversible optical properties that vary with temperature. Thermochromic windows are adaptive window systems for incorporation into building envelopes. Thermochromic windows respond by absorbing sunlight and turning the sunlight energy into heat. As the thermochromic film warms it changes its light transmission level from less absorbing to more absorbing. The more sunlight it absorbs the lower the light level going through it. By using the sun's own energy the window adapts based solely on the directness and amount of sunlight. Thermochromic materials will normally reduce optical transparency by absorption and/or reflection, and are specular (maintaining vision).

A thermochromic window is defined with a Construction object which references a special layer defined with a WindowMaterial:GlazingGroup:Thermochromic object. The WindowMaterial:GlazingGroup:Thermochromic object further references a series of WindowMaterial:Glazing objects corresponding to each specification temperature of the TC layer.

This object specifies a layer of thermochromic glass, part of a thermochromic window. An example file ThermochromicWindow.idf is included in the EnergyPlus installation.

Field: Name

A unique user assigned name for a particular thermochromic glass material.

Field Set (Optical Data Temperature, Window Material Glazing Name) is extensible.

Field: Optical Data Temperature <N>

The temperature of the TC glass layer corresponding to the optical data of the TC layer. Unit is °C.

Field: Window Material Glazing Name <N>

The window glazing (defined with WindowMaterial:Glazing) name that provides the TC glass layer performance at the above specified temperature.

The IDD definition for the object follows:

```
WindowMaterial:GlazingGroup:Thermochromic,
  \min-fields 3
  \extensible:2 - repeat last two fields remembering to remove ; from "inner" fields.
  \memo thermochromic glass at different temperatures
A1 , \field Name
    \required-field
    \type alpha
N1 , \field Optical Data Temperature 1
    \required-field
    \units C
    \ip-units F
    \type real
A2 , \field Window Material Glazing Name 1
    \required-field
    \type object-list
    \object-list GlazingMaterialName
N2 , \field Optical Data Temperature 2
    \units C
    \ip-units F
    \type real
A3 ; \field Window Material Glazing Name 2
    \type object-list
    \object-list GlazingMaterialName
```

IDF Examples


```
Construction,  
  window_const,          !- Name  
  Usual_Glass,           !- Layer 1  
  AIR_6MM,               !- Layer 2  
  TCGlazings,           !- Layer 3  
  AIR_6MM,               !- Layer 4  
  Usual_Glass;          !- Layer 5
```

```
WindowMaterial:Gas,  
  AIR_6MM,               !- Name  
  Air,                  !- Gas Type  
  0.0063;               !- Thickness {m}
```

```
! Added for thermochromic glazings  
WindowMaterial:GlazingGroup:Thermochromic,  
  TCGlazings,  
  0 , TCGlazing0,  
  20, TCGlazing20,  
  25, TCGlazing25,  
  30, TCGlazing30,  
  35, TCGlazing35,  
  40, TCGlazing40,  
  45, TCGlazing45,  
  50, TCGlazing50,  
  55, TCGlazing55,  
  60, TCGlazing60,  
  65, TCGlazing65,  
  75, TCGlazing75,  
  85, TCGlazing85;
```

```
WindowMaterial:Glazing,
TCGlazing0,  !- Name
SpectralAverage,  !- Optical Data Type
,             !- Window Glass Spectral Data Set Name
0.0030,       !- Thickness
0.2442,       !- Solar Transmittance at Normal Incidence
0.7058,       !- Front Side Solar Reflectance at Normal Incidence
0.7058,       !- Back Side Solar Reflectance at Normal Incidence
0.3192,       !- Visible Transmittance at Normal Incidence
0.6308,       !- Front Side Visible Reflectance at Normal Incidence
0.6308,       !- Back Side Visible Reflectance at Normal Incidence
0.0000,       !- Infrared Transmittance at Normal Incidence
0.9000,       !- Front Side Infrared Hemispherical Emissivity
0.9000,       !- Back Side Infrared Hemispherical Emissivity
0.0199,       !- Conductivity
1.0000,       !- Dirt Correction Factor for Solar and Visible Transmittance
No;          !- Solar Diffusing
```

```
WindowMaterial:Glazing,
TCGlazing20,  !- Name
SpectralAverage,  !- Optical Data Type
,             !- Window Glass Spectral Data Set Name
0.0030,       !- Thickness
0.2442,       !- Solar Transmittance at Normal Incidence
0.7058,       !- Front Side Solar Reflectance at Normal Incidence
0.7058,       !- Back Side Solar Reflectance at Normal Incidence
0.3192,       !- Visible Transmittance at Normal Incidence
0.6308,       !- Front Side Visible Reflectance at Normal Incidence
0.6308,       !- Back Side Visible Reflectance at Normal Incidence
0.0000,       !- Infrared Transmittance at Normal Incidence
0.9000,       !- Front Side Infrared Hemispherical Emissivity
0.9000,       !- Back Side Infrared Hemispherical Emissivity
0.0199,       !- Conductivity
1.0000,       !- Dirt Correction Factor for Solar and Visible Transmittance
No;          !- Solar Diffusing
```

```
WindowMaterial:Glazing,
TCGlazing25,  !- Name
SpectralAverage,  !- Optical Data Type
,             !- Window Glass Spectral Data Set Name
0.0030,       !- Thickness
0.2442,       !- Solar Transmittance at Normal Incidence
0.7058,       !- Front Side Solar Reflectance at Normal Incidence
0.7058,       !- Back Side Solar Reflectance at Normal Incidence
0.3192,       !- Visible Transmittance at Normal Incidence
0.6308,       !- Front Side Visible Reflectance at Normal Incidence
0.6308,       !- Back Side Visible Reflectance at Normal Incidence
0.0000,       !- Infrared Transmittance at Normal Incidence
0.9000,       !- Front Side Infrared Hemispherical Emissivity
0.9000,       !- Back Side Infrared Hemispherical Emissivity
0.0199,       !- Conductivity
1.0000,       !- Dirt Correction Factor for Solar and Visible Transmittance
No;          !- Solar Diffusing
```

```
WindowMaterial:Glazing,
TCGlazing30,  !- Name
SpectralAverage,  !- Optical Data Type
,             !- Window Glass Spectral Data Set Name
0.0030,       !- Thickness
0.2442,       !- Solar Transmittance at Normal Incidence
0.7058,       !- Front Side Solar Reflectance at Normal Incidence
0.7058,       !- Back Side Solar Reflectance at Normal Incidence
0.3192,       !- Visible Transmittance at Normal Incidence
0.6308,       !- Front Side Visible Reflectance at Normal Incidence
0.6308,       !- Back Side Visible Reflectance at Normal Incidence
0.0000,       !- Infrared Transmittance at Normal Incidence
0.9000,       !- Front Side Infrared Hemispherical Emissivity
0.9000,       !- Back Side Infrared Hemispherical Emissivity
0.0199,       !- Conductivity
1.0000,       !- Dirt Correction Factor for Solar and Visible Transmittance
No;          !- Solar Diffusing
```

```

WindowMaterial:Glazing,
TCGlazing35, !- Name
SpectralAverage, !- Optical Data Type
, !- Window Glass Spectral Data Set Name
0.0030, !- Thickness
0.2442, !- Solar Transmittance at Normal Incidence
0.7058, !- Front Side Solar Reflectance at Normal Incidence
0.7058, !- Back Side Solar Reflectance at Normal Incidence
0.3192, !- Visible Transmittance at Normal Incidence
0.6308, !- Front Side Visible Reflectance at Normal Incidence
0.6308, !- Back Side Visible Reflectance at Normal Incidence
0.0000, !- Infrared Transmittance at Normal Incidence
0.9000, !- Front Side Infrared Hemispherical Emissivity
0.9000, !- Back Side Infrared Hemispherical Emissivity
0.0199, !- Conductivity
1.0000, !- Dirt Correction Factor for Solar and Visible Transmittance
No; !- Solar Diffusing

```

```

WindowMaterial:Glazing,
TCGlazing40, !- Name
SpectralAverage, !- Optical Data Type
, !- Window Glass Spectral Data Set Name
0.0030, !- Thickness
0.2442, !- Solar Transmittance at Normal Incidence
0.7058, !- Front Side Solar Reflectance at Normal Incidence
0.7058, !- Back Side Solar Reflectance at Normal Incidence
0.3192, !- Visible Transmittance at Normal Incidence
0.6308, !- Front Side Visible Reflectance at Normal Incidence
0.6308, !- Back Side Visible Reflectance at Normal Incidence
0.0000, !- Infrared Transmittance at Normal Incidence
0.9000, !- Front Side Infrared Hemispherical Emissivity
0.9000, !- Back Side Infrared Hemispherical Emissivity
0.0199, !- Conductivity
1.0000, !- Dirt Correction Factor for Solar and Visible Transmittance
No; !- Solar Diffusing

```

```

WindowMaterial:Glazing,
TCGlazing45, !- Name
SpectralAverage, !- Optical Data Type
, !- Window Glass Spectral Data Set Name
0.0030, !- Thickness
0.2442, !- Solar Transmittance at Normal Incidence
0.7058, !- Front Side Solar Reflectance at Normal Incidence
0.7058, !- Back Side Solar Reflectance at Normal Incidence
0.3192, !- Visible Transmittance at Normal Incidence
0.6308, !- Front Side Visible Reflectance at Normal Incidence
0.6308, !- Back Side Visible Reflectance at Normal Incidence
0.0000, !- Infrared Transmittance at Normal Incidence
0.9000, !- Front Side Infrared Hemispherical Emissivity
0.9000, !- Back Side Infrared Hemispherical Emissivity
0.0199, !- Conductivity
1.0000, !- Dirt Correction Factor for Solar and Visible Transmittance
No; !- Solar Diffusing

```

```

WindowMaterial:Glazing,
TCGlazing50, !- Name
SpectralAverage, !- Optical Data Type
, !- Window Glass Spectral Data Set Name
0.0030, !- Thickness
0.2442, !- Solar Transmittance at Normal Incidence
0.7058, !- Front Side Solar Reflectance at Normal Incidence
0.7058, !- Back Side Solar Reflectance at Normal Incidence
0.3192, !- Visible Transmittance at Normal Incidence
0.6308, !- Front Side Visible Reflectance at Normal Incidence
0.6308, !- Back Side Visible Reflectance at Normal Incidence
0.0000, !- Infrared Transmittance at Normal Incidence
0.9000, !- Front Side Infrared Hemispherical Emissivity
0.9000, !- Back Side Infrared Hemispherical Emissivity
0.0199, !- Conductivity
1.0000, !- Dirt Correction Factor for Solar and Visible Transmittance

```

```

No;      !- Solar Diffusing

WindowMaterial:Glazing,
TCGlazing55, !- Name
SpectralAverage, !- Optical Data Type
,          !- Window Glass Spectral Data Set Name
0.0030,    !- Thickness
0.2442,    !- Solar Transmittance at Normal Incidence
0.7058,    !- Front Side Solar Reflectance at Normal Incidence
0.7058,    !- Back Side Solar Reflectance at Normal Incidence
0.3192,    !- Visible Transmittance at Normal Incidence
0.6308,    !- Front Side Visible Reflectance at Normal Incidence
0.6308,    !- Back Side Visible Reflectance at Normal Incidence
0.0000,    !- Infrared Transmittance at Normal Incidence
0.9000,    !- Front Side Infrared Hemispherical Emissivity
0.9000,    !- Back Side Infrared Hemispherical Emissivity
0.0199,    !- Conductivity
1.0000,    !- Dirt Correction Factor for Solar and Visible Transmittance
No;      !- Solar Diffusing

WindowMaterial:Glazing,
TCGlazing60, !- Name
SpectralAverage, !- Optical Data Type
,          !- Window Glass Spectral Data Set Name
0.0030,    !- Thickness
0.2442,    !- Solar Transmittance at Normal Incidence
0.7058,    !- Front Side Solar Reflectance at Normal Incidence
0.7058,    !- Back Side Solar Reflectance at Normal Incidence
0.3192,    !- Visible Transmittance at Normal Incidence
0.6308,    !- Front Side Visible Reflectance at Normal Incidence
0.6308,    !- Back Side Visible Reflectance at Normal Incidence
0.0000,    !- Infrared Transmittance at Normal Incidence
0.9000,    !- Front Side Infrared Hemispherical Emissivity
0.9000,    !- Back Side Infrared Hemispherical Emissivity
0.0199,    !- Conductivity
1.0000,    !- Dirt Correction Factor for Solar and Visible Transmittance
No;      !- Solar Diffusing

WindowMaterial:Glazing,
TCGlazing65, !- Name
SpectralAverage, !- Optical Data Type
,          !- Window Glass Spectral Data Set Name
0.0030,    !- Thickness
0.2442,    !- Solar Transmittance at Normal Incidence
0.7058,    !- Front Side Solar Reflectance at Normal Incidence
0.7058,    !- Back Side Solar Reflectance at Normal Incidence
0.3192,    !- Visible Transmittance at Normal Incidence
0.6308,    !- Front Side Visible Reflectance at Normal Incidence
0.6308,    !- Back Side Visible Reflectance at Normal Incidence
0.0000,    !- Infrared Transmittance at Normal Incidence
0.9000,    !- Front Side Infrared Hemispherical Emissivity
0.9000,    !- Back Side Infrared Hemispherical Emissivity
0.0199,    !- Conductivity
1.0000,    !- Dirt Correction Factor for Solar and Visible Transmittance
No;      !- Solar Diffusing

WindowMaterial:Glazing,
TCGlazing75, !- Name
SpectralAverage, !- Optical Data Type
,          !- Window Glass Spectral Data Set Name
0.0030,    !- Thickness
0.2442,    !- Solar Transmittance at Normal Incidence
0.7058,    !- Front Side Solar Reflectance at Normal Incidence
0.7058,    !- Back Side Solar Reflectance at Normal Incidence
0.3192,    !- Visible Transmittance at Normal Incidence
0.6308,    !- Front Side Visible Reflectance at Normal Incidence
0.6308,    !- Back Side Visible Reflectance at Normal Incidence
0.0000,    !- Infrared Transmittance at Normal Incidence
0.9000,    !- Front Side Infrared Hemispherical Emissivity
0.9000,    !- Back Side Infrared Hemispherical Emissivity
0.0199,    !- Conductivity

```

```

1.0000,  !- Dirt Correction Factor for Solar and Visible Transmittance
No;      !- Solar Diffusing

WindowMaterial:Glazing,
TCGlazing85,  !- Name
SpectralAverage,  !- Optical Data Type
,            !- Window Glass Spectral Data Set Name
0.0030,      !- Thickness
0.2442,      !- Solar Transmittance at Normal Incidence
0.7058,      !- Front Side Solar Reflectance at Normal Incidence
0.7058,      !- Back Side Solar Reflectance at Normal Incidence
0.3192,      !- Visible Transmittance at Normal Incidence
0.6308,      !- Front Side Visible Reflectance at Normal Incidence
0.6308,      !- Back Side Visible Reflectance at Normal Incidence
0.0000,      !- Infrared Transmittance at Normal Incidence
0.9000,      !- Front Side Infrared Hemispherical Emissivity
0.9000,      !- Back Side Infrared Hemispherical Emissivity
0.0199,      !- Conductivity
1.0000,      !- Dirt Correction Factor for Solar and Visible Transmittance
No;          !- Solar Diffusing

```

Thermochromic Window Outputs

Window Thermochromic Layer Temperature [C]

The temperature of the TC glass layer of a TC window at each time step.

Window Thermochromic Layer Specification Temperature [C]

The temperature under which the optical data of the TC glass layer are specified.

The overall properties (U-factor/SHGC/VT) of the thermochromic windows at different specification temperatures are reported in the EIO file. These window constructions are created by EnergyPlus during run time. They have similar names with suffix “_TC_XX” where XX represents a specification temperature.

WindowMaterial:Gas). If an airflow window has a between-glass shade or blind, the gas in the gap on either side of the shade or blind must be air.

Field: Airflow Source

The source of the gap airflow. The choices are:

IndoorAir: Indoor air from the window’s zone is passed through the window.

OutdoorAir: Outdoor air is passed through the window.

Field: Airflow Destination

This is where the gap air goes after passing through the window. The choices are:

IndoorAir: The gap air goes to the indoor air of the window’s zone.

OutdoorAir: The gap air goes to the outside air.

ReturnAir: The gap air goes to the return air for the window’s zone. This choice is allowed only if Airflow Source = InsideAir. If the return air flow is zero, the gap air goes to the indoor air of the window’s zone. If the sum of the gap airflow for all of the windows in a zone with Airflow Destination = ReturnAir exceeds the return airflow, then the difference between this sum and the return airflow goes to the indoor air.

Figure 29 shows the allowed combinations of Airflow Source and Airflow Destination. The allowed combinations of Airflow Source and Airflow Destination are:

IndoorAir → OutdoorAir

IndoorAir → IndoorAir

IndoorAir → ReturnAir

OutdoorAir → IndoorAir

OutdoorAir → OutdoorAir

Field: Maximum Flow Rate

The maximum value of the airflow, in m^3/s per m of glazing width. The value is typically 0.006 to $0.009 \text{ m}^3/\text{s}\cdot\text{m}$ (4 to 6 cfm/ft).

The airflow can be modulated by specifying Airflow Has Multiplier Schedule = Yes and giving the name of the Airflow Multiplier Schedule (see below).

The fan energy used to move the air through the gap is generally very small and so is ignored.

Field: Airflow Control Type

Specifies how the airflow is controlled. The choices are:

AlwaysOnAtMaximumFlow. The airflow is always equal to Maximum Airflow.

AlwaysOff. The airflow is always zero.

ScheduledOnly. The airflow in a particular timestep equals Maximum Airflow times the value of the Airflow Multiplier Schedule for that timestep.

Field: Airflow Is Scheduled

Specifies if the airflow is scheduled. The choices are:

Yes. The airflow is scheduled.

No. The airflow is not scheduled.

If Yes, Airflow Multiplier Schedule Name is required.

Field: Airflow Multiplier Schedule Name

The name of a schedule with values between 0.0 and 1.0. The timestep value of the airflow is Maximum Airflow times the schedule value. Required if Airflow Is Scheduled = Yes. Unused if Airflow Is Scheduled = No. This schedule should have a ScheduleType with Numeric Type = Continuous and Range = 0.0 : 1.0.

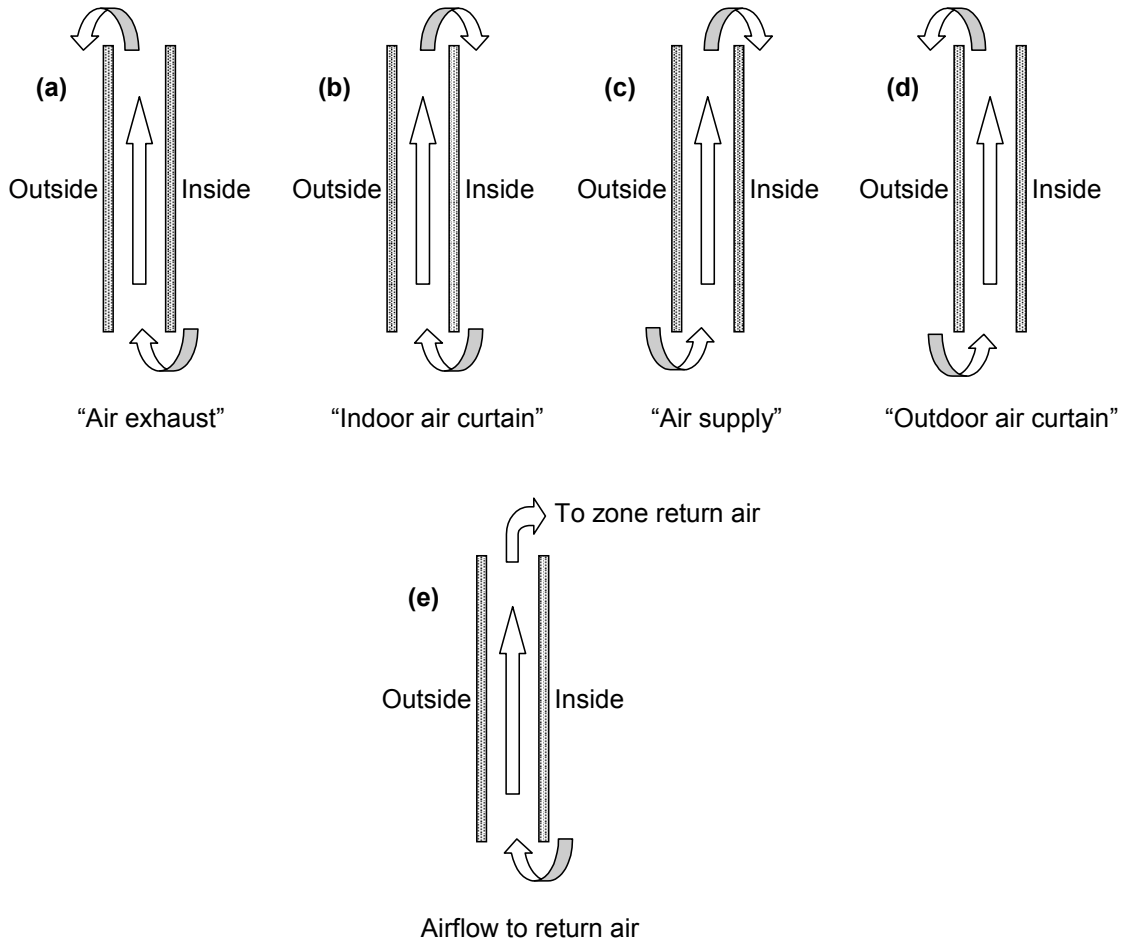


Figure 29. Gap airflow configurations for airflow windows. (a) **Air exhaust window:** Airflow Source = InsideAir, Airflow Destination = OutsideAir; (b) **Indoor air curtain window:** Airflow Source = InsideAir, Airflow Destination = InsideAir; (c) **Air supply window:** Airflow Source = OutsideAir, Airflow Destination = InsideAir; (d) **Outdoor air curtain window:** Airflow Source = OutsideAir, Airflow Destination = OutsideAir; (e) **Airflow to Return Air:** Airflow Source = InsideAir, Airflow Destination = ReturnAir. Based on "Active facades," Version no. 1, Belgian Building Research Institute, June 2002.

```

WindowProperty:AirflowControl,
  \memo Used to control forced airflow through a gap between glass layers
  \min-fields 7
A1 , \field Name
    \required-field
    \type object-list
    \object-list SubSurfNames
    \note Name must be that of an exterior window with two or three glass layers.
A2 , \field Airflow Source
    \type choice
    \key IndoorAir
    \key OutdoorAir
    \default IndoorAir
A3 , \field Airflow Destination
    \type choice
    \key IndoorAir
    \key OutdoorAir
    \key ReturnAir
    \default OutdoorAir
N1 , \field Maximum Flow Rate
    \units m3/s-m
    \note Above is m3/s per m of glazing width
    \ip-units ft3/min-ft
    \default 0.0
    \minimum 0.0
A4 , \field Airflow Control Type
    \type choice
    \key AlwaysOnAtMaximumFlow
    \key AlwaysOff
    \key ScheduledOnly
    \note ScheduledOnly requires that Airflow Has Multiplier Schedule Name = Yes
    \note and that Airflow Multiplier Schedule Name is specified.
    \default AlwaysOnAtMaxFlow
A5 , \field Airflow Is Scheduled
    \type choice
    \key Yes
    \key No
    \default No
    \note If Yes, then Airflow Multiplier Schedule Name must be specified
A6 ; \field Airflow Multiplier Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note Required if Airflow Is Scheduled = Yes.
    \note Schedule values are 0.0 or 1.0 and multiply Maximum Air Flow.

```

An IDF example: window with a constant airflow from inside to outside at 0.008 m³/s-m.

```

WindowProperty:AirflowControl,    !- Used to control forced airflow through a gap between glass layers
  Zn001:Wall001:Win002,          !- Name of Associated Window
  InsideAir,                      !- Airflow Source
  OutsideAir,                     !- Airflow Destination
  0.008,                          !- Maximum Airflow (m3/s per m of glazing width)
  AlwaysOnAtMaxFlow,             !- Airflow Control Type
  No,                             !- Airflow Has Multiplier Schedule?
  ;                               !- Name of Airflow Multiplier Schedule

```

WindowProperty:StormWindow

This object allows you to assign a movable exterior glass layer (“storm window” or “storm glass”) that is usually applied to a window in the winter to reduce heat loss and removed in the summer. A WindowProperty:StormWindow object is required for each window that has an associated storm window. It is assumed that:

- When the storm glass is in place it is the outermost layer of the window, it covers only the glazed part of the window and not the frame, and it forms a tight seal. See Figure 30.
- When the storm glass is not in place it is completely removed and has no effect on window heat transfer.
- The gap between the storm glass and rest of the glazing is filled with air.

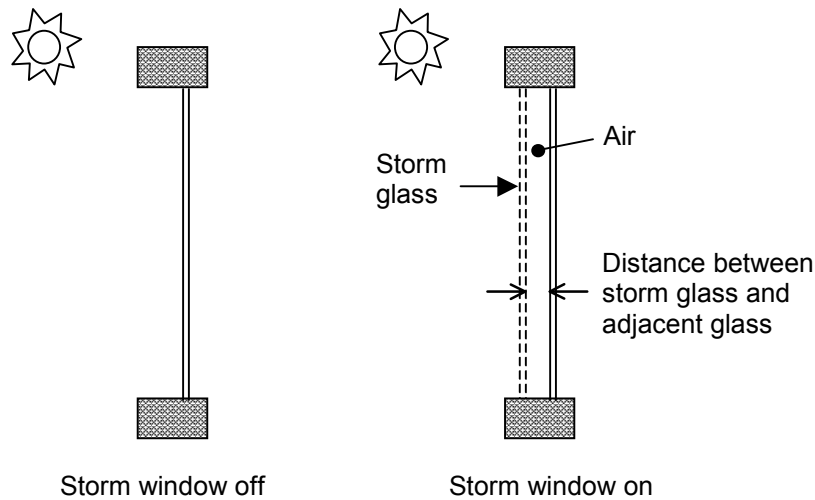


Figure 30. Section through a single-glazed window without (left) and with (right) a storm glass layer. Not to scale.

With the addition of a storm window, single glazing effectively becomes double glazing, double glazing becomes triple glazing, etc.

The presence of a storm window is indicated by the report variable “Storm Window On/Off Flag” (see “Window Output Variables”). This flag is **0** if the storm window is off, **1** if it is on, and **-1** if the window does not have an associated storm window.

The program automatically creates a window construction (ref: Construction) that consists of the storm window glass layer and its adjacent air layer added to the original (unshaded, or “bare”) window construction. In the eplusout.eio file this construction is called `BARECONSTRUCTIONWITHSTORMWIN:n`, where *n* is the number of the associated StormWin object. If the window has a shaded construction, the program creates a construction called `SHADEDCONSTRUCTIONWITHSTORMWIN:n` that consists of the storm window glass layer and its adjacent air layer added to the original shaded window construction.

The program also creates a WindowMaterial:Gas layer corresponding to the air layer adjacent to the storm glass. In the eplusout.eio file this layer is called `AIR:STORMWIN:kMM`, where *k* is the thickness of the air layer expressed as an integer number of millimeters.

Field: Window Name

This is the name of a window (or glass door) to which the storm glass is applied. Not all windows can accept WindowProperty:StormWindow. The rules are:

- The window must be an exterior window. WindowProperty:StormWindow is not applicable to interior (interzone) windows.
- The window construction (without the storm glass layer) can have up to three glass layers.
- If the window has an associated shaded construction (ref: WindowProperty:ShadingControl), that construction can have an interior shade or blind and up to three glass layers, or a between-glass shade or blind and two glass layers. The shaded construction cannot have an exterior shade or blind, cannot have a between-glass shade or blind and three glass layers, and cannot be switchable glazing.
- The window cannot be an airflow window, i.e., a window that has an associated WindowProperty:AirflowControl.

Field: Storm Glass Layer Name

This is the name of a window glass material. Storm windows are assumed to consist of a single layer of glass. A storm window frame, if present, is ignored.

Field: Distance Between Storm Glass Layer and Adjacent Glass

The separation between the storm glass and the rest of the window (Figure 30). It is measured from the inside of the storm glass layer to the outside of the adjacent glass layer.

Field: Month that Storm Glass Layer Is Put On

The number of the month (January = 1, February = 2, etc.) during which the storm window is put in place.

Field: Day of Month that Storm Glass Layer Is Put On

The day of the month that the storm window is put in place. It is assumed that the storm window is put in place at the beginning of this day, i.e., during the first simulation timestep of the day, and remains in place until that month and day given by the following two fields.

Field: Month that Storm Glass Layer Is Taken Off

The number of the month (January = 1, February = 2, etc.) during which the storm window is removed.

Field: Day of Month that Storm Glass Layer Is Taken Off

The day of the month that the storm window is removed. It is assumed that the storm window is removed at the beginning of this day, i.e., during the first simulation timestep of the day, and stays off until the month and day given by Month that Storm Glass Layer Is Put On, Day of Month that Storm Glass Layer Is Put On.

In the northern hemisphere, the month the storm window is put on is generally greater than the month it is taken off (for example put on in month 10, when it starts to get cold, and taken off in month 5, when it starts to warm up). In the southern hemisphere this is reversed: month on is less than month off.

```
WindowProperty:StormWindow,
  \min-fields 7
  \memo This is a movable exterior glass layer that is usually applied in the winter
  \memo and removed in the summer.
A1, \field Window Name
  \note Must be the name of a FenestrationSurface:Detailed object with Surface Type = WINDOW.
  \note The WindowProperty:StormWindow object can only be used with exterior windows.
  \required-field
  \type alpha
A2, \field Storm Glass Layer Name
  \note Must be a WindowMaterial:Glazing or WindowMaterial:Glazing:RefractionExtinctionMethod
  \note Gap between storm glass layer and adjacent glass layer is assumed to be filled
  \note with Air
  \required-field
  \type object-list
  \object-list GlazingMaterialName
```

```

N1, \field Distance Between Storm Glass Layer and Adjacent Glass
    \type real
    \minimum> 0.0
    \maximum 0.5
    \default 0.050
N2, \field Month that Storm Glass Layer is Put On
    \required-field
    \minimum 1
    \maximum 12
    \type integer
N3, \field Day of Month that Storm Glass Layer is Put On
    \required-field
    \minimum 1
    \maximum 31
    \type integer
N4, \field Month that Storm Glass Layer is Taken Off
    \required-field
    \minimum 1
    \maximum 12
    \type integer
N5; \field Day of Month that Storm Glass Layer is Taken Off
    \required-field
    \minimum 1
    \maximum 31
    \type integer

```

An IDF example of WindowProperty:StormWindow. The storm window is put in place on October 15 and removed on May 1.

```

WindowProperty:StormWindow,
Window1, !- Name of Window to Which Storm Window Glass Layer is Applied
GlassA, !- Name of Material:WindowGlass or MATERIAL:WindowGlass:AltInput that is the storm window layer
0.060, !- Distance from storm window to adjacent glass (m)
10, !- Month that Storm Window Is Put On
15, !- Day of Month that Storm Window Is Put On
5, !- Month that Storm Window Is Taken Off
1; !- Day of Month that Storm Window Is Taken Off

```

Importing Windows from WINDOW 5

The WINDOW 5 program calculates the U-value, Solar Heat Gain Coefficient, solar transmission/absorption characteristics, visible transmission characteristics and other properties of a window under standard indoor and outdoor conditions. WINDOW 5 treats the whole window system—glazing, frame and divider. A sub-program of WINDOW 5 called THERM uses a 2-D finite element calculation to determine the effective conductance of frame, divider and edge-of-glass elements. Another sub-program, OPTICS 5, determines the solar-optical properties of glazing, including laminates and coated glass.

WINDOW 5 writes a data file containing a description of the window that was analyzed. An example is shown below. This file, which can be named by the user, can be read by EnergyPlus. By default, the file name is “Window5DataFile.dat” and is located in the EnergyPlus “run” folder (*the same folder that has the EnergyPlus.exe file*). Or, as illustrated below, you may input the file name (including path or relative path) to the object. For more complete description and examples, see the object description -- Construction:WindowDataFile.

In this way, the same window that was created in WINDOW 5 can be imported into EnergyPlus for annual energy analysis without having to re-input the window data. To obtain WINDOW 5 go to <http://windows.lbl.gov>. A major advantage of using WINDOW 5 to create window input for EnergyPlus is that you will have direct access to WINDOW 5’s expanding database of over 1000 different glass types; and you will be able to browse through this database according to different criteria (color, transmittance, solar heat gain coefficient, etc.) to help you select the best glass type for your application.

Although WINDOW 5 writes only one window entry on the WINDOW 5 data file, EnergyPlus users can combine two or more of these files to end up with a single WINDOW 5 data file

with multiple window entries of different types. In this way a library of windows from WINDOW 5 can be built up if so desired. If you combine files like this you should be sure not to leave out or change any of lines from the original files.

1. There are three methods for inputting window constructions in EnergyPlus:
 - a) input full spectral data for each layer in the IDF,
 - b) input spectral average data for each layer in the IDF,
 - c) import WINDOW 5 report containing layer-by-layer calculated values and overall glazing system angular values.

2. The SHGC calculations in EnergyPlus for window layers input using full spectral data use a spectral weighting data set (derived from Optics5 data file ISO-9845GlobalNorm.std) that is different from the WINDOW 5 default spectral weighting data set (W5_NFRC_2003.std). This difference accounts for most of the variation in SHGC values reported by EnergyPlus and WINDOW 5 for full spectral data window layer input. This variation is more pronounced for window constructions of three glass layers or more.

3. Users intending to select a window construction based on SHGC value for energy code compliance should base their selection on the value reported by WINDOW 5 since this is the officially recognized value.

Please note that there is a bug in WINDOW 5 that causes two of the lines in the EnergyPlus data file to be joined. This bug is fixed in versions of Window 5.02 (and above). To be sure, you can check the data file for a line that looks like:

```
GLAZING SYSTEM OPTICAL DATA Angle 0 10 20 30 40 50 60 70 80 90 Hemis
```

The fixed version of the program will not show the above line; rather, there will be two lines such as shown below. If you have the above condition, with an editor you would break this into two lines:

```
GLAZING SYSTEM OPTICAL DATA
Angle 0 10 20 30 40 50 60 70 80 90 Hemis
```

In EnergyPlus, the Window5 data file is searched for each “Construction from Window5 Data File” object in the EnergyPlus input. This object has a very simple form:

```
Construction:WindowDataFile,
ConstructionName,
FileName; ! Default is Window5DataFile.dat in the "run" folder.
```

If there is a window called ConstructionName on the Window5 data file, the data for that window is read from the file and the following EnergyPlus objects and their names are created. The “W5” prefixed to these names indicates that the object originated in the Window5 data file.

- **WindowMaterial:Glazing** for each of the glass layers. They will be named **W5:ConstructionName:GLASS1**, **W5:ConstructionName:GLASS2**, etc.
- **WindowMaterial:Gas** or **WindowMaterial:GasMixture** for each of the gap layers. They will be named **W5:ConstructionName:GAP1**, **W5:ConstructionName:GAP2**, etc.
- **WindowProperty:FrameAndDivider** (if the window on the Window5 data file has a frame and/or divider). It will be named **W5:ConstructionName**. This WindowProperty:FrameAndDivider will be assigned to any window on the input file that

has a construction called “ConstructionName” *even if that window has referenced another WindowProperty:FrameAndDivider (i.e., if WindowProperty:FrameAndDivider Name for that window is specified)*. In this case a warning will result.

Note that:

An entry on the WINDOW 5 data file usually has just one glazing system. It is also possible to have an entry with two glazing systems separated by a horizontal or vertical mullion. In this case, the two glazing systems can have different dimensions and different properties. For example, one of the two glazing systems could be single glazed and the other could be double glazed. An example of the two glazing system case is given in the sample WINDOW 5 data file shown below (although in this case the properties of the two glazing systems are the same).

EnergyPlus handles the “one glazing system” and “two glazing systems” cases differently. If there is one glazing system, the glazing system height and width from the Window5 data file are not used. Instead, the window dimensions are obtained from the window vertices that have been specified on the IDF file. However, a warning message will result if the height or width calculated from the window’s vertex inputs differs from the corresponding Window5 data file values by more than 10%. This warning is given since the effective frame and edge-of-glass conductances on the WINDOW 5 data file can depend on the window dimensions if the frame is non-uniform, i.e., consists of sections with different values of width, projection, or thermal properties.

If the WINDOW 5 data file entry has two glazing systems, System1 and System2, the following happens, as shown in the figure below. Assume that the original window is called WinOriginal. System1 is assigned to WinOriginal. Then EnergyPlus automatically creates a second window, called WinOriginal:2, and assigns System2 to it. The dimensions of WinOriginal are ignored; the dimensions of System1 on the data file are assigned to it, but the position of the lower left-hand vertex of WinOriginal is retained. The dimensions of System2 on the data file are assigned to WinOriginal:2. The lower left-hand vertex of WinOriginal:2 is determined from the mullion orientation and width.

Note: WinOriginal would have been the IDF window definition – it’s dimensions will be overridden by the systems dimensions from the Window 5 data file. Two windows will be made and called WinOriginal and WinOriginal:2.

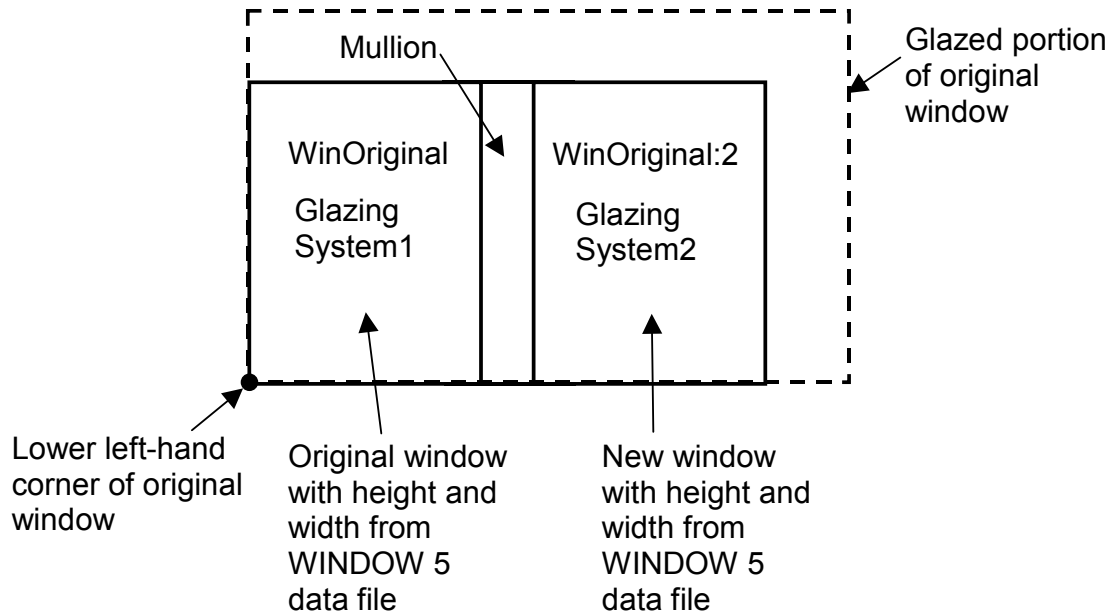


Figure 31. Window5 Glazing system with dual glazing constructions

The Window5 Data File contains no information on shading devices. See “Specify the Material Name of the Shading Device” under WindowProperty:ShadingControl for a method to attach a shading layer to windows read in from this file.

Following is an example WINDOW 5 data file for a slider window with two identical double low-E glazing systems separated by a horizontal mullion. Each system has a frame and divider. Note that all dimensions, such as glazing height and width, are in millimeters; when EnergyPlus reads the file these are converted to meters. Following the data file example is a description of the contents of the file. That data used by EnergyPlus is shown in bold.

```

Window5 Data File for EnergyPlus
Window 5.0 v5.0.73
Date : Tue Nov 13 17:07:40 2001
Window name : DoubleLowE
Description : Horizontal Slider, AA
# Glazing Systems: 2
GLAZING SYSTEM DATA: Height Width nPanels Uval-center SC-center SHGC-center Tvis-center
System1 : 1032 669 2 1.660 0.538 0.467 0.696
System2 : 1033 669 2 1.660 0.538 0.467 0.696
FRAME/MULLION DATA: Width OutsideProj InsideProj Cond EdgeCondRatio SolAbs VisAbs Emiss Orient'n (null)
L Sill : 97.3 25.4 25.4 500.000 1.467 0.500 0.500 0.90
R Sill : 97.3 25.4 25.4 500.000 1.467 0.500 0.500 0.90
L Head : 70.2 25.4 25.4 18.822 1.490 0.500 0.500 0.90
R Head : 70.2 25.4 25.4 18.822 1.490 0.500 0.500 0.90
Top L Jamb : 54.3 25.4 25.4 31.141 1.503 0.500 0.500 0.90
Bot L Jamb : 54.3 25.4 25.4 500.000 1.494 0.500 0.500 0.90
Top R Jamb : 70.2 25.4 25.4 500.000 1.518 0.500 0.500 0.90
Bot R Jamb : 97.6 25.4 25.4 264.673 1.547 0.500 0.500 0.90
Mullion : 53.5 25.4 25.4 500.000 1.361 0.500 0.500 0.90 Horizontal
Average frame: 75.5 25.4 25.4 326.149 1.464 0.500 0.500 0.90
DIVIDER DATA : Width OutsideProj InsideProj Cond EdgeCondRatio SolAbs VisAbs Emiss Type #Hor #Vert
System1 : 25.4 25.4 25.4 3.068 1.191 0.500 0.500 0.900 DividedLite 2 3
System2 : 25.4 25.4 25.4 3.068 1.191 0.500 0.500 0.900 DividedLite 2 3
GLASS DATA : Layer# Thickness Cond Tsol Rfsol Rbsol Tvis Rfvis Rbvis Tir EmissF EmissB SpectralDataFile
System1 : 1 3.00 0.900 0.50 0.33 0.39 0.78 0.16 0.13 0.00 0.16 0.13 CMFTIR_3.AFG
: 2 6.00 0.900 0.77 0.07 0.07 0.88 0.08 0.08 0.00 0.84 0.84 CLEAR_6.DAT
System2 : 1 3.00 0.900 0.50 0.33 0.39 0.78 0.16 0.13 0.00 0.16 0.13 CMFTIR_3.AFG
: 2 6.00 0.900 0.77 0.07 0.07 0.88 0.08 0.08 0.00 0.84 0.84 CLEAR_6.DAT
GAP DATA : Gap# Thick nGasses
System1 : 1 12.70 1
System2 : 1 12.70 1
GAS DATA : GasName Fraction MolWeight ACond BCond CCond AVisc BVisc CVisc ASpHeat BSpHeat CSpHeat
System1 Gap1 : Air 1.0000 28.97 0.002873 7.76e-5 0.0 3.723e-6 4.94e-8 0.0 1002.737 0.012324 0.0
System2 Gap1 : Air 1.0000 28.97 0.002873 7.76e-5 0.0 3.723e-6 4.94e-8 0.0 1002.737 0.012324 0.0
GLAZING SYSTEM OPTICAL DATA
Angle 0 10 20 30 40 50 60 70 80 90 Hemis
System1
Tsol 0.408 0.410 0.404 0.395 0.383 0.362 0.316 0.230 0.106 0.000 0.338
Abs1 0.177 0.180 0.188 0.193 0.195 0.201 0.218 0.239 0.210 0.001 0.201
Abs2 0.060 0.060 0.061 0.061 0.063 0.063 0.061 0.053 0.038 0.000 0.059
Rfsol 0.355 0.350 0.348 0.350 0.359 0.374 0.405 0.478 0.646 0.999 0.392
Rbsol 0.289 0.285 0.283 0.282 0.285 0.296 0.328 0.411 0.594 1.000 0.322
Tvis 0.696 0.700 0.690 0.677 0.660 0.625 0.548 0.399 0.187 0.000 0.581
Rfvis 0.207 0.201 0.198 0.201 0.212 0.234 0.278 0.374 0.582 0.999 0.260
Rbvis 0.180 0.174 0.173 0.176 0.189 0.215 0.271 0.401 0.648 1.000 0.251
System2
Tsol 0.408 0.410 0.404 0.395 0.383 0.362 0.316 0.230 0.106 0.000 0.338
Abs1 0.177 0.180 0.188 0.193 0.195 0.201 0.218 0.239 0.210 0.001 0.201
Abs2 0.060 0.060 0.061 0.061 0.063 0.063 0.061 0.053 0.038 0.000 0.059
Rfsol 0.355 0.350 0.348 0.350 0.359 0.374 0.405 0.478 0.646 0.999 0.392
Rbsol 0.289 0.285 0.283 0.282 0.285 0.296 0.328 0.411 0.594 1.000 0.322
Tvis 0.696 0.700 0.690 0.677 0.660 0.625 0.548 0.399 0.187 0.000 0.581
Rfvis 0.207 0.201 0.198 0.201 0.212 0.234 0.278 0.374 0.582 0.999 0.260
Rbvis 0.180 0.174 0.173 0.176 0.189 0.215 0.271 0.401 0.648 1.000 0.251
    
```

Description of Contents of Window5 Data File

(Quantities used in EnergyPlus are in bold; others are informative only)

Second line = version of WINDOW5 used to create the data file

Date = date the data file was created

Window name = name of this window; chosen by WINDOW5 user; EnergyPlus user enters the same name in EnergyPlus as name of a "Construction from Window5 Data File" object. EnergyPlus will search the Window5 data file for an entry of this name.

Description = One-line description of the window; this is treated as a comment.

Glazing Systems: 1 or 2; value is usually 1 but can be 2 if window has a horizontal or vertical mullion that separates the window into two glazing systems that may or may not be different.

GLAZING SYSTEM DATA

System1, System2: separate characteristics given if window has a mullion.

Height, *width = height and width of glazed portion (i.e., excluding frame; and, if mullion present, excluding mullion).

nPanels = number of glass layers

Uval-center = center-of-glass U-value (including air films) under standard winter conditions* (W/m²)

SC-center = center-of-glass shading coefficient under standard summer conditions*.

SHCG-center = center-of-glass solar heat gain coefficient under standard summer conditions*.

Tvis-center = center-of-glass visible transmittance at normal incidence

FRAME/MULLION DATA

L,R Sill = left, right sill of frame

L,R Head = left, right header of frame

Top L, Bot L jamb = top-left, bottom-left jamb of frame

Bot L, Bot R jamb = bottom-left, bottom-right jamb of frame

Average frame = average characteristics of frame for use in EnergyPlus calculation. If mullion is present, original window is divided into two separate windows with the same average frame (with the mullion being split lengthwise and included in the average frame).

Width = width (m)

OutsideProj = amount of projection from outside glass (m)

InsideProj = amount of projection from inside glass (m)

Cond = effective surface-to-surface conductance (from THERM calculation) (W/m²)

EdgeCondRatio = ratio of surface-to-surface edge-of-glass conductance to surface-to-surface center-of-glass conductance (from THERM calculation)

SolAbs = solar absorptance

VisAbs = visible absorptance

Emiss = hemispherical thermal emissivity

Orientation = Horizontal or Vertical (mullion only); = None if no mullion.

DIVIDER DATA

Width through **Emiss** are the same as for FRAME/MULLION DATA

#Hor = number of horizontal dividers

#Vert = number of vertical dividers

Type = DividedLite or Suspended

GLASS DATA

System1, System2: separate characteristics are given if window has a mullion.

Cond = conductivity (W/m-K)

Tsol = spectral-average solar transmittance at normal incidence

Rfsol = spectral-average front solar reflectance at normal incidence

Rbsol = spectral-average back solar reflectance at normal incidence

Tvis = spectral-average visible transmittance at normal incidence

Rfvis = spectral-average front visible reflectance at normal incidence

Rbvis = spectral-average back visible reflectance at normal incidence

Tir = hemispherical IR transmittance

EmissF = hemispherical front emissivity

EmissB = hemispherical back emissivity

SpectralDataFile = name of spectral data file with wavelength-dependent transmission and reflection data used by WINDOW 5 to calculate the glazing system optical data. "None" will appear here if spectral-average data for this glass layer were used by WINDOW 5.

GAP DATA

System1, System2: separate characteristics are given if the window has a mullion.

Thick = thickness (m)

nGasses = number of gasses (1, 2 or 3)

GasName = name of the gas

Fraction = fraction of the gas

MolecWeight = molecular weight of the Nth gas

(In the following, conductivity, viscosity and specific heat as a function of temperature, T (deg K), are expressed as $A + B*T + C*T^2$)

ACond = A coeff of conductivity (W/m-K)

BCond = B coeff of conductivity (W/m-K²)

CCond = C coeff of conductivity (W/m-K³)

AVisc = A coeff of viscosity (g/m-s)

BVisc = B coeff of viscosity (g/m-s-K)

CVisc = C coeff of viscosity (g/m-s-K²)

ASpHeat = A coeff of specific heat (J/kg-K)

BSpHeat = B coeff of specific heat (J/kg-K²)

CSpHeat = C coeff of specific heat (J/kg-K³)

GLAZING SYSTEM OPTICAL DATA

System1, System2: separate characteristics are given if the window has a mullion.

Hemisph = hemispherical (i.e., diffuse)

Tsol = solar transmittance vs. angle of incidence

AbsN = solar absorptance of Nth layer vs. angle of incidence

Rfsol = front solar reflectance vs. angle of incidence

Rbsol = back solar reflectance vs. angle of incidence

Tvis = visible transmittance vs. angle of incidence

Rfvis = front visible reflectance vs. angle of incidence

Rbvis = back visible reflectance vs. angle of incidence

*Standard conditions are

Winter:

Indoor air temperature = 21.1C (70F)

Outdoor air temperature = -17.8C (0F)

Wind speed = 6.71 m/s (15 mph)

No solar radiation

Summer:

Indoor air temperature = 23.9C (75F)

Outdoor air temperature = 31.7C (89F)

Wind speed = 3.35 m/s (7.5 mph)

783 W/m² (248 Btu/h-ft²) incident beam solar radiation normal to glazing

Zone Thermal Output(s)

In addition to the canned Surface reports (view the Reports section later in this document) and surface variables (above), the following variables are available for all zones:

```

Zone,Sum,Zone Total Internal Radiant Heat Gain [J]
Zone,Sum,Zone Total Internal Visible Heat Gain [J]
Zone,Sum,Zone Total Internal Convective Heat Gain [J]
Zone,Sum,Zone Total Internal Latent Gain [J]
Zone,Sum,Zone Total Internal Total Heat Gain [J]
Zone,Average,Zone Mean Air Temperature [C]
HVAC,Average,Zone/Sys Air Temperature[C]
Zone,Average,Zone Mean Radiant Temperature [C]
Zone,Average,Zone Operative Temperature [C]
HVAC,Sum,Zone/Sys Sensible Heating Energy[J]
HVAC,Sum,Zone/Sys Sensible Cooling Energy[J]
HVAC,Average,Zone/Sys Sensible Heating Rate[W]
HVAC,Average,Zone/Sys Sensible Cooling Rate[W]
HVAC,Average,Zone Air Humidity Ratio[]
HVAC,Average,Zone Air Relative Humidity[%]

```

Two of these are of particular interest:

```

Zone,Average,Zone Mean Air Temperature [C]
HVAC,Average,Zone/Sys Air Temperature [C]

```

These two variable outputs are/should be identical. However, note that they can be reported at different time intervals. “Zone Mean Air Temperature” is only available on the Zone/HB timestep (Number of Timesteps per Hour) whereas “Zone/Sys Air Temperature” can be reported at the HVAC timestep (which can vary).

Zone Mean Air Temperature [C]

From the code definition, the zone mean air temperature is the average temperature of the air temperatures at the system timestep. Remember that the zone heat balance represents a “well stirred” model for a zone, therefore there is only one mean air temperature to represent the air temperature for the zone.

Zone/Sys Air Temperature[C]

This is very similar to the mean air temperature in the last field. The “well stirred” model for the zone is the basis, but this temperature is also available at the “detailed” system timestep.

Zone Mean Radiant Temperature [C]

The Mean Radiant Temperature (MRT) in degrees Celsius of a space is really the measure of the combined effects of temperatures of surfaces within that space. The larger the surface area and the closer one is to it, the more effect the surface temperature of that surface has on each other. The MRT is the measure of all these surface areas and temperatures.

Zone Operative Temperature [C]

Zone Operative Temperature (OT) is the average of the Zone Mean Air Temperature (MAT) and Zone Mean Radiant Temperature (MRT), $OT = 0.5 \cdot MAT + 0.5 \cdot MRT$. This report variable is not affected by the type of thermostat controls in the zone, and does not include the direct effect of high temperature radiant systems. See also Zone Thermostat Operative Temperature.

Zone/Sys Sensible Heating Energy[J]

This field represents the sensible heating energy in Joules that is actually supplied by the system to that zone for the timestep reported. This is the sensible heating rate multiplied by the simulation timestep. This is calculated and reported from the Correct step in the Zone Predictor-Corrector module. . This field is not multiplied by zone or group multipliers.

Zone/Sys Sensible Heating (and Cooling) Energy (and Rate) all report the heating or cooling delivered by the HVAC system to a zone. These values are calculated by multiplying the supply air mass flow rate by the difference between the supply air temperature and the zone air temperature. This does not always

indicate the operation of heating or cooling coils. For example, cooling will be reported if the supply air is cooled due to the introduction of outside air, even if all coils are off.

Note that these variables are calculated at the system timestep. When reported at the "detailed" reporting frequency, these variable will never show heating and cooling both in the same system timestep. If reported at a frequency less than "Detailed" (for example, Hourly) values may appear in both the heating and cooling variable for the same hour if the system cooled the zone for part of the reporting period and heated the zone for another part of the reporting period.

Zone/Sys Sensible Cooling Energy[J]

This field represents the sensible cooling energy in Joules that is actually supplied by the system to that zone for the timestep reported. This is the sensible cooling rate multiplied by the simulation timestep. This is calculated and reported from the Correct step in the Zone Predictor-Corrector module. This field is not multiplied by zone or group multipliers.

Zone/Sys Sensible Heating Rate[W]

This field represents the sensible heating rate in Watts that is actually supplied by the system to that zone for the timestep reported. This is calculated and reported from the Correct step in the Zone Predictor-Corrector module. This field is not multiplied by zone or group multipliers.

Zone/Sys Sensible Cooling Rate[W]

This field represents the sensible cooling rate in Watts that is actually supplied by the system to that zone for the timestep reported. This is calculated and reported from the Correct step in the Zone Predictor-Corrector module. This field is not multiplied by zone or group multipliers.

Zone Air Humidity Ratio[]

This field represents the air humidity ratio after the correct step for each zone. The humidity ratio is the mass of water vapor to the mass of dry air contained in the zone in (kg water/kg air) and is unitless.

Zone Air Relative Humidity[%]

This field represents the air relative humidity ratio after the correct step for each zone. The relative humidity is in percent and uses the Zone Air Temperature, the Zone Air Humidity Ratio and the Outside Barometric Pressure for calculation.

Zone Total Internal Radiant Heat Gain [J]

This field represents the sum of radiant gains from specific internal sources (e.g. equipment) throughout the zone in joules. This includes radiant gain from People, Lights, Electric Equipment, Gas Equipment, Other Equipment, Hot Water Equipment, and Steam Equipment.

Zone-Total Internal Visible Heat Gain [J]

This field expresses the sum of heat gain in joules that is the calculated short wavelength radiation gain from lights in the zones. This calculation uses the total energy from lights and the fraction visible to realize this value, summed over the zones in the simulation.

Zone Total Internal Convective Heat Gain [J]

This field represents the sum of convective gains from specific sources (e.g. equipment) throughout the zone in joules. This includes convective gain from People, Lights, Electric Equipment, Gas Equipment, Other Equipment, Hot Water Equipment, and Steam Equipment.

Zone Total Internal Latent Gain [J]

This field represents the sum of latent gains from specific internal sources (e.g. equipment) throughout the zone in joules. This includes latent gain from People, Electric Equipment, Gas Equipment, Other Equipment, Hot Water Equipment, and Steam Equipment.

Zone Total Internal Total Heat Gain [J]

This field represents the sum of all heat gains throughout the zone in joules. This includes all heat gains from People, Lights, Electric Equipment, Gas Equipment, Other Equipment, Hot Water Equipment, and Steam Equipment.

Group – Advanced Surface Concepts

This group of objects describe concepts applied to heat transfer surfaces that are of an advanced nature. Careful consideration must be given before using these.

SurfaceControl:MoveableInsulation

Movable insulation can be used/scheduled on any surface regular surface (such as a wall, floor, roof, etc.) but not on a subsurface (such as a window, use WindowProperty:ShadingControl instead). With movable insulation, no reference is made in the surface that is using the insulation – rather the movable insulation statement references the surface to which it is applied.

Exterior movable insulation has undergone some testing and appears to producing expected results. At the modification of this section of the Input/Output Reference (April 2002), interior movable insulation has not yet been tested. The underlying principle has been implemented in EnergyPlus for both interior and exterior movable insulation with the possibility for exterior movable insulation to be transparent (transparent insulation material or TIM). Basically, the addition of movable insulation allows the user to schedule an extra amount of insulation on either the inside or outside surface of a wall (or both). The insulation must be a simple, homogenous material layer (linked to a material definition within the input data file). Note that EnergyPlus allows the exterior movable insulation layer to be transparent to short wavelength radiation (solar). In this case, incident solar is split between the plane between the movable insulation and the surface and the plane between the movable insulation and the surrounding air. This calculation is fairly basic and based on the solar transmittance of the insulation layer (material properties). Using transparent layers for exterior movable insulation allows solar energy to penetrate deeper into a construction where it can be stored for later use in the building (similar in concept to a Trombe Wall).

Field: Insulation Type

This field determines whether the movable insulation is applied to the inside or the outside of the surface by entering “Inside” or “Outside”, respectively.

Field: Surface Name

This field refers the movable insulation back to a particular surface (ref: Building Surfaces) via its user assigned name so that EnergyPlus knows where to apply this extra layer of insulation. This will affect either the inside or outside surface heat balance of this surface depending on the value in the insulation type field (see previous field).

Field: Material Name

This field refers to a material layer (e.g., Material, Material:NoMass, or WindowMaterial:Glazing; transparent layers are only valid for outside movable insulation) via its user assigned name. This provides the program with a full complement of material properties so that the effect of the insulation (R-value and solar transmittance) can be correctly taken into account by EnergyPlus.

Field: Schedule Name

This field is a schedule that theoretically can be any positive real number but was originally intended to be a parameter between 0.0 and 1.0. Its purpose is to act as a fractional modifier on the resistance of the material layer. The actual thermal resistance of the movable insulation is equal to the resistance of the material layer times the current value in the movable insulation schedule. A value of 0.0 simply means that the movable insulation is not present.

The IDD description of movable insulation is as follows:

```
SurfaceControl:MoveableInsulation,
  \memo Exterior or Interior Insulation on surfaces
  A1, \field Insulation Type
      \required-field
      \type choice
      \key Outside
      \key Inside
  A2, \field Surface Name
      \required-field
      \type object-list
      \object-list SurfaceNames
  A3, \field Material Name
      \required-field
  A4; \field Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
```

An example of this syntax implemented in an input file is:

```
SurfaceControl:MoveableInsulation,
  Exterior,                ! Insulation Type
  Zone001:Wall001,        ! Surface Name
  TransparentInsulationMaterial, ! Material Name
  PresentInWinterSchedule; ! Schedule Name
```

SurfaceProperty:OtherSideCoefficients

By referencing the Other Side Coefficients statement in the surface statements (i.e. Outside Boundary Condition), the temperature of the outer plane of a surface (see Figure 32) can be directly controlled. Other side coefficients can also be used to control the exterior convective heat transfer coefficient of a surface and the corresponding exterior air temperature. It should be noted that solar effects are not accounted for when other side coefficients are used. In addition, if other side coefficients are specified for a surface, they also hold for subsurfaces of that surface (though subsurfaces can have their own coefficient set).

Other side coefficients have the same effect on all types of heat transfer surfaces. In other words, an interior surface with other side coefficients specified and an exterior wall with identical other side coefficients specified are simulated exactly the same. A surface that uses other side coefficients should be thought of as a new or separate type of surface. All heat transfer surfaces are simulated in the same manner through conduction transfer functions. The only difference between the various types of heat transfer surfaces is the environment on the other side of the surface. For example, the other side environment of an exterior surface is the outdoor environment. For an interior surface, the temperature of the outer plane of the surface is set equal to the temperature of the inner plane of the surface. Similarly, a surface with other side coefficients specified will allow the user to control the other side environment.

SurfaceProperty:OtherSideCoefficients,

```

\memo This object sets the other side conditions for a surface in a variety of ways.
\min-fields 8
A1, \field Name
\required-field
\reference OSCNames
\reference OutFaceEnvNames
N1, \field Combined Convective/Radiative Film Coefficient
\required-field
\type real
\note if>0, this field becomes the exterior convective/radiative film coefficient
\note and the other fields are used to calculate the outdoor air temperature
\note then exterior surface temperature based on outdoor air and specified coefficient
\note if<=0, then remaining fields calculate the outside surface temperature
\note following fields are used in the equation:
\note SurfTemp=N7*TempZone + N4*OutdoorDry-bulb + N2*N3 + GroundTemp*N5 + WindSpeed*N6*OutdoorDry-bulb
N2, \field Constant Temperature
\units C
\type real
\default 0
\note This parameter will be overwritten by the values from the Constant Temperature Schedule Name
(below) if one is present
N3, \field Constant Temperature Coefficient
\note This coefficient is used even with a Schedule. It should normally be 1.0 in that case
\default 1
N4, \field External Dry-Bulb Temperature Coefficient
\type real
\default 0
N5, \field Ground Temperature Coefficient
\type real
\default 0
N6, \field Wind Speed Coefficient
\type real
\default 0
N7, \field Zone Air Temperature Coefficient
\type real
\default 0
A2, \field Constant Temperature Schedule Name
\note Name of schedule for values of constant temperature.
\note Schedule values replace any value specified in the field Constant Temperature.
\type object-list
\object-list ScheduleNames
A3, \field Sinusoidal Variation of Constant Temperature Coefficient
\note Optionally used to vary Constant Temperature Coefficient with unitary sine wave
\type choice
\key Yes
\key No
\default No
N8; \field Period of Sinusoidal Variation
\note Use with sinusoidal variation to define the time period
\type real
\units hr
\default 24
\minimum> 0

```

Heat transfer through a surface is an extremely important component in the calculation of zone loads. The information to calculate this heat transfer is readily available if the surface is exposed to the outdoor environment or to another zone that is being simulated. Occasionally, a user will want to model the heat transfer through a surface that is adjacent to an area that is not included in the EnergyPlus model. For example, an office area is attached to a warehouse and the user is only interested in simulating the office area. An interior surface with other side coefficients specified could be used to control the environment on the other side of the surface, thereby accounting for the heat transfer through the adjoining surface.

Other Side Coefficients affects the "other side" of a surface as described below. Each coefficient has a special meaning. You may enter a 0 or blank if you are not using a particular coefficient. Note that there are two potential ways to use other side coefficients. Either they

are used to set the temperature of the exterior side surface directly (if the combined convective/radiative coefficient below is less than or equal to zero) or to set both the film coefficient (positive value for the combined convective/radiative coefficient below) and the outside air temperature.

Field: Name

This, of course, is the string referenced in the Surface statement that is using OtherSideCoefficients as the Outside Boundary Condition.

Field: Combined Convective/Radiative Film Coefficient

This is a trigger value. If the value is greater than zero, then it is taken to be the combined convective/radiative film coefficient. In this case (value > 0), the remaining fields are used first to calculate the outside air temperature for the surface and then to calculate the outside surface temperature based on the outside air temperature and the film coefficient. If this field is less than or equal to zero, then the remaining fields are used to calculate the surface temperature (not the outside air temperature). The units for this field are the same as for a convective heat transfer coefficient: $W/(m^2 \cdot K)$. This is referred to as “C1” in the reference below.

Field: Constant Temperature

This field defines a temperature term that is a constant part of the calculation either of the surface or outside air temperature. This parameter is shown as “C5” in the equation below. The units for this parameter are C. If a schedule name is included as the second parameter, the value of this parameter will be overridden by the value from the schedule.

Field: Constant Temperature Coefficient

This field defines a constant coefficient that is applied to the constant temperature (see previous field). This parameter is shown as “C4” in the equation below. This parameter is dimensionless. The value of this parameter should be 1.0 if a schedule is used to set C5.

Field: External Dry-Bulb Temperature Coefficient

This field defines a constant coefficient that is applied to the outside air dry-bulb temperature. This parameter is shown as “C3” in the equation below. This parameter is dimensionless.

Field: Ground Temperature Coefficient

This field defines a constant coefficient that is applied to the ground temperature. This parameter is shown as “C6” in the equation below. This parameter is dimensionless.

Field: Wind Speed Coefficient

This field defines a constant coefficient that is applied to the product of the outside air dry-bulb temperature and the wind speed. This parameter is shown as “C7” in the equation below. This parameter has dimensions of inverse velocity or s/m.

Field: Zone Air Temperature Coefficient

This field defines a constant coefficient that is applied to the temperature of the zone to which this surface belongs. This parameter is shown as “C2” in the equation below. This parameter is dimensionless.

Field: Constant Temperature Schedule Name

This field is used to supply a schedule name. That schedule will supply the “constant” temperature value C5. Note that the value of the C4 field should normally be 1.0 if a schedule is used for C5. Field is alpha. If not blank, it must be a valid schedule name.

Field: Sinusoidal Variation of Constant Temperature Coefficient

This field is optional and can be used to define an alternate method of prescribing the coefficient that is applied to the constant temperature (see the fields Constant Temperature and Constant Temperature Coefficient). This parameter is shown as “C4” in the equation below. If this field is omitted, left blank, or set to “No,” then C4 is a constant (defined in the field Constant Temperature Coefficient). However if this is set to “Yes,” then the value of C4 varies with a unitary sine wave in the following way:

$$C4 = \text{Sin} \left(2\pi \frac{(\text{time of day})}{(\text{period})} \right)$$

The value for “period” is controlled in the following field. The value for “time of day” is based on the zone timestep and is in units of hours. The sine function here uses input as radians. When using this option, the value for C4 will vary between -1.0 and 1.0 and the value put in the field Constant Temperature Coefficient is not used. This option cannot be used at the same time as scheduling a constant temperature with the previous field.

Field: Period of Sinusoidal Variation

This field is used to define the period of the sine wave when using the Sinusoidal Variation of Constant Temperature Coefficient capability selected in the previous field. This field is the time period of the sine wave in units of hours. The default is 24 hours and provides a diurnal sine wave. The value entered here is “period” in the equation in the previous field.

The coefficients listed above are used in the following equation:

$$T = C2 * Tzone + C3 * Toadb + C4 * C5 + C6 * Tgrnd + C7 * Wspd * Toadb$$

where:

T = Outside Air Temperature when N1 (Combined convective/radiative film Coeff) > 0

T = Exterior Surface Temperature when N1 (Combined convective/radiative film Coeff) <= 0

Tzone = Temperature of the zone being simulated (°C)

Toadb = Dry-bulb temperature of the outdoor air (°C)

Tgrnd = Temperature of the ground (°C)

Wspd = Outdoor wind speed (m/sec)

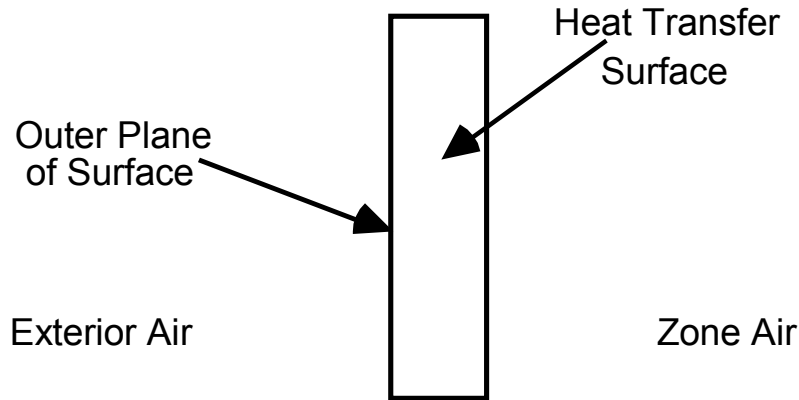


Figure 32. Illustration for Other Side Coefficients

```
SurfaceProperty:OtherSideCoefficients, OSCCoef:Zn005:Wall1003, !- OSC Name
! Example input for second ground temperature
0.0000000E+00, !- OSC SurfFilmCoef
0.000000, !- OSC Temp
1.000000, !- OSC Temp Coef
0.000000, !- OSC dry-bulb
0.000000, !- OSC GrndTemp
0.000000, !- OSC WindSpdCoeff
0.000000, !- OSC ZoneAirTemp
GroundTempSched; ! Name of schedule defining additional ground temperature.
```

```
SurfaceProperty:OtherSideCoefficients, OSCCoef:Zn005:Wall1004, !- OSC Name
! Example input for outside heat transfer coefficient of 1.23, using Tosdb
1.230000, !- OSC SurfFilmCoef
0.000000, !- OSC Temp
0.000000, !- OSC Temp Coef
1.000000, !- OSC dry-bulb
0.000000, !- OSC GrndTemp
0.000000, !- OSC WindSpdCoeff
0.000000; !- OSC ZoneAirTemp
```

SurfaceProperty:OtherSideConditionsModel

By referencing the Other Side Conditions Model statement in the surface statements (i.e. Outside Boundary Condition), the boundary conditions for the outer plane of the mass wall can be connected to the appropriate model for various multi-skin components. The types of multi-skin components that use this object include systems that are mounted to the outside surface using standoffs that create a small air gap – see Figure 33. This type of modeling allows using the usual heat transfer calculations for the underlying surface with other types of multi-skin component models that are available including: unglazed transpired solar collectors, ventilated photovoltaic panels, and naturally ventilated facades.

The boundary condition values are determined dynamically by the program using internal component models. If you want to define other side surface temperatures or convection conditions, then use SurfaceProperty:OtherSideCoefficients instead of this object.

It should be noted that when other side conditions models are used, solar effects are removed from the surface’s outside face heat balance, but are used in modeling the component adjacent to that surface.

The IDD entry is:

```
SurfaceProperty:OtherSideConditionsModel,
  \memo This object sets up modifying the other side conditions for a surface from other model
  results.
  A1, \field Name
    \required-field
    \reference OSCMNames
    \reference OutFaceEnvNames
  A2; \field Type of Modeling
    \type choice
    \key GapConvectionRadiation
    \note GapConvectionRadiation provides boundary conditions for convection
    \note and linearized thermal radiation across a gap or cavity
    \note on the other side of the surface that are modeled sperately.
```

Field: Name

This is the string referenced in the Surface statement that is using OtherSideModel as the Exterior Environment.

Field: Type of Modeling

This is a string key selection used to identify the type of model that will be used to determine boundary conditions. The only available choice is "GapConvectionRadiation."

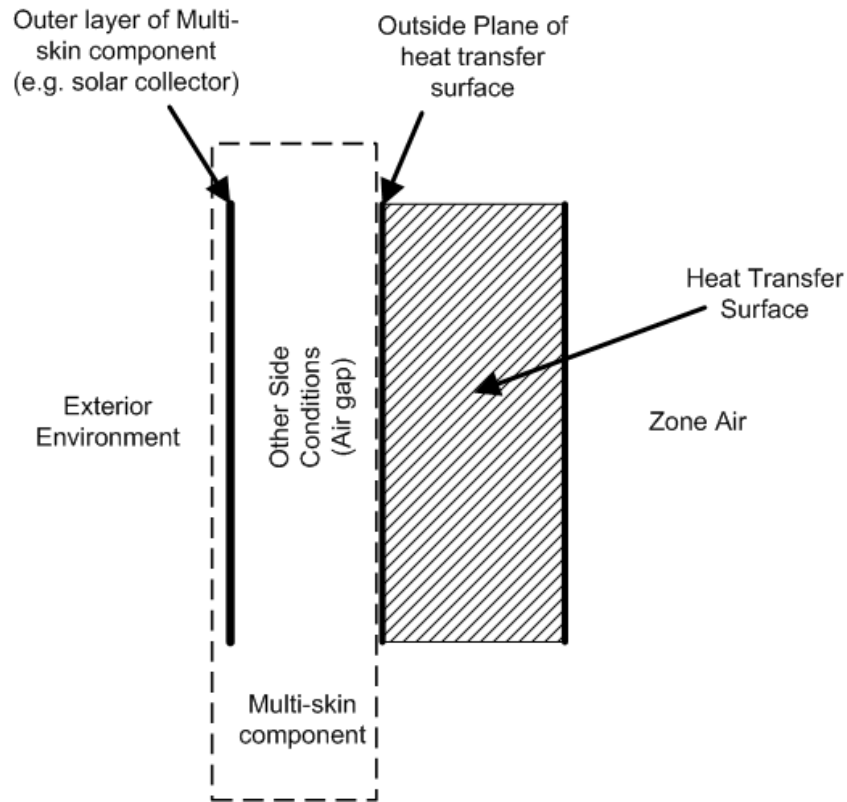


Figure 33. Illustration for Other Side Conditions Model

An example specification is:

```
SurfaceProperty:OtherSideConditionsModel,
  UTSC OSCM ZN11, ! OtherSideConditionsModel Name
  GapConvectionRadiation; ! Type of Modeling used to determine Boundary Conditions
```

SurfaceProperty:ConvectionCoefficients

The convection coefficients of each surface, both exterior and interior, are automatically calculated during EnergyPlus execution. These calculations are “governed” by other objects such as the Inside Convection Algorithm (overall default) and the Zone Inside Convection Algorithm (Zone Default) and the Outside Convection Algorithm (overall default) and/or the Zone Outside Convection Algorithm (Zone Default). Usually, that will be enough flexibility for most users. However, if you need to match pre-existing convection coefficients (from another program) or are trying to match a test suite of results, you may wish to use the “override” convection coefficients in the following object. This object allows for a single surface to be given specific convection coefficients.

Note that surfaces with “SurfaceProperty:OtherSideCoefficients” cannot use this object with the “outside” coefficient – attempting to do so will cause a severe error; SurfaceProperty:OtherSideCoefficients surfaces can apply an “inside” coefficient. And, surfaces with “Ground” exposure do not use the “outside” coefficient that might be supplied here. Note, too, that some lower boundaries are used regardless by certain surface types (i.e. Window) or certain algorithm types.

Field: Surface Name

This field is the applicable surface name for the user supplied convection coefficient.

Fields (Convection Location, Type, Coefficient & Schedule Name)

For simplicity, the descriptions of these field occur together – however, the fields are used sequentially when put into the IDF file (reference the IDF examples following the descriptions).

Field: Convection Coefficient 1 Location

Field: Convection Coefficient 2 Location

This field contains the word “Outside” or “Inside” depending on which location is being described.

Field: Convection Coefficient 1 Type

Field: Convection Coefficient 2 Type

The entries can be of several types: value (simple value) or schedule (scheduled value) and the usual allowable types for Outside or Inside. The field contains the keys: *Value*, *Schedule*, *Simple*, *Detailed* (all of the preceding are applicable to both “Inside” and “Outside”) and allowable for “Outside”: *BLAST*, *TARP*, *DOE-2*, *MoWitt*. Please see the discussion under SurfaceConvectionAlgorithm:Inside or SurfaceConvectionAlgorithm:Outside for further explanation.

Field: Convection Coefficient 1

Field: Convection Coefficient 2

If the Convection type was “Value”, then this field is filled and contains the simple value to be used. Otherwise, this can be blank.

Field: Convection Coefficient 1 Schedule Name

Field: Convection Coefficient 2 Schedule Name

If the Convection type was “Schedule”, then this field contains the name of a schedule describing the value to be used during the time intervals for the schedule.

The complete IDD definition for the ConvectionCoefficients object follows:

```

SurfaceProperty:ConvectionCoefficients,
  \memo Allow user settable interior and/or exterior convection coefficients.
  \memo Note that some other factors may limit the lower bounds for these values, such as
  \memo for windows, the interior convection coefficient must be >.28,
  \memo for trombe wall algorithm selection (zone), the interior convection coefficient must be >.1
  \memo for detailed interior convection, the lower limit is also .1
A1, \field Surface Name
  \required-field
  \type object-list
  \object-list SurfaceNames
A2, \field Convection Coefficient 1 Location
  \required-field
  \type choice
  \key Outside
  \key Inside
A3, \field Convection Coefficient 1 Type
  \required-field
  \type choice
  \key Value
  \key Schedule
  \key Simple
  \key Detailed
  \key BLAST
  \key TARP
  \key DOE-2
  \key MoWitt
N1, \field Convection Coefficient 1
  \note used if Convection Type=Value, then minimum must be > 0.0, Maximum <= 1000.
  \units W/m2-K
A4, \field Convection Coefficient 1 Schedule Name
  \note used if Convection Type=Schedule
  \type object-list
  \object-list ScheduleNames
-- repeat previous four fields (Convection Coefficient Location, Convection Coefficient Type, Convection
Coefficient, Convection Coefficient Schedule Name

```

In IDF usage:

```

SurfaceProperty:ConvectionCoefficients,
Zn001:Wall001, ! Surface Name
Outside,      ! Convection Coefficient 1 Location
Value,       ! Convection Coefficient 1 Type
9.8,         ! Convection Coefficient 1
,            ! Convection Coefficient 1 Schedule Name
! {blank because using value}
Inside,      ! Convection Coefficient 2 Location
Schedule,   ! Convection Coefficient 2 Type
,           ! Convection Coefficient 2 {blank because using schedule}
MyInteriorCC; ! Convection Coefficient 2 Schedule Name
! {blank because using value}

SurfaceProperty:ConvectionCoefficients,
Zn001:Wall002, ! Surface Name
Inside,      ! Convection Coefficient 1 Location
Value,       ! Convection Coefficient 1 Type
.8,         ! Convection Coefficient 1
,           ! Convection Coefficient 1 Schedule Name
! {blank because using value}
Outside,    ! Convection Coefficient 2 Location
Value,     ! Convection Coefficient 2 Type
5.5;      ! Convection Coefficient 2

SurfaceProperty:ConvectionCoefficients,
Zn001:Wall003, ! Surface Name
Outside,     ! Convection Coefficient 1 Location
Value,      ! Convection Coefficient 1 Type
9.8;       ! Convection Coefficient 1

```

SurfaceProperty:ConvectionCoefficients:MultipleSurface

The convection coefficients of each surface, both outside and inside, are automatically calculated during EnergyPlus execution. These calculations are “governed” by other objects such as the Inside Convection Algorithm (overall default) and the Zone Inside Convection Algorithm (Zone Default) and the Outside Convection Algorithm (overall default) and/or the Zone Outside Convection Algorithm (Zone Default). Usually, that will be enough flexibility for most users. However, if you need to match pre-existing convection coefficients (from another program) or are trying to match a test suite of results, you may wish to use the “override” convection coefficients in the following object. This object is similar to the preceding “ConvectionCoefficients” object but allows multiple surfaces to be assigned a type with one object entry.

Note that surfaces with “SurfaceProperty:OtherSideCoefficients” cannot use this object with the “outside” coefficient – attempting to do so will ignore OSC surfaces during a multiple surface “apply”; SurfaceProperty:OtherSideCoefficients surfaces can apply an “inside” coefficient. And, surfaces with “Ground” exposure do not use the “outside” coefficient that might be supplied here. Note, too, that some lower boundaries are used regardless by certain surface types (i.e. Window) or certain algorithm types.

Field: Surface Type

This field is the applicable surface name for the user supplied convection coefficient. The allowable surface types are:

- AllExteriorSurfaces (all surfaces that are “external environment” surfaces)
- AllExteriorWindows (all windows that are “external environment” surfaces)
- AllExteriorWalls
- AllExteriorRoofs
- AllExteriorFloors
- AllInteriorSurface (all surfaces that are “internal” surfaces)
- AllInteriorWindows
- AllInteriorCeilings
- AllInteriorFloors

Fields (Convection Location, Type, Coefficient & Schedule Name)

For simplicity, the descriptions of these field occur together – however, the fields are used sequentially when put into the IDF file (reference the IDF examples following the descriptions).

Field: Convection Coefficient 1 Location

Field: Convection Coefficient 2 Location

This field contains the word “Outside” or “Inside” depending on which location is being described.

Field: Convection Coefficient 1 Type

Field: Convection Coefficient 2 Type

The entries can be of several types: value (simple value) or schedule (scheduled value) and the usual allowable types for Outside or Inside. The field contains the keys: *Value*, *Schedule*, *Simple*, *Detailed* (all of the preceding are applicable to both “Inside” and “Outside”) and allowable for “Outside”: *BLAST*, *TARP*, *DOE-2*, *MoWitt*. Please see the discussion under SurfaceConvectionAlgorithm:Inside or SurfaceConvectionAlgorithm:Outside for further explanation.

Field: Convection Coefficient 1**Field: Convection Coefficient 2**

If the Convection type was “Value”, then this field is filled and contains the simple value to be used. Otherwise, this can be blank.

Field: Convection Coefficient 1 Schedule Name**Field: Convection Coefficient 2 Schedule Name**

If the Convection type was “Schedule”, then this field contains the name of a schedule describing the value to be used during the time intervals for the schedule.

The complete IDD definition for the object follows:

```
SurfaceProperty:ConvectionCoefficients:MultipleSurface,
  \memo Allow user settable interior and/or exterior convection coefficients.
  \memo Note that some other factors may limit the lower bounds for these values, such as
  \memo for windows, the interior convection coefficient must be >.28,
  \memo for trombe wall algorithm selection (zone), the interior convection coefficient must be >.1
  \memo for detailed interior convection, the lower limit is also .1
A1, \field Surface Type
  \required-field
  \type choice
  \key AllExteriorSurfaces
  \key AllExteriorWindows
  \key AllExteriorWalls
  \key AllExteriorRoofs
  \key AllExteriorFloors
  \key AllInteriorSurfaces
  \key AllInteriorWalls
  \key AllInteriorWindows
  \key AllInteriorCeilings
  \key AllInteriorFloors
A2, \field Convection Coefficient 1 Location
  \required-field
  \type choice
  \key Outside
  \key Inside
A3, \field Convection Coefficient 1 Type
  \required-field
  \type choice
  \key Value
  \key Schedule
  \key Simple
  \key Detailed
  \key BLAST
  \key TARP
  \key DOE-2
  \key MoWitt
N1, \field Convection Coefficient 1
  \note used if Convection Value Type=value, then minimum must be > 0.0, Maximum <= 1000.
  \units W/m2-K
A4, \field Convection Coefficient 1 Schedule Name
  \note used if Convection Coefficient Type=Schedule
  \type object-list
  \object-list ScheduleNames
-- repeat previous four fields (Convection Coefficient Location, Convection Coefficient Type, Convection
Coefficient, Convection Coefficient Schedule Name
```

In IDF usage:

```
SurfaceProperty:ConvectionCoefficients:MultipleSurface,
AllExteriorWindows, ! Surface Types
Outside, ! Convection Coefficient 1 Location
MoWitt; ! Convection Coefficient 1 Type
```

Convection Coefficients Outputs

Outputs for the User Supplied Convection Coefficients appear as values in the Surface Report Variables (*Surface Int Convection Coeff* and *Surface Ext Convection Coeff*). What the program expects to use is shown in the Surface Details report (*Report, Surfaces, Details*;))

SurfaceProperties:VaporCoefficients

Advanced/Research Usage: The internal and external vapor transfer coefficients that are used by the CombinedHeatAndMoistureFiniteElement model are automatically calculated during EnergyPlus execution using information on the convection coefficients. However it is sometimes useful to be able to “override” the calculation and set fixed values of vapor transfer coefficient for a single surface. These coefficients are only used by the CombinedHeatAndMoistureFiniteElement model and will be ignored by other solution algorithms.

Field: Surface Name

This field is the applicable surface name for the user supplied vapor transfer coefficient.

Field: Constant External Vapor Transfer Coefficient

Select ‘yes’ to use the value supplied as the external vapor transfer coefficient

Field: External Vapor Coefficient Value

HAMT will use this value to calculate the vapour transfer into and out off the external surface of this surface. Units are kg/Pa.s.m².

Field: Constant Internal vapor Transfer Coefficient

Select ‘yes’ to use the value supplied as the internal vapor transfer coefficient

Field: Internal Vapor Coefficient Value

The CombinedHeatAndMoistureFiniteElement algorithm will use this value to calculate the vapor transfer into and out of the internal surface of this surface. Units are kg/Pa.s.m².

```

SurfaceProperties:VaporCoefficients,
  \memo The interior and external vapor transfer coefficients.
  \memo Normally these value are calculated using the heat convection coefficient values.
  \memo Use this object to used fixed constant values.
  \memo Units are kg/Pa.s.m2
  \memo This will only work with the CombinedHeatAndMoistureFiniteElement algorithm for surfaces.
  \memo Other algorithms will ignore these coefficients
A1, \field Surface Name
  \required-field
  \type object-list
  \object-list SurfaceNames
A2, \field Constant External Vapor Transfer Coefficient
  \required-field
  \type choice
  \key Yes
  \key No
  \default No
N1, \field External Vapor Coefficient Value
  \note Units are kg/Pa.s.m2
  \default 0
A3, \field Constant Internal vapor Transfer Coefficient
  \required-field
  \type choice
  \key Yes
  \key No
  \default No
N2; \field Internal Vapor Coefficient Value
  \note Units are kg/Pa.s.m2
  \default 0

```

Below is an example input of vapor transfer coefficients for a surface.

```

SurfaceProperties:VaporCoefficients,
  South wall,      !- Surface Name
  Yes,            !- Constant External Vapor Transfer Coefficient
  0.0000000625,   !- External Vapor Coefficient Value
  Yes,            !- Constant Internal vapor Transfer Coefficient
  0.00000002;     !- Internal Vapor Coefficient Value

```

SurfaceProperty:ExteriorNaturalVentedCavity

This object is used to model a multi-skin exterior heat transfer surface. This is a special case where the outside face is a slightly detached layer forming a naturally ventilated cavity. The actual outer surface is referred to as the baffle. The modeling here assumes that the heat capacity in the outer baffle can be neglected since it is much lower than the underlying mass surface. This object is used with the `BuildingSurface:Detailed` object where the Heat Transfer surfaces are referred to as the underlying surfaces. The constructions and materials for the `BuildingSurface:Detailed` object should reflect the construction of just the underlying surface. The `Surface:HeatTransfer:ExteriorNaturalVentedCavity` object is used to describe the decoupled layer, or baffle, and the characteristics of the cavity and openings for natural ventilation. This object is also used in conjunction with the `OtherSideConditionsModel`.

The area and orientation are obtained from **BuildingSurface:Detailed** objects, which are referenced by name. This object can be used to model certain types of photovoltaic mounting configurations such as interlocking roof pavers. If the baffle covers only part of a surface, then that surface should be split into separate **BuildingSurface:Detailed** objects where one matches the size of the baffle. A single baffle can be associated with as many **BuildingSurface:Detailed** objects as desired (although if you need to use more than 10 surfaces, then the IDD will need to be extended). The base heat transfer surfaces need not be contiguous nor have the same orientation, but the program will issue warnings if surfaces have widely ranging tilts and azimuths.

Note that the model involves predicting the rates that ambient air moves in and out of the cavity. Accurate modeling of these air flows would be extremely challenging and so the models provided through this object are simplistic engineering models based on discharge coefficients that are sensitive to wind and bouancy effects. The accuracy depends on the

values for, and applicability of, the discharge coefficients and unfortunately little research is available to help characterize these. The models should be considered rudimentary and the user is encouraged to explore different values for the coefficients in attempts to bound the importance of natural ventilation for the cavities. See the Engineering Reference for more details.

Field: Name

This field contains a unique name for the ventilated cavity.

Field: Boundary Conditions Model Name

This field contains the name of an SurfaceProperty:OtherSideConditionsModel object declared elsewhere in the input file. This will connect the baffle and ventilated cavity to the exterior boundary conditions for the underlying heat transfer surface.

Field: Area Fraction of Openings

This field is used to enter an area fraction for what part of the baffle consists of openings. The area of the openings will set to the product of this field and the sum of the area of the underlying surfaces.

Field: Thermal Emissivity of Exterior Baffle Material

This field is used to enter the thermal emissivity of the baffle. This surface property is for longwave infrared radiation. The property is used for both sides of collector. Most painted materials have an emissivity of 0.9.

Field: Solar Absorptivity of Exterior Baffle

This field is used to enter the solar absorptivity of the baffle. This surface property is for shortwave, solar radiation. The property is used for the front side of the baffle that faces the environment. Darker colors have a higher absorptivity. While black is the highest performance, other colors might be used to match the color scheme of the rest of the façade.

Field: Height Scale for Buoyancy-Driven Ventilation

This field is used to enter a nominal height scale for prediction ventilation induced by buoyancy. This value (ΔH_{NPL}) is defined as the height from the midpoint of the lower opening to the neutral pressure level. Increasing the value will increase the ventilation rate due to buoyancy.

Field: Effective Thickness of Cavity Behind Exterior Baffle

This field is used to enter a nominal gap thickness for the collector. This distance value is only used when the collector is near horizontal to determine a length scale in the vertical direction for buoyancy calculations. For example, if the collector is mounted on a flat roof, its tilt-adjusted height is zero and the program will use this gap thickness as a length scale rather than the height from the previous field.

Field: Ratio of Actual Surface Area to Projected Surface Area

This field is used to enter a factor that accounts for the extra surface area resulting from and uneven baffle surface. Corrugations may be present to help stiffen the baffle or ventilated roofing tiles may have more surface area for convection heat transfer than the underlying surface. The projected surface area is obtained by the program from the (flat) underlying surfaces. If the baffle is flat then this ratio is 1.0. If the baffle is corrugated, then this ratio will be greater than one with a typical value might be 1.165.

Field: Roughness of Exterior Surface

This field is used to describe the relative roughness of the baffle material. This field is similar to one in the **Material** object. This parameter only influences the convection coefficients, more specifically the exterior convection coefficient. A special keyword is expected in this

field with the options being “VeryRough”, “Rough”, “MediumRough”, “MediumSmooth”, “Smooth”, and “VerySmooth” in order of roughest to smoothest options.

Field: Effectiveness for Perforations with Respect to Wind

This field is used to enter a value for the coefficient used to determine natural air exchanges from wind. Wind will cause exterior air to move in and out of the cavity. C_v is an arbitrary coefficient used to model the effectiveness of openings and depends on opening geometry and the orientation with respect to the wind. C_v should probably be in the range 0.05 to 0.65. Increasing C_v will increase the amount of natural ventilation. The following equation shows how C_v is used in the program to predict the volumetric flow rate due to wind:

$$\dot{V}_{\text{wind}} = C_v A_{in} U_{\infty}$$

Field: Discharge Coefficient for Openings with Respect to Buoyancy Driven Flow

This field is used to enter a value for the coefficient used to determine natural air exchanges from buoyancy. Stack or buoyancy effects will cause exterior air to move in and out of the cavity. C_d is an arbitrary discharge coefficient that depends on the geometry of the opening. C_d should probably be in the range 0.1 to 1.0. Increasing C_d will increase the amount of natural ventilation. The following equations show how C_d is used in the program to predict the volume flow rate due to buoyancy:

$$\dot{V}_{\text{thermal}} = C_D A_{in} \sqrt{2g\Delta H_{NPL} (T_{a,cav} - T_{amb}) / T_{a,cav}} \quad (\text{if } T_{a,cav} > T_{amb})$$

$$\dot{V}_{\text{thermal}} = C_D A_{in} \sqrt{2g\Delta H_{NPL} (T_{amb} - T_{a,cav}) / T_{amb}} \quad (\text{if } T_{amb} > T_{a,cav} \text{ and baffle is vertical})$$

where ΔH_{NPL} is the value input into the field above for the height scale for buoyancy-driven ventilation.

Field(s): Surface <1 thru x> Name

The remaining fields are used to name the **BuildingSurface:Detailed** objects that are associated with the exterior naturally vented cavity. These are the underlying heat transfer surfaces and are defined elsewhere in the input file. These surfaces should all specify **OtherSideConditionsModel** as their exterior environment. The input object can currently accommodate up to ten surfaces, but it is extensible by modifying the Energy+.idd entry.

The IDD entry for this object is:

```
SurfaceProperty:ExteriorNaturalVentedCavity,
  \extensible:1 - repeat last field, remembering to remove ; from "inner" fields.
A1, \field Name
  \required-field
  \type alpha
  \reference VentedCavityNames
A2, \field Boundary Conditions Model Name
  \note Enter the name of a SurfaceProperty:OtherSideConditionsModel object
  \type object-list
  \object-list OSCMNames
N1, \field Area Fraction of Openings
  \type real
  \minimum > 0
  \units dimensionless
N2, \field Thermal Emissivity of Exterior Baffle Material
  \type real
  \minimum 0
  \maximum 1
  \units dimensionless
```

```

N3, \field Solar Absorbitivity of Exterior Baffle
    \type real
    \minimum 0
    \maximum 1
    \units dimensionless
N4, \field Height Scale for Buoyancy-Driven Ventilation
    \type real
    \minimum> 0.0
N5, \field Effective Thickness of Cavity Behind Exterior Baffle
    \type real
    \minimum> 0.
    \units m
    \note if corrugated, use average depth
N6, \field Ratio of Actual Surface Area to Projected Surface Area
    \type real
    \note this parameter is used to help account for corrugations in the collector
    \default 1.0
    \minimum 0.8
    \maximum 2.0
    \units dimensionless
A3, \field Roughness of Exterior Surface
    \required-field
    \type choice
    \key VeryRough
    \key Rough
    \key MediumRough
    \key MediumSmooth
    \key Smooth
    \key VerySmooth
N7, \field Effectiveness for Perforations with Respect to Wind
    \type real
    \units dimensionless
    \default 0.25
    \minimum> 0
    \maximum 1.5
N8, \field Discharge Coefficient for Openings with Respect to Buoyancy Driven Flow
    \type real
    \units dimensionless
    \default 0.65
    \minimum> 0.0
    \maximum 1.5
A4, \field Surface 1 Name
    \required-field
    \type object-list
    \object-list AllShadingAndHTSsurfNames
<<snipped>>
A13; \field Surface 10 Name
    \type object-list
    \object-list AllShadingAndHTSsurfNames

```

An example IDF entry is

```

SurfaceProperty:ExteriorNaturalVentedCavity,
  PVRoofPaverExtVentCav1 ,      ! Name
  PVRoofPaverSystem1,          ! OtherSideConditionsModel Object Name
  0.02,                          ! Area Fraction of Openings
  0.9,                            ! Thermal Emissivity of Exterior Baffle Material
  0.92,                           ! Solar Absorbitivity of Exterior Baffle
  0.05,                           ! Height scale for buoyancy-driven ventilation
  0.05,                           ! Effective Thickness of Cavity Behind Exterior Baffle
  0.97,                           ! Ratio of Actual surface area to projected surface area
  Smooth ,                        ! Roughness of collector
  0.1 ,                            ! Cv, Effectiveness for perforations with respect to Wind
  0.5 ,                            ! Cd, Discharge Coefficient for Openings with respect to
  buoyancy-driven flow
  Zn001:Roof001 ;                ! Surface Name

```

SurfaceProperty:ExteriorNaturalVentedCavity Outputs

In addition to related output that can be obtained for all surfaces, these outputs are available for exterior naturally vented cavity configurations:

HVAC,Average, Exterior Cavity Drybulb Temperature[C]
 HVAC,Average, Exterior Baffle Temperature[C]
 HVAC,Average, Exterior Cavity Air Changes per Hour Passive[ACH]
 HVAC,Average, Exterior Cavity Total Natural Vent Mass Flow[kg/s]
 HVAC,Average, Exterior Cavity Total Natural Vent Mass Flow from Wind[kg/s]
 HVAC,Average, Exterior Cavity Total Natural Vent Mass Flow from Bouyancy[kg/s]

Exterior Cavity Drybulb Temperature[C]

The temperature of air inside the cavity behind the baffle.

Exterior Baffle Temperature [C]

The surface temperature of the exterior baffle material itself.

Exterior Cavity Air Changes per Hour Passive[ACH]

The rate of natural ventilation air exchange between the plenum and ambient when the collector is inactive in Air Changes per Hour.

Exterior Cavity Total Natural Vent Mass Flow[kg/s]

The mass flow rate of natural ventilation air exchange between the plenum and ambient when the collector is inactive.

Exterior Cavity Total Natural Vent Mass Flow from Wind[kg/s]

The part of mass flow rate of natural ventilation air exchange between the plenum and ambient when the collector is inactive due to wind-driven forces.

Exterior Cavity Total Natural Vent Mass Flow from Bouyancy[kg/s]

The part of mass flow rate of natural ventilation air exchange between the plenum and ambient when the collector is inactive due to bouyancy-driven forces.

GeometryTransform

This object provides a simple method of altering the footprint geometry of a model. The intent is to provide a single parameter that can be used to reshape the building description contained in the rest of the input file. This object was implemented for use in parametric massing studies and with the optimization program GenOpt. Although building footprint is often constrained in practice, analysts may find this object useful for investigating how building form impacts daylighting and solar gains on the east and west facades with out having to change all of the surface geometry input.

Aspect Ratio is defined as the overall length in the East-West direction divided by the overall length in the North-South direction.

This object should be used with considerable care since it will completely alter the geometry modeled by EnergyPlus and may have unintended side effects. The surface areas of all horizontal surfaces may change radically with corresponding changes in Zone floor areas. The total floor area will not change but individual horizontal surfaces will gain and loose area. Vertical surfaces will have the same height but will gain and lose length. Lighting and electrical equipment design levels for individual zones will likely have a different energy per unit area in the transformed geometry.

The surface geometry must be set to **Relative**, see **GlobalGeometryRules**. Of course, the coordinates must be entered in relative coordinates as well.

Since windows in EnergyPlus need to be rectangular, it is possible to define a horizontal window (skylight) that once transformed is no longer rectangular and will cause EnergyPlus to halt. To avoid this problem, horizontal windows should be defined orthogonal to the

Cardinal directions and building rotation (see **Building**) used to orient the final form with respect to North.

The object doesn't create any specific output, but the results of using it can be understood by viewing DXF output files. Figure 34 shows an example of a building that has been morphed using the Aspect Ratio Transform object. Using this object allowed the same geometry input to generate both of the models represented in by their DXF output files.

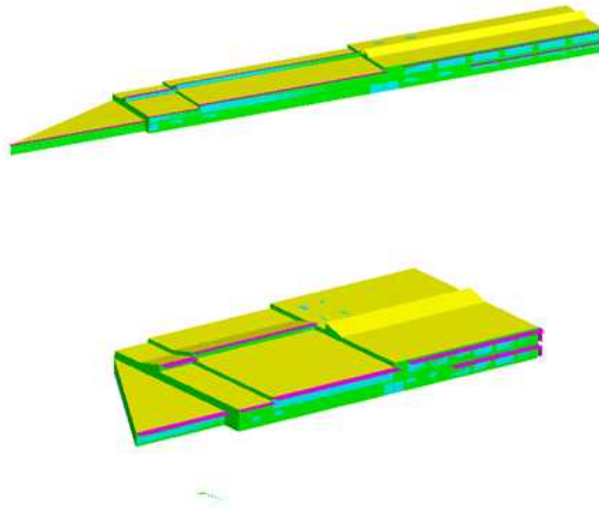


Figure 34. Example of Geometry Transform -- Aspect Ratio

The definition from the IDD:

```

GeometryTransform,
  \unique-object
  A1, \field Plane of Transform
      \required-field
      \type choice
      \key XY
      \default XY
      \note only current allowed value is "XY"
  N1, \field Current Aspect Ratio
      \required-field
      \minimum> 0
      \note Aspect ratio of building as described in idf
  N2; \field New Aspect Ratio
      \required-field
      \minimum> 0
      \note Aspect ratio to transform to during run

```

Field: Plane of Transform

This field specifies the plane that the geometry transform should act on. It is currently restricted to altering the horizontal footprint of a building and must be set to "XY."

Field: Current Aspect Ratio

This field specifies the aspect ratio of the building geometry described in the rest of the input file. It is used to scale the new aspect ratio. If this field is set to 1.0, then the altered building will not necessarily have the new aspect ratio defined in the next field.

Field: New Aspect Ratio

This field specifies the aspect ratio that the building described in the rest of the input file will be changed to.

ZoneProperty:UserViewFactors

EnergyPlus has two options for specifying the thermal radiation exchange view factors between surfaces in a zone: the approximate option and the user input option. Because the actual geometric arrangement within a zone is very complex, the approximate method of including thermal mass and other forced exchanges is more realistic than trying to come up with “exact” view factors. However, in some research situations it might be desirable to have control of the view factors used. For this reason, a user input mode has been included in EnergyPlus. The two modes are described in the next sections.

Approximate Option

The first option produces approximate results and uses an area weighted scheme to calculate "view factors" between surfaces within a thermal zone. Each surface uses the total area that it can “see” among the other surfaces. The approximate view factor from this surface to each other surface is then the area of the receiving surface over the sum of areas that are visible to the sending surface.

In order to account in some limited way for the fact that certain surfaces will not see each other, several assumptions have been built into this view factor approximation. First, a surface cannot see itself. Second, surfaces with approximately the same azimuth (facing direction) and tilt ("same" being within a built in limit) will not see each other. This means that a window will not see the wall that it is placed on, for example. Third, floors cannot see each other. Fourth, if the surface is a floor, ceiling, roof, or internal mass, the rule for the same azimuth and tilt eliminating radiant exchange between surfaces is waived when the receiving surface is floor, roof, ceiling, or internal mass as long as both surfaces are not floors.

Note that this does not take into account that surfaces may be "around the corner" from each other and in reality not see each other at all. Rooms are assumed to be convex rather than concave in this method.

To summarize, using the Surface “Class”, the approximate view factors have:

1. No surface sees itself.
2. No Floor sees another floor.
3. All other surface types see Internal Mass.
4. All other surface types see floors.
5. Floors always see ceilings.
6. Floors always see roofs.
7. All other surfaces whose tilt or facing angle differences are greater than 10 degrees see each other.

If geometry is correct, conditions 1,3, and 7 should take care of all surfaces, but the other conditions supply common sense when the geometry is incorrect. More information about the EnergyPlus view factor calculation is contained in the Engineering Reference document.

User Input View Factors

The second option for specifying view factors requires user input values. These should be used with care in research or special situations. The input values are specified in an object named UserViewFactors in the idd and idf. They are identified by their row and column

number in the view factor array. In other words, the view factor is traditionally $F_{i,j}$, and the value along with i and j are specified in the idf . A segment of the idd is shown below.

```
ZoneProperty:UserViewFactors,
  \extensible:3 - copy last three fields, remembering to remove ;
  \format ViewFactor
A1, \field Zone Name
  \type alpha
  \reference ZoneNames
N1, \field i 1
  \note index for following Fij
  \note the view factor numbers are triples in the order i, j, Fij.
  \type integer
N2, \field j 1
  \note index for following Fij
  \note the view factor numbers are triples in the order i, j, Fij.
  \type integer
N3, \field Fij 1
  \type real
  \maximum 1.0
--reduced for brevity --
N70, \field i 24
  \note index for following Fij
  \note the view factor numbers are triples in the order i, j, Fij.
  \type integer
N71, \field j 24
  \note index for following Fij
  \note the view factor numbers are triples in the order i, j, Fij.
  \type integer
N72; \field Fij 24
  \type real
  \maximum 1.0
```

An example idf object is shown below. Note that the alpha field is the zone name for which the view factors apply.

```
ZoneProperty:UserViewFactors,
  ! example with unrealistic view factors that show
  ! a scheme for checking the input.
core,          ! zone name
1,1,.11,      ! triple of i, j, and Fij
1,2,.12,
1,5,.15,
2,2,.22,
2,3,.23,
4,2,.42,
4,5,.45,
5,1,.51,
5,6,.56,
3,6,.36,
4,6,.46,
6,5,.65,
6,4,.64;
```

In order to get user view factors ready for inclusion in an input file, several steps must be taken. First, because EnergyPlus has a data structure for zones that only is defined at initialization, it is necessary to use EnergyPlus to determine the surface numbers (i,j) before a UserViewFactors object can be constructed. This is done by making a run with a special object. This takes the form:

```
Output:Reports,Surfaces,ViewFactorInfo;
```

This will trigger EnergyPlus to produce a special output section in the file `eplusout.eio`. This file, which is csv format, can be opened in Excel, and will show detailed information about the surfaces in all the zones. The example and procedure for using this information is shown in the Output Details and Examples Document.

Group – Room Air Models

Room Air Models

The group of input objects described in this section is used to account for non-uniform room air temperatures that may occur within the interior air volume of a zone. Room air modeling was added to EnergyPlus starting with Version 1.2. Although there are many types of analyses (comfort, indoor air quality, etc) that might benefit from localized modeling of how room air varies across space, only the *temperature* distribution of room air within the zone is currently addressed in EnergyPlus. This allows surface heat transfer and air system heat balance calculations to be made taking into account natural thermal stratification of air and different types of intentional air distribution designs such as under-floor and side-wall displacement ventilation that purport to extract room air at higher-than-mean temperatures. Note that EnergyPlus does **not** have completely general methods of modeling room air that are applicable to every conceivable type of airflow that might occur in a zone. Such models (e.g. RANS-CFD) are too computationally expensive to use with EnergyPlus for the foreseeable future. The models that are available in EnergyPlus offer only limited modeling capabilities for select room airflow configurations. Also note that because the complete mixing model for room air has long been the standard in building energy simulation, there is not currently a consensus on how to best model non-uniform air temperatures in buildings. Therefore, it is up to the user to have a good understanding of when, where, and how to apply the room air models available in EnergyPlus. The rest of this section provides some guidance in the way of examples and further discussion of the models available in EnergyPlus.

EnergyPlus offers the different types of air models listed in the table below along with the input objects associated with the use of that model.

Table 8. Summary of Room Air Models

Air Model Key	Air model Algorithm	Applicability	Input Objects Required
Mixing	Well-Mixed	All zones	None, default
UserDefined	User Defined	All zones	'RoomAirModelType', 'RoomAir:TemperaturePattern:UserDefined', RoomAir:TemperaturePattern:***'
OneNodeDisplacementVentilation	Mundt	displacement ventilation	'RoomAirModelType', 'RoomAirSettings:OneNodeDisplacementVentilation', 'RoomAir:Node'
ThreeNodeDisplacementVentilation	UCSD Displacement Ventilation	displacement ventilation	'RoomAirModelType', 'RoomAirSettings:ThreeNodeDisplacementVentilation'
UnderFloorAirDistributionInterior	UCSD UFAD Interior Model	Interior zones served by a UFAD system	'RoomAirModelType', 'RoomAirSettings:UnderFloorAirDistributionInterior'
UnderFloorAirDistributionExterior	UCSD UFAD Exterior Model	Exterior zones served by a UFAD system	'RoomAirModelType', 'RoomAirSettings:UnderFloorAirDistributionExterior'
CrossVentilation	UCSD Cross Ventilation	cross ventilation	'RoomAirModelType', 'RoomAirSettings:CrossVentilation'

RoomAirModelType

EnergyPlus uses the RoomAirModelType object to determine which air model is available for use in a given zone during the simulation. If no RoomAirModelType object is specified (for each zone or the whole building), then EnergyPlus will run with the conventional, completely mixing air model (for each zone or the whole building). Include a RoomAirModelType for each zone that the user wants modeled using a more detailed method. Currently only a single RoomAirModelType object can be specified for each zone; you cannot switch between models during a simulation. However, the UCSD Displacement, Cross Ventilation and UFAD models switch from displacement to mixing ventilation when the operating conditions do not give rise to unmixed flow. The following parameters are fields required by the RoomAirModelType object.

Field: Name

This alpha field is the air model name selected by user. It is used as an identifier

Field: Zone Name

This alpha field indicates the unique name of a Zone object defined elsewhere in the input file. The type of room air model selected will be applied to this zone.

Field: Room-Air Modeling Type

This alpha field indicates the room-air model used for the specified zone. Currently, there are three options for different air models. Entering the keyword 'Mixing' specifies the conventional complete-mixing air model. Note that Mixing is the default and no RoomAirModelType object would be needed to use the complete-mixing model. Entering the keyword 'UserDefined' specifies the User Defined Room Air Temperature Patterns. Entering the keyword 'OneNodeDisplacementVentilation' specifies the Mundt one node displacement ventilation air model for displacement ventilation. Entering the keyword 'ThreeNodeDisplacementVentilation' specifies the three-node displacement ventilation model developed by the University of California, San Diego (UCSD DV). Entering the keyword 'CrossVentilation' specifies the two-zone cross ventilation model developed by the University of California, San Diego (UCSD CV). Entering the keyword 'UnderFloorAirDistributionInterior' specifies the two-node interior zone under floor air distribution model developed by the University of California, San Diego (UCSD UFI). Entering the keyword 'UnderFloorAirDistributionExterior' specifies the two-node exterior zone under floor air distribution model developed by the University of California, San Diego (UCSD UFE).

Field: Air Temperature Coupling Strategy

This alpha field indicates how air temperatures predicted by the air models are used by the surface heat balance calculation. Two different coupling schemes are available: Direct (also known as *T-couple*) or Indirect (*DT-couple*). In general, indirect coupling is more suited to situations where room air is well controlled and/or the room air model is less robust. Direct coupling is more suited for floating zone air temperatures and/or accurate room air models.

The Mundt model can use either coupling scheme; the UCSD DV, UCSD CV, UCSD UFI, and UCSD UFE models ignore this field and use direct coupling.

Input either *Direct* or *Indirect*

The idd entry follows.

```

RoomAirModelType,
  A1, \field Name
      \required-field
      \type alpha
  A2, \field Zone Name
      \required-field
      \type object-list
      \object-list ZoneNames
  A3, \field Room-Air Modeling Type
      \required-field
      \type choice
      \key Mixing
      \note Complete mixing air model
      \key UserDefined
      \note UserDefined Room Air Temperature Patterns
      \note needs RoomAir:TemperaturePattern:UserDefined object referencing this Zone
      \key OneNodeDisplacementVentilation
      \note Mundt roomair model for displacement ventilation with single floor air node
      \note needs RoomAirSettings:OneNodeDisplacementVentilation object referencing this Zone
      \key ThreeNodeDisplacementVentilation
      \note (UCSD three-node displacement ventilation model)
      \note needs RoomAirSettings:ThreeNodeDisplacementVentilation object referencing this Zone
      \key CrossVentilation
      \note (UCSD two-zone cross ventilation model)
      \note needs RoomAirSettings:CrossVentilation object referencing this Zone
      \key UnderFloorAirDistributionInterior
      \note 2-Node UFAD model for interior zones
      \note needs RoomAirSettings:UnderFloorAirDistributionInterior object referencing this Zone
      \key UnderFloorAirDistributionExterior
      \note (2-Node UFAD model for exterior zones)
      \note needs RoomAirSettings:UnderFloorAirDistributionExterior object referencing this Zone
      \default MIXING
  A4; \field Air Temperature Coupling Strategy
      \type choice
      \key Direct
      \key Indirect
      \default Direct

```

An example idf entry follows

```

RoomAirModelType,
  MOD1,      !- Room-Air Model Name
  ZONE ONE,  !- Zone Name
  ThreeNodeDisplacementVentilation, !- Room-Air Modeling Type
  Direct;    !- Air Temperature Coupling Strategy

```

RoomAir:TemperaturePattern:UserDefined

This object is used to explicitly define temperature patterns that are to be applied to the mean air temperature within a thermal zone. This Room Air modeling option is made available for a number of reasons. It allows modeling the consequences of air temperature variations during the design phase when little information is available about the specifics of the air distribution system or positioning of various loads. This option can be used to evaluate the energy implications of different design targets for the temperature patterns. It also provides a method of modeling the annual energy use implications for air temperature distributions determined using separate analyses or measurements. For example, this option could be used to understand the annual energy implications of an air distribution system that has been previously analyzed using Computational Fluid Dynamics.

This approach differs from the other Room Air modeling in that the static temperature pattern is not really *modeled* so that it will respond to conditions that develop during the simulation. More sophisticated dynamic Room Air models will adjust the temperature pattern based on various factors, such as air system flow rate, floor temperature, or rates of internal heat gains. The user-defined temperature distribution patterns are fixed at the beginning and EnergyPlus simply provides results that include the implications of those patterns. This user-defined

distribution option may also be useful for checking dynamic Room Air models by using “bounding” analysis.

Note that using this object carries a certain degree of responsibility. It would be very easy to define a pattern that is non-physical and will lead to erroneous results. The user-defined temperature distributions should (probably) be balanced about the mean so that basic conservation of energy laws are not violated.

Field: Name

This field provides a unique name for this object.

Field: Zone Name

This field provides the unique name of a zone described elsewhere in the file.

Field: Availability Schedule Name

This field provides the name of a schedule that will determine if this model is available. When not available the room air is modeled as completely mixed. When it is available, then a user-defined temperature distribution will be applied. This schedule should be set to “1.0” when model is available and “0.0” when the model is not to be used.

Field: Pattern Control Schedule Name

This field provides the name of schedule that will be used to control which user-defined RoomAir temperature pattern will be applied at any given time. This schedule needs to have integer values that are closely coordinated with those defined as the second field in one of the RoomAir:TemperaturePattern:* objects described below. These schedule values provide the link to the actual patterns to be used throughout the day. This allows controlling which user-defined pattern is used at different times during the simulation. For example, one could use one pattern when the air system is scheduled to be on, and a different pattern when the air system is schedule to be off. Or if the user has knowledge of how the air temperature pattern changes over the course of day in response to changing thermal loads, then this schedule can be used to control when individual patterns are used. For example, a control schedule could use a pattern designated as number 100 from 18:00 to 6:00, pattern number 200 from 6:00 to 12:00, and pattern number 300 from 12:00 to 18:00.

IDD entry for this object is:

```
RoomAir:TemperaturePattern:UserDefined,
  A1 , \field Name
      \required-field
      \type alpha
  A2 , \field Zone Name
      \required-field
      \type object-list
      \object-list ZoneNames
  A3 , \field Availability Schedule Name
      \type object-list
      \object-list ScheduleNames
  A4 ; \field Pattern Control Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note The schedule should contain integer values that
      \note correspond to unique Control Integer fields in
      \note one of the RoomAir:TemperaturePattern:* objects.
```

An example of this object is

```
RoomAir:TemperaturePattern:UserDefined,
  Ground Floor South Air Temp Contrls , ! Name
  ZN2_S_1 , ! Zone Name
  Always_on , ! Availability Schedule Name
  Roomair Pattern 1; ! Pattern Control Schedule Name
```

RoomAir:TemperaturePattern:ConstantGradient

This object is used to model room air with a fixed temperature gradient in the vertical direction. This fixed-slope method is about the simplest distribution pattern.

In addition to the vertical temperature gradient, there are three other parameters included in the pattern that are important. The first two might affect how the air system conditioning the room is operated. The first describes the temperature difference between the mean air temperature and the point where the sensor of a drybulb thermostat is situated. The second describes the temperature difference between the mean and the point where system air is being extracted from the zone. This is considered important because the changes in temperature difference between supply and return can affect how an air system is controlled to meet the loads. The third parameter can affect the zone air heat balance by altering the temperature of the air leaving the zone through exhaust fans.

One example of a source of input data for the vertical temperature gradient is ANSI/ASHRAE Standard 55-2004 Thermal Environmental Conditions for Human Occupancy. Table 5.2.4.3 in this Standard specifies an allowable vertical temperature difference between head level and ankle level of 3°C (5°F). If we assume a head to ankle length scale of 1.5 m (5 ft), this leads to a temperature gradient of 3°C/1.5m, or 2.0 °C/m.

Field: Name

This field provides a unique name for this object.

Field: Control Integer for Pattern Control Schedule Name

This field should contain an integer value that is unique among all other RoomAir:TemperaturePattern:* objects. The value used here needs to be in the Pattern Control Schedule for those times when this pattern is to be used for the Room Air Temperature Distribution.

Field: Thermostat Offset

This field specifies the temperature difference between where the thermostat is situated and the mean air temperature.

Field: Return Air Offset

This field specifies the temperature difference between the air leaving the zone and returning to the air system and the mean air temperature.

Field: Exhaust Air Offset

This field specifies the temperature difference between the air leaving the zone and being exhausted out of the building and the mean air temperature.

Field: Temperature Gradient

This field specifies the gradient, or slope, of temperature changes in the vertical direction in °K/m.

IDD entry for this object is:

```

RoomAir:TemperaturePattern:ConstantGradient,
  A1, \field Name
      \required-field
      \type alpha
  N1, \field Control Integer for Pattern Control Schedule Name
      \note reference this entry in Schedule Name
      \type integer
      \required-field
  N2, \field Thermostat Offset
      \note = (Temp at thermostat- Mean Air Temp)
      \units deltaC
      \type real
  N3, \field Return Air Offset
      \note = (Tleaving - Mean Air Temp )
      \units deltaC
      \type real
  N4, \field Exhaust Air Offset
      \note = (Texhaust - Mean Air Temp) deg C
      \units deltaC
      \type real
  N5; \field Temperature Gradient
      \note Slope of temperature change in vertical direction
      \units K/m
      \type real

```

An example of this object is:

```

RoomAir:TemperaturePattern:ConstantGradient,
  half C per Meter,      ! Name
  10005,      ! Control Integer for Pattern Control Schedule Name
  0.0,      ! Thermostat Offset (Temp at thermostat- Mean Air Temp) [C]
  1.0,      ! Return Air Offset (Tleaving - Mean Air Temp ) [C]
  1.0,      ! Exhaust Air Offset (Texhaust - Mean Air Temp) [C]
  0.5;      ! Temperature Gradient Deg C/m

```

RoomAir:TemperaturePattern:TwoGradient

This object provides various controls over the value of the gradient used for determining the pattern of room air temperatures. It is similar to previous object RoomAir:TemperaturePattern:ConstantGradient object but simplifies the potentially arduous task of preparing and scheduling a large number of those objects. With this object, two different gradients are entered and user is given several options for controlling how the program will interpolate between the two bounds. The user inputs the height of the location of thermostat, return air, and exhaust air in meters rather than the temperature offset.

Field: Name

This field provides a unique name for this object.

Field: Control Integer for Pattern Control Schedule Name

This field should contain an integer value that is unique among all other RoomAir:TemperaturePattern:* objects. The value used here needs to be in the Pattern Control Schedule for those times when this pattern is to be used for the Room Air Temperature Distribution.

Field: Thermostat Height

This field specifies the distance above the floor where the thermostat is situated. This height is used by the model to determine the thermostat temperature relative to the mean air temperature by applying the gradient.

Field: Return Air Height

This field specifies the distance above the floor where the air leaves the zone and returns to the air system, and the mean air temperature. This height is used by the model to determine the return air temperature relative to the mean air temperature by applying the gradient.

Field: Exhaust Air Height

This field specifies the distance above the floor where the air leaves the zone and enters an exhaust device such as an exhaust fan. This height is used by the model to determine the exhaust air temperature relative to the mean air temperature by applying the gradient.

Field: Temperature Gradient Lower Bound

This field specifies the gradient, or slope, of temperature changes in the vertical direction in °C/m.

Field: Temperature Gradient Upper Bound

This field specifies the gradient, or slope, of temperature changes in the vertical direction in °C/m.

Field: Gradient Interpolation Mode

This field specifies how the program will vary between the two gradients. Select one of the following keywords to choose the simulation data used to scale: 'Outdoor Environment Drybulb Temperature', 'Zone Drybulb Temperature', 'Delta Outdoor and Zone Temperature', 'Sensible Cooling Load', and 'Sensible Heating Load'. These are explained in detail below. All of these options have several things in common. They are essentially hard-coded. There is no support for a general method. The interpolation scheme is based on some variable that might reasonably be expected to correlate with gradient changes. This variable's current value is used to continually adjust the value of the vertical gradient for room air temperature.

OutdoorDryBulbTemperature: This key directs the program to interpolate between upper and lower values of the vertical gradient based on the outdoor air temperature. If the outdoor temperature exceeds the upper limit set in the next field, then the gradient entered in the 'Temperature Gradient Upper Bound' field is used. Similarly if the outdoor air temperature is below the value set in the 'Lower Temperature' field, then the gradient entered in the 'Temperature Gradient Lower Bound' is used. For outdoor temperatures that lie between the upper and lower bounds, the gradient is determined by linear interpolation between the two.

ZoneDryBulbTemperature: This key directs the program to interpolate between upper and lower values of the vertical gradient based on the mean zone air temperature. If the mean zone air temperature exceeds the upper limit set in the next field, then the gradient entered in the 'Temperature Gradient Upper Bound' field is used. Similarly if the mean zone air temperature is below the value set in the 'Lower Temperature' field, then the gradient entered in the 'Temperature Gradient Lower Bound' is used. For mean zone air temperatures that lie between the upper and lower bounds, the gradient is determined by linear interpolation between the two.

ZoneAndOutdoorTemperatureDifference: This key directs the program to interpolate between upper and lower values of the vertical gradient based on the difference between the outdoor environment and the mean zone air temperature. If the temperature difference exceeds the upper limit set in the next field, then the gradient entered in the 'Temperature Gradient Upper Bound' field is used. Similarly if the temperature difference is below the value set in the 'Lower Temperature' field, then the gradient entered in the 'Temperature Gradient Lower Bound' is used. For temperature differences that lie between the upper and lower bounds, the gradient is determined by linear interpolation between the two.

SensibleCoolingLoad: This key directs the program to interpolate between upper and lower values of the vertical gradient based on the sensible cooling load. If the cooling load exceeds the upper limit set in the next field, then the gradient entered in the 'Temperature Gradient Upper Bound' field is used. Similarly if the cooling load is below the value set in the 'Lower

Temperature' field, then the gradient entered in the 'Temperature Gradient Lower Bound' is used. For cooling loads that lie between the upper and lower bounds, the gradient is determined by linear interpolation between the two.

SensibleHeatingLoad: This key directs the program to interpolate between upper and lower values of the vertical gradient based on the sensible heating load. If the heating load exceeds the upper limit set in the next field, then the gradient entered in the 'Temperature Gradient Upper Bound' field is used. Similarly if the heating load is below the value set in the 'Lower Temperature' field, then the gradient entered in the 'Temperature Gradient Lower Bound' is used. For heating loads that lie between the upper and lower bounds, the gradient is determined by linear interpolation between the two.

Field: Upper Temperature Bound

This field is used to enter the upper bound on temperature values in Celsius. It is required for the interpolation modes based on temperature.

Field: Lower Temperature Bound

This field is used to enter the lower bound on temperature values in Celsius. It is required for the interpolation modes based on temperature.

Field: Upper Heat Rate Bound

This field is used to enter the upper bound on heat rate values. It is required for the interpolation modes based on load. Both heating and cooling loads are entered as positive numbers (in watts).

Field: Lower Heat Rate Bound

This field is used to enter the lower bound on heat rate values. It is required for the interpolation modes based on load. Both heating and cooling loads are entered as positive numbers (in watts).

IDD entry for this object is:

```
RoomAir:TemperaturePattern:TwoGradient,
A1, \field Name
    \required-field
    \type alpha
N1, \field Control Integer for Pattern Control Schedule Name
    \note reference this entry in Schedule Name
    \type integer
    \required-field
N2, \field Thermostat Height
    \note = Distance from floor of zone
    \units m
    \type real
N3, \field Return Air Height
    \note = Distance from floor of zone
    \units m
    \type real
N4, \field Exhaust Air Height
    \note = Distance from floor of zone
    \units m
    \type real
```

```

N5, \field Temperature Gradient Lower Bound
    \note Slope of temperature change in vertical direction
    \units K/m
    \type real
N6, \field Temperature Gradient Upper Bound
    \note Slope of temperature change in vertical direction
    \units K/m
    \type real
A2, \field Gradient Interpolation Mode
    \type choice
    \key OutdoorDryBulbTemperature
    \key ZoneDryBulbTemperature
    \key ZoneAndOutdoorTemperatureDifference
    \key SensibleCoolingLoad
    \key SensibleHeatingLoad
N7, \field Upper Temperature Bound
    \units C
    \type real
N8, \field Lower Temperature Bound
    \units C
    \type real
N9, \field Upper Heat Rate Bound
    \units W
    \type real
N10; \field Lower Heat Rate Bound
    \units W
    \type real

```

An example of this object follows. This pattern will apply no gradient (effectively the mixing model) if zone air temperatures are 22.5 C or lower. It will apply a gradient of 1 degree Celsius per meter if zone temperatures are 26.0 C or higher. For zone air temperatures between 22.5 and 26.0 it will determine the gradient by linear interpolation and use a gradient between 0.0 and 1.0 C/m depending on where the zone air temperature is in the range.

```

RoomAir:TemperaturePattern:TwoGradient,
Mixed to one C per M by Zone DB, ! Name
2002, ! Control Integer for Pattern Control Schedule
1.1, ! Thermostat Height meters
4.5, ! Return Air Height
3.5, ! Exhaust Air Height
0.0, ! Temperature Gradient Lower Bound Deg C/m
1.0, ! Temperature Gradient Upper Bound Deg C/m
ZoneDrybulbTemperature, ! Gradient Interpolation Mode
26.0, ! Upper Temperature [C]
22.5, ! Lower Temperature [C] !
, ! Upper Heat Rate [W]
; ! Lower Heat Rate [W]

```

RoomAir:TemperaturePattern:NondimensionalHeight

This object defines a distribution pattern for air temperatures relative to the current mean air temperature as a function of height. The height, referred to as Zeta, is non-dimensional by normalizing with the zone ceiling height. (The actual zone ceiling height can be explicitly entered in the 'Zone' object but if not it is calculated by EnergyPlus from the surfaces attached to the zone.) The temperature differences are not non-dimensional and remain in units of degrees Celsius.

An example of a vertical temperature pattern is shown in the figure below. The pattern itself is treated as a piecewise, linear model of air temperature as a function of height. This Zeta-DeltaTai curve, or lookup table, is then mapped to surfaces defined elsewhere in the file. The centroid of each surface and zone ceiling height are used to automatically assign Zeta values within the program. The zone named in the referencing RoomAir:TemperaturePattern:UserDefined object is used to determine which surfaces will be associated with the pattern when it is applied. A single pattern object can be reused for multiple zones and times.

In addition to the vertical temperature pattern there are three other parameters included in the pattern that are important. The first two might affect how the air system conditioning the room is operated. The first describes the temperature difference between the mean air temperature and the point where the sensor of a drybulb thermostat is situated. The second describes the temperature difference between the mean and the point where system air is being extracted from the zone. This is considered important because the changes in temperature difference between supply and return can affect how an air system is controlled to meet the loads. The third parameter can affect the zone air heat balance by altering the temperature of the air leaving the zone through exhaust fans.

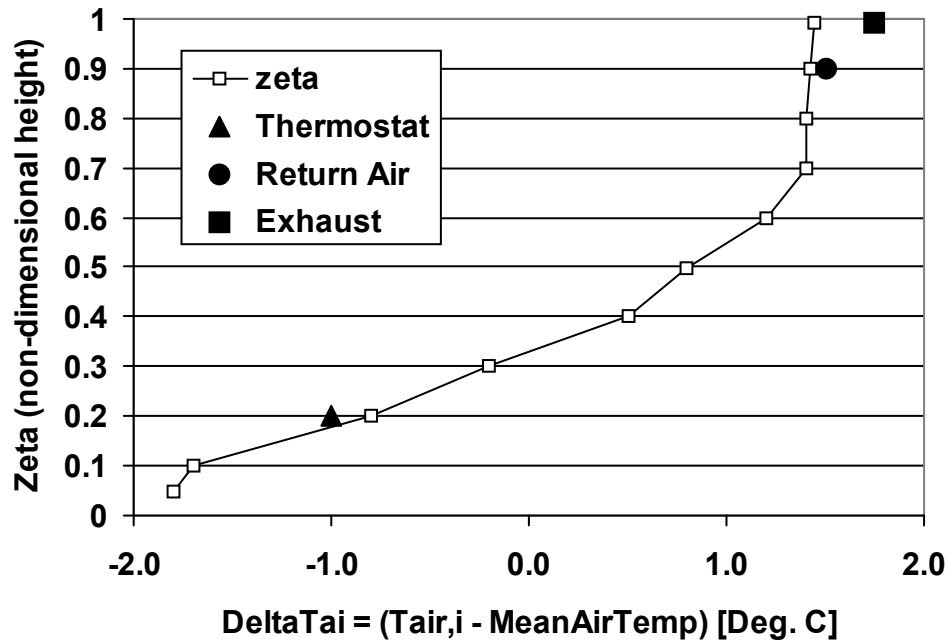


Figure 35. Example of a Vertical Air Temperature Pattern

Field: Name

This field provides a unique name for this object.

Field: Control Integer for Pattern Control Schedule Name

This field should contain an integer value that is unique among all other RoomAir Temperature Pattern objects. The value used here needs to be in the Pattern Control Schedule for those times when this pattern is to be used for the Room Air Temperature Distribution.

Field: Thermostat Offset

This field specifies the temperature difference between where the thermostat is situated and the mean air temperature.

Field: Return Air Offset

This field specifies the temperature difference between the air leaving the zone and returning to the air system and the mean air temperature.

Field: Exhaust Air Offset

This field specifies the temperature difference between the air leaving the zone and being exhausted out of the building and the mean air temperature.

Field Set Zeta and Temperature Difference

The remaining fields contain pairs of values that define a lookup table for the temperature pattern in the vertical direction. The first value is Zeta and the second value is DeltaTai. This object is extensible, by duplicating the last two fields and revising the IDD – note that you will have to replace “inner” semi-colons with commas.

Field: Pair <#> Zeta non-dimensional Height

Zeta is the normalized height and should be a fractional value from 0.0 to 1.0. A value of 0.0 corresponds to the floor and a value of 1.0 corresponds to the ceiling. The Zeta values need to be in increasing value.

Field: Pair <#> Delta Adjacent Air Temperature

DeltaT_{ai} is the temperature difference between the air temperature at the associated Zeta (T_{ai}) and the mean air temperature and is given in degrees Celsius.

The idd entry for this object is:

```
RoomAir:TemperaturePattern:NondimensionalHeight,
  \extensible:2 - repeat last two fields remembering to remove ; from "inner" fields.
  A1, \field Name
  \required-field
  \type alpha
  N1, \field Control Integer for Pattern Control Schedule Name
  \note this value should appear in as a schedule value
  \type integer
  \required-field
  N2, \field Thermostat Offset
  \note = (Temp at thermostat- Mean Air Temp)
  \units deltaC
  \type real
  N3, \field Return Air Offset
  \note = (Temp leaving - Mean Air Temp ) deg C
  \units deltaC
  \type real
  N4, \field Exhaust Air Offset
  \note = (Temp exhaust - Mean Air Temp) deg C
  \units deltaC
  \type real
  \note the remaining feilds have pairs that describe the relative
  \note temperature pattern in the vertical direction of a zone
  \note Zeta is the nondimensional height (in z-direction). on [0..1]
  \note DeltaTai = (Tai - MAT) in units of deg. C
  \note relative deg C on [-10.0 .. 20.0 ]
  N5, \field Pair 1 Zeta Nondimensional Height
  \type real
  \required-field
  N6, \field Pair 1 Delta Adjacent Air Temperature
  \type real
  \required-field
  \units deltaC
  \minimum -10.0
  \maximum 20.0
  reduced for brevity
```

An example of this object corresponding to the figure above is:

```
RoomAir:TemperaturePattern:NondimensionalHeight,
  Rough UFAD Approx , ! Name
  3001 , ! Control Integer for Pattern Control Schedule
```

```

! note reference this entry in Schedule
-1.0 , ! Thermostat Offset
1.5 , ! Return Air Offset (Tleaving - Mean Air Temp ) deg C
1.75, ! Exhaust Air Offset (Texhaust - Mean Air Temp) deg C
0.05, -1.8, ! pair 1 (Zeta , DeltaTai)
0.1, -1.7 , ! pair 2 (Zeta , DeltaTai)
0.2, -0.8 , ! pair 3 (Zeta , DeltaTai)
0.3, -0.2, ! pair 4 (Zeta , DeltaTai)
0.4, 0.5, ! pair 5 (Zeta , DeltaTai)
0.5, 0.8, ! pair 6 (Zeta , DeltaTai)
0.6, 1.2, ! pair 7 (Zeta , DeltaTai)
0.7, 1.4, ! pair 8 (Zeta , DeltaTai)
0.8, 1.4, ! pair 9 (Zeta , DeltaTai)
0.9, 1.42, ! pair 10 (Zeta , DeltaTai)
0.95, 1.44; ! pair 11 (Zeta , DeltaTai)

```

RoomAir:TemperaturePattern:SurfaceMapping

This object defines a distribution pattern for the air temperatures adjacent to individual surfaces. This object uses the specific names of individual surfaces defined elsewhere in the model. This pattern allows controlling the adjacent air temperature on a surface-by-surface basis rather than by height. This allows modeling different adjacent air temperatures on the opposite sides of the zone.

In addition to the surface mappings there are three other parameters included in the pattern that are important. The first two might affect how the air system conditioning the room is operated. The first describes the temperature difference between the mean air temperature and the point where the sensor of a drybulb thermostat is situated. The second describes the temperature difference between the mean and the point where system air is being extracted from the zone. This is considered important because the changes in temperature difference between supply and return can affect how an air system is controlled to meet the loads. The third parameter can affect the zone air heat balance by altering the temperature of the air leaving the zone through exhaust fans.

Field: Name

This field provides a unique name for this object.

Field: Control Integer for Pattern Control Schedule Name

This field should contain an integer value that is unique among all other RoomAir Temperature Pattern objects. The value used here needs to be in the Pattern Control Schedule for those times when this pattern is to be used for the RoomAir Temperature Distribution.

Field: Thermostat Offset

This field specifies the temperature difference between where the thermostat is situated and the mean air temperature.

Field: Return Air Offset

This field specifies the temperature difference between the air leaving the zone and returning to the air system and the mean air temperature.

Field: Exhaust Air Offset

This field specifies the temperature difference between the air leaving the zone and being exhausted out of the building and the mean air temperature.

Field Set: Surface Name, Temperature Difference**Fields (6 and on): Pairs of Surface Names and Temperature Differences**

The remaining fields contain pairs that define a lookup table for the temperature pattern on a surface-by-surface basis. This object is extensible, by duplicating the last two fields and revising the IDD – note that you will have to replace “inner” semi-colons with commas.

Field: Surface Name Pair <#>

The name of a surface defined elsewhere in the input file.

Field: Delta Adjacent Air Temperature Pair <#>

ΔT_{ai} is the temperature difference between the air temperature adjacent to the associated surface (T_{ai}) and the mean air temperature and is given in degrees Celsius. The IDD entry for this object is:

```
RoomAir:TemperaturePattern:SurfaceMapping,
  \extensible:2 - repeat last two fields remembering to remove ; from "inner" fields.
  A1, \field Name
      \required-field
      \type alpha
  N1, \field Control Integer for Pattern Control Schedule Name
      \note reference this entry in schedule
      \type integer
      \required-field
  N2, \field Thermostat Offset
      \note = (Temp at thermostat- Mean Air Temp)
      \units deltaC
  N3, \field Return Air Offset
      \note = (Tleaving - Mean Air Temp ) deg C
      \units deltaC
  N4, \field Exhaust Air Offset
      \note = (Texhaust - Mean Air Temp) deg C
      \units deltaC
  A2, \field Surface Name Pair 1
      \required-field
      \type object-list
      \object-list AllHeatTranSurfNames
  N5, \field Delta Adjacent Air Temperature Pair 1
      \required-field
      \type real
      \units deltaC
  Reduced for brevity
```

An example of this object, which might be used to elevate temperatures near west windows in the afternoon, is:

```
RoomAir:TemperaturePattern:SurfaceMapping,
  GroundFloor SW Corner Hot Near West Wall, ! Name
  4001, ! Control Integer for Pattern Control Schedule Name
  0.0, ! Thermostat Offset(Temp at thermostat- Mean Air Temp)
  0.0, ! Return Air Offset deg C
  0.0, ! Exhaust Air Offset
  ZN1_SW_1:W_ExtWall:1 , 0.8, ! pair 1 (Surface Name , DeltaTai)
  ZN1_SW_1:W_ExtWall:2 , 0.9, ! pair 2 (Surface Name , DeltaTai)
  ZN1_SW_1:W_ExtWall:3 , 1.0, ! pair 3 (Surface Name , DeltaTai)
  ZN1_SW_1:W_ExtWall:4, 1.1, ! pair 4 (Surface Name , DeltaTai)
  ZN1_SW_1:W_ExtWall:5, 1.3, ! pair 5 (Surface Name , DeltaTai)
  ZN1_SW_1:W_ExtWall:6, 1.5, ! pair 6 (Surface Name , DeltaTai)
  ZN1_SW_1:W_ExtWall:7, 1.7, ! pair 7 (Surface Name , DeltaTai)
  ZN1_SW_1:W_ExtWall:8, 2.1, ! pair 8 (Surface Name , DeltaTai)
  ZN1_SW_1:W_ExtWall:9, 2.4 ; ! pair 8 (Surface Name , DeltaTai)
```

RoomAir:Node

The RoomAir:Node object is used to define air nodes for a nodal air model. The number of air node objects that need to be specified depends on the nodal air model selected. (However, currently only the Mundt model uses this object). In order to use the Mundt model, the user must specify six or more RoomAir:Node objects of different types for each zone. The exact number of RoomAir:Node in the model will vary based on the resolution of walls. If walls (heat transfer surfaces) are split into separate segments in the vertical direction, then more air nodes of type 'MundtRoom' will be useful. At a minimum, for the Mundt model RoomAir Nodes of the following type are required: 'Inlet', 'Floor', 'Control', 'Ceiling', 'MundtRoom', and 'Return.'

Field: Name

This alpha field is a name for the air node. It should be unique and is used as an identifier

Field: Node Type

This alpha field indicates the type of this air node. The following explains options available for use with the Mundt nodal air model.

Inlet is specified for the air node located where the system air enters the zone.

Floor is specified for the air node located near the floor.

Control is specified for the air node located near the thermostat.

Ceiling is specified for the air node located near the ceiling.

MundtRoom is specified for the air node located adjacent to the wall(s).

Return is specified for the air node located where the system air leaves the zone.

Field: Zone Name

This field indicates the name of the zone (Ref: Zone) that this air node belongs to. This should be the unique name of a zone object defined elsewhere in the input file.

Field: Height of Nodal Control Volume Center

This numeric field indicates the height of the air node center. Air models such as the Mundt model compute the air temperature as a function of height and the value entered here will be used to determine a result for this node. The value should be specified in meters and relative to the floor of the zone.

Field: Surface <#> Name

These remaining alpha fields indicate the names of the surfaces (Ref: Surface) that are interacting convectively with this air node. This field is optional and related to the previous field. Currently, at most 20 surfaces are allowed to interact with a single air node. Only those nodes that interact with the inside faces of surfaces need to specify surface names. Each surface should couple to no more than 1 node.

The idd entry follows.

```
RoomAir:Node,
  \memo define an air node for some types of nodal air models
  A1, \field Name
      \type Alpha
  A2, \field Node Type
      \required-field
      \type choice
      \key Inlet
      \key Floor
      \key Control
      \key Ceiling
      \key MundtRoom
      \key Return
```

```

A3, \field Zone Name
    \required-field
    \type object-list
    \object-list ZoneNames
N1, \field Height of Nodal Control Volume Center
    \required-field
    \type real
    \units m
A4 , \field Surface 1 Name
    \type object-list
    \object-list AllHeatTranSurfNames
<reduced for brevity>
A23; \field Surface 20 Name
    \type object-list
    \object-list AllHeatTranSurfNames

```

An IDF example:

```

RoomAir:Node,
    WESTZN:FLOORAIR,    !- Node Name
    Floor,              !- Node Type
    WEST ZONE,          !- Name of Zone to Which the Air Node Belongs
    0.1,                !- Height of Nodal Control Volume Center {m}
    WESTZN:FLOOR:LEFF, !- surface name
    WESTZN:FLOOR:RIGHT; !- surface name

```

RoomAirSettings:OneNodeDisplacementVentilation

The RoomAirSettings:OneNodeDisplacementVentilation object is used to specify additional input parameters required by the Mundt model that are not available in other input objects in EnergyPlus. A single object will be used for the zone.

Field: Zone Name

This alpha field indicates the name of the zone (Ref: Zone) for the required input parameters as specified in the following fields.

Field: Fraction of Convective Internal Loads Added to Floor Air

This numeric field indicates what fraction of the convective part of the internal gains is added to the air near the floor in the zone specified.

Field: Fraction of Infiltration Internal Loads Added to Floor Air

This numeric field indicates what fraction of the infiltration air enters near the floor in the zone specified.

The idd entry follows:

```

RoomAirSettings:OneNodeDisplacementVentilation,
    \memo The Mundt model for displacement ventilation
A1 , \field Zone Name
    \required-field
    \type object-list
    \object-list ZoneNames
N1 , \field Fraction of Convective Internal Loads Added to Floor Air
    \type real
    \minimum 0.0
    \maximum 1.0
N2 ; \field Fraction of Infiltration Internal Loads Added to Floor Air
    \type real
    \minimum 0.0
    \maximum 1.0

```

An IDF example:

```

RoomAirSettings:OneNodeDisplacementVentilation,
    WEST ZONE, !- Zone Name
    0.1, !- Fraction of internal loads from the convective Floor Air

```

0.1; !- Fraction of internal loads from the Infiltration Air
--

RoomAirSettings:ThreeNodeDisplacementVentilation

This model is applicable to spaces that are served by a low velocity floor-level displacement ventilation air distribution system. Furthermore, the dominant sources of heat gain should be from people and other localized sources located in the occupied part of the room. The model should be used with caution in zones which have large heat gains or losses through exterior walls or windows or which have considerable direct solar gain. The model predicts three temperatures in the room:

- A foot level temperature (T_{FLOOR}). The floor region is 0.2 meters deep and T_{FLOOR} represents the temperature at the mid-point of the region.
- An occupied subzone temperature (T_{OC}), representing the temperature in the region between the floor layer and the upper, mixed layer.
- An upper node representing the mixed-layer/outflow temperature (T_{MX}) essential for overall energy budget calculations and for modeling comfort effects of the upper layer temperature.

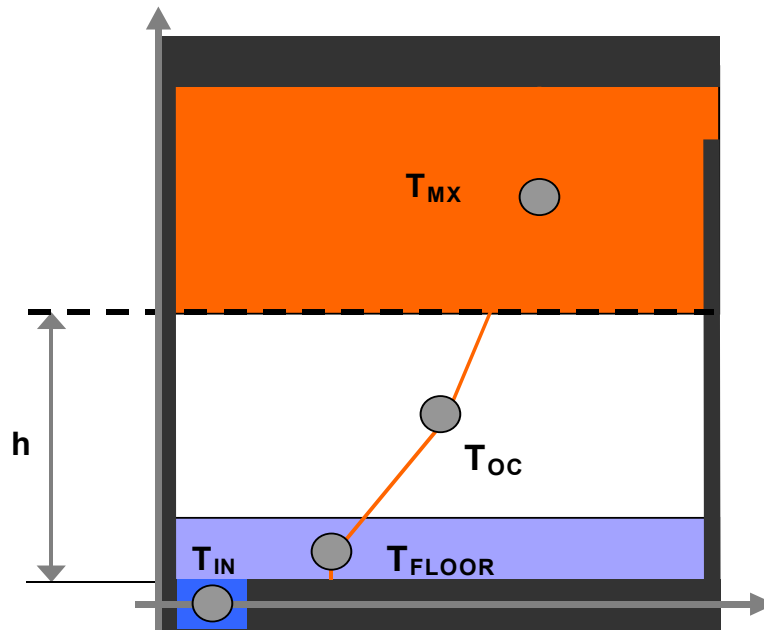


Figure 36. Schematic representation of the three temperature points and temperature gradients

The following fields are used to define an instance of the 'UCSD Displacement Ventilation Model Controls' object.

Field: Zone Name

This field provides the unique name of a zone described elsewhere in the file. A single instance of the 'UCSD Displacement Ventilation Model Controls' object is needed for each zone that is to be modeled using this method.

Field: Gain Distribution Schedule Name

This field specifies the unique name of schedule defined elsewhere in the input file. The schedule values are the fractions of the convective portion of the internal gains in the occupied subzone that remain in the occupied subzone. The remainder of the convective portion of the internal gains in the occupied subzone enters the plumes and is carried to the upper subzone. The types of internal gains that are assumed to be located in the occupied subzone are:

- people
- task lights
- electric equipment
- gas equipment
- hot water equipment
- steam equipment
- other equipment
- baseboard heat

Types of internal gains that are assumed to be in the upper subzone are:

- general lights
- tubular daylighting devices
- high temperature radiant heaters

The schedule values should be between 0 and 1. A value of 1 means that all the convection gains from equipment, task lights and people are dispersed in the lower occupied subzone. Conversely a value of 0 puts all the lower subzone convective gains into the plumes rising into the upper well-mixed subzone.

Field: Number of Plumes per Occupant

This field specifies number of plumes per occupant. Plumes are associated with localized sources of convective heat gain from people and equipment. For example, a value of 2.0 would be used if each occupant has a computer that generates a separate plume that does not merge with the plume from the occupant in the lower, occupied, subzone.

Field: Thermostat Height

This field is the height in meters of the thermostat/temperature control sensor above the floor.

Field: Comfort Height

The height in meters above the floor at which air temperature is calculated for comfort purposes. The air temperature at this height is used in calculating the available measures of comfort: Fanger, Pierce or KSU. The default is 1.1 meters.

Field: Temperature Difference Threshold for Reporting

This field specifies a minimum temperature difference between the upper mixed subzone and the occupied subzone that will be used to trigger whether or not the displacement ventilation auxiliary outputs will be calculated. These outputs are *DV Transition Height*, *DV Fraction Min Recommended Flow Rate*, *DV Average Temp Gradient* and *DV Maximum Temp Gradient*. They are set to negative values when the temperature difference is less than the threshold and the output *DV Zone Is Mixed* is set to 1.

The value should be greater than or equal to zero and is in units of degrees Centigrade. The default value is 0.4 degrees C.

The idd for this object follows.

```
RoomAirSettings:ThreeNodeDisplacementVentilation,
  \memo The UCSD model for Displacement Ventilation
A1 , \field Zone Name
  \note Name of Zone being described. Any existing zone name
  \required-field
  \type object-list
  \object-list ZoneNames
```



```

A2 , \field Gain Distribution Schedule Name
     \note Distribution of the convective heat gains between the occupied and mixed zones.
     \note 0<= Accepted Value <= 1.
     \note In the DV model 1 means all convective gains in the lower layer.
     \required-field
     \type object-list
     \object-list ScheduleNames
N1 , \field Number of Plumes per Occupant
     \note Used only in the UCSD displacement ventilation model.
     \note Effective number of separate plumes per occupant in the occupied zone.
     \note Plumes that merge together in the occupied zone count as one.
     \required-field
     \type real
     \minimum> 0.0
     \default 1.0
N2 , \field Thermostat Height
     \note Height of thermostat/temperature control sensor above floor
     \type real
     \minimum> 0.0
     \default 1.1
N3 , \field Comfort Height
     \note Height at which air temperature is calculated for comfort purposes
     \type real
     \minimum> 0.0
     \default 1.1
N4 ; \field Temperature Difference Threshold for Reporting
     \note Minimum temperature difference between predicted upper and lower layer
     \note temperatures above which DV auxilliary outputs are calculated.
     \note These outputs are 'DV Transition Height', 'DV Fraction Min Recommended Flow Rate'
     \note 'DV Average Temp Gradient' and 'DV Maximum Temp Gradient'. They
     \note are set to negative values when the temperature difference is less than the
     \note threshold and the output 'DV Zone Is Mixed' is set to 1
     \required-field
     \type real
     \minimum 0.0
     \default 0.4

```

An example input:

```

RoomAirSettings:ThreeNodeDisplacementVentilation,
  ZONE ONE,  !- Zone Name
  Constant - .2,  !- Gain Distribution Schedule Name
  1,  !- Number of Plumes per Occupant
  ,  !- Thermostat Height
  ,  !- Comfort Height
  .3;  !- Temp. Difference Threshold for Displacement Ventilation

```

RoomAirSettings:CrossVentilation

This UCSD Cross Ventilation Room Air Model provides a simple model for heat transfer and vertical temperature profile prediction in cross ventilated rooms. The model distinguishes two regions in the room, the main jet region and the recirculations, and predicts characteristic airflow velocities and average air temperatures. Cross Ventilation (CV) is common in many naturally ventilated buildings, with air flowing through windows, open doorways and large internal apertures across rooms and corridors in the building.

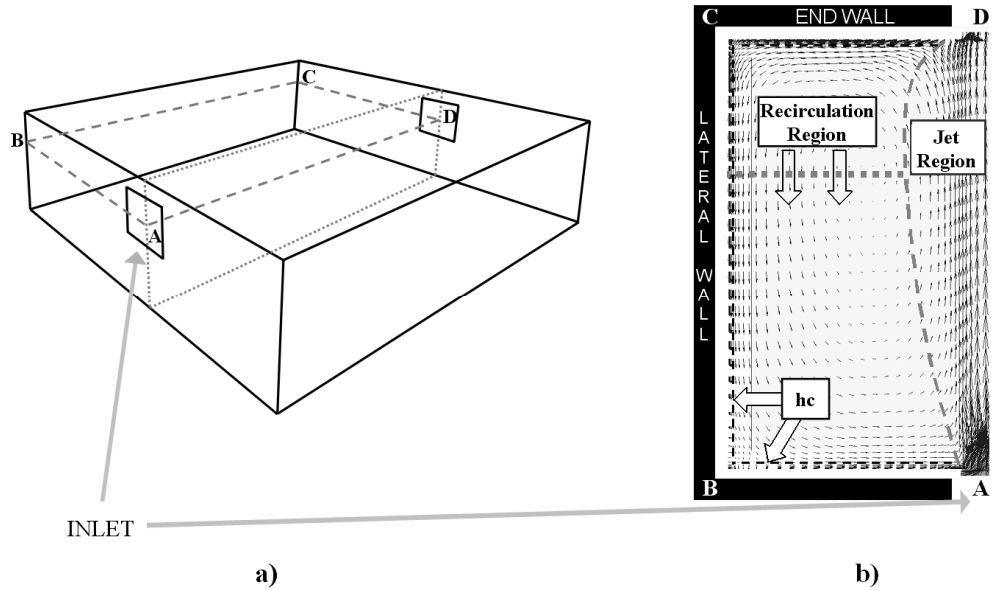


Figure 37. Schematic representation of room air geometry a) schematic representation of a room geometry that generates cross ventilation airflow. b) the proposed model distinguishes two regions in the flow: jet and recirculation (shown here in a CFD simulation of one half of a symmetrical room).

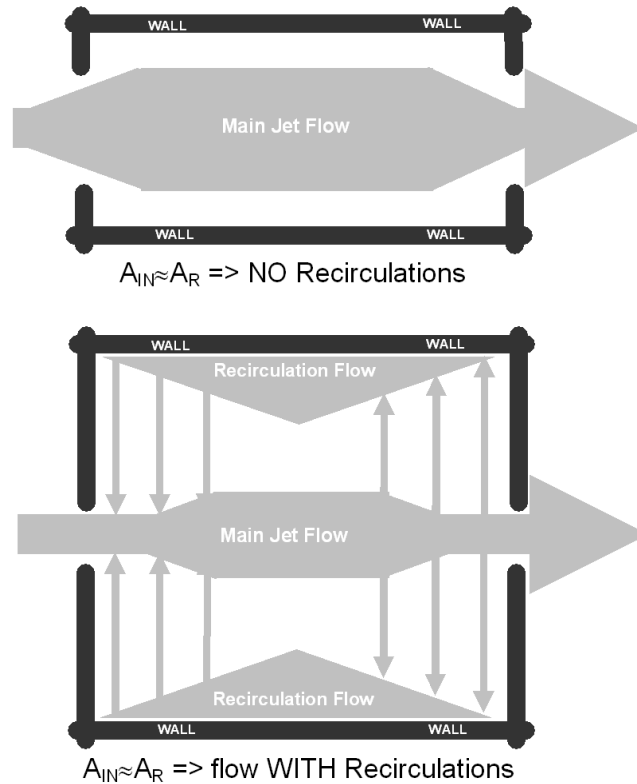


Figure 38. Schematic top view –possible airflow patterns in cross-ventilation.

The following fields are used to define an instance of the 'UCSD Cross Ventilation Model Controls' object.

Field: Zone Name

This field provides the unique name of a zone described elsewhere in the file. A single instance of the 'UCSD Cross Ventilation Model Controls' object is needed for each zone that is to be modeled using this method.

Field: Gain Distribution Schedule Name

This field specifies the unique name of schedule defined elsewhere in the input file. The schedule values are the fractions of the convective portion of the internal gains in the jet and recirculation regions.

The schedule values should be between 0 and 1. A value of 1 means that all the convective gains are dispersed in the jet region. Conversely a value of 0 puts all the convective gains into the recirculation region.

Field: Airflow Region Used for Thermal Comfort Evaluation

Required field whenever thermal comfort is predicted defines air temperature and mean airflow velocity that will be used in the Fanger model conditions must refer to one of the two regions defined in the model: jet or recirculation. Possible choices: **Jet** or **Recirculation**.

```
RoomAirSettings:CrossVentilation,
A1 , \field Zone Name
      \note Name of Zone being described. Any existing zone name
      \required-field
      \type object-list
      \object-list ZoneNames
A2 , \field Gain Distribution Schedule Name
      \note Distribution of the convective heat gains between the jet and recirculation zones.
      \note 0<= Accepted Value <= 1.
      \note In the CV model 1 means all convective gains in the jet region.
      \required-field
      \type object-list
      \object-list ScheduleNames
A3 ; \field Airflow Region Used for Thermal Comfort Evaluation
      \note Required field whenever thermal comfort is predicted
      \note defines Air temperature and Airflow velocity that will be used in the Fanger model
      \note conditions must refer to one of the two regions: jet or recirculation
      \type choice
      \key Jet
      \key Recirculation
```

An example input:

```
RoomAirSettings:CrossVentilation,
  ZONE ONE,  !- Zone Name
  Constant - .2,  !- Gain Distribution Schedule
  Recirculation;  !- Region used for thermal comfort evaluation
```

RoomAirSettings:UnderFloorAirDistributionInterior

This model is applicable to interior spaces that are served by an underfloor air distribution system. The dominant sources of heat gain should be from people, equipment, and other localized sources located in the occupied part of the room. The model should be used with caution in zones which have large heat gains or losses through exterior walls or windows or which have considerable direct solar gain. The model predicts two temperatures in the room:

- An occupied subzone temperature (T_{OC}), representing the temperature in the region between the floor and the boundary of the upper subzone..
- An upper subzone temperature (T_{MX}) essential for overall energy budget calculations and for modeling comfort effects of the upper layer temperature.

The following fields are used to define an instance of the 'UCSD UFAD Interior Model Controls' object.

Field: Zone Name

This field provides the unique name of a zone described elsewhere in the file. A single instance of the 'RoomAirSettings:UnderFloorAirDistributionInterior' object is needed for each zone that is to be modeled using this method.

Field: Number of Diffusers

The total number of diffusers in this zone. This field can be allowed to Autocalculate (in which case it is set to the design occupancy level; i.e., number of people). If the design occupancy is low or zero but there are still heat sources that could generate buoyancy driven plumes, the user should input a value based on the design supply air flow rate of the zone and the design flow rate of an individual diffuser. In the absence of any other information, divide the zone area by 100 ft². The default for this field is Autocalculate.

Field: Power per Plume

The power in watts incorporated in a buoyancy driven thermal plume. Normally we assume all the loads of a workstation create a single plume so that this represents the convective heat gain from a workstation – 1 person, 1 computer terminal, plus any task lighting. A typical value would be 220 watts. However, the model assumes an “equivalent” plume derived from the zone extraction rate normalized to the number of workstations/occupants. This field should be allowed to default – the program will calculate a value based upon the occupancy and the extraction rate. The default is Autocalculate.

Field: Design Effective Area of Diffuser

This is the design air flow opening area in square meters of a single diffuser. The default value depends on the diffuser type. For swirl diffusers it is 0.075 m², for variable area diffusers 0.035 m², for horizontal swirl diffusers 0.006 m², and for linear bar grilles 0.03 m². The default is *Autocalculate*.

Field: Diffuser Slot Angle from Vertical

This input describes the angle at which air emerges from the diffusers. It should be the angle in degrees between the vertical and the diffuser slots. The defaults depend on the diffuser type: for swirl diffusers it is 28 degrees, for variable area diffusers 45 degrees, for DV diffusers 73 degrees, and for linear bar grilles 15 degrees.

Field: Thermostat Height

This field is the height in meters of the thermostat/temperature control sensor above the floor. The default is 1.2 meters.

Field: Comfort Height

The height in meters above the floor at which air temperature is calculated for comfort purposes. The air temperature at this height is used in calculating the available measures of comfort: Fanger, Pierce or KSU. The default is 1.1 meters.

Field: Temperature Difference Threshold for Reporting

This field specifies a minimum temperature difference between the upper subzone and the occupied subzone that will be used to trigger whether or not the UFAD auxiliary outputs will be calculated. These outputs are *UF Transition Height* and *UF Average Temp Gradient*. They are set to zero when the temperature difference is less than the threshold and the output *UF Zone Is Mixed* is set to 1.

The value should be greater than or equal to zero and is in units of degrees Centigrade. The default value is 0.4 degrees C.

Field: Diffuser Type

The choices for this alpha field are **Swirl** | **VariableArea** | **HorizontalSwirl** | **LinearBarGrille** | **Custom**. The swirl and displacement diffusers are fixed area diffusers. The variable area diffusers maintain an approximately constant exit velocity. Linear bar grilles are normally used in exterior zones and are fixed area diffusers. Custom is used to signify that the user intends to input the coefficients A – E (see below) rather than let the program set the coefficients based on diffuser type. The default is *Swirl*.

Field: Transition Height

An optional field to allow the user to specify the transition height (meters above floor) rather than have the program calculate it. The default is 1.7 meters.

Field: Coefficient A

The coefficient A in the formula: $Kc = A \cdot \Gamma^B + C + D \cdot \Gamma + E \cdot \Gamma^2$. Gamma is a variable that characterizes the amount of stratification in a UFAD zone. Kc is the fraction of the total internal convective heat gain that is assigned to the lower (occupied) subzone. The coefficients in the formula are defaulted based upon diffuser type. A user would normally allow this field to default. The default is *autocalulate*.

Field: Coefficient B

The coefficient B in the formula: $Kc = A \cdot \Gamma^B + C + D \cdot \Gamma + E \cdot \Gamma^2$. Gamma is a variable that characterizes the amount of stratification in a UFAD zone. Kc is the fraction of the total internal convective heat gain that is assigned to the lower (occupied) subzone. The coefficients in the formula are defaulted based upon diffuser type. A user would normally allow this field to default. The default is *autocalulate*.

Field: Coefficient C

The coefficient C in the formula: $Kc = A \cdot \Gamma^B + C + D \cdot \Gamma + E \cdot \Gamma^2$. Gamma is a variable that characterizes the amount of stratification in a UFAD zone. Kc is the fraction of the total internal convective heat gain that is assigned to the lower (occupied) subzone. The coefficients in the formula are defaulted based upon diffuser type. A user would normally allow this field to default. The default is *autocalulate*.

Field: Coefficient D

The coefficient D in the formula: $Kc = A \cdot \Gamma^B + C + D \cdot \Gamma + E \cdot \Gamma^2$. Gamma is a variable that characterizes the amount of stratification in a UFAD zone. Kc is the fraction of the total internal convective heat gain that is assigned to the lower (occupied) subzone. The coefficients in the formula are defaulted based upon diffuser type. A user would normally allow this field to default. The default is *autocalulate*.

Field: Coefficient E

The coefficient E in the formula: $Kc = A \cdot \Gamma^B + C + D \cdot \Gamma + E \cdot \Gamma^2$. Gamma is a variable that characterizes the amount of stratification in a UFAD zone. Kc is the fraction of the total internal convective heat gain that is assigned to the lower (occupied) subzone. The coefficients in the formula are defaulted based upon diffuser type. A user would normally allow this field to default. The default is *autocalulate*.

The IDD definition of the object is:

```

RoomAirSettings:UnderFloorAirDistributionInterior,
  \min-fields 15
A1 , \field Zone Name
     \note Name of Zone with underfloor air distribution
     \required-field
     \type object-list
     \object-list ZoneNames
N1 , \field Number of Diffusers
     \note Total number of diffusers in this zone
     \type real
     \minimum> 0.0
     \autocalculatable
     \default autocalculate
N2 , \field Power per Plume
     \type real
     \minimum 0.0
     \units W
     \autocalculatable
     \default autocalculate
N3 , \field Design Effective Area of Diffuser
     \type real
     \units m2
     \minimum> 0.0
     \autocalculatable
     \default Autocalculate
N4 , \field Diffuser Slot Angle from Vertical
     \type real
     \units deg
     \minimum 0.0
     \maximum 90.
     \autocalculatable
     \default Autocalculate
N5 , \field Thermostat Height
     \note Height of thermostat/temperature control sensor above floor
     \units m
     \type real
     \minimum> 0.0
     \default 1.2
N6 , \field Comfort Height
     \note Height at which air temperature is calculated for comfort purposes
     \units m
     \type real
     \minimum> 0.0
     \default 1.1
N7 , \field Temperature Difference Threshold for Reporting
     \note Minimum temperature difference between predicted upper and lower layer
     \note temperatures above which UFAD auxilliary outputs are calculated.
     \note These outputs are 'UF Transition Height'and 'UF Average Temp Gradient'. They
     \note are set to zero values when the temperature difference is less than the
     \note threshold and the output 'UF Zone Is Mixed' is set to 1
     \units deltaC
     \required-field
     \type real
     \minimum 0.0
     \default 0.4
A2 , \field Floor Diffuser Type
     \required-field
     \type choice
     \key Custom
     \key Swirl
     \key VariableArea
     \key HorizontalSwirl
     \key LinearBarGrille
     \default Swirl
N8 , \field Transition Height
     \note user-specified height above floor of boundary between occupied and upper subzones
     \type real
     \units m
     \minimum> 0.0
     \autocalculatable
     \default 1.7

```

```

N9, \field Coefficient A
    \note Coefficient A in Formula  $K_c = A \cdot \Gamma^B + C + D \cdot \Gamma + E \cdot \Gamma^2$ 
    \note  $K_c$  is the fraction of the total zone load attributable to the lower subzone
    \type real
    \autocalculatable
    \default Autocalculate
N10, \field Coefficient B
    \note Coefficient B in Formula  $K_c = A \cdot \Gamma^B + C + D \cdot \Gamma + E \cdot \Gamma^2$ 
    \note  $K_c$  is the fraction of the total zone load attributable to the lower subzone
    \type real
    \autocalculatable
    \default Autocalculate
N11, \field Coefficient C
    \note Coefficient C in Formula  $K_c = A \cdot \Gamma^B + C + D \cdot \Gamma + E \cdot \Gamma^2$ 
    \note  $K_c$  is the fraction of the total zone load attributable to the lower subzone
    \type real
    \autocalculatable
    \default Autocalculate
N12, \field Coefficient D
    \note Coefficient D in Formula  $K_c = A \cdot \Gamma^B + C + D \cdot \Gamma + E \cdot \Gamma^2$ 
    \note  $K_c$  is the fraction of the total zone load attributable to the lower subzone
    \type real
    \autocalculatable
    \default Autocalculate
N13; \field Coefficient E
    \note Coefficient E in Formula  $K_c = A \cdot \Gamma^B + C + D \cdot \Gamma + E \cdot \Gamma^2$ 
    \note  $K_c$  is the fraction of the total zone load attributable to the lower subzone
    \type real
    \autocalculatable
    \default Autocalculate

```

An example input is:

```

RoomAirModelType,
SPACE5-1 RoomAir Model,  !- Name
SPACE5-1,                !- Zone Name
UnderFloorAirDistributionInterior, !- Room-Air Modeling Type
DIRECT;                  !- Air Temperature Coupling Strategy

RoomAirSettings:UnderFloorAirDistributionInterior,
SPACE5-1,                !- Zone Name
Autocalculate,          !- Number of Diffusers
Autocalculate,          !- Power per Plume
Autocalculate,          !- Design Effective Area of Diffuser {m2}
Autocalculate,          !- Diffuser Slot Angle from Vertical {deg}
,                        !- Thermostat Height {m}
,                        !- Comfort Height {m}
0.001,                  !- Temperature Difference Threshold for Reporting {deltaC}
Swirl,                  !- Diffuser Type
1.7,                    !- Transition Height {m}
Autocalculate,          !- Coefficient A
Autocalculate,          !- Coefficient B
Autocalculate,          !- Coefficient C
Autocalculate,          !- Coefficient D
Autocalculate;          !- Coefficient E

```

RoomAirSettings:UnderFloorAirDistributionExterior

This model is applicable to exterior spaces that are served by an underfloor air distribution system. The dominant sources of heat gain should be from people, equipment, and other localized sources located in the occupied part of the room, as well as convective gain coming from a warm window. The model predicts two temperatures in the room:

- An occupied subzone temperature (T_{OC}), representing the temperature in the region between the floor and the boundary of the upper subzone..
- An upper subzone temperature (T_{MX}) essential for overall energy budget calculations and for modeling comfort effects of the upper layer temperature.

The following fields are used to define an instance of the 'UCSD UFAD Exterior Model Controls' object.

Field: Zone Name

This field provides the unique name of a zone described elsewhere in the file. A single instance of the 'RoomAirSettings:UnderFloorAirDistributionExterior' object is needed for each zone that is to be modeled using this method.

Field: Number of Diffusers

The total number of diffusers in this zone. This field can allowed to Autocalculate (in which case it is set to the design occupancy level; i.e., number of people). If the design occupancy is low or zero but there are still heat sources that could generate buoyancy driven plumes, the user should input a value based on the design supply air flow rate of the zone and the design flow rate of an individual diffuser. In the absence of any other information, divide the zone area by 100 ft². The default for this field is Autocalculate.

Field: Power per Plume

The power in watts incorporated in a buoyancy driven thermal plume. Normally we assume all the loads of a workstation create a single plume so that this represents the convective heat gain from a workstation – 1 person, 1 computer terminal, plus any task lighting. A typical value would be 220 watts. However, the model assumes an "equivalent" plume derived from the zone extraction rate normalized to the number of workstations/occupants. This field should be allowed to default – the program will calculate a value based upon the occupancy and the extraction rate. The default is Autocalculate.

Field: Design Effective Area of Diffuser

This is the design air flow opening area in square meters of a single diffuser. The default value depends on the diffuser type. For swirl diffusers it is 0.075 m², for variable area diffusers 0.035 m², for horizontal swirl diffusers 0.006 m², and for linear bar grilles 0.03 m². The default is *Autocalculate*.

Field: Diffuser Slot Angle from Vertical

This input describes the angle at which air emerges from the diffusers. It should be the angle in degrees between the vertical and the diffuser slots. The defaults depend on the diffuser type: for swirl diffusers it is 28 degrees, for variable area diffusers 45 degrees, for DV diffusers 73 degrees, and for linear bar grilles 15 degrees.

Field: Thermostat Height

This field is the height in meters of the thermostat/temperature control sensor above the floor. The default is 1.2 meters.

Field: Comfort Height

The height in meters above the floor at which air temperature is calculated for comfort purposes. The air temperature at this height is used in calculating the available measures of comfort: Fanger, Pierce or KSU. The default is 1.1 meters.

Field: Temperature Difference Threshold for Reporting

This field specifies a minimum temperature difference between the upper subzone and the occupied subzone that will be used to trigger whether or not the UFAD auxiliary outputs will be calculated. These outputs are *UF Transition Height* and *UF Average Temp Gradient*. They are set to zero when the temperature difference is less than the threshold and the output *UF Zone Is Mixed* is set to 1.

The value should be greater than or equal to zero and is in units of degrees Centigrade. The default value is 0.4 degrees C.

Field: Diffuser Type

The choices for this alpha field are **Swirl** | **VariableArea** | **HorizontalSwirl** | **LinearBarGrille** | **Custom**. The swirl and displacement diffusers are fixed area diffusers. The variable area diffusers maintain an approximately constant exit velocity. Linear bar grilles are normally used in exterior zones and are fixed area diffusers. Custom is used to signify that the user intends to input the coefficients A – E (see below) rather than let the program set the coefficients based on diffuser type. The default is *Swirl*.

Field: Transition Height

An optional field to allow the user to specify the transition height (meters above floor) rather than have the program calculate it. The default is 1.7 meters.

Field: Coefficient A

The coefficient A in the formula: $Kc = A \cdot \Gamma^B + C + D \cdot \Gamma + E \cdot \Gamma^2$. Gamma is a variable that characterizes the amount of stratification in a UFAD zone. Kc is the fraction of the total internal convective heat gain that is assigned to the lower (occupied) subzone. The coefficients in the formula are defaulted based upon diffuser type. A user would normally allow this field to default. The default is *autocalulate*.

Field: Coefficient B

The coefficient B in the formula: $Kc = A \cdot \Gamma^B + C + D \cdot \Gamma + E \cdot \Gamma^2$. Gamma is a variable that characterizes the amount of stratification in a UFAD zone. Kc is the fraction of the total internal convective heat gain that is assigned to the lower (occupied) subzone. The coefficients in the formula are defaulted based upon diffuser type. A user would normally allow this field to default. The default is *autocalulate*.

Field: Coefficient C

The coefficient C in the formula: $Kc = A \cdot \Gamma^B + C + D \cdot \Gamma + E \cdot \Gamma^2$. Gamma is a variable that characterizes the amount of stratification in a UFAD zone. Kc is the fraction of the total internal convective heat gain that is assigned to the lower (occupied) subzone. The coefficients in the formula are defaulted based upon diffuser type. A user would normally allow this field to default. The default is *autocalulate*.

Field: Coefficient D

The coefficient D in the formula: $Kc = A \cdot \Gamma^B + C + D \cdot \Gamma + E \cdot \Gamma^2$. Gamma is a variable that characterizes the amount of stratification in a UFAD zone. Kc is the fraction of the total internal convective heat gain that is assigned to the lower (occupied) subzone. The coefficients in the formula are defaulted based upon diffuser type. A user would normally allow this field to default. The default is *autocalulate*.

Field: Coefficient E

The coefficient E in the formula: $Kc = A \cdot \Gamma^B + C + D \cdot \Gamma + E \cdot \Gamma^2$. Gamma is a variable that characterizes the amount of stratification in a UFAD zone. Kc is the fraction of the total internal convective heat gain that is assigned to the lower (occupied) subzone. The coefficients in the formula are defaulted based upon diffuser type. A user would normally allow this field to default. The default is *autocalulate*.

The IDD definition of the object is:

```

RoomAirSettings:UnderFloorAirDistributionExterior,
  \min-fields 15
  A1 , \field Zone Name
        \note Name of Zone being described. Any existing zone name
        \required-field
        \type object-list
        \object-list ZoneNames
  N1 , \field Number of Diffusers per Zone
        \type real
        \minimum> 0.0
        \autocalculatable
        \default Autocalculate
  N2 , \field Power per Plume
        \type real
        \minimum 0.0
        \units W
        \autocalculatable
        \default autocalculate
  N3 , \field Design Effective Area of Diffuser
        \type real
        \units m2
        \minimum> 0.0
        \autocalculatable
        \default Autocalculate
  N4 , \field Diffuser Slot Angle from Vertical
        \type real
        \units deg
        \minimum 0.0
        \maximum 90.
        \autocalculatable
        \default autocalculate
  N5 , \field Thermostat Height
        \note Height of thermostat/temperature control sensor above floor
        \units m
        \type real
        \minimum> 0.0
        \default 1.2
  N6 , \field Comfort Height
        \note Height at which Air temperature is calculated for comfort purposes
        \units m
        \type real
        \minimum> 0.0
        \default 1.1
  N7 , \field Temperature Difference Threshold for Reporting
        \note Minimum temperature difference between upper and lower layer
        \note temperatures above which UFAD auxilliary outputs are calculated.
        \note These outputs are 'UF Transition Height'and 'UF Average Temp Gradient'. They
        \note are set to zero values when the temperature difference is less than the
        \note threshold and the output 'UF Zone Is Mixed' is set to 1
        \units deltaC
        \required-field
        \type real
        \minimum 0.0
        \default 0.4
  A2 , \field Floor diffuser type
        \required-field
        \type choice
        \key Custom
        \key Swirl
        \key VariableArea
        \key HorizontalSwirl
        \key LinearBarGrille
        \default Swirl
  N8 , \field Transition Height
        \note User-specified height above floor of boundary between occupied and upper subzones
        \type real
        \units m
        \minimum> 0.0
        \autocalculatable
        \default 1.7
  N9, \field Coefficient A in formula  $Kc = A*\Gamma**B + C + D*\Gamma + E*\Gamma**2$ 

```

```

\ note Kc is the fraction of the total zone load attributable to the lower subzone
\ type real
\ autocalculatable
\ default Autocalculate
N10, \ field Coefficient B in formula  $Kc = A*Gamma**B + C + D*Gamma + E*Gamma**2$ 
\ note Kc is the fraction of the total zone load attributable to the lower subzone
\ type real
\ autocalculatable
\ default Autocalculate
N11, \ field Coefficient C in formula  $Kc = A*Gamma**B + C + D*Gamma + E*Gamma**2$ 
\ note Kc is the fraction of the total zone load attributable to the lower subzone
\ type real
\ autocalculatable
\ default Autocalculate
N12, \ field Coefficient D in formula  $Kc = A*Gamma**B + C + D*Gamma + E*Gamma**2$ 
\ note Kc is the fraction of the total zone load attributable to the lower subzone
\ type real
\ autocalculatable
\ default Autocalculate
N13; \ field Coefficient E in formula  $Kc = A*Gamma**B + C + D*Gamma + E*Gamma**2$ 
\ note Kc is the fraction of the total zone load attributable to the lower subzone
\ type real
\ autocalculatable
\ default Autocalculate

```

An example input is:

```

RoomAirSettings:UnderFloorAirDistributionExterior,
SPACE1-1,                !- Zone Name
Autocalculate,           !- Number of Diffusers per Zone
Autocalculate,           !- Power per Plume
Autocalculate,           !- Design Effective Area of Diffuser {m2}
Autocalculate,           !- Diffuser Slot Angle from Vertical {deg}
,                         !- Thermostat Height {m}
,                         !- Comfort Height {m}
0.001,                   !- Temperature Difference Threshold for Reporting {deltaC}
LinearBarGrille,         !- Diffuser Type
1.7,                     !- Transition Height {m}
Autocalculate,           !- Coefficient A
Autocalculate,           !- Coefficient B
Autocalculate,           !- Coefficient C
Autocalculate,           !- Coefficient D
Autocalculate;           !- Coefficient E

```

Room Air Model Outputs

Each room air model sets up outputs specific to that model. The effect of room air modeling is usually to adjust the adjacent air temperature along the inside surface of heat transfer surfaces. The output report “Surface Int Adjacent Air Temperature [C]” is provided for this and described under Surfaces:HeatTransfer .

Mundt Model / OneNodeDisplacementVentilation Outputs

The following output is available for the Mundt model.

```
Mundt RoomAir Model Air Node Temp [C]
```

Mundt RoomAir Model Air Node Temp [C]

This report variable provides the drybulb air temperature used in, or calculated by, the Mundt model. The selection key is the name of an air node defined in a ROOMAIR Node object.

ThreeNodeDisplacementVentilation Outputs

```

HVAC,Average,DV Mixed Subzone Temperature[C]
HVAC,Average,DV Occupied Subzone Temperature[C]
HVAC,Average,DV Floor Subzone Temperature[C]

```

HVAC,Average,DV Transition Height [m]
 HVAC,Average,DV Fraction Min Recommended Flow Rate
 HVAC,Average,DV Zone Is Mixed [0-No 1-Yes]
 HVAC,Average,DV Average Temp Gradient [K/m]
 HVAC,Average,DV Maximum Temp Gradient [K/m]
 HVAC,Average,DV Effective Air Temperature for Comfort [C]
 HVAC,Average,DV Thermostat Temperature [C]

DV Mixed Subzone Temperature[C]

The temperature of the upper well-mixed subzone in degrees C.

DV Occupied Subzone Temperature[C]

The average temperature of the lower, stratified, occupied subzone in degrees C.

DV Floor Subzone Temperature[C]

The temperature of the region near the floor in degrees C.

DV Transition Height [m]

The height above the floor, in meters, of the boundary between the lower occupied subzone and the upper well-mixed subzone.

DV Fraction Min Recommended Flow Rate

The ratio of the minimum recommended flow rate to the actual flow rate. Here flow rate means the sum of infiltration, ventilation, mixing and system air flow rates. The minimum flow is the flow needed to establish the boundary between the occupied and mixed subzones at 1.5 meters.

DV Zone Is Mixed [0-No 1-Yes]

An integer flag that indicates whether the zone is mixed (single node well-mixed zone model used) or stratified (UCSD DV model used). The value 1 means well-mixed; 0 means stratified.

DV Average Temp Gradient [K/m]

The temperature gradient between the middle of the floor region and the middle of the well-mixed upper subzone in degrees Kelvin per meter.

DV Maximum Temp Gradient [K/m]

The maximum of the temperature gradient between the middle of the floor region and the middle of the occupied subzone and the temperature gradient between the middle of the occupied subzone and the middle of the well-mixed subzone. The gradient is in degrees Kelvin per meter.

DV Effective Air Temperature for Comfort [C]

The temperature at the user specified comfort height in degrees C.

DV Thermostat Temperature [C]

The temperature at the height of the thermostat (specified by user input) in degrees C.

CrossVentilation Model Outputs

Zone,Average,CV Jet Region Temperature[C]
 Zone,Average,CV Recirculation Region Temperature[C]
 Zone,Average,CV Jet Region Average Velocity[m/s]
 Zone,Average,CV Recirculation Region Average Velocity[m/s]
 Zone,Average,CV Inflow Aperture Area[m2]
 Zone,Average,CV Room Length[m]
 Zone,Average,CV Ratio Between Recirculation and Inflow Rate

```
Zone,Average,CV Zone Air is Mixing [1-Yes 0-No]
Zone,Average,CV Recirculations Occur In The Flow [1-Yes 0-No]
```

CV Jet Region Temperature[C]

Average air temperature in the jet region of the flow in degrees C.

CV Recirculation Region Temperature[C]

Average air temperature in the recirculation region of the flow in degrees C.

CV Jet Region Average Velocity[m/s]

Average airflow velocity in the jet region of the flow in meters per second.

CV Recirculation Region Average Velocity[m/s]

Average airflow velocity in the recirculation region of the flow in meters per second.

CV Inflow Aperture Area[m2]

Area of the inflow aperture in square meters. This area can change due to variation in wind direction (as inflow aperture changes) or variations in the opening schedule.

CV Room Length[m]

Length of the room along the cross ventilation direction, in meters.

CV Ratio Between Recirculation And Inflow Rate

Ration between airflow rate in the recirculation region and inflow rate, non-dimensional.

CV Zone Air is Mixing [1-Yes 0-No]

An integer flag that indicates whether the zone is mixed (single node well-mixed zone model used) or significant momentum conservation is occurring (UCSD CV model used). The value 1 means well-mixed; 0 means cross ventilation is present. Transition to mixed flow can occur due to three mechanism: reduction in inflow velocity, reduction in inflow aperture area and dominance of buoyancy effects.

CV Recirculations Occur In The Flow [1-Yes 0-No]

An integer flag that indicates whether recirculations are present in the flow. A cross ventilation flow does not have recirculations whenever the inflow area is similar to the room cross section area (such as airflow in a typical corridor).

UnderFloorAirDistributionInterior/Exterior Model Outputs

```
HVAC,Average,UF Mixed Subzone Temperature [C]
HVAC,Average,UF Occupied Subzone Temperature [C]
HVAC,Average,UF Transition Height [m]
HVAC,Average,UF Zone Is Mixed [0-No 1-Yes]
HVAC,Average,UF Average Temp Gradient [K/m]
HVAC,Average,UF Effective Air Temperature for Comfort [C]
HVAC,Average,UF Thermostat Temperature [C]
HVAC,Average,UF Gamma
HVAC,Average,UF Power In Plumes [W]
HVAC,Average,Phi
HVAC,Average,UF Plume Power from Windows [W]UCSD Supply Air Temp
HVAC,Average,Phi
```

UF Mixed Subzone Temperature[C]

The temperature of the upper subzone in degrees C.

UF Occupied Subzone Temperature[C]

The temperature of the lower, occupied subzone in degrees C.

UF Transition Height [m]

The height above the floor, in meters, of the boundary between the lower occupied subzone and the upper subzone..

UF Zone Is Mixed [0-No 1-Yes]

An integer flag that indicates whether the zone is mixed (single node well-mixed zone model used) or stratified (UCSD UFI model used). The value 1 means well-mixed; 0 means stratified.

UF Average Temp Gradient [K/m]

The temperature gradient between the middle of the occupied subzone and the middle of the upper subzone in degrees Kelvin per meter.

UF Effective Air Temperature for Comfort [C]

The temperature at the user specified comfort height in degrees C.

UF Thermostat Temperature [C]

The temperature at the height of the thermostat (specified by user input) in degrees C.

UF Gamma

Value of gamma – a dimensionless “height” used in calculating the transition height. Lower values of gamma indicate increased stratification, higher values less. Generally the values should be between 2 and 30.

UF Power In Plumes [W]

The heat in watts driving the plumes in the occupied subzone.

UF Plume Power from Windows [W]

The convective heat gain from windows in an UnderFloorAirDistributionExterior zone.

Phi

Phi is a measure of temperature stratification in the space. It is the difference between the occupied subzone temperature and the supply temperature divided by difference between the return temperature and the supply temperature. Technically it is equal to Kc. As phi approaches 1, the space is fully mixed. As phi approaches 0, the space becomes fully stratified. Expressed as an equation:

$$(T_{occ} - T_{sup}) / (T_{ret} - T_{sup})$$

Group – Internal Gains (People, Lights, Other internal zone equipment)

Not all the influence for energy consumption in the building is due to envelope and ambient conditions. This group of objects describes other internal gains that may come into play (People, Lights, Various Equipment Types).

People

The people statement is used to model the occupant's affect on the space conditions. The following definition addresses the basic affects as well as providing information that can be used to report the thermal comfort of a group of occupants. The Fanger, Pierce Two-Node, and Kansas State UniversityTwo-Node thermal comfort models are available in EnergyPlus. A user may select any of these models for each People statement by simply adding the appropriate choice keyword after the air velocity schedule name. Thermal comfort calculations will only be made for people statements that include specific requests for these thermal comfort models.

Field: Name

The name of the People object. Must be unique across all People objects.

Field: Zone Name

This field is the name of the zone (ref: Zone) and links a particular people statement to a thermal zone in the building.

Field: Number of People Schedule Name

This field is the name of the schedule (ref: Group -- Schedules) that modifies the number of people parameter (see previous field). The schedule values can be any positive number. The actual number of people in a zone as defined by this statement is the product of the number of people field and the value of the schedule specified by name in this field.

Field: Number of People Calculation Method

This field is a key/choice field that tells which of the next three fields are filled and is descriptive of the method for calculating the nominal number of occupants (people) in the Zone. The key/choices are:

- People

With this choice, the method used will be a straight insertion of the number of occupants (people). (The Number of People field should be filled.)

- People/Area

With this choice, the method used will be a factor per floor area of the zone. (The People per Zone Floor Area field should be filled).

- Area/Person

With this choice, the method used will be a factor of floor area per person. (The Zone Floor Area per Person field should be filled).

Field: Number of People

This field is used to represent the maximum number of people in a zone that is then multiplied by a schedule fraction (see schedule field). In EnergyPlus, this is slightly more flexible in that the number of people could be a “diversity factor” applied to a schedule of real numbers. Note that while the schedule value can vary from hour to hour, the number of people field is constant for all simulation environments.

Field: People per Zone Floor Area

This factor (person/m²) is used, along with the Zone Floor Area to determine the maximum number of people as described in the Number of People field. The choice from the method field should be “people/area”.

Field: Zone Floor Area per Person

This factor (m²/person) is used, along with the Zone Floor Area to determine the maximum number of people as described in the Number of People field. The choice from the method field should be “area/person”.

Field: Fraction Radiant

This field is a decimal number between 0.0 and 1.0 and is used to characterize the type of heat being given off by people in a zone. The number specified in this field will be multiplied by the total sensible energy emitted by people to give the amount of long wavelength radiation gain from human beings in a zone. The remainder of the sensible load is assumed to be convective heat gain. Note that latent gains from people are not included in either the radiant or convective heat gains. See the Engineering Reference document for more details.

Field: Sensible Heat Fraction

The user can use this field to specify a fixed sensible fraction for the heat gain due to this PEOPLE object. Normally the program calculates the sensible/latent split; this field gives the user control over this split. This field is autocalculated: if the field is blank or **autocalculate**, the program will calculate the sensible/latent split; if a value is entered, it will be used as the sensible fraction of the current total heat gain.

Field: Activity Level Schedule Name

This field is the name of the schedule that determines the amount of heat gain per person in the zone under design conditions. This value is modified somewhat based on a correlation to account for variations in space temperature. The schedule values may be any positive number and the units for this parameter is Watts per person. This schedule represents the total heat gain per person including convective, radiant, and latent. An internal algorithm is used to determine what fraction of the total is sensible and what fraction is latent. Then, the sensible portion is divided into radiant and convective portions using the value specified for Fraction Radiant (above). See the Engineering Reference document for more details.

Values for activity level can range anywhere from approximately 100-150 Watts per person for most office activities up to over 900 Watts per person for strenuous physical activities such as competitive wrestling. The following table (Table 9) is based on Table 4 from the 2005 ASHRAE Handbook of Fundamentals, page 8.6. In addition to the information from the ASHRAE HOF, there is an added column of values in W/Person such as necessary for the activity level schedule values. This column uses the standard adult body surface area of 1.8 m² to multiply the activity levels in W/m² that are used in the table.

Field: Enable ASHRAE 55 comfort warnings

This field accepts either “Yes” or “No” as values. When “Yes” is specified, warnings are generated when the space conditions are outside of the ASHRAE 55 comfort range as discussed in the sections that follow titled “Simplified ASHRAE 55-2004 Graph Related Outputs” and “Simplified ASHRAE 55 Warnings.” The default is not to provide these warnings so if you want to know if your space is outside this comfort range you must set this field to Yes.

Table 9. Metabolic Rates for Various Activities

Activity	Activity Level W/Person EnergyPlus Schedule Value	Activity Level W/m²	met*
<i>Resting</i>			
Sleeping	72	40	0.7
Reclining	81	45	0.8
Seated, quiet	108	60	1
Standing, relaxed	126	70	1.2
<i>Walking (on level surface)</i>			
3.2 km/h (0.9 m/s)	207	115	2
4.3 km/h (1.2 m/s)	270	150	2.6
6.4 km/h (1.8 m/s)	396	220	3.8
<i>Office Activities</i>			
Reading, seated	99	55	1
Writing	108	60	1
Typing	117	65	1.1

Filing, seated	126	70	1.2
Filing, standing	144	80	1.4
Walking about	180	100	1.7
Lifting/packing	216	120	2.1
<i>Miscellaneous Occupational Activities</i>			
Cooking	171 to 207	95 to 115	1.6 to 2.0
Housecleaning	207 to 360	115 to 200	2.0 to 3.4
Seated, heavy limb movement	234	130	2.2
Machine work			
sawing (table saw)	189	105	1.8
light (electrical industry)	207 to 252	115 to 140	2.0 to 2.4
heavy	423	235	4
Handling 50 kg bags	423	235	4
Pick and shovel work	423 to 504	235 to 280	4.0 to 4.8
<i>Miscellaneous Leisure Activities</i>			
Dancing, social	252 to 459	140 to 255	2.4 to 4.4
Calisthenics/exercise	315 to 423	175 to 235	3.0 to 4.0
Tennis, singles	378 to 486	210 to 270	3.6 to 4.0
Basketball	522 to 792	290 to 440	5.0 to 7.6
Wrestling, competitive	738 to 909	410 to 505	7.0 to 8.7

***Note that one met = 58.1 W/m²**

Field: Mean Radiant Temperature Calculation Type

This field specifies the type of Mean Radiant Temperature (MRT) calculation the user wishes to use for the thermal comfort model. At the present time, there are two options for MRT calculation type: zone averaged and surface weighted. The default calculation is "ZoneAveraged". In the zone averaged MRT calculation, the MRT used for the thermal comfort calculations is for an "average" point in the zone. MRT is calculated based on an area-emissivity weighted average of all of the surfaces in the zone. In cases where the emissivity of all of the surfaces are sufficiently small (near zero), the mean radiant temperature will be set to the mean air temperature of the space to avoid divide by zero errors. The other MRT calculation type is "SurfaceWeighted". The goal of this calculation type is to estimate a person in the space close to a particular surface without having to define exact view factors for all of the surfaces and the location of the person in the space. The MRT used in the thermal comfort calculations when the "surface weighted" calculation type is selected is actually the average of the temperature of the surface to which the person is closest (defined by the next field "Surface Name") and the zone averaged MRT (defined above). The surface temperature alone is not used because in theory the maximum view factor from a person to any flat surface is roughly 0.5. In the "surfaceweighted" calculation, the surface in question actually gets slightly more weighting than 50% since the surface selected is still a part of the zone average MRT calculation. Again, this simplification was made to avoid the specification of view factors and the exact location of the person.

A third option is to use "angelfactor". This option allows for more explicit positioning of the person within the space by defining the angle factors from the person to the various surfaces in the zone. This option requires the user to list the surfaces that the person can see from a radiation standpoint and also define the angle (or view) factor for each surface. The

AngleFactorList object (see next object description) is intended to give the user this opportunity.

Field: Surface Name/Angle Factor List Name

This field is only valid when the user selects “surfaceweighted” for the MRT calculation type (see the previous input field description). In this case, the field is the name of a surface within the zone the people are residing. This surface will be used in the MRT calculation as defined above to come up with a more representative MRT for a person near a particular surface. The MRT used for thermal comfort calculations using the “surface weighted” MRT calculation method is the average of the temperature of the surface specified in this field and the “zone averaged” MRT (see the Mean Radiant Temperature calculation type field above).

Field: Work Efficiency Schedule Name

This field is the name of the schedule that determines the efficiency of energy usage within the human body that will be used for thermal comfort calculations. Note that all energy produced by the body is assumed to be converted to heat for the zone heat balance calculation. A value of zero corresponds to all of the energy produced in the body being converted to heat. A value of unity corresponds to all of the energy produced in the body being converted to mechanical energy. The values for this parameter defined in the schedule must be between 0.0 and 1.0. Any value greater than zero will result in a reduction of heat that impacts the thermal comfort energy balance of a person within the space.

Field: Clothing Insulation Schedule Name

This field is the name of the schedule that defines the amount of clothing being worn by a typical zone occupant during various times in the simulation period. This parameter must be a positive real number and has units of Clo. Typical values for Clo can be seen in the ASHRAE 2005 HOF Table 7, page 8.8 (for clothing ensembles) and Table 8, page 8.9 (for garment values).

Field: Air Velocity Schedule Name

This field is the name of the schedule that approximates the amount of air movement in the space as a function of time throughout the simulation period. The user has control over this parameter through the schedule that requires the individual numbers in the schedule to be positive real numbers having units of meters per second.

Field: Thermal Comfort Model Type (up to 3 allowed)

The final one to three fields are optional and are intended to trigger various thermal comfort models within EnergyPlus. By entering the keywords Fanger, Pierce or KSU, the user signifies that either the Fanger, Pierce Two-Node or Kansas State UniversityTwo-Node Thermal Comfort Model results are requested from EnergyPlus for this particular people statement. Note that since up to three models may be specified, the user may opt to have EnergyPlus calculate the thermal comfort for people identified with this people statement using all three models if desired. Note that the KSU model is computationally intensive and may noticeably increase the execution time of the simulation. For descriptions of the thermal comfort calculations, see the Engineering Reference document.

```

PEOPLE,
People,
  A1 , \field Name
        \required-field
        \type alpha
        \reference PeopleNames
  A2 , \field Zone Name
        \required-field
        \type object-list
        \object-list ZoneNames
  A3 , \field Number of People Schedule Name
        \required-field
        \type object-list
        \note units in schedule should be fraction applied to number of people (0.0 - 1.0)
        \object-list ScheduleNames
  A4 , \field Number of People Calculation Method
        \note The entered calculation method is used to create the maximum number of people
        \note for this set of attributes (i.e. sensible fraction, schedule, etc)
        \note Choices: People -- simply enter number of occupants.
        \note People per Zone Floor Area -- enter the number to apply.  Value * Floor Area = Number of
people
        \note Zone Floor Area per person -- enter the number to apply.  Floor Area / Value = Number of
people
        \required-field
        \type choice
        \key People
        \key People/Area
        \key Area/Person
        \default people
  N1 , \field Number of People
        \type real
        \minimum 0
  N2 , \field People per Zone Floor Area
        \type real
        \minimum 0
        \units person/m2
  N3 , \field Zone Floor Area per Person
        \type real
        \minimum 0
        \units m2/person
  N4 , \field Fraction Radiant
        \required-field
        \type real
        \minimum 0.0
        \maximum 1.0

```

```

N5, \field Sensible Heat Fraction
    \note if input, overrides program calculated sensible/latent split
    \autocalculatable
    \default autocalculate
    \minimum 0.0
    \maximum 1.0
A5 , \field Activity Level Schedule Name
    \required-field
    \note Note that W has to be converted to mets in TC routine
    \type object-list
    \note units in schedule are W/person
    \object-list ScheduleNames
A6 , \field Enable ASHRAE 55 Comfort Warnings
    \type choice
    \key Yes
    \key No
    \default No
A7 , \field Mean Radiant Temperature Calculation Type
    \note optional (only required for thermal comfort runs)
    \type choice
    \key ZoneAveraged
    \key SurfaceWeighted
    \key AngleFactor
    \default ZoneAveraged
A8 , \field Surface Name/Angle Factor List Name
    \type object-list
    \object-list AllHeatTranAngFacNames
    \note optional (only required for thermal comfort runs)
A9 , \field Work Efficiency Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note units in schedule are 0.0 to 1.0
    \note optional (only required for thermal comfort runs)
A10, \field Clothing Insulation Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note use "Clo" from ASHRAE or Thermal Comfort guides
    \note optional (only required for thermal comfort runs)
A11, \field Air Velocity Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note units in the schedule are m/s
    \note optional (only required for thermal comfort runs)
A12, \field Thermal Comfort Model 1 Type
    \type choice
    \key Fanger
    \key Pierce
    \key KSU
    \note optional (only needed for people thermal comfort results reporting)
A13, \field Thermal Comfort Model 2 Type
    \type choice
    \key Fanger
    \key Pierce
    \key KSU
    \note optional (second type of thermal comfort model and results reporting)
A14; \field Thermal Comfort Model 3 Type
    \type choice
    \key Fanger
    \key Pierce
    \key KSU
    \note optional (third thermal comfort model and report type)

```

The following IDF example allows for a maximum of 31 people with scheduled occupancy of “Office Occupancy”, 60% radiant using an Activity Schedule of “Activity Sch”. The example allows for thermal comfort reporting.

```

People,
Kitchen_ZN_1_FLR_1,  !- Name
Kitchen_ZN_1_FLR_1,  !- Zone Name
BLDG_OCC_SCH,        !- Schedule Name
People,              !- Number of People Calculation Method
25.2000,,,          !- Number of People
0.3000,             !- Fraction Radiant
AUTOCALCULATE,      !- User Specified Sensible Fraction
ACTIVITY_SCH,       !- Activity Level Schedule Name
No,                 !- Enable ASHRAE 55 comfort warnings
ZoneAveraged,       !- MRT Calculation
,                   !- Surface Name
WORK_EFF_SCH,       !- Work Efficiency Schedule Name
CLOTHING_SCH,       !- Clothing Schedule Name
AIR_VELO_SCH,       !- Air Velocity Schedule Name
Fanger;             !- Thermal Comfort Report

```

A simpler example, without using the thermal comfort reporting option:

```

People,
RIGHT FORK,          !- Name
RIGHT FORK,          !- Zone Name
Dorm Occupancy,     !- Number of People SCHEDULE Name
people,              !- Number of People calculation method
8.00000,,,          !- Number of People
0.6000000,          !- Fraction Radiant
Autocalculate,      !- user specified sensible fraction
Activity Sch,        !- Activity level SCHEDULE Name

```

And with the sensible fraction specified:

```

People,
SPACE1-1 People 1,  !- Name
SPACE1-1,           !- Zone Name
OCCUPY-1,           !- Number of People SCHEDULE Name
people,             !- Number of People calculation method
11,,,              !- Number of People
0.3,                !- Fraction Radiant
0.55,               !- user specified sensible fraction
ActSchd;            !- Activity level SCHEDULE Name

```

People Outputs

People objects have output variables for individual objects and for zone totals.

People specific outputs include:

```

Zone,Average,People Number Of Occupants []
Zone,Sum,People Radiant Heat Gain [J]
Zone,Sum,People Convective Heat Gain [J]
Zone,Sum,People Latent Heat Gain [J]
Zone,Sum,People Sensible Heat Gain [J]
Zone,Sum,People Total Heat Gain [J]
Zone,Average,Zone People Number Of Occupants []
Zone,Sum,Zone People Radiant Heat Gain [J]
Zone,Sum,Zone People Convective Heat Gain [J]
Zone,Sum,Zone People Latent Heat Gain [J]
Zone,Sum,Zone People Sensible Heat Gain [J]
Zone,Sum,Zone People Total Heat Gain [J]
Zone,Average,FangerPMV
Zone,Average,PiercePMVET
Zone,Average,PiercePMVSET
Zone,Average,PierceDISC
Zone,Average,PierceTSENS
Zone,Average,KsuTSV

```

People Number Of Occupants []

This field is the number of people for this PEOPLE object during the timestep in question.

People Radiant Heat Gain [J]

This field is the amount of radiant heat gain for this PEOPLE object in Joules. This is determined by the current sensible heat gain from people to the zone and the “Fraction Radiant” specified in the input. The radiant gains from people are distributed to the surfaces using an area weighting scheme.

People Convective Heat Gain [J]

This field is the amount of convective heat gain for this PEOPLE object in Joules. This is determined by the current sensible heat gain from people to the zone and the “Fraction Radiant” specified in input. Note that the radiant and convective gains should add up to the sensible heat gain from people. The convective heat gain from people is added to the zone air heat balance directly.

People Latent Heat Gain [J]

This field is the amount of latent heat gain for this PEOPLE object in Joules. This amount is based on the number of people in the space as well as the total amount of energy produced by a typical person defined by the activity schedule in the input. An internal algorithm is used to determine what fraction of the total is sensible and what fraction is latent. Details about this split are included in the Engineering Reference document.

People Sensible Heat Gain [J]

This field is the amount of sensible heat gain for this PEOPLE object in Joules. This amount is based on the number of people in the space as well as the total amount of energy produced by a typical person defined by the activity schedule in the input. An internal algorithm (described in the Engineering Reference document) is used to determine what fraction of the total is sensible and what fraction is latent. The sensible plus the latent heat gain from people equals the total gain specified in the input.

People Total Heat Gain [J]

This field is the total amount of heat gain for this PEOPLE object in Joules. This is derived from the activity level times the number of occupants.

Zone People Number Of Occupants []

This field is the total number of people within the zone during the timestep in question.

Zone People Radiant Heat Gain [J]

This field is the amount of radiant heat gain from people within the zone in Joules. This is determined by the current sensible heat gain from people to the zone and the “Fraction Radiant” specified in the input. The radiant gains from people are distributed to the surfaces using an area weighting scheme.

Zone People Convective Heat Gain [J]

This field is the amount of convective heat gain from people within the zone in Joules. This is determined by the current sensible heat gain from people to the zone and the “Fraction Radiant” specified in input. Note that the radiant and convective gains should add up to the sensible heat gain from people. The convective heat gain from people is added to the zone air heat balance directly.

Zone People Latent Heat Gain [J]

This field is the amount of latent heat gain from people within the zone in Joules. This amount is based on the number of people in the space as well as the total amount of energy produced by a typical person defined by the activity schedule in the input. An internal algorithm is used to determine what fraction of the total is sensible and what fraction is latent. Details about this split are included in the Engineering Reference document.

Zone People Sensible Heat Gain [J]

This field is the amount of sensible heat gain from people within the zone in Joules. This amount is based on the number of people in the space as well as the total amount of energy produced by a typical person defined by the activity schedule in the input. An internal algorithm (described in the Engineering Reference document) is used to determine what fraction of the total is sensible and what fraction is latent. The sensible plus the latent heat gain from people equals the total gain specified in the input.

Zone People Total Heat Gain [J]

This field is the total amount of heat gain from people within the zone in Joules. Derived from the activity level times the number of occupants, this is summed for each people object within a zone.

ThermalComfortMRT [C]

This report variable is the mean radiant temperature used in the thermal comfort calculations. This value is computed according to the "MRT Calculation Type" specified in the PEOPLE object. If a high temperature radiant system is present in the zone, this value will be adjusted according to the current heater operation and the "Fraction of radiant energy incident on people" specified in the HIGH TEMP RADIANT SYSTEM object.

Note for all Thermal Comfort reporting: Though the published values for thermal comfort "vote" have a discrete scale (e.g. -3 to +3 or -4 to +4), the calculations in EnergyPlus are carried out on a continuous scale and, thus, reporting may be "off the scale" with specific conditions encountered in the space. This is not necessarily an error in EnergyPlus – rather a different approach that does not take the "limits" of the discrete scale values into account.

FangerPMV

This field is the "predicted mean vote" (PMV) calculated using the Fanger thermal comfort model.

PiercePMVET

This field is the "predicted mean vote" (PMV) calculated using the effective temperature and the Pierce two-node thermal comfort model.

PiercePMVSET

This field is the "predicted mean vote" (PMV) calculated using the "standard" effective temperature and the Pierce two-node thermal comfort model.

PierceDISC

This field is the "discomfort index" calculated using the the Pierce two-node thermal comfort model.

PierceTSENS

This field is the "thermal sensation index" (PMV) calculated using the Pierce two-node thermal comfort model.

KsuTSV

This field is the "thermal sensation vote" (TSV) calculated using the KSU two-node thermal comfort model.

Simplified ASHRAE 55-2004 Graph Related Outputs

The following output variables are all based on whether the humidity ratio and the operative temperature is within the region shown in ASHRAE Standard 55-2004 in Figure 5.2.1.1. For these outputs the operative temperature is simplified to be the average of the air temperature and the mean radiant temperature. For summer, the 0.5 Clo level is used and, for winter, the 1.0 Clo level is used. The graphs below are based on the following tables which extend the ASHRAE values to zero humidity ratio.

Table 10. Winter Clothes (1.0 Clo)

Operative Temp(degC)	Humidity Ratio
19.6	0.012
23.9	0.012
26.3	0.000
21.7	0.000

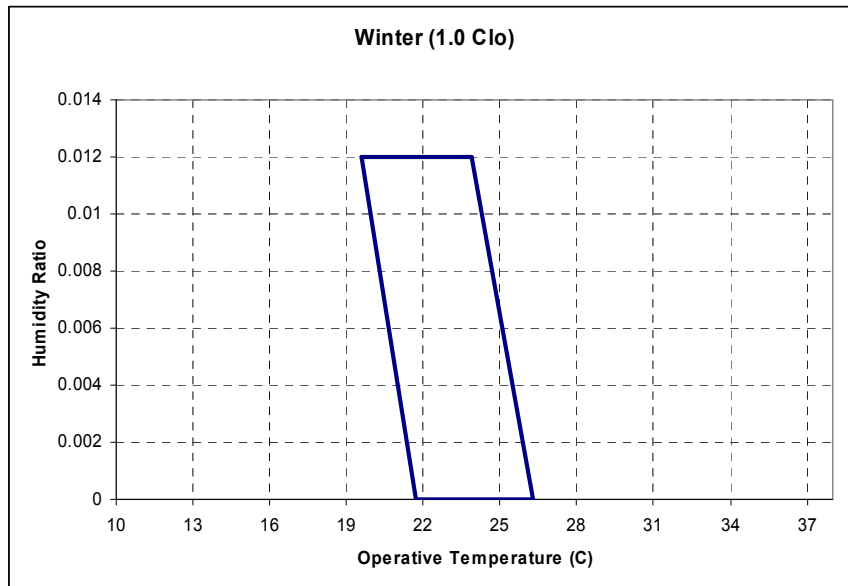


Figure 39. Winter Comfort Range

Table 11. Summer Clothes (0.5 Clo)

Operative Temp(degC)	Humidity Ratio
23.6	0.012
26.8	0.012
28.3	0.000
25.1	0.000

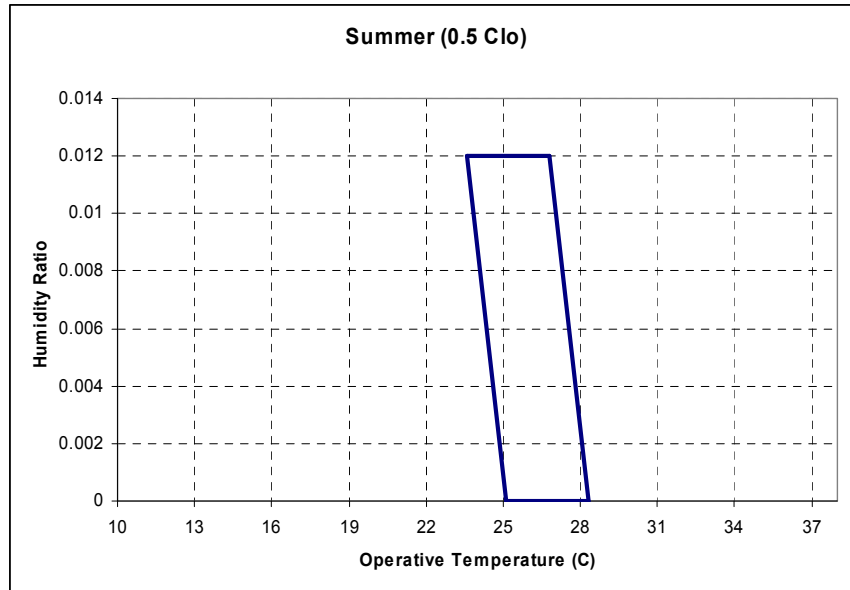


Figure 40. Summer Comfort Range

Time Not Comfortable Summer Clothes[hr]

The time when the zone is occupied that the combination of humidity ratio and operative temperature is not in the ASHRAE 55-2004 summer clothes region (see above)

Time Not Comfortable Winter Clothes[hr]

The time when the zone is occupied that the combination of humidity ratio and operative temperature is not in the ASHRAE 55-2004 winter clothes region (see above)

Time Not Comfortable Summer or Winter Clothes[hr]

The time when the zone is occupied that the combination of humidity ratio and operative temperature is not in the ASHRAE 55-2004 summer or winter clothes region (see above)

Time Not Comfortable Summer Clothes Any Zone[hr]

The time when any zone is occupied that the combination of humidity ratio and operative temperature is not in the ASHRAE 55-2004 summer clothes region (see above)

Time Not Comfortable Winter Clothes Any Zone [hr]

The time when any zone is occupied that the combination of humidity ratio and operative temperature is not in the ASHRAE 55-2004 winter clothes region (see above)

Time Not Comfortable Summer or Winter Clothes Any Zone [hr]

The time when any zone is occupied that the combination of humidity ratio and operative temperature is not in the ASHRAE 55-2004 summer or winter clothes region (see above)

Simplified ASHRAE 55 Warnings

The simplified ASHRAE 55 calculations may be computed for occupied zones and, possibly, warnings are shown on the .err file at the end of each simulated environment. To enable this option set the “Enable ASHRAE 55 comfort warnings” field of the People object to Yes. These warnings will not be generated by default.

If you enable the warnings, the simplified ASHRAE 55 calculations are done for occupied zones and, possibly, warnings are shown on the .err file at the end of each simulated environment.

```

** Warning ** More than 4% of time (350.4 hours) uncomfortable in zone ZSF1
**   ~~~   ** 553.0 hours were uncomfortable based on ASHRAE 55-2004 graph (Section 5.2.1.1)
**   ~~~   ** During Environment [10/01 - 09/30]: CHICAGO IL USA TMY2-94846 WMO#=725300
** Warning ** More than 4% of time (350.4 hours) uncomfortable in zone ZNF1
**   ~~~   ** 827.8 hours were uncomfortable based on ASHRAE 55-2004 graph (Section 5.2.1.1)
**   ~~~   ** During Environment [10/01 - 09/30]: CHICAGO IL USA TMY2-94846 WMO#=725300
** Warning ** More than 4% of time (350.4 hours) uncomfortable in zone ZSF2
**   ~~~   ** 593.5 hours were uncomfortable based on ASHRAE 55-2004 graph (Section 5.2.1.1)
**   ~~~   ** During Environment [10/01 - 09/30]: CHICAGO IL USA TMY2-94846 WMO#=725300
** Warning ** More than 4% of time (350.4 hours) uncomfortable in zone ZNF2
**   ~~~   ** 875.8 hours were uncomfortable based on ASHRAE 55-2004 graph (Section 5.2.1.1)
**   ~~~   ** During Environment [10/01 - 09/30]: CHICAGO IL USA TMY2-94846 WMO#=725300

```

You may decide if you need to change parameters to reduce these “uncomfortable” hours. The individual report variables shown previously may help you get more details on when these are occurring.

Following are some suggestions that might be applicable:

- Eliminate occupancy when conditioning equipment is off.
- Note that the ASHRAE graph lower limit is (19.6C to 21.7C) – heating setpoints may need to be nearer 22.2C (72F) than 21.1C (70F).
- Unoccupied heating setpoint should be nearer 16.7C (62F) rather than 12.8C (55F) to reduce the start up recovery.
- Start the occupied setpoint schedule, fan availability schedule, cooling pump availability schedule, reheat coil availability, one hour before occupancy. Seasonal turn on and off of equipment may cause more warnings (but potentially more energy consumption).
- Unoccupied cooling setpoint should be nearer 29.4C (85F) rather than 40.0 (104F) to reduce the start up recovery.

ComfortViewFactorAngles

When requesting EnergyPlus to do a thermal comfort calculation, the program user has three options for defining how the mean radiant temperature will be calculated. The user may select “zoneaveraged” which results in a mean radiant temperature that is characteristic of an “average” location near the center of the zone. The user may also elect to place the person near a particular surface by selecting “surfaceweighted” in the People statement. This takes the average of the zone mean radiant temperature and the temperature of the surface that the person is near and uses this value as the mean radiant temperature when calculating thermal comfort.

The third option is for the user to more explicitly position the person within the space by defining the angle factors from the person to the various surfaces in the zone. This option requires the user to list the surfaces that the person can see from a radiation standpoint and also define the angle (or view) factor for each surface. The AngleFactorList input line is intended to give the user this opportunity.

Field: Name

This field is an unique user assigned name for the list of surfaces that can be seen radiantly by the person for whom thermal comfort is to be evaluated. Any reference to this list by a People statement will use this name.

Field: Zone Name

Zone Name for this surface list. Each of the surfaces listed must be in this zone.

Field: Surface <#> Name

This field is the name of a surface in the zone seen by the person.

Field: Angle Factor <#>

This field is the fraction that this surface contributes to the total mean radiant temperature. This can be thought of as a weighting factor for this surface and the actual mean radiant temperature used in the thermal comfort model is simply the sum of all angle factors multiplied by the corresponding inside surface temperature. Note that the Surface Name/Angle Factor pair can be repeated up to 20 times. The sum of all angle factors within any angle factor list must equal unity, otherwise the program will not accept the input as valid.

The IDD Definition for this object:

```
ComfortViewFactorAngles,
  A1 , \field Name
      \type alpha
      \reference AllHeatTranAngFacNames
  A2 , \field Zone Name
      \type object-list
      \object-list ZoneNames
  A3 , \field Surface 1 Name
      \type object-list
      \object-list AllHeatTranSurfNames
  N1 , \field Angle Factor 1
      \type real
      \minimum 0.0
      \maximum 1.0
  A4 , \field Surface 2 Name
      \type object-list
      \object-list AllHeatTranSurfNames
  N2 , \field Angle Factor 2
      \type real
      \minimum 0.0
      \maximum 1.0
-- reduced for brevity
```

An example IDF with an electric low temperature radiant system is shown below.

```
ComfortViewFactorAngles,
  South Zone Angle Factors, !- name of angle factor list
  South Zone, !- Zone Name
  Zn001:Flr001, !- Surface name 1
  0.75, !- Angle factor for surface 1
  Zn001:Wall001, !- Surface name 2
  0.15, !- Angle factor for surface 2
  Zn001:Roof001, !- Surface name 3
  0.10; !- Angle factor for surface 3
```

Lights

The Lights statement allows you to specify information about a zone's electric lighting system, including design power level and operation schedule, and how the heat from lights is distributed thermally.

A zone may have multiple Lights statements. For example, one statement may describe the general lighting in the zone and another the task lighting. Or you can use multiple Lights statements for a zone that has two or more general lighting systems that differ in design level, schedule, etc.

Field: Name

The name of the LIGHTS object.

Field: Zone Name

The name of the thermal zone (ref: Zone) that this Lights statement refers to.

Field: Schedule Name

The name of the schedule that modifies the lighting power design level (see next field). The schedule values can be any positive number. The electrical input for lighting in a particular timestep is the product of the design level and the value of this schedule in that timestep. If the design level is the maximum lighting power input the schedule should contain values between 0.0 and 1.0.

Field: Design Level Calculation Method

This field is a key/choice field that tells which of the next three fields are filled and is descriptive of the method for calculating the nominal lighting level in the Zone. The key/choices are:

- LightingLevel

With this choice, the method used will be a straight insertion of the lighting level (Watts) for the Zone. (The Lighting Level field should be filled.)

- Watts/Area

With this choice, the method used will be a factor per floor area of the zone. (The Watts per Zone Floor Area field should be filled).

- Watts/Person

With this choice, the method used will be a factor of lighting level (watts) per person. (The Watts per person field should be filled).

Field: Lighting Level

This is typically the maximum electrical power input (in Watts) to lighting in a zone, including ballasts, if present. This value is multiplied by a schedule fraction (see previous field) to get the lighting power in a particular timestep. In EnergyPlus, this is slightly more flexible in that the lighting design level could be a “diversity factor” applied to a schedule of real numbers.

Field: Watts per Zone Floor Area

This factor (watts/m²) is used, along with the Zone Floor Area to determine the maximum lighting level as described in the Lighting Level field. The choice from the method field should be “watts/area”.

Field: Watts per Person

This factor (watts/person) is used, along with the number of occupants (people) to determine the maximum lighting level as described in the Lighting Level field. The choice from the method field should be “watts/person”.

Heat Gains from Lights:

The electrical input to lighting ultimately appears as heat that contributes to zone loads or to return air heat gains. In EnergyPlus this heat is divided into four different fractions. Three of these are given by the input fields Return Air Fraction, Fraction Radiant and Fraction Visible. A fourth, defined as the fraction of the heat from lights convected to the zone air, is calculated by the program as:

$$f_{\text{convected}} = 1.0 - (\text{Return Air Fraction} + \text{Fraction Radiant} + \text{Fraction Visible})$$

You will get an error message if Return Air Fraction + Fraction Radiant + Fraction Visible exceeds 1.0.

These fractions depend on the type of lamp and luminaire, whether the luminaire is vented to the return air, etc.

Field: Return Air Fraction

The fraction of the heat from lights that goes into the zone return air (i.e., into the zone outlet node). If the return air flow is zero or the zone has no return air system, the program will put this fraction into the zone air. Return Air Fraction should be non-zero only for luminaires that are return-air ducted (see Table 12 and Figure 41). (However, see the field “Return Air Fraction Is Calculated from Plenum Temperature,” below, for an approach to modeling the case where Return Air Fraction is caused by *conduction* between a luminaire that is in contact with a return-air plenum.)

Field: Fraction Radiant

The fraction of heat from lights that goes into the zone as long-wave (thermal) radiation. The program calculates how much of this radiation is absorbed by the inside surfaces of the zone according the area times thermal absorptance product of these surfaces.

Field: Fraction Visible

The fraction of heat from lights that goes into the zone as visible (short-wave) radiation. The program calculates how much of this radiation is absorbed by the inside surfaces of the zone according the area times solar absorptance product of these surfaces.

Approximate values of Return Air Fraction, Fraction Radiant and Fraction Visible are given in Table 12 for overhead fluorescent lighting for the luminaire configurations shown in Figure 41.

Table 12. Approximate values of Return Air Fraction, Fraction Radiant and Fraction Visible for overhead fluorescent lighting for different luminaire configurations. These values assume that no light heat goes into an adjacent zone. Source: *Lighting Handbook: Reference & Application*, 8th Edition, Illuminating Engineering Society of North America, New York, 1993, p. 355.

Field Name	Luminaire Configuration, Fluorescent Lighting				
	Suspended	Surface mount	Recessed	Luminous and louvered ceiling	Return-air ducted
Return Air Fraction	0.0	0.0	0.0	0.0	0.54
Fraction Radiant	0.42	0.72	0.37	0.37	0.18
Fraction Visible	0.18	0.18	0.18	0.18	0.18
$f_{convected}$	0.40	0.10	0.45	0.45	0.10

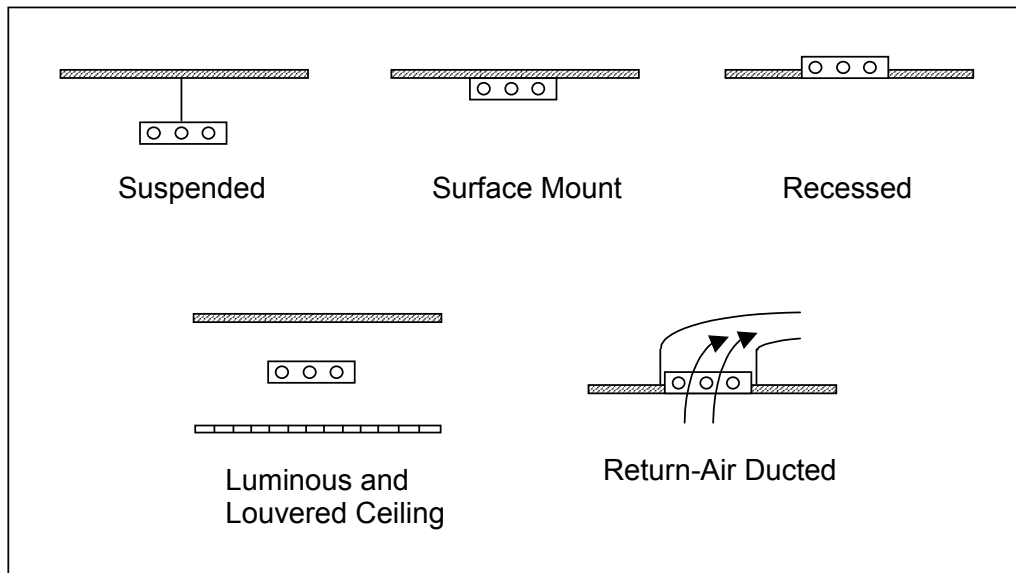


Figure 41. Overhead fluorescent luminaire configurations.

Field: Fraction Replaceable

This field defines the daylighting control for the LIGHTS object.

If **Daylighting:Controls** or **Daylighting:DELight:Controls** is specified for the zone, this field is used as an on/off flag for dimming controls. If set to 0.0, the lights are not dimmed by the daylighting controls. If set to 1.0, the lights are allowed to be dimmed by the daylighting controls.

Field: End-Use Subcategory

Allows you to specify a user-defined end-use subcategory, e.g., "Task Lights", "Hall Lights", etc. A new meter for reporting is created for each unique subcategory (ref: Output:Meter and). Subcategories are also reported in the ABUPS table. If this field is omitted or blank, the lights will be assigned to the "General" end-use subcategory.

Field: Return Air Fraction Calculated from Plenum Temperature

Accepts values Yes or No (the default). Yes is for advanced used only. In this case the program will calculate the return air fraction by assuming that it is due to conduction of some of the light heat into the zone's return air plenum and that the amount of the conduction depends on the plenum air temperature. A Yes value should only be used for luminaires that are recessed and non-vented, as shown in Figure 42.

The value you enter for the Return Air Fraction field will be ignored and you can enter, for fluorescent lighting, Fraction Radiant = 0.37 and Fraction Visible = 0.18, as indicated in Table 12.

This feature requires that the coefficients described below be determined from measurements or detailed calculations since they are very sensitive to the luminaire type, lamp type, thermal resistance between fixture and plenum, etc.

If "Return Air Fraction Is Calculated from Plenum Temperature" = Yes, the return air fraction is calculated *each timestep* from the following empirical correlation:

$$(\text{Return Air Fraction})_{\text{calculated}} = C_1 - C_2 \times T_{\text{plenum}}$$

where T_{plenum} is the previous-time-step value of the return plenum air temperature (deg C), and C_1 and C_2 are the values of the coefficients entered in the next two fields.

To compensate for the change in the return air fraction relative to its input value, the program modifies Fraction Radiant and $f_{\text{convected}}$ by a scale factor such that

$$(\text{Return Air Fraction})_{\text{calculated}} + (\text{Fraction Radiant})_{\text{modified}} + (f_{\text{convected}})_{\text{modified}} + (\text{Fraction Visible})_{\text{input}} = 1.0$$

It is assumed that Fraction Visible is a constant equal to its input value.

Field: Return Air Fraction Function of Plenum Temperature Coefficient 1

The coefficient C_1 in the equation for $(\text{Return Air Fraction})_{\text{calculated}}$.

Field: Return Air Fraction Function of Plenum Temperature Coefficient 2

The coefficient C_2 in the equation for $(\text{Return Air Fraction})_{\text{calculated}}$. Its units are $1/^\circ\text{C}$.

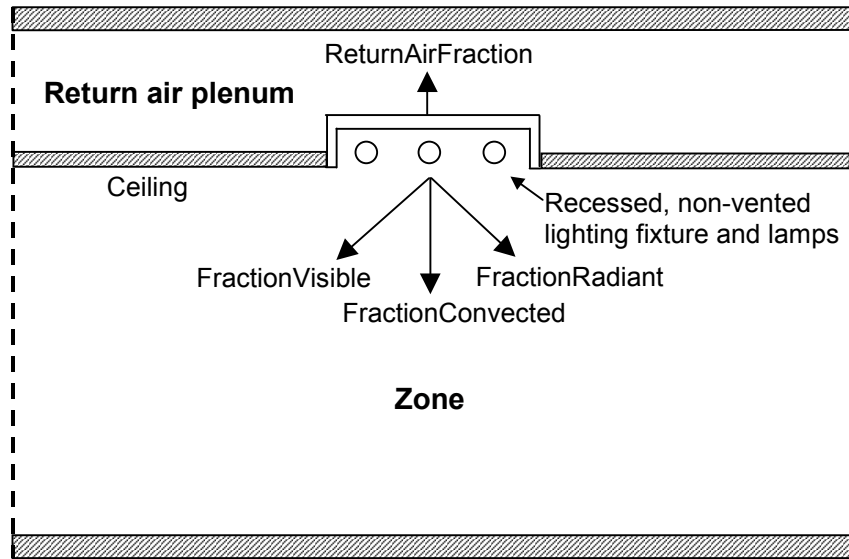


Figure 42. Vertical section through a zone and its return air plenum showing recessed lighting (not to scale). The heat from lights is divided into four fractions, three of which—ReturnAirFraction, FractionRadiant and FractionConvected—depend on plenum air temperature.

```
Lights,
  \min-fields 10
  A1 , \field Name
        \required-field
        \type alpha
        \reference LightsNames
  A2 , \field Zone Name
        \required-field
        \type object-list
        \object-list ZoneNames
  A3 , \field Schedule Name
        \required-field
        \type object-list
        \object-list ScheduleNames
        \note units in schedule should be fraction applied to design level of lights, generally (0.0 - 1.0)
  A4 , \field Design Level Calculation Method
        \note The entered calculation method is used to create the maximum amount of lights
        \note for this set of attributes
        \note Choices: LightingLevel => Lighting Level -- simply enter watts of lights
        \note Watts/Area => Watts per Zone Floor Area -- enter the number to apply. Value * Floor Area =
Lights
  \note Watts/Person => Watts per Person -- enter the number to apply. Value * Occupants = Lights
  \required-field
  \type choice
  \key LightingLevel
  \key Watts/Area
  \key Watts/Person
  \default LightingLevel
  N1 , \field Lighting Level
        \units W
        \type real
        \minimum 0
        \ip-units W
  N2 , \field Watts per Zone Floor Area
        \type real
        \minimum 0
        \units W/m2
        \ip-units W/ft2
  N3 , \field Watts per Person
        \type real
        \minimum 0
        \units W/person
```



```

\ip-units W/person
N4 , \field Return Air Fraction
\required-field
\note Used only for sizing calculation if return-air-fraction
\note coefficients are specified.
\type real
\minimum 0.0
\maximum 1.0
\default 0
N5 , \field Fraction Radiant
\required-field
\type real
\minimum 0.0
\maximum 1.0
\default 0
N6 , \field Fraction Visible
\required-field
\type real
\minimum 0.0
\maximum 1.0
\default 0
N7 , \field Fraction Replaceable
\required-field
\note For Daylighting:Controls and Daylighting:DElight:Controls,
\note must be 0 or 1: 0 = no dimming control, 1 = full dimming control
\type real
\minimum 0.0
\maximum 1.0
\default 1.0
A5 , \field End-Use Subcategory
\type alpha
\retaincase
\default General
A6 , \field Return Air Fraction Calculated from Plenum Temperature
\type choice
\key Yes
\key No
\default No
N8 , \field Return Air Fraction Function of Plenum Temperature Coefficient 1
\note Used only if Return Air Fraction Is Calculated from Plenum Temperature = Yes
\note Equation is Return Air Fraction = Coefficient#1 - Coefficient#2 X PlenumTemp(degC)
\type real
\minimum 0.0
\default 0.0
N9 ; \field Return Air Fraction Function of Plenum Temperature Coefficient 2
\note Used only if Return Air Fraction Is Calculated from Plenum Temperature = Yes
\note Equation is Return Air Fraction = Coefficient#1 - Coefficient#2 X PlenumTemp(degC)
\type real
\units 1/K
\minimum 0.0
\default 0.0

```

An IDF example:

```

Lights,
RIGHT FORK Lights 1,      !- Name
RIGHT FORK,              !- Zone Name
Office Lighting,         !- SCHEDULE Name
LightingLevel,          !- Design Level calculation method
1039.706,,,              !- Lighting Level {W}
0.0000000E+00,          !- Return Air Fraction
0.4000000,              !- Fraction Radiant
0.2000000,              !- Fraction Visible
1.0,                    !- Fraction Replaceable
GeneralLights;          !- End-Use Subcategory

```

Lights Report Outputs

If daylighting controls are operating in the zone, all of the Lights objects with a Fraction Replaceable greater than zero will be reduced by a multiplicative factor that accounts for how much the electric lighting is lowered due to daylighting.

Lights objects have output variables for individual objects and for zone totals.

```

Zone,Average,Lights Electric Power [W]
Zone,Sum,Lights Radiant Heat Gain [J]
Zone,Sum,Lights Visible Heat Gain [J]
Zone,Sum,Lights Convective Heat Gain [J]
Zone,Sum,Lights Return Air Heat Gain [J]
Zone,Sum,Lights Total Heat Gain [J]
Zone,Sum,Lights Electric Consumption [J]
Zone,Average,Zone Lights Electric Power [W]
Zone,Sum,Zone Lights Radiant Heat Gain [J]
Zone,Sum,Zone Lights Visible Heat Gain [J]
Zone,Sum,Zone Lights Convective Heat Gain [J]
Zone,Sum,Zone Lights Return Air Heat Gain [J]
Zone,Sum,Zone Lights Total Heat Gain [J]
Zone,Sum,Zone Lights Electric Consumption [J]

```

Lights Electric Power [W]

The electric power input for the lights.

Lights Radiant Heat Gain [J]

The amount of heat gain from lights that is in the form of long-wave (thermal) radiation entering the zone. This heat is absorbed by the inside surfaces of the zone according to an area times long-wave absorptance weighting scheme.

Lights Visible Heat Gain [J]

The amount of heat gain from lights that is in the form of visible (short-wave) radiation entering the zone. This heat is absorbed by the inside surfaces of the zone according to an area times short-wave absorptance weighting scheme.

Lights Convective Heat Gain [J]

The amount of heat gain from lights that is convected to the zone air.

Lights Return Air Heat Gain [J]

The amount of heat gain from lights that goes into the zone's return air (and, therefore, does not directly contribute to the zone load). If the zone has no return air system or the zone's air system is off, this heat will be added to the zone air.

Lights Total Heat Gain [J]

The total heat gain from lights. It is the sum of the following four outputs, i.e., Total Heat Gain = Return Air Heat Gain + Radiant Heat Gain + Visible Heat Gain + Convective Heat Gain. It is also equal to the electrical input to the lights.

Lights Electric Consumption [J]

The lighting electrical consumption including ballasts, if present. These will have the same value as Lights Total Heat Gain (above).

Zone Lights Electric Power [W]

The electric power input for all lights in the zone.

Zone Lights Radiant Heat Gain [J]

The amount of heat gain from all lights in the zone that is in the form of long-wave (thermal) radiation entering the zone. This heat is absorbed by the inside surfaces of the zone according to an area times long-wave absorptance weighting scheme.

Zone Lights Visible Heat Gain [J]

The amount of heat gain from all lights in the zone that is in the form of visible (short-wave) radiation entering the zone. This heat is absorbed by the inside surfaces of the zone according to an area times short-wave absorptance weighting scheme.

Zone Lights Convective Heat Gain [J]

The amount of heat gain from all lights in the zone that is convected to the zone air.

Zone Lights Return Air Heat Gain [J]

The amount of heat gain from all lights in the zone that goes into the zone's return air (and, therefore, does not directly contribute to the zone load). If the zone has no return air system or the zone's air system is off, this heat will be added to the zone air.

Zone Lights Total Heat Gain [J]

The total heat gain from all lights in the zone. It is the sum of the following four outputs, i.e., Total Heat Gain = Return Air Heat Gain + Radiant Heat Gain + Visible Heat Gain + Convective Heat Gain. It is also equal to the electrical input to the lights.

Zone Lights Electric Consumption [J]

The lighting electrical consumption for all lights in the zone including ballasts, if present. This will have the same value as Zone Lights Total Heat Gain (above). However, this amount is also shown in the Electricity meters that are associated with the zone:

- Electricity:Facility,
- Electricity:Building,
- Electricity:Zone:<Zone Name>.

In addition, depending on use, it will be shown in:

- InteriorLights: Electricity and
- InteriorLights:Electricity:Zone :<Zone Name>.

Meters for Lights Outputs

As described in the Lights Outputs, values for lights will show up on the following meters:

Table 13. Distribution of Lights to Meters

Meter Name	Scope	Lights Specifics
Electricity:Facility	Entire Facility	All
Electricity:Building	All Zones	All
Electricity:Zone:<Zone Name>	Specific Zone	All
InteriorLights:Electricity	All Zones	Lights Use
InteriorLights:Electricity:Zone:<Zone Name>	Specific Zone	Lights Use
<End-Use Subcategory>:InteriorLights:Electricity	Specific Subcategory	Lights Use

ElectricEquipment

Field: Name

The name of the ElectricEquipment object.

Field: Zone Name

This field is the name of the zone (ref: Zone) and attaches a particular electric equipment statement to a thermal zone in the building.

Field: Schedule Name

This field is the name of the schedule that modifies the design level parameter for electric equipment (see next field). The schedule values can be any positive number. The actual electrical input for equipment in a zone as defined by this statement is the product of the design level field and the value of the schedule specified by name in this field.

Field: Design Level Calculation Method

This field is a key/choice field that tells which of the next three fields are filled and is descriptive of the method for calculating the nominal electric equipment level in the Zone. The key/choices are:

- EquipmentLevel

With this choice, the method used will be a straight insertion of the electric equipment level (Watts) for the Zone. (The Design Level field should be filled.)

- Watts/Area

With this choice, the method used will be a factor per floor area of the zone. (The Watts per Zone Floor Area field should be filled).

- Watts/Person

With this choice, the method used will be a factor of equipment level (watts) per person. (The Watts per Person field should be filled).

Field: Design Level

This field (in Watts) is typically used to represent the maximum electrical input to equipment in a zone that is then multiplied by a schedule fraction (see previous field). In EnergyPlus, this is slightly more flexible in that the electric equipment design level could be a “diversity factor” applied to a schedule of real numbers. Note that while the schedule value can vary from hour to hour, the design level field is constant for all simulation environments.

Field: Watts per Zone Floor Area

This factor (watts/m²) is used, along with the Zone Area to determine the maximum equipment level as described in the Design Level field. The choice from the method field should be “Watts/Area”.

Field: Watts per Person

This factor (watts/person) is used, along with the number of occupants (people) to determine the maximum equipment level as described in the Design Level field. The choice from the method field should be “Watts/Person”.

Heat Gains from Electric Equipment:

The electrical input to the equipment ultimately appears as heat that contributes to zone loads. In EnergyPlus this heat is divided into four different fractions. Three of these are given by the input fields Fraction Latent, Fraction Radiant and Fraction Lost. A fourth, defined as the fraction of the heat from electric equipment convected to the zone air, is calculated by the program as:

$$f_{\text{convected}} = 1.0 - (\text{Fraction Latent} + \text{Fraction Radiant} + \text{Fraction Lost})$$

You will get an error message if Fraction Latent + Fraction Radiant + Fraction Lost exceeds 1.0.

Field: Fraction Latent

This field is a decimal number between 0.0 and 1.0 and is used to characterize the amount of latent heat given off by electric equipment in a zone. The number specified in this field will be multiplied by the total energy consumed by electric equipment to give the amount of latent energy produced by the electric equipment. This energy affects the moisture balance within the zone.

Field: Fraction Radiant

This field is a decimal number between 0.0 and 1.0 and is used to characterize the amount of long-wave radiant heat being given off by electric equipment in a zone. The number specified in this field will be multiplied by the total energy consumed by electric equipment to give the amount of long wavelength radiation gain from electric equipment in a zone.

Field: Fraction Lost

This field is a decimal number between 0.0 and 1.0 and is used to characterize the amount of "lost" heat being given off by electric equipment in a zone. The number specified in this field will be multiplied by the total energy consumed by electric equipment to give the amount of heat which is "lost" and does not impact the zone energy balances. This might correspond to electrical energy converted to mechanical work or heat that is vented to the atmosphere.

Field: End-Use Subcategory

Allows you to specify a user-defined end-use subcategory, e.g., "Computers", "Copy Machines", etc. A new meter for reporting is created for each unique subcategory (ref: Report Meter). Subcategories are also reported in the ABUPS table. If this field is omitted or blank, the equipment will be assigned to the "General" end-use subcategory.

```
ElectricEquipment,
  A1 , \field Name
      \required-field
      \type alpha
      \reference ElectricEquipmentNames
  A2 , \field Zone Name
      \required-field
      \type object-list
      \object-list ZoneNames
  A3 , \field Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
      \note units in schedule should be fraction applied to design level of electric equipment, generally
(0.0 - 1.0)
  A4 , \field Design Level Calculation Method
      \note The entered calculation method is used to create the maximum amount of lights
      \note for this set of attributes
      \note Choices: EquipmentLevel => Equipment Level -- simply enter watts of equipment
      \note Watts/Area => Watts per Zone Floor Area -- enter the number to apply. Value * Floor Area =
Equipment Level
      \note Watts/Person => Watts per Person -- enter the number to apply. Value * Occupants = Equipment
Level
      \required-field
      \type choice
      \key EquipmentLevel
      \key Watts/Area
      \key Watts/Person
      \default EquipmentLevel
```

```

N1 , \field Design Level
    \units W
    \type real
    \minimum 0
    \ip-units W
N2 , \field Watts per Zone Floor Area
    \type real
    \minimum 0
    \units W/m2
    \ip-units W/ft2
N3 , \field Watts per Person
    \type real
    \minimum 0
    \units W/person
    \ip-units W/person
N4 , \field Fraction Latent
    \required-field
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0
N5 , \field Fraction Radiant
    \required-field
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0
N6 , \field Fraction Lost
    \required-field
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0
A5 ; \field End-Use Subcategory
    \type alpha
    \retaincase
    \default General

```

An IDF example:

```

ElectricEquipment,
  DORM ROOMS AND COMMON AREAS ElecEq 1,  !- Name
  DORM ROOMS AND COMMON AREAS,  !- Zone Name
  Residence Equipment,  !- SCHEDULE Name
  EquipmentLevel,  !- Design Level calculation method
  9210.921,  !- Design Level {W}
  ,  !- Watts per Zone Floor Area {watts/m2}
  ,  !- Watts per Person {watts/person}
  0.0000000E+00,  !- Fraction Latent
  0.3000000,  !- Fraction Radiant
  0.0000000E+00,  !- Fraction Lost
  Computers;  !- End-use Subcategory

```

GasEquipment

Field: Name

The name of the GasEquipment object.

Field: Zone Name

This field is the name of the zone and attaches a particular gas equipment statement to a thermal zone in the building.

Field: Schedule Name

This field is the name of the schedule that modifies the design level parameter for gas equipment (see next field). The schedule values can be any positive number. The actual energy input for gas equipment in a zone as defined by this statement is the product of the design level field and the value of the schedule specified by name in this field.

Field: Design Level Calculation Method

This field is a key/choice field that tells which of the next three fields are filled and is descriptive of the method for calculating the nominal gas equipment level in the Zone. The key/choices are:

- EquipmentLevel

With this choice, the method used will be a straight insertion of the gas equipment level (Watts) for the Zone. (The Design Level field should be filled.)

- Watts/Area

With this choice, the method used will be a factor per floor area of the zone. (The Watts per Zone Floor Area field should be filled).

- Watts/Person

With this choice, the method used will be a factor of equipment level (watts) per person. (The Watts per person field should be filled).

Field: Design Level

This field (in Watts) is typically used to represent the maximum energy input to gas equipment in a zone that is then multiplied by a schedule fraction (see previous field). In EnergyPlus, this is slightly more flexible in that the gas equipment design level could be a “diversity factor” applied to a schedule of real numbers. Note that while the schedule value can vary from hour to hour, the design level field is constant for all simulation environments.

Field: Watts per Zone Floor Area

This factor (watts/m²) is used, along with the Zone Area to determine the maximum equipment level as described in the Design Level field. The choice from the method field should be “Watts/Area”.

Field: Watts per Person

This factor (watts/person) is used, along with the number of occupants (people) to determine the maximum equipment level as described in the Design Level field. The choice from the method field should be “Watts/Person”.

Heat Gains from Gas Equipment:

The fuel input to the equipment ultimately appears as heat that contributes to zone loads. In EnergyPlus this heat is divided into four different fractions. Three of these are given by the input fields Fraction Latent, Fraction Radiant and Fraction Lost. A fourth, defined as the fraction of the heat from gas equipment convected to the zone air, is calculated by the program as:

$$f_{\text{convected}} = 1.0 - (\text{Fraction Latent} + \text{Fraction Radiant} + \text{Fraction Lost})$$

You will get an error message if Fraction Latent + Fraction Radiant + Fraction Lost exceeds 1.0.

Field: Fraction Latent

This field is a decimal number between 0.0 and 1.0 and is used to characterize the amount of latent heat given off by gas equipment in a zone. The number specified in this field will be multiplied by the total energy consumed by gas equipment to give the amount of latent energy produced by the gas equipment. This energy affects the moisture balance within the zone.

Field: Fraction Radiant

This field is a decimal number between 0.0 and 1.0 and is used to characterize the amount of long-wave radiant heat being given off by gas equipment in a zone. The number specified in

this field will be multiplied by the total energy consumed by gas equipment to give the amount of long wavelength radiation gain from gas equipment in a zone.

Field: Fraction Lost

This field is a decimal number between 0.0 and 1.0 and is used to characterize the amount of "lost" heat being given off by gas equipment in a zone. The number specified in this field will be multiplied by the total energy consumed by gas equipment to give the amount of heat which is "lost" and does not impact the zone energy balances. This might correspond to input energy converted to mechanical work or heat that is vented to the atmosphere.

Field: End-Use Subcategory

Allows you to specify a user-defined end-use subcategory, e.g., "Cooking", "Clothes Drying", etc. A new meter for reporting is created for each unique subcategory (ref: Report Meter). Subcategories are also reported in the ABUPS table. If this field is omitted or blank, the equipment will be assigned to the "General" end-use subcategory.

```
GasEquipment,
  A1 , \field Name
        \required-field
        \type alpha
        \reference GasEquipmentNames
  A2 , \field Zone Name
        \required-field
        \type object-list
        \object-list ZoneNames
  A3 , \field Schedule Name
        \required-field
        \type object-list
        \object-list ScheduleNames
- 1.0)
  A4 , \field Design Level Calculation Method
        \note The entered calculation method is used to create the maximum amount of lights
        \note for this set of attributes
        \note Choices: EquipmentLevel => Equipment Level -- simply enter watts of equipment
        \note Watts/Area => Watts per Zone Floor Area -- enter the number to apply. Value * Floor Area =
Equipment Level
Level
\note Watts/Person => Watts per Person -- enter the number to apply. Value * Occupants = Equipment
Level
  \required-field
  \type choice
  \key EquipmentLevel
  \key Watts/Area
  \key Watts/Person
  \default EquipmentLevel
  N1 , \field Design Level
        \units W
        \type real
        \minimum 0
        \ip-units W
  N2 , \field Watts per Zone Floor Area
        \type real
        \minimum 0
        \units W/m2
  N3 , \field Watts per Person
        \type real
        \minimum 0
        \units W/Person
```



```

N4 , \field Fraction Latent
    \required-field
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0
N5 , \field Fraction Radiant
    \required-field
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0
N6 , \field Fraction Lost
    \required-field
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0
A5 ; \field End-Use Subcategory
    \type alpha
    \retaincase
    \default General

```

An IDF example:

```

GasEquipment,
  DORM ROOMS AND COMMON AREAS GasEq 1,  !- Name
  DORM ROOMS AND COMMON AREAS,  !- Zone Name
  Gas Eq Sch,  !- SCHEDULE Name
  EquipmentLevel,  !- Design Level calculation method
  29287.51,  !- Design Level {W}
  ,  !- Watts per Zone Floor Area {watts/m2}
  ,  !- Watts per Person {watts/person}
  0,  !- Fraction Latent
  0.3,  !- Fraction Radiant
  0,  !- Fraction Lost
  Cooking;  !- End-Use Subcategory

```

OtherEquipment, HotWaterEquipment, SteamEquipment

In addition to Electric and Gas equipment types, Other (unspecified source), Hot Water and Steam equipment types are available. One notable feature of the OtherEquipment is that the Design Level field can have negative (heat loss) values. The definitions are the same as for GasEquipment.

IDF Examples:

```

HotWaterEquipment,
  SPACE2-1 HWEq 1,  !- Name
  SPACE2-1,  !- Zone Name
  EQUIP-1,  !- SCHEDULE Name
  EquipmentLevel,  !- Design Level calculation method
  300,  !- Design Level {W}
  ,  !- Watts per Zone Floor Area {watts/m2}
  ,  !- Watts per Person {watts/person}
  0.2,  !- Fraction Latent
  0.1,  !- Fraction Radiant
  0.5,  !- Fraction Lost
  Dishwashing;  !- End-Use Subcategory

```

```

SteamEquipment,
  SPACE4-1 ElecEq 1,      !- Name
  SPACE4-1,              !- Zone Name
  EQUIP-1,               !- SCHEDULE Name
  EquipmentLevel,       !- Design Level calculation method
  1050,                  !- Design Level {W}
  ,                      !- Watts per Zone Floor Area {watts/m2}
  ,                      !- Watts per Person {watts/person}
  0.5,                   !- Fraction Latent
  0.3,                   !- Fraction Radiant
  0,                     !- Fraction Lost
  Laundry;               !- End-Use Subcategory

```

```

OtherEquipment,
  BASE-1 OthEq 1,       !- Name
  BASE-1,               !- Zone Name
  ALWAYSON,             !- SCHEDULE Name
  EquipmentLevel,       !- Design Level calculation method
  6766.,                 !- Design Level {W}
  ,                      !- Watts per Zone Floor Area {watts/m2}
  ,                      !- Watts per Person {watts/person}
  0,                     !- Fraction Latent
  0.3,                   !- Fraction Radiant
  0;                     !- Fraction Lost

```

Electric, Gas, Other, HotWater, Steam Equipment Outputs

Each type of equipment object has output variables for individual objects and for zone totals.

Electric Equipment

```

Zone,Average,Electric Equipment Electric Power [W]
Zone,Sum,Electric Equipment Radiant Heat Gain [J]
Zone,Sum,Electric Equipment Convective Heat Gain [J]
Zone,Sum,Electric Equipment Latent Heat Gain [J]
Zone,Sum,Electric Equipment Lost Heat Gain [J]
Zone,Sum,Electric Equipment Total Heat Gain [J]
Zone,Sum,Electric Equipment Electric Consumption [J]
Zone,Average,Zone Electric Equipment Electric Power [W]
Zone,Sum,Zone Electric Equipment Radiant Heat Gain [J]
Zone,Sum,Zone Electric Equipment Convective Heat Gain [J]
Zone,Sum,Zone Electric Equipment Latent Heat Gain [J]
Zone,Sum,Zone Electric Equipment Lost Heat Gain [J]
Zone,Sum,Zone Electric Equipment Total Heat Gain [J]
Zone,Sum,Zone Electric Equipment Electric Consumption [J]

```

Gas Equipment

```

Zone,Average,Gas Equipment Gas Consumption Rate [W]
Zone,Sum,Gas Equipment Radiant Heat Gain [J]
Zone,Sum,Gas Equipment Convective Heat Gain [J]
Zone,Sum,Gas Equipment Latent Heat Gain [J]
Zone,Sum,Gas Equipment Lost Heat Gain [J]
Zone,Sum,Gas Equipment Total Heat Gain [J]
Zone,Sum,Gas Equipment Gas Consumption [J]
Zone,Average,Zone Gas Equipment Gas Consumption Rate [W]
Zone,Sum,Zone Gas Equipment Radiant Heat Gain [J]
Zone,Sum,Zone Gas Equipment Convective Heat Gain [J]
Zone,Sum,Zone Gas Equipment Latent Heat Gain [J]
Zone,Sum,Zone Gas Equipment Lost Heat Gain [J]
Zone,Sum,Zone Gas Equipment Total Heat Gain [J]
Zone,Sum,Zone Gas Equipment Gas Consumption [J]

```

HotWater Equipment

Zone,Average,Hot Water Equipment Purchased Heating Consumption Rate [W]
 Zone,Sum,Hot Water Equipment Radiant Heat Gain [J]
 Zone,Sum,Hot Water Equipment Convective Heat Gain [J]
 Zone,Sum,Hot Water Equipment Latent Heat Gain [J]
 Zone,Sum,Hot Water Equipment Lost Heat Gain [J]
 Zone,Sum,Hot Water Equipment Total Heat Gain [J]
 Zone,Sum,Hot Water Equipment Purchased Heating Consumption [J]
 Zone,Average,Zone Hot Water Equipment Purchased Heating Consumption Rate [W]
 Zone,Sum,Zone Hot Water Equipment Radiant Heat Gain [J]
 Zone,Sum,Zone Hot Water Equipment Convective Heat Gain [J]
 Zone,Sum,Zone Hot Water Equipment Latent Heat Gain [J]
 Zone,Sum,Zone Hot Water Equipment Lost Heat Gain [J]
 Zone,Sum,Zone Hot Water Equipment Total Heat Gain [J]
 Zone,Sum,Zone Hot Water Equipment Purchased Heating Consumption [J]

Steam Equipment

Zone,Average,Steam Equipment Purchased Heating Consumption Rate [W]
 Zone,Sum,Steam Equipment Radiant Heat Gain [J]
 Zone,Sum,Steam Equipment Convective Heat Gain [J]
 Zone,Sum,Steam Equipment Latent Heat Gain [J]
 Zone,Sum,Steam Equipment Lost Heat Gain [J]
 Zone,Sum,Steam Equipment Total Heat Gain [J]
 Zone,Sum,Steam Equipment Purchased Heating Consumption [J]
 Zone,Average,Zone Steam Equipment Purchased Heating Consumption Rate [W]
 Zone,Sum,Zone Steam Equipment Radiant Heat Gain [J]
 Zone,Sum,Zone Steam Equipment Convective Heat Gain [J]
 Zone,Sum,Zone Steam Equipment Latent Heat Gain [J]
 Zone,Sum,Zone Steam Equipment Lost Heat Gain [J]
 Zone,Sum,Zone Steam Equipment Total Heat Gain [J]
 Zone,Sum,Zone Steam Equipment Purchased Heating Consumption [J]

Other Equipment

Zone,Sum,Other Equipment Radiant Heat Gain [J]
 Zone,Sum,Other Equipment Convective Heat Gain [J]
 Zone,Sum,Other Equipment Latent Heat Gain [J]
 Zone,Sum,Other Equipment Lost Heat Gain [J]
 Zone,Sum,Other Equipment Total Heat Gain [J]
 Zone,Sum,Zone Other Equipment Radiant Heat Gain [J]
 Zone,Sum,Zone Other Equipment Convective Heat Gain [J]
 Zone,Sum,Zone Other Equipment Latent Heat Gain [J]
 Zone,Sum,Zone Other Equipment Lost Heat Gain [J]
 Zone,Sum,Zone Other Equipment Total Heat Gain [J]

Electric Equipment Electric Power [W]

Gas Equipment Gas Consumption Rate [W]

Hot Water Equipment Purchased Heating Consumption Rate [W]

Steam Equipment Purchased Heating Consumption Rate [W]

This field is the energy consumption rate for the equipment object in Watts.

Electric Equipment Radiant Heat Gain [J]

Gas Equipment Radiant Heat Gain [J]

Hot Water Equipment Radiant Heat Gain [J]

Steam Equipment Radiant Heat Gain [J]

Other Equipment Radiant Heat Gain [J]

This field is the amount of radiant heat gain for the equipment object in Joules. This is determined by the current heat gain from the equipment to the zone and the “Fraction Radiant” specified in the input. The radiant gains (long wavelength) are distributed to the surfaces using an area weighting scheme.

Electric Equipment Convective Heat Gain [J]***Gas Equipment Convective Heat Gain [J]******Hot Water Equipment Convective Heat Gain [J]******Steam Equipment Convective Heat Gain [J]******Other Equipment Convective Heat Gain [J]***

This field is the amount of convective heat gain for the equipment object in Joules. This is determined by the current heat gain from the equipment to the zone and the “Fraction Radiant”, “Fraction Lost”, “Fraction Latent” specified in input (1-FractionRadiant-FractionLost-FractionLatent = FractionConvected). The convective heat gain is added to the zone air heat balance directly.

Electric Equipment Latent Heat Gain [J]***Gas Equipment Latent Heat Gain [J]******Hot Water Equipment Latent Heat Gain [J]******Steam Equipment Latent Heat Gain [J]******Other Equipment Latent Heat Gain [J]***

This field is the amount of latent heat gain for the equipment object in Joules. This is determined by the current heat gain from the equipment to the zone and the “Fraction Latent” specified in the input.

Electric Equipment Lost Heat Gain [J]***Gas Equipment Lost Heat Gain [J]******Hot Water Equipment Lost Heat Gain [J]******Steam Equipment Lost Heat Gain [J]******Other Equipment Lost Heat Gain [J]***

This field is the amount of “lost” heat gain for the equipment object in Joules. This is determined by the current heat gain from the equipment to the zone and the “Fraction Lost” specified in the input. This amount does not affect the energy heat balance in the zone.

Electric Equipment Total Heat Gain [J]***Gas Equipment Total Heat Gain [J]******Hot Water Equipment Total Heat Gain [J]******Steam Equipment Total Heat Gain [J]******Other Equipment Total Heat Gain [J]***

The total heat gain field is sum of several other fields (radiant, latent, convective). This field is expressed in joules.

Electric Equipment Electric Consumption [J]

The electric equipment consumption field is sum of the other fields (radiant, latent, convective, lost). This field is expressed in joules.

Gas Equipment Gas Consumption [J]

The gas equipment consumption field is sum of the other fields (radiant, latent, convective, lost). This field is expressed in joules.

Hot Water Equipment Purchased Heating Consumption [J]***Steam Equipment Purchased Heating Consumption [J]***

The equipment consumption field is sum of the other fields (radiant, latent, convective, lost). This field is expressed in joules.

Zone Electric Equipment Electric Power [W]***Zone Gas Equipment Gas Consumption Rate [W]******Zone Hot Water Equipment Purchased Heating Consumption Rate [W]******Zone Steam Equipment Purchased Heating Consumption Rate [W]***

This field is the energy consumption rate for all equipment within the zone in Watts.

Zone Electric Equipment Radiant Heat Gain [J]***Zone Gas Equipment Radiant Heat Gain [J]******Zone Hot Water Equipment Radiant Heat Gain [J]******Zone Steam Equipment Radiant Heat Gain [J]******Zone Other Equipment Radiant Heat Gain [J]***

This field is the amount of radiant heat gain for all equipment within the zone in Joules. This is determined by the current heat gain from the equipment to the zone and the “Fraction Radiant” specified in the input. The radiant gains (long wavelength) are distributed to the surfaces using an area weighting scheme.

Zone Electric Equipment Convective Heat Gain [J]***Zone Gas Equipment Convective Heat Gain [J]******Zone Hot Water Equipment Convective Heat Gain [J]******Zone Steam Equipment Convective Heat Gain [J]******Zone Other Equipment Convective Heat Gain [J]***

This field is the amount of convective heat gain for all equipment within the zone in Joules. This is determined by the current heat gain from the equipment to the zone and the “Fraction Radiant”, “Fraction Lost”, “Fraction Latent” specified in input ($1 - \text{FractionRadiant} - \text{FractionLost} - \text{FractionLatent} = \text{FractionConvected}$). The convective heat gain is added to the zone air heat balance directly.

Zone Electric Equipment Latent Heat Gain [J]***Zone Gas Equipment Latent Heat Gain [J]******Zone Hot Water Equipment Latent Heat Gain [J]******Zone Steam Equipment Latent Heat Gain [J]******Zone Other Equipment Latent Heat Gain [J]***

This field is the amount of latent heat gain for all equipment within the zone in Joules. This is determined by the current heat gain from the equipment to the zone and the “Fraction Latent” specified in the input.

Zone Electric Equipment Lost Heat Gain [J]***Zone Gas Equipment Lost Heat Gain [J]******Zone Hot Water Equipment Lost Heat Gain [J]******Zone Steam Equipment Lost Heat Gain [J]******Zone Other Equipment Lost Heat Gain [J]***

This field is the amount of “lost” heat gain for all equipment within the zone in Joules. This is determined by the current heat gain from the equipment to the zone and the “Fraction Lost” specified in the input. This amount does not affect the energy heat balance in the zone.

Zone Electric Equipment Total Heat Gain [J]***Zone Gas Equipment Total Heat Gain [J]******Zone Hot Water Equipment Total Heat Gain [J]******Zone Steam Equipment Total Heat Gain [J]******Zone Other Equipment Total Heat Gain [J]***

The total heat gain field is sum of several other fields (radiant, latent, convective) for all equipment in the zone. This field is expressed in joules.

Zone Electric Equipment Electric Consumption [J]

The electric equipment consumption field is sum of the other fields (radiant, latent, convective, lost) for all equipment in the zone. This field is expressed in joules. This amount is also shown in the Electricity meters that are associated with the zone – Electricity:Facility, Electricity:Building, Electricity:Zone:<Zone Name>, and InteriorEquipment:Electricity.

Zone Gas Equipment Gas Consumption [J]

The gas equipment consumption field is sum of the other fields (radiant, latent, convective, lost) for all equipment in the zone. This field is expressed in joules. This amount is also shown in the Gas meters that are associated with the zone – Gas:Facility, Gas:Building, Gas:Zone:<Zone Name>, and InteriorEquipment:Gas. Gas, here, refers to “Natural Gas” fuel.

Zone Hot Water Equipment Purchased Heating Consumption [J]***Zone Steam Equipment Purchased Heating Consumption [J]***

The equipment consumption field is sum of the other fields (radiant, latent, convective, lost) for all equipment in the zone. This field is expressed in joules. These amounts are shown on the PurchasedHeating meters.

Note that zone energy consumption is not reported for OTHER EQUIPMENT and does not go on any meter.

ZoneBaseboard:OutdoorTemperatureControlled

This object specifies outside temperature-controlled (OTC) baseboard heating. The capacities (high and low) are specified in W at the temperatures specified. The schedule allows both capacities to change hourly on a proportional basis. This baseboard heater does not operate if the outdoor dry-bulb is above the high temperature limit. Between the high temperature and the low temperature, the capacity is interpolated (linear) between the high and the low capacity values. Below the low temperature, the capacity is set at the low

capacity value. This allows the user to add baseboard heat to a perimeter zone starting at a prescribed temperature and then slowly increases this capacity to a max value.

Example:

Temperature High = 10 C Capacity High = 100,000 W

Temperature Low = 0 C Capacity Low = 500,000 W

Table 14. Outdoor Temperature Controlled Baseboard Heat Temperature vs. Capacity

Outdoor Dry-bulb(C)	Baseboard Output
>10	0
10	100,000
8	180,000
6	260,000
4	340,000
2	420,000
0	500,000
< 0	500,000

Field: Name

The name of the ZoneBaseboard:OutdoorTemperatureControlled object.

Field: Zone Name

This field is the name of the zone and attaches the baseboard heat equipment statement to a thermal zone in the building.

Field: Schedule Name

This field is the name of the schedule that modifies the capacities (high and low) for baseboard heat equipment (see next field). The schedule values can be any positive number. The actual energy input for the baseboard equipment in a zone as defined by this statement depends on the actual outdoor temperature and where that temperature is in the range of Low Temperature to High Temperature..

Field: Capacity at Low Temperature

This is the baseboard equipment capacity (Watts) at the low temperature limit.

Field: Low Temperature

If the outdoor dry-bulb temperature (degrees Celsius) is at or below the low temperature the baseboard heater operates at the low temperature capacity.

Field: Capacity at High Temperature

This is the baseboard equipment capacity (Watts) at the high temperature limit.

Field: High Temperature

If the outdoor dry-bulb temperature (degrees Celsius) is greater than the high temperature the baseboard heater will not operate.

Field: Fraction Radiant

This field is a decimal number between 0.0 and 1.0 and is used to characterize the type of heat being given off by baseboard heat equipment in a zone. The number specified in this field will be multiplied by the total energy consumed by the baseboard heat equipment to give the amount of long wavelength radiation gain to the zone.

Field: End-Use Subcategory

Allows you to specify a user-defined end-use subcategory, e.g., "Perimeter Baseboards", etc. A new meter for reporting is created for each unique subcategory (ref: Report Meter). Subcategories are also reported in the ABUPS table. If this field is omitted or blank, the baseboard equipment will be assigned to the "General" end-use subcategory.

```

ZoneBaseboard:OutdoorTemperatureControlled,
  A1 , \field Name
      \required-field
      \type alpha
      \reference BaseboardHeatNames
  A2 , \field Zone Name
      \required-field
      \type object-list
      \object-list ZoneNames
  A3 , \field Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
      \note units in Schedule should be fraction applied to capacity of the baseboard heat equipment,
generally (0.0 - 1.0)
  N1 , \field Capacity at Low Temperature
      \required-field
      \type real
      \units W
      \minimum > 0
  N2 , \field Low Temperature
      \required-field
      \units C
      \type real
  N3 , \field Capacity at High Temperature
      \required-field
      \type real
      \units W
      \minimum 0
  N4 , \field High Temperature
      \required-field
      \units C
      \type real
  N5 , \field Fraction Radiant
      \required-field
      \type real
      \minimum 0.0
      \maximum 1.0
      \default 0
  A4 ; \field End-Use Subcategory
      \type alpha
      \retaincase
      \default General

```

An IDF example:

```

ZoneBaseboard:OutdoorTemperatureControlled,
SPACE4-1 BBHeat 1,      !- Name
SPACE4-1,              !- Zone Name
EQUIP-1,               !- SCHEDULE Name
1500,                  !- Capacity at low temperature {W}
0,                     !- Low Temperature {C}
500,                   !- Capacity at high temperature {W}
10,                    !- High Temperature {C}
0.5,                   !- Fraction Radiant
Baseboard Heat;       !- End-Use Subcategory

```

ZoneBaseboard:OutdoorTemperatureControlled Output

ZoneBaseboard:OutdoorTemperatureControlled objects have output variables for individual objects and for zone totals. The following outputs are available:

```

Zone,Average,Baseboard Heat Electric Power [W]
Zone,Sum,Baseboard Heat Radiant Heat Gain [J]

```


Zone, Sum, Baseboard Heat Convective Heat Gain [J]
Zone, Sum, Baseboard Heat Total Heat Gain [J]
Zone, Sum, Baseboard Heat Electric Consumption [J]
Zone, Average, Zone Baseboard Heat Electric Power [W]
Zone, Sum, Zone Baseboard Heat Radiant Heat Gain [J]
Zone, Sum, Zone Baseboard Heat Convective Heat Gain [J]
Zone, Sum, Zone Baseboard Heat Total Heat Gain [J]
Zone, Sum, Zone Baseboard Heat Electric Consumption [J]

Baseboard Heat Electric Power [W]

This field is the electric power for the BASEBOARD HEAT object in Watts.

Baseboard Heat Radiant Heat Gain [J]

This field is the amount of radiant heat gain for the BASEBOARD HEAT object in Joules. This is determined by the current heat gain from the heater to the zone and the “Fraction Radiant” specified in the input. The radiant gains (long wavelength) are distributed to the surfaces using an area weighting scheme.

Baseboard Heat Convective Heat Gain [J]

This field is the amount of convective heat gain for the BASEBOARD HEAT object in Joules. This is determined by the current heat gain from the heater to the zone and the “Fraction Radiant” specified in input ($1 - \text{FractionRadiant} = \text{FractionConvected}$). The convective heat gain is added to the zone air heat balance directly.

Baseboard Heat Total Heat Gain [J]

This field is the total amount of heat gain for the BASEBOARD HEAT object in Joules. This is determined by the sum of the radiant and convective heat gains from the baseboard heat.

Baseboard Heat Electric Consumption [J]

The outdoor temperature controlled baseboard heat option is assumed to be fueled by electricity. This field is the same as the Baseboard Heat Total Heat Gain (above) in joules.

Zone Baseboard Heat Electric Power [W]

This field is the electric power for all BASEBOARD HEAT objects within the zone in Watts.

Zone Baseboard Heat Radiant Heat Gain [J]

This field is the amount of radiant heat gain for all BASEBOARD HEAT objects within the zone in Joules. This is determined by the current heat gain from the heater to the zone and the “Fraction Radiant” specified in the input. The radiant gains (long wavelength) are distributed to the surfaces using an area weighting scheme.

Zone Baseboard Heat Convective Heat Gain [J]

This field is the amount of convective heat gain for all BASEBOARD HEAT objects within the zone in Joules. This is determined by the current heat gain from the heater to the zone and the “Fraction Radiant” specified in input ($1 - \text{FractionRadiant} = \text{FractionConvected}$). The convective heat gain is added to the zone air heat balance directly.

Zone Baseboard Heat Total Heat Gain [J]

This field is the total amount of heat gain for all BASEBOARD HEAT objects within the zone in Joules. This is determined by the sum of the radiant and convective heat gains from the baseboard heat.

Zone Baseboard Heat Electric Consumption [J]

The outdoor temperature controlled baseboard heat option is assumed to be fueled by electricity. This field is the same as the Baseboard Heat Total Heat Gain (above) in joules. However, this amount is also shown in the Electricity meters that are associated with the

zone – Electricity:Facility, Electricity:Building, Electricity:Zone:<Zone Name>, and InteriorEquipment:Electricity.

Meters for Equipment Outputs

As described in each of the equipment sections, values for specific equipments will show up on the following meters:

Table 15. Distribution of Equipment to Meters

Meter Name	Scope	Equipment Specifics
Electricity:Facility	Entire Facility	Electric Equipment, OTC Baseboard Heat
Electricity:Building	All Zones	Electric Equipment, OTC Baseboard Heat
Electricity:Zone:<Zone Name>	Specific Zone	Electric Equipment, OTC Baseboard Heat
InteriorEquipment:Electricity	AllZones	Electric Equipment, OTC Baseboard Heat
<End-Use Subcategory>:InteriorEquipment:Electricity	Specific Subcategory	Electric Equipment, OTC Baseboard Heat
Gas:Facility	Entire Facility	Gas Equipment
Gas:Building	All Zones	Gas Equipment
Gas:Zone:<Zone Name>	Specific Zone	Gas Equipment
InteriorEquipment:Gas	AllZones	Gas Equipment
<End-Use Subcategory>:InteriorEquipment:Gas	Specific Subcategory	Gas Equipment

Group – Daylighting

Daylighting can be invoked in EnergyPlus by the use of two objects: **Daylighting:Controls** and **Daylighting:DELight:Controls**. These are described in the following object descriptions.

```

Daylighting dimming controls for the Lights object are activated by setting the Fraction Replaceable field to 1. Setting the field to 0 turns off the dimming controls.
Lights,
  Office Lights 1,          !- Name
  Main Office,             !- Zone Name
  Office Lights Schedule, !- Schedule Name
  LightingLevel,          !- Design Level calculation method
  1039.706, ,,            !- Lighting Level {W}
  0.0,                    !- Return Air Fraction
  0.35,                    !- Fraction Radiant
  0.25,                    !- Fraction Visible
  1.0,                    !- Fraction Replaceable -- activates dimming control by DAYLIGHTING objects
  Ambient Lighting;       !- End-Use Subcategory
    
```

Prior to version 1.3, dimming control was activated by setting the End-Use Subcategory (formerly called LightsEndUseKey) to "GeneralLights" when desired, and deactivated by setting to "TaskLights" when not desired.

Note that Daylighting:Controls and Daylighting:DELight:Controls objects may be intermixed in a single IDF but may not be used in the same zone.

Daylighting:Controls

In this method daylighting illuminance levels are calculated and then used to determine how much the electric lighting can be reduced. The daylight illuminance level in a zone depends on many factors, including sky condition; sun position; calculation point; location, size, and glass transmittance of windows; window shading devices; and reflectance of interior surfaces. Reduction of electric lighting depends on daylight illuminance level, illuminance set point, fraction of zone controlled and type of lighting control.

Field: Zone name

The name of the zone to which the following daylighting-related input applies.

Field: Total Daylighting Reference Points

Allowed values are 1 or 2. This is the number of reference points in the zone at which horizontal daylighting illuminance will be calculated based on input for the following fields. It is assumed that the photocells that control the overhead electric lighting respond to the light levels at the specified reference points.

Fields: (X,Y,Z) of First Reference Point

Required if Total Daylighting Reference Points = 1 or 2. These three fields are the X, Y and Z values of the First Reference point in the coordinate system you specified for daylighting reference points in the GlobalGeometryRules object. Figure 43 shows an example using the relative coordinate (to zone) system. Z is typically at desk height (0.8 m).

If you want to divide a thermal zone into two independently-controlled lighting zones, then Total Daylighting Reference Points should be set to 2 and (X,Y,Z) of the Second Reference Point (see following input fields) should also be specified.

Fields: (X,Y,Z) of Second Reference Point

The X, Y, and Z coordinates, in the same coordinate system, of the second daylighting reference point. Required if Total Daylighting Reference Points = 2. See Figure 43 for an example.

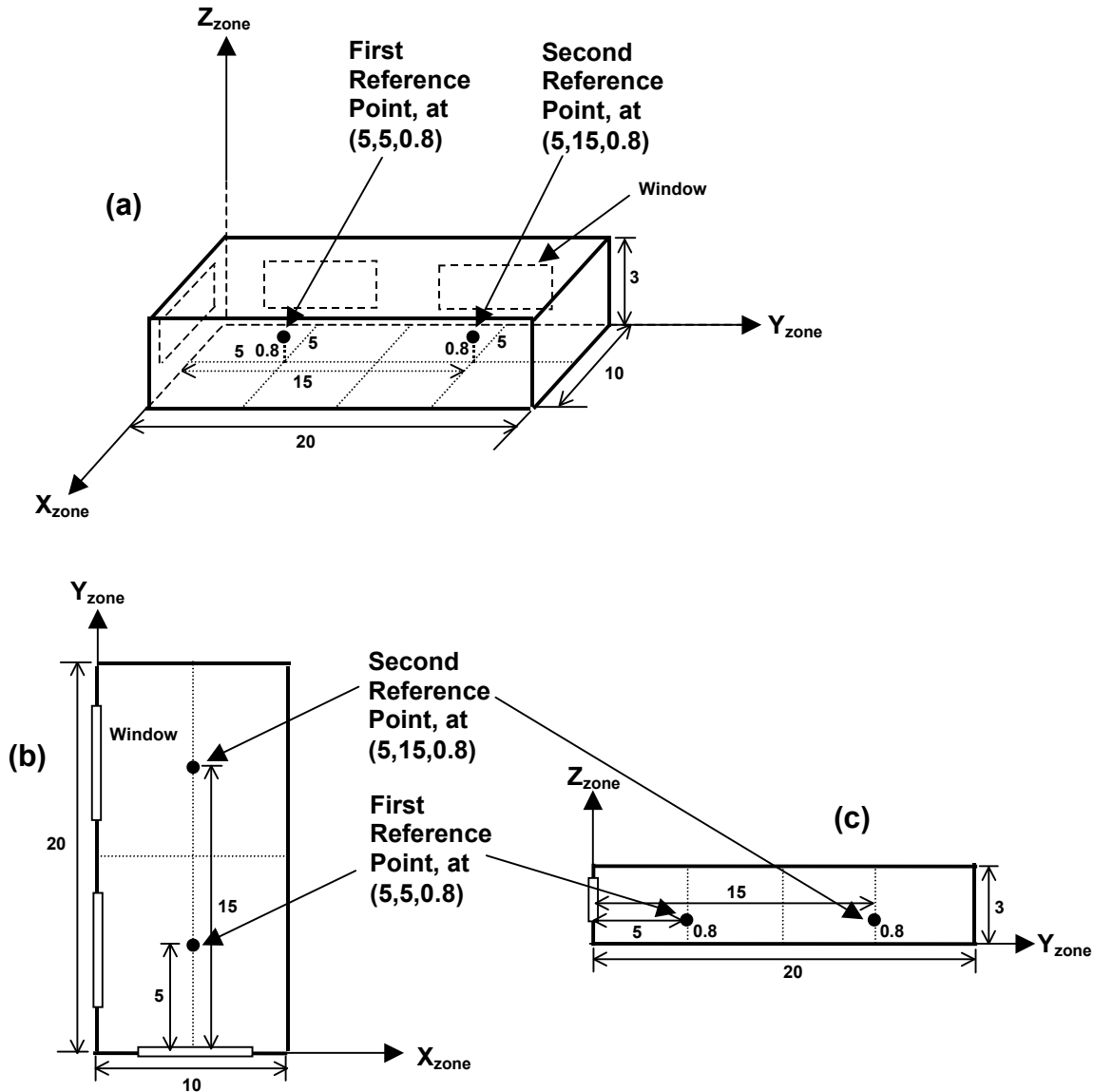


Figure 43. Example showing location of daylighting reference points in the zone coordinate system (relative) of a rectangular zone with three windows. (a) Perspective view, (b) plan view, (c) elevation view. All dimensions are in meters.

Field: Fraction of Zone Controlled by First Reference Point

The fraction of the zone’s floor-area whose electric lighting is controlled by the daylight illuminance at the First Reference Point. If there is only one reference point then a fraction equal to

$$1.0 - (\text{Fraction of Zone Controlled by First Reference Point})$$

is assumed to have no lighting control.

Field: Fraction of Zone Controlled by Second Reference Point

The fraction of the zone’s floor-area whose electric lighting is controlled by the daylight illuminance at the Second Reference Point. Required if Total Daylighting Reference Points = 2. A fraction equal to

$$1.0 - ([\text{Fraction of Zone Controlled by First Reference Point}] + [\text{Fraction of Zone Controlled by Second Reference Point}])$$

is assumed to have no lighting control.

Field: Illuminance SetPoint at First Reference Point

The desired lighting level (in lux) at the First Reference Point. This is the lighting level that would be produced at this reference point at night if the overhead electric lighting were operating at full input power. Recommended values depend on type of activity; they may be found, for example, in the Lighting Handbook of the Illuminating Engineering Society of North America. A typical value for general office work (excluding computer terminals) is 500 lux.

Field: Illuminance SetPoint at Second Reference Point

The desired lighting level (in lux) at the Second Reference Point. Required if Total Daylighting Reference Points = 2. This is the lighting level that would be produced at this reference point at night if the overhead electric lighting were operating at full input power.

Field: Lighting Control Type

The type of overhead electric lighting control. All reference points specified are assumed to have this type of control.

For Lighting Control Type = 1 (continuous), the overhead lights dim continuously and linearly from (maximum electric power, maximum light output) to (minimum electric power, minimum light output) as the daylight illuminance increases. The lights stay on at the minimum point with further increase in the daylight illuminance.

For Lighting Control Type = 2 (stepped), the electric power input and light output vary in discrete, equally spaced steps. The number of steps is given by Number of Steps (Excluding Off) of Stepped Control. For example, if Number of Steps = 3 and Illuminance Setpoint = 600, then the following table shows the fraction of the lights that are on vs. daylight illuminance.

Table 16. Stepped Lighting Control Example

Example of a Stepped Lighting Control System with Three Steps	
Daylight illuminance	Fraction of lights that are on
0-200	1.0
200-400	2/3
400-600	1/3
600 and above	0.0

Lighting Control Type = 3 (continuous/off) is the same as Lighting Control Type = 1 except that the lights switch off completely when the minimum dimming point is reached.

Field: Glare Calculation Azimuth Angle of View Direction Clockwise from Zone y-Axis

Daylight glare from a window depends on occupant view direction. It is highest when you look directly at a window and decreases as you look away from a window. This field specifies the view direction for calculating glare. It is the angle, measured clockwise in the horizontal plane, between the zone y-axis and the occupant view direction.

Field: Maximum Allowable Discomfort Glare Index

If a daylit zone has windows with shading devices (except exterior screens), the shades will be deployed if the daylight glare at the First Reference Point exceeds the value of this field. To get this type of glare control you have to specify Trigger = Glare, GlareOrSolarOnWindow, GlareOrHorizontalSolar, GlareOrOutsideAirTemp, GlareOrZoneAirTemp or GlareOrZoneLoad in WindowProperty:ShadingControl for one or more windows in the zone (see WindowProperty:ShadingControl).

If a zone has two or more windows with glare control, the shading devices will be deployed one by one in the order in which the windows are input until the glare level at each reference point falls below Maximum Allowable Discomfort Glare Index or is as close as possible to it.

The following table gives recommended values of Maximum Allowable Discomfort Glare Index.

Table 17. Recommended Values -- Discomfort Glare Index

Recommended Values of Maximum Allowable Discomfort Glare Index	
Activity or zone type	Maximum Allowable Discomfort Glare Index
Art Galleries	16
<i>Factories</i>	
Rough work	28
Engine assembly	26
Fine assembly	24
Instrument assembly	22
Hospital wards	18
Laboratories	22
Museums	20
Offices	22
School classrooms	20

Field: Minimum Input Power Fraction for Continuous Dimming Control

For Lighting Control Type = 1 (continuous), the lowest power the lighting system can dim down to, expressed as a fraction of maximum input power (see figure, below). For Lighting Control Type = 3 (continuous/off) this is the power fraction reached just before the lights switch off completely.

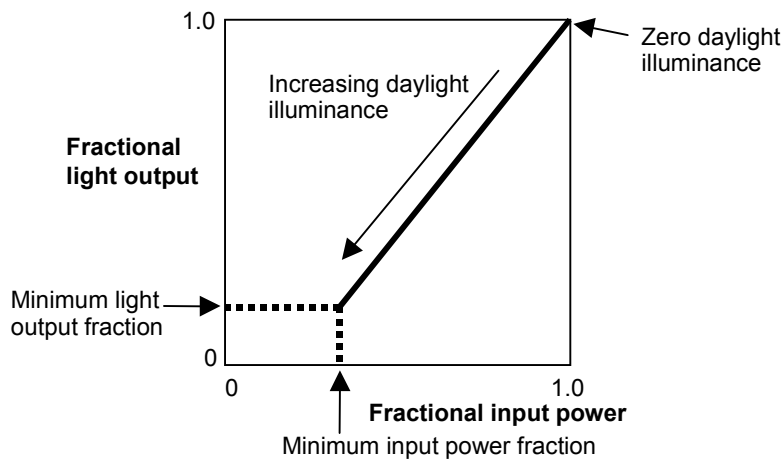


Figure 44. Illustration of continuous dimming relationship

The figure above shows the relationship between electric light output and electrical input.

Field: Minimum Light Output Fraction for Continuous Dimming Control

For Lighting Control Type = 1 (continuous), the lowest lighting output the lighting system can dim down to, expressed as a fraction of maximum light output (see figure, above). This is the

fractional light output that the system produces at minimum input power. For Lighting Control Type = 3 (continuous/off) this is the power fraction reached just before the lights switch off completely.

Field: Number of Stepped Control Steps

The number of steps, excluding off, in a stepped lighting control system (see figure, below). Required and must be >0 if Lighting Control Type = 2. The steps are assumed to be equally spaced.

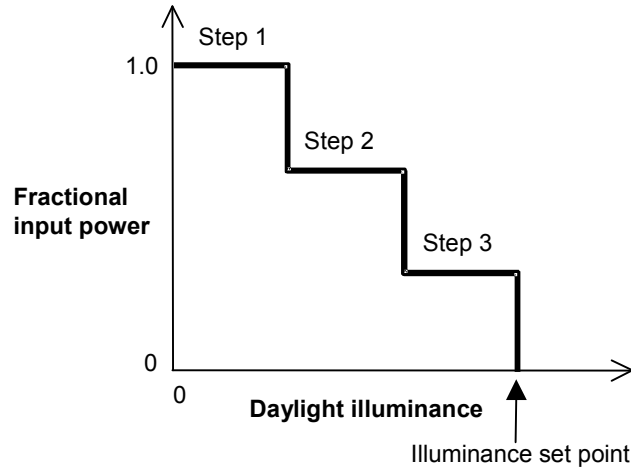


Figure 45. Stepped lighting control with Number of Steps = 3.

Field: Probability Lighting will be Reset When Needed in Manual Stepped Control

May be specified if a stepped lighting control system (Lighting Control Type = 2) is manually operated, such as in a simple, one-step (on-off) system. Gives the probability the occupants of a daylit zone will set the electric lights to the correct level to obtain the required illuminance. The rest of the time the lights are assumed to be set one step too high. For example, consider an on-off lighting system (Number of Steps = 1) with a set point of 600 lux and 0.7 reset probability. Then, when daylighting exceeds 600 lux, the electric lights will be off 70% of the time and on 30% of the time.

```
Daylighting:Controls,
  \min-fields 19
  \memo Dimming of overhead electric lighting is determined from
  \memo interior daylight illuminance calculated at one or two reference points.
  \memo reference points are given in coordinates specified in the GlobalGeometryRules object
  \memo Daylighting Reference Point CoordinateSystem field
  \memo Glare from daylighting is also calculated.
A1 , \field Zone Name
  \required-field
  \type object-list
  \object-list ZoneNames
N1 , \field Total Daylighting Reference Points
  \type integer
  \minimum 1
  \maximum 2
  \default 1
```

```
N2 , \field X-Coordinate of First Reference Point
    \units m
    \type real
N3 , \field Y-Coordinate of First Reference Point
    \units m
    \required-field
    \type real
N4 , \field Z-Coordinate of First Reference Point
    \units m
    \default 0.8
    \type real
N5 , \field X-Coordinate of Second Reference Point
    \units m
    \type real
    \note Required if Total Daylighting Reference Points = 2
N6 , \field Y-Coordinate of Second Reference Point
    \units m
    \type real
    \note Required if Total Daylighting Reference Points = 2
N7 , \field Z-Coordinate of Second Reference Point
    \units m
    \type real
    \minimum 0.0
    \default 0.8
N8 , \field Fraction of Zone Controlled by First Reference Point
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 1.0
N9 , \field Fraction of Zone Controlled by Second Reference Point
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0.0
N10, \field Illuminance Setpoint at First Reference Point
    \units lux
    \type real
    \minimum 0.0
    \default 500
N11, \field Illuminance Setpoint at Second Reference Point
    \units lux
    \type real
    \minimum 0.0
    \default 500
N12, \field Lighting Control Type
    \type integer
    \minimum 1
    \maximum 3
    \note 1=continuous,2=stepped,3=continuous/off
    \default 1
N13, \field Glare Calculation Azimuth Angle of View Direction Clockwise from Zone y-Axis
    \required-field
    \units deg
    \minimum 0
    \maximum 360
N14, \field Maximum Allowable Discomfort Glare Index
    \type real
    \minimum 1
    \note The default is for general office work
    \default 22
N15, \field Minimum Input Power Fraction for Continuous Dimming Control
    \type real
    \minimum 0.0
    \maximum 0.6
    \default 0.3
N16, \field Minimum Light Output Fraction for Continuous Dimming Control
    \type real
    \minimum 0.0
    \maximum 0.6
    \default 0.2
```



```

N17, \field Number of Stepped Control Steps
     \note for Lighting Control Type=2, this field cannot be zero.
     \type integer
     \default 1
N18; \field Probability Lighting will be Reset When Needed in Manual Stepped Control
     \type real
     \minimum 0.0
     \maximum 1.0
     \default 1.0

```

An IDF example:

```

Daylighting:Controls, ! Zone Name
1, ! Total Daylighting Reference Points
3.048,3.048,0.9, ! X,Y,Z coordinates of first reference point {m}
0.0,0.0,0.0, ! X,Y,Z coordinates of second reference point, if present {m}
0.99, ! Fraction of zone controlled by first reference point
0.0, ! Fraction of zone controlled by second reference point, if present
500., ! Illuminance setpoint at first reference point {lux}
500., ! Illuminance setpoint at second reference point, if present {lux}
1, ! Lighting control type {1=continuous,2=stepped,3=continuous/off}
180.0, ! Azimuth angle of view direction for glare calculation {deg},
! measured clockwise from zone y-axis. Value of 180 gives view
! (from reference point) that is directly at window, maximizing glare.
20.0, ! Maximum discomfort glare index for window shade control
0.3, ! Minimum input power fraction for continuous dimming control
0.2, ! Minimum light output fraction for continuous dimming control
0, ! Number of steps, excluding off, for stepped control
1.0; ! Probability electric lighting will be reset when needed (used only
! for stepped control, to simulate manual on/off control)

```

Guidelines for Daylighting Modeling (Detailed Method)

Following are some guidelines for preparing EnergyPlus input to model the effects of daylighting. Before studying these guidelines, however, you should read the description of each input field under Daylighting:Controls, and review the IDF example, above, and the sample daylighting input, PurchAirWithDaylighting.idf.

Use of Window Multipliers

If an exterior wall in a daylit zone has a number of identical windows, the windows should be entered separately rather than using a window multiplier (ref: FenestrationSurface:Detailed). Using a multiplier would give an incorrect illuminance calculation since individual windows would not be positioned correctly on the wall.

Use of Zone Multipliers

A zone multiplier should not be used on a daylit zone if the windows in the zone are shadowed by exterior obstructions like trees or neighboring buildings, or by obstructions caused by other parts of building. The reason for this is that the shadowing on the windows of the multiplied zone may be different from zone to zone depending on exactly how the shadows fall on the zones. However, a zone multiplier may be used on a daylit zone if the shadowing is by overhangs, fins and/or window setback.

Thermal Zoning for Daylighting

To correctly calculate both direct and inter-reflected daylight illuminance you should try to model a thermal zone consisting of several similar rooms separated by interior walls as a representative room with a zone multiplier (ref: Zone). An example of this is shown in Figure 46. Room-1 is the representative room, with a zone multiplier = 4.

Interior walls IW-1, IW-2 and IW-3 should be treated as adiabatic, i.e., they should have Outside Boundary Condition = Surface and Outside Boundary Condition Object = IW-1, IW-2,

or IW-3, respectively (ref: BuildingSurface:Detailed). Similarly, if the ceiling and floor of Room-1 are interior surfaces, they should be treated as adiabatic.

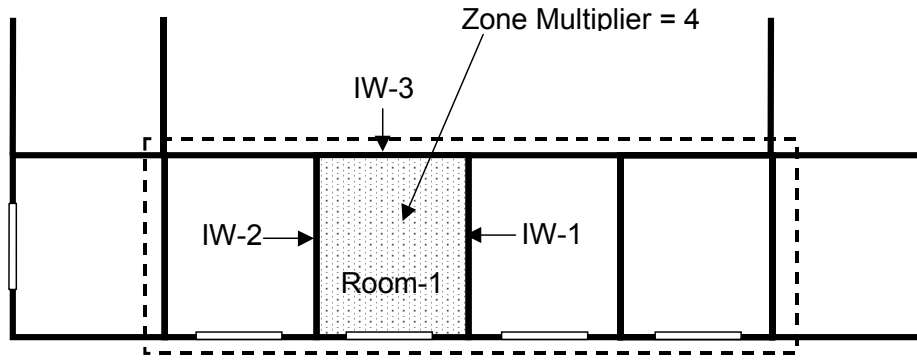


Figure 46. For daylighting purposes the thermal zone enclosed by the dashed boundary line should be modeled as a typical zone (Room-1) with a zone multiplier of 4.

Sometimes a representative room cannot be found. Figure 47 shows a section of a building with four rooms having different daylighting characteristics because of different floor area, orientation and/or window size. In this case lumping the rooms into a single thermal zone would give nonsensical daylighting illuminance values because of the presence of the interior walls, which EnergyPlus ignores when calculating illuminance reaching a reference point directly from a window (i.e., without reflection). The solution in this case is to describe each room as a separate thermal zone with its own daylighting reference points, and input the interior walls because these will participate in the calculation of inter-reflected illuminance.

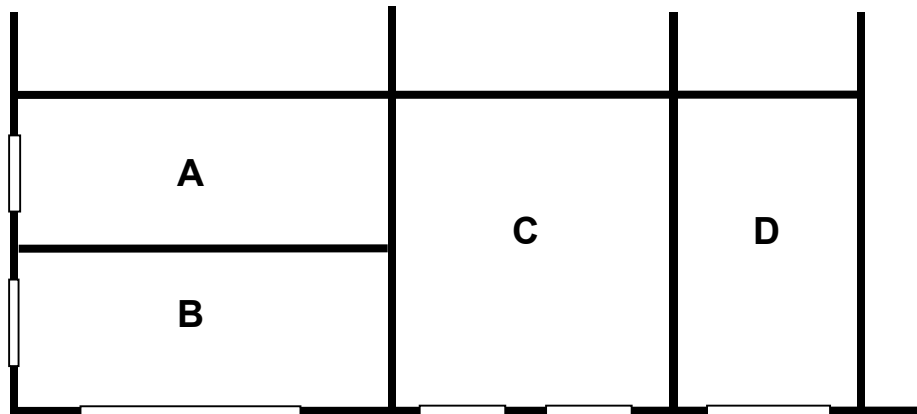


Figure 47. Rooms A, B, C and D have different daylighting characteristics. If lumped into a single thermal zone the daylighting calculation will be less accurate because the blockage of direct light by the interior walls between these rooms is modeled with some simplifications (see Interior Obstructions below). To get a good daylighting calculation each room should be input as a separate thermal zone.

Multiple Lighting Zones

The detailed daylighting calculation allows a thermal zone to be divided into two independently-controlled lighting zones. (See the fields: Fraction of Zone Controlled by First Reference Point, Fraction of Zone Controlled by Second Reference Point, Illuminance SetPoint at First Reference Point, and Illuminance SetPoint at Second Reference Point.) An example is shown in Figure 48, where a relatively deep thermal zone has two lighting zones of equal area.

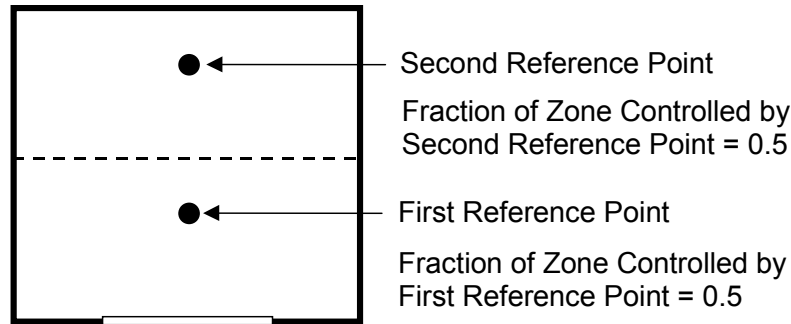


Figure 48. Two independently-controlled lighting zones, each with 50% of the area of the thermal zone.

Fins, Overhangs and Other Exterior Obstructions

The daylighting calculation accounts for the presence of exterior obstructions in determining the amount of light that strikes the windows. For daylighting purposes exterior obstructions fall into three categories:

- (1) Fins, overhangs, trees, neighboring buildings, etc., entered with the objects Shading:Zone:Detailed, Shading:Site:Detailed, or Shading:Building:Detailed.
- (2) Building surfaces like walls and roofs (in an L-shaped building, for example).
- (3) Surfaces associated with window setback.

Category (1) obstructions can have an associated solar transmittance schedule (see description of the field Transmittance Schedule Name for these shading surfaces). If this schedule is not specified, the surface is opaque (has zero transmittance).

The daylighting calculation takes the transmittance into account in determining, for example, how much light enters a window through a translucent awning. It is assumed that the solar and visible transmittance is the same and that the surfaces are non-diffusing, i.e., they do not change the direction of transmitted light. Ref:Daylighting:Controls.

Category (2) and (3) surfaces are assumed to be opaque.

Surfaces in all three categories are assumed to be black, i.e., they do not reflect light, unless you set if “Reflections” option is chosen in the Building object. Then obstructions can reflect light, such as the top of an overhang reflecting light onto the window above. Ref: Building, Field: Solar Distribution (with reflections options).

Interior Obstructions

The daylighting calculation accounts for the presence of interior obstructions that lie between a window and a reference point. Unlike exterior obstructions, which can be light transmitting, interior obstructions are assumed to be opaque. Interior obstructions can reduce or eliminate the light directly reaching the reference point through a window.

However, interior obstructions that are walls, ceilings or floors are reflecting so they contribute to the inter-reflected component of daylight illuminance as do the non-obstructing zone surfaces.

Interior obstructions can belong to the Shading object series. This type of obstruction is assumed to be non-reflecting so does not contribute to the inter-reflected component of daylight illuminance.

An example of an interior obstruction that is a wall in an L-shaped room is shown in Figure 49. Here, wall A (or, equivalently, Wall B) prevents light from directly getting to the Reference Point from the window.

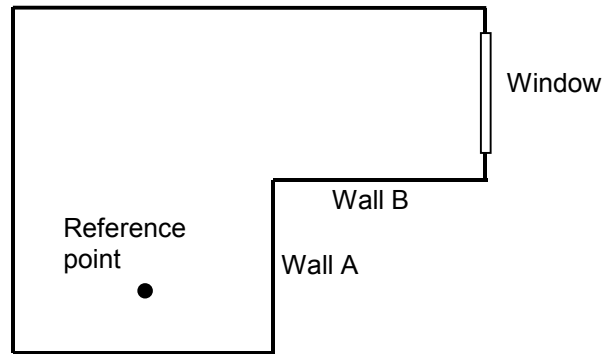


Figure 49. Wall A (or Wall B) is an interior obstruction that prevents light from directly reaching the daylighting reference point from the window.

Double Façades: Daylighting through Interior Windows

The Daylighting:Controls method, with no additional user input, calculates the contribution of daylight that passes into a target zone through interior windows.⁷ The origin of this daylight is exterior windows in adjacent zones that share interior windows with the target zone. This capability is aimed at daylighting through a **double façade** (also called “double envelope” or “double skin.”)

This is illustrated in Figure 50, which shows a double-façade buffer zone, Z0, with exterior windows EW1 and EW2. Z0 shares interior windows IW1, IW2 and IW3 with daylit occupied zones ZD1, ZD2 and ZD3, respectively (“daylit” here means the zone has an associated Daylighting:Controls object). The daylight illuminance at reference points RP1, RP2 and RP3 comes from the interior windows and has two main sources:

1. Daylight that passes through both an exterior window and an interior window in Z0 and reaches a reference point without reflection. This is called “direct illuminance.”
2. Daylight from Z0 that passes through an interior window and reaches a reference point by inter-reflection in the daylit zone. Because the program calculates this source from the interior solar distribution in Z0 it is recommended that the most accurate calculation of this distribution be made, which occurs if Solar Distribution = FullInteriorAndExterior in the Building object.

A third possible source is neglected because it is generally small in double-façade cases. This is daylight that is reflected from the surfaces of Z0, passes through an interior window and then reaches a reference point without inter-reflection in the daylit zone.

PurchAirWithDoubleFacadeDaylighting.idf is an input example of daylighting through an interior window.

⁷ Formerly, only the exterior windows in a zone could provide daylight to that zone.

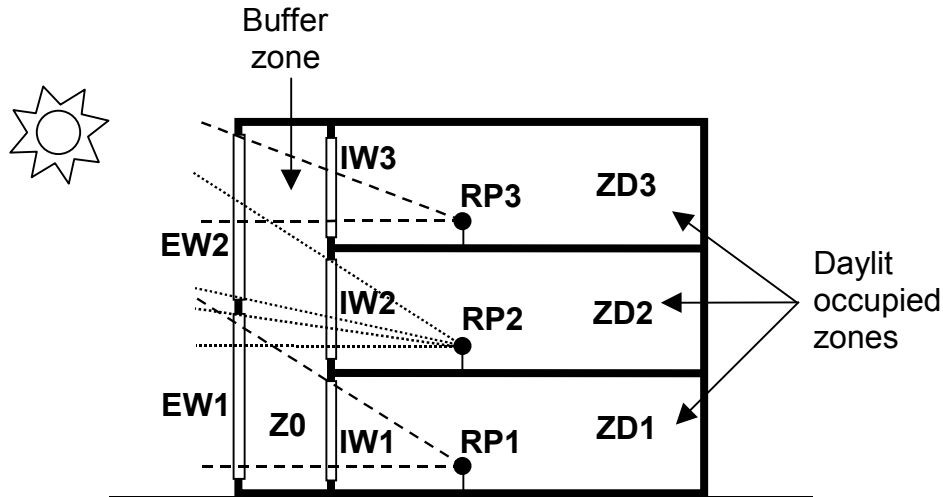


Figure 50. Vertical section through a double-façade building showing daylighting through interior windows. The dashed lines show that (1) reference point RP1 receives direct light from exterior window EW1 via interior window IW1; (2) RP2 receives direct light from EW1 and EW2 via IW2; and (3) RP3 receives direct light from EW2 via IW3.

Interior Window Daylighting Configurations that EnergyPlus Can Calculate

Figure 51 shows schematically the general configuration of daylighting through interior windows that can be calculated with EnergyPlus. Here, daylit zone ZD has one or more interior windows that are adjacent to other zones, each of which has one or more exterior windows. ZD itself may or may not have exterior windows. If it does, then the daylight illuminance from its exterior and interior windows will be additive. The zones adjacent to ZD may or may not be daylit and may or may not have other interior windows that are not adjacent to ZD. (The program does not consider the illuminance in ZD from electric lighting in adjacent zones.)

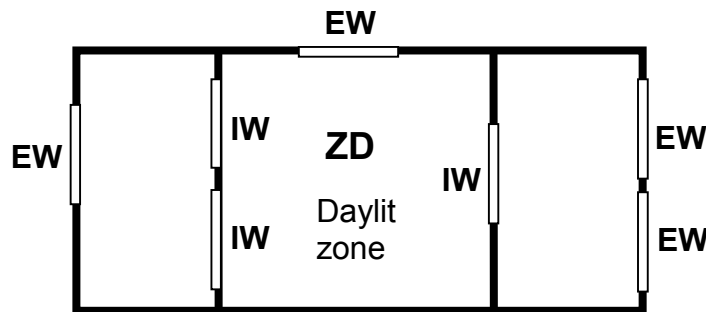


Figure 51. General configuration of daylighting through interior windows that can be calculated with EnergyPlus. IW = interior window, EW = exterior window.

Interior Window Daylighting Configurations that EnergyPlus Cannot Calculate

Figure 52 shows schematically a configuration of daylighting through interior windows that cannot be calculated with EnergyPlus. Here, zone Z has an interior window that is adjacent to zone Z1 which in turn has an interior window adjacent to zone Z2. However, the daylight from the exterior window in Z2 that enters Z after passing through Z1 is not calculated because Z2 is not adjacent to Z.

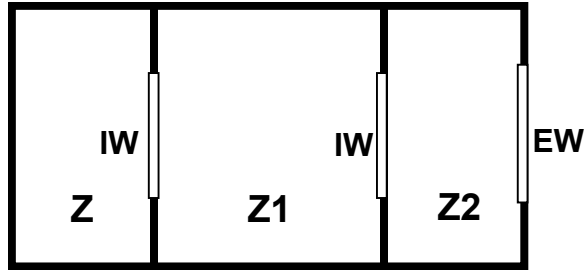


Figure 52. Configuration in which daylighting of zone Z through its interior window cannot be calculated with EnergyPlus. IW = interior window, EW = exterior window.

Restrictions on Shading Devices

There are two restrictions on the use of exterior-window shading devices when a daylight zone has interior windows:

- 1) If two daylight zones share an interior window, neither zone can have an exterior window whose shading device does glare control (i.e., the WindowProperty:ShadingControl for the exterior window has Glare Control Is Active = Yes).
- 2) If two daylight zones share an interior window, neither zone can have an exterior window with a WindowProperty:ShadingControl that has Shading Control Type = MeetDaylightIlluminanceSetpoint.

DElight Daylighting Method

The DElight method of analyzing daylighting in buildings is very similar to that used in the Detailed method. For each point in time, DElight calculates the interior daylighting illuminance at specified reference points and then determines how much the electric lighting can be reduced while still achieving a combined daylighting and electric lighting illuminance target. The daylight illuminance level in a zone depends on many factors, including exterior light sources; location, size, and visible light transmittance of simple and complex fenestration systems; reflectance of interior surfaces; and location of calculation reference points. The subsequent reduction of electric lighting depends on daylight illuminance level, illuminance set point, fraction of zone controlled, and type of lighting control.

There are two primary differences between the Detailed and DElight methods of calculating interior illuminance levels. The first is that DElight includes the capability of analyzing complex fenestration systems that include geometrically complicated shading systems (e.g., roof monitors) and/or optically complicated glazings (e.g., prismatic or holographic glass). The second key difference is that DElight uses a radiosity method to calculate the effects of light reflection inside a zone. These methods are discussed in more detail in the engineering documentation.

There are other important differences between the two methods. One is the inability of DElight to perform the type of dynamic shading controls possible using the Detailed method at each point in time during the thermal simulation (e.g., changes in electrochromic glazing transmittances and blind slat angles). Another is the DElight ability to include more than two reference points in its interior illuminance and electric lighting reduction calculations. A third is the current lack of visual quality (e.g., glare) calculations performed by DElight. Fourth, the modeling of interior obstructions is different in the two methods. In the DElight method interior obstructions block interreflections but do not block the initial direct illuminance. In the Detailed method, interior obstructions block the initial direct illuminance but do not block interreflections. See the engineering documentation for more details.

Input for invoking the DElight method involves three object types: **Daylighting:DElight:Controls**, **Daylighting:DElight:ReferencePoint**, and **Daylighting:DElight:ComplexFenestration**. Each of these objects is described below.

Daylighting:DELight:Controls

The first input object required for invoking the DELight method is the Daylighting:DELight:Controls object, which defines the parameters of each daylighting zone within a building. This object must be associated with a specific thermal zone within the building for which the reduction in electric lighting due to daylight illuminance will be accounted.

Field: Name

User name of the DELight daylighting zone to which the following input applies.

Field: Zone Name

The name of the thermal Zone hosting this DELight daylighting zone. This must be a valid name that has been associated with a thermal Zone contained in the same EnergyPlus input data file.

Field: Lighting Control Type

The type of overhead electric lighting control. All reference points specified are assumed to have this type of control.

For Lighting Control Type = 1 (continuous), the overhead lights dim continuously and linearly from (maximum electric power, maximum light output) to (minimum electric power, minimum light output) as the daylight illuminance increases. The lights stay on at the minimum point with further increase in the daylight illuminance.

For Lighting Control Type = 2 (stepped), the electric power input and light output vary in discrete, equally spaced steps. The number of steps is given by Number of Steps (Excluding Off) of Stepped Control. For example, if Number of Steps = 3 and Illuminance Setpoint = 600, then the following table shows the fraction of the lights that are on vs. daylight illuminance.

Table 18. Stepped Lighting Control Example

Example of a Stepped Lighting Control System with Three Steps	
Daylight illuminance	Fraction of lights that are on
0-200	1.0
200-400	2/3
400-600	1/3
600 and above	0.0

Lighting Control Type = 3 (continuous/off) is the same as Lighting Control Type = 1 except that the lights switch off completely when the minimum dimming point is reached.

Field: Minimum Input Power Fraction for Continuous Dimming Control

For Lighting Control Type = 1 (continuous), the lowest power the lighting system can dim down to, expressed as a fraction of maximum input power (see figure, below). For Lighting Control Type = 3 (continuous/off) this is the power fraction reached just before the lights switch off completely.

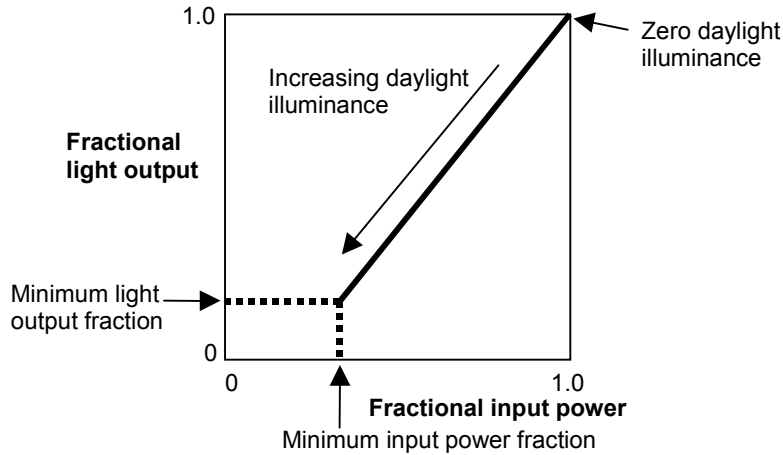


Figure 53. Illustration of continuous dimming relationship

The figure above shows the relationship between electric light output and electrical input.

Field: Minimum Light Output Fraction for Continuous Dimming Control

For Lighting Control Type = 1 (continuous), the lowest lighting output the lighting system can dim down to, expressed as a fraction of maximum light output (see figure, above). This is the fractional light output that the system produces at minimum input power. For Lighting Control Type = 3 (continuous/off) this is the power fraction reached just before the lights switch off completely.

Field: Number of Steps (Excluding Off) for Stepped Control

The number of steps, excluding off, in a stepped lighting control system (see figure, below). Required and must be >0 if Lighting Control Type = 2. The steps are assumed to be equally spaced.

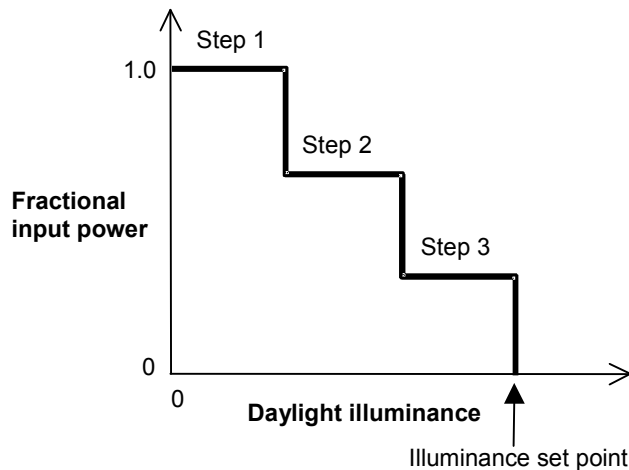


Figure 54. Stepped lighting control with Number of Steps = 3.

Field: Probability Lighting Will Be Reset When Needed in Manual Stepped Control

May be specified if a stepped lighting control system (Lighting Control Type = 2) is manually operated, such as in a simple, one-step (on-off) system. Gives the probability the occupants of a daylit zone will set the electric lights to the correct level to obtain the required illuminance. The rest of the time the lights are assumed to be set one step too high. For

example, consider an on-off lighting system (Number of Steps = 1) with a set point of 600 lux and 0.7 reset probability. Then, when daylighting exceeds 600 lux, the electric lights will be off 70% of the time and on 30% of the time.

Field: Gridding Resolution

The maximum surface area for nodes in gridding (subdividing) all surfaces in the DElight zone. All reflective and transmitting surfaces will be subdivided into approximately square nodes that do not exceed this maximum. Higher resolution subdivisions require greater calculation times, but generally produce more accurate results. This same gridding resolution is also used to subdivide any Complex Fenestration System surfaces. It is advisable to perform at least one simulation of new input using a small gridding resolution such as 0.1m2 to compare these results against simulation runs at lower resolution (i.e., higher maximum area nodal grids) to get a sense of possible levels of error.

```
Daylighting:DElight:Controls,
  \min-fields 8
  \memo Dimming of overhead electric lighting is determined from
  \memo DElight calculated interior daylight illuminance at one or more reference points.
A1 , \field Name
  \required-field
  \type alpha
  \reference DElightZoneNames
A2 , \field Zone Name
  \note Name of Thermal Zone hosting the given DElight Zone
  \required-field
  \type object-list
  \object-list ZoneNames
N1 , \field Lighting Control Type
  \type real
  \minimum 1
  \maximum 3
  \note 1=continuous,2=stepped,3=continuous/off
  \default 1
N2 , \field Minimum Input Power Fraction for Continuous Dimming Control
  \type real
  \minimum 0.0
  \maximum 0.6
  \default 0.3
N3 , \field Minimum Light Output Fraction for Continuous Dimming Control
  \type real
  \minimum 0.0
  \maximum 0.6
  \default 0.2
N4 , \field Number of Stepped Control Steps
  \type integer
  \note for Lighting Control Type=2, this field cannot be zero.
  \default 1
N5 , \field Probability Lighting will be Reset When Needed in Manual Stepped Control
  \type real
  \minimum 0.0
  \maximum 1.0
  \default 0.0
N6; \field Gridding Resolution
  \units m2
  \type real
  \note Maximum surface area for nodes in gridding all surfaces in the DElight zone.
  \note All reflective and transmitting surfaces will be subdivided
  \note into approximately square nodes that do not exceed this maximum.
  \note Higher resolution subdivisions require greater calculation times,
  \note but generally produce more accurate results.
  \minimum> 0.0
```

An IDF example:

```
Daylighting:DELight:Controls,  
  DELight NORTH ZONE, !- DELight Zone Name  
  NORTH ZONE, !- Zone Name  
  1, !- Lighting control type  
  0.3, !- Minimum input power fraction for continuous dimming control  
  0.2, !- Minimum light output fraction for continuous dimming control  
  0, !- Number of steps (excluding off) for stepped control  
  1.0, !- Probability lighting will be reset when needed in manual stepped control  
  1.0; !- Gridding Resolution {m2}
```

Daylighting:DELight:ReferencePoint

The second input object required for invoking the DELight method is the Daylighting:DELight:ReferencePoint object, which defines the parameters of each Reference Point within the associated DELight daylighting zone. This object must be associated with a specific Daylighting:DELight:Controls object instance. There may be up to a maximum of 100 Reference Points for each DELight daylighting zone. Each Reference Point that is input does NOT need to be included in the control of the electric lighting system within the zone. This is determined by the fraction of the zone controlled by each Reference Point, which can be input as 0. Note that the sum of all Reference Point control fractions must equal 1 to obtain correct overall results.

Field: Name

User name of the DELight daylighting Reference Point to which the following input applies.

Field: DELight Name

The name of the Daylighting:DELight:Controls object instance hosting this Reference Point. This must be a valid name that has been associated with a DELight daylighting Zone contained in the same EnergyPlus input data file.

Fields: (X,Y,Z) of Reference Point

These three fields are the X, Y and Z values of the Reference point in the coordinate system you specified for daylighting reference points in the GlobalGeometryRules object. Figure 55 shows an example using the relative coordinate (to zone) system. Z is typically at work surface height (e.g., 0.8m for a desk).

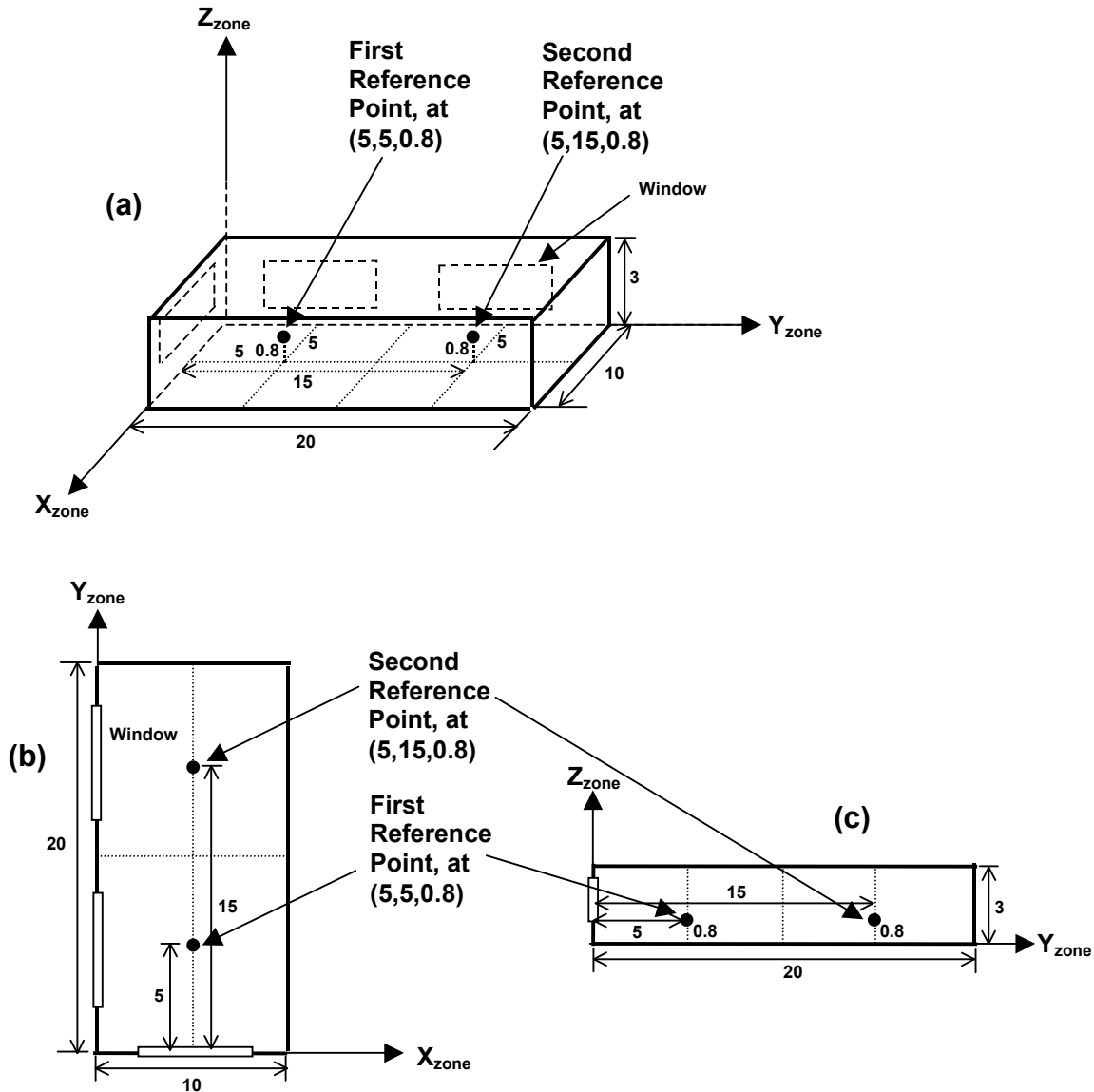


Figure 55. Example showing location of two daylighting reference points in the zone coordinate system (relative) of a rectangular zone with three windows. (a) Perspective view, (b) plan view, (c) elevation view. All dimensions are in meters.

Field: Fraction of Zone Controlled by Reference Point

The zone floor-area fraction of the electric lighting that is controlled by the daylight illuminance at this Reference Point. If the sum of the values for this field for all Reference Points input for a given daylighting zone is less than 1.0, then the remaining fraction (i.e., 1.0 – Sum) is assumed to not have lighting control.

Note that Reference Points may be input with a 0.0 value for this fraction. In this case, daylight factors and interior illuminance values will be calculated for the Reference Point, but it will play no role in controlling the electric lighting within the daylighting zone to which it belongs.

Field: Illuminance Setpoint at Reference Point

The desired lighting level (in lux) at this Reference Point. This is assumed to be the lighting level that would be produced at this reference point at night if the overhead electric lighting were operating at full input power. Recommended values depend on the type of activity and may be found, for example, in the Lighting Handbook of the Illuminating Engineering Society of North America. A typical value for general office work (excluding computer terminals) is 500 lux.

```
Daylighting:DELight:ReferencePoint,
  \min-fields 7
  \memo DElight reference point for illuminance calculation and electric lighting dimming.
  \memo reference points are given in coordinates specified in the GlobalGeometryRules object
  \memo Daylighting Reference Point CoordinateSystem field
  \memo There is a maximum number of 100 reference points per Daylighting:DElight zone.
A1 , \field Name
  \type alpha
A2 , \field DElight Name
  \required-field
  \type object-list
  \object-list DElightZoneNames
N1 , \field X-coordinate of Reference Point
  \required-field
  \units m
  \type real
N2, \field Y-coordinate of Reference Point
  \required-field
  \units m
  \type real
N3, \field Z-coordinate of Reference Point
  \required-field
  \units m
  \type real
N4 , \field Fraction of Zone Controlled by Reference Point
  \required-field
  \type real
  \minimum 0.0
  \maximum 1.0
  \default 1.0
N5; \field Illuminance Setpoint at Reference Point
  \required-field
  \units lux
  \type real
  \minimum 0.0
  \default 500
```

An IDF example:

```
Daylighting:DELight:ReferencePoint,
  RefPt 2,           !- Reference Point Name
  DElight NORTH ZONE, !- DElight Zone Name
  5.0, !- X-coordinate of reference point {m}
  3.0, !- Y-coordinate of reference point {m}
  0.9, !- Z-coordinate of reference point {m}
  0.5, !- Fraction of zone controlled by reference point
  500.; !- Illuminance setpoint at reference point {lux}
```

Daylighting:DELight:ComplexFenestration

The third input object related to the DElight method is the Daylighting:DElight: Complex Fenestration object. The DElight daylighting analysis method can be applied to daylighting zones that contain only simple fenestration systems such as windows and skylights that are

standard EnergyPlus sub-surfaces. In this situation, no Daylighting:DElight: Complex Fenestration object would be input.

In addition to analyzing simple fenestration systems, DElight includes the capability of analyzing complex fenestration systems such as geometrically complicated static shading systems (e.g., roof monitors) and/or optically complicated glazings (e.g., prismatic or holographic glass). This capability is based on characterizing these complex fenestration systems (CFS) using bi-directional transmittance distribution functions (BTDF). In general, BTDF data for a specific CFS must be either measured or simulated (e.g., using ray-tracing techniques) prior to employing DElight to analyze it within EnergyPlus. The current implementation of DElight CFS calculations within EnergyPlus supports two approaches to the input of BTDF, an analytical approach and a file-based approach. The details of inputting these two approaches are described below under the User Complex Fenestration Type field.

Two analytical CFS BTDF types are currently supported, window and light shelf. The file-based approach requires that a user has access to a data file containing raw BTDF data that DElight reads as additional input during its analysis calculations. BTDF data files are described separately since it is anticipated that individual EnergyPlus users will not create these data files themselves.

The methods related to characterizing and analyzing CFS using BTDF are still evolving. DElight is an early implementation of CFS analysis methods. These methods, and the input associated with them here, will likely change in the future.

Field: User Name

User name of the DElight daylighting Complex Fenestration to which the following input applies.

Field: Complex Fenestration Type

Type name of the DElight daylighting Complex Fenestration system to be analyzed. This type name must take one of the following two forms.

```
BTDF^GEN^Analytical Type^Normal Visible Transmittance^Dispersion Angle
```

```
BTDF^FILE^Filename
```

The first form above is for supported analytical CFS types which currently include WINDOW and LIGHTSHELF. While these analytical types are relatively simple, they represent flexible ways to explore diffusing CFS systems and the impact of light shelves in redirecting light through an aperture. Each of these types also requires the visible transmittance of the CFS at normal incidence angle, and a dispersion angle (in degrees) that represents the “spread” of transmitted light. A small dispersion angle of 10 corresponds to clear glazing while a large angle of 90 corresponds to perfectly diffusing glazing. The “^” symbol must be used as a delimiter between sub-fields within this Complex Fenestration type name string as shown in the IDF example for WINDOW below, and in the DElight sample input data files.

The second form above is for CFS types for which there is pre-measured or pre-simulated BTDF data. In this case the Filename sub-field must be a valid data file name that is associated with an existing BTDF dataset that DElight can use in its calculations.

Field: Building Surface Name

The name of the heat transfer surface object instance hosting this Complex Fenestration, analogous to the Building Surface Name field for subsurfaces such as Windows. This must be a valid name that has been associated with a heat transfer surface contained in the same EnergyPlus input data file.

Field: Window Name

The name of the Window (ref: FenestrationSurface:Detailed object) instance that will be used to account for the geometry, and the solar/thermal gains/losses, of the Complex Fenestration system surface. This must be a valid name that has been associated with a Window contained in the same EnergyPlus input data file. The geometry for the Complex Fenestration is taken from the geometry input for this standard EnergyPlus subsurface, hence the term “Doppelganger.”

Note that DELight only deals with the visible spectrum of light transmitted through a Complex Fenestration. To account for the solar/thermal influences of a Complex Fenestration, a geometrically coincident subsurface that will be accounted for by methods already within EnergyPlus must be defined in the input data file. This is an interim solution to the issue of accounting for solar/thermal influences that will likely change as techniques analogous to the daylighting analysis of BTDF are developed.

Field: Fenestration Rotation

The in-plane counter-clockwise rotation angle between the Complex Fenestration optical reference direction and the base edge of the Doppelganger Surface geometry. The Complex Fenestration optical reference direction is the direction of the zero azimuth angle for the BDTF dataset. This Rotation angle will typically be zero when the Doppelganger surface is rectangular and its width edge is aligned with the Complex Fenestration optical reference direction.

```
Daylighting:DELight:ComplexFenestration,
  \min-fields 5
  \memo Used for DELight Complex Fenestration of all types
A1, \field Name
  \required-field
  \note Only used for user reference
  \type alpha
A2, \field Complex Fenestration Type
  \required-field
  \note Used to select the appropriate Complex Fenestration BTDF data
  \type alpha
A3, \field Building Surface Name
  \required-field
  \note This is a reference to a valid surface object (such as BuildingSurface:Detailed) hosting
  \note this complex fenestration, analogous to the base surface Name
  \note field for subsurfaces such as Windows.
  \type object-list
  \object-list SurfaceNames
A4, \field Window Name
  \required-field
  \note This is a reference to a valid FenestrationSurface:Detailed window object
  \note used to account for the geometry, and the solar and thermal gains/losses,
  \note of the Complex Fenestration
  \type object-list
  \object-list SubSurfNames
N1; \field Fenestration Rotation
  \units deg
  \type real
  \note In-plane counter-clockwise rotation angle of the Complex Fenestration
  \note optical reference direction and the base edge of the Complex Fenestration.
  \note The Rotation will typically be zero when the host and CFS surfaces
  \note are rectangular and height and width edges are aligned.
  \default 0.0
```

An IDF example for an analytical WINDOW type CFS:

```

Daylighting:DELight:ComplexFenestration,
Window CFS,      !- DElight Complex Fenestration User Name
BTDF^GEN^WINDOW^1.0^20.0,      !- Complex Fenestration Type
ZN003:WALL001,  !- Complex Fenestration Host Surface
Zn003:Wall001:Doppel001, !- Doppelganger Surface Name
0.0;             !- Fenestration Rotation {degrees}

```

DElight Output

In addition to the daylighting-specific outputs for DElight listed below, two ASCII text files are created during an EnergyPlus run that includes DElight analysis. Following completion of an EnergyPlus run, these files are given names that consist of the project name appended with DElight.in and DElight.out. The format of these files is described in the Output Details and Examples document.

The following daylighting-specific outputs are available for Daylighting:DELight:Controls within the standard EnergyPlus output environment:

```

Zone,Average,DElight Reference Point Daylight Illuminance [lux]
Zone,Average,Ltg Power Multiplier from Daylighting []

```

DElight Reference Point Daylight Illuminance [lux]

The total daylight illuminance at a DElight reference point from all of the exterior windows in a daylit zone.

Ltg Power Multiplier from Daylighting []

The amount by which the overhead electric lighting power in a zone is multiplied due to usage of DElight calculated daylighting to dim or switch electric lights. For example, if the multiplier is M and the electric power without dimming is P, then the electric power with dimming is M*P. The multiplier varies from 0.0, which corresponds to maximum dimming (zero electric lighting), to 1.0, which corresponds to no dimming.

Daylighting Output

The following daylighting-specific outputs are available for Daylighting:Controls:

```

Zone,Average,Exterior Beam Normal Illuminance [lux]
Zone,Average,Exterior Horizontal Beam Illuminance [lux]
Zone,Average,Exterior Horizontal Illuminance From Sky [lux]
Zone,Average,Luminous Efficacy of Beam Solar Radiation [lum/W]
Zone,Average,Luminous Efficacy of Sky Diffuse Solar Radiation [lum/W]
Zone,Average,Sky Clearness for Daylighting Calculation []
Zone,Average,Sky Brightness for Daylighting Calculation []
Surface,Average,Daylight Luminance of Window As Viewed From Ref Point 1
[cd/m2]
Surface,Average,Daylight Illum at Ref Point 1 from Window [lux]
Zone,Average,Daylight Illum at Ref Point 1 [lux]
Zone,Average,Glare Index at Ref Point 1 []
Surface,Average,Daylight Luminance of Window As Viewed From Ref Point 2
[cd/m2]
Surface,Average,Daylight Illum at Ref Point 2 from Window [lux]
Zone,Average,Daylight Illum at Ref Point 2 [lux], if applicable
Zone,Average,Glare Index at Ref Point 2 [], if applicable
Zone,Average,Ltg Power Multiplier from Daylighting []

```

Exterior Beam Normal Illuminance [lux]

Beam normal illuminance of the sun at the earth's surface, measured in lux (lumens/m²)

Exterior Horizontal Beam Illuminance [lux]

Beam illuminance on an unobstructed horizontal plane at the earth's surface. Equals "Exterior Beam Normal Illuminance" times sine of solar altitude.

Exterior Horizontal Illuminance From Sky [lux]

Illuminance from sky solar radiation on an unobstructed horizontal plane at the earth's surface. The total exterior horizontal illuminance is the sum of "Exterior Horizontal Beam Illuminance" and "Exterior Horizontal Illuminance From Sky."

Luminous Efficacy of Beam Solar Radiation [lum/W]

A measure of the visible light content of beam solar radiation; equal to the number of lumens per watt of beam solar radiation. Depends on atmospheric conditions (moisture, turbidity, cloudiness) and solar altitude.

Luminous Efficacy of Sky Diffuse Solar Radiation [lum/W]

A measure of the visible light content of sky diffuse solar radiation; equal to the number of lumens per watt of sky diffuse solar radiation. Depends on atmospheric conditions (moisture, turbidity, cloudiness) and solar altitude.

Sky Clearness for Daylighting Calculation []

Clearness of sky. One of the factors used to determine sky type and luminous efficacy of solar radiation (see *EnergyPlus Engineering Document*). Sky Clearness close to 1.0 corresponds to an overcast sky. Sky Clearness > 6 is a clear sky.

Sky Brightness for Daylighting Calculation []

Brightness of sky. One of the factors used to determine sky type and luminous efficacy of solar radiation (see *EnergyPlus Engineering Document*).

Daylight Luminance of Window As Viewed From Ref Point 1 [cd/m²]

The area-averaged luminance of an exterior window as viewed from the first reference point in the daylit zone containing the window. In general, higher window luminance values are associated with higher daylight glare values. (Printed only for exterior windows in daylit zones without interior windows.)

Daylight Illum at Ref Point 1 from Window [lux]

The contribution from a particular exterior window to the daylight illuminance at the first reference point in the daylit zone containing the window. (Not printed for exterior windows in daylit zones with interior windows.)

Daylight Illum at Ref Point 1 [lux]

The total daylight illuminance at the first reference point from all of the exterior windows in a daylit zone.

Glare Index at Ref Point 1 []

The daylight glare index at the first reference point in a daylit zone.

Daylight Luminance of Window As Viewed From Ref Point 2 [cd/m²]

The area-averaged luminance of an exterior window as viewed from the second reference point, if present, in the daylit zone containing the window. Note that, for a bare window, this value can be different from the corresponding value at the first reference point since different regions of the sky and ground will be visible from the two reference points, and different ranges of angles of incidence and associated glass transmittance values will be involved. (Not printed for exterior windows in daylit zones with interior windows.)

Daylight Illum at Ref Point 2 from Window [lux]

The contribution from a particular exterior window to the daylight illuminance at the second reference point, if present, in the daylit zone containing the window. (Not printed for exterior windows in daylit zones with interior windows.)

Glare Index at Ref Point 2 []

The daylight glare index at the second reference point, if present, in a daylit zone.

Ltg Power Multiplier from Daylighting []

The amount by which the overhead electric lighting power in a zone is multiplied due to usage of daylighting to dim or switch electric lights. For example, if the multiplier is M and the electric power without dimming is P, then the electric power with dimming is M*P. The multiplier varies from 0.0, which corresponds to maximum dimming (zero electric lighting), to 1.0, which corresponds to no dimming.

Output:IlluminanceMap

The Output:IlluminanceMap object expands on the reporting capabilities of the daylighting simulation. For any zone simulated with Daylighting:Controls, the illuminance map can generate up to a 10 x 10 grid of additional daylighting reference points. The resulting map is output as a comma delimited text file that can be imported into a spreadsheet program for rapid visualization of the daylighting illuminance patterns in a zone.

```
Output:IlluminanceMap,
  \min-fields 9
  \memo reference points are given in coordinates specified in the GlobalGeometryRules object
  \memo Daylighting Reference Point CoordinateSystem field
A1 , \field Name
  \required-field
A2 , \field Zone Name
  \required-field
  \type object-list
  \object-list ZoneNames
N1 , \field Z height
  \units m
  \type real
  \default 0.0
N2 , \field X Minimum Coordinate
  \units m
  \type real
  \default 0.0
N3 , \field X Maximum Coordinate
  \units m
  \type real
  \default 1.0
N4 , \field Number of X Grid Points
  \type integer
  \minimum> 0
  \maximum 10
  \default 2
N5 , \field Y Minimum Coordinate
  \units m
  \type real
  \default 0.0
N6 , \field Y Maximum Coordinate
  \units m
  \type real
  \default 1.0
N7 ; \field Number of Y Grid Points
  \type integer
  \minimum> 0
  \maximum 10
  \default 2
```

Field: Name

The name of the map object.

Field: Zone Name

Reference to a zone with Daylighting:Controls.

Field: Z Height

The height or elevation of the grid of daylighting points.

Field: X Minimum Coordinate

The minimum X coordinate boundary for the map.

Field: X Maximum Coordinate

The maximum X coordinate boundary for the map.

Field: Number of X Grid Points

The number of daylighting reference points in the X direction from the minimum to the maximum boundaries. (Maximum of 10.)

Field: Y Minimum Coordinate

The minimum Y coordinate boundary for the map.

Field: Y Maximum Coordinate

The maximum Y coordinate boundary for the map.

Field: Number of Y Grid Points

The number of daylighting reference points in the Y direction from the minimum to the maximum boundaries. (Maximum of 10.)

Note: Daylighting factors cannot be accurately calculated for reference points that are very close to a wall or window (less than 0.15 m or 6 inches). An error is reported for a reference point that is too close to a window, but no error is reported for a point that is too close to a wall.

```
Output:IlluminanceMap,
Daylit Map,          ! Map Name
Daylit Zone,        ! Zone Name
0,                  ! Z Height [m]
0.1,                ! X Minimum Coordinate [m]
4.9,                ! X Maximum Coordinate [m]
10,                 ! Number of X Grid Points
0.1,                ! Y Minimum Coordinate [m]
9.9,                ! Y Maximum Coordinate [m]
10;                 ! Number of Y grid Points
```

Since not all zones are rectangular, it is possible to have map points that are outside the zone. Any illuminance registered at these points is inaccurate and, additionally, a “*” marks these values for easy observance.

OutputControl:IlluminanceMap:Style

This object specifies the “style” for the illuminance map output (described in the Output Details and Examples document). As described above (see: EnergyPlus Output Processing), the user may select the “style” for the daylighting illuminance map output file (eplusmap.<ext>).

Field: Column Separator

For this field, the desired separator for columns is entered. “Comma” creates comma separated fields/columns in the outputs (eplusmap.csv file is created). “Tab” creates tab separated fields/columns in the outputs (eplusmap.tab file is created). “Fixed” creates space

separated fields/columns in the outputs (eplusmap.txt file is created) but these are not necessarily lined up for easy printing.

Note that both tab and comma separated files easily import into Excel™ or other spreadsheet programs. The tab delimited files can also be viewed by text editors, word processing programs and easily converted to “tables” within those programs.

```
OutputControl:IlluminanceMap:Style,
  \memo default style for the Daylighting Illuminance Map is comma -- this works well for
  \memo importing into spreadsheet programs such as Excel(tm) but not so well for word
  \memo processing programs -- there tab may be a better choice. fixed puts spaces between
  \memo the "columns"
  \unique-object
A1; \field Column Separator
  \type choice
  \key Comma
  \key Tab
  \key Fixed
  \default Comma
```

Daylighting Devices

Daylighting devices work in conjunction with the Daylighting:Controls object to simulate components that can improve daylighting in a zone.

Daylighting devices are also tightly integrated into the zone heat balance. The thermal effects of these devices are simulated with or without the use of a Daylighting:Controls object.

There are two types of daylighting device in EnergyPlus: tubular daylighting devices and daylighting shelves.

DaylightingDevice:Tubular

Tubular daylighting devices (TDDs), also known as tubular skylights or light pipes, are used to bring natural exterior daylight into the hard-to-reach, interior spaces of a building.

TDDs consist of three components: a dome, a pipe, and a diffuser.

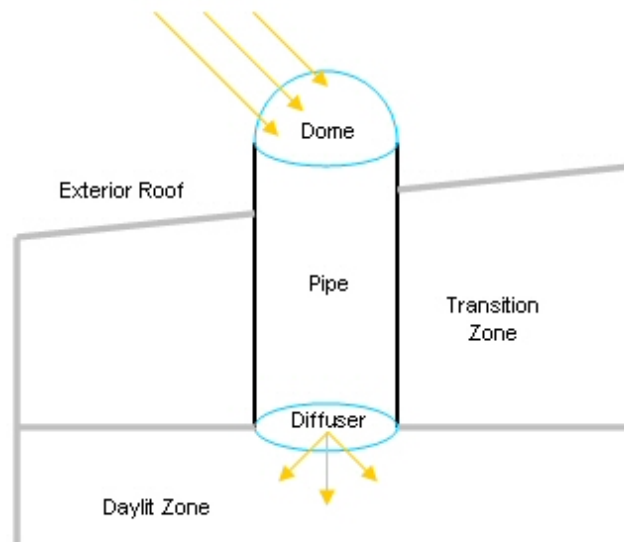


Figure 56. Tubular daylighting device diagram.

In EnergyPlus each of these components corresponds to an object in the input file.

The dome and diffuser are defined in the same way as windows using the FenestrationSurface:Detailed object. The *Surface Type* field must be specified as TubularDaylightDome or TubularDaylightDiffuser accordingly.

The location and orientation of the dome surface affect the total amount of daylight collected. The *Base Surface* of the diffuser object determines to which zone the daylighting is delivered. The location and orientation of the diffuser surface affect the amount of daylight received at the Daylighting:Controls reference points.

Although the object definition is the same as for a window, there are several restrictions on TubularDaylightDome and TubularDaylightDiffuser objects:

- Shading control devices are not allowed.
- Frames and dividers are not allowed.
- Multipliers must be 1.0.
- Dome, diffuser, and pipe areas (as given by diameter) must be approximately equal.
- Outside face environment objects are not allowed.
- Dome and diffuser constructions cannot be more than one layer.

Since commercial TDDs are assumed to be cylindrical in shape, it is recommended that the circular areas of the actual dome and diffuser be approximated with a square of equivalent area for the TubularDaylightDome and TubularDaylightDiffuser objects. Although it is possible to use a triangular surface instead, a square is a much better geometric approximation of a circle.

Note that the TubularDaylightDome surface is allowed to have a different position and tilt from the roof base surface. If the actual TDD projects some height above the roof surface, the TubularDaylightDome coordinates should be located accordingly.

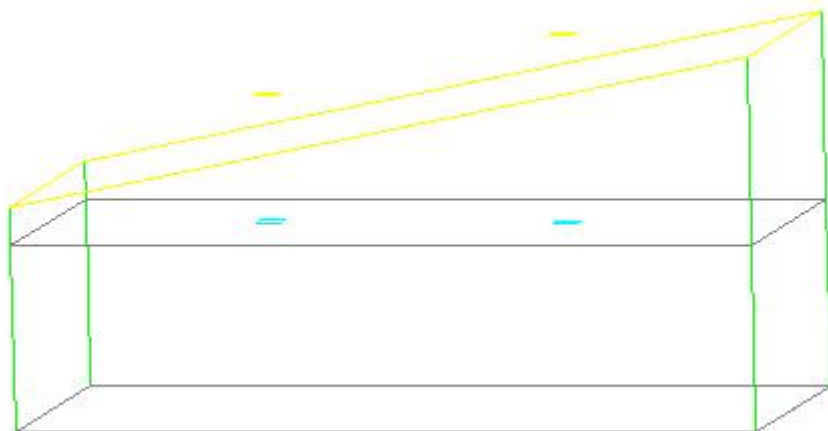


Figure 57. Tubular daylighting device DXF output.

The TubularDaylightDome surface automatically casts a shadow on the roof base surface. However, since the pipe is not represented by a surface, it will not cast a shadow. If this effect must be simulated, one or more SURFACE:SHADING objects can be used.

The dome and diffuser objects are connected by the DAYLIGHTING DEVICE:TUBULAR object:

```

DAYLIGHTING DEVICE:TUBULAR,
DaylightingDevice:Tubular,
  \extensible:2 Duplicate the last two fields Transition Zone Name and Transition Zone Length
A1 , \field Name
  \required-field
  \type alpha
A2 , \field Dome Name
  \note This must refer to a subsurface object of type TubularDaylightDome
  \required-field
  \type object-list
  \object-list SubSurfNames
A3 , \field Diffuser Name
  \note This must refer to a subsurface object of type TubularDaylightDiffuser
  \note Delivery zone is specified in the diffuser object
  \required-field
  \type object-list
  \object-list SubSurfNames
A4 , \field Construction Name
  \required-field
  \type object-list
  \object-list ConstructionNames
N1 , \field Diameter
  \required-field
  \units m
  \type real
  \minimum> 0
N2 , \field Total Length
  \note The exterior exposed length is the difference between total and sum of zone lengths
  \required-field
  \units m
  \type real
  \minimum> 0
N3 , \field Effective Thermal Resistance
  \note R value between TubularDaylightDome and TubularDaylightDiffuser
  \required-field
  \units m2-K/W
  \type real
  \minimum> 0
  \default 0.28
A5 , \field Transition Zone 1 Name
  \type object-list
  \object-list ZoneNames
N4 , \field Transition Zone 1 Length
  \units m
  \type real
  \minimum 0.0
<snipped>
A8 , \field Transition Zone 4 Name
  \type object-list
  \object-list ZoneNames
N7; \field Transition Zone 4 Length
  \units m
  \type real
  \minimum 0.0

```

Field: Name

The name of the TDD object.

Field: Dome Name

Reference to a FenestrationSurface:Detailed object with *Surface Type* TubularDaylightDome.

Field: Diffuser Name

Reference to a FenestrationSurface:Detailed object with *Surface Type* TubularDaylightDiffuser.

Field: Construction Name

The construction of the TDD pipe. The visible and solar absorptance of the inside material layer determines the reflectivity of the inner mirrored surface of the TDD. This is very important for the overall transmittance of the TDD.

Field: Diameter

The diameter [m] of the TDD pipe. The area of the pipe must match the areas of the dome and diffuser.

Field: Total Length

The total length [m] of the TDD pipe between the dome and the diffuser, including the exterior part above the roof. The exterior length is determined internally by subtracting the transition zone lengths from the total length.

Field: Effective Thermal Resistance

The effective thermal resistance [$\text{m}^2\text{-K/W}$], i.e. R-value, of the TDD between the exterior dome surface and the interior diffuser surface.

Field: Transition Zone<#> Name

Name of zone that the TDD pipe passes through before reaching the delivery zone.

Field: Transition Zone <#> Length

Length of pipe [m] in the transition zone. This is used for determining heat gains due to solar absorbed by the pipe in each transition zone. The distribution of absorbed solar gains can be customized by adjusting the length of pipe in each transition zone. The transition zone gain is proportional to the length of pipe in the zone. If no transition zones are specified, all solar absorbed by the pipe is lost to the exterior environment.

The *Transition Zone Name* and *Transition Zone Length* fields can be repeated for additional transition zones.

```

DaylightingDevice:Tubular,
  Pipe1,           !- Object Name
  Dome1,           !- Dome Name
  Diffuser1,       !- Diffuser Name
  Reflective Aluminum, !- Construction Name
  0.3556,          !- Diameter [m] (approximately 14", a standard size)
  1.4,             !- Total Length [m] (subtract zone lengths to get outdoor exposed length)
  0.28,           !- Effective Thermal Resistance [m2-K/W] between TubularDaylightDome and
!                 TubularDaylightDiffuser
  Attic Zone,      !- Transition Zone 1 Name
  1.1;             !- Transition Zone 1 Length [m]

FenestrationSurface:Detailed,
  Dome1, !- Subsurface Name
  TubularDaylightDome, !- Surface Type
  Clear Acrylic Dome, !- Construction Name (only 1 layer allowed in construction)
  Attic Roof, !- Base Surface Name
  , !- Outside Face Environment (not allowed for TubularDaylightDome)
  0.0, !- VF to Ground
  , !- Window Shading Control (not allowed for TubularDaylightDome)
  , !- Frame/Divider Name (not allowed for TubularDaylightDome)
  1.0, !- Multiplier (must be 1.0 for TubularDaylightDome)
  4, !- Number of Vertices
  2.3425, 3.1575, 3.9,
  2.3425, 2.8425, 3.9,
  2.6575, 2.8425, 3.9,
  2.6575, 3.1575, 3.9;

FenestrationSurface:Detailed,
  Diffuser1, !- Subsurface Name
  TubularDaylightDiffuser, !- Surface Type
  Frosted Acrylic Diffuser, !- Construction Name (only 1 layer allowed in construction)
  Daylit Zone Ceiling, !- Base Surface Name
  , !- Outside Face Environment (not allowed for TubularDaylightDiffuser)
  0.0, !- VF to Ground
  , !- Window Shading Control (not allowed for TubularDaylightDiffuser)
  , !- Frame/Divider Name (not allowed for TubularDaylightDiffuser)
  1.0, !- Multiplier (must be 1.0 for TubularDaylightDiffuser)
  4, !- Number of Vertices
  2.3425, 3.1575, 2.5,
  2.3425, 2.8425, 2.5,
  2.6575, 2.8425, 2.5,
  2.6575, 3.1575, 2.5;

```

Tubular Daylighting Device Output

The following output variables are specific to the DaylightingDevice:Tubular object:

```

Zone,Average,TDD Transmitted Solar [W]
Zone,Average,TDD Pipe Absorbed Solar [W]
Zone,Average,TDD Heat Gain [W]
Zone,Average,TDD Heat Loss [W]
Zone,Average,TDD Beam Solar Transmittance []
Zone,Average,TDD Beam Visible Transmittance []
Zone,Average,TDD Diffuse Solar Transmittance []
Zone,Average,TDD Diffuse Visible Transmittance []

```

In addition, several surface and window variables are also reported for the TubularDaylightDome and TubularDaylightDiffuser objects. For the TubularDaylightDome:

```

Zone,Average,Surface Ext Sunlit Area [m2]
Zone,Average,Surface Ext Sunlit Fraction []
Zone,Average,Surface Ext Solar Incident[W/m2]
Zone,Average,Surface Ext Solar Beam Incident[W/m2]
Zone,Average,Surface Ext Solar Sky Diffuse Incident[W/m2]
Zone,Average,Surface Ext Solar Ground Diffuse Incident[W/m2]
Zone,Average,Surface Ext Solar Beam Cosine Of Incidence Angle[]
Zone,Average,Window Transmitted Solar[W]
Zone,Average,Window Solar Absorbed:All Glass Layers[W]

```

For the TubularDaylightDiffuser:

Zone,Average,Surface Ext Solar Incident[W/m2] (*incident inside of pipe*)
 Zone,Average,Window Transmitted Solar[W] (*same as TDD Transmitted Solar*)
 Zone,Average,Window Solar Absorbed:All Glass Layers[W]

DaylightingDevice:Shelf

Daylighting shelves, or simply light shelves, are another device for bringing more daylight into a building. Installed as an accessory to a window, daylighting shelves work by reflecting exterior light onto the ceiling of a room. Daylighting shelves can have an inside shelf, an outside shelf, or both.

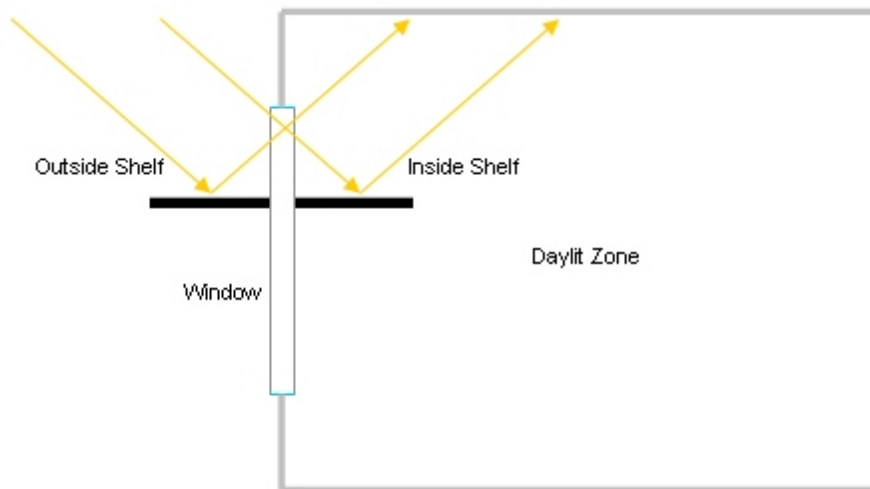


Figure 58. Daylighting shelf diagram.

The inside shelf redistributes light that would have entered the zone anyway. Instead of entering as a beam, all light is reflected onto the zone ceiling and is converted to diffuse shortwave radiation.

The outside shelf changes the amount of light entering the zone. If the shelf surface is more reflective than the ground, it can increase the amount of light incident on the upper part of the window. However, the shading effect of the outside shelf on the lower part of the window must also be considered as it can easily negate any gain achieved in the upper part of the window. All light reflected from the outside shelf that enters the upper window is assumed to strike the ceiling.

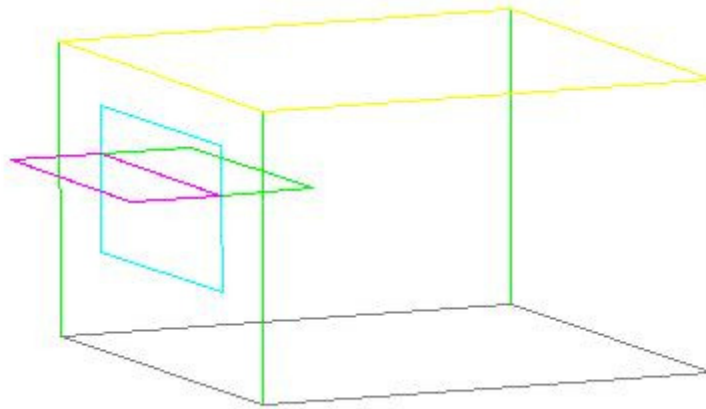


Figure 59. Daylighting shelf DXF output.

In EnergyPlus a daylighting shelf is simulated using a DaylightingDevice:Shelf object in combination with up to three other objects: a window, a heat transfer surface, and an attached shading surface.

The window must be divided into two window surfaces: an upper window and a lower window. The upper window interacts directly with the daylighting shelf object and is not allowed to have any shading control devices or frames or dividers. The lower window does not interact with the daylighting shelf object, but does receive shading from the outside shelf. There are no restrictions on the lower window.

The inside shelf is defined as a regular heat transfer surface in the zone. However, the surface must have the *Outside Boundary Condition* field set to Surface with itself as the other zone surface. Shading and thermal mass effects are taken into account.

The outside shelf is defined as a Shading:Zone:Detailed object. The visible and solar absorptance of the outside material layer determines the reflectivity of the shelf.

NOTE: Unlike a regular Shading:Zone:Detailed object, the vertices of the outside shelf surface must be ordered so that the outward normal vector points *upward*, i.e. toward the upper window. This is necessary in order for the outside shelf to properly receive sunlight and shading from other surfaces. A mirror shading surface with the outward normal vector pointing in the opposite direction is automatically created by the program to shade the lower window.

The inside shelf and outside shelf are both optional. However, if neither shelf is specified, the daylighting shelf object has no effect on the simulation.

```
DaylightingDevice:Shelf,
  A1 , \field Name
      \required-field
      \type alpha
  A2 , \field Window Name
      \required-field
      \type object-list
      \object-list SubSurfNames
```

```

A3 , \field Inside Shelf Name
      \note This must refer to a BuildingSurface:Detailed or equivalent object
      \note This surface must be its own Surface for other side boundary conditions.
      \type object-list
      \object-list SurfaceNames
A4 , \field Outside Shelf Name
      \note This must refer to a Shading:Zone:Detailed object
      \type object-list
      \object-list AttachedShadingSurfNames
A5 , \field Outside Shelf Construction Name
      \note Required if outside shelf is specified
      \type object-list
      \object-list ConstructionNames
N1 ; \field View Factor To Outside Shelf
      \type real
      \minimum 0.0
      \maximum 1.0

```

Field: Name

The name of the daylighting shelf object.

Field: Window Name

Reference to a FenestrationSurface:Detailed object with *Surface Type* WINDOW.

Field: Inside Shelf Name

Reference to a BuildingSurface:Detailed object. This field is optional. If used, this surface must have OTHERZONESURFACE specified for the *Outside Face Environment* field and the referenced other zone surface must be itself. The number of vertices of this surface object must be 4.

Field: Outside Shelf Name

Reference to a Shading:Zone:Detailed object. This field is optional. If used, the number of vertices of this surface object must be 4.

Field: Outside Shelf Construction Name

Reference to a CONSTRUCTION object. This field is required if an outside shelf is specified. The visible and solar absorptance of the outside material layer determines the shelf reflectivity.

Field: View Factor To Outside Shelf

User defined value for the view factor from the window to the outside shelf. This field is optional. If not specified, an exact view factor is calculated for two perpendicular rectangles of the same width having a shared edge. If the given surfaces do not meet these geometric requirements, it is necessary to specify a value here.

NOTE: It is up to the user to adjust the view factor to ground of the upper window to account for the part of the view blocked by the outside shelf. The calculated *View Factor To Outside Shelf* is reported in the eio file for this purpose. For the typical case where the shelf is parallel to the ground and the upper window is perpendicular to the ground, the view factor to ground is simply: $0.5 - \text{View Factor To Outside Shelf}$.

```

DaylightingDevice:Shelf,
Shelf, !- Name
Daylit Upper Window, !- Window Name
Inside Shelf, !- Inside Shelf Name
Outside Shelf, !- Outside Shelf Name
Shelf Construction; !- Outside Shelf Construction Name (required if outside shelf specified)
! 0.29; !- View Factor To Outside Shelf (optional)

FenestrationSurface:Detailed,
Daylit Upper Window, !- Subsurface Name
Window, !- Surface Type
Standard Window, !- Construction Name
Daylit South Wall, !- Base Surface Name
, !- Outside Face Environment
0.211, !- VF to Ground (user must adjust to account for view factor to outside shelf)
, !- Window Shading Control (not allowed)
, !- Frame/Divider Name (not allowed)
1.0, !- Multiplier (must be 1.0)
4, !- Number of Vertices
1.0, 0.0, 2.8,
1.0, 0.0, 2.0,
4.0, 0.0, 2.0,
4.0, 0.0, 2.8;

BuildingSurface:Detailed,
Inside Shelf, !- Surface Name
Wall, !- Surface Type
Shelf Construction, !- Construction Name
Daylit Zone, !- Zone Name
OtherZoneSurface, !- Exterior Conditions (must be OtherZoneSurface)
Inside Shelf, !- Target (must be itself)
NoSun, !- Solar Exposure
NoWind, !- Wind Exposure
0.0, !- VF to Ground
4, !- Number of Vertices
1.0, 0.0, 2.0,
4.0, 0.0, 2.0,
4.0, 1.0, 2.0,
1.0, 1.0, 2.0;

Shading:Zone:Detailed,
Outside Shelf, !- Surface Name
Daylit South Wall, !- Base Surface Name
, !- Shading Transmittance Schedule (default is always opaque)
4, !- Number of Vertices
1.0, 0.0, 2.0, !- Outward normal vector must point up toward the upper window
1.0, -1.0, 2.0,
4.0, -1.0, 2.0,
4.0, 0.0, 2.0;

```

Shelf Daylighting Device Output

The view factor to outside shelf calculation shows up in the .eio file along with the associated window and window view factors to sky and ground:

```

! <Shelf Details>,Name,View Factor to Outside Shelf,Window Name,Window View
Factor to Sky,Window View Factor to Ground
SHELF,0.29,DAYLIT UPPER WINDOW,0.50,0.21

```

This variable reports the calculated *View Factor To Outside Shelf* so that the user can correctly adjust the view factor to ground of the upper window.

The usual window and surface variables are relevant for the upper window:

```

Zone,Average,Surface Ext Sunlit Area [m2]
Zone,Average,Surface Ext Sunlit Fraction []
Zone,Average,Surface Ext Solar Incident[W/m2]
Zone,Average,Surface Ext Solar Beam Incident[W/m2]
Zone,Average,Surface Ext Solar Sky Diffuse Incident[W/m2]
Zone,Average,Surface Ext Solar Ground Diffuse Incident[W/m2]

```

```
Zone,Average,Surface Ext Solar Beam Cosine Of Incidence Angle[]
Zone,Average,Window Transmitted Solar[W]
Zone,Average,Window Solar Absorbed:All Glass Layers[W]
Zone,Average,Window Heat Gain[W]
Zone,Average,Window Heat Loss[W]
```

The following surface variables are reported for the outside shelf surface, if specified:

```
Zone,Average,Surface Ext Sunlit Area [m2]
Zone,Average,Surface Ext Sunlit Fraction []
Zone,Average,Surface Ext Solar Incident[W/m2]
Zone,Average,Surface Ext Solar Beam Incident[W/m2]
Zone,Average,Surface Ext Solar Sky Diffuse Incident[W/m2]
Zone,Average,Surface Ext Solar Ground Diffuse Incident[W/m2]
Zone,Average,Surface Ext Solar Beam Cosine Of Incidence Angle[]
```

DaylightingDevice:LightWell

This object specifies the properties of a “light well,” which is an opening often found underneath skylights (see Figure 46). The well attenuates the light transmitted by the skylight. The attenuation is characterized by the **well efficiency**, which is the ratio of the amount of light leaving the well to the amount of light entering the well. The well efficiency varies from close to 1.0 to close to zero if there is high attenuation. The well efficiency is used only in the EnergyPlus detailed daylighting calculation, where it multiplies the beam and diffuse light transmitted by the skylight. (The well efficiency is not used in calculating the solar gain through the skylight.)

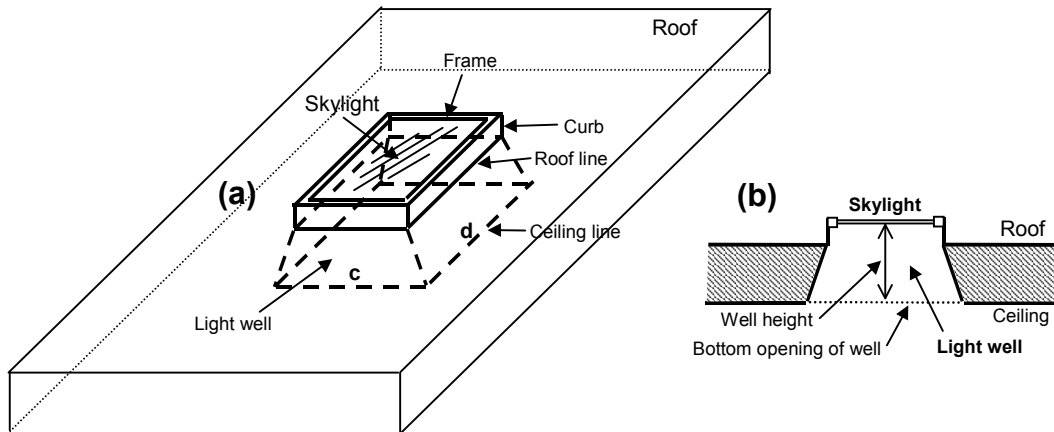


Figure 60. Skylight with light well: (a) perspective view, (b) vertical section.

If the bottom of the light well is a rectangle of side lengths c and d, as shown in (a), then the perimeter of the bottom of the well = 2(c+d) and the area = cd (see description of field names for the Light Well object).

The well efficiency depends on the visible reflectance of well’s side walls and on the well cavity ratio, WCR, which is given by:

$$WCR = \frac{2.5 \times \text{Well Height} \times \text{Well Perimeter}}{\text{Well Area}}$$

Well Height, Well Perimeter and Well Area are shown or discussed in Figure 46 and described below in the field definitions for the Light Well object.

Figure 47 is a graph that shows well efficiency vs. WCR for different side wall reflectances. For use in the EnergyPlus calculation, a fit has been made to this graph that gives the

following mathematical expression, where “Reflectance” is the user input value of the well-wall reflectance expressed as a fraction:

$$\text{Well efficiency} = e^{-WCR*(0.16368-0.144678*\text{Reflectance})}$$

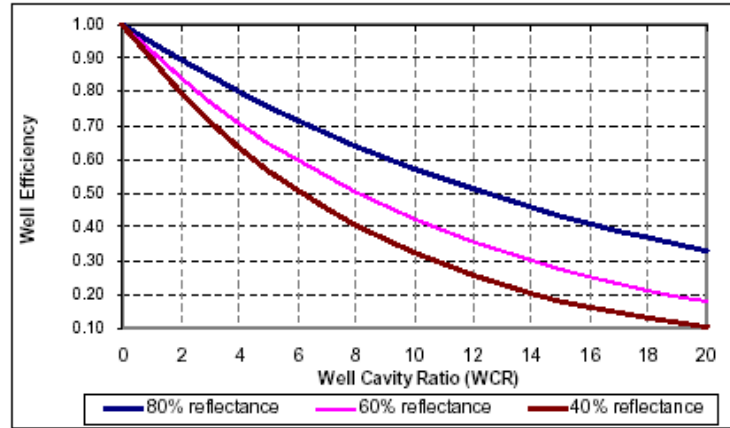


Figure 61. Graph showing light well efficiency vs. well cavity ratio (WCR) for well-wall visible reflectances of 80% (upper curve), 60% (middle curve) and 40% (lower curve). Based on Fig. 8-21 of the Lighting Handbook: Reference and Application, 8th Edition, 1993, Illuminating Engineering Society of North America.

Field: Exterior Window Name

The name of the exterior window that this Light Well is associated with. Generally this is a skylight in a roof. However, light wells can be applied to an exterior window of any slope. Light wells can be assigned to both rectangular and triangular exterior windows, but they should not be assigned to interior windows. Note that the sides of the light well can be sloped and the bottom of the light well can be any shape, not just rectangular.

Field: Height of Well

The distance from the bottom of the skylight to the bottom of the well. If the skylight and well bottom are not coplanar, this is the distance from the center of the bottom of the skylight to center of the bottom of the well. See Figure 46.

Field: Perimeter of Bottom of Well

The perimeter of the bottom opening of the well. See Figure 46.

Field: Area of Bottom of Well

The area of the bottom opening of the well. A warning will be issued if this area is less than the area of the skylight, including frame if present. See Figure 46.

Field: Visible Reflectance of Well Walls

The visible reflectance of the side walls of the well. If the walls do not all have the same reflectance, an area-weighted average value can be used.

```
DaylightingDevice:LightWell,
  \min-fields 5
  \memo Applies only to exterior windows in daylighting-controlled zones or
  \memo in zones that share an interior window with a daylighting-controlled zone.
  \memo Generally used with skylights.
  A1, \field Exterior Window Name
      \required-field
      \type alpha
  N1, \field Height of Well
      \note Distance from Bottom of Window to Bottom of Well
```

```
\required-field
\minimum 0.0
```

```
N2, \field Perimeter of Bottom of Well
    \required-field
    \minimum> 0.0
N3, \field Area of Bottom of Well
    \required-field
    \minimum> 0.0
N4; \field Visible Reflectance of Well Walls
    \minimum 0.0
    \maximum 1.0
    \required-field
```

An IDF example:

```
DaylightingDevice:LightWell, ! The well is 60% reflecting, is 1.2m high and has a 2.5m x 5.5m
bottom opening.
Skylight-1, !- Name of Exterior Window that this Light Well Applies To
1.2,      !- Height of Well(m)
16.0,    !- Perimeter of Bottom of Well (m)
13.75,   !- Area of Bottom of Well (m2)
0.60;    !- Visible Reflectance of Well Walls
```

Daylighting Modeling Options

The following table shows what input objects/fields to use to model different daylighting options. It also gives the name of an example input, if available, that demonstrates the option.

Table 19. Daylighting Modeling Options

Option	Object/Field or Output Variable	Input File
Allow a thermal zone to be daylit	Daylighting:Controls, Daylighting:DELight:Controls	PurchAirWithDaylighting.idf, DElight-Detailed- Comparison.idf
Specify visible transmittance of the glazing	WindowMaterial:Glazing	PurchAirWithDaylighting.idf
Specify the visible transmittance of a shading device	WindowMaterial:Shade, WindowMaterial:Screen or WindowMaterial:Blind	PurchAirWindowBlind.idf
Use a shading device to control glare	WindowMaterial:Shade or WindowMaterial:Blind; WindowProperty:ShadingControl*	PurchAirWindowBlind.idf
Use electrochromic glazing to control glare	WindowProperty:ShadingControl/Sh ading Type = SwitchableGlazing, Shading Control Type = On If High Glare, Glare Control Is Active = Yes*	PurchAirWithDaylighting.idf
Adjust electrochromic glazing to just meet daylighting illuminance setpoint	WindowProperty:ShadingControl/Sh ading Type = SwitchableGlazing, Shading Control Type = MeetDaylightIlluminanceSetpoint*	
Print an illuminance map	Daylighting:Illuminance Map*	
Control electric lighting response to daylight illuminance level	Daylighting:Controls/Lighting Control Type = Continuous, Stepped or Continuous/Off, plus other fields; or Daylighting:DELight:Controls/Lightin	PurchAirWithDaylighting.idf; DElight-Detailed- Comparison.idf

	g Control Type = Continuous, Stepped or Continuous/Off, plus other fields	
Add a light shelf (with Daylighting:Controls)	DaylightingDevice:Shelf *	DaylightingDeviceShelf.idf
Add a light shelf (with Daylighting:DELight:Controls)	Daylighting:DELight:Controls	DELightCFSLightShelf.idf
Add a light pipe	DaylightingDevice:Tubular *	DaylightingDeviceTubular.idf
Model a skylight having a light well	DaylightingDevice:LightWell *	
Model daylighting through double facade	See “Double Facades: Daylighting through Interior Windows”*	PurchAirWithDoubleFacade Daylighting.idf
Add diffusing (translucent) glass	WindowMaterial:Glazing/Solar Diffusing = Yes*	
Model complex fenestration	Daylighting:DELight:Controls	DELightCFSWindow.idf
Get a radiosity-based interior light inter-reflection calculation	Daylighting:DELight:Controls	DELight-Detailed-Comparison.idf
Find effect on daylighting of solar reflected from overhangs, neighboring buildings, etc.	Building/SolarDistribution uses “withReflections” option	
Find visible transmittance effect of dirt on window	WindowMaterial:Glazing/Dirt Correction Factor for Solar and Visible Transmittance*	

*Used only with Daylighting:Controls

Group – Exterior Energy Use Equipment

To facilitate the reporting of exterior consumption (to the building’s heat balance/loads considerations), several objects have been included. The consumption related to these items will appear on meters specific to the items.

Exterior:Lights

Field: Name

This descriptive name allows the values of exterior lights consumption to appear in the “normal” output variable list as well as the meters. It cannot be blank nor can it be duplicated by other Exterior:Lights statements.

Field: Schedule Name

A schedule will allow the exterior lights consumption to be operationally different, hour to hour as well as seasonally. Fractional values in the basic schedule will be applied to the design level field below.

Field: Design Level

This field (in Watts) is typically used to represent the maximum electrical input to exterior lighting fixtures that is then multiplied by a schedule fraction (see previous field). In EnergyPlus, this is slightly more flexible in that the lighting design level could be a “diversity factor” applied to a schedule of real numbers. Note that while the schedule value can vary from hour to hour and seasonally, the design level field is constant for all simulation environments.

Field: Control Option

This field is used to determine how the exterior lights are controlled. There are currently two options, ‘ScheduleNameOnly’ and ‘AstronomicalClock.’ If this field is omitted or left blank then the program will default to Schedule Name Only mode. The ‘ScheduleNameOnly’ mode

dictates that the exterior lights always follow the schedule named in the field above. The 'AstronomicalClock' mode dictates that despite what the schedule indicates, the exterior lights will not run when the sun is up. Using the Astronomical Clock mode makes it simple to model exterior lights that are controlled by a photocell or other controller that ensures that outdoor lights will not run during the daytime. However, the Astronomical Clock control works off of the position of the sun and therefore does not operate exactly like a photocell. During the night, the schedule values are still applied in the usual way.

Field: End-Use Subcategory

Allows you to specify a user-defined end-use subcategory, e.g., "Grounds Lights", "Facade Lights", etc. A new meter for reporting is created for each unique subcategory (ref: Report Meter). Subcategories are also reported in the ABUPS table. If this field is omitted or blank, the lights will be assigned to the "General" end-use subcategory.

```
Exterior:Lights,
  \memo only used for Meter type reporting, does not affect building loads
  A1 , \field Name
      \required-field
      \type alpha
      \reference ExteriorLightsNames
  A2 , \field Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
      \note units in schedule should be fraction applied to capacity of the exterior lights equipment,
generally (0.0 - 1.0)
  N1 , \field Design Level
      \required-field
      \units W
      \type real
      \minimum 0
      \ip-units W
  A3, \field Control Option
      \note Astronomical Clock option overrides schedule to turn lights off when sun is up
      \type choice
      \key ScheduleNameOnly
      \key AstronomicalClock
  A4 ; \field End-Use Subcategory
      \type alpha
      \retaincase
      \default General
```

An IDF Example:

```
Exterior:Lights,
  OutsideLights,      !- Name
  ON,                 !- SCHEDULE Name
  1000,               !- Design Level
  AstronomicalClock, !- Control Option
  Grounds Lights;    !- End-Use Subcategory
```

Exterior Lights Outputs

Output for exterior lights appears in three possible places. It will appear on two meters (Electricity:Facility and ExteriorLights:Electricity) as well as in its own designated value in the standard output file.

```
Zone,Meter,Electricity:Facility [J]
Zone,Meter,ExteriorLights:Electricity [J]
Zone,Sum,Exterior Lights-Electric Consumption [J]
```


Exterior:FuelEquipment**Field: Name**

This descriptive name allows the values of exterior equipment consumption to appear in the “normal” output variable list as well as the meters. It cannot be blank nor can it be duplicated by other Exterior:FuelEquipment or Exterior:WaterEquipment statements.

Field: Fuel Use Type

This field designates the appropriate meter for the exterior fuel equipment. Valid fuel types are: Electricity, NaturalGas, PropaneGas, FuelOil#1, FuelOil#2, Diesel, Gasoline, Coal, Steam, DistrictHeating, and DistrictCooling. The fuel type triggers the application of consumption amounts to the appropriate energy meters.

Field: Schedule Name

A schedule will allow the exterior lights consumption to be operationally different, hour to hour as well as seasonally. Fractional values in the basic schedule will be applied to the design level field below.

Field: Design Level

This field (Watts) is typically used to represent the maximum input to exterior fixtures that is then multiplied by a schedule fraction (see previous field). In EnergyPlus, this is slightly more flexible in that the design level could be a “diversity factor” applied to a schedule of real numbers. Note that while the schedule value can vary from hour to hour and seasonally, the design level field is constant for all simulation environments.

Field: End-Use Subcategory

Allows you to specify a user-defined end-use subcategory, e.g., "Fountains", etc. A new meter for reporting is created for each unique subcategory (ref: Report Meter). Subcategories are also reported in the ABUPS table. If this field is omitted or blank, the equipment will be assigned to the "General" end-use subcategory.

```

Exterior:FuelEquipment,
  \memo only used for Meter type reporting, does not affect building loads
A1 , \field Name
  \required-field
  \type alpha
  \reference ExteriorFuelEquipmentNames
A2 , \field Fuel Use Type
  \required-field
  \type choice
  \key Electricity
  \key NaturalGas
  \key PropaneGas
  \key FuelOil#1
  \key FuelOil#2
  \key Diesel
  \key Gasoline
  \key Coal
  \key Steam
  \key DistrictHeating
  \key DistrictCooling
A3 , \field Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
  \note units in schedule should be fraction applied to capacity of the exterior fuel equipment,
generally (0.0 - 1.0)
N1 , \field Design Level
  \required-field
  \units W
  \type real
  \minimum 0
  \ip-units W
A4 ; \field End-Use Subcategory
  \type alpha
  \retaincase
  \default General

```

IDF Examples:

```

Exterior:FuelEquipment,OutsideGasEq,Gas,ON,1000;
Exterior:FuelEquipment,OutsideCoalEq,Coal,ON,1000;
Exterior:FuelEquipment,OutsideFuelOil1Eq,FuelOil#1,ON,1000;
Exterior:FuelEquipment,OutsideFuelOil2Eq,FuelOil#2,ON,1000;
Exterior:FuelEquipment,OutsideLPGEq,PropaneGas,ON,1000;

```

Exterior:WaterEquipment

Field: Name

This descriptive name allows the values of exterior equipment consumption to appear in the “normal” output variable list as well as the meters. It cannot be blank nor can it be duplicated by other Exterior:FuelEquipment or Exterior:WaterEquipment statements.

Field: FuelUseType

For Exterior:WaterEquipment, only “Water” is current allowed for this field.

Field: Schedule Name

A schedule will allow the exterior water consumption to be operationally different, hour to hour as well as seasonally. Fractional values in the basic schedule will be applied to the design level field below.

Field: Design Level

This field (in m3/s) is typically used to represent the maximum volumetric flow for water fixtures that is then multiplied by a schedule fraction (see previous field). In EnergyPlus, this is slightly more flexible in that the exterior water equipment design level could be a “diversity

factor” applied to a schedule of real numbers. Note that while the schedule value can vary from hour to hour and seasonally, the design level field is constant for all simulation environments.

Field: End-Use Subcategory

Allows you to specify a user-defined end-use subcategory, e.g., "Landscaping", etc. A new meter for reporting is created for each unique subcategory (ref: Report Meter). Subcategories are also reported in the ABUPS table. If this field is omitted or blank, the equipment will be assigned to the "General" end-use subcategory.

```
Exterior:WaterEquipment,
  \memo only used for Meter type reporting, does not affect building loads
  A1 , \field Name
      \required-field
      \type alpha
      \reference ExteriorWaterEquipmentNames
  A2 , \field Fuel Use Type
      \type choice
      \key Water
      \default Water
  A3 , \field Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
      \note units in Schedule should be fraction applied to capacity of the exterior water equipment,
      generally (0.0 - 1.0)
```

```
N1 , \field Design Level
    \required-field
    \units m3/s
    \type real
    \minimum 0
  A4 ; \field End-Use Subcategory
      \type alpha
      \retaincase
      \default General
```

IDF Example:

```
Exterior:WaterEquipment,OutsideWaterEq,Water,ON,10000;
```

Exterior Fuel Equipment, Exterior Water Equipment Outputs

Output for exterior equipment consumption appears in three possible places. It will appear on two meters (<FuelType>:Facility and ExteriorEquipment:<FuelType>) as well as in its own designated value in the standard output file, ExteriorEq Misc-<FuelType> Consumption. Consumption also appears on any user-defined end-use subcategory meters, i.e., <End-Use Subcategory>:ExteriorEquipment:<FuelType>. All outputs are in [J] except water consumption which is in [m3]

```
Zone,Meter,Electricity:Facility [J]
Zone,Meter,ExteriorEquipment:Electricity [J]
Zone,Sum,ExteriorEq Misc-Electric Consumption [J]

Zone,Meter,Gas:Facility [J]
Zone,Meter,ExteriorEquipment:Gas [J]
Zone,Sum,ExteriorEq Misc-Gas Consumption [J]

Zone,Meter,Water:Facility [m3]
Zone,Meter,ExteriorEquipment:Water [m3]
Zone,Sum,ExteriorEq Misc-Water Consumption [m3]

Zone,Meter,Coal:Facility [J]
Zone,Meter,ExteriorEquipment:Coal [J]
Zone,Sum,ExteriorEq Misc-Coal Consumption [J]
```

```

Zone,Meter,FuelOil#1:Facility [J]
Zone,Meter,ExteriorEquipment:FuelOil#1 [J]
Zone,Sum,ExteriorEq Misc-FuelOil#1 Consumption [J]

Zone,Meter,Propane:Facility [J]
Zone,Meter,ExteriorEquipment:Propane [J]
Zone,Sum,ExteriorEq Misc-Propane Consumption [J]

```

```

Zone,Meter,FuelOil#2:Facility [J]
Zone,Meter,ExteriorEquipment:FuelOil#2 [J]
Zone,Sum,ExteriorEq Misc-FuelOil#2 Consumption [J]

Zone,Meter,Gasoline:Facility [J]
Zone,Meter,ExteriorEquipment:Gasoline [J]
Zone,Sum,ExteriorEq Misc-Gasoline Consumption [J]

Zone,Meter,Diesel:Facility [J]
Zone,Meter,ExteriorEquipment:Diesel [J]
Zone,Sum,ExteriorEq Misc-Diesel Consumption [J]

Zone,Meter,Steam:Facility [J]
Zone,Meter,ExteriorEquipment:Steam [J]
Zone,Sum,ExteriorEq Misc-Steam Consumption [J]

Zone,Meter,PurchasedHeating:Facility [J]
Zone,Meter,ExteriorEquipment:PurchasedHeating [J]
Zone,Sum,ExteriorEq Misc-PurchasedHeating Consumption [J]

Zone,Meter,PurchasedCooling:Facility [J]
Zone,Meter,ExteriorEquipment:PurchasedCooling [J]
Zone,Sum,ExteriorEq Misc-PurchasedCooling Consumption [J]

```

Group – Airflow

An important characteristic of energy consumption in buildings is the airflow between zones and airflow due to natural ventilation (e.g., open windows) or mechanically-induced ventilation (e.g., exhaust air fans). This group of objects describes those elements.

The AirflowNetwork model can also be used to model infiltration and mixing (zone-to-zone air flow) with or without the HVAC air distribution system operating (see Group – Airflow Network).

ZoneInfiltration:DesignFlowRate

Infiltration is the unintended flow of air from the outdoor environment directly into a thermal zone. Infiltration is generally caused by the opening and closing of exterior doors, cracks around windows, and even in very small amounts through building elements. The basic equation used to calculate infiltration with this object is:

$$Infiltration = (I_{design})(F_{schedule}) \left[A + B|(T_{zone} - T_{odb})| + C(WindSpeed) + D(WindSpeed^2) \right]$$

More advanced infiltration calculations are possible using the EnergyPlus AirflowNetwork model for natural infiltration driven by wind and/or by forced air. Infiltration described by the equation shown above is entered into EnergyPlus using the following syntax. Exfiltration (the leakage of zone air to the outside) is generally handled better as zone exhaust air in the zone equipment description.

The question of typical values for these coefficients is subject to debate. Ideally, one should do a detailed analysis of the infiltration situation and then determine a custom set of coefficients using methods such as those laid out in Chapter 26 of the ASHRAE Handbook of Fundamentals. The EnergyPlus defaults are 1,0,0,0 which give a constant volume flow of infiltration under all conditions.

BLAST (one of the EnergyPlus predecessors) used the following values as defaults: 0.606, 0.03636, 0.1177, 0. These coefficients produce a value of 1.0 at 0C deltaT and 3.35 m/s (7.5 mph) windspeed, which corresponds to a typical summer condition. At a winter condition of 40C deltaT and 6 m/s (13.4 mph) windspeed, these coefficients would increase the infiltration rate by a factor of 2.75.

In DOE-2 (the other EnergyPlus predecessor), the air change method defaults are (adjusted to SI units) 0, 0, 0.224 (windspeed), 0. With these coefficients, the summer conditions above would give a factor of 0.75, and the winter conditions would give 1.34. A windspeed of 4.47 m/s (10 mph) gives a factor of 1.0.

The source of the BLAST defaults is noted in the BLAST documentation as:

"Empirical equation and the coefficient default were determined from ASHRAE journal articles and other data on the effects of outdoor weather conditions."

The source of the DOE-2 defaults is based on examining the infiltration relationships described in the ASHRAE Handbook of Fundamentals.

The EnergyPlus example files use all of the above, the BLAST defaults in some (e.g., GeometryTest), the DOE-2 defaults in some (e.g., 5ZoneAirCooled), and the EnergyPlus defaults in some (e.g., LgOffVAVDetCoil).

The local outdoor dry-bulb temperature used in the above basic equation (T_{odb}) is typically a function of the height of the zone centroid above ground. The corresponding zone name is given in the second field. The local outdoor dry-bulb temperature calculation procedure is given in the section of "Local Outdoor Air Temperature Calculation" in the Engineering Reference.

The local outdoor wind speed used in the above basic equation (WindSpeed) is also a function of the height of the zone centroid above ground. The corresponding zone name is given in the second field. The local outdoor wind speed calculation procedure is given in the section of "Local Wind Speed Calculation" in the Engineering Reference.

Note: When the value of the Wind Speed Profile Exponent field in the Site:HeightVariation is equal to 0.0. The local wind speed is always equal to the wind speed given in the weather data and will not be dependent on zone centroid height. Similarly, if the value of the Air Temperature Gradient Coefficient is set equal to 0 the local air dry-bulb temperature is also always equal to the air dry-bulb temperature given in the weather data and will not be dependent on zone centroid height.

One or more infiltration objects can be defined for each zone, and the resulting infiltration rate for the zone will simply be the summation of the flow rates specified by the infiltration objects.

Field: Name

The name of the ZoneInfiltration:DesignFlowRate object. This needs to be unique across all different ZoneInfiltration objects.

Field: Zone Name

This field is the name of the zone (ref: Zone) and attaches a particular infiltration statement to a thermal zone in the building.

Field: Schedule Name

This field is the name of the schedule (ref: Schedule) that modifies the maximum design volume flow rate (I_{design}). This fraction between 0.0 and 1.0 is noted as F_{schedule} in the above equation.

Field: Design Flow Rate Calculation Method

This field is a key/choice field that tells which of the next four fields are filled and is descriptive of the method for calculating the design volume flow rate. The key/choices are:

- Flow/Zone

With this choice, the method used will be a straight insertion of the design volume flow rate. (The Design Flow Rate field should be filled.)

- Flow/Area

With this choice, the method used will be a factor per floor area of the zone. (The flow per Zone Area field should be filled).

- Flow/ExteriorArea

With this choice, the method used will be a factor per exterior surface area of the zone. (The flow per Exterior Surface Area field should be filled).

- Flow/ExteriorWallArea

With this choice, the method used will be a factor per exterior wall surface area of the zone. (The flow per Exterior Surface Area field should be filled).

- AirChanges/Hour

With this choice, the method used will be the number of air changes per hour for the infiltration amount. This factor, along with the Zone Volume, will be used to determine the Design Flow Rate. (The Air Changes per Hour field should be filled).

Field: Design Flow Rate

This field denotes the full design volume flow rate (m^3/s). The previous field should choose “flow/zone” as the choice. The design volume flow rate (noted as I_{design} in the above equation) is the maximum amount of infiltration expected at design conditions. The flow rate is expressed in units of . The design value is modified by the schedule fraction (see Field:Schedule Name) and user specified coefficients (see “coefficient” fields below).

Field: Flow per Zone Floor Area

This factor ($\text{m}^3/\text{s}\cdot\text{m}^2$) is used, along with the Zone Area to determine the maximum Design Volume Flow Rate as described in the Design Volume Flow Rate field. The choice from the method field should be “Flow/Area”.

Field: Flow per Exterior Surface Area

This factor ($\text{m}^3/\text{s}\cdot\text{m}^2$) is used, along with the Exterior Surface Area in the Zone to determine the maximum Design Volume Flow Rate as described in the Design Volume Flow Rate field. The choice from the method field should be “Flow/Exteriorarea” or “Flow/ExteriorWallArea”.

Field: Air Changes per Hour

This factor is used, along with the Zone Volume to determine the maximum Design Volume Flow Rate as described in the Design Volume Flow Rate field. The choice from the method field should be “AirChanges/Hour”.

Field: Constant Term Coefficient

This number is the “A” parameter in the above infiltration equation. It is part of the user specified modifying parameters that are a function of environmental factors. This parameter, however, is a constant under all conditions and is not modified by any environmental effect. As a result, it is dimensionless.

Field: Temperature Term Coefficient

This number is the “B” parameter in the above infiltration equation. It is part of the user specified modifying parameters that are a function of environmental factors. This parameter is modified by the temperature difference between the outdoor and indoor air dry-bulb temperatures. The units for this parameter are inverse Celsius.

Field: Velocity Term Coefficient

This number is the “C” parameter in the above infiltration equation. It is part of the user specified modifying parameters that are a function of environmental factors. This parameter is modified by the speed of wind being experienced outside the building. The units for this parameter are s/m.

Field: Velocity Squared Term Coefficient

This number is the “D” parameter in the above infiltration equation. It is part of the user specified modifying parameters that are a function of environmental factors. This parameter is modified by square of the speed of wind being experienced outside the building. The units for this parameter are s^2/m^2 .

```

ZoneInfiltration:DesignFlowRate,
  \min-fields 12
  \memo Infiltration is specified as a design level which is modified by a Schedule fraction,
temperature difference and wind speed:
  \memo Infiltration=Idesign * FSchedule * (A + B*(Tzone-Todb) + C*WindSpd + D * WindSpd**2)
A1 , \field Name
  \required-field
  \type alpha
A2 , \field Zone Name
  \required-field
  \type object-list
  \object-list ZoneNames
A3 , \field Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames

```

```

A4 , \field Design Flow Rate Calculation Method
    \note The entered calculation method is used to create the maximum amount of infiltration
    \note for this set of attributes
    \note Choices: Flow/Zone => Design Flow Rate -- simply enter Design Flow Rate
    \note Flow/Area => Flow per Zone Area - Value * Floor Area (zone) = Design Flow Rate
    \note Flow/ExteriorArea => Flow per Exterior Surface Area - Value * Exterior Surface Area (zone) =
Design Flow Rate
    \note Flow/ExteriorWallArea => Flow per Exterior Surface Area - Value * Exterior Wall Surface Area
(zone) = Design Flow Rate
    \note AirChanges/Hour => Air Changes per Hour - Value * Floor Volume (zone) adjusted for m3/s =
Design Volume Flow Rate
    \note "Idesign" in Equation is the result.
    \required-field
    \type choice
    \key Flow/Zone
    \key Flow/Area
    \key Flow/ExteriorArea
    \key Flow/ExteriorWallArea
    \key AirChanges/Hour
    \default Flow/Zone
N1 , \field Design Flow Rate
    \units m3/s
    \type real
    \minimum 0
    \ip-units ft3/min
N2 , \field Flow per Zone Area
    \type real
    \minimum 0
    \units m3/s-m2
N3 , \field Flow per Exterior Surface Area
    \note use key Flow/ExteriorArea for all exterior surface area
    \note use key Flow/ExteriorWallArea to include only exterior wall area
    \units m3/s-m2
    \type real
    \minimum 0
N4 , \field Air Changes per Hour
    \type real
    \minimum 0
N5 , \field Constant Term Coefficient
    \required-field
    \note "A" in Equation
    \type real
    \minimum 0
    \default 1
N6 , \field Temperature Term Coefficient
    \required-field
    \note "B" in Equation
    \type real
    \minimum 0
    \default 0
N7 , \field Velocity Term Coefficient
    \required-field
    \note "C" in Equation
    \type real
    \minimum 0
    \default 0
N8 ; \field Velocity Squared Term Coefficient
    \required-field
    \note "D" in Equation
    \type real
    \minimum 0
    \default 0

```

An IDF example:


```

ZoneInfiltration:DesignFlowRate,
Infiltration 1,      !- Name
DORM ROOMS AND COMMON AREAS, !- Zone Name
Infiltration Sch,  !- SCHEDULE Name
Flow/Zone,         !- Design Volume Flow Rate calculation method
2.831685,          !- Design Volume Flow Rate {m3/s}
,                  !- Flow per Zone Area {m3/s/m2}
,                  !- Flow per Exterior Surface Area {m3/s/m2}
,                  !- Air Changes Per Hour
0.6060000,        !- Constant Term Coefficient
3.6359996E-02,   !- Temperature Term Coefficient
0.1177165,       !- Velocity Term Coefficient
0.0000000E+00;   !- Velocity Squared Term Coefficient

```

ZoneInfiltration:EffectiveLeakageArea

ZoneInfiltration:EffectiveLeakageArea model is similar to the other infiltration objects but uses a different equation to model the unintended flow of air from the outdoor environment directly into a thermal zone. Infiltration is generally caused by the opening and closing of exterior doors, cracks around windows, and even in very small amounts through building elements. This model is based on work by Sherman and Grimsrud (1980) and is appropriate for smaller, residential-type buildings. The equation used to calculate infiltration in the effective leakage area model is:

$$Infiltration = (F_{Schedule}) \frac{A_L}{1000} \sqrt{C_s \Delta T + C_w (WindSpeed)^2}$$

where ΔT is the average difference between zone air temperature and the outdoor air temperature and the other coefficients are described below.

Note that the coefficients for the “EffectiveLeakageArea” model are not interchangeable with the similarly named coefficients in the “FlowCoefficient” model (see ZoneInfiltration:FlowCoefficient object).

One or more infiltration objects of different types can be defined for each zone, and the resulting infiltration rate for the zone will simply be the summation of the flow rates specified by the infiltration objects.

Field: Name

The name of the ZoneInfiltration:EffectiveLeakageArea object. This needs to be unique across all different ZoneInfiltration objects.

Field: Zone Name

This field is the name of the zone (ref: Zone) and attaches a particular infiltration statement to a thermal zone in the building.

Field: Schedule Name

This field is the name of a schedule (ref: Schedule) that modifies the volume flow rate calculated by the model. This fraction between 0.0 and 1.0 is noted as $F_{Schedule}$ in the above equation.

Field: Effective Air Leakage Area

This field is the effective air leakage area, in cm^2 , at 4 Pa. This is the value A_L in the equation above. Effective leakage area data can be obtained from a whole-building pressure test (eg. blower door test). ASHRAE Handbook of Fundamentals also lists typical values component leakage areas for low-rise residential (e.g. Table 1 in Chapter 26 of HoF 2001). The value should correspond to a pressure difference of 4 Pa.

Field: Stack Coefficient

This field is the value of the stack coefficient, C_s in the equation above. The coefficient has units of $(L/s)^2/(cm^4 \cdot K)$. Values for the “Basic Model Stack Coefficient” listed in the ASHRAE Handbook of Fundamentals (2005 and 2001) are:

One story house	Two story house	Three story house
0.000145	0.000290	0.000435

Field: Wind Coefficient

This field is the value of the wind coefficient, C_w in the equation above. The coefficient has units of $(L/s)^2/(cm^4 \cdot (m/s)^2)$. Values for the “Basic Model Wind Coefficient” listed in the ASHRAE Handbook of Fundamentals (2005 chapter 27; 2001, Chapter 26) depend on the type of shelter and are listed in the following tables.

Shelter class	One story house	Two story house	Three story house
1	0.000319	0.000420	0.000494
2	0.000246	0.000325	0.000382
3	0.000174	0.000231	0.000271
4	0.000104	0.000137	0.000161
5	0.000032	0.000042	0.000049

Shelter class	Description
1	No obstructions or local shielding
2	Typical shelter for an isolated rural house
3	Typical shelter caused by other buildings across the street
4	Typical shelter for urban buildings on larger lots
5	Typical shelter produced by buildings that are immediately adjacent.

```

ZoneInfiltration:EffectiveLeakageArea,
  \min-fields 6
  \memo Infiltration is specified as effective leakage area at 4 Pa, schedule fraction, stack and
wind coefficients, and
  \memo is a function of temperature difference and wind speed:
  \memo Infiltration=FSchedule * (AL /1000) SQRT(Cs*(Tzone-Todb)| + Cw*WindSpd**2 )
A1 , \field Name
  \required-field
  \type alpha
A2 , \field Zone Name
  \required-field
  \type object-list
  \object-list ZoneNames
A3 , \field Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
N1 , \field Effective Air Leakage Area
  \note "AL" in Equation
  \note units are cm2 (square centimeters)
  \minimum> 0
  \type real
  \required-field
N2 , \field Stack Coefficient
  \note "Cs" in Equation
  \minimum> 0
  \type real
  \required-field
N3 ; \field Wind Coefficient
  \note "Cw" in Equation
  \minimum> 0
  \type real
  \required-field

```

An example IDF object is

```

ZoneInfiltration:EffectiveLeakageArea,
  LIVING ZONE Infil 1,      !- Name
  LIVING ZONE,             !- Zone Name
  INF-SCHED,               !- Schedule Name
  500.0,                   !- Effective Air Leakage Area
  0.000145,                !- Stack Coefficient
  0.000174 ;               !- Wind Coefficient

```

ZoneInfiltration:FlowCoefficient

ZoneInfiltration:FlowCoefficient model is similar to the other infiltration objects but uses a different equation to model the unintended flow of air from the outdoor environment directly into a thermal zone. Infiltration is generally caused by the opening and closing of exterior doors, cracks around windows, and even in very small amounts through building elements. This reformulated model is based on the AIM-2 model by Walker and Wilson (1998) and is appropriate for smaller, residential-type buildings. The equation used to calculate infiltration in the flow coefficient model is:

$$Infiltration = (F_{Schedule}) \sqrt{(c C_s \Delta T^n)^2 + (c C_w (s * WindSpeed)^{2n})^2}$$

Where ΔT is the average difference between zone air temperature and the outdoor air temperature and the other coefficients are described below.

Note that the coefficients for the “Flow Coefficient” model are not interchangeable with the similarly named coefficients in the “Effective Leakage Area” model (see ZoneInfiltration:EffectiveLeakageArea object).

One or more infiltration objects of different types can be defined for each zone, and the resulting infiltration rate for the zone will simply be the summation of the flow rates specified by the infiltration objects.

Field: Name

The name of the ZoneInfiltration:FlowCoefficient object. This needs to be unique across all different ZoneInfiltration objects.

Field: Zone Name

This field is the name of the zone (ref: Zone) and attaches a particular infiltration statement to a thermal zone in the building.

Field: Schedule Name

This field is the name of a schedule (ref: Schedule) that modifies the volume flow rate calculated by the model. This fraction between 0.0 and 1.0 is noted as F_{schedule} in the above equation.

Field: Flow Coefficient

This field is the flow coefficient in $\text{m}^3/(\text{s}\cdot\text{Pa}^n)$. This is the value c in the equation above. The flow coefficient can be determined from the effective leakage area and whole-building pressure tests (eg. blower door test).

Field: Stack Coefficient

This field is the value of the stack coefficient, C_s in the equation above. The coefficient has units of $(\text{Pa}/\text{K})^n$. Values for the “Enhanced Model Stack Coefficient” listed in the ASHRAE Handbook of Fundamentals (2005 and 2001) are:

	One story house	Two story house	Three story house
With Flue	0.069	0.089	0.107
No Flue	0.054	0.078	0.098

Field: Pressure Exponent

This field is the value of the pressure exponent, n in the equation above. The pressure exponent generally lies between 0.6 and 0.7 with a typical value of $n = 0.67$ for the enhanced model.

Field: Wind Coefficient

This field is the value of the wind coefficient, C_w in the equation above. The coefficient has units of $(\text{Pa}\cdot\text{s}^2/\text{m}^2)^n$. Values for the “Enhanced Model Wind Coefficient” listed in the ASHRAE Handbook of Fundamentals (2005 and 2001) are:

	One story house	Two story house	Three story house
Basement/slab; With Flue	0.142	0.156	0.167
Basement/slab; No Flue	0.156	0.170	0.170
Crawlspace; With Flue	0.128	0.142	0.154
Crawlspace; No Flue	0.128	0.142	0.151

Field: Shelter Factor

This field is the value of the wind coefficient, s in the equation above. The coefficient is dimensionless. Values for the “Enhanced Model Shelter Factor” listed in the ASHRAE Handbook of Fundamentals (2005 and 2001) are:

Shelter class	No Flue	One story house with flue	Two story house with flue	Three story house with flue
1	1.00	1.10	1.07	1.06
2	0.90	1.02	0.98	0.97
3	0.70	0.86	0.81	0.79
4	0.50	0.70	0.64	0.61
5	0.30	0.54	0.47	0.43

Shelter class	Description
1	No obstructions or local shielding
2	Typical shelter for an isolated rural house
3	Typical shelter caused by other buildings across the street
4	Typical shelter for urban buildings on larger lots
5	Typical shelter produced by buildings that are immediately adjacent.

```

ZoneInfiltration:FlowCoefficient,
  \min-fields 8
  \memo Infiltration is specified as flow coefficient, schedule fraction, stack and wind
coefficients, and
  \memo is a function of temperature difference and wind speed:
  \memo Infiltration=FSchedule * SQRT( (c * Cs*(Tzone-Todb)**n)**2 + (c* Cw*(s * WindSpd)**2n)**2
)
A1 , \field Name
  \required-field
  \type alpha
A2 , \field Zone Name
  \required-field
  \type object-list
  \object-list ZoneNames
A3 , \field Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
N1 , \field Flow Coefficient
  \note "c" in Equation
  \minimum> 0
  \type real
  \required-field
N2 , \field Stack Coefficient
  \note "Cs" in Equation
  \minimum> 0
  \type real
  \required-field
N3 , \field Pressure Exponent
  \note "n" in Equation
  \minimum> 0
  \type real
  \required-field
  \default 0.67
N4 , \field Wind Coefficient
  \note "Cw" in Equation
  \minimum> 0
  \type real
  \required-field
N5 ; \field Shelter Factor
  \note "s" in Equation
  \minimum> 0
  \type real
  \required-field

```

An Example IDF object is:

```

ZoneInfiltration:FlowCoefficient,
LIVING ZONE Infil 1,      !- Name
LIVING ZONE,             !- Zone Name
INF-SCHED,              !- Schedule Name
0.05,                   !- Flow Coefficient
0.089,                  !- Stack Coefficient
0.67 ,                  !- Pressure Exponent
0.156 ,                 !- Wind Coefficient
0.64;                   !- Shelter Factor

```

ZoneInfiltration Outputs

Current infiltration output values:

```

HVAC,Sum,Zone Infiltration Sensible Heat Loss [J]
HVAC,Sum,Zone Infiltration Sensible Heat Gain [J]
HVAC,Sum,Zone Infiltration Latent Heat Loss [J]
HVAC,Sum,Zone Infiltration Latent Heat Gain [J]
HVAC,Sum,Zone Infiltration Total Heat Loss [J]
HVAC,Sum,Zone Infiltration Total Heat Gain [J]
HVAC,Sum,Zone Infiltration Volume [m3]
HVAC,Sum,Zone Infiltration Mass [kg]
HVAC,Average,Zone Infiltration Air Change Rate [ach]

```

Zone Infiltration Sensible Heat Loss [J]

The sensible (temperature) heat loss that occurs when the infiltration air temperature (outdoor) < zone air temperature.

Zone Infiltration Sensible Heat Gain [J]

The sensible (temperature) heat gain that occurs when the infiltration air temperature (outdoor) >= zone air temperature.

Zone Infiltration Latent Heat Loss [J]

The latent heat loss that occurs when the infiltration air humidity ratio (outdoor) < zone air humidity ratio.

Zone Infiltration Latent Heat Gain [J]

The latent heat gain that occurs when the infiltration air humidity ratio (outdoor) >= zone air humidity ratio.

Zone Infiltration Total Heat Loss [J]

The total heat loss that occurs when the sum of Zone Infiltration Sensible Heat Gain and Zone Infiltration Latent Heat Gain < the sum of Zone Infiltration Sensible Heat Loss and Zone Infiltration Latent Heat Loss.

Zone Infiltration Total Heat Gain [J]

The total heat gain that occurs when the sum of Zone Infiltration Sensible Heat Gain and Zone Infiltration Latent Heat Gain >= the sum of Zone Infiltration Sensible Heat Loss and Zone Infiltration Latent Heat Loss.

Zone Infiltration Volume [m3]

The volume flow of the Infiltration air.

Zone Infiltration Mass [kg]

The mass flow of the Infiltration air.

Zone Infiltration Air Change Rate [ach]

The rate of infiltration in air changes per hour.

ZoneVentilation

ZoneVentilation is the purposeful flow of air from the outdoor environment directly into a thermal zone in order to provide some amount of non-mechanical cooling. Ventilation as specified by this input syntax is intended to model “simple” ventilation as opposed to the more detailed ventilation investigations that can be performed with the AirflowNetwork model or with air systems that have outdoor air mixers. Simple ventilation in EnergyPlus can be controlled by a schedule and through the specification of minimum, maximum and delta temperatures as described below. The temperatures can be either single constant values for the entire simulation or schedules which can vary over time. As with infiltration, the actual flow rate of ventilation air can be modified by the temperature difference between the inside

and outside environment and the wind speed. The basic equation used to calculate ventilation in EnergyPlus is:

$$Ventilation = (V_{design})(F_{schedule}) \left[A + B|T_{zone} - T_{odb}| + C(WindSpeed) + D(WindSpeed^2) \right]$$

The local outdoor dry-bulb temperature used in the above basic equation (T_{odb}) is typically a function of the height of the zone centroid above ground. The corresponding zone name is given in the second field. The local outdoor dry-bulb temperature calculation procedure is given in the section of “Local Outdoor Air Temperature Calculation” in the Engineering Reference.

The local outdoor wind speed used in the above basic equation ($WindSpeed$) is also a function of the height of the zone centroid above ground. The corresponding zone name is given in the second field. The local outdoor wind speed calculation procedure is given in the section of “Local Wind Speed Calculation” in the Engineering Reference.

Note: When the value of the Wind Speed Profile Exponent field in the Site:HeightVariation is equal to 0.0. The local wind speed is always equal to the wind speed given in the weather data and will not be dependent on zone centroid height. Similarly, if the value of the Air Temperature Gradient Coefficient is set equal to 0 the local air dry-bulb temperature is also always equal to the air dry-bulb temperature given in the weather data and will not be dependent on zone centroid height.

One or more ventilation objects can be defined for each zone, and the resulting ventilation rate for the zone will simply be the summation of the flow rates specified by the ventilation objects.

More advanced ventilation calculations are possible using the EnergyPlus AirflowNetwork model.

Field: Name

The name of the ZoneVentilation object.

Field: Zone Name

This field is the name of the zone (ref: Zone) and attaches a particular ventilation statement to a thermal zone in the building.

Field: Schedule Name

This field is the name of the schedule (ref: Schedule) that modifies the maximum design volume flow rate (V_{design}). This fraction between 0.0 and 1.0 is noted as $F_{schedule}$ in the above equation.

Field: Design Flow Rate Calculation Method

This field is a key/choice field that tells which of the next four fields are filled and is descriptive of the method for calculating the design volume flow rate. The key/choices are:

■ Flow/Zone

With this choice, the method used will be a straight insertion of the design volume flow rate. (The Design Flow Rate field should be filled.)

■ Flow/Area

With this choice, the method used will be a factor per floor area of the zone. (The Flow per Zone Floor Area field should be filled).

■ Flow/Person

With this choice, the method used will be a factor per nominal number of people in the zone. (The Flow per Person field should be filled).

■ AirChanges/Hour

With this choice, the method used will be the number of air changes per hour for the infiltration amount. This factor, along with the Zone Volume, will be used to determine the Design Flow Rate. (The Air Changes per Hour field should be filled).

Field: Design Flow Rate

This field denotes the full design volume flow rate (m^3/s). The previous field should choose “flow/zone” as the choice. The design volume flow rate (noted as V_{design} in the above equation) is the maximum amount of ventilation expected at design conditions. The design value is modified by the schedule fraction (see Field: Schedule Name) and user specified coefficients (see four “coefficient” fields below).

Field: Flow Rate per Zone Floor Area

This factor ($\text{m}^3/\text{s}\cdot\text{m}^2$) is used, along with the Zone Area to determine the maximum Design Volume Flow Rate as described in the Design Volume Flow Rate field. The choice from the method field should be “flow/area”.

Field: Flow Rate per Person

This factor ($\text{m}^3/\text{s}\cdot\text{person}$) is used, along with the nominal (maximum) number of occupants (people) in the Zone to determine the maximum Design Volume Flow Rate as described in the Design Volume Flow Rate field. The choice from the method field should be “flow/person”.

Field: Air Changes per Hour

With this choice, the method used will be the number of air changes per hour for the ventilation amount. This factor, along with the Zone Volume, will be used to determine the Design Flow Rate. The choice from the method field should be “AirChanges/Hour”.

Field: Ventilation Type

This alpha character string defines the type of ventilation as one of the following options: Natural, Exhaust, or Intake.. Natural ventilation is assumed to be air movement/exchange a result of openings in the building façade and will not consume any fan energy. Values for fan pressure and efficiency for natural ventilation are ignored. For either Exhaust or Intake, values for fan pressure and efficiency define the fan electric consumption. For Natural and Exhaust ventilation, the conditions of the air entering the space are assumed to be equivalent to outside air conditions. For Intake ventilation, an appropriate amount of fan heat is added to the air stream.

Field: Fan Pressure Rise

This is the pressure rise experienced across the fan in Pascals (N/m^2). This is a function of the fan and plays a role in determining the amount of energy consumed by the fan.

Field: Fan Total Efficiency

This is the total fan efficiency (a decimal number between 0.0 and 1.0). This is a function of the fan and plays a role in determining the amount of energy consumed by the fan.

Field: Constant Term Coefficient

This number is the “A” parameter in the above ventilation equation. It is part of the user specified modifying parameters that are a function of environmental factors. This parameter, however, is a constant under all conditions and is not modified by any environmental effect. As a result, it is dimensionless.

Field: Temperature Term Coefficient

This number is the “B” parameter in the above ventilation equation. It is part of the user specified modifying parameters that are a function of environmental factors. This parameter is

modified by the temperature difference between the outdoor and indoor air dry-bulb temperatures. The units for this parameter are inverse Celsius.

Field: Velocity Term Coefficient

This number is the “C” parameter in the above ventilation equation. It is part of the user specified modifying parameters that are a function of environmental factors. This parameter is modified by the speed of wind being experienced outside the building. The units for this parameter are s/m.

Field: Velocity Squared Term Coefficient

This number is the “D” parameter in the above ventilation equation. It is part of the user specified modifying parameters that are a function of environmental factors. This parameter is modified by square of the speed of wind being experienced outside the building. The units for this parameter are s^2/m^2 .

Field: Minimum Indoor Temperature

This is the indoor temperature (in Celsius) below which ventilation is shutoff. The minimum value for this field is -100.0°C and the maximum value is 100.0°C. The default value is -100.0°C if the field is left blank. This lower temperature limit is intended to avoid overcooling a space and thus result in a heating load. For example, if the user specifies a minimum temperature of 20°C, ventilation is assumed to be available if the zone air temperature is above 20°C. If the zone air temperature drops below 20°C, then ventilation is automatically turned off.

Field: Minimum Indoor Temperature Schedule Name

This alpha field defines the name of a schedule (ref. Schedule) which contains the minimum indoor temperature (in Celsius) below which ventilation is shutoff as a function of time. The minimum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field and has the same functionality as the Minimum Indoor Temperature field. If the user enters a valid schedule name, the minimum temperature values specified in this schedule will supersede the constant value specified in the Minimum Indoor Temperature field.

Field: Maximum Indoor Temperature

This is the indoor temperature (in Celsius) above which ventilation is shutoff. The minimum value for this field is -100.0°C and the maximum value is 100.0°C. The default value is 100.0°C if the field is left blank. This upper temperature limit is intended to avoid overheating a space and thus result in a cooling load. For example, if the user specifies a maximum temperature of 28°C, ventilation is assumed to be available if the zone air temperature is below 28°C. If the zone air temperature increases to 28°C, then ventilation is automatically turned off.

Field: Maximum Indoor Temperature Schedule Name

This alpha field defines the name of a schedule (ref. Schedule) which contains the maximum indoor temperature (in Celsius) above which ventilation is shutoff as a function of time. The minimum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field and has the same functionality as the Maximum Indoor Temperature field. If the user enters a valid schedule name, the maximum temperature values specified in this schedule will supersede the constant value specified in the Maximum Indoor Temperature field.

Field: Delta Temperature

This is the temperature difference (in Celsius) between the indoor and outdoor air dry-bulb temperatures below which ventilation is shutoff. The minimum value for this field is -100.0°C

and the default value is also -100.0°C if the field is left blank. This field allows ventilation to be stopped if the temperature outside is too warm and could potentially heat the space. For example, if the user specifies a delta temperature of 2°C, ventilation is assumed to be available if the outside air temperature is at least 2°C cooler than the zone air temperature. If the outside air dry-bulb temperature is less than 2°C cooler than the indoor dry-bulb temperature, then ventilation is automatically turned off.

The values for this field can include negative numbers. This allows ventilation to occur even if the outdoor temperature is above the indoor temperature. The Delta Temperature is used in the code in the following way:

IF ((IndoorTemp - OutdoorTemp) < DeltaTemperature) Then ventilation is not allowed.

Thus, if a large negative number is input for DeltaTemperature, the ventilation can be kept on even if the outdoor temperature is greater than the indoor temperature. This is useful for uncontrolled natural ventilation (open windows) or as a way to estimate the effect of required ventilation air for load calculations.

Field: Delta Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the temperature difference (in Celsius) between the indoor and outdoor air dry-bulb temperatures below which ventilation is shutoff as a function of time. The minimum temperature difference value in the schedule can be -100°C. This field is an optional field and has the same functionality as the Delta Temperature field. If the user enters a valid schedule name, the delta temperature values specified in this schedule will supersede the constant value specified in the Delta Temperature field.

Field: Minimum Outdoor Temperature

This is the outdoor temperature (in Celsius) below which ventilation is shut off. The minimum value for this field is -100.0°C and the maximum value is 100.0°C. The default value is -100.0°C if the field is left blank. This lower temperature limit is intended to avoid overcooling a space, which could result in a heating load.

Field: Minimum Outdoor Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the minimum outdoor temperature (in Celsius) below which ventilation is shutoff as a function of time. The minimum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field and has the same functionality as the Minimum Outdoor Temperature field. If the user enters a valid schedule name, the temperature values in this schedule will supersede the constant value specified in the Minimum Outdoor Temperature field.

Field: Maximum Outdoor Temperature

This is the outdoor temperature (in Celsius) above which ventilation is shut off. The minimum value for this field is -100.0°C and the maximum value is 100.0°C. The default value is 100.0°C if the field is left blank. This upper temperature limit is intended to avoid overheating a space, which could result in a cooling load.

Field: Maximum Outdoor Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the minimum outdoor temperature (in Celsius) above which ventilation is shutoff as a function of time. The minimum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field and has the same functionality as the Maximum Outdoor Temperature field. If the user enters a valid schedule name, the temperature values in this schedule will supersede the constant value specified in the Maximum Outdoor Temperature field.

Field: Maximum Wind Speed

This is the wind speed (m/s) above which ventilation is shut off. This can help simulate conditions where one would normally close windows to avoid chaos in a space (papers blowing around, etc).

```

ZoneVentilation,
  \min-fields 15
  \memo Ventilation is specified as a design level which is modified by a schedule fraction,
temperature difference and wind speed:
  \memo Ventilation=Vdesign * Fschedule * (A + B*(Tzone-Todb) + C*WindSpd + D * WindSpd**2)
A1 , \field Name
  \required-field
  \type alpha
  \reference VentilationNames
A2 , \field Zone Name
  \required-field
  \type object-list
  \object-list ZoneNames
A3 , \field Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
A4 , \field Design Flow Rate Calculation Method
  \note The entered calculation method is used to create the maximum amount of ventilation
  \note for this set of attributes
  \note Choices: Flow/Zone => Design Flow Rate -- simply enter Design Flow Rate
  \note Flow/Area => Flow Rate per Zone Floor Area - Value * Floor Area (zone) = Design Flow Rate
  \note Flow/Person => Flow Rate per Person - Value * #people = Design Flow Rate
  \note AirChanges/Hour => Air Changes per Hour - Value * Floor Volume (zone) adjusted for m3/s =
Design Volume Flow Rate
  \note "Vdesign" in Equation is the result.
  \required-field
  \type choice
  \key Flow/Zone
  \key Flow/Area
  \key Flow/Person
  \key AirChanges/Hour
  \default Flow/Zone
N1 , \field Design Flow Rate
  \units m3/s
  \type real
  \minimum 0
N2 , \field Flow Rate per Zone Floor Area
  \type real
  \minimum 0
  \units m3/s-m2
N3 , \field Flow Rate per Person
  \type real
  \minimum 0
  \units m3/s-person
N4 , \field Air Changes per Hour
  \type real
  \minimum 0
A5 , \field Ventilation Type
  \required-field
  \type choice
  \key Natural
  \key Intake
  \key Exhaust
  \default Natural

```

```
N5 , \field Fan Pressure Rise
    \required-field
    \note pressure rise across the fan
    \type real
    \units Pa
    \minimum 0
    \default 0
N6 , \field Fan Total Efficiency
    \required-field
    \type real
    \minimum > 0
    \default 1
N7 , \field Constant Term Coefficient
    \required-field
    \note "A" in Equation
    \type real
    \default 1
    \minimum 0
N8 , \field Temperature Term Coefficient
    \required-field
    \note "B" in Equation
    \type real
    \default 0
    \minimum 0
N9 , \field Velocity Term Coefficient
    \required-field
    \note "C" in Equation
    \type real
    \default 0
    \minimum 0
N10, \field Velocity Squared Term Coefficient
    \required-field
    \note "D" in Equation
    \type real
    \default 0
    \minimum 0
N11, \field Minimum Indoor Temperature
    \note this is the indoor temperature below which ventilation is shutoff
    \units C
    \type real
    \minimum -100
    \maximum 100
    \default -100
A6 , \field Minimum Indoor Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note This schedule contains the indoor temperature versus time below which
    \note ventilation is shutoff.
N12, \field Maximum Indoor Temperature
    \note this is the indoor temperature above which ventilation is shutoff
    \units C
    \type real
    \minimum -100
    \maximum 100
    \default 100
A7 , \field Maximum Indoor Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note This schedule contains the indoor temperature versus time above which
    \note ventilation is shutoff.
```

```

N13, \field Delta Temperature
      \note this is the temperature differential between indoor and outdoor below which ventilation is
shutoff
      \units deltaC
      \type real
      \minimum -100
      \default -100
A8 , \field Delta Temperature Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note This schedule contains the temperature differential between indoor and outdoor
      \note versus time below which ventilation is shutoff.
N14, \field Minimum Outdoor Temperature
      \note this is the outdoor temperature below which ventilation is shutoff
      \units C
      \type real
      \minimum -100
      \maximum 100
      \default -100
A9 , \field Minimum Outdoor Temperature Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note This schedule contains the outdoor temperature versus time below which
      \note ventilation is shutoff.
N15, \field Maximum Outdoor Temperature
      \note this is the outdoor temperature above which ventilation is shutoff
      \units C
      \type real
      \minimum -100
      \maximum 100
      \default 100
A10, \field Maximum Outdoor Temperature Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note This schedule contains the outdoor temperature versus time above which
      \note ventilation is shutoff.
N16; \field Maximum Wind Speed
      \note this is the outdoor wind speed above which ventilation is shutoff
      \units m/s
      \type real
      \minimum 0
      \maximum 40
      \default 40

```

An IDF example:

```

ZoneVentilation,
  Ventilation 1,  !- Name
  ZONE 2,        !- Zone Name
  Simple Vent,   !- Schedule Name
  Flow/Zone,    !- Design Volume Flow Rate calculation method
  6.131944,     !- Design Volume Flow Rate {m3/s}
  ,             !- Volume Flow Rate per area {m3/s/m2}
  ,             !- Volume Flow Rate per person {m3/s/person}
  ,             !- Air Changes Per Hour
  INTAKE,       !- Ventilation Type
  400.0,        !- Fan Pressure Rise{Pa}
  0.9,          !- Fan Total Efficiency
  0.6060000    , !- Constant Term Coefficient
  2.0199999E-02, !- Temperatur Term Coefficient
  5.9800001E-04, !- Velocity Term Coefficient
  0.0000000E+00; !- Velocity Squared Term Coefficient
  18.0,         !- Minimum Indoor Temperature {C}
  ,            !- Minimum Indoor Temperature Schedule Name
  ,            !- Maximum Indoor Temperature {C}
  ,            !- Maximum Indoor Temperature Schedule Name
  1.0;         !- Delta temperature {C}

```

```

ZoneVentilation,
  SPACE1-1 Ventl 1,      !- Name
  SPACE1-1,             !- Zone Name
  NightVentSched,      !- SCHEDULE Name
  Flow/Zone,           !- Design Volume Flow Rate calculation method
  .05295,              !- Design Volume Flow Rate {m3/s}
  ,                    !- Volume Flow Rate per area {m3/s/m2}
  ,                    !- Volume Flow Rate per person {m3/s/person}
  ,                    !- Air Changes Per Hour
  Intake,              !- Ventilation Type
  67.,                 !- Fan Pressure Rise
  .7,                  !- Fan Total Efficiency
  1,                   !- Constant Term Coefficient
  0,                   !- Temperature Term Coefficient
  0,                   !- Velocity Term Coefficient
  0,                   !- Velocity Squared Term Coefficient
  ,                    !- Minimum Indoor Temperature {C}
  MinIndoorTemp,      !- Minimum Indoor Temperature Schedule Name
  ,                    !- Maximum Indoor Temperature {C}
  MaxIndoorTemp,      !- Maximum Indoor Temperature Schedule Name
  ,                    !- Delta Temperature {deltaC}
  DeltaTemp,          !- Delta Temperature Schedule Name
  ,                    !- Minimum Outdoor Temperature {C}
  MinOutdoorTemp,    !- Minimum Outdoor Temperature Schedule Name
  ,                    !- Maximum Outdoor Temperature {C}
  MaxOutdoorTemp,    !- Maximum Outdoor Temperature Schedule Name
  40;                  !- Maximum WindSpeed {m/s}

```

ZoneVentilation Outputs

Current ventilation output variables:

```

HVAC,Sum,Zone Ventilation Sensible Heat Loss [J]
HVAC,Sum,Zone Ventilation Sensible Heat Gain [J]
HVAC,Sum,Zone Ventilation Latent Heat Loss [J]
HVAC,Sum,Zone Ventilation Latent Heat Gain [J]
HVAC,Sum,Zone Ventilation Total Heat Loss [J]
HVAC,Sum,Zone Ventilation Total Heat Gain [J]
HVAC,Sum,Zone Ventilation Volume [m3]
HVAC,Sum,Zone Ventilation Mass [kg]
HVAC,Sum,Zone Ventilation Fan Electric Consumption [J]
HVAC,Average,Zone Ventilation Inlet Air Temperature [C]

```

Zone Ventilation Sensible Heat Loss [J]

The sensible (temperature) heat loss that occurs when the ventilation inlet air temperature < zone air temperature. If multiple ventilation objects are specified for a particular zone, the ventilation inlet air temperature is from each ventilation object for the zone.

Zone Ventilation Sensible Heat Gain [J]

The sensible (temperature) heat gain that occurs when the ventilation inlet air temperature >= zone air temperature. If multiple ventilation objects are specified for a particular zone, the ventilation inlet air temperature is from each ventilation object for the zone.

Zone Ventilation Latent Heat Loss [J]

The latent heat loss that occurs when the Ventilation air humidity ratio (outdoor) < zone air humidity ratio.

Zone Ventilation Latent Heat Gain [J]

The latent heat gain that occurs when the Ventilation air humidity ratio (outdoor) >= zone air humidity ratio.

Zone Ventilation Total Heat Loss [J]

The total heat loss that occurs when the sum of Zone Ventilation Sensible Heat Gain and Zone Ventilation Latent Heat Gain < the sum of Zone Ventilation Sensible Heat Loss and Zone Ventilation Latent Heat Loss.

Zone Ventilation Total Heat Gain [J]

The total heat gain that occurs when the sum of Zone Ventilation Sensible Heat Gain and Zone Ventilation Latent Heat Gain >= the sum of Zone Ventilation Sensible Heat Loss and Zone Ventilation Latent Heat Loss.

Zone Ventilation Volume [m3]

The volume flow of the ventilation air.

Zone Ventilation Mass [kg]

The mass flow of the ventilation air.

Zone Ventilation Air Change Rate [ach]

The volume flow rate of the ventilation air in air changes per hour.

Zone Ventilation Fan Electric Consumption [J]

The fan electrical consumption for Intake or Exhaust ventilation types.

Zone Ventilation Inlet Air Temperature [C]

This is equal to the outdoor air temperature except when INTAKE fan power is included. When intake fan power is used, then the additional heat due to the fan is added to the outdoor temperature and this will be reported as the inlet air temperature. If multiple ventilation objects are specified for a particular zone, the reported value is the mass flow weighted temperature for the multiple ventilation objects specified for this zone.

ZoneMixing

In EnergyPlus, the ZoneMixing syntax is intended to allow simplified treatment of air exchange between zones. Note that this statement only affects the energy balance of the “receiving” zone and that this statement will not produce any effect on the “source” zone. Mixing statements can be complementary and include multiple zones, but the balancing of flows between zones is left to the user’s discretion. The use of the Cross Mixing syntax (ref: Cross Mixing) can allow for automatic balancing of flows and energy flow rates between zones but is hindered by the limitation of only a single cross mixing statement per zone. More advanced mixing calculations are possible using the EnergyPlus AirflowNetwork model for multi-zone airflow with or without HVAC system operation. Mixing is entered using the following syntax.

Field: Name

The name of the ZoneMixing object.

Field: Zone Name

This field is the name of the zone (ref: Zone) receiving the amount of air being exchanged and attaches a particular mixing statement to a thermal zone in the building.

Field: Schedule Name

This field is the name of the schedule (ref: Schedule) that modifies the maximum design volume flow rate parameter (see next field). This fraction between 0.0 and 1.0 modifies the design level parameter.

Field: Design Flow Rate Calculation Method

This field is a key/choice field that tells which of the next four fields are filled and is descriptive of the method for calculating the design volume flow rate. The key/choices are:

- Flow/Zone

With this choice, the method used will be a straight insertion of the design volume flow rate. (The Design Flow Rate field should be filled.)

- Flow/Area

With this choice, the method used will be a factor per floor area of the zone. (The Flow per Zone Floor Area field should be filled).

- Flow/Person

With this choice, the method used will be a factor per nominal number of people in the zone. (The Flow per Person field should be filled).

- AirChanges/Hour

With this choice, the method used will be the number of air changes per hour for the infiltration amount. This factor, along with the Zone Volume, will be used to determine the Design Flow Rate. (The Air Changes per Hour field should be filled).

Field: Design Flow Rate

This field denotes the full design volume flow rate (m^3/s). The previous field should choose “flow/zone” as the choice. The design volume flow rate is the maximum amount of mixing air expected. The design value is modified by the schedule fraction (see Field: Schedule Name) and user specified coefficients (see four “coefficient” fields below).

Field: Flow Rate per Zone Floor Area

This factor ($\text{m}^3/\text{s}\cdot\text{m}^2$) is used, along with the Zone Area to determine the maximum Design Volume Flow Rate as described in the Design Volume Flow Rate field. The choice from the method field should be “Flow/Area”.

Field: Flow Rate per Person

This factor ($\text{m}^3/\text{s}\cdot\text{person}$) is used, along with the nominal (maximum) number of occupants (people) in the Zone to determine the maximum Design Volume Flow Rate as described in the Design Volume Flow Rate field. The choice from the method field should be “Flow/Person”.

Field: Air Changes per Hour

With this choice, the method used will be the number of air changes per hour for the mixing amount. This factor, along with the Zone Volume, will be used to determine the Design Flow Rate. The choice from the method field should be “AirChanges/Hour”.

Field: Source Zone Name

This field is the name of the “source” zone (ref: Zone) that exhausts the amount of air specified by the design level and schedule fields to the zone named in the zone name field.

Field: Delta Temperature

This number controls when mixing air from the source zone is sent to the receiving zone. This parameter is a temperature and is expressed in units of Celsius. If this field is positive, the temperature of the zone from which the air is being drawn (source zone) must be “Delta Temperature” warmer than the receiving zone air or else no mixing occurs. If this field is negative, the temperature of the source zone must be “Delta Temperature” cooler than the receiving zone air or else no mixing occurs. If this parameter is zero, mixing occurs regardless of the relative zone temperatures.

Field: Delta Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the temperature difference (in Celsius) between the source zone and receiving zone air dry-bulb temperatures as a function of time. This field is an optional field and has the same functionality as the Delta Temperature field. If the user enters a valid schedule name, the delta temperature values specified in this schedule will supersede the constant value specified in the Delta Temperature field.

Field: Minimum Zone Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the minimum receiving zone temperature (in Celsius) below which mixing is shutoff as a function of time. The minimum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field. If this field is not entered, the minimum zone temperature control is not applied.

Field: Maximum Zone Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the maximum receiving zone temperature (in Celsius) above which mixing is shutoff as a function of time. The maximum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field. If this field is not entered, the maximum zone temperature control is not applied.

Note: The maximum zone temperature when mixing is shutoff must be greater than or equal to the minimum zone temperature when mixing is shutoff at any given time. Otherwise, warnings will be issued and the maximum zone shutoff temperature will be set to the minimum zone shutoff temperature.

Field: Minimum Source Zone Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the minimum source zone temperature (in Celsius) below which mixing is shutoff as a function of time. The minimum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field. If this field is not entered, the minimum source zone temperature control is not applied.

Field: Maximum Source Zone Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the maximum source zone temperature (in Celsius) above which mixing is shutoff as a function of time. The maximum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field. If this field is not entered, the maximum source zone temperature control is not applied.

Note: The maximum source zone temperature when mixing is shutoff must be greater than or equal to the minimum source zone temperature when mixing is shutoff at any given time. Otherwise, warnings will be issued and the maximum source zone shutoff temperature will be set to the minimum source zone shutoff temperature.

Field: Minimum Outdoor Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the minimum outdoor temperature (in Celsius) below which mixing is shutoff as a function of time. The minimum temperature value in the schedule can be -100°C and the maximum value can be

100°C. This field is an optional field. If this field is not entered, the minimum outdoor temperature control is not applied.

Field: Maximum Outdoor Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the maximum outdoor temperature (in Celsius) above which mixing is shutoff as a function of time. The maximum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field. If this field is not entered, the maximum outdoor temperature control is not applied.

Note: The maximum outdoor temperature when mixing is shutoff must be greater than or equal to the minimum outdoor temperature which mixing is shutoff at any given time. Otherwise, a warning will be issued and the maximum outdoor shutoff temperature will be set to the minimum outdoor shutoff temperature.

```

ZoneMixing,
\min-fields 9
A1 , \field Name
    \required-field
    \type alpha
A2 , \field Zone Name
    \required-field
    \type object-list
    \object-list ZoneNames
A3 , \field Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A4 , \field Design Flow Rate Calculation Method
    \note The entered calculation method is used to create the maximum amount of ventilation
    \note for this set of attributes
    \note Choices: Flow/Zone => Design Flow Rate -- simply enter Design Flow Rate
    \note Flow/Area => Flow Rate per Zone Floor Area - Value * Floor Area (zone) = Design Flow Rate
    \note Flow/Person => Flow Rate per Person - Value * #people = Design Flow Rate
    \note AirChanges/Hour => Air Changes per Hour - Value * Floor Volume (zone) adjusted for m3/s =
Design Volume Flow Rate
    \note "Vdesign" in Equation is the result.
    \required-field
    \type choice
    \key Flow/Zone
    \key Flow/Area
    \key Flow/Person
    \key AirChanges/Hour
    \default Flow/Zone
N1 , \field Design Flow Rate
    \units m3/s
    \type real
    \minimum 0
N2 , \field Flow Rate per Zone Floor Area
    \type real
    \minimum 0
    \units m3/s-m2
N3 , \field Flow Rate per Person
    \type real
    \minimum 0
    \units m3/s-person
N4 , \field Air Changes per Hour
    \type real
    \minimum 0

```

```

A5 , \field Source Zone Name
    \required-field
    \type object-list
    \object-list ZoneNames
N5 , \field Delta Temperature
    \units deltaC
    \type real
    \default 0
    \note This field contains the constant temperature differential between source and
    \note receiving zones below which mixing is shutoff.
A6 , \field Delta Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note This schedule contains the temperature differential between source and receiving
    \note zones versus time below which mixing is shutoff.
A7 , \field Minimum Zone Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note This schedule contains the zone dry-bulb temperature versus time below which
    \note mixing is shutoff.
A8 , \field Maximum Zone Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note This schedule contains the zone dry-bulb temperature versus time above which
    \note mixing is shutoff.
A9 , \field Minimum Source Zone Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note This schedule contains the source zone dry-bulb temperature versus time below
    \note which mixing is shutoff.
A10, \field Maximum Source Zone Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note This schedule contains the source zone dry-bulb temperature versus time above
    \note which mixing is shutoff.
A11, \field Minimum Outdoor Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note This schedule contains the outdoor temperature versus time below which
    \note mixing is shutoff.
A12; \field Maximum Outdoor Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note This schedule contains the outdoor temperature versus time above which
    \note mixing is shutoff.

```

An IDF Example:

```

ZoneMixing,
  Kitchen_ZN_1_FLR_1 Exhaust Fanmixing_0,  !- Name
  Kitchen_ZN_1_FLR_1,  !- Zone Name
  Hours_of_operation,  !- Schedule Name
  Flow/Zone,  !- Design Flow Rate Calculation Method
  1.4540,  !- Design Level
  ,  !- Volume Flow Rate per Area {m3/s/m2}
  ,  !- Volume Flow Rate Per Person {m3/s/person}
  ,  !- Air Changes per Hour {ACH}
  CAFETERIA_ZN_1_FLR_1,  !- Source Zone Name
  0.0;  !- Delta Temperature

```

Mixing Outputs

```

HVAC,Sum,Zone Mixing Volume [m3]
HVAC,Sum,Zone Mixing Mass [kg]
HVAC,Sum,Zone Mixing Sensible Heat Loss [J]
HVAC,Sum,Zone Mixing Sensible Heat Gain [J]

```

```

HVAC,Sum,Zone Mixing Latent Heat Loss [J]
HVAC,Sum,Zone Mixing Latent Heat Gain [J]
HVAC,Sum,Zone Mixing Total Heat Loss [J]
HVAC,Sum,Zone Mixing Total Heat Gain [J]

```

Zone Mixing Volume [m3]

The air volume in m³ entering the zone due to mixing during the hour or timestep.

Zone Mixing Mass [kg]

The air mass in kg entering the zone due to mixing during the hour or timestep. The air mass is calculated using the air volume flow from each “source” zone and the density of air calculated for the average conditions (temperature and humidity) between the “source” and “receiving” zones.

Zone Mixing Sensible Heat Loss [J]

Zone Mixing Sensible Heat Gain [J]

The sensible (temperature) heat transfer due to mixing in the host (receiving) zone is the sum of all the incoming air mass flow rates multiplied by the elapsed time, the specific heat (calculated for the average conditions (temperature and humidity) between the “source” and “receiving” zones) and the temperature differences between the host zone and corresponding source zones. If the heat transfer is negative, the heat transfer is considered to be a zone mixing sensible heat loss. If the heat transfer is positive, the heat transfer is considered to be a zone mixing sensible heat gain.

Zone Mixing Latent Heat Loss [J]

Zone Mixing Latent Heat Gain [J]

The latent heat transfer due to mixing in the host (receiving) zone is the sum of all the incoming air mass flow rates multiplied by the elapsed time, the heat of vaporization (calculated for the average conditions (temperature and humidity) between the “source” and “receiving” zones) and the humidity ratio differences between the host zone and corresponding source zones. If the heat transfer is negative, the heat transfer is considered to be a zone mixing latent heat loss. If the heat transfer is positive, the heat transfer is considered to be a zone mixing latent heat gain.

Zone Mixing Total Heat Loss [J]

The total heat loss due to mixing that occurs when the sum of Zone Mixing Sensible Heat Gain and Zone Mixing Latent Heat Gain < the sum of Zone Mixing Sensible Heat Loss and Zone Mixing Latent Heat Loss.

Zone Mixing Total Heat Gain [J]

The total heat gain due to mixing that occurs when the sum of Zone Mixing Sensible Heat Gain and Zone Mixing Latent Heat Gain >= the sum of Zone Mixing Sensible Heat Loss and Zone Mixing Latent Heat Loss.

ZoneCrossMixing

The ZoneCrossMixing syntax is ideally suited for two zones that exchange an equal amount of air between each other and do not have any air exchange with other zones. As with Mixing (ref: Mixing), this is a simplified view of interzone airflow in EnergyPlus. The main difference between Mixing and Cross Mixing is that Cross Mixing has an energy effect on both the source and the receiving zone, thus maintaining both the air mass and energy balances in the two zones.

Cross Mixing can be entered once, in one of the mixing zones; or twice, once for each zone. The object should be entered once if Delta Temperature > 0.0 and it is desirable to have

mixing only when the source zone is warmer than the receiving zone. This might be the case when the warmer zone is below the colder zone and the mixing is buoyancy driven. If the zones are next to each other, separated by an open doorway, it would be more suitable to input a cross mixing object for each zone. Then mixing would occur if the zone temperatures differed by Delta Temperature or greater regardless of which is the warmer zone.

If Delta Temperature = 0.0, Cross Mixing can be entered either once or twice: the effect is exactly the same.

Cross Mixing is entered using the following syntax.

Field: Name

The name of the ZoneCrossMixing object.

Field: Zone Name

This field is the name of the zone (ref: Zone) receiving the amount of air being exchanged and attaches a particular cross mixing statement to a thermal zone in the building.

Field: Schedule Name

This field is the name of the schedule (ref: Schedule) that modifies the maximum design volume flow rate parameter (see next field). This fraction between 0.0 and 1.0 modifies the design level parameter.

Field: Design Flow Rate Calculation Method

This field is a key/choice field that tells which of the next four fields are filled and is descriptive of the method for calculating the design volume flow rate. The key/choices are:

■ Flow/Zone

With this choice, the method used will be a straight insertion of the design volume flow rate. (The Design Flow Rate field should be filled.)

■ Flow/Area

With this choice, the method used will be a factor per floor area of the zone. (The Flow per Zone Floor Area field should be filled).

■ Flow/Person

With this choice, the method used will be a factor per nominal number of people in the zone. (The flow per person field should be filled).

■ AirChanges/Hour

With this choice, the method used will be the number of air changes per hour for the infiltration amount. This factor, along with the Zone Volume, will be used to determine the Design Flow Rate. (The Air Changes per Hour field should be filled).

Field: Design Flow Rate

This field denotes the full design volume flow rate (m^3/s). The previous field should choose “flow/zone” as the choice. The design volume flow rate is the maximum amount of mixing air expected. The design value is modified by the schedule fraction (see Field: Schedule Name) and user specified coefficients (see four “coefficient” fields below).

Field: Flow Rate per Zone Floor Area

This factor ($m^3/s-m^2$) is used, along with the Zone Area to determine the maximum Design Volume Flow Rate as described in the Design Volume Flow Rate field. The choice from the method field should be “Flow/Area”.

Field: Flow Rate per Person

This factor ($m^3/s-person$) is used, along with the nominal (maximum) number of occupants (people) in the Zone to determine the maximum Design Volume Flow Rate as described in

the Design Volume Flow Rate field. The choice from the method field should be “Flow/Person”.

Field: Air Changes per Hour

With this choice, the method used will be the number of air changes per hour for the mixing amount. This factor, along with the Zone Volume, will be used to determine the Design Flow Rate. The choice from the method field should be “AirChanges/Hour”.

Field: Source Zone Name

This field is the name of the “source” zone (ref: Zone) that exhausts the amount of air specified by the design level and schedule fields to the zone named in the zone name field. In reality, the “source” and “receiving” zones are interchangeable since the cross-mixed air affects both zones.

Field: Delta Temperature

This number controls when mixing air from the source zone is sent to the receiving zone. This parameter is a temperature and is expressed in units of Celsius. If this field is positive, the temperature of the zone from which air is being drawn (“source zone”) must be “Delta Temperature” warmer than the zone air or no mixing occurs. If this field is zero, mixing occurs regardless of the relative air temperatures. Negative values for “Delta Temperature” are not permitted.

Field: Delta Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the temperature difference (in Celsius) between the source zone and receiving zone air dry-bulb temperatures as a function of time. This field is an optional field and has the same functionality as the Delta Temperature field. If the user enters a valid schedule name, the delta temperature values specified in this schedule will supersede the constant value specified in the Delta Temperature field.

Field: Minimum Zone Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the minimum receiving zone temperature (in Celsius) below which cross mixing is shutoff as a function of time. The minimum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field. If this field is not entered, the minimum zone temperature control is not applied.

Field: Maximum Zone Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the maximum receiving zone temperature (in Celsius) above which cross mixing is shutoff as a function of time. The maximum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field. If this field is not entered, the maximum zone temperature control is not applied.

Note: The maximum zone temperature when cross mixing is shutoff must be greater than or equal to the minimum zone temperature when cross mixing is shutoff at any given time. Otherwise, warnings will be issued and the maximum zone shutoff temperature will be set to the minimum zone shutoff temperature.

Field: Minimum Source Zone Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the minimum source zone temperature (in Celsius) below which cross mixing is shutoff as a function of time. The minimum temperature value in the schedule can be -100°C and the maximum

value can be 100°C. This field is an optional field. If this field is not entered, the minimum source zone temperature control is not applied.

Field: Maximum Source Zone Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the maximum source zone temperature (in Celsius) above which cross mixing is shutoff as a function of time. The maximum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field. If this field is not entered, the maximum source zone temperature control is not applied.

Note: The maximum source zone temperature when cross mixing is shutoff must be greater than or equal to the minimum source zone temperature when cross mixing is shutoff at any given time. Otherwise, warnings will be issued and the maximum source zone shutoff temperature will be set to the minimum source zone shutoff temperature.

Field: Minimum Outdoor Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the minimum outdoor temperature (in Celsius) below which cross mixing is shutoff as a function of time. The minimum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field. If this field is not entered, the minimum outdoor temperature control is not applied.

Field: Maximum Outdoor Temperature Schedule Name

This alpha field contains the name of a schedule (ref. Schedule) which contains the maximum outdoor temperature (in Celsius) above which cross mixing is shutoff as a function of time. The maximum temperature value in the schedule can be -100°C and the maximum value can be 100°C. This field is an optional field. If this field is not entered, the maximum outdoor temperature control is not applied.

Note: The maximum outdoor temperature when cross mixing is shutoff must be greater than or equal to the minimum outdoor temperature which cross mixing is shutoff at any given time. Otherwise, a warning will be issued and the maximum outdoor shutoff temperature will be set to the minimum outdoor shutoff temperature.

```
ZoneCrossMixing,
  \min-fields 9
  A1 , \field Name
        \required-field
        \type alpha
  A2 , \field Zone Name
        \required-field
        \type object-list
        \object-list ZoneNames
  A3 , \field Schedule Name
        \required-field
        \type object-list
        \object-list ScheduleNames
```



```

A4 , \field Design Flow Rate Calculation Method
    \note The entered calculation method is used to create the maximum amount of ventilation
    \note for this set of attributes
    \note Choices: Flow/Zone => Design Flow Rate -- simply enter Design Flow Rate
    \note Flow/Area => Flow Rate per Zone Floor Area - Value * Floor Area (zone) = Design Flow Rate
    \note Flow/Person => Flow Rate per Person - Value * #people = Design Flow Rate
    \note AirChanges/Hour => Air Changes per Hour - Value * Floor Volume (zone) adjusted for m3/s =
Design Volume Flow Rate
    \note "Vdesign" in Equation is the result.
    \required-field
    \type choice
    \key Flow/Zone
    \key Flow/Person
    \key Flow/Area
    \key AirChanges/Hour
    \default Flow/Zone
N1 , \field Design Flow Rate
    \units m3/s
    \type real
    \minimum 0
N2 , \field Flow Rate per Zone Floor Area
    \type real
    \minimum 0
    \units m3/s-m2
N3 , \field Flow Rate per Person
    \type real
    \minimum 0
    \units m3/s-person
N4 , \field Air Changes per Hour
    \type real
    \minimum 0
A5 , \field Source Zone Name
    \required-field
    \type object-list
    \object-list ZoneNames
N5 , \field Delta Temperature
    \units deltaC
    \minimum 0.0
    \type real
    \default 0
    \note This field contains the constant temperature differential between source and
    \note receiving zones below which cross mixing is shutoff. This value must be greater
    \note than or equal to zero.
A6 , \field Delta Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note This schedule contains the temperature differential between source and receiving
    \note zones versus time below which cross mixing is shutoff.
A7 , \field Minimum Zone Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note This schedule contains the indoor temperature versus time below which
    \note cross mixing is shutoff.
A8 , \field Maximum Zone Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note This schedule contains the indoor temperature versus time above which
    \note cross mixing is shutoff.
A9 , \field Minimum Source Zone Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note This schedule contains the source zone dry-bulb temperature versus time below
    \note which cross mixing is shutoff.
A10, \field Maximum Source Zone Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note This schedule contains the source zone dry-bulb temperature versus time above
    \note which cross mixing is shutoff.

```

```

A11, \field Minimum Outdoor Temperature Schedule Name
\type object-list
\object-list ScheduleNames
\note This schedule contains the outdoor temperature versus time below which
\note cross mixing is shutoff.
A12; \field Maximum Outdoor Temperature Schedule Name
\type object-list
\object-list ScheduleNames
\note This schedule contains the outdoor temperature versus time above which
\note cross mixing is shutoff.

```

An IDF Example:

```

ZoneCrossMixing,
  1stFloor-Garage,  !- Name
  GARAGE,          !- Zone Name
  Always On,       !- SCHEDULE Name
  Flow/Zone,       !- Design Flow Rate calculation method
  0.1,             !- Design Flow Rate {m3/s}
  ,                !- Flow Rate per Area {m3/s/m2}
  ,                !- Flow Rate per Person {m3/s/person}
  ,                !- Air Changes Per Hour
  1ST-FLOOR,      !- Source Zone Name
  1.0;            !- Delta temp
ZoneCrossMixing,
  Garage-1stFloor, !- Name
  1ST-FLOOR,       ! Zone Name
  Always On,       !- SCHEDULE Name
  flow/zone,       !- Design Flow Rate calculation method
  0.1,             !- Design Flow Rate {m3/s}
  ,                !- Flow Rate per area {m3/s/m2}
  ,                !- Flow Rate per person {m3/s/person}
  ,                !- Air Changes Per Hour
  GARAGE,          ! Source Zone Name
  1.0;            ! Delta temp

```

Cross Mixing Outputs

```

HVAC,Sum,Zone Mixing Volume [m3]
HVAC,Sum,Zone Mixing Mass [kg]
HVAC,Sum,Zone Mixing Sensible Heat Loss [J]
HVAC,Sum,Zone Mixing Sensible Heat Gain [J]
HVAC,Sum,Zone Mixing Latent Heat Loss [J]
HVAC,Sum,Zone Mixing Latent Heat Gain [J]
HVAC,Sum,Zone Mixing Total Heat Loss [J]
HVAC,Sum,Zone Mixing Total Heat Gain [J]

```

Zone Mixing Volume [m3]

The air volume in m³ entering the zone due to cross mixing during the hour or timestep.

Zone Mixing Mass [kg]

The air mass in kg entering the zone due to cross mixing during the hour or timestep. The air mass is calculated using the air volume flow from each “source” zone and the density of air calculated for the average conditions (temperature and humidity) between the “source” and “receiving” zones.

Zone Mixing Sensible Heat Loss [J]

Zone Mixing Sensible Heat Gain [J]

The sensible (temperature) heat transfer due to cross mixing in the host (receiving) zone is the sum of all the incoming air mass flow rates multiplied by the elapsed time, the specific heat (calculated for the average conditions (temperature and humidity) between the “source” and “receiving” zones) and the temperature differences between the host zone and

corresponding source zones. If the heat transfer is negative, the heat transfer is considered to be a zone mixing sensible heat loss. If the heat transfer is positive, the heat transfer is considered to be a zone mixing sensible heat gain.

Zone Mixing Latent Heat Loss [J]

Zone Mixing Latent Heat Gain [J]

The latent heat transfer due to cross mixing in the host (receiving) zone is the sum of all the incoming air mass flow rates multiplied by the elapsed time, the heat of vaporization (calculated for the average conditions (temperature and humidity) between the “source” and “receiving” zones) and the humidity ratio differences between the host zone and corresponding source zones. If the heat transfer is negative, the heat transfer is considered to be a zone mixing latent heat loss. If the heat transfer is positive, the heat transfer is considered to be a zone mixing latent heat gain.

Zone Mixing Total Heat Loss [J]

The total heat loss due to cross mixing that occurs when the sum of Zone Mixing Sensible Heat Gain and Zone Mixing Latent Heat Gain < the sum of Zone Mixing Sensible Heat Loss and Zone Mixing Latent Heat Loss.

Zone Mixing Total Heat Gain [J]

The total heat gain due to cross mixing that occurs when the sum of Zone Mixing Sensible Heat Gain and Zone Mixing Latent Heat Gain >= the sum of Zone Mixing Sensible Heat Loss and Zone Mixing Latent Heat Loss.

ZoneEarthtube (Earth Tube)

An earth tube is a long, underground metal or plastic pipe through which air is drawn. During cooling season, as air travels through the pipe, it gives up some of its heat to the surrounding soil and enters the room as cooler air. Similarly, during heating season, as air travels through the pipe, it receives some of its heat from the soil and enters the room as warmer air. Simple earth tubes in EnergyPlus can be controlled by a schedule and through the specification of minimum, maximum, and delta temperatures as described below. As with infiltration and ventilation, the actual flow rate of air through the earth tube can be modified by the temperature difference between the inside and outside environment and the wind speed. The basic equation used to calculate air flow rate of earth tube in EnergyPlus is:

$$EarthTubeFlowRate = (E_{design})(F_{schedule}) \left[A + B |T_{zone} - T_{odb}| + C (WindSpeed) + D (WindSpeed^2) \right]$$

For the simulation of the earth tube, a weather data file is required and, therefore, the earth tube can not run without weather data file. The required input fields to simulate the earth tube include the average soil surface temperature, the amplitude of soil surface temperature, and the phase constant of soil surface temperature. These fields should be calculated in advance by using a separate stand-alone program (CalcSoilSurfTemp) and should be input into earth tube.

CalcSoilSurfTemp – Auxiliary Programs Document

The CalcSoilSurfTemp program is simple and requires only two input fields : soil condition and soil surface condition in addition to a valid weather file. For soil condition, the user should select the number corresponding to the actual condition of the soil surrounding the earth tube from the four following options: 1. HEAVY AND SATURATED, 2. HEAVY AND DAMP, 3. HEAVY AND DRY and 4. LIGHT AND DRY. This determines the thermal diffusivity and thermal conductivity of the surrounding soil. For soil surface conditions, the user should select the number corresponding to the actual condition of the ground surface above the earth tube from the eight following options: 1. BARE AND WET, 2. BARE AND MOIST, 3. BARE AND ARID, 4. BARE AND DRY, 5. COVERED AND WET, 6. COVERED AND MOIST,

7. COVERED AND ARID and 8. COVERED AND DRY. This determines the absorption coefficient and the fraction of evaporation rate of the ground surface.

From this information and an analysis of the weather for the location selected, the CalcSoilSurfTemp program (ref. Auxiliary Programs document) calculates the three parameters listed above. The user must then add these parameters as input into EnergyPlus. The full input description of an earth tube in EnergyPlus is given below.

Field: Zone Name

This field is the name of the zone (ref: Zone) and attaches a particular earth tube statement to a thermal zone in the building.

Field: Schedule Name

This field is the name of the schedule (ref: Schedule) that modifies the maximum design volume flow rate parameter (see next field). This fraction between 0.0 and 1.0 is noted as F_{schedule} in the above equation.

Field: Design Flow Rate

This number (noted as E_{design} in the above equation) is the maximum amount of air mass flow rate of the earth tube expected at design conditions. The flow rate is expressed in units of m^3/s . The design value is modified by the schedule fraction (see previous field) and user specified coefficients (see last four fields).

Field: Minimum Zone Temperature when Cooling

This is the indoor temperature (in Celsius) below which the earth tube is shut off. This lower temperature limit is intended to avoid overcooling a space and thus result in a heating load. For example, if the user specifies a minimum temperature of 20°C , earth tube is assumed to be available if the zone air temperature is above 20°C . If the zone air temperature drops below 20°C , then earth tube is automatically turned off.

Field: Maximum Zone Temperature when Heating

This is the indoor temperature (in Celsius) above which the earth tube is shut off. This higher temperature limit is intended to avoid overheating a space and thus result in a cooling load. For example, if the user specifies a maximum temperature of 20°C , earth tube is assumed to be available if the zone air temperature is below 20°C . If the zone air temperature rises above 20°C , then earth tube is automatically turned off.

Field: Delta Temperature

This is the temperature difference (in Celsius) between the indoor and outdoor air dry-bulb temperatures below which the earth tube is shut off. This is to allow the earth tube to be stopped either if the temperature outside is too warm and could potentially heat the space or if the temperature outside is too cold and could potentially cool the space. For example, if the user specifies a delta temperature of 2°C , earth tube is assumed to be available if the temperature difference between indoor and outdoor temperature is at least 2°C . If the outside air dry-bulb temperature is less than 2°C cooler or warmer than the indoor dry-bulb temperature, then the earth tube is automatically turned off.

Field: Earthtube Type

This alpha character string defines the type of earth tube as one of the following options: Natural, Exhaust, or Intake. A natural earth tube is assumed to be air movement/exchange that will not consume any fan energy or is the result of natural air flow through the tube and into the building. Values for fan pressure and efficiency for a natural flow earth tube are ignored. For either EXHAUST or Intake, values for fan pressure and efficiency define the fan electric consumption. For Natural and Exhaustearth tubes, the conditions of the air entering

the space are assumed to be equivalent to the air which is cooled or heated by passing along the pipe. For Intake earth tubes, an appropriate amount of fan heat is added to the air stream.

Field: Fan Pressure Rise

This is the pressure rise experienced across the fan in Pascals (N/m²). This is a function of the fan and plays a role in determining the amount of energy consumed by the fan.

Field: Fan Total Efficiency

This is the total fan efficiency (a decimal number between 0.0 and 1.0). This is a function of the fan and plays a role in determining the amount of energy consumed by the fan.

Field: Pipe Radius

This is the radius of the earth tube/pipe (in meters). This plays a role in determining the amount of heat transferred from the surrounding soil to the air passing along the pipe. If the pipe has non-circular cross section, user can use the concept of hydraulic diameter as follows.

$$D = 4 \times \text{Area} / \text{Perimeter}$$

However, since this field requires the pipe radius, hydraulic diameter should be divided by two.

Field: Pipe Thickness

This is the thickness of the pipe wall (in meters). This plays a role in determining the amount of heat transferred from the surrounding soil to the air passing along the pipe.

Field: Pipe Length

This is the total length of the pipe (in meters). This plays a role in determining the amount of heat transferred from the surrounding soil to the air passing along the pipe. As the length of the pipe becomes longer, the amount of the heat transfer becomes larger.

Field: Pipe Thermal Conductivity

This is the thermal conductivity of the pipe (in W/m°C). This plays a role in determining the amount of heat transferred from the surrounding soil to the air passing along the pipe.

Field: Pipe Depth Under Ground Surface

This is the depth of the pipe under the ground surface (in meters). This plays a role in determining the temperature of the soil surrounding the pipe.

Field: Soil Condition

This alpha character string defines the actual condition of the soil surrounding the earth tube and can be one of any of the following options: HeavyAndSaturated, HeavyAndDamp, HeavyAndDry or LightAndDry. This determines the thermal diffusivity and thermal conductivity of the surrounding soil, which play a role in determining the amount of heat transferred from the surrounding soil to the air passing along the pipe.

Field: Average Soil Surface Temperature

This is the annual average soil surface temperature straight above the earth tube, which plays a role in determining the temperature of the soil surrounding the pipe. This field should be calculated in advance using the separate CalcSoilSurfTemp program.

Field: Amplitude of Soil Surface Temperature

This is the amplitude of soil surface temperature above the earth tube, which plays a role in determining the temperature of the soil surrounding the pipe. This is the difference between

the maximum and minimum soil surface temperature for the whole year divided by two. This field should be calculated in advance using the separate CalcSoilSurfTemp program.

Field: Phase Constant of Soil Surface Temperature

This is the phase constant of the soil surface temperature straight above the earth tube, which play a role in determining the temperature of the soil surrounding the pipe at particular time. This is the time elapsed from the beginning of the year until the soil surface temperature reaches the minimum value of the year. This field should be calculated in advance using the separate CalcSoilSurfTemp program.

Field: Constant Term Flow Coefficient

This number is the “A” parameter in the above earth tube equation. It is part of the user specified modifying parameters that are a function of environmental factors. This parameter, however, is a constant under all conditions and is not modified by any environmental effect. As a result, it is dimensionless.

Field: Temperature Term Flow Coefficient

This number is the “B” parameter in the above earth tube equation. It is part of the user specified modifying parameters that are a function of environmental factors. This parameter is modified by the temperature difference between the outdoor and indoor air dry-bulb temperatures. The units for this parameter are inverse Celsius.

Field: Velocity Term Flow Coefficient

This number is the “C” parameter in the above earth tube equation. It is part of the user specified modifying parameters that are a function of environmental factors. This parameter is modified by the speed of wind being experienced outside the building. The units for this parameter are s/m.

Field: Velocity Squared Term Flow Coefficient

This number is the “D” parameter in the above earth tube equation. It is part of the user specified modifying parameters that are a function of environmental factors. This parameter is modified by square of the speed of wind being experienced outside the building. The units for this parameter are s^2/m^2 .

The IDD is shown next. The highlighted field names can be obtained from the extra CalcSoilSurfTemp program.

```
ZoneEarthtube,
  \min-fields 22
  \memo Earth Tube is specified as a design level which is modified by a Schedule fraction,
temperature difference and wind speed:
  \memo Earthtube=Edesign * Fschedule * (A + B*|(Tzone-Todb)| + C*WindSpd + D * WindSpd**2)
A1, \field Zone Name
  \required-field
  \type object-list
  \object-list ZoneNames
A2, \field Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
N1, \field Design Flow Rate
  \required-field
  \units m3/s
  \note "Edesign" in Equation
  \type real
  \minimum 0
```

```
N2, \field Minimum Zone Temperature when Cooling
\required-field
\note this is the indoor temperature below which the earth tube is shut off
\units C
\type real
\minimum -100
\maximum 100
N3, \field Maximum Zone Temperature when Heating
\required-field
\note this is the indoor temperature above which the earth tube is shut off
\units C
\type real
\minimum -100
\maximum 100
N4, \field Delta Temperature
\required-field
\note This is the temperature difference between indoor and outdoor below which the earth tube is
shut off
\units deltaC
\type real
\minimum 0
A3, \field Earthtube Type
\required-field
\type choice
\key Natural
\key Intake
\key Exhaust
\default Natural
N5, \field Fan Pressure Rise
\required-field
\note pressure rise across the fan
\type real
\units Pa
\minimum 0
\default 0
N6, \field Fan Total Efficiency
\required-field
\type real
\minimum> 0
\default 1
N7, \field Pipe Radius
\required-field
\units m
\type real
\minimum> 0
\default 1
N8, \field Pipe Thickness
\required-field
\units m
\type real
\minimum> 0
\default 0.2
N9, \field Pipe Length
\required-field
\units m
\type real
\minimum> 0
\default 15
N10, \field Pipe Thermal Conductivity
\required-field
\units W/m-K
\type real
\minimum> 0
\default 200
N11, \field Pipe Depth Under Ground Surface
\required-field
\units m
\type real
\minimum> 0
\default 3
A4, \field Soil Condition
```

```
\required-field
\type choice
\key HeavyAndSaturated
\key HeavyAndDamp
\key HeavyAndDry
\key LightAndDry
\default HeavyAndDamp
N12, \field Average Soil Surface Temperature
\required-field
\units C
\type real
\default 0
N13, \field Amplitude of Soil Surface Temperature
\required-field
\units C
\type real
\minimum 0
\default 0
N14, \field Phase Constant of Soil Surface Temperature
\required-field
\units days
\type real
\minimum 0
\default 0
N15, \field Constant Term Flow Coefficient
\required-field
\note "A" in Equation
\type real
\default 1
N16, \field Temperature Term Flow Coefficient
\required-field
\note "B" in Equation
\type real
\default 0
N17, \field Velocity Term Flow Coefficient
\required-field
\note "C" in Equation
\type real
\default 0
N18; \field Velocity Squared Term Flow Coefficient
\required-field
\note "D" in Equation
\type real
\default 0
```

An IDF example:


```

EARTHTUBE,
Zone 2,           !- Zone Name
Simple EarthTube, !- Schedule Name
3.425198,        !- Design Volume Flow Rate
10.0,           !- Minimum Zone Temperature when Cooling
30.0,           !- Maximum Zone Temperature when Heating
1.0,            !- Delta Temperature
NATURAL,        !- EarthTube Type
350.0,          !- Fan Pressure Rise
0.9,            !- Fan Total Efficiency
0.25,           !- Pipe Radius
0.2,            !- Pipe Thickness
15.0,           !- Pipe Length
200.0,          !- Pipe Thermal Conductivity
3.5,            !- Pipe Depth Under Ground Surface
HeavyAndDamp,   !- Soil Condition
15.0,           !- Average Soil Surface Temperature
5.6,            !- Amplitude of Soil Surface Temperature
0.0,            !- Phase Constant of Soil Surface Temperature
0.6060000,     , !- Constant Term Flow Coef
2.0199999E-02, !- Temp Term Flow Coef
5.9800001E-04, !- Velocity Term Flow Coef
0.0000000E+00; !- Velocity**2 Term Flow Coef

```

EarthTube Outputs

Current EarthTube output variables:

```

Zone, Sum, Zone EarthTube Sensible Heat Loss [J]
Zone, Sum, Zone EarthTube Sensible Heat Gain [J]
Zone, Sum, Zone EarthTube Volume [m3]
Zone, Sum, Zone EarthTube Mass [kg]
Zone, Sum, Zone EarthTube Fan Electric Consumption [J]
Zone, Average, Zone EarthTube Inlet Air Temperature [C]

```

Zone EarthTube Sensible Heat Loss [J]

The sensible (temperature) heat loss that occurs when the earth tube air temperature (outdoor) < zone air temperature

Zone EarthTube Sensible heat gain [J]

The sensible (temperature) heat gain that occurs when the earth tube air temperature (outdoor) >= zone air temperature

Zone EarthTube Volume [m3]

The volume flow of the earth tube air

Zone EarthTube Mass [kg]

The mass flow of the earth tube air

Zone EarthTube Fan Electric Consumption [J]

The fan electrical consumption for intake or exhaust earth tube types

Zone EarthTube Inlet Air Temperature [C]

This is equal to the temperature of the air which is cooled or heated by passing along the pipe except when INTAKE fan power is included. When intake fan power is used, then the additional heat due to the fan is added and this will be reported as the inlet air temperature.

ZoneCoolTower:Shower

A cooltower (which is sometimes referred to as a wind tower or a shower cooling tower) is a component that is intended to model a passive downdraught evaporative cooling (PDEC) that is designed to capture the wind at the top of a tower and cool the outside air using water evaporation before delivering it to a space. The air flow in these systems is natural as the

evaporation process increases the density of the air causing it to fall through the tower and into the space without the aid of a fan. A cooltower typically consists of a water spray or an evaporative pad, a shaft, and a water tank or reservoir. Wind catchers to improve the wind-driven performance at the top of the tower are optional. Water is pumped over an evaporative device by water pump which is the only component consumed power for this system. This water cools and humidifies incoming air and then the cool, dense air naturally falls down through shaft and leaves through large openings at the bottom of cooltowers.

The shower cooling tower can be controlled by a schedule and the specification of maximum water flow rate and volume flow rate as well as minimum indoor temperature. The actual flow rate of water and air can be controlled as users specify the fractions of water loss and flow schedule. The required input fields include effective tower height and exit area to obtain the temperature and flow rate of the air exiting the tower. A schedule and rated power for the water pump are also required to determine the power consumed. The component typically has a stand alone water system that is not added to the water consumption from mains. However, users are required to specify the water source through an optional field, the name of water supply storage tank, in case any water comes from a water main. The model is described more fully in the Engineering Reference document.

This model requires weather information obtained from either design day or weather file specifications. The control is accomplished by either specifying the water flow rate or obtaining the velocity at the outlet with inputs and weather conditions when the water flow rate is unknown. As with infiltration, ventilation, and earth tubes, the component is treated in a similar fashion to “natural ventilation” in EnergyPlus. The input data dictionary definition of a shower cooling tower is as follows.

Field: Name

This field is a unique user assigned name for each cooltower. Any reference to this unit by another object will use this name.

Field: Available Schedule Name

This field is the name of the schedule that denotes whether the cooltower can run during a given hour.

Field: Zone Name

This field is the name of the zone (ref: Zone) and attaches a particular cooltower statement to a thermal zone in the building.

Field: Water Supply Storage Tank Name

This field is optional. It is used to describe where the cooltower obtains water used for evaporative cooling. If blank or omitted, then the cooltower will obtain water directly from local water main. If the name of a Water Storage Tank object is used here, then the cooltower will obtain its water from that tank. If a tank is specified, the cooltower will attempt to obtain all the water it uses from the tank. However, if the tank cannot provide all the water the cooltower needs, then the cooltower will still operate and obtain the rest of the water it needs from the mains (referred to as ‘Starved’ water).

Field: Flow Control Type

This field specifies how the user wishes to control the cooltower. The air flow from the cooltower may be controlled by either the water flow rate along with the water pump schedule or naturally driven by wind flow. The user must select from the following options: **WaterFlowSchedule** and **WindDrivenFlow**. If the user either wishes to control the water flow rate or has information about the water flow rate, **WaterFlowSchedule** must be selected. **WindDrivenFlow** for cooltower flow control must be selected when the water flow rate is unknown and the user wishes to have the flow rate of both air and water controlled by the external weather conditions (wind speed). If the user does not select a control type, **WindDrivenFlow** is assumed as a flow control type.

Field: Pump Flow Rate Schedule Name

This field modifies the maximum flow rate of water through the cooltower in m³/sec. This input is “optional.” If the user does not enter a schedule, the flow rate through the cooltower is assumed to be constant during all hours that it is operating based on the value entered in the previous input field. Note that the values for this schedule must be between zero and one.

Field: Maximum Water Flow Rate

This field is the maximum water flow rate distributed to the tower in m³/s. This limit is intended to avoid over estimation of water flow rate, which leads higher air flow rate and exit temperature of the air.

Field: Effective Tower Height

This field is the effective tower height for evaporative cooling, from the water spray to the top of the exit in m.

Field: Airflow Outlet Area

This field is the area at the exit of the tower in m². This field is used to determine the air flow rate leaving the tower with the velocity of the air flow.

Field: Maximum Air Flow Rate

This field is the maximum volumetric flow rate of the air leaving the tower in m³/s. This airflow maximum allows the cooltower performance to be limited if the outside wind speed and the tower height are relatively high and thus result in high airflow supplied to the space.

Field: Minimum Indoor Temperature

This field is the minimum indoor temperature in Celsius below which cooltower is shutoff. This lower temperature limit is intended to avoid overcooling a space and thus result in a heating load. For example, if the user specifies a minimum temperature of 20°C, cooltower is assumed to be available if the zone air temperature is above 20°C. If the zone air temperature drops below 20°C, then cooltower is automatically turned off.

Field: Fraction of Water Loss

This field specifies the fraction of the loss of water during either operation or transient operation. If the user does not enter a fraction, no loss of water is assumed and the cooltower water consumption includes only evaporation. Note that the fraction must be between zero and one.

Field: Fraction of Flow Schedule

This field specifies the fraction of the airflow that actually goes to the outside. The user who wishes to control the actual flow to the inside of the building must specify the value of the fraction. If the user does not enter a fraction, the calculated flow rate is the “zone cooltower volume flow rate.” Note that the fraction must be between zero and one.

Field: Rated Power Consumption

This field is the pump’s rated power consumption in Watts.

```

ZoneCoolTower:Shower,
A1, \field Name
    \required-field
A2, \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A3, \field Zone Name
    \required-field
    \type object-list
    \object-list ZoneNames
A4, \field Water Supply Storage Tank Name
    \note In case of stand alone tank or underground water, leave this input blank
    \type object-list
    \object-list WaterStorageTankNames
A5, \field Flow Control Type
    \note Water flow schedule should be selected when the water flow rate is known.
    \note Wind-driven flow should be selected when the water flow rate is unknown.
    \type choice
    \key WaterFlowSchedule
    \key WindDrivenFlow
    \default WindDrivenFlow
A6, \field Pump Flow Rate Schedule Name
    \type object-list
    \object-list ScheduleNames
N1, \field Maximum Water Flow Rate
    \required-field
    \units m3/s
    \type real
N2, \field Effective Tower Height
    \note This field is from either the spray or the wet pad to the top of the outlet.
    \required-field
    \units m
    \type real
N3, \field Airflow Outlet Area
    \note User have to specify effective area when outlet area is relatively bigger than the cross
sectional area
    \note of cooltower. If the number of outlet is more than one, assume the air passes through only one.
    \required-field
    \units m2
    \type real
N4, \field Maximum Air Flow Rate
    \required-field
    \units m3/s
    \type real
    \minimum 0
N5, \field Minimum Indoor Temperature
    \required-field
    \note This field is to specify the indoor temperature below which cooltower is shutoff.
    \units C
    \type real
    \minimum -100
    \maximum 100
N6, \field Fraction of Water Loss
    \minimum 0
    \maximum 1
N7, \field Fraction of Flow Schedule
    \minimum 0
    \maximum 1
N8; \field Rated Power Consumption
    \required-field
    \units W
    \type real

```

Below is an example input for a cooltower.

```

ZoneCoolTower:Shower
Cool Tower 1,      !- Name of cooltowers
Zone 1,           !- Zone name
Simple Vent,      !- Schedule
,                !- Name of water supply storage tanks
WindDrivenFlow,   !- Flow control type
0.0005,          !- Water flow rate from the spray in m3/s
,                !- schedule for flow rate (optional, non-existent means constant)
5.0,             !- Effective tower height in m
1.0,             !- Exit area in m2
10.0,           !- Maximum supply air volume flow rate in m3/s
18.0,           !- Minimum indoor temperature to prevent overcooling in C
0.05,           !- Fraction of Water loss
0.05,           !- Fraction of flow that goes to outside
250.0;          !- Rated power consumption in W

```

ZoneCoolTower:Shower Outputs

```

Zone,Sum,Zone CoolTower Sensible Heat Loss [J]
Zone,Sum,Zone CoolTower Sensible Heat Loss Rate [W]
Zone,Sum,Zone CoolTower Latent Heat Loss [J]
Zone,Sum,Zone CoolTower Latent Heat Loss Rate [W]
Zone,Sum,Zone CoolTower Volume Flow Rate[m3/s]
Zone,Sum,Zone CoolTower Mass Flow Rate [kg/s]
Zone,Sum,Zone CoolTower Inlet Temperature [C]
Zone,Sum,Zone CoolTower Inlet Humidity Ratio
Zone,Sum,Zone CoolTower Exit Temperature [C]
Zone,Sum,Zone CoolTower Exit Humidity Ratio
Zone,Sum,Zone CoolTower Water Consumption [m3]
Zone,Sum,Zone CoolTower Tank Water Consumption [m3]
Zone,Sum,Zone CoolTower Starved Water Consumption [m3]
Zone,Sum,Zone CoolTower Pump Electric Consumption [W]
Zone,Sum,Zone CoolTower Pump Electric Energy [J]

```

Zone Cooltower Sensible Heat Loss [J]

The sensible heat loss that occurs when the temperature at the exit of the cooltower is less than that of the zone.

Zone Cooltower Sensible Heat Loss Rate [W]

Zone Cooltower Latent Heat Loss [J]

The latent heat loss that occurs when the humidity ratio at the exit of the cooltower is greater than that of the zone.

Zone Cooltower Latent Heat Loss Rate [W]

Zone Cooltower Volume Flow Rate [m3/s]

The volumetric flow rate of the air leaving the cooltower

Zone Cooltower Volume [m3]

The sum of actual volumetric flow of the air leaving cooltower

Zone Cooltower Mass Flow Rate [kg/s]

The mass flow rate of the air leaving the cooltower

Zone Cooltower Mass [kg]

The sum of actual mass flow of the air leaving the cooltower

Zone Cooltower Inlet Temperature [C]

The dry-bulb temperature of the outdoor air the inlet of the cooltower

Zone Cooltower Inlet Humidity Ratio [C]

The humidity ratio of the outdoorair at the inlet of the cooltower

Zone Cooltower Exit Temperature [C]

The temperature at the exit of the cooltower.

Zone Cooltower Exit Humidity Ratio [C]

The humidity ratio of the air at the exit of the cooltower.

Cooltower Water Consumption [m3]

The water consumption includes not only the direct thermodynamics of water evaporation but also other sources of consumption such as drift or concentration blow down specified by users throughout all processes during the operation.

Cooltower Mains Water Mains Draw [m3]

This is the water consumed by the cooltower that actually be met by the mains water. This report variable appears only when the water comes from mains.

Cooltower Tank Water Consumption [m3]

This is the water consumed by the cooltower that actually be met by the water storage tank. If any amount of the water is starved from mains, this water consumption is the difference between the cooltower water consumption and the following output. This report variable appears only when the water comes from storage tank waters.

Cooltower Starved Water Consumption [m3]

This is the source (mains) of water consumed by the cooltower that could not actually be met by the storage tank. This report variable appears only when the water comes from storage tank waters.

Zone Cooltower Pump Electric Consumption [W]

The power consumed by the recirculating pump in Watts.

Zone Cooltower Pump Electric Energy [J]

The energy consumed by the recirculating pump in Joule.

ZoneThermalChimney (Thermal Chimney)

A thermal chimney is a vertical shaft utilizing solar radiation to enhance the natural ventilation in buildings. It consists of a absorber wall, air gap and glass cover with high solar transmissivity. For the high solar absorption, it is usually south facing.

The key output parameter in the thermal chimney model is the enhanced amount of natural ventilation rate caused by the presence of a thermal chimney. In order to determine the enhanced ventilation, the discharge air temperature from a thermal chimney should be calculated, which, in turn, should be computed based on the information on the absorber wall temperature, glass cover temperature and the vertical air temperature distribution within the thermal chimney. Among them, energy balances for the absorber wall and the glass cover are carried out using the existing algorithm currently available in EnergyPlus, which has the similar approach to the Trombe wall. As stated in the Trombe wall object as well, this approach allows the flexibility for users to specify the various wall parameters and to explore unusual configurations. On the other hand, the vertical air temperature distribution and the resultant discharge air temperature of the thermal chimney are computed using the separate thermal chimney algorithm described in the Engineering Reference document.

Similar to the Trombe wall model, a zone is coupled to the desired surface via an interzone partition. To simulate the thermal chimney, the Solar Distribution field in the Building object should be set to FullInteriorAndExterior so that the majority of the solar flux is directed on the

absorber wall. For a normal sized thermal chimney zone, the user can set the Zone Inside Convection Algorithm to “Detailed”, which takes into account natural convection effects intended for a normal zone. For a narrow cavity zone having high aspect ratios, there is no built-in algorithm for calculating the correct convection coefficients on the inside of thermal chimney zone walls. One option is to use the “Detailed” convection algorithm similar to the Trombe wall model. However, some error may be incurred when used with a narrow zone. Another option is to use the SurfaceProperty:ConvectionCoefficients object to schedule coefficients that have been determined beforehand by the user. In addition, the wall construction of the adjoining zone must be the mirror image of the wall construction in the thermal chimney zone.

The full input description of a thermal chimney in EnergyPlus is given below.

Field: Name

This field is a unique user assigned name for an instance of the thermal chimney system.

Field: Zone Name

This field is the name of the thermal chimney zone (ref: Zone). Since the thermal chimney is not only a system component but also a zone itself, this field is also necessary. It should be differentiated from the *Zone name* field described later.

Field: Availability Schedule Name

This field is the name of the schedule (ref: Schedule) that denotes whether the thermal chimney can operate during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the system is available and can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the system is not available and must be off for the hour.

Field: Width of the Absorber Wall

This number is the width of the absorber wall in the thermal chimney. The width is expressed in units of m. Even though this value is specified in Surface objects as well, this value is used to compute the discharge air temperature and the enhanced ventilation rate caused by the thermal chimney.

Field: Cross Sectional Area of Air Channel Outlet

This number is the cross sectional area of air channel outlet. The area is expressed in units of m². The enhanced air flow rate by the thermal chimney is dependent on cross sectional areas of air channel inlet and outlet. Cross sectional areas of air channel inlet will be described later in conjunction with the distance from the top of thermal chimney to each inlet and relative ratios of air flow rates passing through each inlet.

Field: Discharge Coefficient

This dimensionless number is the discharge coefficient of the thermal chimney. The ventilation rate enhanced by the thermal chimney is also dependent on the discharge coefficient.

Field: Zone <#> Name

This field is the name of the zone (ref: Zone) to which the thermal chimney is attached. It is used in conjunction with the next three fields. Note that up to 20 sets of zone name, distance from the top of the thermal chimney to each inlet, relative ratios of air flow rates passing through each zone and cross sectional areas of each air channel inlet may be entered for a single thermal chimney if multiple zones share the common thermal chimney.

Field: Distance from Top of Thermal Chimney to Inlet <#>

This field is the distance from the top of the thermal chimney to each inlet corresponding to each zone. It is used in conjunction with the zone name, relative ratios of air flow rates

passing through each zone and cross sectional areas of each air channel inlet. The distance is expressed in units of m. The air flow rate enhanced by the thermal chimney is dependent on the distance between the thermal chimney outlet and inlet.

Field: Relative Ratios of Air Flow Rates Passing through Zone <#>

This dimensionless number is the relative ratio of air flow rates enhanced by the thermal chimney passing through each zone. The total air flow rate enhanced by the thermal chimney is distributed to each zone based on this number if multiple zones share the common thermal chimney. It is used in conjunction with the zone name, the distance from the top of the thermal chimney to each inlet and cross sectional areas of each air channel inlet. Not that the sum of all ratios must be equal to 1.0.

Field: Cross Sectional Areas of Air Channel Inlet <#>

This field is the cross sectional areas of each air channel inlet corresponding to each zone. It is used in conjunction with the zone name, the distance from the top of the thermal chimney to each inlet and relative ratios of air flow rates passing through each zone. The area is expressed in units of m². The air flow rate enhanced by the thermal chimney is dependent on cross sectional areas of air channel inlet and outlet.

```
ZoneThermalChimney,
  \min-fields 10
  A1, \field Name
      \required-field
  A2, \field Zone Name
      \note Name of zone that is the thermal chimney
      \required-field
      \type object-list
      \object-list ZoneNames
  A3, \field Availability Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
  N1, \field Width of the Absorber Wall
      \required-field
      \units m
      \type real
      \minimum 0
  N2, \field Cross Sectional Area of Air Channel Outlet
      \required-field
      \units m2
      \type real
      \minimum 0
  N3, \field Discharge Coefficient
      \required-field
      \type real
      \minimum 0
      \maximum 1
      \default 0.8
```



```

A4, \field Zone 1 Name
    \required-field
    \type object-list
    \object-list ZoneNames
N4, \field Distance from Top of Thermal Chimney to Inlet 1
    \required-field
    \units m
    \type real
    \minimum 0
N5, \field Relative Ratios of Air Flow Rates Passing through Zone 1
    \required-field
    \type real
    \minimum 0
    \maximum 1
    \default 1.0
N6, \field Cross Sectional Areas of Air Channel Inlet 1
    \required-field
    \units m2
    \type real
    \minimum 0
<reduced for brevity>

```

An IDF example:

```

ZoneThermalChimney,
ThermalChimney1,           !- Name of Thermal Chimney System
ThermalChimneyZone,       !- Name of Thermal Chimney Zone
ThermalChimneyAvail,      !- Availability Schedule Name
3.5,                       !- Width of the Absorber Wall
0.04,                      !- Cross Sectional Area of Air Channel Outlet
0.8,                       !- Discharge Coefficient
Zone1,                     !- Zone Name 1
8.0,                       !- Distance from the Top of the Thermal Chimney to Inlet 1
0.8,                       !- Relative Ratios of Air Flow Rates Passing through Zone 1
0.02,                      !- Cross Sectional Areas of Air Channel Inlet 1
Zone2,                     !- Zone Name 2
5.0,                       !- Distance from the Top of the Thermal Chimney to Inlet 2
0.2,                       !- Relative Ratios of Air Flow Rates Passing through Zone 2
0.02;                      !- Cross Sectional Areas of Air Channel Inlet 2

```

ZoneThermalChimney Outputs

Current ThermalChimney output variables:

```

Zone, Sum, Zone ThermalChimney Sensible Heat Loss [J]
Zone, Sum, Zone ThermalChimney Sensible Heat Gain [J]
Zone, Sum, Zone ThermalChimney Volume [m3]
Zone, Sum, Zone ThermalChimney Mass [kg]
System, Average, Thermal Chimney Total Volumetric Flow Rate [m^3/s]
System, Average, Thermal Chimney Total Mass Flow Rate [kg/s]
System, Average, Thermal Chimney Air Outlet Temperature [C]

```

Zone ThermalChimney-Heat Loss [J]

The sensible (temperature) heat loss of each zone that occurs when the thermal chimney cools the zone air

Zone ThermalChimney-Heat Gain [J]

The sensible (temperature) heat gain of each zone that occurs when the thermal chimney heats the zone air

Zone ThermalChimney-Volume [m3]

The air volumetric flow of each zone enhanced by the thermal chimney

Zone ThermalChimney-Mass [kg]

The air mass flow of each zone enhanced by the thermal chimney

Thermal Chimney Total Volumetric Flow Rate [m³/s]

The total air volumetric flow rate caused by the thermal chimney

Thermal Chimney Total Mass Flow Rate [kg/s]

The total air mass flow rate caused by the thermal chimney

Thermal Chimney Air Outlet Temperature [C]

The temperature of the air which is discharged from the thermal chimney through the outlet

Group – Design Objects**Input for Design Calculations and Component Autosizing****Overview**

In order for EnergyPlus to successfully calculate zone design heating and cooling loads and air flow rates and for the program to use these results to automatically size the HVAC components a number of input objects must be present and certain object input fields must be entered.

- The input file should contain a SimulationControl object. The 1st field *Do Zone Sizing Calculation* should be entered as *Yes*. This will cause a zone sizing simulation to be done using all the design days in the input file as weather. If there are no air or water loops in the HVAC input fields 2 and 3 can be set to *No*. If there are one or more air loops (i.e., there is at least one AirLoopHVAC object in the input file) then the 2nd field *Do System Sizing Calculation* should be entered as *Yes*. If there are one or more water loops (Plant Loop objects) then the 3rd field *Do Plant Sizing Calculation* should be set to *Yes*. Finally either the 4th field (*Run Simulation for Sizing Periods*) or the 5th field (*Run Simulation for Weather File Run Periods*) should be set to *Yes* in order to autosize the components and do a real simulation using the autosized components. The component autosizing calculations are done on the first pass through the HVAC system in the real simulation.
- There must be at least 2 (up to any number) SizingPeriod objects present. Normally one will be for summer conditions and one for winter. The summer day should normally have the field *Day Type* set to *SummerDesignDay*. The winter design day should normally have *Day Type* set to *WinterDesignDay*.
- To apply a global sizing factor include the Sizing:Parameters object.
- For each controlled zone in the input file there should be a corresponding Sizing:Zone object. Similarly for each AirLoopHVAC there should be a Sizing:System object. And for each Plant or Condenser Loop there should be a Sizing:Plant object. Note however that if a controlled zone has no corresponding Zone Sizing object the data from the first Zone Sizing object will be used. Thus if all the zone sizing information is the same only one Zone Sizing object need be entered.
- Only controlled zones are included in the zone and system sizing calculations. Thus for a design air flow rate to be calculated for a zone, it must contain a thermostat *even though it might not need or have a thermostat in the full simulation*. An illustration would be a three zone building with a packaged single zone system and a thermostat in one of the zones. In order for the two slave zones to be included in the design air flow calculations they must be treated as if they have a thermostat: there must be a ZoneControl:Thermostat for each of the slave zones.
- Some attention should be paid to schedules. In a weekly schedule object the 9th and 10th day schedules are for summer and winter design days respectively. This means that if a DesignDay object has field *Day Type* set to *SummerDesignDay* the day schedule for summer design days will be in effect. Similarly if a DesignDay object has field *Day Type* set to *WinterDesignDay* the day schedule for winter design days will be in effect. Some possible applications of this capability are:

- 1) setting internal loads (lights, equipment, occupancy) to maximum all day for cooling and to zero all day for heating;
- 2) setting heating and cooling thermostat set points to constant values (no set up or set back);
- 3) setting heating and cooling equipment to be always on.

None of these applications are necessarily recommended but these and other uses of the special design day schedules may prove useful for specific situations.

Component Autosizing

For autosizing to occur at the component level the user must enter the special value *autosize* in the numeric fields for which autosizing is available. Those fields can be found by looking at the Energy+.idd data dictionary file or under individual object details in this document. Fields that can be autosized are denoted with the comment *\autosizable*. An example of a few components and fields that are autosizable are listed in the following table.

Table 20. Example Details of Autosizable Objects/Fields

Component / Object	Field(s)
AirLoopHVAC:Unitary:Furnace:HeatOnly	Maximum Supply Air Temperature
	Supply Air Flow Rate
	Fraction of Supply Air Flow That Goes Through the Controlling Zone
AirLoopHVAC:UnitaryHeatCool:VAVChangeoverBypass	System Air Flow Rate During Cooling Operation
	System Air Flow Rate During Heating Operation
	System Air Flow Rate When No Cooling or Heating is Needed
	Outdoor Air Flow Rate During Cooling Operation
	Outdoor Air Flow Rate During Heating Operation
	Outdoor Air Flow Rate When No Cooling or Heating is Needed

Sizing Factors

There are 3 places in the input where the user can impose sizing factors.

1. In Sizing Parameters (object: Sizing:Parameters), the user can specify an over-all sizing factor. This factor is applied to all the zone design loads and air flow rates resulting from the zone sizing calculations.
2. In Zone Sizing (object: Sizing:Zone), the user can specify a sizing factor for a specific zone. The factor is applied to the calculated zone design loads and air flow rates for the zone named in the Sizing:Zone object. This sizing factor overrides the global sizing factor. That is, a zone sizing factor, if specified, replaces the global sizing factor for the named zone.
3. For some plant components (basically all central chillers, boilers and cooling towers) the user can specify a sizing factor that modifies the autosized component capacity and flow rates. These factors are applied after the application of global or zone sizing factors. They are primarily used to split the design load between multiple components. These sizing factors can change the autosizing of the associated loops and pumps. The following rules are followed the effect of plant component sizing factors on loops and pumps.

- a. For supply side branches, the sizing factors of all components in series on the branch are summed and the result becomes the branch sizing factor. If there is a branch pump its autosized design flow rate is multiplied by the branch sizing factor.
- b. For each loop, if the average of the branch sizing factors is less than 1, the loop sizing factor is set equal to the sum of the branch sizing factors. If the average is greater than 1, the loop sizing factor is set equal to the maximum of the branch sizing factors. The loop sizing factor is applied to the loop design flow rate (if autosized) and to the loop pump flow rate (if autosized).

Mixing User-Specified and Autosized Inputs

Mixed user-specified and autosized inputs can be successfully used if the following points and suggestions are followed.

1. Each component is autosized independently. Thus user input for a flow rate in one component will have no effect on other components’ autosized flow rates. For instance, specifying the chilled water loop pump’s rated flow rate will have no effect on the autosizing of the chiller’s design evaporator flow rate or on the plant loop’s autosized maximum loop flow rate.
2. Within a component it is OK to mix user-specified and autosized inputs. In the Chiller:Electric, for example, it is fine to specify the nominal capacity and autosize the other input fields.
3. If the user wants to specify a zone or system air flow rate it should be done using the Sizing:Zone and Sizing:System objects rather than done in the individual components.
4. The plant loop flow rates are sized from the total design demand of the components connected to each loop. The components demanding water need not be autosized for the plant loop autosizing to work successfully. So the user could specify all the air side components and autosize all the plant loops and plant components. Or specify the chilled water loop flow rate, chilled water pump inputs and chiller inputs and let the condenser loop and tower autosize.

Component Sizing Output

The results of the component autosizing calculations are reported on the *eplusout.eio* file. For each component field that has been autosized the object type, object name, field description with unit, and value are printed out as comma separated data on a line beginning with *Component Sizing*. Examples of this are shown in the Output Details and Examples document.

The complete list of objects that have autosized fields is shown in the following table.

Table 21. Complete list of Objects with autosized Fields

Object Name	Object Name	Object Name
AirLoopHVAC	Coil:Cooling:DX:MultiSpeed	HVACTemplate:Zone:PTAC
AirLoopHVAC:Unitary:Furnace:HeatCool	Coil:Cooling:DX:SingleSpeed	HVACTemplate:Zone:PThp
AirLoopHVAC:Unitary:Furnace:HeatOnly	Coil:Cooling:DX:TwoSpeed	HVACTemplate:Zone:Unitary
AirLoopHVAC:UnitaryHeatCool	Coil:Cooling:Water	HVACTemplate:Zone:VAV
AirLoopHVAC:UnitaryHeatCool:VAVChangeoverBypass	Coil:Cooling:Water:DetailedGeometry	HVACTemplate:Zone:VAV:FanPowered
AirLoopHVAC:UnitaryHeatOnly	Coil:Cooling:WaterToAirHeatPump:ParameterEstimation	PlantEquipmentOperation:ComponentSetpoint
AirLoopHVAC:UnitaryHeatPump:Air	Coil:Heating:DX:MultiSpeed	PlantLoop

rToAir		
AirLoopHVAC:UnitaryHeatPump:AirToAir:MultiSpeed	Coil:Heating:DX:SingleSpeed	Pump:ConstantSpeed
AirLoopHVAC:UnitaryHeatPump:WaterToAir	Coil:Heating:Electric	Pump:VariableSpeed
AirTerminal:DualDuct:ConstantVolume	Coil:Heating:Gas	Pump:VariableSpeed:Condensate
AirTerminal:DualDuct:VAV	Coil:Heating:Steam	RoomAirSettings:UnderFloorAirDistributionExterior
AirTerminal:SingleDuct:ConstantVolume:FourPipeInduction	Coil:Heating:Water	RoomAirSettings:UnderFloorAirDistributionInterior
AirTerminal:SingleDuct:ConstantVolume:Reheat	Coil:Heating:WaterToAirHeatPump:ParameterEstimation	Sizing:System
AirTerminal:SingleDuct:ParallelPIU:Reheat	CoilPerformance:DX:Cooling	SolarCollector:FlatPlate:PhotovoltaicThermal
AirTerminal:SingleDuct:SeriesPIU:Reheat	CondenserLoop	ThermalStorage:ChilledWater:Mixed
AirTerminal:SingleDuct:Uncontrolled	Controller:OutdoorAir	ThermalStorage:ChilledWater:Stratified
AirTerminal:SingleDuct:VAV:HeatAndCool:NoReheat	Controller:WaterCoil	WaterHeater:Mixed
AirTerminal:SingleDuct:VAV:HeatAndCool:Reheat	CoolingTower:SingleSpeed	WaterHeater:Stratified
AirTerminal:SingleDuct:VAV:NoReheat	CoolingTower:TwoSpeed	ZoneHVAC:Baseboard:Convective:Electric
AirTerminal:SingleDuct:VAV:Reheat	CoolingTower:VariableSpeed	ZoneHVAC:Baseboard:Convective:Water
AirTerminal:SingleDuct:VAV:Reheat:VariableSpeedFan	Fan:ConstantVolume	ZoneHVAC:Baseboard:RadiantConvective:Water
Boiler:HotWater	Fan:OnOff	ZoneHVAC:EnergyRecoveryVentilator
	Fan:VariableVolume	ZoneHVAC:FourPipeFanCoil
Boiler:Steam	FanPerformance:NightVentilation	ZoneHVAC:HighTemperatureRadiant
Branch	Fluidcooler:SingleSpeed	ZoneHVAC:IdealLoadsAirSystem
Chiller:Absorption	Fluidcooler:TwoSpeed	ZoneHVAC:LowTemperatureRadiant:Electric
Chiller:Absorption:Indirect	HeaderedPumps:ConstantSpeed	ZoneHVAC:LowTemperatureRadiant:VariableFlow
Chiller:CombustionTurbine	HeaderedPumps:VariableSpeed	ZoneHVAC:PackagedTerminalAirConditioner
Chiller:ConstantCOP	HeatExchanger:AirToAir:SensibleAndLatent	ZoneHVAC:PackagedTerminalHeatPump
Chiller:Electric	HeatExchanger:WatersideEconomizer	ZoneHVAC:UnitHeater
Chiller:Electric:EIR	HVACTemplate:Plant:Boiler	ZoneHVAC:UnitVentilator
Chiller:Electric:ReformulatedEIR	HVACTemplate:Plant:Chiller	ZoneHVAC:VentilatedSlab
Chiller:EngineDriven	HVACTemplate:Plant:Tower	ZoneHVAC:WindowAirConditioner
ChillerHeater:Absorption:DirectFired	HVACTemplate:System:Unitary	
AirLoopHVAC	HVACTemplate:System:VAV	EvaporativeCooler:Indirect:ResearchSpecial

User or External Zone Design Flow Rate Inputs

In EnergyPlus the autosizing calculations start with a calculation of the zone design air flow rates using zone by zone design day simulations. The resulting zone design air flow rates and daily air flow sequences are used in the subsequent HVAC and central plant air and fluid flow design calculations and in the component autosizing calculations. The user can override or change the calculated zone design air flow rates in several ways.

- 1) The user can enter a value for *Sizing Factor* in the *Sizing:Parameters* object (see description below).
- 2) The user can specify a zone level *Zone Sizing Factor* in each *Sizing:Zone* object.
- 3) For each zone the user can input a *Cooling Design Air Flow Rate* and/or a *Heating Design Air Flow Rate* (and specify *Cooling Design Air Flow Method = Flow/Zone* and *Heating Design Air Flow Method = Flow/Zone*). These user inputs override the calculated values. The program divides the user input cooling or heating design air flow rate by the calculated values and uses the result as a zone sizing factor to multiply all the elements in the design heating and cooling air flow and load sequences. From this point the design calculations proceed as usual.

User or External System Design Flow Rate Inputs

Using the results of the zone design air flow rate calculation (including any user input or altered flow rates) EnergyPlus proceeds to calculate central air system flow rates and cooling and heating loads. The results of this calculation can be overridden in the following way.

For each system (AirLoopHVAC), in the corresponding *Sizing:System* object, specify *Cooling Design Air Flow Method* to be *Flow/System* and input a value for *Cooling Design Air Flow Rate*. Similarly for heating specify *Heating Design Air Flow Method* to be *Flow/System* and input a value for *Heating Design Air Flow Rate*.

Sizing:Parameters

This object allows the user to specify a global sizing ratio. This ratio will be applied at the zone level to all of the zone heating and cooling loads and air flow rates. These new loads and air flow rates are then used to calculate the system level flow rates and capacities and are used in all of the component sizing calculations.

The user can also specify the width (in load timesteps) of a moving average window which can be used to smooth the calculated zone design flow sequences. The use of this parameter is described below.

Field: Sizing Factor

The global sizing ratio applied to all of the zone design load and air flow rates.

Field: Timesteps in Averaging Window

The number of load timesteps in the zone design flow sequence averaging window. The default is 1, in which case the calculated zone design flow rates are averaged over the load timestep.

The zone design air flow rate calculation is performed assuming a potentially infinite supply of heating or cooling air at a fixed temperature. Thus the calculated design air flow rate will always be able to meet any load or change in load no matter how large or abrupt. In reality air flow rates are limited by duct sizes and fan capacities. The idealized zone design flow calculation may result in unrealistically large flow rates, especially if the user is performing the sizing calculations using thermostat schedules with night setup or setback. The calculated zone design flow rates are always averaged over the load timestep. The user may want to perform a broader average to mitigate the effect of thermostat setup and setback and prevent the warm up or cool down flow rates from dominating the design flow rate calculation.. Specifying the width of the averaging window allows the user to do this.

For example, if the load calculation timestep is 15 minutes and the user specifies the *Timesteps in Averaging Window* to be 4, the zone design air flows will be averaged over a time period of 1 hour. Specifying 8 would result in averaging over a 2 hour period.

```
Sizing:Parameters,
  \unique-object
  \min-fields 1
  N1; \field Sizing Factor
      \type real
      \minimum> 0.0
      \default 1.0
  N2; \field Timesteps in Averaging Window
      \note blank => set the timesteps in averaging window to Number of Timesteps per Hour resulting in a
1 hour averaging window
      \type integer
      \minimum 1
```

Sizing Parameters Outputs

The sizing factor and the averaging window size are reported out on the *eplusout.eio* file. An example is:

```
! <Load Timesteps in Zone Design Calculation Averaging Window>, Value
Timesteps in Averaging Window, 1
! <Sizing Factor Information>, Sizing Factor ID, Value
Sizing Factor, Global, 1.3000
Sizing Factor, Zone SPACE1-1, 1.3000
Sizing Factor, Zone SPACE2-1, 1.3000
Sizing Factor, Zone SPACE3-1, 1.3000
Sizing Factor, Zone SPACE4-1, 1.3000
Sizing Factor, Zone SPACE5-1, 1.3000
```

OutputControl:Sizing:Style

As described above (see: EnergyPlus Output Processing), the user may select the “style” for the sizing result files (*epluszsz.<ext>*, *eplussz.<ext>*). This object applies to all sizing output files.

```
OutputControl:Sizing:Style,
  \memo default style for the Sizing output files is comma -- this works well for
  \memo importing into spreadsheet programs such as Excel(tm) but not so well for word
  \memo processing programs -- there tab may be a better choice. fixed puts spaces between
  \memo the "columns"
  \unique-object
  A1; \field Column Separator
      \required-field
      \type choice
      \key Comma
      \key Tab
      \key Fixed
```

Field: Column Separator

For this field, the desired separator for columns is entered. “Comma” creates comma separated fields/columns in the outputs (*eplus<sizing type>.csv* files are created). “Tab” creates tab separated fields/columns in the outputs (*eplus<sizing type>.tab* files are created). “Fixed” creates space separated fields/columns in the outputs (*eplus<sizing type>.txt* files are created) but these are not necessarily lined up for easy printing.

Note that both tab and comma separated files easily import into Excel™ or other spreadsheet programs. The tab delimited files can also be viewed by text editors, word processing programs and easily converted to “tables” within those programs.

Sizing:Zone

The Sizing:Zone object provides the data needed to perform a zone design air flow calculation for a single zone. This calculation assumes a variable amount of supply air at a fixed temperature and humidity. The information needed consists of the zone inlet supply air

conditions: temperature and humidity ratio for heating and cooling. The calculation is done for every design day included in the input. The maximum cooling load and air flow and the maximum heating load and air flow are then saved for the system level design calculations and for the component automatic sizing calculations.

The Sizing:Zone object is also the place where the user can input the design outdoor air flow rate. This can be specified in a number of ways as is described below under *outside air flow method*. This data is saved for use in the system sizing calculation of for sizing zone components that use outside air.

The user can also place limits on the heating and design cooling air flow rates. See *Heating Design Air Flow Method* and *cooling design air flow method* below and the explanations of the various heating and cooling flow input fields.

Field: Zone Name

The name of the Zone corresponding to this Sizing:Zone object. This is the zone for which the design air flow calculation will be made using the input data of this Sizing:Zone Object.

Field: Zone Cooling Design Supply Air Temperature

The supply air temperature in degrees Celsius for the zone cooling design air flow rate calculation. Air is supplied to the zone at this temperature during the cooling design day simulation, The zone load is met by varying the zone air flow rate. The maximum zone flow rate is saved as the zone cooling design air flow rate.

Field: Zone Heating Design Supply Air Temperature

The supply air temperature in degrees Celsius for the zone heating design air flow rate calculation. Air is supplied to the zone at this temperature during the heating design day simulation, The zone load is met by varying the zone air flow rate. The maximum zone flow rate is saved as the zone heating design air flow rate.

Field: Zone Cooling Design Supply Air Humidity Ratio

The humidity ratio in kilograms of water per kilogram of dry air of the supply air in the zone cooling design air flow rate calculation.

Field: Zone Heating Design Supply Air Humidity Ratio

The humidity ratio in kilograms of water per kilogram of dry air of the supply air in the zone heating design air flow rate calculation.

Field: Outdoor Air Method

The input must be either *Flow/Zone*, or *Flow/Person*, *Flow/Area*, *Sum*, or *Maximum*. *Flow/Zone* means that the program will use the input of the field *Outdoor Air Flow* as the zone design outdoor air flow rate. *Flow/Person* means the program will use the input from the field *Outdoor Air Flow per Person* and the maximum occupancy to calculate a zone design outdoor air flow rate. *Sum* means that the flows calculated from the fields *Outdoor Air Flow per Person*, *Outdoor Air Flow per Area* and *Outdoor Air Flow per Zone* will be added to obtain the zone design outdoor air flow rate. *Maximum* means that the maximum flow derived from *Outdoor Air Flow per Person*, *Outdoor Air Flow per Area* and *Outdoor Air Flow per Zone* will be used for the zone design outdoor air flow rate. The default is *Flow/Person*.

Field: Outdoor Air Flow per Person

The design outdoor air flow rate per person for this zone in cubic meters per second. The default is 0.00944 (20 cfm per person). An outdoor air flow rate is calculated based on the total number of people for all People statements assigned to the zone. Occupancy schedule values are not applied. This input is used if *Outdoor Air Method* is one of *Outdoor Air Flow per Person*, *Sum*, or *Maximum*.

Field: Outdoor Air Flow per Zone Floor Area

The design outside air volumetric flow rate per square meter of floor area (units are $\text{m}^3/\text{s}\cdot\text{m}^2$). This input is multiplied by the zone area to obtain a flow rate. This input is used if *Outdoor Air Method* is *Flow/Area*, *Sum* or *Maximum*.

Field: Outdoor Air Flow per Zone

The design outdoor air flow rate for this zone in cubic meters per second. This input field is used if *Outdoor Air Method* is *Flow/Zone*, *Sum* or *Maximum*.

Field: Zone Sizing Factor

This input is a zone level sizing ratio. The zone design heating and cooling air flow rates and loads will be multiplied by the number input in this field. This input overrides the building level sizing factor input in the Sizing:Parameters object.

Field: Cooling Design Air Flow Method

The input must be either *Flow/Zone*, *DesignDay*, or *DesignDayWithLimit*. *Flow/Zone* means that the program will use the input of the field *Cooling Design Air Flow Rate* as the zone design cooling air flow rate. *DesignDay* means the program will calculate the zone design cooling air flow rate using the Sizing:Zone input data and a design day simulation without imposing any limits other than those set by the minimum outside air requirements. *DesignDayWithLimit* means that the maximum from *Cooling Minimum Air Flow per Zone Floor Area* and *Cooling Minimum Air Flow* will set a lower limit on the design maximum cooling air flow rate. The default method is *DesignDay*: i.e., the program uses the calculated design values subject to ventilation requirements.

Field: Cooling Design Air Flow Rate

The design zone cooling air flow rate in cubic meters per second. This input is used if *Cooling Design Air Flow Method* is specified as *Flow/Zone*. The applicable zone or building level sizing factor is applied to this value.

Field: Cooling Minimum Air Flow per Zone Floor Area

The minimum zone cooling volumetric flow rate per square meter (units are $\text{m}^3/\text{s}\cdot\text{m}^2$). This field is used when *Cooling Design Air Flow Method* is specified as *DesignDayWithLimit*. In this case it sets a lower bound on the zone design cooling air flow rate. In all cases the maximum flow derived from *Cooling Minimum Air Flow per Zone Floor Area*, *Cooling Minimum Air Flow*, and *Cooling Minimum Air Flow Fraction* is used to set a minimum supply air flow rate for the zone for VAV systems. The default is .000762, corresponding to .15 cfm/ft^2 . The applicable sizing factor is not applied to this value.

Field: Cooling min air flow

The minimum zone cooling volumetric flow rate in m^3/s . This field is used when *Cooling Design Air Flow Method* is specified as *DesignDayWithLimit*. In this case it sets a lower bound on the zone design cooling air flow rate. In all cases the maximum flow derived from *Cooling Minimum Air Flow per Zone Floor Area*, *Cooling Minimum Air Flow*, and *Cooling Minimum Air Flow Fraction* is used to set a minimum supply air flow rate for the zone for VAV systems. The default is zero. The applicable sizing factor is not applied to this value.

Field: Cooling min air flow fraction

The minimum zone design cooling volumetric flow rate expressed as a fraction of the zone design cooling volumetric flow rate. . In all cases the maximum flow derived from *Cooling Minimum Air Flow per Zone Floor Area*, *Cooling Minimum Air Flow*, and *Cooling Minimum Air Flow Fraction* is used to set a minimum supply air flow rate for the zone for VAV systems. The default is zero. This input is currently used in sizing the fan minimum flow rate. It does not currently affect other component autosizing.

Field: Heating Design Air Flow Method

The input must be either *Flow/Zone*, *DesignDay*, or *DesignDayWithLimit*. *Flow/Zone* means that the program will use the input of the field *Heating Design Air Flow Rate* as the zone design heating air flow rate. *DesignDay* means the program will calculate the zone design heating air flow rate using the *Sizing:Zone* input data and a design day simulation without imposing any limits other than those set by the minimum outside air requirements. *DesignDayWithLimit* means that the maximum from *Heating Minimum Air Flow per Zone Floor Area* and *Heating Minimum Air Flow* will set a lower limit on the design maximum cooling air flow rate. The default method is *DesignDay*: i.e., the program uses the calculated design values subject to ventilation requirements.

Field: Heating Design Air Flow Rate

The design zone heating air flow rate in cubic meters per second. This input is used if *Heating Design Air Flow Method* is specified as *Flow/Zone*.

Field: Heating Maximum Air Flow per Zone Floor Area

The maximum zone heating volumetric flow rate per square meter (units are $\text{m}^3/\text{s}\cdot\text{m}^2$). This field is used when *Heating Design Air Flow Method* is specified as *DesignDayWithLimit*. In this case it sets an upper bound on the zone design heating air flow rate. In all cases the maximum flow derived from *Heating Maximum Air Flow per Zone Floor Area*, *Heating Maximum Air Flow*, and *Heating Maximum Air Flow Fraction* is used to set a maximum heating supply air flow rate for the zone for VAV systems. The default is .002032, corresponding to .40 cfm/ft². This input is not currently used for autosizing any of the components.

Field: Heating Maximum Air Flow

The maximum zone heating volumetric flow rate in m^3/s . This field is used when *Heating Design Air Flow Method* is specified as *DesignDayWithLimit*. In this case it sets an upper bound on the zone design heating air flow rate. In all cases the maximum flow derived from *Heating Maximum Air Flow per Zone Floor Area*, *Heating Maximum Air Flow*, and *Heating Maximum Air Flow Fraction* is used to set a maximum heating supply air flow rate for the zone for VAV systems. The default is .1415762, corresponding to 300 cfm. This input is not currently used for autosizing any of the components.

Field: Heating Maximum Air Flow Fraction

The maximum zone design heating volumetric flow rate expressed as a fraction of the zone design cooling volumetric flow rate. In all cases the maximum flow derived from *Heating Maximum Air Flow per Zone Floor Area*, *Heating Maximum Air Flow*, and *Heating Maximum Air Flow Fraction* is used to set a maximum heating supply air flow rate for the zone for VAV systems. The default is 0.3. This input is not currently used for autosizing any of the components.

IDD Description:

```
Sizing:Zone,
  \min-fields 20
  A1, \field Zone Name
      \required-field
      \type object-list
      \object-list ZoneNames
  N1, \field Zone Cooling Design Supply Air Temperature
      \required-field
      \type real
      \units C
  N2, \field Zone Heating Design Supply Air Temperature
      \required-field
      \type real
      \units C
```

```

N3, \field Zone Cooling Design Supply Air Humidity Ratio
\required-field
\type real
\units kg-H2O/kg-air
N4, \field Zone Heating Design Supply Air Humidity Ratio
\required-field
\type real
\units kg-H2O/kg-air
A2, \field Outdoor Air Method
\type choice
\key Flow/Person
\key Flow/Zone
\key Flow/Area
\key Sum
\key Maximum
\default Flow/Person
N5, \field Outdoor Air Flow per Person
\type real
\units m3/s
\default 0.00944
\note .00944 is 20 cfm per person
\note This input is used if the field Outdoor Air Method is
\note Flow/Person, Sum, or Maximum
N6, \field Outdoor Air Flow per Zone Floor Area
\units m3/s-m2
\default 0.0
\note This input is used if the field Outdoor Air Method is
\note Flow/Area, Sum, or Maximum
N7, \field Outdoor Air Flow per Zone
\type real
\units m3/s
\note This input is used if the field Outdoor Air Method is
\note Flow/Zone, Sum, or Maximum
N8, \field Zone Sizing Factor
\note if blank, global sizing factor from Sizing:Parameters is used.
A3, \field Cooling Design Air Flow Method
\type choice
\key Flow/Zone
\key DesignDay
\key DesignDayWithLimit
\default DesignDay
N9, \field Cooling Design Air Flow Rate
\type real
\units m3/s
\minimum 0
\default 0
\note This input is used if Cooling Design Air Flow Method is Flow/Zone
N10, \field Cooling Minimum Air Flow per Zone Floor Area
\type real
\units m3/s-m2
\minimum 0
\default .000762
\note default is .15 cfm/ft2
\note This input is used if Cooling Design Air Flow Method is design day with limit
N11, \field Cooling Minimum Air Flow
\type real
\units m3/s
\minimum 0
\default 0
\note This input is used if Cooling Design Air Flow Method is design day with limit
N12, \field Cooling Minimum Air Flow Fraction
\note fraction of the Cooling design Air Flow Rate
\type real
\minimum 0
\default 0
\note This input is currently used in sizing the Fan minimum Flow Rate.
\note It does not currently affect other component autosizing.

```

```

A4, \field Heating Design Air Flow Method
    \type choice
    \key Flow/Zone
    \key DesignDay
    \key DesignDayWithLimit
    \default DesignDay
N13,\field Heating Design Air Flow Rate
    \type real
    \units m3/s
    \minimum 0
    \default 0
    \note This input is used if Heating Design Air Flow Method is Flow/Zone.
N14,\field Heating Maximum Air Flow per Zone Floor Area
    \type real
    \units m3/s-m2
    \minimum 0
    \default .002032
    \note default is .40 cfm/ft2
    \note This input is not currently used for autosizing any of the components.
N15,\field Heating Maximum Air Flow
    \type real
    \units m3/s
    \minimum 0
    \default .1415762
    \note default is 300 cfm
    \note This input is not currently used for autosizing any of the components.
N16;\field Heating Maximum Air Flow Fraction
    \note fraction of the Cooling Design Air Flow Rate
    \note This input is not currently used for autosizing any of the components.
    \type real
    \minimum 0
    \default 0.3

```

An IDF example:

```

Sizing:Zone,
SPACE5-1,           !- Name of a zone
14.,                !- Zone cooling design supply air temperature {C}
50.,                !- Zone heating design supply air temperature {C}
0.009,              !- Zone cooling design supply air humidity ratio {kg-H2O/kg-air}
0.004,              !- Zone heating design supply air humidity ratio {kg-H2O/kg-air}
sum,                !- outside air method
.00236,             !- outside air flow per person {m3/s}
.000305,            !- outside air flow per zone area {m3/s-m2}
0.0,                !- outside air flow {m3/s}
0.0,                !- zone sizing factor
designdaywithlimit, !- Cooling Design Air Flow Method
,                   !- cooling design air flow rate {m3/s}
,                   !- Cooling Minimum Air Flow per zone area {m3/s-m2}
,                   !- Cooling Minimum Air Flow {m3/s}
,                   !- fraction of the cooling design air flow rate
designday,           !- Heating Design Air Flow Method
,                   !- heating design air flow rate {m3/s}
,                   !- heating max air flow per zone area {m3/s-m2}
,                   !- heating max air flow {m3/s}
;                   !- fraction of the cooling design air flow rate

```

Zone Sizing Outputs

The zone design air flow rates and loads are output onto the local file “epluszsz.<ext>” where <ext> is the extension from the sizing style object (default is csv – a comma separated file *epluszsz.csv*). The columns are clearly labeled. It will easily import into Excel or other spreadsheet program that accepts delimited files. All of these values are design air flow rates and loads *calculated by the program*. No sizing factors have been applied.

The calculated zone design air flow rates and the user input or altered zone design air flow rates are also reported on the *eplusout.eio* file. The values are printed out for each zone as comma separated records beginning with *Zone Sizing*. Items output on the *eio* file are: zone name, load type (heating or cooling), design load, calculated design air flow rate, user design

air flow rate, design day name, time of peak, outside temperature at peak, outside humidity ratio at peak.

Sizing:System

The Sizing:System object contains the input needed to perform a central forced air system design air flow, heating capacity, and cooling capacity calculation for a system serving one or more zones. The information needed consists of the outside environmental conditions and the design supply air temperatures, outdoor air flow rate, and minimum system air flow ratio.

The outside conditions come from the design days in the input. A system sizing calculation is performed for every design day in the input file and the resulting maximum heating and cooling air flow rates and capacities are saved for use in the component sizing calculations.

Supply air conditions are specified by inputting a supply air temperature for cooling, a supply air temperature for heating, and a preheat temperature.

The system sizing calculation sums the zone design air flow rates to obtain a system supply air flow rate. The design conditions and the outdoor air flow rate are used to calculate a design mixed air temperature. The temperature plus the design supply air temperatures allows the calculation of system design heating and cooling capacities.

Field: AirLoop Name

The name of the AirLoopHVAC corresponding to this Sizing:System object. This is the air system for which the design calculation will be made using the input data of this Sizing:System Object.

Field: Type of Load to Size On

The user specified type of load on which to size the central system. The choices are *sensible*, *latent*, or *total*. Only *sensible* is operational.

Field: Design Outdoor Air Flow Rate

The design outdoor air flow rate in cubic meters per second. Generally this should be the minimum outdoor air flow. It is used for both heating and cooling design calculations. The assumption for cooling is that any outdoor air economizer will be closed. If *Autosize* is input the outdoor air flow rate will be taken from the sum of the zone outdoor air flow rates.

Field: Minimum System Air Flow Ratio

The design minimum central air flow ratio. This ratio is the minimum system air flow rate divided by the maximum system air flow rate. The value must be between 0 and 1. For constant volume systems the ratio should be set to 1. Note that this ratio should be set to reflect what the user expects the system flow rate to be when maximum heating demand occurs. This ratio is used in calculating the central system heating capacity. Thus if the system is VAV with the zone VAV dampers held at minimum flow when there is a zone heating demand, this ratio should be set to the minimum flow ratio. If the zone VAV dampers are reverse action and can open to full flow to meet heating demand, this ratio should be set to 1.

Field: Preheat Design Temperature

The design air temperature exiting the preheat coil (if any) in degrees Celsius.

Field: Preheat Design Humidity Ratio

The design humidity ratio exiting the preheat coil (if any) in kilograms of water per kilogram of dry air.

Field: Precool Design Temperature

The design air temperature exiting the precooling coil (if any) in degrees Celsius.

Field: Precool Design Humidity Ratio

The design humidity ratio exiting the precooling coil (if any) in kilograms of water per kilogram of dry air.

Field: Central Cooling Design Supply Air Temperature

The design supply air temperature for cooling in degrees Celsius. This should be the temperature of the air exiting the central cooling coil.

Field: Central Heating Design Supply Air Temperature

The design supply air temperature for heating in degrees Celsius. This can be either the reset temperature for a single duct system or the actual hot duct supply air temperature for dual duct systems. It should be the temperature at the exit of the main heating coil.

Field: Sizing Option

If the input is *coincident* the central system air flow rate will be sized on the sum of the coincident zone air flow rates. If the input is *noncoincident* the central system air flow rate will be sized on the sum of the noncoincident zone air flow rates. The default is noncoincident.

Field: 100% Outdoor Air in Cooling

Entering Yes means the system will be sized for cooling using 100% outdoor air. Entering No means the system will be sized for cooling using minimum outside air (the default).

Field: 100% Outdoor Air in Heating

Entering Yes means the system will be sized for heating using 100% outdoor air. Entering No means the system will be sized for heating using minimum outside air (the default).

Field: Central Cooling Design Supply Air Humidity Ratio

The design humidity ratio in kilograms of water per kilogram of dry air at the exit of the central cooling coil. The default is .008.

Field: Central Heating Design Supply Air Humidity Ratio

The design humidity ratio in kilograms of water per kilogram of dry air at the exit of the central heating coil. The default is .008.

Field: Cooling Design Air Flow Method

The input must be either *DesignDay* or *Flow/System*. *DesignDay* means the program will calculate the system design cooling air flow rate using the System Sizing input data and a design day simulation. *Flow/System* means that the program will use the input of the field *Cooling Design Air Flow Rate* as the system design cooling air flow rate. The default method is *DesignDay*: i.e., the program uses the calculated design values.

Field: Cooling Design Air Flow Rate

The design system cooling air flow rate in cubic meters per second. This input is an alternative to using the program calculated value.

Field: Heating Design Air Flow Method

The input must be either *DesignDay* or *Flow/System*. *DesignDay* means the program will calculate the system design heating air flow rate using the System Sizing input data and a design day simulation. *Flow/System* means that the program will use the input of the field *Heating Design Air Flow Rate* as the system design heating air flow rate. . The default method is *DesignDay*: i.e., the program uses the calculated design values.

Field: Heating Design Air Flow Rate

The design system heating air flow rate in cubic meters per second. This input is an alternative to using the program calculated value.

The full IDD specification follows:

```
Sizing:System,
  \min-fields 19
  A1, \field AirLoop Name
      \required-field
      \type object-list
      \object-list AirPrimaryLoops
  A2, \field Type of Load to Size On
      \note Sensible is the only available option
      \required-field
      \type choice
      \key Sensible
      !\key Latent
      !\key Total
      \default Sensible
  N1, \field Design Outdoor Air Flow Rate
      \type real
      \units m3/s
      \autosizable
  N2, \field Minimum System Air Flow Ratio
      \required-field
      \type real
      \minimum 0.0
      \maximum 1.0
  N3, \field Preheat Design Temperature
      \required-field
      \type real
      \units C
  N4, \field Preheat Design Humidity Ratio
      \required-field
      \type real
      \units kg-H2O/kg-Air
  N5, \field Precool Design Temperature
      \required-field
      \type real
      \units C
  N6, \field Precool Design Humidity Ratio
      \required-field
      \type real
      \units kg-H2O/kg-Air
  N7, \field Central Cooling Design Supply Air Temperature
      \required-field
      \type real
      \units C
  N8, \field Central Heating Design Supply Air Temperature
      \required-field
      \type real
      \units C
  A3, \field Sizing Option
      \type choice
      \key Coincident
      \key NonCoincident
      \default NonCoincident
```

```

A4, \field 100% Outdoor Air in Cooling
    \type choice
    \key Yes
    \key No
    \default No
A5, \field 100% Outdoor Air in Heating
    \type choice
    \key Yes
    \key No
    \default No
N9, \field Central Cooling Design Supply Air Humidity Ratio
    \required-field
    \type real
    \default 0.008
    \units kg-H2O/kg-Air
N10, \field Central Heating Design Supply Air Humidity Ratio
    \required-field
    \type real
    \default 0.008
    \units kg-H2O/kg-Air
A6, \field Cooling Design Air Flow Method
    \type choice
    \key Flow/System
    \key DesignDay
    \default DesignDay
N11, \field Cooling Design Air Flow Rate
    \type real
    \units m3/s
    \minimum 0
    \default 0
A7, \field Heating Design Air Flow Method
    \type choice
    \key Flow/System
    \key DesignDay
    \default DesignDay
N12, \field Heating Design Air Flow Rate
    \type real
    \units m3/s
    \minimum 0
    \default 0

```

An IDF example:

```

Sizing:System,
  VAV Sys 1,          !- name of an AirLoopHVAC object
  sensible,          !- type of load to size on
  autosize,          !- Design (minimum) outside air volumetric flow rate {m3/s}
  0.3,               !- minimum system air flow ratio
  4.5,               !- Preheat design temperature {C}
  .008,              !- Preheat design humidity ratio {kg-H2O/kg-air}
  11.0,              !- Precool design temperature {C}
  .008,              !- Precool design humidity ratio {kg-H2O/kg-air}
  12.8,              !- Central cooling design supply air temperature {C}
  16.7,              !- Central heating design supply air temperature {C}
  noncoincident,    !- Sizing Option
  no,                !- Cooling 100% Outside Air
  no,                !- Heating 100% Outside Air
  0.008,             !- Central cooling design supply air humidity ratio {kg-H2O/kg-air}
  0.008,             !- Central heating design supply air humidity ratio {kg-H2O/kg-air}
  designday,        !- Cooling Design Air Flow Method
  0,                 !- cooling design air flow rate {m3/s}
  designday,        !- Heating Design Air Flow Method
  0;                 !- heating design air flow rate {m3/s}

```

System Sizing Outputs

The system design air flow rates and heating and cooling capacities are output onto the local file “eplussz.<ext>” where <ext> is the extension from the sizing style object (default is csv – a comma separated file *eplussz.csv*). The columns are clearly labeled. It will easily import

into Excel or other spreadsheet program that accepts delimited files. The results are calculated values and do not include any user input system flow rates.

The calculated system design air flow rates and the user input system design air flow rates are also reported on the *eplusout.eio* file. The values are printed out for each system as comma separated records beginning with *System Sizing*. An example is:

```
! <System Sizing Information>, System Name, Field Description, Value
System Sizing, VAV SYS 1, Calculated Cooling Design Air Flow Rate [m3/s], 1.3194
System Sizing, VAV SYS 1, User Cooling Design Air Flow Rate [m3/s], 1.5000
System Sizing, VAV SYS 1, Calculated Heating Design Air Flow Rate [m3/s], 0.90363
System Sizing, VAV SYS 1, User Heating Design Air Flow Rate [m3/s], 1.0000
```

Plant Sizing

The Plant Sizing object contains the input needed for the program to calculate the heating, cooling, and condenser loop flow rates. This information is initially used by components that use water for heating or cooling such as hot or chilled water coils to calculate their maximum water flow rates. These flow rates are then summed for use in calculating the Plant Loop flow rates.

The program will size any number of chilled water, hot water, and condenser loops. There should be one Plant Sizing object for each plant loop that is to be autosized.

Field: Plant or Condenser Loop Name

The name of a Plant Loop or Condenser Loop object corresponding to this Plant Sizing object. This is the plant loop for which this data will be used for calculating the loop flow rate.

Field: Loop Type

The possible inputs are *Heating*, *Steam*, *Cooling*, or *Condenser*.

Field: Design Loop Exit Temperature

The water temperature in degrees Celsius at the exit of the supply side of the plant loop. Thus this is the temperature of the water supplied to the inlet of chilled or hot water coils.

Field: Loop Design Temperature Difference

The design temperature rise (for cooling or condenser loops) or fall (for heating loops) in degrees Celsius across the demand side of a plant loop.

The full IDD specification is:

```
Sizing:Plant,
  \min-fields 4
  A1, \field Plant or Condenser Loop Name
      \note Enter the name of a PlantLoop or a CondenserLoop object
      \required-field
      \type object-list
      \object-list PlantLoops
  A2, \field Loop Type
      \required-field
      \type choice
      \key Heating
      \key Cooling
      \key Condenser
      \key Steam
  N1, \field Design Loop Exit Temperature
      \required-field
      \type real
      \units C
  N2; \field Loop Design Temperature Difference
      \required-field
      \type real
      \units deltaC
      \minimum> 0.0
```

An IDF example:

```
Sizing:Plant,  
  Chilled Water Loop, ! name of loop  
  Cooling,            ! type of loop  
  7.22,              ! chilled water supply temperature  
  6.67;              ! chilled water delta T
```

Plant Sizing Outputs

The loop flow rates are reported on the *eplusout.eio* file along with the component sizing results.

HVAC: Primary and Secondary Systems

The HVAC and equipment section of the EnergyPlus input data dictionary and input data file are slightly more complex than the description of building geometry, internal gains, etc. because of the interconnections of the various parts of an HVAC system. In EnergyPlus, there are several portions to the HVAC simulation. All of these parts must be correctly specified in order to arrive at a valid simulation model. The goal of this section is to provide the interface developer with guidelines on what input is expected and also provide some background on basic EnergyPlus simulation methodology.

An EnergyPlus HVAC simulation consists of various components that are connected physically in the actual system by ducts, piping, etc. Every component in an HVAC system must have an inlet and outlet "node". In the actual system, a node might be a point in the system at which fluid properties can be measured. In an EnergyPlus simulation, the nodes are points at which fluid properties are evaluated and passed on to subsequent equipment.

Components are linked together to form various loops within the simulation. Thus, the output node from one component also serves as the inlet node to the next component. Loops are constructed by defining these loops and also defining the components on the loops. The figure below shows a generic example of the loop-node concept.

Loop nodes are a key defining feature in EnergyPlus. As a result, it is recommended that one of the first steps taken in defining an HVAC system in EnergyPlus be the definition of a node diagram or map. This is helpful for visualization of the entire system. Such a map could be created electronically within an interface or could be kept in the background out of the sight of the user.

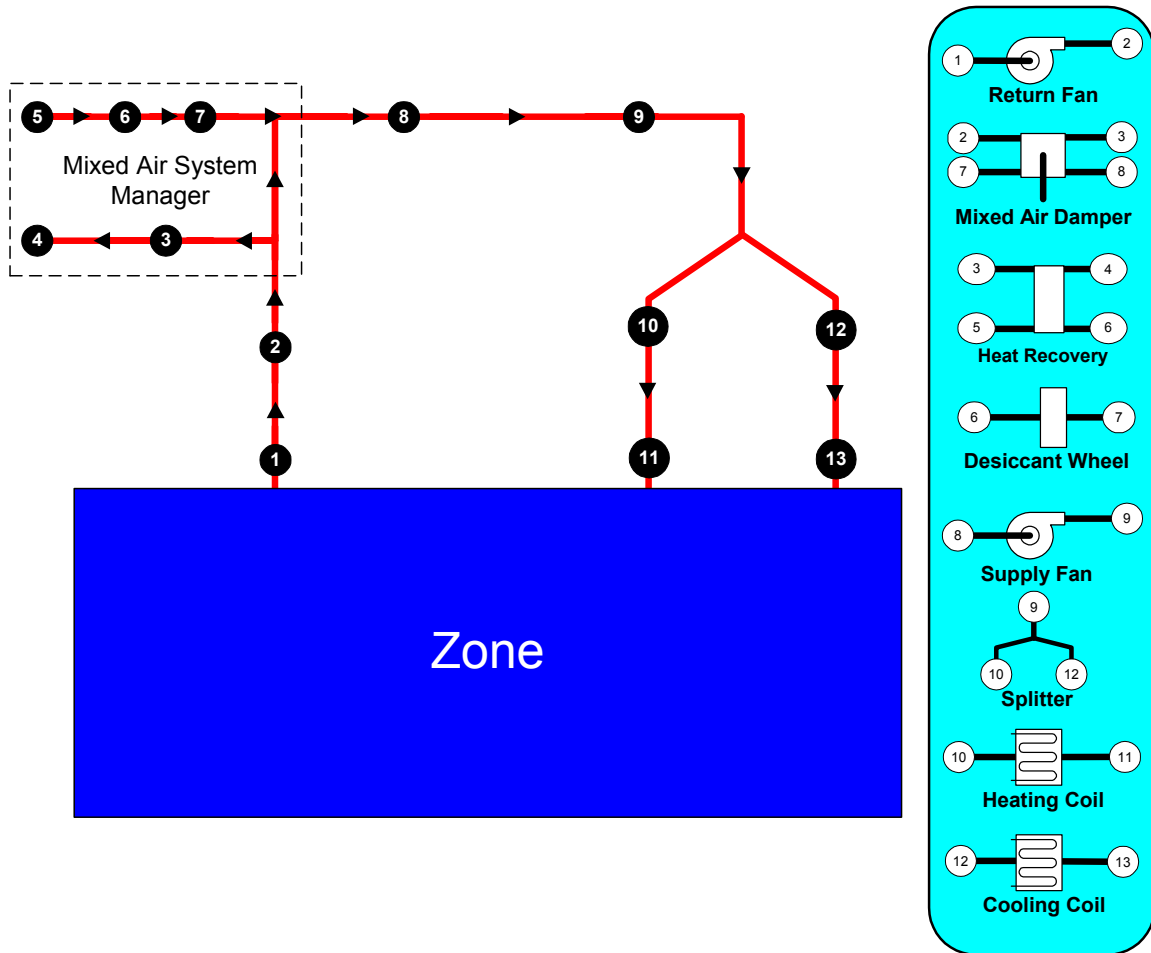


Figure 62. Example Node Diagram

So that these loops are manageable and more clearly defined both in the input and in the simulation, six different loop sections can be defined in an EnergyPlus input file. In general, these six types are in essence three pairs of loop sections that make up three distinct loops: a zone/air loop, a plant loop, and a condenser loop. The six loop section types are defined below.

Air Loop: The air loop is defined by the section of the zone/air loop that starts after the zone return streams are combined and continues on until just before any air stream(s) are branched off to individual zones. The starting point of the air loop is fairly straightforward. The ending point is slightly more complex but can be understood with some examples. For instance, in a terminal reheat system, the end of the air loop would typically be considered the node following the cooling coil. In a dual duct system, the air loop would have two ending points that would correspond to the nodes after the cooling coil and after the heating coil/humidifier. In most cases, the air loop has a single starting point and up to three ending points (for a 3 deck system).

Zone Equipment: The zone equipment section of the input file is defined as more or less the rest of the zone/air loop (outside air is handled separately as a subset of the air loop). This includes everything from where the ducts are split to serve various zones up through where the return ducts from various zones are mixed into a single return duct. Zone equipment can include dampers and reheat coils as well as zone specific conditioning systems such as thermostatic baseboard or a window air conditioner. Most control issues are typically dealt with in the zone equipment section of the simulation.

Plant Loop Demand Side: One side of the plant is where energy is “demanded” by various components that make up the air loop or zone equipment. Typically, this is the water side of equipment such as coils, baseboard, radiant heating and cooling, etc. The demand side of this loop can also include mixers, flow splitters, and a bypass.

Plant Loop Supply Side: The other side of the plant loop is where energy is “supplied” by various components. The components typically found on the supply side include pumps, boilers, chillers, purchased heating and cooling, ice storage, etc. As with the demand side, this loop can also include mixers, flow splitters, and a bypass.

Condenser Loop Demand Side: The condenser loop demand side is analogous to the plant loop demand side. In fact, much of the code and structures are similar. In the case of the condenser loop, energy is typically “demanded” by a chiller condenser. Note that coils, radiant systems, etc. could also be a part of the demand side in the case of free cooling chillers, well water condensers, ground loops, etc.

Condenser Loop Supply Side: This side of the condenser loop consists of the cooling tower, well water, etc. type components. It supplies (rejects) energy that would then be used at the chiller condensers on the other side of the loop.

The section of the input file for describing the HVAC system tends to follow this structure presented above. Both plant and condenser loops are defined with a master description and then branch off into supply and demand side details. Linkage between the two sides is done using node numbers in the master statement. The air loop and zone equipment descriptions are slightly more complex due to the wide range of potential systems that are anticipated. Note that in every section controls become a key element and must be addressed. Each of the following sections details either a loop, a portion of a loop, or controls.

Group – Node-Branch Management

Nodes, Branch Lists and **Branches** define the topography of the HVAC connections.

NodeList

For convenience, the NodeList object can be used to identify all the nodes before use. It is not required for this purpose. The advantage of listing all the nodes in this manner would allow any “node” output variables to be grouped according to user wishes.

There are other lines of input syntax that require the use of a NodeList as part of the input. These syntax items include: OutdoorAir:NodeList and the SetpointManager objects. In these two cases, the use of a NodeList statement is mandatory if there is more than one node in this particular “list”. For example, if the outside air only has a single inlet node, then the name of that node can replace the node list name in the input syntax. As a result of this mandatory specification of node lists for certain types of input, nodes can, obviously, and may be members of more than one list.

Field: Name

This alpha designation must be unique among all the Node List Names. It is used as reference in various objects (e.g. OutdoorAir:NodeList).

Field: Node <#> Name (up to 25 allowed)

Each unique Node identifier creates a Node structure with various attributes depending on the type of node. Typical values include Temperature, Mass Flow Rate, and Temperature Set Point. The alpha designators are associated with a particular node.

```

NodeList,
  \min-fields 2
  \memo This object is used in places where lists of nodes may be
  \memo needed, e.g. ZoneHVAC:EquipmentConnections field Zone Air Inlet Node or NodeList Name
A1 , \field Name
  \required-field
  \type alpha
  \reference NodeLists
A2 , \field Node 1 Name
  \required-field
  \type alpha
A3 , \field Node 2 Name
  \type alpha
A4 , \field Node 3 Name
  \type alpha
-- etc to 25 Node names per NodeList

```

Though each NodeList is limited to 25 nodes, several node lists may be entered if you choose to identify all the nodes up front. For example:

```

NodeList, Nodes1-25,
NODE_1,NODE_2,NODE_3,NODE_4,NODE_5,NODE_6,NODE_7,NODE_8,NODE_9,NODE_10,
NODE_11,NODE_12,NODE_13,NODE_14,NODE_15,NODE_16,NODE_17,NODE_18,NODE_19,NODE_20,
NODE_21,NODE_22,NODE_23,NODE_24,NODE_25;
NodeList, Nodes26-49,NODE_26,NODE_27,NODE_28,NODE_29,NODE_30,
NODE_31,NODE_32,NODE_33,NODE_34,NODE_35,NODE_36,NODE_37,NODE_38,NODE_39,NODE_40,
NODE_41,NODE_42,NODE_43,NODE_44,NODE_45,NODE_46,NODE_47,NODE_48,NODE_49;

```

Node List Outputs

A simple detail of Nodes and numbers assigned appears in the `eplusout.bnd` file:

```

! <Node>,<NodeNumber>,<Node Name>,<Node Fluid Type>,<# Times Node Referenced After Definition>
Node,1,OUTSIDE AIR INLET NODE 1,Air,2
Node,2,VAV SYS 1 INLET NODE,Air,3
Node,3,MIXED AIR NODE 1,Air,5
Node,4,MAIN COOLING COIL 1 OUTLET NODE,Air,3
Node,5,MAIN HEATING COIL 1 OUTLET NODE,Air,4
Node,6,VAV SYS 1 OUTLET NODE,Air,7...

```

In addition, properties of each node is available during the simulation:

```

HVAC,Average,System Node Temp[C]
HVAC,Average,System Node MassFlowRate[kg/s]
HVAC,Average,System Node Humidity Ratio[]
HVAC,Average,System Node Setpoint Temp[C]
HVAC,Average,System Node Setpoint Temp Hi[C]
HVAC,Average,System Node Setpoint Temp Lo[C]
HVAC,Average,System Node Setpoint Humidity Ratio[]
HVAC,Average,System Node Setpoint Humidity Ratio Min[]
HVAC,Average,System Node Setpoint Humidity Ratio Max[]
HVAC,Average,System Node Relative Humidity[%]
HVAC,Average,System Node Pressure[Pa]
HVAC,Average,System Node VolFlowRate[m3/s]
HVAC,Average,System Node Enthalpy[J/kg]
HVAC,Average,System Node Wetbulb Temp[C]
HVAC,Average,System Node Quality[]
HVAC,Average,System Node Height[m]

```

The following node variables are "advanced" and normally used for debugging unusual cases:

```

HVAC,Average,System Node TempMin[C]
HVAC,Average,System Node TempMax[C]
HVAC,Average,System Node MassFlowRateMin[kg/s]
HVAC,Average,System Node MassFlowRateMax[kg/s]
HVAC,Average,System Node MassFlowRateMinAvail[kg/s]

```

HVAC, Average, System Node MassFlowRateMaxAvail[kg/s]
 HVAC, Average, System Node MassFlowRateSetPoint[kg/s]

System Node Temp[C]

The current temperature at a system node in degrees C. For air nodes, this is the dry-bulb temperature.

System Node MassFlowRate[kg/s]

The current mass flow rate at a system node in kg/s.

System Node Humidity Ratio

The current humidity ratio at a system node in kg-water/kg-dry-air. Not applicable for liquid nodes.

System Node Setpoint Temp[C]

The current setpoint temperature at a system node in degrees C. Some controllers and equipment types sense this single setpoint.

System Node Setpoint Temp Hi[C]

The current upper setpoint temperature at a system node in degrees C. Some controllers and equipment types use dual setpoints at a single node.

System Node Setpoint Temp Lo[C]

The current lower setpoint temperature at a system node in degrees C. Some controllers and equipment types use dual setpoints at a single node.

System Node Setpoint Humidity Ratio

The current humidity ratio setpoint at a system node in kg-water/kg-dry-air. Some controllers and equipment types sense this single setpoint. Not applicable for liquid nodes.

System Node Setpoint Humidity Ratio Min[]

The current minimum desired humidity ratio at a system node in kg-water/kg-dry-air. Some controllers and equipment types use the min/max values as dual setpoints at a single node. Not applicable for liquid nodes.

System Node Setpoint Humidity Ratio Max[]

The current maximum desired humidity ratio at a system node in kg-water/kg-dry-air. Some controllers and equipment types use the min/max values as dual setpoints at a single node. Not applicable for liquid nodes.

System Node Relative Humidity [%]

The current relative humidity (calculated from the node temperature, node humidity ratio and standard barometric pressure for the location). Not applicable for liquid nodes.

System Node Pressure[Pa]

The current pressure at a system node in Pa.

System Node VolFlowRate[m3/s]

The current volume flow rate at a system node in m3/s.

System Node Enthalpy[J/kg]

The current enthalpy at a system node in J/kg.

System Node Wetbulb Temp[C]

The current wet-bulb temperature at a system node in degrees C. Not applicable for liquid nodes.

System Node Quality[]

The current system node vapor fraction/percent {0.0-1.0}.

System Node Height[]

The current system node height {m}. Only applicable to outdoor air nodes.

Advanced Node Reporting

The following system node variables are available when you request “Diagnostics, DisplayAdvancedReportVariable;”. They are normally used for debugging unusual system cases and may not be available for all systems. Also, their definitions may change based on the usage in the system.

System Node TempMin[C]**System Node TempMax[C]**

These node variables represent the min/max of loops or branches.

System Node MassFlowRateMin[kg/s]**System Node MassFlowRateMax[kg/s]**

These node variables hold the maximum possible and the minimum allowable flow rates for a particular component. As such, they represent the “hardware limit” on the flow rate for the component. By convention, these variables are stored at the component outlet node. Since components share their nodes (the outlet node of one component is the inlet node of the next component), the protocol must be strictly followed. These variables are set by each component at the beginning of the simulation and are never reset thereafter.

System Node MassFlowRateMinAvail[kg/s]**System Node MassFlowRateMaxAvail[kg/s]**

These node variables represent the *loop* maximum and minimum flow rate for the current configuration of the loop on which the component resides. All components should change the max/min available values so that they lie within the max/min flow rate range for the component. The component simulation reads the current loop min/max available flow rate from its inlet node (“Init” routine) and writes the updated min/max available flow rate to its outlet node (“Update” routine).

System Node MassFlowRateSetPoint[kg/s]**BranchList**

A branch list is intended to define the branches or portions of a particular loop that are present on an individual loop such as a plant or condenser loop. Thus, the BranchList syntax simply provides a list of branch names (see Branch syntax) that then refer to more detailed syntax in another part of the input file. The syntax for describing a list of branches is given below.

Branches in BranchList objects MUST be listed in flow order: inlet branch, then parallel branches, then outlet branch. Branches are simulated in the order listed.

```

BranchList,
\extensible:1 Just duplicate last field and \ comments (changing numbering, please)
\memo Branches MUST be listed in Flow order: Inlet branch, then parallel branches, then Outlet branch.
\memo Branches are simulated in the order listed. Branch names cannot be duplicated within a single
branch list.
  A1, \field Name
      \required-field
      \reference BranchLists
  A2, \field Branch 1 Name
      \required-field
      \type object-list
      \object-list Branches
  A3, \field Branch 2 Name
      \type object-list
      \object-list Branches
  A4, \field Branch 3 Name
      \type object-list
      \object-list Branches
<reduced for brevity>
  A100, \field Branch 49 Name
        \type object-list
        \object-list Branches
  A101; \field Branch 50 Name
        \type object-list
        \object-list Branches

```

Field: Name

A unique name to identify the branch list.

Field: Branch <#> Name

Branch name in the list. As noted above, Branches in BranchList objects MUST be listed in flow order: inlet branch, then parallel branches, then outlet branch. Branches are simulated in the order listed.

An example of this statement in an IDF is:

```

BranchList, Cooling Supply Side Branches,
  CW Pump Branch,
  Little Chiller Branch,
  Big Chiller Branch,
  Purchased Cooling Branch,
  Supply Bypass Branch,
  Cooling Supply Outlet;

```

Branch List Output

No output directly related to Branch Lists current is presented.

Branch

Branches can be considered the mid-level grouping of items in the EnergyPlus HVAC loop scheme. Components are the lowest level of information. A collection of components in series forms a branch. Every branch must have at least one component, but it may have several components in series. The **branch** defines the order that components appear on the branch. Moreover, a collection of branches and their connecting information form a loop. Therefore, a branch is a collection of components while a loop is a collection of branches. Thus, components are specified for particular HVAC loops by assigning them to branches and then connecting those branches together to form a loop. It should be noted that each component also has at least two nodes associated with it—an inlet node and an outlet node. These nodes, by default, are also part of the branch to which their components are assigned. It should be noted that each branch must have at least one component on it. A “null” branch

such as one where the first component on the loop is in reality a splitter or mixer should be defined as a single PIPE component.

Field: Name

This alpha field is the identifying name that allows the branch to be referenced by other elements such as the PlantLoop and CondenserLoop statements.

Field: Maximum Flow Rate

This field is the maximum flow rate (m³/sec) allowed on a particular branch. This number will set an absolute maximum flow rate for all components on the loop. Even if components are defined with a higher flow rate, EnergyPlus will limit the flow on this particular branch to the value entered here by the user. Currently this is used in the Air Loop and is not a required field in the Plant and Condenser Loop. The example files for the Plant and Condenser Loops leave this field blank to simplify flow input.

Field Set (Branch Specifications) – up to 11 allowed

Following the two introductory items, there are up to eleven groups of 5 repeated items: a type, a name, inlet and outlet node names, and a branch control type. All of these items refer to a particular component on the branch. The first component defined by these items will be the first component on this branch, etc. through the end of the list.

Field: Component <#> Object Type

This field is the component object type (object name). The component type refers to other elements within the input file and specifies what kind of component this is. The objects in the “Group – Plant Equipment” section are valid here when the Branch is used in Plant specifications. Fans, coils and Outside Air Systems are also valid component types for the Branch object. Pipes are also valid for this field.

Field: Component <#> Name

The component name is a reference name to distinguish between potentially multiple occurrences of a particular component type in an input file. The set of component type and component name must be unique. (You can only have 1 Boiler object with name MYBOILER).

Field: Component <#> Inlet Node Name

This field references an inlet node name that will be found in the actual component specification.

Field: Component <#> Outlet Node Name

This field references an outlet node name that will be found in the actual component specification.

Field: Component <#> Branch Control Type

The final item in each field-set is the component flow control and how this component relates to the overall flow of the branch. If the field value is **Active**, then this component will try to control the flow through this branch within the limits of the other components on the branch. An ON/OFF status of the Active component in the branch would determine if the branch is completely ON or OFF. A slightly different control type is **SeriesActive**. When one component on a branch is SeriesActive, all other components on that branch also have to be SeriesActive. This type of component tries to set the flow when it is ON, just like an Active component does. However, when this component is OFF, it will just pass the inlet mass flow rate instead of turning the branch OFF. A **Passive** component will simply take whatever amount of flow has been passed to it. The **Bypass** designation should only be used for a branch that has a single component (usually a Pipe). A bypass is used to handle excess flow

when a pump or fan cannot throttle down to send only the amount of flow requested by other components on the loop.

```
Branch,
  \extensible:5 Just duplicate last 5 fields and \ comments (changing numbering, please)
  \memo List components on the branch in simulation and connection order
  \memo Note: this should NOT include splitters or mixers which define
  \memo endpoints of branches
A1, \field Name
  \required-field
  \reference Branches
N1, \field Maximum Flow Rate
  \default 0
  \units m3/s
  \minimum 0
  \autosizable
A2, \field Component 1 Object Type
  \required-field
A3, \field Component 1 Name
  \required-field
A4, \field Component 1 Inlet Node Name
  \required-field
A5, \field Component 1 Outlet Node Name
  \required-field
A6, \field Component 1 Branch Control Type
  \required-field
  \type choice
  \key Active
  \key Passive
  \key SeriesActive
  \key Bypass
  \note for ACTIVE, Component tries to set branch flow and turns off branch if the component is off
  \note for PASSIVE, Component does not try to set branch flow
  \note for SERIESACTIVE, component is active but does not turn off branch when the component is off
  \note for BYPASS, Component designates a loop bypass
A7, \field Component 2 Object Type
A8, \field Component 2 Name
A9, \field Component 2 Inlet Node Name
A10, \field Component 2 Outlet Node Name
A11, \field Component 2 Branch Control Type
  \type choice
  \key Active
  \key Passive
  \key SeriesActive
  \key Bypass
  \note for ACTIVE, Component tries to set branch flow and turns off branch if the component is off
  \note for PASSIVE, Component does not try to set branch flow
  \note for SERIESACTIVE, component is active but does not turn off branch when the component is off
  \note for BYPASS, Component designates a loop bypass
-- reduced for brevity, up to 11 components allowed per branch
```

An example of this statement in an IDF is:

```
Branch,
  Air Loop Main Branch,      !- Branch Name
  1.75,                      !- Maximum Branch Flow Rate {m3/s}
  UNITARYSYSTEM:VAV:CHANGEVERBYPASS, !- Comp1 Type
  GasHeat CBVAV System,     !- Comp1 Name
  Air Loop Inlet Node,      !- Comp1 Inlet Node Name
  Air Loop Outlet Node,     !- Comp1 Outlet Node Name
  Active;                   !- Comp1 Branch Control Type
```

And a more complex one:

```

BRANCH,
  Air Loop Main Branch,      !- Branch Name
  1.3,                      !- Maximum Branch Flow Rate {m3/s}
  FAN:SIMPLE:ConstVolume,   !- Comp1 Type
  Supply Fan 1,             !- Comp1 Name
  Air Loop Inlet Node,      !- Comp1 Inlet Node Name
  Cooling Coil Air Inlet Node, !- Comp1 Outlet Node Name
  Active,                   !- Comp1 Branch Control Type
  COIL:Water:DetailedFlatCooling, !- Comp2 Type
  Detailed Cooling Coil,    !- Comp2 Name
  Cooling Coil Air Inlet Node, !- Comp2 Inlet Node Name
  Air Loop Outlet Node,     !- Comp2 Outlet Node Name
  Passive;                  !- Comp2 Branch Control Type

```

Branch Output

The components on a branch are in series and that list is in simulation and connection order. Each branch must obey the rules: the outlet for component 1 has to have the same node name as the inlet for component 2, and so forth.

Eplusout.err contains the test for “individual branch integrity”:

```

***** Testing Individual Branch Integrity
***** Testing Branch=AIR LOOP MAIN BRANCH
***** ...passed
***** Testing Branch=COOLING DEMAND INLET
***** ...passed
***** Testing Branch=COOLING COIL BRANCH
***** ...passed
***** Testing Branch=DEMAND BYPASS BRANCH
***** ...passed
***** Testing Branch=COOLING DEMAND OUTLET
***** ...passed
***** Testing Branch=COOLING SUPPLY OUTLET
***** ...passed

```

ConnectorList

A connector list is a collection of either one or two connection devices (Connector:Mixer or Connector:Splitter). Due to the definition of a loop in EnergyPlus, there is a maximum of one mixer and one splitter allowed for each loop segment. This limitation still allows a tremendous amount of flexibility to the user and can also still be solved within a reasonable amount of time and without a complex solver routine. The connection list simply allows the specification of the types and names of these devices. This allows the main loop statements to have the flexibility to have multiple lists that can have one or more item.

Field: Name

This field is an identifying name that will be referenced to main loop statements using this connector list. The name must be unique among connector list names.

Field-Set: Connection Object Type and Identifying Name (up to 2 allowed)

Depending on the loop, either one or two of the connectors will be specified. If this particular loop only has a single connector (either Connector:Mixer or Connector:Splitter), then only the first two items (type of connection and identifying name of connector) are included. If both a mixer and splitter are present, the additional type of connection and identifying name must be included. Note that the order that the items appear is inconsequential—either the Connector:Mixer or the Connector:Splitter may appear first. This will not affect the simulation.

Field: Connector 1 Object Type

This field contains the connector type **Connector:Mixer** or **Connector:Splitter**.

Field: Connector 1 Name

This field is an identifying name for the connector. It will be used by other objects in the input file.

Field: Connector 2 Object Type (optional)

This field contains the connector type **Connector:Mixer** or **Connector:Splitter**.

Field: Connector 2 Name (optional)

This field is an identifying name for the connector. It will be used by other objects in the input file.

```
ConnectorList,
  \memo only two connectors allowed per loop
  \memo if two entered, one must be Connector:Splitter and one must be Connector:Mixer
A1, \field Name
  \required-field
  \reference ConnectorLists
A2, \field Connector 1 Object Type
  \required-field
  \key Connector:Splitter
  \key Connector:Mixer
A3, \field Connector 1 Name
  \required-field
A4, \field Connector 2 Object Type
  \key Connector:Splitter
  \key Connector:Mixer
A5; \field Connector 2 Name
```

An example of this statement in an IDF is:

```
ConnectorList LIST, Cooling Supply Side Connectors,
  Connector:Splitter, CW Loop Splitter,
  Connector:Mixer, CW Loop Mixer;
```

Connector List Outputs

No output directly related to Connector Lists is currently presented.

Pipe:Adiabatic

In reality, every component is connected to its closest neighbors via a pipe or a duct. At the current time, such detail is not needed in EnergyPlus. Thus, the Pipe:Adiabatic component is currently used more as a connection device (for branches that really do not have any components associated with them) or as a bypass than anything else. As such, its input is very simple and its algorithm is equally simple. The current algorithm for a pipe is simply to pass the inlet conditions to the outlet of the pipe component. In the future, when pressure simulations and friction tabulation capabilities are added to EnergyPlus, a pipe may be a required element between components.

Field: Name

This alpha field is used as an identifying field for the pipe.

Field: Inlet Node Name

This alpha field is used as an identifying field for the pipe inlet node.

Field: Outlet Node Name

This alpha field is used as an identifying field for the pipe outlet node.

```
Pipe:Adiabatic,
  \memo Passes Inlet Node state variables to Outlet Node state variables
  A1, \field Name
      \required-field
  A2, \field Inlet Node Name
      \required-field
  A3; \field Outlet Node Name
      \required-field
```

An example of this statement in an IDF is:

```
Pipe:Adiabatic,
  Demand Side Inlet Pipe,
  CW Demand Inlet Node,
  CW Demand Entrance Pipe Outlet Node;
```

Pipe Outputs

There are no outputs directly related to Pipes.

Pipe:Adiabatic:Steam

To connect the various components in a steam system regardless of it being the condensate or the steam side of the loop steam pipe needs to be used. In reality, every component is connected to its closest neighbors via a pipe or a duct. At the current time, such detail is not needed in EnergyPlus. Thus, the Pipe:Adiabatic:Steam component is currently used more as a connection device (for branches that really do not have any components associated with them). As such, its input is very simple and its algorithm is equally simple. The current algorithm for a pipe is simply to pass the inlet conditions to the outlet of the pipe component.

Field: Name

This alpha field is used as an identifying field for the steam pipe.

Field: Inlet Node Name

This alpha field is used as an identifying field for the steam pipe inlet node.

Field: Outlet Node Name

This alpha field is used as an identifying field for the steampipe outlet node.

```
Pipe:Adiabatic:Steam,
  \memo Passes Inlet Node state variables to Outlet Node state variables
  A1, \field Name
      \required-field
  A2, \field Inlet Node Name
      \required-field
  A3; \field Outlet Node Name
      \required-field
```

An example of this statement in an IDF is:

```
Pipe:Adiabatic:Steam,
  Steam Demand 1 Steam Inlet Pipe,           !- PipeName
  Steam Demand 1 Steam Demand Inlet Node,    !- Inlet Node Name
  Steam Demand 1 Steam Demand Entrance Pipe Outlet Node; !- Outlet Node Name
```

Steam Pipe Outputs

There are no outputs directly related to Steam Pipes.

Pipe:Indoor

This object specifies inputs which are used to simulate the heat transfer from a plant loop pipe placed in a zone or when a user schedule is used to specify an environment.

Currently, Pipe Heat Transfer (Pipe:Indoor, Pipe:Outdoor, Pipe:Underground) objects are allowed on the supply side of plant loops or condenser loops. Due to simulation restrictions, pipe heat transfer objects are not allowed on the demand side of a loop.

The data definition for object is shown below.

```
Pipe:Indoor,
  \memo Pipe model with transport delay and heat transfer to the environment.
  \memo Heat transfer pipes only allowed on loop supply sides
A1, \field Name
  \required-field
A2, \field Construction Name
  \required-field
  \type object-list
  \object-list ConstructionNames
A3, \field Fluid Inlet Node Name
  \type alpha
  \required-field
A4, \field Fluid Outlet Node Name
  \required-field
  \type alpha
A5, \field Fluid Name
  \note (water, ethylene glycol, etc.)
  \type object-list
  \object-list GlycolConcentrations
  \required-field
  \default Water
A6, \field Environment Type
  \type choice
  \key Zone
  \key Schedule
  \default Zone
A7, \field Ambient Temperature Zone Name
  \type object-list
  \object-list ZoneNames
A8, \field Ambient Temperature Schedule Name
  \type object-list
  \object-list ScheduleNames
A9, \field Ambient Air Velocity Schedule Name
  \type object-list
  \object-list ScheduleNames
N1, \field Pipe Inside Diameter
  \type real
  \units m
  \minimum> 0
  \ip-units in
N2; \field Pipe Length
  \type real
  \units m
  \minimum> 0.0
```

Field: Name

This alpha field is used as an identifying field for the pipe.

Field: Construction Name

This alpha field references a 'wall' construction object that gives a layer-by-layer description of the pipe wall and its insulation. The construction object follows standard conventions, describing material properties for each layer beginning with the outermost insulation layer and ending with the pipe wall layer.

Field: Fluid Inlet Node Name

This alpha field contains the name of the pipe fluid inlet node.

Field: Fluid Outlet Node Name

This alpha field contains the name of the pipe fluid outlet node.

Field: Fluid Name

This alpha field contains the fluid name. This name will be validated against Fluid Names (ref: Fluid Properties section below) in the input file.

Field: Environment Type

Environment type is the environment in which the pipe is placed. It can be either **Zone** or **Schedule**. If specified as Zone, a zone name must be specified in the next field. If specified as Schedule, the Ambient Temperature Zone can be left blank, while a schedule must be specified for the temperature and air velocity.

Field: Ambient Temperature Zone Name

If **Zone** is specified as the environment type, this field is used to specify the name of the zone in which the pipe is located. The zone temperature is used to calculate the heat transfer rate from the pipe.

Field: Ambient Temperature Schedule Name

If **Schedule** is specified as the environment type, this field is used to specify the name of the temperature schedule that gives the ambient air temperature surrounding the pipe. This temperature is used as the outside boundary condition to calculate heat transfer from the pipe.

Field: Ambient Air Velocity Schedule Name

If **Schedule** is specified as the environment type, this field is used to specify the name of the velocity schedule that gives the air velocity near the pipe. This velocity is used to calculate the convection heat transfer coefficient used in the pipe heat transfer calculation.

Field: Pipe Inside Diameter

This field is used to enter the inside diameter of the pipe in units of m. Pipe inside diameter must be a positive number.

Field: Pipe Length

This field is used to enter the length of the pipe in units of m. Pipe length must be a positive number.

An example of this object in an IDF is:

```
Pipe:Indoor,
  Pipe Heat Transfer Towers,      !- name of outside panel heat exchanger
  Insulated Pipe,                !- Construction name
  Condenser Tower Outlet Node,    !- Compl Inlet Node Name
  HTPipe Outlet Node,            !- Compl Outlet Node Name
  Water,                          !- Fluid name
  Zone,                           !- field Ambient Temperature Outside Air Node name
  0.05,                           !- Pipe Inside Diameter (thickness in construction data)
  100.0;                          !- pipe length
```

Pipe:Indoor Outputs

```
HVAC,Average, Pipe Heat Transfer Fluid Heat Transfer Rate [W]
HVAC,Average, Pipe Heat Transfer Environmental Heat Transfer Rate [W]
HVAC,SUM, Pipe Heat Transfer Fluid Heat Transfer Energy [J]
HVAC,SUM, Pipe Heat Transfer Environmental Heat Transfer Energy [J]
HVAC,Average, Pipe Heat Transfer Fluid Mass Flow Rate [kg/s]
HVAC,Average, Pipe Heat Transfer Fluid Inlet Temperature [T]
HVAC,Average, Pipe Heat Transfer Fluid Outlet Temperature [T]
HVAC,Average, Pipe Heat Transfer Fluid Volume Flow Rate [m3/s]
```

Pipe Heat Transfer Fluid Heat Transfer rate [W]

The output provides the total amount of heat loss/gain in the fluid from pipe inlet to outlet.

Pipe Heat Transfer Environmental Heat Transfer rate [W]

The output provides the amount of heat loss/gain from pipe wall to the environment.

Pipe Heat Transfer Fluid Heat Transfer Energy [J]

Total energy fluid has lost/gained between pipe inlet and outlet. It is metered on EnergyTransfer with an end use of Pipes.

Pipe Heat Transfer Environmental Heat Transfer Energy [J]

Total energy lost from the external pipe surface.

Pipe Heat Transfer Fluid Mass Flow Rate [kg/s]

Mass flow rate of the fluid in the pipe.

Pipe Heat Transfer Fluid Inlet Temperature [C]**Pipe Heat Transfer Fluid Outlet Temperature [C]**

Temperature of fluid at entering and exiting of pipe.

Pipe Heat Transfer Fluid Volume Flow Rate [m3/s]

Fluid volumetric flow rate, (mass flow rate / density)

Pipe:Outdoor

This object specifies inputs which are used to simulate the heat transfer from a plant loop pipe placed in an outdoor environment.

Currently, Pipe Heat Transfer (Pipe:Indoor, Pipe:Outdoor, Pipe:Underground) objects are allowed on the supply side of plant loops or condenser loops. Due to simulation restrictions, pipe heat transfer objects are not allowed on the demand side of a loop.

The data definition for object is shown below.

```
Pipe:Outdoor,
  \memo Pipe model with transport delay and heat transfer to the environment.
  \memo Heat transfer pipes only allowed on loop supply sides
A1, \field Name
   \required-field
A2, \field Construction Name
   \required-field
   \type object-list
   \object-list ConstructionNames
A3, \field Fluid Inlet Node Name
   \type alpha
   \required-field
A4, \field Fluid Outlet Node Name
   \required-field
   \type alpha
A5, \field Fluid Name
   \note (water, ethylene glycol, etc.)
   \type object-list
   \object-list GlycolConcentrations
   \required-field
   \default Water
A6, \field Ambient Temperature Outdoor Air Node Name
   \type alpha
```



```

N1, \field Pipe Inside Diameter
    \type real
    \units m
    \minimum> 0
    \ip-units in
N2; \field Pipe Length
    \type real
    \units m
    \minimum> 0.0

```

Field: Name

This alpha field is used as an identifying field for the pipe.

Field: Construction Name

This alpha field references a 'wall' construction object that gives a layer-by-layer description of the pipe wall and its insulation. The construction object follows standard conventions, describing material properties for each layer beginning with the outermost insulation layer and ending with the pipe wall layer.

Field: Fluid Inlet Node Name

This alpha field contains the name of the pipe fluid inlet node.

Field: Fluid Outlet Node Name

This alpha field contains the name of the pipe fluid outlet node.

Field: Fluid Name

This alpha field contains the fluid name. This name will be validated against Fluid Names (ref: Fluid Properties section below) in the input file.

Field: Ambient Temperature Outside Air Node Name

Ambient temperature outdoor air node is a node representing outdoor air with which pipe transfers heat. The node should be included in an outdoor air node list.

Field: Pipe Inside Diameter

This field is used to enter the inside diameter of the pipe in units of m. Pipe inside diameter must be a positive quantity.

Field: Pipe Length

This field is used to enter the length of the pipe in units of m. Pipe length must be a positive quantity.

An example of this statement in an IDF is:

```

Pipe:Outdoor,
  Pipe Heat Transfer Towers,      !- name of outside panel heat exchanger
  Insulated Pipe,                !- Construction name
  Condenser Tower Outlet Node,    !- Compl Inlet Node Name
  HTPipe Outlet Node,            !- Compl Outlet Node Name
  Water,                          !- Fluid name
  PipeHeatTransfer Inlet Node,    !- field Ambient Temperature Outside Air Node name
  0.05,                          !- Pipe Inside Diameter (thickness given in construction data)
  100.0;                          !- pipe length

```

Pipe:Outdoor Outputs

```

HVAC,Average, Pipe Heat Transfer Fluid Heat Transfer Rate [W]
HVAC,SUM, Pipe Heat Transfer Fluid Heat Transfer Energy [J]
HVAC,Average, Pipe Heat Transfer Fluid Mass Flow Rate [kg/s]
HVAC,Average, Pipe Heat Transfer Fluid Inlet Temperature [T]
HVAC,Average, Pipe Heat Transfer Fluid Outlet Temperature [T]
HVAC,Average, Pipe Heat Transfer Fluid Volume Flow Rate [m3/s]

```

Pipe Heat Transfer Fluid Heat Transfer rate [W]

The output provides the total amount of heat loss/gain in the fluid from pipe inlet to outlet.

Pipe Heat Transfer Fluid Heat Transfer Energy [J]

Total energy fluid has lost/gained between pipe inlet and outlet. It is metered on EnergyTransfer with an end use of Pipes.

Pipe Heat Transfer Mass Flow Rate [kg/s]

Mass flow rate of the fluid in the pipe.

Pipe Heat Transfer Inlet Temperature [C]**Pipe Heat Transfer Outlet Temperature [C]**

Temperature of fluid at entering and exiting of pipe.

Pipe Heat Transfer Fluid Volume Flow Rate [m3/s]

Fluid volumetric flow rate, (mass flow rate / density)

Pipe:Underground

This object specifies inputs which are used to simulate the heat transfer from a plant loop pipe placed underground.

Currently, Pipe Heat Transfer (Pipe:Indoor, Pipe:Outdoor, Pipe:Underground) objects are allowed on the supply side of plant loops or condenser loops. Due to simulation restrictions, pipe heat transfer objects are not allowed on the demand side of a loop.

The data definition for the object is shown below.

```
Pipe:Underground,
  \memo Buried Pipe model: For pipes buried at a depth less
  \memo than one meter, this is an alternative object to:
  \memo 'HeatExchanger:Surface'
  \memo Heat transfer pipes only allowed on loop supply sides
A1, \field Name
  \required-field
A2, \field Construction Name
  \required-field
  \type object-list
  \object-list ConstructionNames
A3, \field Fluid Inlet Node Name
  \type alpha
  \required-field
A4, \field Fluid Outlet Node Name
  \type alpha
  \required-field
A5, \field Fluid Name
  \note (water, ethylene glycol, etc.)
  \type object-list
  \object-list GlycolConcentrations
  \required-field
  \default water
```

```

A6, \field Sun Exposure
    \required-field
    \type choice
    \key SunExposed
    \key NoSun
N1, \field Pipe Inside Diameter
    \note pipe thickness is defined in the Construction object
    \type real
    \units m
    \minimum> 0
    \ip-units in
N2, \field Pipe Length
    \type real
    \units m
    \minimum> 0.0
A7, \field Soil Material Name
    \type alpha
    \required-field
N3, \field Average Soil Surface Temperature
    \note optional
    \units C
    \type real
    \default 0
N4, \field Amplitude of Soil Surface Temperature
    \note optional
    \units C
    \type real
    \minimum 0
    \default 0
N5, \field Phase Constant of Soil Surface Temperature
    \note optional
    \units days
    \type real
    \minimum 0
    \default 0

```

Field: Name

This alpha field is used as an identifying field for the pipe.

Field: Construction Name

This alpha field references a basic construction object that gives a layer-by-layer description of the pipe wall and insulation. The construction object follows standard conventions, describing material properties for each layer beginning with the outermost layer, the insulation, if it exists, and ending with the pipe wall layer. The construction object may have either one or two layers. If only one, then the material must be the pipe wall. If two, then insulation is utilized.

Field: Fluid Inlet Node Name

This alpha field contains the name of the pipe fluid inlet node.

Field: Fluid Outlet Node Name

This alpha field contains the name of the pipe fluid outlet node.

Field: Fluid Name

This alpha field contains the fluid name. This name will be validated against a set of fluid names in the input file. Water and glycol mixtures are typically used for these cases.

Field: Sun Exposure

This alpha field allows the user to specify one of two options: NoSun or SunExposed. For SunExposed, the simulation includes diffuse and beam solar effects on the ground surface. For NoSun, no solar effects are included.

Field: Pipe Inside Diameter

This field is used to enter the inside diameter of the pipe in units of m. Pipe inside diameter must be a positive quantity.

Field: Pipe Length

This field is used to enter the length of the pipe in units of {m}. Pipe length must be a positive quantity.

Field: Soil Material Name

This references a Material object that contains the soil properties and thickness. Note that when defining the soil layer, the thickness should be the thickness of soil between the pipe wall and the ground surface.

Field: Average Soil Surface Temperature

If a GroundTemperatures:Surface object is not given in the input, this is #1 of 3 inputs that must be given directly. This represents the annual average soil temperature above the pipe. This field can be calculated in advance using the separate CalcSoilSurfTemp program.

Field: Amplitude of Soil Surface Temperature

If a GroundTemperatures:Surface object is not given in the input, this is #2 of 3 inputs that must be given directly. This represents the annual average soil temperature variation from the average temperature itself. For example, if this were represented as a sine wave, this would simply be the amplitude of the curve. This field can be calculated in advance using the separate CalcSoilSurfTemp program.

Field: Phase Constant of Soil Surface Temperature

If a GroundTemperatures:Surface object is not given in the input, this is #3 of 3 inputs that must be given directly. This represents the time elapsed from the beginning of the year to the date of minimum surface temperature. For example, if this were represented as a sine wave, this would simply be the phase shift of the curve. This field can be calculated in advance using the separate CalcSoilSurfTemp program

In order to avoid having to run the preprocessor program to generate soil temperature, the user may choose to simply input a GroundTemperatures:Surface object. This object inputs average monthly surface temperatures. These temperatures are then used within the model to develop average ground surface data. This ground surface data can then be used as part of the model boundary condition set. Without a set of surface ground temperatures, the model will require user input of the three last input fields.

An example of this object in an IDF is:

```

Pipe:Underground,
  Pipe Heat Transfer Towers,      !- Name of Pipe
  Insulated Buried Pipe,         !- Construction Name
  Condenser Tower Outlet Node,   !- Inlet Node Name
  HTPipe Outlet Node,           !- Outlet Node Name
  Water,                         !- Fluid Name
  SunExposed,                   !- Sun Exposure
  0.05,                          !- Pipe Inside Diameter
  20.0,                          !- pipe Length
  Buried Pipe Soil,             !- Soil Material
  13,                            !- Average Soil Surface Temperature
  1.5,                           !- Amplitude of Soil Surface Temperature
  30;                             !- Phase Constant of Soil Surface Temperature

Construction,
  Insulated Buried Pipe,         !- Name
  Buried Pipe Insulation,       !- Layer #1
  Buried Pipe Steel;           !- Layer #2

Material,
  Buried Pipe Soil,            !- Name
  Smooth,                      !- Roughness
  1.5,                          !- Thickness {m}
  0.36,                         !- Conductivity {W/m-K}
  2000.0,                       !- Density {kg/m3}
  1200.0,                       !- Specific Heat {J/kg-K}
  0.9,                          !- Thermal Absorptance
  0.5,                           !- Solar Absorptance
  0.5;                           !- Visible Absorptance

```

Pipe:Underground Outputs

```

HVAC, Average, Pipe Heat Transfer Fluid Heat Transfer Rate [W]
HVAC, SUM, Pipe Heat Transfer Fluid Heat Transfer Energy [J]
HVAC, Average, Pipe Heat Transfer Fluid Mass Flow Rate [kg/s]
HVAC, Average, Pipe Heat Transfer Fluid Volume Flow Rate [m3/s]
HVAC, Average, Pipe Heat Transfer Fluid Inlet Temperature [C]
HVAC, Average, Pipe Heat Transfer Fluid Outlet Temperature [C]

```

Pipe Heat Transfer Fluid Heat Transfer rate [W]

The output provides the total amount of heat loss/gain in the fluid from pipe inlet to outlet.

Pipe Heat Transfer Fluid Heat Transfer Energy [J]

Total energy fluid has lost/gained between pipe inlet and outlet. It is metered on EnergyTransfer with an end use of Pipes.

Pipe Heat Transfer Fluid Mass Flow Rate [kg/s]

Mass flow rate of the fluid in the pipe.

Pipe Heat Transfer Fluid Volume Flow Rate [m3/s]

Fluid volumetric flow rate, (mass flow rate / density)

Pipe Heat Transfer Fluid Inlet Temperature [C]

Pipe Heat Transfer Fluid Outlet Temperature [C]

Temperature of fluid at entrance and exit of pipe.

Group – Plant-Condenser Loops

PlantLoop

The main elements of the PlantLoop syntax are described in further detail below. A map of how the input for this portion of the HVAC input fits together is provided in the following diagram.

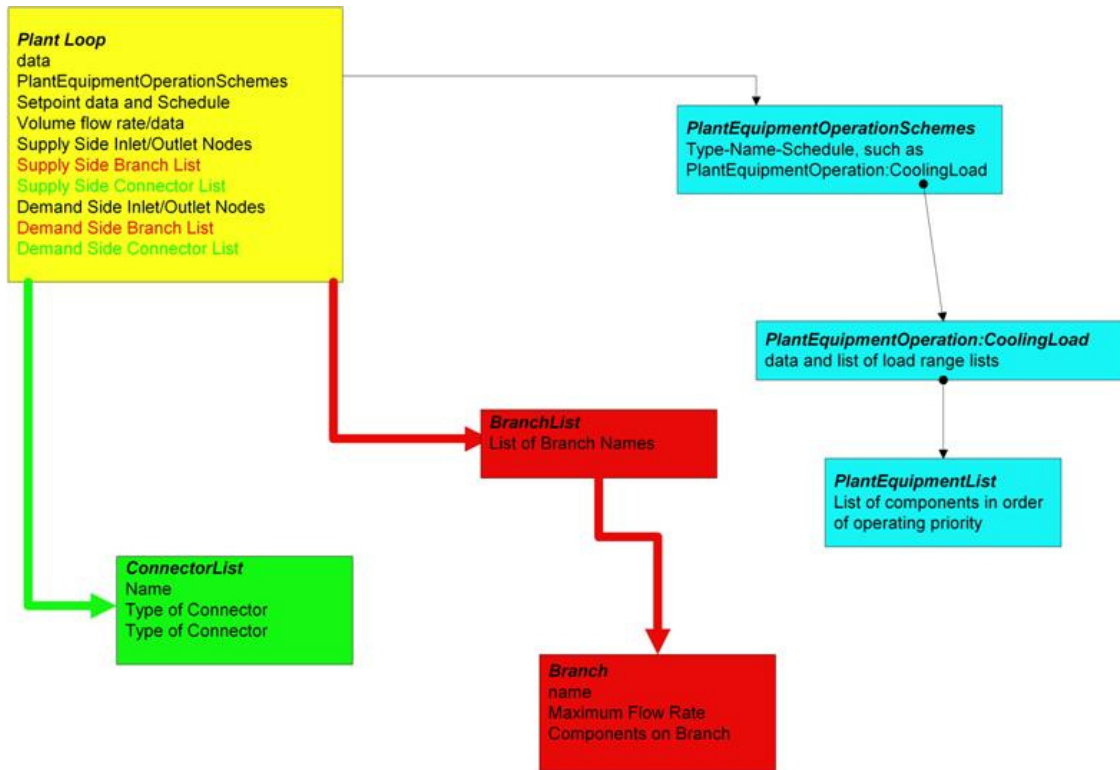


Figure 63. Plant Loop Input Syntax Map

Field: Name

This alpha field is used as an identifying field for the plant loop.

Field: Fluid Type

This alpha field must be a keyword selected from the list of available fluids for an EnergyPlus plant loop. Either “Water” or “Steam” may be used..

Field: Plant Equipment Operation Scheme Name

This alpha field is used as an identifying field for the plant operation scheme. This field ties to the PlantEquipmentOperationSchemes input structure, which must also be defined.

Field: Loop Temperature Setpoint Node Name

This alpha field is used to identify the node which the Loop Manager will access the temperature setpoint that it will try to maintain. This is typically the Plant Loop Supply Side Outlet Node so that it will not interfere with component temperature setpoints. An associated temperature setpoint manager will need to be defined.

Field: Maximum Loop Temperature

This numeric field contains the maximum allowable temperature in Celsius for this loop.

Field: Minimum Loop Temperature

This numeric field contains the minimum allowable temperature in Celsius for this loop.

Field: Maximum Loop Flow Rate

This numeric field contains the maximum loop flow rate in cubic meters per second. This parameter is also used when the user chooses to autocalculate the loop volume. See Volume of the Plant Loop below and the Engineering Manual for more details.

Field: Minimum Loop Flow Rate

This numeric field contains the minimum loop flow rate in cubic meters per second.

Field: Plant Loop Volume

Volume of the plant loop in m³. This numeric field contains the loop volume for the entire loop, ie. both the demand side the the supply side. This is used for the loop capacitance calculation which updates the loop temperature from one timestep to the next and introduces some time delay between the supply and demand sides of the loop. Loop volume (m³) could be calculated from pipe size data but this is not usually known. If zero volume is specified the demand inlet temperature is set to the supply outlet temperature at the previous system timestep. If a very large capacitance is specified unrealistic time delay may result and there may be poor response to changes in loop setpoint temperature. The loop capacitance **autocalculate** option gives reasonable values for most system sizes. This calculation is described in the Engineering Reference manual.

Field: Plant Side Inlet Node Name

This required alpha field contains the identifying name given to the Plant Side Inlet Node.

Field: Plant Side Outlet Node Name

This required alpha field contains the identifying name given to the Plant Side Outlet Node.

Field: Plant Side Branch List Name

This required alpha field contains the identifying name given to the Plant Side Branch List.

Field: Plant Side Connector List Name

This alpha field contains the identifying name given to the Plant Side Connector List.

Field: Demand Side Inlet Node Name

This required alpha field contains the identifying name given to the Demand Side Inlet Node.

Field: Demand Side Outlet Node Name

This required alpha field contains the identifying name given to the Demand Side Outlet Node.

Field: Demand Side Branch List Name

This required alpha field contains the identifying name given to the Demand Side Branch List.

Field: Demand Side Connector List Name

This alpha field contains the identifying name given to the Demand Side Connector List.

Field: Load Distribution Scheme

This alpha field contains the Load Distribution Scheme Keyword. The Load Distribution Scheme selects the algorithm used to sequence equipment operation in order to meet the plant loop demand. Currently, two schemes are functional. **Sequential** uses each piece of equipment to its maximum part load ratio and will operate the last required piece of equipment between its minimum and maximum part load ratio in order to meet the loop

demand. **Optimal** operates each piece of equipment at its optimal part load ratio and will operate the last component between its minimum and maximum part load ratio in order to meet the loop demand. **Uniform** evenly distributes the loop demand amongst all available components on the equipment list for a given load range.

The complete IDD for the Plant Loop is shown below:

Field: Availability Manager List Name

This alpha field contains the identifying name given to the System Availability Manager List.

Field: Plant Loop Demand Calculation Scheme

There are two plant loop demand calculations schemes in EnergyPlus. There is a SingleSetPoint and a DualSetPointDeadband; the SingleSetPoint is the default if this field is left blank. In the SingleSetPoint scheme the Plant Loop requires that a Set Point Manager set a single setpoint value on Node%TempSetPoint. Examples of this set Point manager would be: Set Point Manager:Scheduled, Set Point Manager:Outside Air, etc. For the DualSetPointDeadband scheme the Plant Loop requires that a Set Point Manager set the high and low setpoint values for Node%TempSetPointHi and Node%TempSetPointLo. Examples of this Set Point manager would be: SetpointManager:Scheduled:DualSetpoint.

The Plant Loop Demand Calculation Scheme determines the amount of heating or cooling necessary to bring the temperature of the Plant Loop to its setpoint(s). When this value is determined then the Load Distribution scheme explained in the previous section takes this value and distributes the load to the appropriate equipment. The demand calculation scheme determines how the load is calculated. See more information in the Engineering Document.

Field: Common Pipe Simulation

This field lets user to choose if a common pipe simulation needs to be performed or not. EnergyPlus allows user two different common pipe options. The two options are “**CommonPipe**” and “**TwoWayCommonPipe**”. In Simple “CommonPipe” case no temperature control is possible, while a “TwoWayCommonPipe” has to be used if the user wishes to control the inlet node of either primary or secondary loop. If not specified the field will default to NONE. If the field is set to NONE and the program finds a pump on the demand side it will result in a fatal error. The common pipe simulation is currently limited to simulating loop-placed pumps, i.e. pumps should be placed on the inlet branch of the loop.


```

PlantLoop,
A1 , \field Name
      \required-field
      \reference PlantLoops
A2 , \field Fluid Type
      \required-field
      \type choice
      \key Water
      \key Steam
      \default Water
A3 , \field Plant Equipment Operation Scheme Name
      \required-field
      \type object-list
      \object-list PlantOperationSchemes
A4 , \field Loop Temperature Setpoint Node Name
      \required-field
N1 , \field Maximum Loop Temperature
      \required-field
      \units C
N2 , \field Minimum Loop Temperature
      \required-field
      \units C
N3 , \field Maximum Loop Flow Rate
      \required-field
      \type real
      \units m3/s
      \autosizable
      \minimum 0
      \ip-units gal/min
N4 , \field Minimum Loop Flow Rate
      \type real
      \units m3/s
      \default 0.0
      \ip-units gal/min
N5 , \field Plant Loop Volume
      \type real
      \units m3
      \autocalculatable
      \minimum 0.0
      \default Autocalculate
      \ip-units gal
A5, \field Plant Side Inlet Node Name
      \required-field
A6, \field Plant Side Outlet Node Name
      \required-field
A7, \field Plant Side Branch List Name
      \required-field
      \type object-list
      \object-list BranchLists
A8, \field Plant Side Connector List Name
      \type object-list
      \object-list ConnectorLists
A9, \field Demand Side Inlet Node Name
      \required-field
A10, \field Demand Side Outlet Node Name
      \required-field
A11, \field Demand Side Branch List Name
      \required-field
      \type object-list
      \object-list BranchLists
A12, \field Demand Side Connector List Name
      \type object-list
      \object-list ConnectorLists
A13, \field Load Distribution Scheme
      \type choice
      \key Optimal
      \key Sequential
      \key Uniform
      \default Sequential

```

```

A14, \field Availability Manager List Name
      \type object-list
      \object-list SystemAvailabilityManagerLists
A15, \field Plant Loop Demand Calculation Scheme
      \type choice
      \key SingleSetpoint
      \key DualSetpointDeadband
      \default SingleSetpoint
A16; \field Common Pipe Simulation
      \type choice
      \key CommonPipe
      \key TwoWayCommonPipe
      \key None
      \default None

```

An example of this statement used in an IDF is:

```

PlantLoop,
  Hot Water Loop,           !- Plant Loop Name
  Water,                   !- Fluid Type
  Hot Loop Operation,      !- Plant Operation Scheme List Name
  HW Loop Outlet Node,     !- Loop Temperature Setpoint Schedule Name
  100,                     !- Maximum Loop Temperature {C}
  10,                      !- Minimum Loop Temperature {C}
  autosize,               !- Maximum Loop Volumetric Flow Rate {m3/s}
  0.0,                    !- Minimum Loop Volumetric Flow Rate {m3/s}
  autosize,               !- volume of the plant loop {m3}
  HW Supply Inlet Node,    !- Plant Side Inlet Node Name
  HW Supply Outlet Node,   !- Plant Side Outlet Node Name
  Heating Supply Side Branches, !- Plant Side Branch List Name
  Heating Supply Side Connectors, !- Plant Side Connector List Name
  HW Demand Inlet Node,    !- Demand Side Inlet Node Name
  HW Demand Outlet Node,   !- Demand Side Outlet Nodes Name
  Heating Demand Side Branches, !- Demand Side Branch List Name
  Heating Demand Side Connectors, !- Demand Side Connector List Name
  Optimal;                 !- Load Distribution Scheme

```

In the above example input there is no system availability manager specified and the Demand Calculation Scheme will default to SingleSetPoint using a single setpoint manager. Common pipe simulation field in the above example will default to “NONE” since it is not specified.

Plant Loop Outputs

In the following output variables, “Debug” denotes variables that are used primarily by the developers and whose names may be cryptic (i.e. SSInletNode – Supply Side Inlet Node).

```

HVAC,Average,Plant Loop Cooling Demand[W]
HVAC,Average,Plant Loop Heating Demand[W]
HVAC,Average,Plant Loop InletNode Flowrate[kg/s]
HVAC,Average,Plant Loop InletNode Temperature[C]
HVAC,Average,Plant Loop OutletNode Temperature[C]
HVAC,Average,Plant Loop Unmet Demand[W]
HVAC,Average,Debug Plant Loop Bypass Fraction
HVAC,Average,Debug SSInletNode Flowrate[kg/s]
HVAC,Average,Debug SSInletNode Temperature[C]
HVAC,Average,Debug SSOutletNode Flowrate[kg/s]
HVAC,Average,Debug SSOutletNode Temperature[C]
HVAC,Average,Common Pipe Mass Flow Rate [Kg/s]
HVAC,Average,Common Pipe Flow Temperature [C]
HVAC,Average,Common Pipe Flow Direction []
HVAC,Average,Primary Side Common Pipe Mass Flow Rate [Kg/s]
HVAC,Average,Secondary Side Common Pipe Mass Flow Rate [Kg/s]
HVAC,Average,Primary Side Common Pipe Flow Direction []
HVAC,Average,Secondary Side Common Pipe Flow Direction []
HVAC,Average,Primary to Secondary Mass Flow Rate [Kg/s]
HVAC,Average,Secondary to Primary Mass Flow Rate [Kg/s]

```

HVAC, Average, Plant Loop System Cycle On/Off Status
--

Plant Loop Cooling Demand [W]

This is the value of the net demand required to meet the cooling setpoint of the loop. If the loop setpoint is met for the current HVAC timestep, Plant Loop Cooling Demand will equal sum of the total cooling demand from the demand side coils on the loop. It will also equal the cooling output of all chillers (or other cooling equipment) on the loop less any pump heat added to the fluid. For example, for a chilled water loop with one chiller and one pump serving one chilled water coil: Plant Loop Cooling Demand will equal the chiller evaporator heat transfer less the pump heat to fluid, and it will also equal the chilled water coil total cooling output.

If the plant loop setpoint is not met, Plant Loop Cooling Demand will equal the sum of the total cooling demand from the demand side coils on the loop plus the additional cooling required to bring the loop flow to setpoint. If the loop remains off setpoint for successive timesteps, the demand required to return to setpoint will repeat in each timestep until the loop reaches setpoint. For this reason, Plant Loop Cooling Demand should not be summed over time, because it will overstate the demand whenever the loop is off setpoint.

Plant Loop Heating Demand [W]

This is the value of the net demand required to meet the heating setpoint of the loop. If the loop setpoint is met for the current HVAC timestep, Plant Loop Heating Demand will equal sum of the total heating demand from the demand side coils on the loop. It will also equal the heating output of all boilers (or other heating equipment) on the loop plus any pump heat added to the fluid. For example, for a hot water loop with one boiler and one pump serving one hot water coil: Plant Loop Heating Demand will equal the boiler heat transfer plus the pump heat to fluid, and it will also equal the hot water coil total heating output.

If the plant loop setpoint is not met, Plant Loop Heating Demand will equal the sum of the total heating demand from the demand side coils on the loop plus the additional heating required to bring the loop flow to setpoint. If the loop remains off setpoint for successive timesteps, the demand required to return to setpoint will repeat in each timestep until the loop reaches setpoint. For this reason, Plant Loop Heating Demand should not be summed over time, because it will overstate the demand whenever the loop is off setpoint.

Plant Loop InletNode Flowrate [kg/s]

This is the value of the mass flow rate at the Inlet to Plant Loop on the supply side. There is not an associated Plant Loop outlet node flow rate since continuity must be maintained in the loop and the inlet must be the same.

Plant Loop InletNode Temperature[C]

This is the value of the temperature at the Inlet to the plant loop on the supply side.

Plant Loop OutletNode Temperature[C]

This is the value of the temperature at the outlet to the plant loop on the supply side.

Plant Loop Unmet Demand [W]

This is the value of the demand NOT provided by the plant equipment to meet the heating or cooling setpoint of the loop. The value is positive when the plant equipment cannot meet the setpoint, and the value is negative when the plant equipment provides more than enough heating or cooling to meet the setpoint. A negative value can happen when the amount of demand is smaller than the minimum capacity of the equipment using the minimum part load ratio.

Common Pipe Mass Flow Rate [Kg/s]

This output gives the magnitude of the flow through common pipe. The value is averaged over the reporting interval.

Common Pipe Flow Temperature [C]

This output gives the value of the temperature of the fluid flowing through common pipe. This value is averaged over the reporting interval.

Common Pipe Flow Direction []

This output gives the direction of flow in common pipe. The value is an integer and can be 0, 1 or 2. Since the output value is averaged over reporting interval, a non-integer value may be shown as an output when the reporting interval is not detailed. An output value of 0 means that there was no flow in common pipe. An output value of 1 means that the secondary flow is greater than primary flow, whereas a value of 2 means that primary flow is greater than secondary flow.

Primary Side Common Pipe Mass Flow Rate [Kg/s]

This report variable gives the mass flow in the primary side common pipe leg in a Two-Way common pipe simulation. Value is averaged over the reporting interval.

Secondary Side Common Pipe Mass Flow Rate [Kg/s]

This report variable gives the mass flow in the secondary side common pipe leg in a Two-Way common pipe simulation. Value is averaged over the reporting interval.

Primary Side Common Pipe Flow Direction []

This report variable gives the direction of flow in a primary side common pipe leg in a Two-Way Common Pipe Simulation. A value of zero means there was no flow in the pipe. A value of 1 means the flow was from top to bottom in EnergyPlus loop schematic. So for primary side, a value of 1 means the flow is from Primary side inlet to Primary side outlet and a value of 2 means flow is from Primary side outlet to Primary side inlet.

Secondary Side Common Pipe Flow Direction []

This report variable gives the direction of flow in a Secondary side common pipe leg in a Two-Way Common Pipe Simulation. A value of zero means there was no flow in the pipe. A value of 1 means the flow was from top to bottom in EnergyPlus loop schematic. So for Secondary side, a value of 1 means the flow is from Secondary side outlet to Secondary side inlet and a value of 2 means flow is from Secondary side inlet to Secondary side outlet. Note that this is opposite to the primary side common pipe.

Primary to Secondary Mass Flow Rate [Kg/s]

This report variable gives the mass flow from primary to secondary side in a Two-Way common pipe simulation. Value is averaged over the reporting interval.

Secondary to Primary Mass Flow Rate [Kg/s]

This report variable gives the mass flow from secondary to primary side in a Two-Way common pipe simulation. Value is averaged over the reporting interval.

Plant Loop System Cycle On/Off Status

This field is the availability status of a Plant Loop. This status flag is a result of the calculations made by the System Availability Manager(s) listed in a System Availability Manager List. When a single availability manager is used in a System Availability Manager List, this is also the availability status reported by the specific availability manager (Ref. System Availability Manager Outputs). When multiple availability managers are used in a System Availability Manager List, the loop availability status is determined by the rules associated with Plant Loops (see rules described for Group – System Availability Managers).

The control status outputs are represented using integers 0 through 2.. These integers represent *NoAction* (0), *ForceOff* (1), and *CycleOn* (2). Since the status output is averaged, the output result may not correspond to the values described here when report variable frequencies other than detailed are used. Use the “detailed” reporting frequency (Ref. Report Variable) to view the availability status at each simulation timestep.

CondenserLoop

The map for condenser loop input is very similar to that for the plant loop. The main differences are some keywords and applicable components. This is depicted in the following diagram.

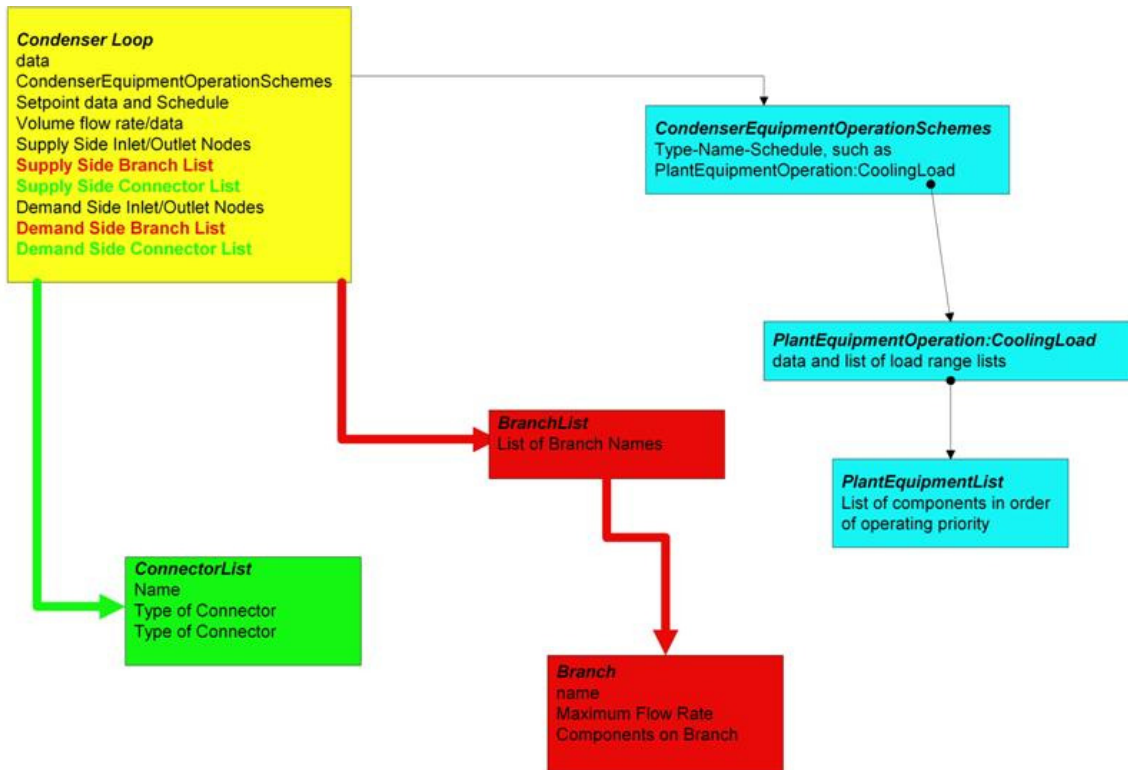


Figure 64. Condenser Loop Input Syntax Map

Field: Name

This alpha field is used as an identifying field for the condenser loop.

Field: Fluid Type

This alpha field must be a keyword selected from the list of available fluids for an EnergyPlus plant loop. Note from the IDD specification that the only currently acceptable one is “Water”.

Field: Condenser Equipment Operation Scheme Name

This alpha field is used as an identifying field for the condenser operation scheme. This field ties to the Condenser Operation Schemes input structure, which must also be defined.

Field: Condenser Loop Temperature Setpoint Node Name or Reference

This alpha field is used to identify the node which the Loop Manager will access the temperature setpoint that it will try to maintain. This is typically the Plant Loop Supply Side Outlet Node so that it will not interfere with component temperature setpoints. An associated temperature setpoint manager will need to be defined.

Another use can be to specify a reference for a condenser type ie. cooling tower or ground heat exchanger. Therefore two additional references can be specified:

Air to use the outdoor air wet-bulb as the setpoint, or

Ground to use the ground temperature as the setpoint.

These conditions vary as the outdoor wet-bulb and ground temperatures vary with the weather file or ground temperature specification.

Field: Maximum Loop Temperature

This numeric field contains the maximum allowable temperature in Celsius for this loop.

Field: Minimum Loop Temperature

This numeric field contains the minimum allowable temperature in Celsius for this loop. This minimum loop temperature is used by the cooling towers to make sure that the minimum is not violated to keep the equipment safe. The minimum is also used to trigger the minimum temperature warning and will notify the user if it gets too low.

Field: Maximum Loop Flow Rate

This numeric field contains the maximum loop flow rate in cubic meters per second.

Field: Minimum Loop Flow Rate

This numeric field contains the minimum loop flow rate in cubic meters per second.

Field: Condenser Loop Volume

Volume of the condenser loop in m³. This numeric field contains the loop volume for the entire loop, i.e., both the demand side and the supply side. This is used for the loop capacitance calculation which updates the loop temperature from one timestep to the next and introduces some time delay between the supply and demand sides of the loop. Loop volume (m³) could be calculated from pipe size data but this is not usually known. If zero volume is specified the demand inlet temperature is set to the supply outlet temperature at the previous system timestep. If a very large capacitance is specified unrealistic time delay may result and there may be poor response to changes in loop setpoint temperature. The loop capacitance **autocalculate** option gives reasonable values for most system sizes. This calculation is described in the Engineering Reference manual.

Field: Condenser Side Inlet Node Name

This required alpha field contains the identifying name given to the Condenser Side Inlet Node.

Field: Condenser Side Outlet Node Name

This required alpha field contains the identifying name given to the Condenser Side Outlet Node.

Field: Condenser Side Branch List Name

This required alpha field contains the identifying name given to the Condenser Side Branch List.

Field: Condenser Side Connector List Name

This required alpha field contains the identifying name given to the Condenser Side Connector List.

Field: Demand Side Inlet Node Name

This required alpha field contains the identifying name given to the Demand Side Inlet Node.

Field: Demand Side Outlet Nodes Name

This required alpha field contains the identifying name given to the Demand Side Outlet Node.

Field: Condenser Demand Side Branch List Name

This required alpha field contains the identifying name given to the Demand Side Branch List.

Field: Condenser Demand Side Connector List Name

This required alpha field contains the identifying name given to the Demand Side Connector List.

Field: Load Distribution Scheme

This alpha field contains the Load Distribution Scheme Keyword. The Load Distribution Scheme selects the algorithm used to sequence equipment operation in order to meet the plant loop demand. Currently, two schemes are functional. **Sequential** uses each piece of equipment to its maximum part load ratio and will operate the last required piece of equipment between its minimum and maximum part load ratio in order to meet the loop demand. **Optimal** operates each piece of equipment at its optimal part load ratio and will operate the last component between its minimum and maximum part load ratio in order to meet the loop demand.

The IDD for Condenser loop is:

```
CondenserLoop,
  A1 , \field Name
      \required-field
      \reference PlantLoops
  A2 , \field Fluid Type
      \required-field
      \type choice
      \key Water
      \default Water
  A3 , \field Condenser Equipment Operation Scheme Name
      \required-field
      \type object-list
      \object-list CondenserOperationSchemes
  A4 , \field Condenser Loop Temperature Setpoint Node Name or Reference
      \note Temperature setpoint Node name, or
      \note Air to use the outdoor air wet-bulb as the setpoint, or
      \note Ground to use the ground temperature as the setpoint
      \required-field
      \type alpha
```

```

N1 , \field Maximum Loop Temperature
    \required-field
    \units C
N2 , \field Minimum Loop Temperature
    \required-field
    \units C
    \minimum 5.0
N3 , \field Maximum Loop Flow Rate
    \type real
    \required-field
    \units m3/s
    \autosizable
    \minimum> 0.0
    \ip-units gal/min
N4 , \field Minimum Loop Flow Rate
    \type real
    \units m3/s
    \default 0.0
    \ip-units gal/min
N5, \field Condenser Loop Volume
    \type real
    \units m3
    \autocalculatable
    \default Autocalculate
    \minimum 0.0
    \ip-units gal
A5, \field Condenser Side Inlet Node Name
    \required-field
A6, \field Condenser Side Outlet Node Name
    \required-field
A7, \field Condenser Side Branch List Name
    \required-field
    \type object-list
    \object-list BranchLists
A8, \field Condenser Side Connector List Name
    \required-field
    \type object-list
    \object-list ConnectorLists
A9, \field Demand Side Inlet Node Name
    \required-field
A10, \field Demand Side Outlet Node Name
    \required-field
A11, \field Condenser Demand Side Branch List Name
    \required-field
    \type object-list
    \object-list BranchLists
A12, \field Condenser Demand Side Connector List Name
    \required-field
    \type object-list
    \object-list ConnectorLists
A13; \field Load Distribution Scheme
    \type choice
    \key Optimal
    \key Sequential
    \default Sequential

```

An example of this statement used in an IDF is:


```

CondenserLoop,
  Chilled Water Condenser Loop,  !- Condenser Loop Name
  Water,                          !- Fluid Type
  Tower Loop Operation,           !- Condenser Operation Scheme List Name
  AIR,                            !- Condenser Loop Temperature Setpoint Node or reference
  80,                             !- Maximum Loop Temperature {C}
  10,                             !- Minimum Loop Temperature {C}
  0.0011,                        !- Maximum Loop Volumetric Flow Rate {m3/s}
  0,                              !- Minimum Loop Volumetric Flow Rate {m3/s}
  autocalculate,                 !- volume of the condenser loop {m3}
  Condenser Supply Inlet Node,    !- Condenser Side Inlet Node Name
  Condenser Supply Outlet Node,   !- Condenser Side Outlet Node Name
  Condenser Supply Side Branches, !- Condenser Side Branch List Name
  Condenser Supply Side Connectors, !- Condenser Side Connector List Name
  Condenser Demand Inlet Node,    !- Demand Side Inlet Node Name
  Condenser Demand Outlet Node,   !- Demand Side Outlet Nodes Name
  Condenser Demand Side Branches, !- Condenser Demand Side Branch List Name
  Condenser Demand Side Connectors, !- Condenser Demand Side Connector List Name
  Sequential,                    !- Load Distribution Scheme

```

Condenser Loop Outputs

```

HVAC,Average,Condenser Loop Inlet Temperature [C]
HVAC,Average,Condenser Loop Outlet Temperature [C]
HVAC,Average,Cond Loop Inlet Temp [C]
HVAC,Average,Cond Loop Outlet Temp [C]

```

PlantLoopConnection

This component is used to connect 2 plant loops together typically to create a Primary-Secondary plant loop system. This system is typically multiple chillers on the primary constant volume loop, with a variable volume flow system to provide flow to multiple cooling coils. This component is simulated on the Supply Side of the Secondary Loop and the results are provided to the Demand Side of the Primary Loop. Look in the Engineering Document for more explanation of the Primary-Secondary Loop Systems.

This object is OBSOLETE. Use the commonpipe options on the PlantLoop to connect two plant loops.

```

PlantLoopConnection,
  \obsolete New=>Use Transition Program or Document
  \memo This component is used to connect to Plant Loops together.
  A1 , \field Name
  \required-field
  A2 , \field Primary Side Inlet Node Name
  \required-field
  A3 , \field Primary Side Outlet Node Name
  \required-field
  A4 , \field Secondary Side Inlet Node Name
  \required-field
  A5 , \field Secondary Side Outlet Node Name
  \required-field
  N1, \field Primary Side Design Maximum Flow Rate
  \required-field
  \units m3/s

```

```

A6, \field Primary Side Flow Mode
    \note Sets the Primary Side to either a Variable or ConstantFlow Simulation
    \type choice
    \key ConstantFlow
    \key VariableFlow !Not implemented yet
    \default ConstantFlow
N2, \field Secondary Side Design Maximum Flow Rate
    \required-field
    \units m3/s
    \ip-units gal/min
A7; \field Secondary Side Flow Mode
    \note Sets the Secondary Side to either a Variable or ConstantFlow Simulation
    \type choice
    \key ConstantFlow !Not implemented yet
    \key VariableFlow
    \default VariableFlow

```

Field: Name

This alpha field contains the identifying name for the Connection Component.

Field: Primary Side Inlet Node Name

This alpha field contains the identifying name for the primary side inlet node.

Field: Primary Side Outlet Node Name

This alpha field contains the identifying name for the primary side outlet node.

Field: Secondary Side Inlet Node Name

This alpha field contains the identifying name for the secondary side inlet node.

Field: Secondary Side Outlet Node Name

This alpha field contains the identifying name for the secondary side outlet node.

Field: Primary Side Design Maximum Flow Rate

Primary Side Design Max Flow Rate is a required field that initializes the primary side of the flow component and has input units of m3/s. This field needs to be set to the same value as the associated Plant Loop.

Field: Primary Side Flow Mode

This alpha field determines if the Primary Side is either a VariableFlow or ConstantFlow Simulation. The default, if not specified, is ConstantFlow.

Field Secondary Side Design Maximum Flow Rate

Secondary Side Design Max Flow Rate is a required field that initializes the secondary side of the flow component and has input units of m3/s. This field needs to be set to the same value as the associated Plant Loop.

Field Secondary Side Flow Mode

This alpha field determines if the Secondary Side is either a VariableFlow or ConstantFlow Simulation. The default, if not specified, is VariableFlow.

An example of this statement in an IDF is:

```

PlantLoopConnection,
  PriSec Loop Connection,
    CW Pri ConnComp Inlet Node, ! Primary_Side_Inlet_Node
    CW Pri ConnComp Outlet Node, ! Primary_Side_Outlet_Node
    CW Sec ConnComp Inlet Node, ! Secondary_Side_Inlet_Node
    CW Sec ConnComp Outlet Node, ! Secondary_Side_Outlet_Node
    0.0011 , ! Max Primary Loop Volumetric Flow Rate
    ConstantFlow, ! Primary Side Flow Mode
    0.001 , ! Max Secondary Loop Volumetric Flow Rate
    VariableFlow; ! Secondary Side Flow Mode

```

PlantLoopConnection Outputs

This component does not have direct outputs from the component since all of the information can be obtained from other report variables and directly from the inlet and outlet nodes.

```

Report Variable,* , Plant Loop InletNode Temperature, hourly;
Report Variable,* , Plant Loop OutletNode Temperature, hourly;
Report Variable,* , Plant Loop InletNode Flowrate, hourly;
.
or
.
Report Variable, CW Pri ConnComp Outlet Node,System Node MassFlowRate, hourly;
Report Variable, CW Pri ConnComp Outlet Node,System Node temp, hourly;

```

PlantLoopConnection:Controlled

This component is used to connect 2 plant loops together typically to create a Primary-Secondary plant loop system, and includes an implied 3-way valve to control the leaving temperature on the secondary side. This component is simulated on the Supply Side of the Secondary Loop and the results are provided to the Demand Side of the Primary Loop. The primary and secondary sides may be either constant flow or variable flow. This component will take the flows set by the respective loops and mix primary supply with secondary return to supply the specified secondary setpoint temperature if possible. Look in the Engineering Document for more explanation of the Primary-Secondary Loop Systems.

This object is OBSOLETE. Use the commonpipe options on the PlantLoop to connect two plant loops.

```

PlantLoopConnection:Controlled,
  \obsolete New=>Use Transition Program or Document
  \memo This component is used to connect to Plant Loops together.
  \memo The controlled connection component simulates a 3-way mixing
  \memo valve to allow the secondary loop to be controlled to a different
  \memo setpoint temperature than the primary loop.
A1 , \field Name
  \required-field
A2 , \field Primary Side Inlet Node Name
  \required-field
A3 , \field Primary Side Outlet Node Name
  \required-field
A4 , \field Secondary Side Inlet Node Name
  \required-field
A5 , \field Secondary Side Outlet Node Name
  \required-field
N1, \field Primary Side Design Maximum Flow Rate
  \required-field
  \units m3/s

```

```

N2, \field Secondary Side Design Maximum Flow Rate
    \required-field
    \units m3/s
    \ip-units gal/min
A6; \field Secondary Side Setpoint Node Name
    \required-field

```

Field: Name

This alpha field contains the identifying name for the Connection Component.

Field: Primary Side Inlet Node Name

This alpha field contains the identifying name for the primary side inlet node.

Field: Primary Side Outlet Node Name

This alpha field contains the identifying name for the primary side outlet node.

Field: Secondary Side Inlet Node Name

This alpha field contains the identifying name for the secondary side inlet node.

Field: Secondary Side Outlet Node Name

This alpha field contains the identifying name for the secondary side outlet node.

Field: Primary Side Design Maximum Flow Rate

Primary Side Design Maximum Flow Rate is a required field that initializes the primary side of the flow component and has input units of m3/s. This field needs to be set to the same value as the associated Plant Loop.

Field Secondary Side Design Maximum Flow Rate

Secondary Side Design Max Flow Rate is a required field that initializes the secondary side of the flow component and has input units of m3/s. This field needs to be set to the same value as the associated Plant Loop.

Field: Secondary Side Setpoint Node Name

This alpha field contains the identifying name for the secondary side setpoint node. A SET POINT MANAGER must be used to place a setpoint on this node. The connection component will mix primary supply flow with secondary return flow to achieve the specified setpoint if possible.

An example of this statement in an IDF is:

```

PlantLoopConnection:Controlled,
  PriSec Loop Connection,  !- Connection Component Name
  CW Pri ConnComp Inlet Node,  !- Primary Side Inlet Node
  CW Pri ConnComp Outlet Node,  !- Primary Side Outlet Node
  CW Sec ConnComp Inlet Node,  !- Secondary Side Inlet Node
  CW Sec ConnComp Outlet Node,  !- Secondary Side Outlet Node
  0.0011,                    !- Primary Side Design Max Flow Rate {m3/s}
  0.001,                      !- Secondary Side Design Max Flow Rate {m3/s}
  CW Sec Supply Outlet Node;  !- Secondary Side Setpoint Node

```

PlantLoopConnection:Controlled Outputs

This component does not have direct outputs from the component since all of the information can be obtained from other report variables and directly from the inlet and outlet nodes.

```

Report Variable,* , Plant Loop InletNode Temperature, hourly;
Report Variable,* , Plant Loop OutletNode Temperature, hourly;
Report Variable,* , Plant Loop InletNode Flowrate, hourly;
.
  or
.
Report Variable, CW Pri ConnComp Outlet Node,System Node MassFlowRate, hourly;
Report Variable, CW Pri ConnComp Outlet Node,System Node temp, hourly;
Report Variable, CW Sec ConnComp Outlet Node,System Node MassFlowRate, hourly;
Report Variable, CW Sec ConnComp Outlet Node,System Node temp, hourly;

```

Group – Plant-Condenser Control

Operation Schemes (Plant and Condenser)

Plants and condenser loops must have some mechanism for controlling the operation of the loop and which equipment is available under what conditions. Since there may be multiple control schemes that are assigned various priorities associated with each loop, an overall operation scheme must be defined. The overall scheme consists of the object name, an identifying name that is referenced in the main plant or condenser loop statement, and a list of operation schemes. Each operation scheme must have the type of operation scheme, its identifying name, and the schedule that defines its availability. Note that the order in which the individual operation schemes appear in this list defines its priority versus the others with the same scheduled availability. The first scheme appearing in the list is given the highest priority, the second scheme has second highest priority, etc. In other words, if according to its schedule, the first operation scheme is available, then it is used by the simulation to define how the plant or condenser loop operates. If it is not available, the second operation scheme in the list is checked to see if it is available until the highest priority scheme that is also available is found. To allow for simultaneous heating and cooling, there is one configuration where multiple operation schemes are available at a given timestep. This is allowed if a user inputs both a heating range based operation and a cooling range based operation with overlapping schedules. The simulation will look at the current loop demand to determine if the cooling scheme should be used or the heating scheme. In other cases, if two schemes overlap (are available at the same time), a fatal error will be encountered.

PlantEquipmentOperationSchemes

Field: Name

This alpha field contains the identifying name given to the Plant Operation Scheme. This name is placed in the Plant Loop object to select this scheme.

Field Set: (Component Object Type, Name, Schedule) up to 8

Operation schemes are listed in "priority" order. Note that each scheme must address the entire load and/or condition ranges for the simulation. The actual one selected for use will be the first that is "Scheduled" on. That is, if control scheme 1 is not "on" and control scheme 2 is -- then control scheme 2 is selected. Only plant equipment should be listed on a Control Scheme for this item.

Field: Control Scheme <#> Object Type

This alpha field contains the keyword for the type of control scheme used. The options for plant control schemes are:

- PlantEquipmentOperation:Uncontrolled
- PlantEquipmentOperation:CoolingLoad
- PlantEquipmentOperation:HeatingLoad
- PlantEquipmentOperation:ComponentSetpoint

Field: Control Scheme <#> Name

This alpha field contains the identifying name given to the control scheme. These must be the named versions of the referenced Control Scheme (e.g.. a Uncontrolled Loop Operation with this name or a Cooling or Heating Load Range Based Operation with this name).

Field: Control Scheme <#> Schedule

This alpha field contains the schedule name for the control scheme. This schedule consists of weeks and days, with the days containing "0 or 1" for each hour of the day. This binary schedule (0 for off, 1 for on) determines if the control scheme is operating for that hour of day or not.

The IDD for the object is:

```
PlantEquipmentOperationSchemes,
  \memo Operation schemes are listed in "priority" order. Note that each scheme
  \memo must address the entire load and/or condition ranges for the simulation.
  \memo The actual one selected for use will be the first that is "Scheduled"
  \memo on. That is, if control scheme 1 is not "on" and control scheme 2
  \memo is -- then control scheme 2 is selected.
  \memo Only plant equipment should be listed on a Control Scheme for this item.
A1 , \field Name
     \required-field
     \reference PlantOperationSchemes
A2 , \field Control Scheme 1 Object Type
     \required-field
     \type choice
     \key PlantEquipmentOperation:CoolingLoad
     \key PlantEquipmentOperation:HeatingLoad
     \key PlantEquipmentOperation:Uncontrolled
     \key PlantEquipmentOperation:ComponentSetpoint
A3 , \field Control Scheme 1 Name
     \required-field
     \type object-list
     \object-list ControlSchemeList
A4 , \field Control Scheme 1 Schedule Name
     \required-field
     \type object-list
     \object-list ScheduleNames
A5 , \field Control Scheme 2 Object Type
     \type choice
     \key PlantEquipmentOperation:CoolingLoad
     \key PlantEquipmentOperation:HeatingLoad
     \key PlantEquipmentOperation:Uncontrolled
     \key PlantEquipmentOperation:ComponentSetpoint
A6 , \field Control Scheme 2 Name
     \type object-list
     \object-list ControlSchemeList
A7 , \field Control Scheme 2 Schedule Name
     \type object-list
     \object-list ScheduleNames
-- reduced for brevity --
```

Examples of this statement in two different IDFs:

```

PlantEquipmentOperationSchemes,
  CW Loop Operation,      !- Name
  PlantEquipmentOperation:CoolingLoad, ! Control Scheme 1 Object Type
  Peak Operation,        !- Control Scheme 1 Name
  On Peak,               !- Control Scheme 1 Schedule
  PlantEquipmentOperation:CoolingLoad, ! Control Scheme 2 Object Type
  Off Peak Operation,    !- Control Scheme 2 Name
  Off Peak;              !- Control Scheme 2 Schedule

PlantEquipmentOperationSchemes,
  CW Loop Operation,      !- Name
  PlantEquipmentOperation:CoolingLoad, ! Control Scheme 1 Object Type
  Central Chiller Only,   !- Control Scheme 1 Name
  PlantOnSched;          !- Control Scheme 1 Schedule

```

In the first IDF example, “PlantEquipmentOperation:CoolingLoad” is the type of control scheme. “Peak Operation” and “Off Peak Operation” are the names of two different load range based controls defined separately (see below --). “On Peak” and “Off Peak” are schedules defined elsewhere in the input file.

The load range based operation scheme has two statements associated with it: a main statement that defines the ranges that individual priority settings are valid and the lists of equipment that may be used for each range.

CondenserEquipmentOperationSchemes

Field: Name

This alpha field contains the identifying name given to the Condenser Operation Scheme.

Field Set: (Component Object Type, Name, Schedule) up to 8

Operation schemes are listed in "priority" order. Note that each scheme must address the entire load and/or condition ranges for the simulation. The actual one selected for use will be the first that is "Scheduled" on. That is, if control scheme 1 is not "on" and control scheme 2 is -- then control scheme 2 is selected. Only condenser equipment should be listed on a Control Scheme for this item.

Field: Control Scheme <#> Object Type

This alpha field contains the keyword for the type of control scheme used. The options for plant control schemes are:

This alpha field contains the keyword for the type of control scheme used. Currently, the available options are:

- PlantEquipmentOperation:Uncontrolled
- PlantEquipmentOperation:CoolingLoad
- PlantEquipmentOperation:HeatingLoad
- PlantEquipmentOperation:OutdoorDryBulb
- PlantEquipmentOperation:OutdoorWetBulb
- PlantEquipmentOperation:OutdoorDewpoint
- PlantEquipmentOperation:OutdoorRelativeHumidity
- PlantEquipmentOperation:OutdoorDryBulbDifference
- PlantEquipmentOperation:OutdoorWetBulbDifference
- PlantEquipmentOperation:OutdoorDewpointDifference

The condenser operation schemes apply to the equipment on the ‘supply side’ of the condenser loop—pumps, cooling towers, ground coupled heat exchangers, etc. The keywords select the algorithm that will be used to determine which equipment is available for each timestep. The Load Schemes schemes select a user specified set of equipment for each user specified range of a particular simulation variable. Load schemes compare the demand on the condenser supply side with specified load ranges and associated equipment

lists. Outdoor schemes compare the current value of an environmental parameter with user specified ranges of that parameter.

Field: Control Scheme <#> Name

This alpha field contains the identifying name given to the control scheme.

Field: Control Scheme <#> Schedule

This alpha field contains the schedule name for the control scheme. This schedule consists of weeks and days, with the days containing "0 or 1" for each hour of the day. This binary schedule (0 for off, 1 for on) determines which control scheme is operating for a particular hour. The schedule facilitates daily or seasonal changes in control schemes to meet demand side management or energy conservation goals.

Scheduling conflicts are handled by selecting the first available scheme in order of appearance in the list.

```
CondenserEquipmentOperationSchemes,
  \memo Operation schemes are listed in "priority" order. Note that each scheme
  \memo must address the entire load and/or condition ranges for the simulation.
  \memo The actual one selected for use will be the first that is "Scheduled"
  \memo on. That is, if control scheme 1 is not "on" and control scheme 2
  \memo is -- then control scheme 2 is selected.
  \memo Only condenser equipment should be listed on a Control Scheme for this item.
A1 , \field Name
  \required-field
  \reference CondenserOperationSchemes
A2 , \field Control Scheme 1 Object Type
  \required-field
  \type choice
  \key PlantEquipmentOperation:Uncontrolled
  \key PlantEquipmentOperation:CoolingLoad
  \key PlantEquipmentOperation:HeatingLoad
  \key PlantEquipmentOperation:OutdoorDryBulb
  \key PlantEquipmentOperation:OutdoorWetBulb
  \key PlantEquipmentOperation:OutdoorRelativeHumidity
  \key PlantEquipmentOperation:OutdoorDewpoint
  \key PlantEquipmentOperation:OutdoorDryBulbDifference
  \key PlantEquipmentOperation:OutdoorWetBulbDifference
  \key PlantEquipmentOperation:OutdoorDewpointDifference
A3 , \field Control Scheme 1 Name
  \required-field
  \type object-list
  \object-list ControlSchemeList
A4 , \field Control Scheme 1 Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
-- reduced for brevity --
```

Examples of this statement in two IDFs:

```
CondenserEquipmentOperationSchemes,
  Tower Loop Operation,      !- CondenserOperationSchemeName
  PlantEquipmentOperation:CoolingLoad, Control Scheme 1 Object Type
  Year Round Tower Operation, !- Control Scheme 1 Name
  PlantOnSched;              !- Control Scheme 1 Schedule

CondenserEquipmentOperationSchemes,Tower Loop Operation,
  PlantEquipmentOperation:CoolingLoad, Peak Load Operation, AFTERNOONSCHEDULE,
  PlantEquipmentOperation:CoolingLoad, OffPeak Load Operation, MORNINGSCHEDULE,
  PlantEquipmentOperation:OutdoorWetBulb, NightOperation, NIGHTSCHEDULE;
```

Each schedule (AFTERNOONSCHEDULE, MORNINGSCHEDULE, NIGHTSCHEDULE) invokes its associated operation scheme (Peak Load Operation, OffPeak Load Operation, NightOperation). The type of operation scheme and its name references the input syntax associated with the range specification and the associated equipment.

PlantEquipmentOperation:Uncontrolled

Uncontrolled loop operation simply specifies a group of equipment that runs ‘uncontrolled’. If the loop runs, this equipment will run also, unless turned off by the loop flow resolver to maintain continuity in the fluid loop.

Field: Name

This alpha field contains the identifying name for the control scheme.

Field: Equipment List Name

This alpha field contains the identifying name for the Equipment List. This field ties to the Load Range Equipment List input structure, which must also be defined.

PlantEquipmentOperation:CoolingLoad**PlantEquipmentOperation:HeatingLoad**

The PlantEquipmentOperation:CoolingLoad and PlantEquipmentOperation:HeatingLoad objects define the different ranges and which equipment list is valid for each range. After the keyword and the identifying name, a series of data trios is expected. In each trio, there is a lower limit for the load range, an upper limit for the load range, and a name that links to an equipment availability list (the PlantEquipmentList or CondenserEquipmentList objects).

Field: Name

This alpha field contains the identifying name for the control scheme.

Field Set: (Lower limit, Upper Limit, Equip List name) up to 10**Field: Load Range <#> Lower Limit**

This numeric field contains the lower demand range (W) for the equipment list. If demand is below this value, then this equipment list will not turn on to meet the demand.

Field: Load Range <#> Upper Limit

This numeric field contains the upper demand range (W) for the equipment list. If demand is above this value, then this equipment list will not turn on to meet the demand.

Field: Priority Control <#> Equipment List Name

This alpha field contains the identifying name for the Equipment List. This field ties to the Load Range Equipment List input structure, which must also be defined.

Below is the data description for the objects.

```
PlantEquipmentOperation:CoolingLoad,
A1 ,\field Name
  \required-field
  \reference ControlSchemeList
N1 ,\field Load Range 1 Lower Limit
  \required-field
  \type real
  \units W
  \minimum 0.0
N2 ,\field Load Range 1 Upper Limit
  \required-field
  \type real
  \units W
  \minimum 0.0
A2 ,\field Priority Control 1 Equipment List Name
  \required-field
  \type object-list
  \object-list PlantAndCondenserEquipmentLists
--reduced for brevity --
```

```

PlantEquipmentOperation:HeatingLoad,
  A1 ,\field Name
      \required-field
      \reference ControlSchemeList
  N1 ,\field Load Range 1 Lower Limit
      \required-field
      \type real
      \units W
      \minimum 0.0
  N2 ,\field Load Range 1 Upper Limit
      \required-field
      \type real
      \units W
      \minimum 0.0
  A2 ,\field Priority Control 1 Equipment List Name
      \required-field
      \type object-list
      \object-list PlantAndCondenserEquipmentLists
--reduced for brevity -

```

An example of these statements in an IDF is:

```

PlantEquipmentOperation:CoolingLoad, Peak Operation,
  0,7000, Chiller Plant,
  7000,24500, Chiller Plant and Purchased,
  24500,500000, Purchased Only;

```

This particular load based operation scheme has three different ranges. “Chiller Plant”, “Chiller Plant and Purchased”, and “Purchased Only” are names which link to various PlantEquipmentList or CondenserEquipmentList objects as described below. Gaps may be left in the operation scheme, but to operate equipment over the entire range, the upper limit of a given range must equal the lower limit of the next range as shown in the example.

PlantEquipmentOperation:OutdoorDryBulb

PlantEquipmentOperation:OutdoorWetBulb

PlantEquipmentOperation:OutdoorRelativeHumidity

PlantEquipmentOperation:OutdoorDewpoint

The outdoor operation objects define the different ranges of the various environmental parameters and which equipment list is valid for each range. After the keyword and the identifying name, a series of data trios is expected. In each trio, there is a lower limit for the load range, an upper limit for the load range, and a name that links to an equipment availability list (the CondenserEquipmentList). IDD excerpts are shown below:

```

PlantEquipmentOperation:OutdoorDryBulb,
  A1 ,\field Name
      \required-field
      \reference ControlSchemeList
  N1 ,\field Dry-bulb Temperature Range 1 Lower Limit
      \required-field
      \type real
      \units C
      \minimum -70
      \maximum 70
  N2 ,\field Dry-Bulb Temperature Range 1 Upper Limit
      \required-field
      \type real
      \units C
      \minimum -70
      \maximum 70
  A2 ,\field Priority Control 1 Equipment List Name
      \required-field
      \type object-list
      \object-list CondenserEquipmentLists
--reduced for brevity -

```

```

PlantEquipmentOperation:OutdoorWetBulb,
  A1 ,\field Name
    \required-field
    \reference ControlSchemeList
  N1 ,\field Wet-Bulb Temperature Range 1 Lower Limit
    \required-field
    \type real
    \units C
    \minimum -70
    \maximum 70
  N2 ,\field Wet-Bulb Temperature Range 1 Upper Limit
    \required-field
    \type real
    \units C
    f
    \maximum 70
  A2 ,\field Priority Control 1 Equipment List Name
    \required-field
    \type object-list
    \object-list CondenserEquipmentLists
--reduced for brevity -

```

```

PlantEquipmentOperation:OutdoorRelativeHumidity,
  A1 ,\field Name
    \required-field
    \reference ControlSchemeList
  N1 ,\field Relative Humidity Range 1 Lower Limit
    \required-field
    \type real
    \units percent
    \minimum 0.0
    \maximum 100.0
  N2 ,\field Relative Humidity Range 1 Upper Limit
    \required-field
    \type real
    \units percent
    \minimum 0.0
    \maximum 100.0
  A2 ,\field Priority Control 1 Equipment List Name
    \required-field
    \type object-list
    \object-list CondenserEquipmentLists
--reduced for brevity -

```

```

PlantEquipmentOperation:OutdoorDewpoint,
  A1 ,\field Name
    \required-field
    \reference ControlSchemeList
  N1 ,\field Dewpoint Temperature Range 1 Lower Limit
    \required-field
    \type real
    \units C
    \minimum -70
    \maximum 70
  N2 ,\field Dewpoint Temperature Range 1 Upper Limit
    \required-field
    \type real
    \units C
    \minimum -70
    \maximum 70
  A2 ,\field Priority Control 1 Equipment List Name
    \required-field
    \type object-list
    \object-list CondenserEquipmentLists
--reduced for brevity -

```

The fields for each of these are:

Field: Name

This alpha field contains the identifying name for the control scheme.

Field Set: (Lower limit, Upper Limit, Equip List name) up to 10

Field: <specific type> Range <#> Lower Limit

This numeric field contains the lower limit (C for temperature operations, Percent for relative humidity operations) for the equipment list. If specific value is below this value, then this equipment list will not turn on to meet the demand.

Field: <specific type> Range <#> Upper Limit

This numeric field contains the lower limit (C for temperature operations, Percent for relative humidity operations) for the equipment list. If specific value is above this value, then this equipment list will not turn on to meet the demand.

Field: Priority Control Equipment List <#> Name

This alpha field contains the identifying name for the Equipment List. This field ties to the Load Range Equipment List input structure, which must also be defined.

PlantEquipmentOperation:OutdoorDryBulbDifference

PlantEquipmentOperation:OutdoorWetBulbDifference

PlantEquipmentOperation:OutdoorDewpointDifference

The Delta Temperature based control strategies help to control any condenser equipment based on the difference between a reference node temperature and any environmental temperature. For example a cooling tower can be controlled by a strategy, which looks at the difference between the tower inlet temperature and wet-bulb temperature. A difference range is specified for each equipment list. IDD excerpts are shown below:

```
PlantEquipmentOperation:OutdoorDryBulbDifference,
A1 ,\field Name
    \required-field
    \reference ControlSchemeList
A2 ,\field Reference Temperature Node Name
    \required-field
    \type alpha
    \units C
N1,\field Dry-Bulb Temperature Difference Range 1 Lower Limit
    \type real
    \units C
    \minimum -50.0
    \maximum 100.0
N2,\field Dry-Bulb Temperature Difference Range 1 Upper Limit
    \type real
    \units C
    \minimum -50.0
    \maximum 100.0
A3, \field Switch 1 Type
    \type choice
    \key On
    \key Off
    \default On
A4 ,\field Priority Control 1 Equipment List Name
    \required-field
    \type object-list
    \object-list CondenserEquipmentLists
--reduced for Brevity--
```

```

PlantEquipmentOperation:OutdoorWetBulbDifference,
  A1 ,\field Name
      \required-field
      \reference ControlSchemeList
  A2 ,\field Reference Temperature Node Name
      \required-field
      \type alpha
      \units C
  N1,\field Wet-Bulb Temperature Difference Range 1 Lower Limit
      \type real
      \units C
      \minimum -50.0
      \maximum 100.0
  N2,\field Wet-Bulb Temperature Difference Range 1 Upper Limit
      \type real
      \units C
      \minimum -50.0
      \maximum 100.0
  A3, \field Switch 1 Type
      \type choice
      \key On
      \key Off
      \default On
  A4 ,\field Priority Control 1 Equipment List Name
      \required-field
      \type object-list
      \object-list CondenserEquipmentLists
--reduced for brevity--

```

Field: Name

This Alpha value contains the identifying name of the control strategy. This name appears as 'control scheme name' in Condenser Operation Scheme object.

Field: Reference Temperature Node Name

This Alpha value specifies the reference node for the operation scheme identified in the first field.

Field Set: (Lower limit, Upper limit, Switch Type, Equipment List)**Field: <specific type> Range <#> Lower Limit**

This numeric field specifies the minimum temperature difference required for the equipment specified in the equipment list to operate.

Field: <specific type> Range <#> Upper Limit

This numeric field specifies the maximum temperature difference below which the equipment specified in the equipment list is available.

Field: <specific type> Switch<#> Type.

This Alpha field specifies whether the equipment list specified for this range should be **On/Off**, for the limits set by the range. If the Switch type is OFF, all applicable equipment is turned OFF in the range. If the switch is ON, the equipment is turned ON in the range. This field allows the user to switch between equipment lists and provides additional flexibility in the control scheme.

Field: Priority Control <#> Equipment List Name

This alpha field specifies a single/group of objects, which are controlled by a particular scheme and is available for ranges specified.

PlantEquipmentOperation:ComponentSetpoint

In addition to load range based control on the plant loop, sequencing the plant components based on the outlet temperature of individual equipment is allowed. This scheme is common to many present-day Energy Management Systems sequencing. In this scheme, the sequencing is done based on the order specified in the control object described below.

Field: Name

This field specifies the name of the operation scheme.

Field Set: Equipment Object Type, Name, Demand Calculation Node, Setpoint Node, Flow Rate, Operation Type)

Field: Equipment <#> Object Type

This field specifies the type of equipment controlled by scheme.

Field: Equipment <#> Name

This field specifies the name of the controlled equipment.

Field: Demand Calculation <#> Node Name

The component demand will be calculated using the difference between the temperature at the demand node and the component set point temperature.

Field: Setpoint <#> Node Name

Each component controlled under temperature based control will have its own set point different from the loop set point. This field specifies component set point node (Generally its outlet temperatures). This node is acted upon by a SetpointManager in order to obtain the setpoint at any simulation timestep.

Field: Component <#> Flow Rate

This numeric field specifies the design flow rate for the component specified in earlier fields. This flow rate is used to calculate the component demand. The field can be set to autosize, if the user wants the program to calculate the design flow. This would generally be set to autosize when the user does not know the component flow rate and does a sizing calculation for the corresponding component.

Field: Operation<#> Type

This alpha field specifies the operation mode for the equipment. The equipment can be in any of the three modes viz. Cooling, Heating and Dual. Dual is used when the components both as heating and cooling equipment (for example heat pumps).

The IDD for the object is listed below:

```

PlantEquipmentOperation:ComponentSetpoint,
  A1, \field Name
      \required-field
      \reference ControlSchemeList
  A2, \field Equipment 1 Object Type
      \required-field
      \type alpha
  A3, \field Equipment 1 Name
      \required-field
      \type alpha
  A4, \field Demand Calculation 1 Node Name
      \required-field
      \type alpha
  A5, \field Setpoint 1 Node Name
      \required-field
      \type alpha
  N1, \field Component 1 Flow Rate
      \required-field
      \type real
      \units m3/s
      \autosizable
  A6, \field Operation 1 Type
      \required-field
      \type choice
      \key Heating
      \key Cooling
      \key Dual
<reduced for brevity>

```

And, as an example in an IDF:

```

PlantEquipmentOperationSchemes,
  CW Loop Operation,          !- PlantOperationSchemeName
  PlantEquipmentOperation:ComponentSetpoint, ! Control Scheme 1 Object Type
  Test Scheme,                !- Control Scheme 1 Name
  On;                          !- Control Scheme 1 Schedule

PlantEquipmentOperation:ComponentSetpoint,
  Test Scheme,
  CHILLER:ELECTRIC,          !- Equipment 1 Object Type
  Little Chiller,            !- Equipment 1 Name
  Little Chiller Inlet Node, !- Demand Calculation 1 Node Name
  Little Chiller Outlet Node, !- Setpoint 1 Node Name
  0.0011,                    !- Component 1 Flow Rate
  COOLING,                   !- Operation 1 Type
  CHILLER:ELECTRIC,          !- Equipment 2 Object Type
  Big Chiller,               !- Equipment 2 Name
  Big Chiller Inlet Node,    !- Demand Calculation 2 Node Name
  Big Chiller Outlet Node,   !- Setpoint 2 Node Name
  0.0011,                    !- Component 2 Flow Rate
  COOLING;                   !- Operation 2 Type

```

PlantEquipmentList

CondenserEquipmentList

The **PlantEquipmentList** and **CondenserEquipmentList** specify available plant and condenser loop equipment respectively for any loop operation scheme. Each statement contains the object name, an identifying name (which links the definition back to one of the operation scheme statements and a variable length of data pairs. These pairs refer to a plant equipment type and an identifying name. The type in this list of pairs must correspond to a valid plant object as described in the next subsection.

Field: Name

This alpha field contains the identifying name for the Equipment List.

Field Set: (Object Type, Name) up to 10

Remember the order of equipment on this list determines operation priority. Equipment on the list first will try to meet demand first. These fields tie to the Equipment Definition input structure, which must also be defined.

Field: Equipment <#> Object Type

This alpha field contains the keyword for the type of equipment in operation. Example: (Chiller:Electric, DistrictCooling). The full list of allowable plant equipment is again found as the objects in the section (Group – Plant Equipment).

Field: Equipment <#> Name

This alpha field contains the identifying name for the equipment in operation. This distinguishes between two different pieces of equipment of the same type.

```
PlantEquipmentList,
  \memo List plant equipment in order of operating priority, 1st in list will be used 1st, etc
  \memo Use only plant equipment in this list.
A1 , \field Name
      \required-field
      \reference PlantAndCondenserEquipmentLists
      \reference PlantEquipmentLists
A2 , \field Equipment 1 Object Type
      \required-field
A3 , \field Equipment 1 Name
      \required-field
--reduced for brevity --

CondenserEquipmentList,
  \memo List condenser equipment in order of operating priority, 1st in list will be used 1st, etc
  \memo Use only condenser equipment in this list.
A1 , \field Name
      \required-field
      \reference PlantAndCondenserEquipmentLists
      \reference CondenserEquipmentLists
A2 , \field Equipment 1 Object Type
      \required-field
A3 , \field Equipment 1 Name
      \required-field
--reduced for brevity --
```

An example of this statement in an IDF is:

```
PlantEquipmentList, Chiller Plant and Purchased,
  Chiller:Electric, Big Chiller,
  DistrictCooling, Purchased Cooling;
```

Note that this list is the middle range defined in the PlantEquipmentOperation:CoolingLoad statement named “Peak Operation” above. This defines the equipment available when the load encountered by the plant (chiller water demand, for example) is between 7000 W and 24500 W. EnergyPlus will run the “Big Chiller” first up to its capacity and then attempt to meet the remaining load (while in that range) with the next piece of equipment (in this case, “Purchased:Cooling”) in the list.

Group – Plant Equipment**Equipment Types**

In each **PlantEquipmentList** described using the above syntax, various equipment types and names must be given. Each type-name pair must then have a corresponding equipment definition. This subsection lists the various equipment types that are available and examples from an IDF. Where appropriate, notes and comments on the input structure are provided.

Generic Chiller Outputs

Many output variable names are common across all chiller types. These generic chiller output names all begin with the word "Chiller". Certain chiller types have additional output variables which are specific to that type of chiller. Specific chiller output names begin with the chiller type, for example, "Gas Absorption Chiller Heating Energy [J]." Chiller energy use is added to the appropriate plant-level meters as a cooling end-use.

```
HVAC,Average,Chiller Electric Power [W]
HVAC,Sum,Chiller Electric Consumption [J]
Zone,Meter,Electricity:Plant [J]
Zone,Meter,Cooling:Electricity [J]

HVAC,Average,Chiller Evap Heat Trans Rate [W]
HVAC,Sum,Chiller Evap Heat Trans [J]
Zone,Meter,EnergyTransfer:Plant [J]
Zone,Meter,Chillers:EnergyTransfer [J]
HVAC,Average,Chiller Evap Water Inlet Temp [C]
HVAC,Average,Chiller Evap Water Outlet Temp [C]
HVAC,Average,Chiller Evap Water Mass Flow Rate [kg/s]

HVAC,Average,Chiller Cond Heat Trans Rate [W]
HVAC,Sum,Chiller Cond Heat Trans [J]
Zone,Meter,HeatRejection:EnergyTransfer [J]

HVAC,Average,Chiller COP [W/W]
```

The following output is applicable only for air-cooled or evap-cooled chillers

```
HVAC,Average,Chiller Cond Air Inlet Temp [C]
```

The following three outputs are only available for water-cooled chillers

```
HVAC,Average,Chiller Cond Water Inlet Temp [C]
HVAC,Average,Chiller Cond Water Outlet Temp [C]
HVAC,Average,Chiller Cond Water Mass Flow Rate [kg/s]
```

```
HVAC,Average,Chiller Shaft Power [W]
HVAC,Sum,Chiller Shaft Energy [J]

Zone,Meter,HeatRecovery:EnergyTransfer [J]
HVAC,Average,Chiller Lube Heat Recovery Rate [W]
HVAC,Sum,Chiller Lube Heat Recovery [J]
HVAC,Average,Chiller Jacket Heat Recovery Rate [W]
HVAC,Sum,Chiller Jacket Heat Recovery [J]
HVAC,Average,Chiller Exhaust Heat Recovery Rate [W]
HVAC,Sum,Chiller Exhaust Heat Recovery [J]
HVAC,Average,Chiller Total Heat Recovery Rate [W]
HVAC,Sum,Chiller Total Heat Recovery [J]
HVAC,Average,Chiller Exhaust Stack Temp[C]
HVAC,Average,Chiller Heat Recovery Inlet Temp [C]
HVAC,Average,Chiller Heat Recovery Outlet Temp [C]
HVAC,Average,Chiller Heat Recovery Mass Flow Rate [kg/s]
```

The following blocks of outputs are for steam and fuel-driven chillers

```
HVAC,Average,Chiller Gas Consumption Rate [W]
HVAC,Sum,Chiller Gas Consumption [J]
Zone,Meter,Gas:Plant [J]
Zone,Meter,Cooling:Gas [J]
HVAC,Average,Chiller Gas Mass Flow Rate [kg/s]
HVAC,Sum,Chiller Gas Mass Consumption [kg]
```

For steam absorption chillers:

HVAC,Average,Chiller Steam Consumption Rate [W]
 HVAC,Sum,Chiller Steam Consumption [J]
 Zone,Meter,Steam:Plant [J]
 Zone,Meter,Cooling:Steam [J]
 HVAC,Average,Chiller Steam Mass Flow Rate [kg/s]

For hot water absorption chillers:

HVAC,Average,Chiller Hot Water Consumption Rate [W]
 HVAC,Sum,Chiller Hot Water Consumption [J]
 Zone,Meter,Steam:Plant [J]
 Zone,Meter,Cooling:EnergyTransfer [J]
 HVAC,Average,Chiller Hot Water Mass Flow Rate [kg/s]

The following output is applicable only for indirect absorption chillers

HVAC,Average,Chiller Part-Load Ratio
 HVAC,Average,Chiller Cycling Fraction

HVAC,Average,Chiller Propane Consumption Rate [W]
 HVAC,Sum,Chiller Propane Consumption [J]
 Zone,Meter,Propane:Plant [J]
 Zone,Meter,Cooling:Propane [J]
 HVAC,Average,Chiller Propane Mass Flow Rate [kg/s]

HVAC,Average,Chiller Diesel Consumption Rate [W]
 HVAC,Sum,Chiller Diesel Consumption [J]
 Zone,Meter,Diesel:Plant [J]
 Zone,Meter,Cooling:Diesel [J]
 HVAC,Average,Chiller Diesel Mass Flow Rate [kg/s]

HVAC,Average,Chiller Gasoline Consumption Rate [W]
 HVAC,Sum,Chiller Gasoline Consumption [J]
 Zone,Meter,Gasoline:Plant [J]
 Zone,Meter,Cooling:Gasoline [J]
 HVAC,Average,Chiller Gasoline Mass Flow Rate [kg/s]

HVAC,Average,Chiller FuelOil#1 Consumption Rate [W]
 HVAC,Sum,Chiller FuelOil#1 Consumption [J]
 Zone,Meter,FuelOil#1:Plant [J]
 Zone,Meter,Cooling:FuelOil#1 [J]
 HVAC,Average,Chiller FuelOil#1 Mass Flow Rate [kg/s]

HVAC,Average,Chiller FuelOil#2 Consumption Rate [W]
 HVAC,Sum,Chiller FuelOil#2 Consumption [J]
 Zone,Meter,FuelOil#2:Plant [J]
 Zone,Meter,Cooling:FuelOil#2 [J]
 HVAC,Average,Chiller FuelOil#2 Mass Flow Rate [kg/s]

Chiller Electric Power [W]***Chiller Electric Consumption [J]***

These outputs are the electric power input to the chiller. In the case of steam or fuel-powered chillers, this represents the internal chiller pumps and other electric power consumption. Consumption is metered on Cooling:Electricity, Electricity:Plant, and Electricity:Facility.

Chiller Evap Heat Trans Rate [W]***Chiller Evap Heat Trans [J]***

These outputs are the evaporator heat transfer which is the cooling delivered by the chiller. Chiller Evap Heat Trans is metered on Chillers:EnergyTransfer, EnergyTransfer:Plant, and EnergyTransfer:Facility.

Chiller Evap Water Inlet Temp [C]**Chiller Evap Water Outlet Temp [C]****Chiller Evap Water Mass Flow Rate [kg/s]**

These outputs are the evaporator (chilled water) inlet and outlet temperatures and flow rate.

Chiller COP [W/W]

This output is the coefficient of performance for the chiller during cooling operation. It is calculated as the evaporator heat transfer rate (Chiller Evap Heat Trans Rate) divided by the “fuel” consumption rate by the chiller. For the constant COP and electric chillers, the “fuel” is electricity so the divisor is Chiller Electric Power [W]. For the absorption chiller, the “fuel” is steam so the divisor is Steam Consumption Rate [W].

For the engine driven chiller and combustion turbine chiller, the output variable is renamed as Chiller Fuel COP to clarify that the primary energy input to the chiller is a gaseous or liquid fuel (natural gas, diesel, gasoline, etc.). The divisor is the appropriate fuel consumption rate (Chiller [fuel type] Consumption Rate).

For the direct fired absorption chiller, this variable is renamed as Direct Fired Absorption Chiller Cooling Fuel COP and the divisor is Direct Fired Absorption Chiller Cooling Gas Consumption Rate.

Note that this variable is reported as zero when the chiller is not operating. When reported for frequencies longer than "detailed" (such as timestep, hourly, daily, monthly or environment), this output will only be meaningful when the chiller is operating for the entire reporting period. To determine an average COP for a longer time period, compute the COP based on total evaporator heat transfer divided by total electric or fuel input over the desired period.

Chiller Part-Load Ratio

This output is the operating part-load ratio of the indirect absorption chiller. This output may fall below the minimum part-load ratio specified in the input. For this case, the Chiller Cycling Fraction is used to further define the performance of the indirect absorption chiller.

Chiller Cycling Fraction

This output is the fraction of the timestep the indirect absorption chiller operates. When the chiller operates above the minimum part-load ratio, a chiller cycling fraction of 1 is reported. When the chiller operates below the minimum part-load ratio, the chiller cycling fraction reports the fraction of the timestep the indirect absorption chiller operates.

Chiller Cond Heat Trans Rate [W]**Chiller Cond Heat Trans [J]**

These outputs are the condenser heat transfer which is the heat rejected from the chiller to either a condenser water loop or through an air-cooled condenser. Chiller Cond Heat Trans is metered on HeatRejection:EnergyTransfer, EnergyTransfer:Plant, and EnergyTransfer:Facility.

Chiller Cond Air Inlet Temp [C]

This output is the condenser (heat rejection) inlet temperature for air-cooled or evap-cooled chillers. For an air-cooled chiller, this output would be the dry-bulb temperature of the air entering the condenser coil. For an evap-cooled chiller, this output would be the wet-bulb temperature of the air entering the evaporatively-cooled condenser coil.

Chiller Cond Water Inlet Temp [C]**Chiller Cond Water Outlet Temp [C]****Chiller Cond Water Mass Flow Rate [kg/s]**

These outputs are the condenser (heat rejection) inlet and outlet temperatures and flow rate for water-cooled chillers.

Chiller Shaft Power [W]**Chiller Shaft Energy [J]**

For engine-driven and turbine-driven chillers, these outputs are the shaft power produced by the prime mover and transferred to the chiller compressor.

Chiller Lube Heat Recovery Rate [W]**Chiller Lube Heat Recovery [J]****Chiller Jacket Heat Recovery Rate [W]****Chiller Jacket Heat Recovery [J]****Chiller Exhaust Heat Recovery Rate [W]****Chiller Exhaust Heat Recovery [J]****Chiller Total Heat Recovery Rate [W]****Chiller Total Heat Recovery [J]**

For chillers with heat recovery, such as engine-driven chillers, these outputs are the components of recoverable energy available. For a given chiller type, one or more of the following components may be applicable: Lube (engine lubricant), Jacket (engine coolant), Exhaust (engine exhaust), and Total. Chiller Lube Heat Recovery, Chiller Jacket Heat Recovery, and Chiller Exhaust Heat Recovery are metered on HeatRecovery:EnergyTransfer, EnergyTransfer:Plant, and EnergyTransfer:Facility.

Chiller Exhaust Stack Temp [C]

This is the exhaust temperature leaving an engine chiller.

Chiller Heat Recovery Inlet Temp [C]**Chiller Heat Recovery Outlet Temp [C]****Chiller Heat Recovery Mass Flow Rate [kg/s]**

These outputs are the heat recovery inlet and outlet temperatures and flow rate for chillers with heat recovery such as engine-driven and gas turbine chillers.

Chiller <FuelType> Consumption Rate [W]**Chiller <FuelType> Consumption [J]****Chiller <FuelType> Mass Flow Rate [kg/s]****Chiller Gas Mass Consumption [kg] (Gas Turbine Chiller only)**

These outputs are the steam or fuel input for steam or fuel-fired chillers. Valid fuel types depend on the type of chiller. <FuelType> may be one of: Gas (natural gas), Steam, Propane, Diesel, Gasoline, FuelOil#1, and FuelOil#2. Consumption is metered on Cooling:<FuelType>, <FuelType>:Plant, and <FuelType>:Facility.

Chiller:Absorption**Field: Name**

This alpha field contains the identifying name for the absorption chiller.

Field: Nominal Capacity

This numeric field contains the nominal cooling capability of the chiller in Watts.

Field: Nominal Pumping Power

This numeric field contains the nominal pumping power of the absorber in Watts.

Field: Chilled Water Inlet Node Name

This required alpha field contains the identifying name for the absorption chiller plant side inlet node.

Field: Chilled Water Outlet Node Name

This required alpha field contains the identifying name for the absorption chiller plant side outlet node.

Field: Condenser Inlet Node Name

This required alpha field contains the identifying name for the absorption chiller condenser side inlet node.

Field: Condenser Outlet Node Name

This required alpha field contains the identifying name given to the Heat Recovery Loop Component Outlet Node.

Field: Minimum Part Load Ratio

This numeric field contains the absorption chiller's minimum part load ratio. The expected range is between 0 and 1. The minimum part load is not the load where the machine shuts off, but where the amount of power remains constant to produce smaller loads than this fraction.

Field: Maximum Part Load Ratio

This numeric field contains the absorption chiller's maximum part load ratio. This value may exceed 1, but the normal range is between 0 and 1.1.

Field: Optimum Part Load Ratio

This numeric field contains the absorption chiller's optimum part load ratio. This is the part load ratio at which the chiller performs at its maximum COP.

Field: Design Condenser Inlet Temperature

This numeric field contains the absorption chiller's condenser inlet design temperature in Celsius.

Field: Design Chilled Water Flow Rate

For variable volume chiller this is the maximum flow and for constant flow chiller this is the design flow rate. The units are in cubic meters per second.

Field: Design Condenser Water Flow Rate

This numeric field contains the absorption chiller's design condenser water flow rate in cubic meters per second.

Generator Heat Input Part Load Ratio Curve

The Generator Heat Input Part Load Ratio Curve is a quadratic equation that determines the Ratio of the generator load on the absorber to the demand on the chiller. The defining equation is:

$$\text{SteamInputRatio} = \frac{C1}{PLR} + C2 + C3 * PLR$$

The following three fields contain the coefficients for the equation.

Field: Coefficient 1 of the Steam Use Part Load Ratio Curve

C1 in the Generator Heat Input Part Load Ratio Curve. This value is obtained by fitting manufacturers' performance data to the curve.

Field: Coefficient 2 of the Steam Use Part Load Ratio Curve

C2 in the Generator Heat Input Part Load Ratio Curve. This value is obtained by fitting manufacturers' performance data to the curve.

Field: Coefficient 3 of the Steam Use Part Load Ratio Curve

C3 in the Generator Heat Input Part Load Ratio Curve. This value is obtained by fitting manufacturers' performance data to the curve.

Pump Electric Use Part Load Ratio Curve

The Pump Electric Use Part Load Ratio Curve is a quadratic equation that determines the Ratio of the actual absorber pumping power to the nominal pumping power. The defining equation is:

$$\text{ElectricInputRatio} = C1 + C2 * PLR + C3 * PLR^2$$

The following three fields contain the coefficients for the equation.

Field: Coefficient 1 of the Pump Electric Use Part Load Ratio Curve

C1 in the Pump Electric Use Part Load Ratio Curve. This value is obtained by fitting manufacturers' performance data to the curve.

Field: Coefficient 2 of the Pump Electric Use Part Load Ratio Curve

C2 in the Pump Electric Use Part Load Ratio Curve. This value is obtained by fitting manufacturers' performance data to the curve.

Field: Coefficient 3 of the Pump Electric Use Part Load Ratio Curve

C3 in the Pump Electric Use Part Load Ratio Curve. This value is obtained by fitting manufacturers' performance data to the curve.

Field: Chilled Water Outlet Temperature Lower Limit

This numeric field contains the lower limit for the evaporator outlet temperature. This temperature acts as a cut off for heat transfer in the evaporator, so that the fluid doesn't get too cold.

Field: Generator Inlet Node Name

This alpha field contains the identifying name given to the Generator Inlet Node. A steam or hot water loop is not required to simulate an absorption chiller. If a steam/hot water loop is used, enter the name of the generator inlet node.

Field: Generator Outlet Node Name

This alpha field contains the identifying name given to the Generator Outlet Node. A steam or hot water loop is not required to simulate an absorption chiller. If a steam/hot water loop is used, enter the name of the generator outlet node.

Field: Chiller Flow Mode

This alpha field determines if the Chiller is either a VariableFlow or ConstantFlow Chiller Simulation. The default, if not specified, is VariableFlow.

Field: Generator Fluid Type

This choice field specifies the type of fluid used to heat the generator solution. The valid choices are **HotWater** or **Steam**. This field should be specified as Steam or left blank if the generator inlet/outlet nodes are not specified.

Field: Design Generator Fluid Flow Rate

This numeric field contains the absorption chiller's design condenser fluid flow rate in cubic meters per second.

Field: Degree of Subcooling in Steam Generator

Ideally, the steam trap located at the outlet of the generator should remove all the condensate immediately, however, there is a delay in this process in actual systems which causes the condensate to SubCool by a certain amount before leaving the generator. This amount of subcooling is included in the heat transferred to the solution in the generator. The minimum value is 0° Celsius and default is 5° Celsius. This field is not used when the generator inlet/outlet node are not specified or the generator is connected to a hot water loop.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. For this component the inputs that would be altered by the sizing factor are: Nominal Capacity, Nominal Pumping Power, Design Chilled Water Flow Rate, Design Condenser Water Flow Rate and Design Generator Fluid Flow Rate. Sizing factor allows the user to size a component to meet part of the design load while continuing to use the autosizing feature.

Below is the input data dictionary description for the Absorption Chiller.

```
Chiller:Absorption,
  \min-fields 23
  \memo This indirect absorption chiller model is the empirical model from the
  \memo Building Loads and System Thermodynamics (BLAST) program. Chiller
  \memo performance curves are generated by fitting catalog data to third order
  \memo polynomial equations. Two sets of coefficients are required.
A1 , \field Name
  \required-field
N1 , \field Nominal Capacity
  \type real
  \units W
  \required-field
  \minimum> 0.0
  \autosizable
N2 , \field Nominal Pumping Power
  \units W
  \required-field
  \ip-units W
  \minimum 0.0
  \autosizable
```

```

A2 , \field Chilled Water Inlet Node Name
    \required-field
A3 , \field Chilled Water Outlet Node Name
    \required-field
A4 , \field Condenser Inlet Node Name
    \required-field
A5 , \field Condenser Outlet Node Name
    \required-field
N3 , \field Minimum Part Load Ratio
    \minimum 0.0
N4 , \field Maximum Part Load Ratio
    \minimum 0.0
N5 , \field Optimum Part Load Ratio
    \minimum 0.0
N6 , \field Design Condenser Inlet Temperature
    \units C
N7 , \field Design Chilled Water Flow Rate
    \note For variable volume this is the max flow & for constant flow this is the flow.
    \type real
    \units m3/s
    \minimum > 0
    \autosizable
    \ip-units gal/min
N8 , \field Design Condenser Water Flow Rate
    \Note The steam use coefficients below specify the
    \Note steam use as a fraction of chiller operating capacity
    \type real
    \units m3/s
    \autosizable
    \minimum > 0.0
    \ip-units gal/min
N9 , \field Coefficient 1 of the Steam Use Part Load Ratio Curve
N10, \field Coefficient 2 of the Steam Use Part Load Ratio Curve
N11, \field Coefficient 3 of the Steam Use Part Load Ratio Curve
N12, \field Coefficient 1 of the Pump Electric Use Part Load Ratio Curve
    \Note The pump electric use coefficients specify the
    \Note pumping power as a Fraction of Nominal pumping power
N13, \field Coefficient 2 of the Pump Electric Use Part Load Ratio Curve
N14, \field Coefficient 3 of the Pump Electric Use Part Load Ratio Curve
N15, \field Chilled Water Outlet Temperature Lower Limit
    \units C
A6 , \field Generator Inlet Node Name
A7 , \field Generator Outlet Node Name
A8 , \field Chiller Flow Mode
    \note Sets this chiller to a VariableFlow or ConstantFlow simulation
    \type choice
    \key ConstantFlow
    \key VariableFlow
    \default VariableFlow
A9 , \field Generator Fluid Type
    \type choice
    \key Steam
    \key HotWater
    \default Steam
    \note This field should be specified as Steam or left blank if generator inlet/outlet nodes are not
used.
N16, \field Design Generator Fluid Flow Rate
    \type real
    \autosizable
    \units m3/s
    \minimum > 0.0
N17, \field Degree of Subcooling in Steam Generator
    \type real
    \units C
    \default 1.0
    \note This field is not used when the generator inlet/outlet nodes are not specified or
    \note the generator is connected to a hot water loop.

```



```

N18; \field Sizing Factor
      \note Multiplies the autosized capacity and flow rates
      \type real
      \minimum> 0.0
      \default 1.0

```

Following is an example input for an Absorption Chiller.

```

Chiller:Absorption,
  Big Chiller,           !- Chiller Name
  50000,                 !- Nominal Capacity {W}
  250,                  !- Nominal Pumping Power {W}
  Big Chiller Inlet Node, !- Plant_Side_Inlet_Node
  Big Chiller Outlet Node, !- Plant_Side_Outlet_Node
  Big Chiller Condenser Inlet Node, !- Condenser_Side_Inlet_Node
  Big Chiller Condenser Outlet Node, !- Condenser_Side_Outlet_Node
  0.15,                 !- Minimum Part Load Ratio
  1.0,                  !- Maximum Part Load Ratio
  0.65,                 !- Opt Part Load Ratio
  35.0,                 !- Temp Design Condenser Inlet {C}
  0.0011,               !- Design Chilled Water Flow Rate {m3/s}
  0.0011,               !- Design Condenser Water Flow Rate {m3/s}
  0.03303,              !- Coefficient1 of the steam use part load ratio curve
  0.6852,               !- Coefficient2 of the steam use part load ratio curve
  0.2818,               !- Coefficient3 of the steam use part load ratio curve
  1.0,                  !- Coefficient1 of the pump electric use part load ratio curve
  0,                    !- Coefficient2 of the pump electric part load ratio curve
  0,                    !- Coefficient3 of the pump electric use part load ratio curve
  5,                    !- Chilled Water Outlet Temperature Lower Limit {C}
  AbsorberSteamInletNode, !- Generator Inlet Node Name
  AbsorberSteamOutletNode, !- Generator Outlet Node Name
  VariableFlow,         !- Chiller Flow Mode
  Steam,                !- Generator Fluid Type
  autosize,             !- Design Generator Volumetric Fluid Flow Rate {m3/s}
  2.0;                  !- Degree of Subcooling in Steam Generator {C}

```

Absorption Chiller Outputs

```

HVAC,Average,Chiller Electric Power [W]
HVAC,Sum,Chiller Electric Consumption [J]
Zone,Meter,Electricity:Plant [J]
Zone,Meter,Cooling:Electricity [J]

HVAC,Average,Chiller Evap Heat Trans Rate [W]
HVAC,Sum,Chiller Evap Heat Trans [J]
Zone,Meter,EnergyTransfer:Plant [J]
Zone,Meter,Chillers:EnergyTransfer [J]
HVAC,Average,Chiller Evap Water Inlet Temp [C]
HVAC,Average,Chiller Evap Water Outlet Temp [C]
HVAC,Average,Chiller Evap Water Mass Flow Rate [kg/s]

HVAC,Average,Chiller Cond Heat Trans Rate [W]
HVAC,Sum,Chiller Cond Heat Trans [J]
Zone,Meter,HeatRejection:EnergyTransfer [J]
HVAC,Average,Chiller Cond Water Inlet Temp [C]
HVAC,Average,Chiller Cond Water Outlet Temp [C]
HVAC,Average,Chiller Cond Water Mass Flow Rate [kg/s]

HVAC,Average,Chiller COP [W/W]

For Chillers with Steam Generators:
HVAC,Average, Chiller Steam Consumption Rate [W]
HVAC,Sum, Chiller Steam Consumption [J]
Zone,Meter,Steam:Plant [J]
Zone,Meter,Cooling:Steam [J]
HVAC,Average,Chiller Steam Mass Flow Rate [kg/s]

```

```
For Chillers with Hot Water Generators:  
HVAC,Average,Chiller Hot Water Consumption Rate [W]  
HVAC,Sum,Chiller Hot Water Consumption [J]  
Zone,Meter,EnergyTransfer:Plant [J]  
Zone,Meter,Cooling:EnergyTransfer [J]  
HVAC,Average,Chiller Hot Water Mass Flow Rate [kg/s]
```

These chiller output variables are defined above under "Generic Chiller Outputs."

Chiller:Absorption:Indirect

The Chiller:Absorption:Indirect object is an enhanced version of the absorption chiller model found in the Building Loads and System Thermodynamics (BLAST) program. This enhanced model is nearly identical to the existing absorption chiller model (Ref. Chiller:Absorption) with the exceptions that: 1) the enhanced indirect absorption chiller model provides more flexible performance curves and 2) chiller performance now includes the impact of varying evaporator, condenser, and generator temperatures. Since these absorption chiller models are nearly identical (i.e., the performance curves of the enhanced model can be manipulated to produce similar results to the previous model), it is quite probable that the Chiller:Absorption model will be deprecated in a future release of EnergyPlus.

Field: Name

This required alpha field contains the identifying name for the indirect absorption chiller.

Field: Nominal Capacity

This required numeric field contains the nominal cooling capability of the chiller in Watts. This field must be greater than 0 and is autosizable.

Field: Nominal Pumping Power

This required numeric field contains the nominal pumping power of the chiller in Watts. The minimum value for this field is 0 and is autosizable.

Field: Chilled Water Inlet Node Name

This required alpha field contains the identifying name for the chiller chilled water inlet node.

Field: Chilled Water Outlet Node Name

This required alpha field contains the identifying name for the chiller chilled water outlet node.

Field: Condenser Inlet Node Name

This required alpha field contains the identifying name for the chiller condenser inlet node.

Field: Condenser Outlet Node Name

This required alpha field contains the identifying name given to the chiller outlet node.

Field: Minimum Part Load Ratio

This numeric field contains the chiller's minimum part-load ratio. The expected range is between 0 and 1. The minimum part load is not the load where the machine shuts off, but where the amount of power remains constant to produce smaller loads than this fraction.

Field: Maximum Part Load Ratio

This numeric field contains the chiller's maximum part-load ratio. This value may exceed 1, but the normal range is between 0 and 1.1.

Field: Optimum Part Load Ratio

This numeric field contains the chiller's optimum part-load ratio. This is the part-load ratio at which the chiller performs at its maximum COP.

Field: Design Condenser Inlet Temperature

This numeric field contains the chiller's condenser inlet design temperature in Celsius. The default value for this field is 30° C and is only used when the Design Chilled Water Flow Rate is autosized.

Field: Condenser Inlet Temperature Lower Limit

This numeric field contains the chiller's lower limit for the condenser entering water temperature in Celsius. The default value for this field is 15° C. If this limit is exceeded, a warning message will report the incident. No correction to chiller capacity is made for low condenser entering water temperatures.

Field: Chilled Water Outlet Temperature Lower Limit

This numeric field contains the chiller's lower limit for the evaporator leaving water temperature in Celsius. The default value for this field is 5° C. If this limit is exceeded, a warning message will report the incident. No correction to chiller capacity is made for low evaporator leaving water temperatures.

Field: Design Chilled Water Flow Rate

This numeric input specifies the design evaporator volumetric flow rate in cubic meters per second. The value specified must be greater than 0 or this field is autosizable. For variable volume chiller this is the maximum flow and for constant flow chiller this is the design flow rate.

Field: Design Condenser Water Flow Rate

This numeric field specifies the chiller's design condenser water flow rate in cubic meters per second. The value specified must be greater than 0 or this field is autosizable.

Field: Chiller Flow Mode

This choice field determines if the chiller is a VariableFlow or ConstantFlow chiller. The default value is VariableFlow.

Field: Generator Heat Input Function of Part Load Ratio Curve Name

This required alpha field specifies the name of the curve used to determine the heat input to the chiller. The curve is a quadratic or cubic curve which characterizes the heat input as a function of chiller part-load ratio. The curve output is multiplied by the chiller's nominal capacity and operating part-load ratio or minimum part-load ratio, whichever is greater, to determine the amount of heat input required for the given operating conditions.

Field: Pump Electric Input Function of Part Load Ratio Curve Name

This alpha field specifies the name of the curve used to determine the pump electrical input to the chiller. The curve is a quadratic or cubic curve which characterizes the pump electrical power as a function of chiller part-load ratio. The curve output is multiplied by the chiller's nominal pumping power and operating part-load ratio or minimum part-load ratio, whichever is greater, to determine the amount of pumping power required for the given operating conditions.

Field: Generator Inlet Node Name

This alpha field contains the identifying name given to the Generator Inlet Node. A steam or hot water loop is not required to simulate an indirect absorption chiller. If a steam/hot water loop is used, enter the name of the generator inlet node.

Field: Generator Outlet Node Name

This alpha field contains the identifying name given to the Generator Outlet Node. A steam or hot water loop is not required to simulate an indirect absorption chiller. If a steam/hot water loop is used, enter the name of the generator outlet node.

Field: Capacity Correction Function of Condenser Temperature Curve Name

This alpha field specifies the name of a quadratic or cubic curve which correlates the chiller's evaporator capacity as a function of condenser entering water temperature. This curve is used to correct nominal capacity at off-design condensing temperatures.

Field: Capacity Correction Function of Chilled Water Temperature Curve Name

This alpha field specifies the name of a quadratic or cubic curve which correlates the chiller's evaporator capacity as a function of evaporator leaving water temperature. This curve is used to correct nominal capacity at off-design evaporator temperatures.

Field: Capacity Correction Function of Generator Temperature Curve Name

This alpha field specifies the name of a quadratic or cubic curve which correlates the chiller's evaporator capacity as a function of generator entering water temperature. This curve is used to correct nominal capacity at off-design evaporator temperatures and is only used when the Generator Fluid Type is specified as Hot Water.

Field: Generator Heat Input Correction Function of Condenser Temperature Curve Name

This alpha field specifies the name of a quadratic or cubic curve which correlates the chiller's heat input as a function of condenser entering water temperature. This curve is used to correct generator heat input at off-design condensing temperatures.

Field: Generator Heat Input Correction Function of Chilled Water Temperature Curve Name

This alpha field specifies the name of a quadratic or cubic curve which correlates the chiller's heat input as a function of evaporator leaving water temperature. This curve is used to correct generator heat input at off-design evaporator temperatures.

Field: Generator Heat Source Type

This choice field specifies the type of fluid used to heat the generator solution. The valid choices are **HotWater** or **Steam**. This input is used to identify the method used to calculate the generator mass flow rate. This field is not used if the generator inlet/outlet nodes are not specified. The default value is Steam.

Field: Design Generator Fluid Flow Rate

This numeric field specifies the chiller's design generator *fluid* flow rate in cubic meters per second. The value specified must be greater than 0 or this field is autosizable. For variable flow chillers this is the maximum generator flow rate, for constant flow chillers this is the flow rate.

Field: Temperature Lower Limit Generator Inlet

This numeric field specifies the lower limit of the generator's entering water temperature. This field is not used if the Generator Fluid Type is specified as steam.

Field: Degree of Subcooling in Steam Generator

Ideally the steam trap located at the outlet of generator should remove all the condensate immediately, however there is a delay in this process in actual systems which causes the condensate to SubCool by a certain degree before leaving the generator. This amount of subcooling is included in the heat transferred to the solution in the generator. The minimum value is 0° Celsius, the maximum value is 20° Celsius, and the default is 1° Celsius.

Field: Degree of Subcooling in Steam Condensate Loop

This essentially represents the heat loss to the atmosphere due to uninsulated condensate return piping to the boiler. Condensate return piping operates at atmospheric pressure and is not insulated. The condensate sub cools to certain degree before it is pumped back to the boiler. The minimum value is 0° Celsius and the default is 0° Celsius.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. For this component the inputs that would be altered by the sizing factor are: Nominal Capacity, Nominal Pumping Power, Design Chilled Water Flow Rate, Design Condenser Water Flow Rate and Design Generator Fluid Flow Rate. Sizing factor allows the user to size a component to meet part of the design load while continuing to use the autosizing feature.

Below is the input data dictionary description for the Indirect Absorption Chiller.

Chiller:Absorption:Indirect,

```

\min-fields 17
  \memo This indirect absorption chiller model is an enhanced model from the
  \memo Building Loads and System Thermodynamics (BLAST) program. Chiller
  \memo performance curves are generated by fitting catalog data to third order
  \memo polynomial equations. The chiller capacity is a function of condenser,
  \memo chilled water, and generator temperatures. The heat input is a function
  \memo of part-load ratio, condenser temperature, and chilled water temperature.
A1 , \field Name
    \type alpha
    \required-field
N1 , \field Nominal Capacity
    \type real
    \required-field
    \units W
    \minimum> 0.0
    \autosizable
N2 , \field Nominal Pumping Power
    \type real
    \required-field
    \units W
    \ip-units W
    \minimum 0.0
    \autosizable
A2 , \field Chilled Water Inlet Node Name
    \type alpha
    \required-field
A3 , \field Chilled Water Outlet Node Name
    \type alpha
    \required-field
A4 , \field Condenser Inlet Node Name
    \type alpha
    \required-field
A5 , \field Condenser Outlet Node Name
    \type alpha
    \required-field
N3 , \field Minimum Part Load Ratio
    \type real
    \minimum 0.0
N4 , \field Maximum Part Load Ratio
    \type real
    \minimum 0.0
N5 , \field Optimum Part Load Ratio
    \type real
    \minimum 0.0
N6 , \field Design Condenser Inlet Temperature
    \type real
    \units C
    \default 30.0
    \note Used only when condenser flow rate is autosized.
N7 , \field Condenser Inlet Temperature Lower Limit
    \type real
    \units C
    \default 15.0
    \note Provides warnings when entering condenser temperature is below minimum.
    \note Capacity is not adjusted when entering condenser temperature is below minimum.

```

```

N8 , \field Chilled Water Outlet Temperature Lower Limit
    \type real
    \units C
    \default 5.0
    \note Capacity is adjusted when leaving chilled water temperature is below minimum.
N9 , \field Design Chilled Water Flow Rate
    \type real
    \units m3/s
    \minimum> 0
    \autosizable
    \ip-units gal/min
    \note For variable flow this is the max flow & for constant flow this is the flow.
N10, \field Design Condenser Water Flow Rate
    \type real
    \units m3/s
    \autosizable
    \minimum> 0.0
    \ip-units gal/min
A6 , \field Chiller Flow Mode
    \type choice
    \key ConstantFlow
    \key VariableFlow
    \default VariableFlow
    \note Sets this chiller to a VariableFlow or ConstantFlow simulation
A7, \field Generator Heat Input Function of Part Load Ratio Curve Name
    \type object-list
    \required-field
    \object-list QuadraticCubicCurves
A8, \field Pump Electric Input Function of Part Load Ratio Curve Name
    \type object-list
    \object-list QuadraticCubicCurves
A9 , \field Generator Inlet Node Name
    \type alpha
    \note Enter the generator inlet node name which connects this chiller to a
    \note steam or hot water plant, otherwise leave this field blank.
    \note Generator nodes are used to model heat input to the chiller.
A10, \field Generator Outlet Node Name
    \type alpha
    \note Enter the generator outlet node name which connects this chiller to a
    \note steam or hot water plant, otherwise leave this field blank.
    \note Generator nodes are used to model heat input to the chiller.
A11, \field Capacity Correction Function of Condenser Temperature Curve Name
    \type object-list
    \object-list QuadraticCubicCurves
    \note Curve which shows the change in normalized capacity to changes in condenser temperature.
A12, \field Capacity Correction Function of Chilled Water Temperature Curve Name
    \type object-list
    \object-list QuadraticCubicCurves
    \note Curve which shows the change in normalized capacity to changes in leaving chilled water
temperature.
A13, \field Capacity Correction Function of Generator Temperature Curve Name
    \type object-list
    \object-list QuadraticCubicCurves
    \note Used when generator fluid type is hot water
    \note Curve which shows the change in normalized capacity to changes in generator temperature.
A14, \field Generator Heat Input Correction Function of Condenser Temperature Curve Name
    \type object-list
    \object-list QuadraticCubicCurves
    \note Curve which shows the change in normalized heat input to changes in condenser temperature.
A15, \field Generator Heat Input Correction Function of Chilled Water Temperature Curve Name
    \type object-list
    \object-list QuadraticCubicCurves
    \note Curve which shows the change in normalized heat input to changes in leaving chilled water
temperature.
A16, \field Generator Heat Source Type
    \type choice
    \key HotWater
    \key Steam
    \default Steam
    \note This field should be specified as steam or left blank if generator inlet/outlet nodes
    \note are not used.

```

```

N11, \field Design Generator Fluid Flow Rate
      \type real
      \units m3/s
      \autosizable
      \note For variable flow this is the max flow and for constant flow this is the flow.
N12, \field Temperature Lower Limit Generator Inlet
      \type real
      \units C
      \default 0.0
      \note Provides warnings when entering generator temperature is below minimum.
      \note Capacity is not adjusted when entering generator temperature is below minimum.
N13, \field Degree of Subcooling in Steam Generator
      \type real
      \units C
      \minimum 0.0
      \maximum 20.0
      \default 1.0
      \note This field is not used when the generator inlet/outlet nodes are not specified or
      \note the generator is connected to a hot water loop.
N14, \field Degree of Subcooling in Steam Condensate Loop
      \type real
      \units C
      \minimum 0.0
      \default 0.0
      \note This field is not used when the generator inlet/outlet nodes are not specified or
      \note the generator is connected to a hot water loop.
N15; \field Sizing Factor
      \note Multiplies the autosized capacity and flow rates
      \type real
      \minimum> 0.0
      \default 1.0

```

Following is an example input for an Absorption Chiller.

```

Chiller:Absorption:Indirect,
  Big Chiller,           !- Chiller Name
  100000,                !- Nominal Capacity {W}
  250,                  !- Nominal Pumping Power {W}
  Big Chiller Inlet Node, !- Evaporator Inlet Node Name
  Big Chiller Outlet Node, !- Evaporator Outlet Node Name
  Big Chiller Condenser Inlet Node, !- Condenser Inlet Node Name
  Big Chiller Condenser Outlet Node, !- Condenser Outlet Node Name
  0.15,                 !- Minimum Part Load Ratio
  1.0,                  !- Maximum Part Load Ratio
  0.65,                 !- Opt Part Load Ratio
  35.0,                 !- Temp Design Condenser Inlet {C}
  10.0,                 !- Temp Lower Limit Condenser Inlet {C}
  5.0,                  !- Chilled Water Outlet Temperature Lower Limit {C}
  0.0011,               !- Design Chilled Water Flow Rate {m3/s}
  0.0011,               !- Design Condenser Water Flow Rate {m3/s}
  VariableFlow,         !- Chiller Flow Mode
  SteamUseFPLR,          !- Generator Heat Input function of part-load ratio curve name
  PumpUseFPLR,           !- Pump Electric Input function of part-load ratio curve name
  AbsorberSteamInletNode, !- Generator Inlet Node Name
  AbsorberSteamOutletNode, !- Generator Outlet Node Name
  CAPfCOND,              !- Capacity Correction function of condenser temperature curve name
  CAPfEVAP,              !- Capacity Correction function of evaporator temperature curve name
  ,                      !- Capacity Correction function of generator temperature curve name
  SteamFCondTemp,        !- Generator Heat Input Correction function of condenser temperature curve name
  SteamFEvapTemp,        !- Generator Heat Input Correction function of evaporator temperature curve name
  Steam,                 !- Generator Heat Source Type
  autosize,              !- Design Generator Volumetric Fluid Flow Rate {m3/s}
  30.0,                  !- Temp Lower Limit Generator Inlet {C}
  2.0,                   !- Degree of Subcooling in Steam Generator {C}
  12.0;                  !- Degree of Subcooling in Steam Condensate Loop {C}

```


Indirect Absorption Chiller Outputs

```

HVAC,Average,Chiller Electric Power [W]
HVAC,Sum,Chiller Electric Consumption [J]
Zone,Meter,Electricity:Plant [J]
Zone,Meter,Cooling:Electricity [J]

HVAC,Average,Chiller Evap Heat Trans Rate [W]
HVAC,Sum,Chiller Evap Heat Trans [J]
Zone,Meter,EnergyTransfer:Plant [J]
Zone,Meter,Chillers:EnergyTransfer [J]
HVAC,Average,Chiller Evap Water Inlet Temp [C]
HVAC,Average,Chiller Evap Water Outlet Temp [C]
HVAC,Average,Chiller Evap Water Mass Flow Rate [kg/s]

HVAC,Average,Chiller Cond Heat Trans Rate [W]
HVAC,Sum,Chiller Cond Heat Trans [J]
Zone,Meter,HeatRejection:EnergyTransfer [J]
HVAC,Average,Chiller Cond Water Inlet Temp [C]
HVAC,Average,Chiller Cond Water Outlet Temp [C]
HVAC,Average,Chiller Cond Water Mass Flow Rate [kg/s]

HVAC,Average,Chiller COP [W/W]
HVAC,Average,Chiller Part-Load Ratio
HVAC,Average,Chiller Cycling Fraction

For Chillers with Steam Generators:
HVAC,Average, Chiller Steam Consumption Rate [W]
HVAC,Sum, Chiller Steam Consumption [J]
Zone,Meter,Steam:Plant [J]
Zone,Meter,Cooling:Steam [J]
HVAC,Average, Chiller Steam Mass Flow Rate [kg/s]
HVAC,Average, Chiller Loop Losses [W]

For Chillers with Hot Water Generators:
HVAC,Average, Chiller Hot Water Consumption Rate [W]
HVAC,Sum, Chiller Hot Water Consumption [J]
Zone,Meter,EnergyTransfer:Plant [J]
Zone,Meter,Cooling:EnergyTransfer [J]
HVAC,Average, Chiller Hot Water Mass Flow Rate [kg/s]

```

These chiller output variables are defined above under "Generic Chiller Outputs."

Chiller:ConstantCOP

This chiller model is based on a simple, constant COP simulation of the chiller. In this case, performance does not vary with chilled water temperature or condenser conditions.

Such a model is useful when the user does not have access to detailed performance data.

```

Chiller:ConstantCOP,
  \min-fields 12
  \memo This constant COP chiller model provides a means of quickly specifying a
  \memo Chiller where performance data is not available.
A1 , \field Name
  \required-field
N1 , \field Nominal Capacity
  \type real
  \autosizable
  \units W
  \required-field
  \minimum 0.0
N2 , \field Nominal COP
  \type real
  \units W/W
  \required-field
  \minimum> 0.0
N3 , \field Design Chilled Water Flow Rate
  \note For variable volume this is the maximum flow and for constant flow this is the flow.
  \units m3/s
  \ip-units gal/min
  \autosizable
  \minimum 0.0
N4 , \field Design Condenser Water Flow Rate
  \type real
  \units m3/s
  \ip-units gal/min
  \autosizable
  \minimum 0.0
A2 , \field Chilled Water Inlet Node Name
  \required-field
A3 , \field Chilled Water Outlet Node Name
  \required-field
A4 , \field Condenser Inlet Node Name
A5 , \field Condenser Outlet Node Name
A6 , \field Condenser Type
  \type choice
  \key AirCooled
  \key WaterCooled
  \key EvaporativelyCooled
  \default AirCooled
A7, \field Chiller Flow Mode
  \note Sets this chiller to a VariableFlow or ConstantFlow simulation
  \type choice
  \key ConstantFlow
  \key VariableFlow
  \default VariableFlow
N5 ; \field Sizing Factor
  \note Multiplies the autosized capacity and flow rates
  \type real
  \minimum> 0.0
  \default 1.0

```

Field: Name

This alpha field contains the identifying name for the constant COP chiller.

Field: Nominal Capacity

This numeric field contains the nominal cooling capability of the chiller in Watts.

Field: Nominal COP

This numeric field contains the Chiller's coefficient of performance.

Field: Design Chilled Water Flow Rate

For variable volume chiller this is the maximum flow and for constant flow chiller this is the design flow rate. The units are in cubic meters per second.

Field: Design Condenser Water Flow Rate

This numeric field contains the electric chiller's design condenser water flow rate in cubic meters per second.

Field: Chilled Water Inlet Node Name

This required alpha field contains the identifying name for the constant COP chiller plant side inlet node.

Field: Chilled Water Outlet Node Name

This required alpha field contains the identifying name for the constant COP chiller plant side outlet node.

Field: Condenser Inlet Node Name

This alpha field contains the identifying name for the constant COP chiller condenser side inlet node. This node name is required if the chiller is WaterCooled, and optional if the chiller is AirCooled or EvaporativelyCooled. If the chiller is AirCooled or EvaporativelyCooled and a condenser inlet node name is specified here, the node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air temperature from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air temperature is taken directly from the weather data. If the chiller is AirCooled or EvaporativelyCooled and this field is left blank, the program automatically creates an outdoor air node and the air temperature information on this node is taken directly from the weather file (no node height adjustment).

Field: Condenser Outlet Node Name

This alpha field contains the identifying name for the constant COP chiller condenser side outlet node. This node name is required if the chiller is WaterCooled, and optional if the chiller is AirCooled or EvaporativelyCooled. If the chiller is AirCooled or EvaporativelyCooled and this field is left blank, the program automatically creates a condenser side outlet air node.

Field: Condenser Type

This alpha field determines what type of condenser will be modeled with this chiller. The 3 type of condensers are AirCooled, WaterCooled, and EvaporativelyCooled with the default being AirCooled if not specified. AirCooled and EvaporativelyCooled do not require a CondenserLoop to be specified, whereas the WaterCooled option requires the full specification of the CondenserLoop and its associated equipment.

Field: Chiller Flow Mode

This alpha field determines if the Chiller is either a VariableFlow or ConstantFlow Chiller Simulation. The default, if not specified, is VariableFlow.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. For this component the inputs that would be altered by the sizing factor are: Nominal Capacity, Design Chilled Water Flow Rate and Design Condenser Water Flow Rate. Sizing Factor allows the user to size a component to meet part of the design load while continuing to use the autosizing feature.

An example of this statement in an IDF is:

```

Chiller:ConstantCOP, Little Chiller,
    25000,          ! Nominal Capacity [W]
    2.5,           ! COP
    0.0011,        ! Design Chilled Water Flow Rate [m3/s]
    0.0011,        ! Design Condenser Water Flow Rate [m3/s]
    Little Chiller Inlet Node, Little Chiller Outlet Node,
    Little Chiller Condenser Inlet Node, Little Chiller Condenser Outlet Node,
    WaterCooled,
    VariableFlow;
    
```

Constant COP Chiller Outputs

```

HVAC,Average,Chiller Electric Power [W]
HVAC,Sum,Chiller Electric Consumption [J]
Zone,Meter,Electricity:Plant [J]
Zone,Meter,Cooling:Electricity [J]

HVAC,Average,Chiller Evap Heat Trans Rate [W]
HVAC,Sum,Chiller Evap Heat Trans [J]
Zone,Meter,EnergyTransfer:Plant [J]
Zone,Meter,Chillers:EnergyTransfer [J]
HVAC,Average,Chiller Evap Water Inlet Temp [C]
HVAC,Average,Chiller Evap Water Outlet Temp [C]
HVAC,Average,Chiller Evap Water Mass Flow Rate [kg/s]

HVAC,Average,Chiller Cond Heat Trans Rate [W]
HVAC,Sum,Chiller Cond Heat Trans [J]
Zone,Meter,HeatRejection:EnergyTransfer [J]
Air-cooled or Evap-cooled:
HVAC,Average,Chiller Cond Air Inlet Temp [C]
Water-cooled:
HVAC,Average,Chiller Cond Water Inlet Temp [C]
HVAC,Average,Chiller Cond Water Outlet Temp [C]
HVAC,Average,Chiller Cond Water Mass Flow Rate [kg/s]
    
```

These chiller output variables are defined above under "Generic Chiller Outputs."

Chiller:Electric

This chiller model is the empirical model from the Building Loads and System Thermodynamics (BLAST) program. Capacity, power, and full load are each defined by a set of performance curves (quadratics). Chiller performance curves are generated by fitting catalog data to third order polynomial equations. The nominal inputs and curves described below are combined as follows to calculate the chiller power:

$$\text{Power} = \text{FracFullLoadPower} \cdot \text{FullLoadPowerRat} \cdot \text{AvailToNominalCapacityRatio} \cdot \frac{\text{NominalCapacity}}{\text{COP}}$$

where:

NominalCapacity = Nominal Capacity field

COP = COP field

AvailToNominalCapacityRatio = the result of the Capacity Ratio Curve

FullLoadPowerRat = the result of the Power Ratio Curve

FracFullLoadPower = the result of the Full Load Ratio Curve

Field: Name

This alpha field contains the identifying name for the electric chiller.

Field: Condenser Type

This alpha field determines what type of condenser will be modeled with this chiller. The 3 type of condensers are AirCooled, WaterCooled, and EvaporativelyCooled with the default being AirCooled if not specified. AirCooled and EvaporativelyCooled do not require a Condenser Loop to be specified, where the WaterCooled option requires the full specification of the Condenser Loop and its associated equipment.

Field: Nominal Capacity

This numeric field contains the nominal cooling capability of the chiller in Watts.

Field: Nominal COP

This numeric field contains the chiller's coefficient of performance. For a water-cooled chiller, this number does not include energy use due to condenser pumps and/or fans. For an air-cooled or evap-cooled chiller, this number includes condenser fan power.

Field: Chilled Water Inlet Node Name

This required alpha field contains the identifying name for the electric chiller plant side inlet node.

Field: Chilled Water Outlet Node Name

This required alpha field contains the identifying name for the electric chiller plant side outlet node.

Field: Condenser Inlet Node Name

This alpha field contains the identifying name for the electric chiller condenser side inlet node. This node name is required if the chiller is WaterCooled, and optional if the chiller is AirCooled or EvaporativelyCooled. If the chiller is AirCooled or EvaporativelyCooled and a condenser inlet node name is specified here, the node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air temperature from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air temperature is taken directly from the weather data. If the chiller is AirCooled or EvaporativelyCooled and this field is left blank, the program automatically creates an outdoor air node and the air temperature information on this node is taken directly from the weather file (no node height adjustment).

Field: Condenser Outlet Node Name

This alpha field contains the identifying name for the electric chiller condenser side outlet node. This node name is required if the chiller is WaterCooled, and optional if the chiller is AirCooled or EvaporativelyCooled. If the chiller is AirCooled or EvaporativelyCooled and this field is left blank, the program automatically creates a condenser side outlet air node.

Field: Minimum Part Load Ratio

This numeric field contains the electric chiller's minimum part load ratio. The expected range is between 0 and 1. The minimum part load is not the load where the machine shuts off, but where the amount of power remains constant to produce smaller loads than this fraction.

Field: Maximum Part Load Ratio

This numeric field contains the electric chiller's maximum part load ratio. This value may exceed 1, but the normal range is between 0 and 1.1.

Field: Optimum Part Load Ratio

This numeric field contains the electric chiller's optimum part load ratio. This is the part load ratio at which the chiller performs at its maximum COP.

Field: Design Condenser Inlet Temperature

This numeric field contains the electric chiller's condenser inlet design temperature in Celsius.

Field: Temperature Rise Coefficient

This numeric field contains the electric chiller's temperature rise coefficient which is defined as the ratio of the required change in condenser water temperature to a given change in chilled water temperature, which maintains the capacity at the nominal value. This is calculated as the following ratio:

$$\frac{TCEnt_{required} - TCEnt_{rated}}{TELV_{required} - TELV_{rated}}$$

where:

$TCEnt_{required}$ = Required entering condenser air or water temperature to maintain rated capacity.

$TCEnt_{rated}$ = Rated entering condenser air or water temperature at rated capacity.

$TELV_{required}$ = Required leaving evaporator water outlet temperature to maintain rated capacity.

$TELV_{rated}$ = Rated leaving evaporator water outlet temperature at rated capacity.

Field: Design Chilled Water Outlet Temperature

This numeric field contains the electric chiller's evaporator outlet design temperature in Celsius.

Field: Design Chilled Water Flow Rate

For variable volume chiller this is the maximum flow and for constant flow chiller this is the design flow rate. The units are in cubic meters per second.

Field: Design Condenser Water Flow Rate

This numeric field contains the electric chiller's design condenser water flow rate in cubic meters per second. For an air-cooled chiller, any number (> 0.0) is a valid entry as this entry is not used within the program when modeling the air-cooled electric chiller.

Capacity Ratio Curve

The Capacity Ratio Curve is a quadratic equation that determines the Ratio of Available Capacity to Nominal Capacity. The defining equation is:

$$AvailToNominalCapacityRatio = C_1 + C_2\Delta_{temp} + C_3\Delta_{temp}^2$$

Where the Delta Temperature is defined as:

$$\Delta_{Temp} = \frac{TempCondIn - TempCondInDesign}{TempRiseCoefficient} - (TempEvapOut - TempEvapOutDesign)$$

$TempCondIn$ = Temperature entering the condenser (water or air temperature depending on condenser type).

$TempCondInDesign$ = Design Condenser Inlet Temperature from User input above.

$TempEvapOut$ = Temperature leaving the evaporator.

$TempEvapOutDesign$ = Design Chilled Water Outlet Temperature from User input above.

$TempRiseCoefficient$ = User Input from above.

The following three fields contain the coefficients for the quadratic equation.

Field: Coefficient 1 of Capacity Ratio Curve

This numeric field contains the first coefficient for the capacity ratio curve.

Field: Coefficient 2 of Capacity Ratio Curve

This numeric field contains the second coefficient for the capacity ratio curve.

Field: Coefficient 3 of Capacity Ratio Curve

This numeric field contains the third coefficient for the capacity ratio curve.

Power Ratio Curve

The Power Ratio Curve is a quadratic equation that determines the Ratio of Full Load Power at Available Capacity to Full Load Power at Nominal Capacity. The defining equation is:

$$FullLoadPowerRatio = C_1 + C_2 AvailToNominalCapRatio + C_3 AvailToNominalCapRatio^2$$

The following three fields contain the coefficients for the quadratic equation.

Field: Coefficient1 of the power ratio curve

This numeric field contains the first coefficient for the power ratio curve.

Field: Coefficient 2 of Power Ratio Curve

This numeric field contains the second coefficient for the power ratio curve.

Field: Coefficient 3 of Power Ratio Curve

This numeric field contains the third coefficient for the power ratio curve.

Full Load Ratio Curve

The Full Load Ratio Curve is a quadratic equation that determines the fraction of full load power. The defining equation is:

$$FracFullLoadPower = C_1 + C_2 PartLoadRatio + C_3 PartLoadRatio^2$$

The following three fields contain the coefficients for the quadratic equation.

Field: Coefficient 1 of Full Load Ratio Curve

This numeric field contains the first coefficient for the full load ratio curve.

Field: Coefficient 2 of Full Load Ratio Curve

This numeric field contains the second coefficient for the full load ratio curve.

Field: Coefficient 3 of Full Load Ratio Curve

This numeric field contains the third coefficient for the full load ratio curve.

Field: Chilled Water Outlet Temperature Lower Limit

This numeric field contains the lower limit for the evaporator outlet temperature. This temperature acts as a cut off for heat transfer in the evaporator, so that the fluid doesn't get too cold.

Field: Chiller Flow Mode

This alpha field determines if the Chiller is either a VariableFlow or ConstantFlow Chiller Simulation. The default, if not specified, is VariableFlow.

Field: Design Heat Recovery Water Flow Rate

This is the design flow rate used if the heat recovery option is being simulated. If this value is greater than 0.0 then a heat recovery loop must be specified and attached to the chiller using the next 2 node fields. To determine how the heat recovery algorithm works look at the

Engineering Manual at the Chiller:Electric with Heat Recovery section. The units are in cubic meters per second.

Field: Heat Recovery Inlet Node Name

This alpha field contains the identifying name for the electric chiller heat recovery side inlet node. A heat recovery loop must be specified and it can only be used with a water-cooled condenser.

Field: Heat Recovery Outlet Node Name(Optional for Heat Recovery)

This alpha field contains the identifying name for the electric chiller heat recovery side outlet node. A heat recovery loop must be specified and it can only be used with a water-cooled condenser.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. For this component the inputs that would be altered by the sizing factor are: Nominal Capacity, Design Chilled Water Flow Rate and Design Condenser Water Flow Rate. Sizing Factor allows the user to size a component to meet part of the design load while continuing to use the autosizing feature.

```
Chiller:Electric,
  \min-fields 27
  \memo This chiller model is the empirical model from the Building Loads
  \memo and System Thermodynamics (BLAST) program. Chiller performance
  \memo curves are generated by fitting catalog data to third order
  \memo polynomial equations. Three sets of coefficients are required.
A1 , \field Name
  \required-field
A2 , \field Condenser Type
  \type choice
  \key AirCooled
  \key WaterCooled
  \key EvaporativelyCooled
  \default AirCooled
N1 , \field Nominal Capacity
  \units W
  \required-field
  \autosizable
  \minimum 0.0
N2 , \field Nominal COP
  \required-field
  \minimum > 0.0
A3 , \field Chilled Water Inlet Node Name
  \required-field
A4 , \field Chilled Water Outlet Node Name
  \required-field
A5 , \field Condenser Inlet Node Name
A6 , \field Condenser Outlet Node Name
N3 , \field Minimum Part Load Ratio
  \minimum 0.0
N4 , \field Maximum Part Load Ratio
  \minimum 0.0
N5 , \field Optimum Part Load Ratio
  \minimum 0.0
```



```

N6 , \field Design Condenser Inlet Temperature
    \units C
N7 , \field Temperature Rise Coefficient
    \required-field
    \minimum> 0.0
N8 , \field Design Chilled Water Outlet Temperature
    \units C
N9 , \field Design Chilled Water Flow Rate
    \note For variable volume this is the maximum flow & for constant flow this is the flow.
    \units m3/s
    \autosizable
    \ip-units gal/min
    \minimum 0.0
N10, \field Design Condenser Water Flow Rate
    \units m3/s
    \autosizable
    \minimum 0.0
    \ip-units gal/min
N11, \field Coefficient 1 of Capacity Ratio Curve
N12, \field Coefficient 2 of Capacity Ratio Curve
N13, \field Coefficient 3 of Capacity Ratio Curve
N14, \field Coefficient 1 of Power Ratio Curve
N15, \field Coefficient 2 of Power Ratio Curve
N16, \field Coefficient 3 of Power Ratio Curve
N17, \field Coefficient 1 of Full Load Ratio Curve
N18, \field Coefficient 2 of Full Load Ratio Curve
N19, \field Coefficient 3 of Full Load Ratio Curve
N20, \field Chilled Water Outlet Temperature Lower Limit
    \units C
A7,  \field Chiller Flow Mode
    \note Sets this chiller to a VariableFlow or ConstantFlow simulation
    \type choice
    \key ConstantFlow
    \key VariableFlow
    \default VariableFlow
N21, \field Design Heat Recovery Water Flow Rate
    \units m3/s
    \minimum 0.0
    \default 0.0
    \note If non-zero, then the heat recovery inlet and outlet node names must be entered.
    \ip-units gal/min
A8 , \field Heat Recovery Inlet Node Name
A9 , \field Heat Recovery Outlet Node Name
N22; \field Sizing Factor
    \note Multiplies the autosized capacity and flow rates
    \type real
    \minimum> 0.0
    \default 1.0

```

An example of this statement in an IDF is:

```

Chiller:Electric,
    Big Chiller,           !- Chiller Name
    WaterCooled,          !- Condenser Type
    100000,                !- Nominal Capacity {W}
    2.75,                  !- COP
    Big Chiller Inlet Node, !- Chilled Water Inlet Node Name
    Big Chiller Outlet Node, !- Chilled Water Outlet Node Name
    Big Chiller Condenser Inlet Node, !- Condenser Inlet Node Name
    Big Chiller Condenser Outlet Node, !- Condenser Outlet Node Name
    .15,                   !- Minimum Part Load Ratio
    1.0,                   !- Maximum Part Load Ratio
    .65,                   !- Optimum Part Load Ratio
    29.44,                 !- Design Condenser Inlet Temperature {C}
    2.682759,              !- Temperature Rise Coefficient
    6.667,                 !- Design Chilled Water Outlet Temperature {C}
    0.0011,                !- Design Chilled Water Flow Rate {m3/s}
    0.0005,                !- Design Condenser Water Flow Rate {m3/s}
    0.94483600,           !- Coefficient 1 of Capacity Ratio Curve
    -.05700880,           !- Coefficient 2 of Capacity Ratio Curve

```

```

-.00185486,      !- Coefficient 3 of Capacity Ratio Curve
1.907846,       !- Coefficient 1 of Power Ratio Curve
-1.20498700,    !- Coefficient 2 of Power Ratio Curve
0.26346230,     !- Coefficient 3 of Power Ratio Curve
0.03303,        !- Coefficient 1 of Full Load Ratio Curve
0.6852,         !- Coefficient 2 of Full Load Ratio Curve
0.2818,         !- Coefficient 3 of Full Load Ratio Curve
5,              !- Chilled Water Outlet Temperature Lower Limit {C}
VariableFlow;   !- Chiller Flow Mode

```

An example of an Air Cooled Chiller:

```

Chiller:Electric,
  Big Chiller,          !- Chiller Name
  AirCooled,           !- Condenser Type
  100000,              !- Nominal Capacity {W}
  2.58,               !- COP
  Big Chiller Inlet Node, !- Chilled Water Inlet Node Name
  Big Chiller Outlet Node, !- Chilled Water Outlet Node Name
  Big Chiller Condenser Inlet Node, !- Condenser Inlet Node Name
  Big Chiller Condenser Outlet Node, !- Condenser Outlet Node Name
  .05,                !- Minimum Part Load Ratio
  1.0,                !- Maximum Part Load Ratio
  .65,               !- Optimum Part Load Ratio
  35.0,              !- Design Condenser Inlet Temperature {C}
  2.778,             !- Temperature Rise Coefficient
  6.67,             !- Design Chilled Water Outlet Temperature {C}
  0.0011,           !- Design Chilled Water Flow Rate {m3/s}
  0.002,            !- Design Condenser Water Flow Rate {m3/s}
  0.9949,           !- Coefficient 1 of Capacity Ratio Curve
  -0.045954,        !- Coefficient 2 of Capacity Ratio Curve
  -0.0013543,       !- Coefficient 3 of Capacity Ratio Curve
  2.333,            !- Coefficient 1 of Power Ratio Curve
  -1.975,           !- Coefficient 2 of Power Ratio Curve
  0.6121,           !- Coefficient 3 of Power Ratio Curve
  0.03303,          !- Coefficient 1 of Full Load Ratio Curve
  0.6852,           !- Coefficient 2 of Full Load Ratio Curve
  0.2818,           !- Coefficient 3 of Full Load Ratio Curve
  5,                !- Chilled Water Outlet Temperature Lower Limit {C}
  VariableFlow;     !- Chiller Flow Mode

OutdoorAir:Node,
  Big Chiller Condenser Inlet Node, !- Node Name
  -1.0;              !- Height Above Ground {m}

```

An example of a Heat Recovery Chiller:

```

Chiller:Electric,
  Big Chiller,          !- Chiller Name
  WaterCooled,         !- Condenser Type
  25000,              !- Nominal Capacity {W}
  2.75,              !- COP
  Big Chiller Inlet Node, !- Chilled Water Inlet Node Name
  Big Chiller Outlet Node, !- Chilled Water Outlet Node Name
  Big Chiller Condenser Inlet Node, !- Condenser Inlet Node Name
  Big Chiller Condenser Outlet Node, !- Condenser Outlet Node Name
  .15,               !- Minimum Part Load Ratio
  1.0,                !- Maximum Part Load Ratio
  .65,               !- Optimum Part Load Ratio
  29.44,             !- Design Condenser Inlet Temperature {C}
  2.682759,         !- Temperature Rise Coefficient
  6.667,            !- Design Chilled Water Outlet Temperature {C}
  0.0011,           !- Design Chilled Water Flow Rate {m3/s}
  0.0005,           !- Design Condenser Water Flow Rate {m3/s}
  0.94483600,       !- Coefficient 1 of Capacity Ratio Curve
  -.05700880,       !- Coefficient 2 of Capacity Ratio Curve
  -.00185486,       !- Coefficient 3 of Capacity Ratio Curve
  1.907846,         !- Coefficient 1 of Power Ratio Curve
  -1.20498700,     !- Coefficient 2 of Power Ratio Curve
  0.26346230,     !- Coefficient 3 of Power Ratio Curve
  0.03303,          !- Coefficient 1 of Full Load Ratio Curve
  0.6852,           !- Coefficient 2 of Full Load Ratio Curve

```

```

0.2818,           !- Coefficient 3 of Full Load Ratio Curve
5,               !- Chilled Water Outlet Temperature Lower Limit {C}
VariableFlow,    !- Chiller Flow Mode
0.00055,        !- Design heat recovery water flow rate {m3/s}
Big Chiller Heat Rec Inlet Node, !- Heat Recovery Inlet Node Name
Big Chiller Heat Rec Outlet Node; !- Heat Recovery Outlet Node Name

```

Electric Chiller Outputs

```

HVAC,Average,Chiller Electric Power [W]
HVAC,Sum,Chiller Electric Consumption [J]
Zone,Meter,Electricity:Plant [J]
Zone,Meter,Cooling:Electricity [J]

HVAC,Average,Chiller Evap Heat Trans Rate [W]
HVAC,Sum,Chiller Evap Heat Trans [J]
Zone,Meter,EnergyTransfer:Plant [J]
Zone,Meter,Chillers:EnergyTransfer [J]
HVAC,Average,Chiller Evap Water Inlet Temp [C]
HVAC,Average,Chiller Evap Water Outlet Temp [C]
HVAC,Average,Chiller Evap Water Mass Flow Rate [kg/s]

HVAC,Average,Chiller COP [W/W]

HVAC,Average,Chiller Cond Heat Trans Rate [W]
HVAC,Sum,Chiller Cond Heat Trans [J]
Zone,Meter,HeatRejection:EnergyTransfer [J]
Air-cooled or Evap-cooled:
HVAC,Average,Chiller Cond Air Inlet Temp [C]
Water-cooled:
HVAC,Average,Chiller Cond Water Inlet Temp [C]
HVAC,Average,Chiller Cond Water Outlet Temp [C]
HVAC,Average,Chiller Cond Water Mass Flow Rate [kg/s]
HeatRecovery:
HVAC,Average,Chiller Heat Recovery Rate [W]
Zone,Meter,HeatRecovery:EnergyTransfer [J]
HVAC,Sum,Chiller Heat Recovery [J]
HVAC,Average,Chiller Heat Recovery Inlet Temp[C]
HVAC,Average,Chiller Heat Recovery Outlet Temp[C]
HVAC,Average,Chiller Heat Recovery Mass Flow Rate [kg/s]

```

These chiller output variables are defined above under "Generic Chiller Outputs."

Chiller:Electric:EIR

This chiller model is the empirical model used in the DOE-2.1 building energy simulation program. The model uses performance information at reference conditions along with three curve fits for cooling capacity and efficiency to determine chiller operation at off-reference conditions. Chiller performance curves can be generated by fitting manufacturer's catalog data or measured data. Performance curves for more than 160 chillers, including the default DOE-2.1E reciprocating and centrifugal chillers, are provided in the EnergyPlus Reference DataSets (Chillers.idf and AllDataSets.idf).

Note: Chiller:Electric:EIR objects and their associated performance curve objects are developed using performance information for a specific chiller and should normally be used together for an EnergyPlus simulation. Changing the object input values, or swapping performance curves between chillers, should be done with caution.

Field: Name

This alpha field contains the identifying name for the electric EIR chiller.

Field: Reference Capacity

This numeric field contains the reference cooling capacity of the chiller in Watts. This should be the capacity of the chiller at the reference temperatures and water flow rates defined below. Alternately, this field can be autosized.

Field: Reference COP

This numeric field contains the chiller's coefficient of performance. This value should **not** include energy use due to pumps, evap-cooled or air-cooled condenser fans, or cooling tower fans. This COP should be at the reference temperatures and water flow rates defined below.

Field: Reference Leaving Chilled Water Temperature

This numeric field contains the chiller's reference leaving chilled water temperature in Celsius. The default value is 6.67°C.

Field: Reference Entering Condenser Fluid Temperature

This numeric field contains the chiller's reference entering condenser fluid temperature in Celsius. The default value is 29.4°C. For water-cooled chillers this is the water temperature entering the condenser (e.g., leaving the cooling tower). For air- or evap-cooled condensers this is the entering outdoor air dry-bulb or wet-bulb temperature, respectively.

Field: Reference Chilled Water Flow Rate

For a variable flow chiller this is the maximum water flow rate and for a constant flow chiller this is the operating water flow rate through the chiller's evaporator. The units are in cubic meters per second. The minimum value for this numeric input field must be greater than zero, or this field can be autosized.

Field: Reference Condenser Water Flow Rate

This numeric field contains the chiller's operating condenser water flow rate in cubic meters per second. For an air- or evaporatively-cooled chiller, any number (> 0.0) is a valid entry since it is disregarded within the program for these condenser types. Alternately, this field can also be autosized.

Field: Cooling Capacity Function of Temperature Curve Name

The name of a biquadratic performance curve (ref: Performance Curves) that parameterizes the variation of the cooling capacity as a function of the leaving chilled water temperature and the entering condenser fluid temperature. The output of this curve is multiplied by the reference capacity to give the cooling capacity at specific temperature operating conditions (i.e., at temperatures different from the reference temperatures). The curve should have a value of 1.0 at the reference temperatures and flow rates specified above. The biquadratic curve should be valid for the range of water temperatures anticipated for the simulation.

Field: Electric Input to Cooling Output Ratio Function of Temperature Curve Name

The name of a biquadratic performance curve (ref: Performance Curves) that parameterizes the variation of the energy input to cooling output ratio (EIR) as a function of the leaving chilled water temperature and the entering condenser fluid temperature. The EIR is the inverse of the COP. The output of this curve is multiplied by the reference EIR (inverse of the reference COP) to give the EIR at specific temperature operating conditions (i.e., at temperatures different from the reference temperatures). The curve should have a value of 1.0 at the reference temperatures and flow rates specified above. The biquadratic curve should be valid for the range of water temperatures anticipated for the simulation.

Field: Electric Input to Cooling Output Ratio Function of Part Load Ratio Curve Name

The name of a quadratic performance curve (ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) as a function of the part-load ratio. The EIR is the inverse of the COP, and the part-load ratio is the actual cooling load divided by the chiller's available cooling capacity. The output of this curve is multiplied by the reference EIR (inverse of the reference COP) and the Energy Input to Cooling Output Ratio Function of Temperature Curve to give the EIR at the specific temperatures and part-load ratio at which the chiller is operating. This curve should have a value of 1.0 when the part-load ratio equals 1.0. The quadratic curve should be valid for the range of part-load ratios anticipated for the simulation.

Field: Minimum Part Load Ratio

This numeric field contains the chiller's minimum part-load ratio. The expected range is between 0 and 1. Below this part-load ratio, the compressor cycles on and off to meet the cooling load. The Minimum Part Load Ratio must be less than or equal to the Maximum Part Load Ratio. The default value is 0.1.

Field: Maximum Part Load Ratio

This numeric field contains the chiller's maximum part-load ratio. This value may exceed 1, but the normal range is between 0 and 1.0. The Maximum Part Load Ratio must be greater than or equal to the Minimum Part Load Ratio. The default value is 1.0.

Field: Optimum Part Load Ratio

This numeric field contains the chiller's optimum part-load ratio. This is the part-load ratio at which the chiller performs at its maximum COP. The optimum part-load ratio must be greater than or equal to the Minimum Part Load Ratio, and less than or equal to the Maximum Part Load Ratio. The default value is 1.0.

Field: Minimum Unloading Ratio

This numeric field contains the chiller's minimum unloading ratio. The expected range is between 0 and 1. The minimum unloading ratio is where the chiller capacity can no longer be reduced by unloading and must be false loaded to meet smaller cooling loads. A typical false loading strategy is hot-gas bypass. The minimum unloading ratio must be greater than or equal to the Minimum Part Load Ratio, and less than or equal to the Maximum Part Load Ratio. The default value is 0.2.

Field: Chilled Water Side Inlet Node

This required alpha field contains the identifying name for the chiller plant side (chilled water) inlet node.

Field: Chilled Water Side Outlet Node

This required alpha field contains the identifying name for the chiller plant side (chilled water) outlet node.

Field: Condenser Inlet Node Name

This alpha field contains the identifying name for the chiller condenser side inlet node. This node name is required if the chiller is WaterCooled, and optional if the chiller is AirCooled or EvaporativelyCooled. If the chiller is AirCooled or EvaporativelyCooled and a condenser inlet node name is specified here, the node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air temperature from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air temperature is taken directly from the weather data. If the chiller is AirCooled or EvaporativelyCooled and this field is left blank, the program automatically creates an outdoor air node and the air temperature information on this node is taken directly from the weather file (no node height adjustment).

Field: Condenser Outlet Node Name

This alpha field contains the identifying name for the chiller condenser side outlet node. This node name is required if the chiller is WaterCooled, and optional if the chiller is AirCooled or EvaporativelyCooled. If the chiller is AirCooled or EvaporativelyCooled and this field is left blank, the program automatically creates a condenser side outlet air node.

Field: Condenser Type

This alpha field determines what type of condenser will be modeled with this chiller. Valid condenser types are AirCooled, WaterCooled, and EvaporativelyCooled with the default being WaterCooled if not specified. AirCooled and EvaporativelyCooled do not require a Condenser Loop to be specified, whereas the WaterCooled option requires the full specification of the Condenser Loop and its associated equipment.

Field: Condenser Fan Power Ratio

This field is used to model condenser fan power associated with air-cooled or evaporatively-cooled condensers (for cooling towers, refer to Group - Condenser Equipment). Enter the ratio of the condenser fan power to the reference chiller cooling capacity in W/W.

Field: Compressor Motor Efficiency

This numeric input represents the fraction of compressor electrical energy consumption that must be rejected by the condenser. Enter a value of 1.0 when modeling hermetic chillers. This value must be between 0.0 and 1.0, with a default value of 1.0.

Field: Leaving Chilled Water Lower Temperature Limit

This numeric field contains the lower limit for the leaving chilled water temperature in Celsius. This temperature acts as a cut off for heat transfer in the evaporator, so that the fluid doesn't get too cold. This input field is currently unused. The default value is 2°C.

Field: Chiller Flow Mode

This alpha field determines if the chiller is modeled with constant or variable water flow through the evaporator. Valid choices are ConstantFlow or VariableFlow, with the default being ConstantFlow.

Field: Design Heat Recovery Water Flow Rate

This is the design heat recovery water flow rate if the heat recovery option is being simulated. If this value is greater than 0.0, a heat recovery loop must be specified and attached to the chiller using the next two node fields. The units are in cubic meters per second.

Field: Heat Recovery Side Inlet Node

This alpha field contains the identifying name for the chiller heat recovery side inlet node. If the user wants to model chiller heat recovery, a heat recovery loop must be specified and it can only be used with a water-cooled condenser.

Field: Heat Recovery Side Outlet Node

This alpha field contains the identifying name for the chiller heat recovery side outlet node. If the user wants to model chiller heat recovery, a heat recovery loop must be specified and it can only be used with a water-cooled condenser.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. For this component the inputs that would be altered by the sizing factor are: Reference Capacity, Reference Chilled Water Flow Rate and Reference Condenser Water Flow Rate. Sizing

Factor allows the user to size a component to meet part of the design load while continuing to use the autosizing feature.

```

Chiller:Electric:EIR,
\min-fields 23
  \memo This chiller model is the empirical model from the DOE-2 building Energy
  \memo simulation program. Chiller performance at off-reference conditions is modeled
  \memo using three polynomial equations. Three curves objects are required.
A1 , \field Name
    \type alpha
    \required-field
N1 , \field Reference Capacity
    \type real
    \units W
    \required-field
    \minimum> 0.0
    \autosizable
N2 , \field Reference COP
    \note Efficiency of the chiller compressor (cooling output/compressor energy input).
    \note Condenser fan power should not be included here.
    \type real
    \units W/W
    \required-field
    \minimum> 0.0
N3 , \field Reference Leaving Chilled Water Temperature
    \type real
    \default 6.67
    \units C
N4 , \field Reference Entering Condenser Fluid Temperature
    \type real
    \default 29.4
    \units C
N5 , \field Reference Chilled Water Flow Rate
    \type real
    \units m3/s
    \minimum> 0
    \autosizable
    \ip-units gal/min
N6 , \field Reference Condenser Water Flow Rate
    \type real
    \units m3/s
    \autosizable
    \minimum> 0.0
    \ip-units gal/min
A2 , \field Cooling Capacity Function of Temperature Curve Name
    \note Cooling capacity as a function of CW supply temp and entering condenser temp
    \required-field
    \type object-list
    \object-list BiquadraticCurves
    \note curve = a + b*CWS + c*CWS**2 + d*ECT + e*ECT**2 + f*CWS*ECT
    \note CWS = supply (leaving) chilled water temperature(C)
    \note ECT = entering condenser fluid temperature(C)
A3 , \field Electric Input to Cooling Output Ratio Function of Temperature Curve Name
    \note Electric Input Ratio (EIR) as a function of temperature
    \note EIR = 1/COP
    \required-field
    \type object-list
    \object-list BiquadraticCurves
    \note curve = a + b*CWS + c*CWS**2 + d*ECT + e*ECT**2 + f*CWS*ECT
    \note CWS = supply (leaving) chilled water temperature(C)
    \note ECT = entering condenser fluid temperature(C)

```

```

A4 , \field Electric Input to Cooling Output Ratio Function of Part Load Ratio Curve Name
    \note Electric Input Ratio (EIR) as a function of Part Load Ratio (PLR)
    \note EIR = 1/COP
    \required-field
    \type object-list
    \object-list QuadraticCurves
    \note quadratic curve = a + b*PLR + c*PLR**2
    \note PLR = part load ratio (cooling load/steady-state capacity)
N7 , \field Minimum Part Load Ratio
    \type real
    \note Part load ratio below which the chiller starts cycling on/off to meet the load.
    \note Must be less than or equal to Maximum Part Load Ratio.
    \minimum 0.0
    \default 0.1
N8 , \field Maximum Part Load Ratio
    \type real
    \note Maximum allowable part load ratio. Must be greater than or equal to Minimum Part Load Ratio.
    \minimum > 0.0
    \default 1.0
N9 , \field Optimum Part Load Ratio
    \type real
    \note Optimum part load ratio where the chiller is most efficient.
    \note Must be greater than or equal to the Minimum Part Load Ratio
    \note and less than or equal to the Maximum Part Load Ratio.
    \minimum > 0.0
    \default 1.0
N10, \field Minimum Unloading Ratio
    \type real
    \note Part load ratio where the chiller can no longer unload and false loading begins.
    \note Minimum unloading ratio must be greater than or equal to the Minimum Part Load Ratio
    \note and less than or equal to the Maximum Part Load Ratio.
    \minimum 0.0
    \default 0.2
A5 , \field Chilled Water Inlet Node Name
    \type alpha
    \required-field
A6 , \field Chilled Water Outlet Node Name
    \type alpha
    \required-field
A7 , \field Condenser Inlet Node Name
    \type alpha
    \note Not required if air-cooled or evaporatively-cooled
A8 , \field Condenser Outlet Node Name
    \type alpha
    \note Not required if air-cooled or evaporatively-cooled
A9 , \field Condenser Type
    \type choice
    \key AirCooled
    \key WaterCooled
    \key EvaporativelyCooled
    \default WaterCooled
N11, \field Condenser Fan Power Ratio
    \type real
    \units W/W
    \minimum 0.0
    \default 0.0
    \note Use for air-cooled or evaporatively-cooled condensers.
    \note Ratio of condenser fan power to reference chiller capacity
N12, \field Compressor Motor Efficiency
    \type real
    \note Fraction of compressor electrical energy that must be rejected by the condenser.
    \note Enter 1.0 or leave this field blank for a hermetic compressor.
    \minimum 0.0
    \maximum 1.0
    \default 1.0
N13, \field Leaving Chilled Water Lower Temperature Limit
    \type real
    \default 2.0
    \units C

```



```

A10, \field Chiller Flow Mode
      \note Sets chilled water flow rate to either constant or variable.
      \type choice
      \key ConstantFlow
      \key VariableFlow
      \default ConstantFlow
N14, \field Design Heat Recovery Water Flow Rate
      \type real
      \note If non-zero, then the heat recovery inlet and outlet node names must be entered.
      \units m3/s
      \minimum 0.0
      \default 0.0
      \ip-units gal/min
A11, \field Heat Recovery Inlet Node Name
      \type alpha
A12, \field Heat Recovery Outlet Node Name
      \type alpha
N15; \field Sizing Factor
      \note Multiplies the autosized capacity and flow rates
      \type real
      \minimum > 0.0
      \default 1.0

```

An example of this statement in an IDF is:

```

! ElectricEIRChiller DOE-2 Centrifugal/5.50COP
! A generic centrifugal chiller from DOE-2.1E
!
Chiller:Electric:EIR,
DOE-2 Centrifugal/5.50COP,  !- Chiller Name
Autosize,                  !- Reference Capacity {W}
5.5,                      !- Reference COP {W/W}
6.67,                    !- Reference Leaving Chilled Water Temperature {C}
29.4,                    !- Reference Entering Condenser Fluid Temperature {C}
Autosize,                  !- Reference Chilled Water Flow Rate {m3/s}
Autosize,                  !- Reference Condenser Water Flow Rate {m3/s}
DOE-2 Centrifugal/5.50COP CAPFT, !- Cooling Capacity Function of Temperature Curve
DOE-2 Centrifugal/5.50COP EIRFT, !- Electric Input to Cooling Output Ratio Function of
      Temperature Curve
DOE-2 Centrifugal/5.50COP EIRFPLR,!- Electric Input to Cooling Output Ratio Function of Part Load
      Ratio Curve
0.1,                      !- Minimum Part Load Ratio
1.0,                      !- Maximum Part Load Ratio
1.0,                      !- Optimum Part Load Ratio
0.2,                      !- Minimum Unloading Ratio
Chilled Water Side Inlet Node, !- Chilled Water Side Inlet Node
Chilled Water Side Outlet Node, !- Chilled Water Side Outlet Node
Condenser Side Inlet Node, !- Condenser Side Inlet Node
Condenser Side Outlet Node, !- Condenser Side Outlet Node
WaterCooled,              !- Condenser Type
',                          !- Condenser Fan Power Ratio {W/W}
1.0,                      !- Compressor Motor Efficiency
2.0,                      !- Leaving Chilled Water Lower Temperature Limit {C}
ConstantFlow;             !- Chiller Evaporator Flow Mode

```

```

!
! Curve set (3 Curves):
!
! Cooling Capacity Function of Temperature Curve for open or hermetic water-cooled centrifugal
  chillers
! x = Leaving Chilled Water Temperature and y = Entering Condenser Water Temperature
! Same as DOE-2.1E HERM-CENT-CAP-FT (CCAPT3) and OPEN-CENT-CAP-FT (CCAPT1)
Curve:Biquadratic,
DOE-2 Centrifugal/5.50COP CAPFT,  !- Name
0.257896E+00,                    !- Coefficient1 Constant
0.389016E-01,                    !- Coefficient2 x
-0.217080E-03,                   !- Coefficient3 x**2
0.468684E-01,                    !- Coefficient4 y
-0.942840E-03,                   !- Coefficient5 y**2
-0.343440E-03,                   !- Coefficient6 x*y
5.0,                              !- Minimum Value of x
10.0,                             !- Maximum Value of x
24.0,                             !- Minimum Value of y
35.0;                             !- Maximum Value of y
!
! Energy Input to Cooling Output Ratio Function of Temperature Curve for open or hermetic water-
  cooled centrifugal chillers
! x = Leaving Chilled Water Temperature and y = Entering Condenser Water Temperature
! Same as DOE-2.1E HERM-CENT-EIR-FT (EIRT3) and OPEN-CENT-EIR-FT (EIRT1)
Curve:Biquadratic,
DOE-2 Centrifugal/5.50COP EIRFT,  !- Name
0.933884E+00,                    !- Coefficient1 Constant
-0.582120E-01,                   !- Coefficient2 x
0.450036E-02,                    !- Coefficient3 x**2
0.243000E-02,                    !- Coefficient4 y
0.486000E-03,                   !- Coefficient5 y**2
-0.121500E-02,                   !- Coefficient6 x*y
5.0,                              !- Minimum Value of x
10.0,                             !- Maximum Value of x
24.0,                             !- Minimum Value of y
35.0;                             !- Maximum Value of y
!
! Energy Input to Cooling Output Ratio Function of Part Load Ratio Curve for open or hermetic
  water-cooled centrifugal chillers
! x = Part Load Ratio (load/capacity)
! Same as DOE-2.1E HERM-CENT-EIR-FPLR (EIRPLR3) and OPEN-CENT-EIR-FPLR (EIRPLR1)
Curve:Quadratic,
DOE-2 Centrifugal/5.50COP EIRFPLR, !- Name
0.222903,                        !- Coefficient1 Constant
0.313387,                        !- Coefficient2 x
0.463710,                        !- Coefficient3 x**2
0.0,                              !- Minimum Value of x
1.0;                              !- Maximum Value of x

```

Electric EIR Chiller Outputs

```

HVAC,Average,Chiller Electric Power [W]
HVAC,Sum,Chiller Electric Consumption [J]
Zone,Meter,Electricity:Plant [J]
Zone,Meter,Cooling:Electricity [J]

HVAC,Average,Chiller Evap Heat Trans Rate [W]
HVAC,Sum,Chiller Evap Heat Trans [J]
Zone,Meter,EnergyTransfer:Plant [J]
Zone,Meter,Chillers:EnergyTransfer [J]
HVAC,Average,Chiller Evap Water Inlet Temp [C]
HVAC,Average,Chiller Evap Water Outlet Temp [C]
HVAC,Average,Chiller Evap Water Mass Flow Rate [kg/s]

HVAC,Average,Chiller COP [W/W]

HVAC,Average,Chiller Cond Heat Trans Rate [W]
HVAC,Sum,Chiller Cond Heat Trans [J]

```

```

Zone,Meter,HeatRejection:EnergyTransfer [J]
HVAC,Average,Chiller Part Load Ratio
HVAC,Average,Chiller Cycling Ratio
HVAC,Average,Chiller False Load Heat Trans Rate [W]
HVAC,Sum,Chiller False Load Heat Trans [J]

Curve object outputs:
HVAC,Average,ChillerCapFTemp
HVAC,Average,ChillerEIRFTemp
HVAC,Average,ChillerEIRFPLR

Air-cooled or Evap-cooled:
HVAC,Average,Chiller Cond Air Inlet Temp [C]
HVAC,Average,Chiller Cond Fan Electric Power [W]
HVAC,Average,Chiller Cond Fan Electric Consumption [J]

Water-cooled:
HVAC,Average,Chiller Cond Water Inlet Temp [C]
HVAC,Average,Chiller Cond Water Outlet Temp [C]
HVAC,Average,Chiller Cond Water Mass Flow Rate [kg/s]

HeatRecovery:
HVAC,Average,Chiller Heat Recovery Rate [W]
Zone,Meter,HeatRecovery:EnergyTransfer [J]
HVAC,Sum,Chiller Heat Recovery [J]
HVAC,Average,Chiller Heat Recovery Inlet Temp[C]
HVAC,Average,Chiller Heat Recovery Outlet Temp[C]
HVAC,Average,Chiller Heat Recovery Mass Flow Rate [kg/s]

```

Most of these chiller output variables are defined above under "Generic Chiller Outputs." Report variables not described above are discussed here.

Chiller Condenser Fan Electric Power [W]

Chiller Condenser Fan Electric Consumption [J]

These outputs are for the electric power consumption of the chiller condenser fan and are applicable to air- or evaporatively-cooled chillers. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Chillers, Group Key = Plant (Ref. Report Meter).

ChillerCapFTemp

This is the output of the curve object Cooling Capacity Function of Temperature Curve.

ChillerEIRFTemp

This is the output of the curve object Electric Input to Cooling Output Ratio Function of Temperature Curve.

ChillerEIRFPLR

This is the output of the curve object Electric Input to Cooling Output Ratio Function of Part Load Curve.

Chiller Part Load Ratio

This output is the ratio of the evaporator heat transfer rate plus the false load heat transfer rate (if applicable) to the available chiller capacity. This value is used to determine ChillerEIRFPLR.

Chiller Cycling Ratio

The cycling ratio is the amount of time the chiller operates during each simulation timestep. If the chiller part-load ratio falls below the minimum part-load ratio, the chiller cycles on and off to meet the cooling load.

Chiller False Load Heat Trans Rate**Chiller False Load Heat Trans**

These outputs are the heat transfer rate and total heat transfer due to false loading of the chiller. When the chiller part-load ratio is below the minimum unloading ratio, the chiller false loads (e.g. hot-gas bypass) to further reduce capacity. The false load heat transfer report variable is not metered.

Chiller:Electric:ReformulatedEIR

This chiller model, developed through the CoolTools™ project sponsored by Pacific Gas and Electric Company (PG&E), is an empirical model similar to EnergyPlus' Chiller:Electric:EIR model. The model uses performance information at reference conditions along with three curve fits for cooling capacity and efficiency to determine chiller operation at off-reference conditions. The model has the same capabilities as the Chiller:Electric:EIR model, but can potentially provide significant accuracy improvement over the Chiller:Electric:EIR model for variable-speed compressor drive and variable condenser water flow applications. Chiller performance curves can be generated by fitting manufacturer's catalog data or measured data. Performance curves developed from manufacturer's performance data are provided in the EnergyPlus Reference DataSets (Chillers.idf and AllDataSets.idf). This chiller model can be used to predict the performance of various chiller types (e.g., reciprocating, screw, scroll, and centrifugal) with water-cooled condensers.

The main difference between this model and the Chiller:Electric:EIR model is the condenser fluid temperature used in the associated performance curves: the Chiller:Electric:ReformulatedEIR model uses the LEAVING condenser water temperature while the Chiller:Electric:EIR model uses the ENTERING condenser water temperature.

Note: Chiller:Electric:Reformulated EIR objects and their associated performance curve objects are developed using performance information for a specific chiller and should almost always be used together for an EnergyPlus simulation. Changing the object input values, or swapping performance curves between chillers, should be done with extreme caution. For example, if the user wishes to model a chiller size that is different from the reference capacity, it is highly recommended that the reference flow rates be scaled proportionately to the change in reference capacity. Although this model can provide more accurate prediction than the Chiller:Electric:EIR model, it requires more performance data to develop the associated performance curves (at least 12 points from full-load performance and 7 points from part-load performance).

Field: Chiller Name

This alpha field contains the identifying name for this chiller.

Field: Reference Capacity

This numeric field contains the reference cooling capacity of the chiller in Watts. This should be the capacity of the chiller at the reference temperatures and water flow rates defined below. Alternately, this field can be autosized.

Field: Reference COP

This numeric field contains the chiller's coefficient of performance. This value should **not** include energy use due to pumps or cooling tower fans. This COP should be at the reference temperatures and water flow rates defined below.

Field: Reference Leaving Chilled Water Temperature

This numeric field contains the chiller's reference leaving chilled water temperature in Celsius. The default value is 6.67°C.

Field: Reference Leaving Condenser Water Temperature

This numeric field contains the chiller's reference leaving condenser water temperature in Celsius. The default value is 35°C.

Field: Reference Chilled Water Flow Rate

For a variable flow chiller this is the maximum water flow rate and for a constant flow chiller this is the operating water flow rate through the chiller's evaporator. The units are in cubic meters per second. The minimum value for this numeric input field must be greater than zero, or this field can be autosized.

Field: Reference Condenser Water Flow Rate

This numeric field contains the chiller's operating condenser water flow rate in cubic meters per second. The units are in cubic meters per second. The minimum value for this numeric input field must be greater than zero, or this field can be autosized.

Field: Cooling Capacity Function of Temperature Curve Name

The name of a biquadratic performance curve (ref: Performance Curves) that parameterizes the variation of the cooling capacity as a function of the leaving chilled water temperature and the leaving condenser water temperature. The output of this curve is multiplied by the reference capacity to give the cooling capacity at specific temperature operating conditions (i.e., at temperatures different from the reference temperatures). The curve should have a value of 1.0 at the reference temperatures and flow rates specified above. The biquadratic curve should be valid for the range of water temperatures anticipated for the simulation (otherwise the program issues warning messages).

Field: Electric Input to Cooling Output Ratio Function of Temperature Curve Name

The name of a biquadratic performance curve (ref: Performance Curves) that parameterizes the variation of the energy input to cooling output ratio (EIR) as a function of the leaving chilled water temperature and the leaving condenser water temperature. The EIR is the inverse of the COP. The output of this curve is multiplied by the reference EIR (inverse of the reference COP) to give the EIR at specific temperature operating conditions (i.e., at temperatures different from the reference temperatures). The curve should have a value of 1.0 at the reference temperatures and flow rates specified above. The biquadratic curve should be valid for the range of water temperatures anticipated for the simulation (otherwise the program issues warning messages).

Field: Electric Input to Cooling Output Ratio Function of Part Load Ratio Curve Name

The name of a bicubic performance curve (ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) as a function of the leaving condenser water temperature and the part-load ratio. The EIR is the inverse of the COP, and the part-load ratio is the actual cooling load divided by the chiller's available cooling capacity. The output of this curve is multiplied by the reference EIR (inverse of the reference COP) and the Energy Input to Cooling Output Ratio Function of Temperature Curve to give the EIR at the specific temperatures and part-load ratio at which the chiller is operating. This curve should have a value of 1.0 at the reference leaving condenser water temperature with the part-load ratio equal to 1.0. The bicubic curve should be valid for the range of condenser water temperatures and part-load ratios anticipated for the simulation (otherwise the program issues warning messages).

Note: Although a bicubic curve requires 10 coefficients (ref. Curve:Bicubic), coefficients 7, 9 and 10 are typically not used in the performance curve described here and should be entered as 0 unless sufficient performance data and regression accuracy exist to justify the use of these coefficients.

Field: Minimum Part Load Ratio

This numeric field contains the chiller's minimum part-load ratio. The expected range is between 0 and 1. Below this part-load ratio, the compressor cycles on and off to meet the cooling load. The Minimum Part Load Ratio must be less than or equal to the Maximum Part Load Ratio. The default value is 0.1.

Field: Maximum Part Load Ratio

This numeric field contains the chiller's maximum part-load ratio. This value may exceed 1, but the normal range is between 0 and 1.0. The Maximum Part Load Ratio must be greater than or equal to the Minimum Part Load Ratio. The default value is 1.0.

Field: Optimum Part Load Ratio

This numeric field contains the chiller's optimum part-load ratio. This is the part-load ratio at which the chiller performs at its maximum COP. The optimum part-load ratio must be greater than or equal to the Minimum Part Load Ratio, and less than or equal to the Maximum Part Load Ratio. The default value is 1.0.

Field: Minimum Unloading Ratio

This numeric field contains the chiller's minimum unloading ratio. The expected range is between 0 and 1. The minimum unloading ratio is where the chiller capacity can no longer be reduced by unloading and must be false loaded to meet smaller cooling loads. A typical false loading strategy is hot-gas bypass. The minimum unloading ratio must be greater than or equal to the Minimum Part Load Ratio, and less than or equal to the Maximum Part Load Ratio. The default value is 0.2.

Field: Chilled Water Side Inlet Node

This required alpha field contains the identifying name for the chiller plant side (chilled water) inlet node.

Field: Chilled Water Side Outlet Node

This required alpha field contains the identifying name for the chiller plant side (chilled water) outlet node.

Field: Condenser Side Inlet Node

This required alpha field contains the identifying name for the chiller condenser side inlet node.

Field: Condenser Side Outlet Node

This required alpha field contains the identifying name for the chiller condenser side outlet node.

Field: Compressor Motor Efficiency

This numeric input represents the fraction of compressor electrical energy consumption that must be rejected by the condenser. Enter a value of 1.0 when modeling hermetic chillers. This value must be between 0.0 and 1.0, with a default value of 1.0.

Field: Leaving Chilled Water Lower Temperature Limit

This numeric field contains the lower limit for the leaving chilled water temperature in Celsius. This temperature acts as a cut off for heat transfer in the evaporator, so that the water doesn't get too cold. This input field is currently unused. The default value is 2°C.

Field: Chiller Flow Mode Type

This alpha field determines if the chiller is modeled with constant or variable water flow through the evaporator. Valid choices are ConstantFlow or VariableFlow, with the default being ConstantFlow.

Field: Design Heat Recovery Water Flow Rate

This is the design heat recovery water flow rate if the heat recovery option is being simulated. If this value is greater than 0.0, a heat recovery loop must be specified and attached to the chiller using the next two node fields. The units are in cubic meters per second.

Field: Heat Recovery Side Inlet Node

This alpha field contains the identifying name for the chiller heat recovery side inlet node. If the user wants to model chiller heat recovery, a heat recovery loop must be specified and it can only be used with a water-cooled condenser.

Field: Heat Recovery Side Outlet Node

This alpha field contains the identifying name for the chiller heat recovery side outlet node. If the user wants to model chiller heat recovery, a heat recovery loop must be specified and it can only be used with a water-cooled condenser.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. For this component the inputs that would be altered by the sizing factor are: Reference Capacity, Reference Chilled Water Flow Rate and Reference Condenser Water Flow Rate. Sizing Factor allows the user to size a component to meet part of the design load while continuing to use the autosizing feature.

```
Chiller:Electric:ReformulatedEIR,
\min-fields 21
  \memo This chiller model is an empirical model, a reformulated version of Chiller:Electric:EIR
  \memo where the performance is a function of condenser leaving fluid Temperature instead of
  \memo condenser entering fluid Temperature. Chiller performance at off-reference conditions is
  \memo modeled using three polynomial equations. Three curve objects are required.
A1 , \field Name
    \type alpha
    \required-field
N1 , \field Reference Capacity
    \type real
    \units W
    \required-field
    \minimum> 0.0
    \autosizable
N2 , \field Reference COP
    \note Efficiency of the chiller compressor (cooling output/compressor energy input).
    \note Condenser fan power should not be included here.
    \type real
    \units W/W
    \required-field
    \minimum> 0.0
```

```

N3 , \field Reference Leaving Chilled Water Temperature
    \type real
    \default 6.67
    \units C
N4 , \field Reference Leaving Condenser Water Temperature
    \type real
    \default 35.0
    \units C
N5 , \field Reference Chilled Water Flow Rate
    \type real
    \units m3/s
    \minimum> 0
    \autosizable
    \ip-units gal/min
N6 , \field Reference Condenser Water Flow Rate
    \type real
    \units m3/s
    \autosizable
    \minimum> 0.0
    \ip-units gal/min
A2 , \field Cooling Capacity Function of Temperature Curve Name
    \note Cooling capacity as a function of supply (leaving) chilled water temperature
    \note and leaving condenser fluid temperature
    \required-field
    \type object-list
    \object-list BiquadraticCurves
    \note curve = a + b*CWS + c*CWS**2 + d*LCT + e*LCT**2 + f*CWS*LCT
    \note CWS = supply (leaving) chilled water temperature(C)
    \note LCT = leaving condenser fluid temperature(C)
A3 , \field Electric Input to Cooling Output Ratio Function of Temperature Curve Name
    \note Electric Input Ratio (EIR) as a function of supply (leaving) chilled water temperature
    \note and leaving condenser fluid temperature.  EIR = 1/COP.
    \required-field
    \type object-list
    \object-list BiquadraticCurves
    \note curve = a + b*CWS + c*CWS**2 + d*LCT + e*LCT**2 + f*CWS*LCT
    \note CWS = supply (leaving) chilled water temperature(C)
    \note LCT = leaving condenser fluid temperature(C)
A4 , \field Electric Input to Cooling Output Ratio Function of Part Load Ratio Curve Name
    \note Electric Input Ratio (EIR) as a function of Part Load Ratio (PLR)
    \note EIR = 1/COP
    \required-field
    \type object-list
    \object-list BicubicCurves
    \note quadratic curve = a + b*LCT + c*LCT**2 + d*PLR + e*PLR**2 + f*LCT*PLR + g*0 + h*PLR**3
    \note + i*0 + j*0
    \note PLR = part load ratio (cooling load/steady-state capacity)
    \note LCT = leaving condenser fluid temperature(C)
N7 , \field Minimum Part Load Ratio
    \type real
    \note Part load ratio below which the chiller starts cycling on/off to meet the load.
    \note Must be less than or equal to Maximum Part Load Ratio.
    \minimum 0.0
    \default 0.1
N8 , \field Maximum Part Load Ratio
    \type real
    \note Maximum allowable part load ratio. Must be greater than or equal to Minimum Part Load Ratio.
    \minimum> 0.0
    \default 1.0
N9 , \field Optimum Part Load Ratio
    \type real
    \note Optimum part load ratio where the chiller is most efficient.
    \note Must be greater than or equal to the Minimum Part Load Ratio
    \note and less than or equal to the Maximum Part Load Ratio.
    \minimum> 0.0
    \default 1.0

```



```

N10, \field Minimum Unloading Ratio
      \type real
      \note Part load ratio where the chiller can no longer unload and false loading begins.
      \note Minimum unloading ratio must be greater than or equal to the Minimum Part Load Ratio
      \note and less than or equal to the Maximum Part Load Ratio.
      \minimum 0.0
      \default 0.2
A5 , \field Chilled Water Inlet Node Name
      \type alpha
      \required-field
A6 , \field Chilled Water Outlet Node Name
      \type alpha
      \required-field
A7 , \field Condenser Inlet Node Name
      \type alpha
      \required-field
A8 , \field Condenser Outlet Node Name
      \type alpha
      \required-field
N11, \field Compressor Motor Efficiency
      \type real
      \note Fraction of compressor electrical energy that must be rejected by the condenser.
      \note Enter 1.0 or leave this field blank for a hermetic compressor.
      \minimum 0.0
      \maximum 1.0
      \default 1.0
N12, \field Leaving Chilled Water Lower Temperature Limit
      \type real
      \default 2.0
      \units C
A9, \field Chiller Flow Mode Type
      \note Sets chilled water flow rate to either constant or variable.
      \type choice
      \key ConstantFlow
      \key VariableFlow
      \default ConstantFlow
N13, \field Design Heat Recovery Water Flow Rate
      \type real
      \note If non-zero, then the heat recovery inlet and outlet node names must be entered.
      \units m3/s
      \minimum 0.0
      \default 0.0
      \ip-units gal/min
A10, \field Heat Recovery Inlet Node Name
      \type alpha
A11, \field Heat Recovery Outlet Node Name
      \type alpha
N14; \field Sizing Factor
      \note Multiplies the autosized capacity and flow rates
      \type real
      \minimum > 0.0
      \default 1.0

```

An example of this statement in an IDF is:

```

Chiller:Electric:ReformulatedEIR,
Main Chiller,                !- Chiller Name
50000,                       !- Reference Capacity {W}
3.99,                        !- Reference COP
6.67,                        !- Reference Leaving Chilled Water Temperature {C}
35.0,                        !- Reference Leaving Condenser Water Temperature {C}
0.00898,                     !- Reference Chilled Water Flow Rate {m3/s}
0.01122,                     !- Reference Condenser Water Flow Rate {m3/s}
Main Chiller RecipCapFT,     !- Cooling Capacity Function of Temperature Curve
Main Chiller RecipEIRFT,    !- Electric Input to Cooling Output Ratio Function of
                             Temperature Curve
Main Chiller RecipEIRFPLR,   !- Electric Input to Cooling Output Ratio Function of Part
                             Load Ratio Curve
0.01,                        !- Minimum Part Load Ratio
1,                            !- Maximum Part Load Ratio
1,                            !- Optimum Part Load Ratio
0.07,                        !- Minimum Unloading Ratio

```

```

Main Chiller ChW Inlet,          !- Chilled Water Side Inlet Node
Main Chiller ChW Outlet,        !- Chilled Water Side Outlet Node
Main Chiller Cnd Inlet,         !- Condenser Side Inlet Node
Main Chiller Cnd Outlet,       !- Condenser Side Outlet Node
1,                               !- Compressor Motor Efficiency
2,                               !- Leaving Chilled Water Lower Temperature Limit (C)
ConstantFlow;                   !- Chiller Flow Mode

```

```

! Cooling capacity to rated capacity function of Temperature Curve
! x = Leaving Chilled Water Temperature and y = Leaving Condenser Water Temperature
Curve:Biquadratic,
  Main Chiller RecipCapFT, !- Name
  0.958546443,            !- Coefficient1 Constant
  0.035168695,           !- Coefficient2 x
  0.000124662,           !- Coefficient3 x**2
  -0.00274551,           !- Coefficient4 y
  -0.00005000,           !- Coefficient5 y**2
  -0.00017234,           !- Coefficient6 x*y
  5.00,                  !- Minimum Value of x
  10.0,                  !- Maximum Value of x
  20.00,                 !- Minimum Value of y
  40.94;                 !- Maximum Value of y

! Energy Input to Cooling Output Ratio Function of Temperature Curve
! x = Leaving Chilled Water Temperature and y = Leaving Condenser Water Temperature
Curve:Biquadratic,
  Main Chiller RecipEIRFT, !- Name
  0.732700123,           !- Coefficient1 Constant
  -0.00834360,           !- Coefficient2 x
  0.000638530,           !- Coefficient3 x**2
  -0.00303753,           !- Coefficient4 y
  0.000484952,           !- Coefficient5 y**2
  -0.00083584,           !- Coefficient6 x*y
  5.00,                  !- Minimum Value of x
  10.0,                  !- Maximum Value of x
  20.00,                 !- Minimum Value of y
  40.94;                 !- Maximum Value of y

! Energy Input to Cooling Output Ratio Function of Part Load Ratio Curve
! x = Leaving Condenser water Temperature and y = Part Load Ratio
Curve:Bicubic,
  Main Chiller RecipEIRFPLR, !- Name
  0.070862846,           !- Coefficient1 Constant
  0.002787560,           !- Coefficient2 x
  -0.00000891,           !- Coefficient3 x**2
  0.230973399,           !- Coefficient4 y
  1.250442176,           !- Coefficient5 y**2
  -0.00216102,           !- Coefficient6 x*y
  0.000000,              !- Coefficient7 x**3
  -0.56300936,           !- Coefficient8 y**3
  0.000000,              !- Coefficient9 x**2*y
  0.000000,              !- Coefficient10 x*y**2
  20.00,                 !- Minimum Value of x
  40.94,                 !- Maximum Value of x
  0.01,                  !- Minimum Value of y
  1.0;                   !- Maximum Value of y

```

Electric Reformulated EIR Chiller Outputs

The output variables for Chiller:Electric:ReformulatedEIR are the same as the output variables for Chiller:Electric:EIR (ref. Electric EIR Chiller Outputs).

Chiller:EngineDriven**Field: Name**

This alpha field contains the identifying name for the engine driven chiller.

Field: Condenser Type

This alpha field determines what type of condenser will be modeled with this chiller. The 3 type of condensers are AirCooled, WaterCooled, and EvaporativelyCooled with the default being AirCooled if not specified. AirCooled and EvaporativelyCooled do not require a Condenser Loop to be specified, where the WaterCooled option requires the full specification of the Condenser Loop and its associated equipment.

Field: Nominal Capacity

This numeric field contains the nominal cooling capability of the chiller in Watts.

Field: Nominal COP

This numeric field contains the chiller's coefficient of performance (COP).

Field: Chilled Water Inlet Node Name

This required alpha field contains the identifying name for the chiller plant side inlet node.

Field: Chilled Water Outlet Node Name

This required alpha field contains the identifying name for the chiller plant side outlet node.

Field: Condenser Inlet Node Name

This alpha field contains the identifying name for the chiller condenser side inlet node. This node name is required if the chiller is WaterCooled, and optional if the chiller is AirCooled or EvaporativelyCooled. If the chiller is AirCooled or EvaporativelyCooled and a condenser inlet node name is specified here, the node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air temperature from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air temperature is taken directly from the weather data. If the chiller is AirCooled or EvaporativelyCooled and this field is left blank, the program automatically creates an outdoor air node and the air temperature information on this node is taken directly from the weather file (no node height adjustment).

Field: Condenser Outlet Node Name

This alpha field contains the identifying name for the chiller condenser side outlet node. This node name is required if the chiller is WaterCooled, and optional if the chiller is AirCooled or EvaporativelyCooled. If the chiller is AirCooled or EvaporativelyCooled and this field is left blank, the program automatically creates a condenser side outlet air node.

Field: Minimum Part Load Ratio

This numeric field contains the chiller's minimum part load ratio. The expected range is between 0 and 1. The minimum part load is not the load where the machine shuts off, but where the amount of power remains constant to produce smaller loads than this fraction.

Field: Maximum Part Load Ratio

This numeric field contains the chiller's maximum part load ratio. This value may exceed 1, but the normal range is between 0 and 1.1.

Field: Optimum Part Load Ratio

This numeric field contains the chiller's optimum part load ratio. This is the part load ratio at which the chiller performs at its maximum COP.

Field: Design Condenser Inlet Temperature

This numeric field contains the chiller's condenser inlet design temperature in Celsius.

Field: Temperature Rise Coefficient

This numeric field contains the electric chiller's temperature rise coefficient which is defined as the ratio of the required change in condenser water temperature to a given change in chilled water temperature, which maintains the capacity at the nominal value. This is calculated as the following ratio:

$$\frac{TCEnt_{required} - TCEnt_{rated}}{TELv_{required} - TELv_{rated}}$$

where:

$TCEnt_{required}$ = Required entering condenser air or water temperature to maintain rated capacity.

$TCEnt_{rated}$ = Rated entering condenser air or water temperature at rated capacity.

$TELv_{required}$ = Required leaving evaporator water outlet temperature to maintain rated capacity.

$TELv_{rated}$ = Rated leaving evaporator water outlet temperature at rated capacity.

Field: Design Chilled Water Outlet Temperature

This numeric field contains the chiller's evaporator outlet design temperature in Celsius.

Field: Design Chilled Water Flow Rate

For variable volume chiller this is the maximum flow and for constant flow chiller this is the design flow rate. The units are in cubic meters per second.

Field: Design Condenser Water Flow Rate

This numeric field contains the chiller's design condenser water flow rate in cubic meters per second.

Capacity Ratio Curve

The Capacity Ratio Curve is a quadratic equation that determines the Ratio of Available Capacity to Nominal Capacity. The defining equation is:

$$AvailToNominalCapacityRatio = C_1 + C_2\Delta_{temp} + C_3\Delta_{temp}^2$$

Where the Delta Temperature is defined as:

$$\Delta_{Temp} = \frac{TempCondIn - TempCondInDesign}{TempRiseCoefficient} - (TempEvapOut - TempEvapOutDesign)$$

$TempCondIn$ = Temperature entering the condenser (water or air temperature depending on condenser type).

$TempCondInDesign$ = Design Condenser Inlet Temperature from User input above.

$TempEvapOut$ = Temperature leaving the evaporator.

$TempEvapOutDesign$ = Design Chilled Water Outlet Temperature from User input above.

$TempRiseCoefficient$ = User Input from above.

The following three fields contain the coefficients for the quadratic equation.

Field: Coefficient 1 of Capacity Ratio Curve

This numeric field contains the first coefficient for the capacity ratio curve.

Field: Coefficient 2 of Capacity Ratio Curve

This numeric field contains the second coefficient for the capacity ratio curve.

Field: Coefficient 3 of Capacity Ratio Curve

This numeric field contains the third coefficient for the capacity ratio curve.

Power Ratio Curve

The Power Ratio Curve is a quadratic equation that determines the Ratio of Full Load to Power. The defining equation is:

$$FullLoadtoPowerRatio = C_1 + C_2 AvailToNominalCapRatio + C_3 AvailToNominalCapRatio^2$$

The following three fields contain the coefficients for the quadratic equation.

Field: Coefficient 1 of Power Ratio Curve

This numeric field contains the first coefficient for the power ratio curve.

Field: Coefficient 2 of Power Ratio Curve

This numeric field contains the second coefficient for the power ratio curve.

Field: Coefficient 3 of Power Ratio Curve

This numeric field contains the third coefficient for the power ratio curve.

Full Load Ratio Curve

The Full Load Ratio Curve is a quadratic equation that determines the fraction of full load power. The defining equation is:

$$FracFullLoadPower = C_1 + C_2 PartLoadRatio + C_3 PartLoadRatio^2$$

The following three fields contain the coefficients for the quadratic equation.

Field: Coefficient 1 of Full Load Ratio Curve

This numeric field contains the first coefficient for the full load ratio curve.

Field: Coefficient 2 of Full Load Ratio Curve

This numeric field contains the second coefficient for the full load ratio curve.

Field: Coefficient 3 of Full Load Ratio Curve

This numeric field contains the third coefficient for the full load ratio curve.

Field Chilled Water Outlet Temperature Lower Limit

This numeric field contains the lower limit for the evaporator outlet temperature. This temperature acts as a cut off for heat transfer in the evaporator, so that the fluid doesn't get too cold.

Field: Fuel Use Curve Name

This alpha field contains the name of the Cooling Load to Fuel Use curve. The curve itself is specified separately using the EnergyPlus Curve Manager. The Fuel Use Curve is a quadratic equation that determines the ratio of Cooling Load to Fuel Energy. The defining equation is:

$$CoolingLoadtoFuelCurve = C_1 + C_2 * PLR + C_3 * PLR^2$$

where PLR is the Part Load Ratio from the Chiller. The Part Load Based Fuel Input Curve determines the ratio of fuel energy per unit time (J/s) / cooling load (W). This is illustrated by the logic block in the Engine Driven Chiller algorithm.

```

IF (PartLoadRat == 0) THEN
  EngineDrivenFuelEnergy = 0
ELSE
  ClnLoadFuelRat =
CurveValue (EngineDrivenChiller (ChillerNum) %ClnLoadtoFuelCurve, PartLoadRat )
  EngineDrivenFuelEnergy = QEvaporator / ClnLoadFuelRat
END IF

```

Field: Jacket Heat Recovery Curve Name

This alpha field contains the name of the Recovery Jacket Heat curve. The curve itself is specified separately using the EnergyPlus Curve Manager. The Recovery Jacket Heat Curve is a quadratic equation that determines the ratio of recovery jacket heat to fuel energy. The defining equation is:

$$\text{RecoveryJacketHeatToFuelRatio} = C_1 + C_2RL + C_3RL^2$$

where RL is the Ratio of Load to Diesel Engine Capacity

Field: Lube Heat Recovery Curve Name

This alpha field contains the name of the Recovery Lube Heat curve. The curve itself is specified separately using the EnergyPlus Curve Manager. The Recovery Lubricant Heat Curve is a quadratic equation that determines the ratio of recovery lube heat to fuel energy. The defining equation is:

$$\text{RecoveryLubeHeatToFuelRatio} = C_1 + C_2RL + C_3RL^2$$

where RL is the Ratio of Load to Diesel Engine Capacity

Field: Total Exhaust Energy Curve Name

This alpha field contains the name of the Total Exhaust Energy curve. The curve itself is specified separately using the EnergyPlus Curve Manager. The Total Exhaust Energy Curve is a quadratic equation that determines the ratio of total exhaust energy to fuel energy. The defining equation is:

$$\text{TotalExhaustToFuelRatio} = C_1 + C_2RL + C_3RL^2$$

where RL is the Ratio of Load to Diesel Engine Capacity

Field: Exhaust Temperature Curve Name

This alpha field contains the name of the Exhaust Temperature curve. The curve itself is specified separately using the EnergyPlus Curve Manager. The Exhaust Temperature Curve is a quadratic equation that determines the absolute exhaust temperature. The defining equation is:

$$\text{AbsoluteExhaustTemperature} = C_1 + C_2RL + C_3RL^2$$

where RL is the Ratio of Load to Diesel Engine Capacity

U-Factor Times Area Curve

The U-Factor Times Area (UA) is an equation that determines the overall heat transfer coefficient for the exhaust gasses with the stack. The heat transfer coefficient ultimately helps determine the exhaust stack temperature. The defining equation is:

$$UA\text{ToCapacityRatio} = C_1\text{EngineCapacity}^{C_2}$$

The following two fields contain the coefficients for the equation.

Field: Coefficient 1 of U-Factor Times Area Curve

This numeric field contains the first coefficient for the overall heat transfer coefficient curve.

Field: Coefficient 2 of U-Factor Times Area Curve

This numeric field contains the second (exponential) coefficient for the overall heat transfer coefficient curve.

Field: Maximum Exhaust Flow per Unit of Power Output

This numeric field contains the maximum exhaust gas mass flow rate per watt of cooling provided by the engine driven chiller

Field: Design Minimum Exhaust Temperature

This numeric field contains the steam saturation temperature in Celsius that would be used to determine the energy recovered from a water jacket heat exchanger on the engine.

Field: Fuel Type

This alpha value specifies the type of fuel used in the engine. The fuel type can be NaturalGas, PropaneGas, Diesel, Gasoline, FuelOil#1, or FuelOil#2.

Field: Fuel Higher Heating Value

This numeric field contains the higher heating value of the fuel used in kJ/kg.

Field: Design Heat Recovery Water Flow Rate

This numeric field specifies the heat recovery volumetric flow rate through the engine in m³/sec. The heat recovery loop manager and hot water tan must also be specified if heat energy is to be recovered from the engine driven chiller.

Field: Heat Recovery Inlet Node Name

This alpha field contains the identifying name for the heat recovery side inlet. If a loop is connected, then the jacket and lubricant heat will be recovered. There is no need for an effectiveness term, since the jacket and lubricant recovered heat energies are the actual recovered energies.

Field: Heat Recovery Outlet Node Name

This alpha field contains the identifying name for the heat recovery side outlet.

Field: Chiller Flow Mode

This alpha field determines if the Chiller is either a Variable or Constant Flow Chiller Simulation. The default, if not specified, is Variable Flow.

Field: Maximum Temperature for Heat Recovery at Heat Recovery Outlet Node

This field sets the maximum temperature that this piece of equipment can produce for heat recovery. The idea behind this field is that the current models do not take temperatures into account for availability and they just pass Q's around the loop without a temperature limit.

This temperature limit puts an upper bound on the recovered heat and limits the maximum temperatures leaving the component.

As temperatures in the loop approach the maximum temperature, the temperature difference between the entering water and the surfaces in the piece of equipment becomes smaller. For the given heat recovery flow rate and that temperature difference the amount of heat recovered will be reduced, and eventually there will be no heat recovered when the entering water temperature is equal to the maximum temperature specified by the user in this field. The reduced amount of heat recovered will diminish if the temperature of the loop approach is the maximum temperature, and this will show up in the reporting. This allows the user to set the availability or the quality of the heat recovered for usage in other parts of the system or to heat domestic hot water supply. The temperature is specified in degrees C.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. For this component the inputs that would be altered by the sizing factor are: Nominal Capacity, Design Chilled Water Flow Rate and Design Condenser Water Flow Rate. Sizing Factor allows the user to size a component to meet part of the design load while continuing to use the autosizing feature.

```

Chiller:EngineDriven,
  \min-fields 43
  \memo This chiller model is the empirical model from the Building Loads
  \memo and System Thermodynamics (BLAST) program. Chiller performance
  \memo curves are generated by fitting catalog data to third order
  \memo polynomial equations. Three sets of coefficients are required.
A1 , \field Name
  \required-field
A2 , \field Condenser Type
  \required-field
  \type choice
  \key AirCooled
  \key WaterCooled
  \key EvaporativelyCooled
  \default AirCooled
N1 , \field Nominal Capacity
  \units W
  \required-field
  \autosizable
  \minimum 0.0
N2 , \field Nominal COP
  \required-field
  \note Nominal Refrigeration Cycle COP
  \minimum > 0.0
A3 , \field Chilled Water Inlet Node Name
  \required-field
A4 , \field Chilled Water Outlet Node Name
  \required-field
A5 , \field Condenser Inlet Node Name
A6 , \field Condenser Outlet Node Name
N3 , \field Minimum Part Load Ratio
  \minimum 0.0
N4 , \field Maximum Part Load Ratio
  \minimum 0.0
N5 , \field Optimum Part Load Ratio
  \minimum 0.0
N6 , \field Design Condenser Inlet Temperature
  \units C
N7 , \field Temperature Rise Coefficient
  \required-field
  \minimum > 0.0

```



```

N8 , \field Design Chilled Water Outlet Temperature
    \units C
N9 , \field Design Chilled Water Flow Rate
    \note For variable volume this is the maximum flow and for constant flow this is the flow.
    \units m3/s
    \autosizable
    \ip-units gal/min
    \minimum 0.0
N10, \field Design Condenser Water Flow Rate
    \units m3/s
    \autosizable
    \ip-units gal/min
    \minimum 0.0
N11, \field Coefficient 1 of Capacity Ratio Curve
N12, \field Coefficient 2 of Capacity Ratio Curve
N13, \field Coefficient 3 of Capacity Ratio Curve
N14, \field Coefficient 1 of Power Ratio Curve
N15, \field Coefficient 2 of Power Ratio Curve
N16, \field Coefficient 3 of Power Ratio Curve
N17, \field Coefficient 1 of Full Load Ratio Curve
N18, \field Coefficient 2 of Full Load Ratio Curve
N19, \field Coefficient 3 of Full Load Ratio Curve
N20, \field Chilled Water Outlet Temperature Lower Limit
    \units C
    \Note Special EngineDriven Chiller Parameters Below
A7, \field Fuel Use Curve Name
    \note Curve is a function of Part Load Ratio (PLR)
    \type object-list
    \object-list QuadraticCurves
    \note curve = a + b*PLR + c*PLR**2
    \note PLR = Ratio of evaporator heat transfer rate to nominal capacity
A8, \field Jacket Heat Recovery Curve Name
    \note Curve is a function of Part Load Ratio (PLR)
    \type object-list
    \object-list QuadraticCurves
    \note curve = a + b*PLR + c*PLR**2
    \note PLR = Ratio of evaporator heat transfer rate to nominal capacity
A9, \field Lube Heat Recovery Curve Name
    \note Curve is a function of Part Load Ratio (PLR)
    \type object-list
    \object-list QuadraticCurves
    \note curve = a + b*PLR + c*PLR**2
    \note PLR = Ratio of evaporator heat transfer rate to nominal capacity
A10, \field Total Exhaust Energy Curve Name
    \note Curve is a function of Part Load Ratio (PLR)
    \type object-list
    \object-list QuadraticCurves
    \note curve = a + b*PLR + c*PLR**2
    \note PLR = Ratio of evaporator heat transfer rate to nominal capacity
A11, \field Exhaust Temperature Curve Name
    \note Curve is a function of Part Load Ratio (PLR)
    \type object-list
    \object-list QuadraticCurves
    \note curve = a + b*PLR + c*PLR**2
    \note PLR = Ratio of evaporator heat transfer rate to nominal capacity
N21, \field Coefficient 1 of U-Factor Times Area Curve
    \note curve = C1 * (nominal capacity)^C2
N22, \field Coefficient 2 of U-Factor Times Area Curve
    \note curve = C1 * (nominal capacity)^C2
N23, \field Maximum Exhaust Flow per Unit of Power Output
    \units (kg/s)/W
    \minimum 0.0
N24, \field Design Minimum Exhaust Temperature
    \units C

```

```

A12, \field Fuel Type
    \required-field
    \type choice
    \key NaturalGas
    \key PropaneGas
    \key Diesel
    \key Gasoline
    \key FuelOil#1
    \key FuelOil#2
N25, \field Fuel Higher Heating Value
    \units kJ/kg
N26, \field Design Heat Recovery Water Flow Rate
    \units m3/s
    \minimum 0.0
    \default 0.0
    \note If non-zero, then the heat recovery inlet and outlet node names must be entered.
    \ip-units gal/min
A13, \field Heat Recovery Inlet Node Name
A14, \field Heat Recovery Outlet Node Name
A15, \field Chiller Flow Mode
    \note Sets this chiller to a VariableFlow or ConstantFlow simulation
    \type choice
    \key ConstantFlow
    \key VariableFlow
    \default VariableFlow
N27, \field Maximum Temperature for Heat Recovery at Heat Recovery Outlet Node
    \units C
    \maximum 100.0
    \minimum 0.0
    \default 60.0
N28; \field Sizing Factor
    \note Multiplies the autosized capacity and flow rates
    \type real
    \minimum> 0.0
    \default 1.0

```

An example of this statement in an IDF is:

```

Chiller:EngineDriven,,
Central Chiller,          !- Chiller Name
WaterCooled,             !- Condenser Type
autosize,                !- Nominal Capacity {W}
2.75,                    !- COP
Central Chiller Inlet Node, !- Chilled Water Inlet Node Name
Central Chiller Outlet Node, !- Chilled Water Outlet Node Name
Central Chiller Condenser Inlet Node, !- Condenser Inlet Node Name
Central Chiller Condenser Outlet Node, !- Condenser Outlet Node Name
0.0,                     !- Minimum Part Load Ratio
1.0,                     !- Maximum Part Load Ratio
.65,                     !- Optimum Part Load Ratio
35.0,                    !- Design Condenser Inlet Temperature {C}
2.778,                   !- Temperature Rise Coefficient
6.67,                    !- Design Chilled Water Outlet Temperature {C}
autosize,                !- Design Chilled Water Flow Rate {m3/s}
autosize,                !- Design Condenser Water Flow Rate {m3/s}
0.9949,                  !- Coefficient 1 of Capacity Ratio Curve
-0.045954,               !- Coefficient 2 of Capacity Ratio Curve
-0.0013543,              !- Coefficient 3 of Capacity Ratio Curve
2.333,                   !- Coefficient 1 of Power Ratio Curve
-1.975,                  !- Coefficient 2 of Power Ratio Curve
0.6121,                  !- Coefficient 3 of Power Ratio Curve
0.03303,                 !- Coefficient 1 of Full Load Ratio Curve
0.6852,                  !- Coefficient 2 of Full Load Ratio Curve
0.2818,                  !- Coefficient 3 of Full Load Ratio Curve
5,                       !- Chilled Water Outlet Temperature Lower Limit {C}

```

```

Fuel Use Curve,           !- the Fuel Use Curve
Jacket Heat Recovery Curve, !- the Recovery Jacket Heat curve
Lube Heat Recovery Curve,!- the Recovery Lube Heat curve
Total Exhaust Energy Curve, !- the Total Exhaust Energy curve
Exhaust Temperature Curve, !- the Exhaust Temperature curve
0.01516,                 !- Coefficient1 of UA curve
0.9,                     !- Coefficient2 of UA curve
0.00063,                 !- Maximum Exhaust Flow per W of Power Output {(kg/s)/W}
150,                     !- Design Minimum Exhaust temp. (Steam Saturation Temperature) {C}
DIESEL,                  !- Fuel Type
45500,                   !- Fuel Heating Value {kJ/kg}
0.0,                     !- Design heat recovery water flow rate {m3/s}
,                          !- Heat Recovery Inlet Node Name
,                          !- Heat Recovery Outlet Node Name
VariableFlow,            !- Chiller Flow Mode
60.0;                    !- Maximum Temp for Heat Recovery. This sets max availability {C}
    
```

Engine Driven Chiller Outputs

```

HVAC,Average,Chiller Electric Power [W]
HVAC,Sum,Chiller Electric Consumption [J]
Zone,Meter,Electricity:Plant [J]
Zone,Meter,Cooling:Electricity [J]

HVAC,Average,Chiller Evap Heat Trans Rate [W]
HVAC,Sum,Chiller Evap Heat Trans [J]
Zone,Meter,EnergyTransfer:Plant [J]
Zone,Meter,Chillers:EnergyTransfer [J]
HVAC,Average,Chiller Evap Water Inlet Temp [C]
HVAC,Average,Chiller Evap Water Outlet Temp [C]
HVAC,Average,Chiller Evap Water Mass Flow Rate [kg/s]

HVAC,Average,Chiller COP [W/W]

HVAC,Average,Chiller Cond Heat Trans Rate [W]
HVAC,Sum,Chiller Cond Heat Trans [J]
Zone,Meter,HeatRejection:EnergyTransfer [J]
Air-cooled or Evap-cooled:
HVAC,Average,Chiller Cond Air Inlet Temp [C]
Water-cooled:
HVAC,Average,Chiller Cond Water Inlet Temp [C]
HVAC,Average,Chiller Cond Water Outlet Temp [C]
HVAC,Average,Chiller Cond Water Mass Flow Rate [kg/s]

HVAC,Average,Chiller Shaft Power [W]
HVAC,Sum,Chiller Shaft Energy [J]

HVAC,Average,Chiller Jacket Heat Recovery Rate [W]
HVAC,Sum,Chiller Jacket Heat Recovery [J]
Zone,Meter,HeatRecovery:EnergyTransfer [J]
HVAC,Average,Chiller Lube Heat Recovery Rate [W]
HVAC,Sum,Chiller Lube Heat Recovery [J]
HVAC,Average,Chiller Exhaust Heat Recovery Rate [W]
HVAC,Sum,Chiller Exhaust Heat Recovery [J]
HVAC,Average,Chiller Total Heat Recovery Rate [W]
HVAC,Sum,Chiller Total Heat Recovery [J]
HVAC,Average,Chiller Heat Recovery Mass Flow Rate [kg/s]
HVAC,Average,Chiller Heat Recovery Inlet Temp[C]
HVAC,Average,Chiller Heat Recovery Outlet Temp[C]
HVAC,Average,Chiller Exhaust Stack Temp[C]

One of the following blocks will be applicable based on fuel type:

HVAC,Average,Chiller Gas Consumption Rate [W]
HVAC,Sum,Chiller Gas Consumption [J]
    
```

```

Zone,Meter,Gas:Plant [J]
Zone,Meter,Cooling:Gas [J]
HVAC,Average,Chiller Gas Mass Flow Rate [kg/s]

HVAC,Average,Chiller Propane Consumption Rate [W]
HVAC,Sum,Chiller Propane Consumption [J]
Zone,Meter,Propane:Plant [J]
Zone,Meter,Cooling:Propane [J]
HVAC,Average,Chiller Propane Mass Flow Rate [kg/s]

HVAC,Average,Chiller Diesel Consumption Rate [W]
HVAC,Sum,Chiller Diesel Consumption [J]
Zone,Meter,Diesel:Plant [J]
Zone,Meter,Cooling:Diesel [J]
HVAC,Average,Chiller Diesel Mass Flow Rate [kg/s]

HVAC,Average,Chiller Gasoline Consumption Rate [W]
HVAC,Sum,Chiller Gasoline Consumption [J]
Zone,Meter,Gasoline:Plant [J]
Zone,Meter,Cooling:Gasoline [J]
HVAC,Average,Chiller Gasoline Mass Flow Rate [kg/s]

HVAC,Average,Chiller FuelOil#1 Consumption Rate [W]
HVAC,Sum,Chiller FuelOil#1 Consumption [J]
Zone,Meter,FuelOil#1:Plant [J]
Zone,Meter,Cooling:FuelOil#1 [J]
HVAC,Average,Chiller FuelOil#1 Mass Flow Rate [kg/s]

HVAC,Average,Chiller FuelOil#2 Consumption Rate [W]
HVAC,Sum,Chiller FuelOil#2 Consumption [J]
Zone,Meter,FuelOil#2:Plant [J]
Zone,Meter,Cooling:FuelOil#2 [J]
HVAC,Average,Chiller FuelOil#2 Mass Flow Rate [kg/s]

```

These chiller output variables are defined above under "Generic Chiller Outputs."

Chiller:CombustionTurbine

This chiller model is the empirical model from the Building Loads and System Thermodynamics (BLAST) program. Chiller performance curves are generated by fitting catalog data to third order polynomial equations. Three sets of coefficients are required.

Field: Name

This alpha field contains the identifying name for the combustion turbine chiller.

Field: Condenser Type

This alpha field determines what type of condenser will be modeled with this chiller. The 3 type of condensers are AirCooled, WaterCooled, and EvaporativelyCooled with the default being AirCooled if not specified. AirCooled and EvaporativelyCooled do not require a Condenser Loop to be specified, where the WaterCooled option requires the full specification of the Condenser Loop and its associated equipment.

Field: Nominal Capacity

This numeric field contains the nominal cooling capability of the chiller in Watts.

Field: Nominal COP

This numeric field contains the chiller's coefficient of performance (COP).

Field: Chilled Water Inlet Node Name

This alpha field contains the identifying name for the combustion turbine chiller plant side inlet node.

Field: Chilled Water Outlet Node Name

This required alpha field contains the identifying name for the combustion turbine chiller plant side inlet node.

Field: Chilled Water Outlet Node Name

This required alpha field contains the identifying name for the combustion turbine chiller plant side outlet node.

Field: Condenser Inlet Node Name

This alpha field contains the identifying name for the combustion turbine chiller condenser side inlet node. This node name is required if the chiller is WaterCooled, and optional if the chiller is AirCooled or EvaporativelyCooled. If the chiller is AirCooled or EvaporativelyCooled and a condenser inlet node name is specified here, the node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air temperature from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air temperature is taken directly from the weather data. If the chiller is AirCooled or EvaporativelyCooled and this field is left blank, the program automatically creates an outdoor air node and the air temperature information on this node is taken directly from the weather file (no node height adjustment).

Field: Condenser Outlet Node Name

This alpha field contains the identifying name for the combustion turbine chiller condenser side outlet node. This node name is required if the chiller is WaterCooled, and optional if the chiller is AirCooled or EvaporativelyCooled. If the chiller is AirCooled or EvaporativelyCooled and this field is left blank, the program automatically creates a condenser side outlet air node.

Field: Minimum Part Load Ratio

This numeric field contains the combustion turbine chiller's minimum part load ratio. The expected range is between 0 and 1. The minimum part load is not the load where the machine shuts off, but where the amount of power remains constant to produce smaller loads than this fraction.

Field: Maximum Part Load Ratio

This numeric field contains the combustion turbine chiller's maximum part load ratio. This value may exceed 1, but the normal range is between 0 and 1.1.

Field: Optimum Part Load Ratio

This numeric field contains the combustion turbine chiller's optimum part load ratio. This is the part load ratio at which the chiller performs at its maximum COP.

Field: Design Condenser Inlet Temperature

This numeric field contains the combustion turbine chiller's condenser inlet design temperature in Celsius.

Field: Temperature Rise Coefficient

This numeric field contains the electric chiller's temperature rise coefficient which is defined as the ratio of the required change in condenser water temperature to a given change in chilled water temperature, which maintains the capacity at the nominal value. This is calculated as the following ratio:

$$\frac{TCEnt_{required} - TCEnt_{rated}}{TELV_{required} - TELV_{rated}}$$

where:

$TCEnt_{required}$ = Required entering condenser air or water temperature to maintain rated capacity.

$TCEnt_{rated}$ = Rated entering condenser air or water temperature at rated capacity.

$TELV_{required}$ = Required leaving evaporator water outlet temperature to maintain rated capacity.

$TELV_{rated}$ = Rated leaving evaporator water outlet temperature at rated capacity.

Field: Design Chilled Water Outlet Temperature

This numeric field contains the combustion turbine chiller's evaporator outlet design temperature in Celsius.

Field: Design Chilled Water Flow Rate

For variable volume chiller this is the maximum flow and for constant flow chiller this is the design flow rate. The units are in cubic meters per second.

Field: Design Condenser Water Flow Rate

This numeric field contains the combustion turbine chiller's design condenser water flow rate in cubic meters per second.

Capacity Ratio Curve

The Capacity Ratio Curve is a quadratic equation that determines the Ratio of Available Capacity to Nominal Capacity. The defining equation is:

$$AvailToNominalCapacityRatio = C_1 + C_2\Delta_{temp} + C_3\Delta_{temp}^2$$

Where the Delta Temperature is defined as:

$$\Delta_{Temp} = \frac{TempCondIn - TempCondInDesign}{TempRiseCoefficient} - (TempEvapOut - TempEvapOutDesign)$$

$TempCondIn$ = Temperature entering the condenser (water or air temperature depending on condenser type).

$TempCondInDesign$ = Design Condenser Inlet Temperature from User input above.

$TempEvapOut$ = Temperature leaving the evaporator.

$TempEvapOutDesign$ = Design Chilled Water Outlet Temperature from User input above.

$TempRiseCoefficient$ = User Input from above.

The following three fields contain the coefficients for the quadratic equation.

Field: Coefficient 1 of Capacity Ratio Curve

This numeric field contains the first coefficient for the capacity ratio curve.

Field: Coefficient 2 of Capacity Ratio Curve

This numeric field contains the second coefficient for the capacity ratio curve.

Field: Coefficient 3 of Capacity Ratio Curve

This numeric field contains the third coefficient for the capacity ratio curve.

Power Ratio Curve

The Power Ratio Curve is a quadratic equation that determines the Ratio of Full Load to Power. The defining equation is:

$$FullLoadtoPowerRatio = C_1 + C_2 AvailToNominalCapRatio + C_3 AvailToNominalCapRatio^2$$

The following three fields contain the coefficients for the quadratic equation.

Field: Coefficient 1 of Power Ratio Curve

This numeric field contains the first coefficient for the power ratio curve.

Field: Coefficient 2 of Power Ratio Curve

This numeric field contains the second coefficient for the power ratio curve.

Field: Coefficient 3 of Power Ratio Curve

This numeric field contains the third coefficient for the power ratio curve.

Full Load Ratio Curve

The Full Load Ratio Curve is a quadratic equation that determines the fraction of full load power. The defining equation is:

$$FracFullLoadPower = C_1 + C_2 PartLoadRatio + C_3 PartLoadRatio^2$$

The following three fields contain the coefficients for the quadratic equation.

Field: Coefficient 1 of Full Load Ratio Curve

This numeric field contains the first coefficient for the full load ratio curve.

Field: Coefficient 2 of Full Load Ratio Curve

This numeric field contains the second coefficient for the full load ratio curve.

Field: Coefficient 3 of Full Load Ratio Curve

This numeric field contains the third coefficient for the full load ratio curve.

Field: Chilled Water Outlet Temperature Lower Limit

This numeric field contains the lower limit for the evaporator outlet temperature. This temperature acts as a cut off for heat transfer in the evaporator, so that the fluid doesn't get too cold.

Fuel Input Curve

The Fuel Input Curve is a polynomial equation that determines the Ratio of Fuel Input to Energy Output. The equation combines both the Fuel Input Curve Coefficients and the Temperature Based Fuel Input Curve Coefficients. The defining equation is:

$$FuelEnergyInput = PLoad * (FIC_1 + FIC_2 RLoad + FIC_3 RLoad^2) * (TBFIC_1 + TBFIC_2 AT_{air} + TBFIC_3 AT_{air}^2)$$

where FIC represents the Fuel Input Curve Coefficients, TBFIC represents the Temperature Based Fuel Input Curve Coefficients, Rload is the Ratio of Load to Combustion Turbine Engine Capacity, and AT_{air} is the difference between the current ambient and design ambient temperatures.

The following three fields contain the coefficients for the fuel input curve.

Field: Coefficient 1 of Fuel Input Curve

This numeric field contains the first coefficient for the Fuel Input Curve.

Field: Coefficient 2 of Fuel Input Curve

This numeric field contains the second coefficient for the Fuel Input Curve.

Field: Coefficient 3 of Fuel Input Curve

This numeric field contains the third coefficient for the Fuel Input Curve.

The following three fields contain the coefficients for the temperature based fuel input curve.

Field: Coefficient 1 of Temperature Based Fuel Input Curve

This numeric field contains the first coefficient for the Temperature Based Fuel Input Curve.

Field: Coefficient 2 of Temperature Based Fuel Input Curve

This numeric field contains the second coefficient for the Temperature Based Fuel Input Curve.

Field: Coefficient 3 of Temperature Based Fuel Input Curve

This numeric field contains the third coefficient for the Temperature Based Fuel Input Curve.

Exhaust Flow Curve

The Exhaust Flow Curve is a quadratic equation that determines the Ratio of Exhaust Gas Flow Rate to Engine Capacity. The defining equation is:

$$ExhaustFlowRate = GTCapacity * (C_1 + C_2 AT_{air} + C_3 AT_{air}^2)$$

where GTCapacity is the Combustion Turbine Engine Capacity, and AT_{air} is the difference between the current ambient and design ambient temperatures.

Field: Coefficient 1 of Exhaust Flow Curve

This numeric field contains the first coefficient for the Exhaust Flow Curve.

Field: Coefficient 2 of Exhaust Flow Curve

This numeric field contains the second coefficient for the Exhaust Flow Curve.

Field: Coefficient 3 of Exhaust Flow Curve

This numeric field contains the third coefficient for the Exhaust Flow Curve.

Exhaust Gas Temperature Curve

The Exhaust Gas Temperature Curve is a polynomial equation that determines the Exhaust Gas Temperature. The equation combines both the Exhaust Gas Temperature Curve Coefficients (Based on the Part Load Ratio) and the (Ambient) Temperature Based Exhaust Gas Temperature Curve Coefficients. The defining equation is:

$$ExhaustTemperature = (C_1 + C_2 RLoad + C_3 RLoad^2) * (TBC_1 + TBC_2 AT_{air} + TBC_3 AT_{air}^2) - 273.15$$

where C represents the Exhaust Gas Temperature Curve Coefficients, TBC are the Temperature Based Exhaust Gas Temperature Curve Coefficients, RLoad is the Ratio of Load to Combustion Turbine Engine Capacity, and AT_{air} is the difference between the actual ambient and design ambient temperatures.

Field: Coefficient 1 of Exhaust Gas Temperature Curve

This numeric field contains the first coefficient for the Exhaust Gas Temperature Curve.

Field: Coefficient 2 of Exhaust Gas Temperature Curve

This numeric field contains the second coefficient for the Exhaust Gas Temperature Curve.

Field: Coefficient 3 of Exhaust Gas Temperature Curve

This numeric field contains the third coefficient for the Exhaust Gas Temperature Curve.

Field: Coefficient 1 of Temperature Based Exhaust Gas Temperature Curve

This numeric field contains the first coefficient for the Temperature Based Exhaust Gas Temperature Curve.

Field: Coefficient 2 of Temperature Based Exhaust Gas Temperature Curve

This numeric field contains the second coefficient for the Temperature Based Exhaust Gas Temperature Curve.

Field: Coefficient 3 of Temperature Based Exhaust Gas Temperature Curve

This numeric field contains the third coefficient for the Temperature Based Exhaust Gas Temperature Curve.

Recovery Lubricant Heat Curve

The Recovery Lubricant Heat Curve is a quadratic equation that determines the recovery lube energy. The defining equation is:

$$\text{RecoveryLubeEnergy} = \text{PLoad} * (C_1 + C_2 \text{RL} + C_3 \text{RL}^2)$$

where Pload is the engine load and RL is the Ratio of Load to Combustion Turbine Engine Capacity

The following three fields contain the coefficients for the quadratic equation.

Field: Coefficient 1 of Recovery Lube Heat Curve

This numeric field contains the first coefficient for the Recovery Lube Heat curve.

Field: Coefficient 2 of Recovery Lube Heat Curve

This numeric field contains the second coefficient for the Recovery Lube Heat curve.

Field: Coefficient 3 of Recovery Lube Heat Curve

This numeric field contains the third coefficient for the Recovery Lube Heat curve.

U-Factor Times Area Curve Curve

The U-Factor Times Area Curve (UA) is an equation that determines the overall heat transfer coefficient for the exhaust gasses with the stack. The heat transfer coefficient ultimately helps determine the exhaust stack temperature. The defining equation is:

$$\text{UAToCapacityRatio} = C_1 \text{GasTurbineEngineCapacity}^{C_2}$$

The following two fields contain the coefficients for the equation.

Field: Coefficient 1 of U-Factor Times Area Curve

This numeric field contains the first coefficient for the overall heat transfer coefficient curve.

Field: Coefficient 2 of U-Factor Times Area Curve

This numeric field contains the second (exponential) coefficient for the overall heat transfer coefficient curve.

Field: Gas Turbine Engine Capacity

This numeric field contains the capacity of the gas turbine engine in watts.

Field: Maximum Exhaust Flow per Unit of Power Output

This numeric field contains the maximum exhaust gas mass flow rate per kilowatt of power out.

Field: Design Steam Saturation Temperature

This numeric field contains the design steam saturation temperature in Celsius.

Field: Fuel Higher Heating Value

This numeric field contains the higher heating value of the fuel used in kJ/kg.

Field: Design Heat Recovery Water Flow Rate

This is the design heat recovery water flow rate if the heat recovery option is being simulated. If this value is greater than 0.0, a heat recovery loop must be specified and attached to the chiller using the next two node fields. The units are in cubic meters per second.

Field: Heat Recovery Inlet Node Name

This alpha field contains the identifying name for the heat recovery side inlet. If a loop is connected, then the jacket and lubricant heat will be recovered. There is no need for an effectiveness term, since the jacket and lubricant recovered heat energies are the actual recovered energies.

Field: Heat Recovery Outlet Node Name

This alpha field contains the identifying name for the heat recovery side outlet.

Field: Chiller Flow Mode

This alpha field determines if the Chiller is either a VariableFlow or ConstantFlow Chiller Simulation. The default, if not specified, is VariableFlow.

Field: Fuel Type

This alpha field determines the type of fuel that the chiller uses. The default is Natural Gas.

Field: Heat Recovery Maximum Temperature

This field sets the maximum temperature that this piece of equipment can produce for heat recovery. The idea behind this field is that the current models do not take temperatures into account for availability and they just pass Q's around the loop without a temperature limit. This temperature limit puts an upper bound on the recovered heat and limits the max temperatures leaving the component.

As temperatures in the loop approach the maximum temperature, the temperature difference between the entering water and the surfaces in the piece of equipment becomes smaller. For the given heat recovery flow rate and that temperature difference the amount of heat recovered will be reduced, and eventually there will be no heat recovered when the entering water temperature is equal to the maximum temperature specified by the user in this field. The reduced amount of heat recovered will diminish if the temperature of the loop approach is the maximum temperature, and this will show up in the reporting. This allows the user to set the availability or the quality of the heat recovered for usage in other parts of the system or to heat domestic hot water supply.

The temperature is specified in degrees C.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. For this component the inputs that would be altered by the sizing factor are: Nominal Capacity, Design Chilled Water Flow Rate and Design Condenser Water Flow Rate. Sizing Factor

allows the user to size a component to meet part of the design load while continuing to use the autosizing feature.

```

Chiller:CombustionTurbine,
  \min-fields 56
  \memo This chiller model is the empirical model from the Building Loads
  \memo and System Thermodynamics (BLAST) program. Chiller performance
  \memo curves are generated by fitting catalog data to third order
  \memo polynomial equations. Three sets of coefficients are required.
A1 , \field Name
  \required-field
A2 , \field Condenser Type
  \type choice
  \key AirCooled
  \key WaterCooled
  \key EvaporativelyCooled
  \default AirCooled
N1 , \field Nominal Capacity
  \units W
  \required-field
  \autosizable
  \minimum 0.0
N2 , \field Nominal COP
  \required-field
  \minimum> 0.0
A3 , \field Chilled Water Inlet Node Name
  \required-field
A4 , \field Chilled Water Outlet Node Name
  \required-field
A5 , \field Condenser Inlet Node Name
A6 , \field Condenser Outlet Node Name
N3 , \field Minimum Part Load Ratio
  \minimum 0.0
N4 , \field Maximum Part Load Ratio
  \minimum 0.0
N5 , \field Optimum Part Load Ratio
  \minimum 0.0
N6 , \field Design Condenser Inlet Temperature
  \units C
N7 , \field Temperature Rise Coefficient
  \required-field
  \minimum> 0.0
N8 , \field Design Chilled Water Outlet Temperature
  \units C
N9 , \field Design Chilled Water Flow Rate
  \note For variable volume this is the max flow & for constant flow this is the flow.
  \units m3/s
  \autosizable
  \ip-units gal/min
  \minimum 0.0
N10, \field Design Condenser Water Flow Rate
  \units m3/s
  \autosizable
  \ip-units gal/min
  \minimum 0.0
N11, \field Coefficient 1 of Capacity Ratio Curve
N12, \field Coefficient 2 of Capacity Ratio Curve
N13, \field Coefficient 3 of Capacity Ratio Curve
N14, \field Coefficient 1 of Power Ratio Curve
N15, \field Coefficient 2 of Power Ratio Curve
N16, \field Coefficient 3 of Power Ratio Curve

```

```

N17, \field Coefficient 1 of Full Load Ratio Curve
N18, \field Coefficient 2 of Full Load Ratio Curve
N19, \field Coefficient 3 of Full Load Ratio Curve
N20, \field Chilled Water Outlet Temperature Lower Limit
      \units C
      \Note Special Gas Turbine Chiller Parameters Below
N21, \field Coefficient 1 of Fuel Input Curve
N22, \field Coefficient 2 of Fuel Input Curve
N23, \field Coefficient 3 of Fuel Input Curve
N24, \field Coefficient 1 of Temperature Based Fuel Input Curve
N25, \field Coefficient 2 of Temperature Based Fuel Input Curve
N26, \field Coefficient 3 of Temperature Based Fuel Input Curve
N27, \field Coefficient 1 of Exhaust Flow Curve
N28, \field Coefficient 2 of Exhaust Flow Curve
N29, \field Coefficient 3 of Exhaust Flow Curve
N30, \field Coefficient 1 of Exhaust Gas Temperature Curve
N31, \field Coefficient 2 of Exhaust Gas Temperature Curve
N32, \field Coefficient 3 of Exhaust Gas Temperature Curve
N33, \field Coefficient 1 of Temperature Based Exhaust Gas Temperature Curve
N34, \field Coefficient 2 of Temperature Based Exhaust Gas Temperature Curve
N35, \field Coefficient 3 of Temperature Based Exhaust Gas Temperature Curve
N36, \field Coefficient 1 of Recovery Lube Heat Curve
N37, \field Coefficient 2 of Recovery Lube Heat Curve
N38, \field Coefficient 3 of Recovery Lube Heat Curve
N39, \field Coefficient 1 of U-Factor Times Area Curve
N40, \field Coefficient 2 of U-Factor Times Area Curve
N41, \field Gas Turbine Engine Capacity
      \autosizable
      \units W
      \minimum> 0.0
N42, \field Maximum Exhaust Flow per Unit of Power Output
      \units (kg/s)/W
N43, \field Design Steam Saturation Temperature
      \units C
N44, \field Fuel Higher Heating Value
      \units kJ/kg
N45, \field Design Heat Recovery Water Flow Rate
      \units m3/s
      \minimum 0.0
      \default 0.0
      \note If non-zero, then the heat recovery inlet and outlet node names must be entered.
      \ip-units gal/min
A7 , \field Heat Recovery Inlet Node Name
A8 , \field Heat Recovery Outlet Node Name
A9 , \field Chiller Flow Mode
      \note Sets this chiller to a VariableFlow or ConstantFlow simulation
      \type choice
      \key ConstantFlow
      \key VariableFlow
      \default VariableFlow
A10, \field Fuel Type
      \required-field
      \type choice
      \key NaturalGas
      \key PropaneGas
      \key Diesel
      \key Gasoline
      \key FuelOil#1
      \key FuelOil#2
      \default NaturalGas
N46, \field Heat Recovery Maximum Temperature
      \units C
      \maximum 100.0
      \minimum 0.0
      \default 80.0
N47; \field Sizing Factor
      \note Multiplies the autosized capacity and flow rates
      \type real
      \minimum> 0.0
      \default 1.0

```

An example of this statement in an IDF is:

```

Chiller:CombustionTurbine,
  Big Chiller,          !- Chiller Name
  WaterCooled,         !- Condenser Type
  30000,               !- Nominal Capacity {W}
  2.75,               !- COP
  Big Chiller Inlet Node, !- Chilled Water Inlet Node Name
  Big Chiller Outlet Node, !- Chilled Water Outlet Node Name
  Big Chiller Condenser Inlet Node, !- Condenser Inlet Node Name
  Big Chiller Condenser Outlet Node, !- Condenser Outlet Node Name
  .15,                !- Minimum Part Load Ratio
  1.0,                !- Maximum Part Load Ratio
  .65,                !- Optimum Part Load Ratio
  35.0,               !- Design Condenser Inlet Temperature {C}
  2.778,              !- Temperature Rise Coefficient
  6.67,               !- Design Chilled Water Outlet Temperature {C}
  0.0011,             !- Design Chilled Water Flow Rate {m3/s}

```

```

0.0011,              !- Design Condenser Water Flow Rate {m3/s}
0.9949,              !- Coefficient 1 of Capacity Ratio Curve
-0.045954,           !- Coefficient 2 of Capacity Ratio Curve
-0.0013543,          !- Coefficient 3 of Capacity Ratio Curve
2.333,               !- Coefficient 1 of Power Ratio Curve
-1.975,              !- Coefficient 2 of Power Ratio Curve
0.6121,              !- Coefficient 3 of Power Ratio Curve
0.03303,             !- Coefficient 1 of Full Load Ratio Curve
0.6852,              !- Coefficient 2 of Full Load Ratio Curve
0.2818,              !- Coefficient 3 of Full Load Ratio Curve
5,                  !- Chilled Water Outlet Temperature Lower Limit {C}
9.41,                !- Coefficient 1 of Fuel Input curve
-9.48,               !- Coefficient 2 of Fuel Input curve
4.32,                !- Coefficient 3 of Fuel Input curve
1.0044,              !- Coefficient 1 of Temperature Based Fuel Input curve
-0.0008,             !- Coefficient 2 of Temperature Based Fuel Input curve
0,                   !- Coefficient 3 of Temperature Based Fuel Input curve
15.63518363,         !- Coefficient 1 of Exhaust Flow curve
-0.03059999,         !- Coefficient 2 of Exhaust Flow curve
-0.0002,             !- Coefficient 3 of Exhaust Flow curve
916.992,             !- Coefficient 1 of Exhaust Gas Temperature curve
307.998,             !- Coefficient 2 of Exhaust Gas Temperature curve
79.992,              !- Coefficient 3 of Exhaust Gas Temperature curve
1.005,               !- Coefficient 1 of Temperature Based Exhaust Gas Temperature c
0.0018,              !- Coefficient 2 of Temperature Based Exhaust Gas Temperature c
0,                   !- Coefficient 3 of Temperature Based Exhaust Gas Temperature c
0.223,               !- Coefficient 1 of Recovery Lube Heat curve
-0.4,                !- Coefficient 2 of Recovery Lube Heat curve
0.2286,              !- Coefficient 3 of Recovery Lube Heat curve
0.01907045,         !- Coefficient 1 of UA curve
0.9,                 !- Coefficient 2 of UA curve
50000,               !- Gas Turbine Engine Capacity {W}
0.00000504,          !- Maximum Exhaust Flow per Unit of Power Output {(kg/s)/W}
150,                 !- Design Steam Saturation Temperature {C}
43500,               !- Fuel Higher Heating Value {kJ/kg}
0.0,                 !- Design Heat Recovery Water Flow Rate {m3/s}
,                    !- Heat Recovery Inlet Node Name
,                    !- Heat Recovery Outlet Node Name
VariableFlow,        !- Chiller Flow Mode
NaturalGas,           !- Fuel Type
80.0;                !- Heat Recovery Maximum Temperature {C}

```

Combustion Turbine Chiller Outputs

```

HVAC,Average,Chiller Electric Power [W]
HVAC,Sum,Chiller Electric Consumption [J]
Zone,Meter,Electricity:Plant [J]
Zone,Meter,Cooling:Electricity [J]

```

```

HVAC,Average,Chiller Evap Heat Trans Rate [W]
HVAC,Sum,Chiller Evap Heat Trans [J]
Zone,Meter,EnergyTransfer:Plant [J]
Zone,Meter,Chillers:EnergyTransfer [J]
HVAC,Average,Chiller Evap Water Inlet Temp [C]
HVAC,Average,Chiller Evap Water Outlet Temp [C]
HVAC,Average,Chiller Evap Water Mass Flow Rate [kg/s]

HVAC,Average,Chiller Cond Heat Trans Rate [W]
HVAC,Sum,Chiller Cond Heat Trans [J]
Zone,Meter,HeatRejection:EnergyTransfer [J]

HVAC,Average,Chiller COP [W/W]

Air-cooled or Evap-cooled:
HVAC,Average,Chiller Cond Air Inlet Temp [C]

Water-cooled:
HVAC,Average,Chiller Cond Water Inlet Temp [C]
HVAC,Average,Chiller Cond Water Outlet Temp [C]
HVAC,Average,Chiller Cond Water Mass Flow Rate [kg/s]

HVAC,Average,Chiller Shaft Power [W]
HVAC,Sum,Chiller Shaft Energy [J]

HVAC,Sum,Chiller Lube Heat Recovery [J]
Zone,Meter,HeatRecovery:EnergyTransfer [J]
HVAC,Average,Chiller Exhaust Stack Temp[C]
HVAC,Average,Chiller Heat Recovery Inlet Temp [C]
HVAC,Average,Chiller Heat Recovery Outlet Temp [C]
HVAC,Average,Chiller Heat Recovery Mass Flow Rate [kg/s]

HVAC,Average,Chiller Gas Consumption Rate [W]
HVAC,Sum,Chiller Gas Consumption [J]
Zone,Meter,Gas:Plant [J]
Zone,Meter,Cooling:Gas [J]
HVAC,Average,Chiller Gas Mass Flow Rate [kg/s]
HVAC,Sum,Chiller Gas Mass Consumption [kg]
HVAC,Average,Chiller Fuel COP [W/W]

```

These chiller output variables are defined above under "Generic Chiller Outputs." The Fuel Type input will determine which fuel type is displayed in the output. In this example with the user choice of Natural Gas, you will have Gas Consumption.

ChillerHeater:Absorption:DirectFired

This chiller is a direct fired absorption chiller-heater which is modeled using performance curves similar to the equivalent chiller in DOE-2.1E. This type of chiller is unusual for EnergyPlus, because it may be used in the same plant on both a chilled water supply branch and a hot water supply branch. The chiller has six node connections for chilled water, condenser water, and hot water, and can provide simultaneous heating and cooling. During simultaneous operation, the heating capacity is reduced as the cooling load increases (for more details see below).

Field: Name

This alpha field contains the identifying name for the chiller.

Field: Nominal Cooling Capacity

This numeric field contains the nominal cooling capability of the chiller in Watts.

Field: Heating to Cooling Capacity Ratio

A positive fraction that represents the ratio of the heating capacity divided by the cooling capacity at rated conditions. The default is 0.8.

Field: Fuel Input to Cooling Output Ratio

A positive fraction that represents the ratio of the instantaneous cooling fuel used divided by the cooling capacity at rated conditions. The default is 0.97.

Field: Fuel Input to Heating Output Ratio

A positive fraction that represents the ratio of the instantaneous heating fuel used divided by the nominal heating capacity. The default is 1.25.

Field: Electric Input to Cooling Output Ratio

A positive fraction that represents the ratio of the instantaneous electricity used divided by the cooling capacity at rated conditions. If the chiller is both heating and cooling only the greater of the computed cooling and heating electricity is used. The default is 0.01.

Field: Electric Input to Heating Output Ratio

A positive fraction that represents the ratio of the instantaneous electricity used divided by the nominal heating capacity. If the chiller is both heating and cooling, the greater of the cooling electricity and heating electricity is used. The default is 0.0.

Field: Chilled Water Inlet Node Name

This required alpha field contains the identifying name for the chiller chilled water side inlet node. This node name must be the same as the inlet node name for the chilled water supply branch on which this chiller is placed.

Field: Chilled Water Outlet Node Name

This required alpha field contains the identifying name for the chiller chilled water side outlet node.

Field: Condenser Inlet Node Name

This required alpha field contains the identifying name for the chiller condenser side inlet node. If the Chiller is AirCooled, the node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air dry-bulb temperature from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air dry-bulb temperature is taken directly from the weather data.

Field: Condenser Outlet Node Name

This required alpha field contains the identifying name for the chiller condenser side outlet node.

Field: Hot Water Inlet Node Name

This required alpha field contains the identifying name for the chiller-heater hot water side inlet node. This node name must be the same as the inlet node name for the hot water supply branch on which this chiller-heater is placed.

Field: Hot Water Outlet Node Name

This required alpha field contains the identifying name for the chiller-heater hot water side outlet node.

Field: Minimum Part Load Ratio

A positive fraction that represents the minimum cooling or heating output possible when operated continually at rated temperature conditions divided by the available cooling or heating capacity at those same conditions. If the load on the chiller is below this fraction, the chiller will cycle. If the chiller is simultaneously heating and cooling, the greater part load ratio will be used. The default is 0.1.

Field: Maximum Part Load Ratio

A positive fraction that represents the maximum cooling or heating output possible when operated continually at rated temperature conditions divided by the available cooling or heating capacity at those same conditions. If greater than 1.0, the chiller is typically thought of as capable of being overloaded. The default is 1.0.

Field: Optimum Part Load Ratio

A positive fraction that represents the optimum cooling or heating output possible when operated continually at rated temperature conditions divided by the available cooling or heating capacity at those same conditions. It represents the most desirable operating point for the chiller. The default is 1.0.

Field: Design Entering Condenser Water Temperature

The temperature in degrees C of the water entering the condenser of the chiller when operating at design conditions. This is usually based on the temperature delivered by the cooling tower in a water cooled application. The default is 29C

Field: Design Leaving Chilled Water Temperature

The temperature in degrees C of the water leaving the evaporator of the chiller when operating at design conditions; also called the chilled water supply temperature or leaving chilled water temperature. The default is 7C.

Field: Design Chilled Water Flow Rate

For variable volume this is the max flow and for constant flow this is the flow.

Field: Design Condenser Water Flow Rate

The water flow rate at design conditions through the condenser in m³/s.

Field: Design Hot Water Flow Rate

The water flow rate at design conditions through the heater side.

Field: Cooling Capacity Function of Temperature Curve

The CoolCapfT curve represents the fraction of the cooling capacity of the chiller as it varies by temperature. The curve is normalized so that at design conditions the value of the curve should be 1.0. The curve is usually a biquadratic or bilinear curve with the input variables being the leaving chilled water temperature and either the entering or leaving condenser water temperature (see *Temperature Curve Input Variable* below). The available cooling capacity is computed as follows:

$$\text{AvailableCoolingCapacity} = \text{NominalCoolingCapacity} * \text{CoolCapFTCurve}(\text{LeavingChilledWaterTemp}, \text{SpecifiedCondenserTemp})$$

Field: Fuel-Input-to Cooling Output Ratio Function of Temperature Curve

The CFIRfT curve represents the fraction of the fuel input to the chiller at full load as it varies by temperature. The curve is normalized so that at design conditions the value of the curve should be 1.0. The curve is usually a biquadratic or bilinear curve with the input variables being the leaving chilled water temperature and either the entering or leaving condenser water temperature (see *Temperature Curve Input Variable* below).

Field: Fuel-Input-to Cooling Output Ratio Function of Part Load Ratio Curve

The CFIRfPLR curve represents the fraction of the fuel input to the chiller as the load the chiller varies but the operating temperatures remain at the design values. The curve is normalized so that at full load the value of the curve should be 1.0. The curve is usually linear or quadratic. The cooling fuel input to the chiller is computed as follows:

$$\text{CoolFuelInput} = \text{AvailableCoolingCapacity} * \text{FuelInputToCoolingOutputRatio} * \\ \text{FuelCoolFTCurve}(\text{LeavingChilledWaterTemp}, \text{SpecifiedCondenserTemp}) * \\ \text{FuelCoolFPLRCurve}(\text{CoolPartLoadRatio})$$

Field: Electric Input to Cooling Output Ratio Function of Temperature Curve Name

The ElecCoolFT curve represents the fraction of the electricity to the chiller at full load as it varies by temperature. The curve is normalized so that at design conditions the of the curve should be 1.0. The curve is usually a biquadratic or bilinear curve with the input variables being the leaving chilled water temperature and either the entering or leaving condenser water temperature (see *Temperature Curve Input Variable* below).

Field: Electric Input to Cooling Output Ratio Function of Part Load Ratio Curve Name

The ElecCoolFPLR curve represents the fraction of the electricity to the chiller as the load on the chiller varies but This operating temperatures remain at the design values. The curve is normalized so that at full load the value of the curve should be 1.0. The curve is usually linear or quadratic. The cooling electric input to the chiller is computed as follows:

$$\text{CoolElectricPower} = \text{NominalCoolingCapacity} * \text{ElectricInputToCoolingOutputRatio} * \\ \text{OnTimeFraction} * \\ \text{ElecCoolFTCurve}(\text{LeavingChilledWaterTemp}, \text{SpecifiedCondenserTemp}) * \\ \text{ElecCoolFPLRCurve}(\text{CoolPartLoadRatio})$$

Field: Heating Capacity Function of Cooling Capacity Curve Name

The HeatCapFCool curve represents how the heating capacity of the chiller varies with cooling capacity when the chiller is simultaneous heating and cooling. The curve is normalized so an input of 1.0 represents the nominal cooling capacity and an output of 1.0 represents the full heating capacity (see the Heating to cooling capacity ratio input) The curve is usually linear or quadratic. The available heating capacity is computed as follows:

$$\text{AvailableHeatingCapacity} = \text{NominalCoolingCapacity} * \text{HeatToCoolCapacityRatio} * \\ \text{HeatCapFCoolCurve}(\text{CoolPartLoadRatio})$$

Field: Fuel Input to Heat Output Ratio During Heating Only Operation

When the chiller is operating as only a heater, the curve is used to represent the fraction of fuel used as the heating load varies. It is normalized so that a value of 1.0 is the full available heating capacity. The curve is usually linear or quadratic and will probably be similar to a boiler curve for most chillers.

$$\text{HeatFuelUseRate} = \text{AvailableHeatingCapacity} * \text{FuelInputToCoolingOutputRatio} * \\ \text{IFuelHeatFHPLRCurve}(\text{HeatPartLoadRatio})$$

Field: Temperature Curve Input Variable

This field sets the second independent variable in the three temperature dependent performance curves to either the leaving or entering condenser water temperature. Manufacturers express the performance of their chillers using either the leaving condenser water temperature (to the tower) or the entering condenser water temperature (from the tower). Valid choices for this field are: LeavingCondenser or EnteringCondenser. It is important that the performance curves and this field are consistent with each other. The default is EnteringCondenser.

Field: Condenser Type

The condenser can either be air cooled or connected to a cooling tower. This alpha field contains the keyword for the type of condenser, either AirCooled, or WaterCooled. The default is WaterCooled.

Field: Chilled Water Temperature Lower Limit

The chilled water supply temperature in degrees C below which the chiller will shut off. The default is 2C

Field: Fuel Higher Heating Value

The fuel higher heating value in kJ/kg. *This field is not currently used.*

Field: Chiller Flow Mode

This alpha field determines if the Chiller is either a Variable or Constant Flow Chiller Simulation. The default, if not specified, is Variable Flow.

Field: Fuel Type

This alpha field determines the type of fuel that the chiller uses. The default is Natural Gas.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. For this component the inputs that would be altered by the sizing factor are: Nominal Cooling Capacity, Design Chilled Water Flow Rate, Design Condenser Water Flow Rate and Design Hot Water Flow Rate. Sizing Factor allows the user to size a component to meet part of the design load while continuing to use the autosizing feature.

```
ChillerHeater:Absorption:DirectFired,
  \min-fields 35
  \memo Direct fired gas absorption chiller-heater using performance curves similar to DOE-2
A1, \field Name
  \required-field
N1 , \field Nominal Cooling Capacity
  \required-field
  \autosizable
  \default Autosize
  \units W
N2 , \field Heating to Cooling Capacity Ratio
  \note A positive fraction that represents the ratio of the
  \note heating capacity divided by the cooling capacity at rated conditions.
  \minimum 0
  \default 0.8
N3 , \field Fuel Input to Cooling Output Ratio
  \note The positive fraction that represents the ratio of the
  \note instantaneous fuel used divided by the cooling capacity at rated conditions.
  \minimum > 0
  \default 0.97
N4 , \field Fuel Input to Heating Output Ratio
  \note The positive fraction that represents the ratio of the
  \note instantaneous fuel used divided by the nominal heating capacity.
  \minimum 0
  \default 1.25
```

```

N5 , \field Electric Input to Cooling Output Ratio
    \note The positive fraction that represents the ratio of the
    \note instantaneous electricity used divided by the cooling capacity at rated conditions.
    \note If the chiller is both heating and cooling only the cooling electricity is used.
    \minimum 0
    \default 0.01
N6 , \field Electric Input to Heating Output Ratio
    \note The positive fraction that represents the ratio of the
    \note instantaneous electricity used divided by the nominal heating capacity.
    \note If the chiller is both heating and cooling only the cooling electricity is used.
    \minimum 0
    \default 0
A2 , \field Chilled Water Inlet Node Name
    \required-field
A3 , \field Chilled Water Outlet Node Name
    \required-field
A4 , \field Condenser Inlet Node Name
    \required-field
A5 , \field Condenser Outlet Node Name
    \required-field
A6 , \field Hot Water Inlet Node Name
    \required-field
A7 , \field Hot Water Outlet Node Name
    \required-field
N7 , \field Minimum Part Load Ratio
    \note The positive fraction that represents the minimum cooling output possible when
    \note operated continually at rated temperature conditions divided by the nominal
    \note cooling capacity at those same conditions. If the load on the chiller is below
    \note this fraction the chiller will cycle.
    \minimum> 0
    \default 0.1
N8 , \field Maximum Part Load Ratio
    \note The positive fraction that represents the maximum cooling output possible at
    \note rated temperature conditions divided by the nominal cooling capacity at those
    \note same conditions. If greater than 1.0, the chiller is typically thought of as
    \note capable of being overloaded.
    \minimum 0.5
    \default 1.0
N9 , \field Optimum Part Load Ratio
    \note The positive fraction that represents the optimal cooling output at rated
    \note temperature conditions divided by the nominal cooling capacity at those same
    \note conditions. It represents the most desirable operating point for the chiller.
    \minimum> 0
    \default 1.0
N10 , \field Design Entering Condenser Water Temperature
    \note The temperature of the water entering the condenser of the chiller when
    \note operating at design conditions. This is usually based on the temperature
    \note delivered by the cooling tower in a water cooled application.
    \default 29
    \units C
N11 , \field Design Leaving Chilled Water Temperature
    \note The temperature of the water leaving the evaporator of the chiller when
    \note operating at design conditions also called the chilled water supply temperature
    \note or leaving chilled water temperature.
    \default 7
    \units C
N12 , \field Design Chilled Water Flow Rate
    \note For variable volume this is the max flow & for constant flow this is the flow.
    \autosizable
    \default Autosize
    \units m3/s
    \ip-units gal/min
N13 , \field Design Condenser Water Flow Rate
    \note The water flow rate at design conditions through the condenser.
    \autosizable
    \default Autosize
    \required-field
    \units m3/s
    \ip-units gal/min

```

```

N14 , \field Design Hot Water Flow Rate
      \note The water flow rate at design conditions through the heater side.
      \autosizable
      \default Autosize
      \units m3/s
      \ip-units gal/min
A8 , \field Cooling Capacity Function of Temperature Curve Name
     \note The CoolCapFT curve represents the fraction of the cooling capacity of the chiller as it
     \note varies by temperature. The curve is normalized so that at design conditions the
     \note value of the curve should be 1.0. The curve is usually a biquadratic or bilinear
     \note curve with the input variables being the leaving chilled water temperature and either
     \note the entering or leaving condenser water temperature.
A9 , \field Fuel Input to Cooling Output Ratio Function of Temperature Curve Name
     \note The curve represents the fraction of the fuel input to the chiller at full load as
     \note it varies by temperature. The curve is normalized so that at design conditions the
     \note value of the curve should be 1.0. The curve is usually a biquadratic or bilinear
     \note curve with the input variables being the leaving chilled water temperature and either
     \note the entering or leaving condenser water temperature.
A10 , \field Fuel Input to Cooling Output Ratio Function of Part Load Ratio Curve Name
      \note The curve represents the fraction of the fuel input to the chiller as the load on
      \note the chiller varies but the operating temperatures remain at the design values.
      \note The curve is normalized so that at full load the value of the curve should be 1.0.
      \note The curve is usually linear or quadratic.
A11 , \field Electric Input to Cooling Output Ratio Function of Temperature Curve Name
      \note The curve represents the fraction of the electricity to the chiller at full load as
      \note it varies by temperature. The curve is normalized so that at design conditions the
      \note value of the curve should be 1.0. The curve is usually a biquadratic or bilinear
      \note curve with the input variables being the leaving chilled water temperature and either
      \note the entering or leaving condenser water temperature.
A12 , \field Electric Input to Cooling Output Ratio Function of Part Load Ratio Curve Name
      \note The curve represents the fraction of the electricity to the chiller as the load on
      \note the chiller varies but the operating temperatures remain at the design values.
      \note The curve is normalized so that at full load the value of the curve should be 1.0.
      \note The curve is usually linear or quadratic.
A13 , \field Heating Capacity Function of Cooling Capacity Curve Name
      \note The curve represents how the heating capacity of the chiller varies with cooling
      \note capacity when the chiller is simultaneous heating and cooling. The curve is normalized
      \note so an input of 1.0 represents the nominal cooling capacity and an output of 1.0
      \note represents the full heating capacity (see the Heating to cooling capacity ratio input)
      \note The curve is usually linear or quadratic.
A14 , \field Fuel Input to Heat Output Ratio During Heating Only Operation
      \note When the chiller is operating as only a heater, this curve is used to represent the
      \note fraction of fuel used as the heating load varies. It is normalized so that a value
      \note of 1.0 is the full heating capacity. The curve is usually linear or quadratic and
      \note will probably be similar to a boiler curve for most chillers.
A15 , \field Temperature Curve Input Variable
      \type choice
      \key LeavingCondenser
      \key EnteringCondenser
      \default EnteringCondenser
      \note Sets the second independent variable in the three temperature dependent performance
      \note curves to either the leaving or entering condenser water temperature. Manufacturers
      \note express the performance of their chillers using either the leaving condenser water
      \note temperature (to the tower) or the entering condenser water temperature (from the tower).
A16 , \field Condenser Type
      \note The condenser can either be air cooled or connected to a cooling tower.
      \type choice
      \key AirCooled
      \key WaterCooled
      \default WaterCooled
N15 , \field Chilled Water Temperature Lower Limit
      \note The chilled water supply temperature below which the chiller
      \note will shut off.
      \units C
      \default 2.0
N16 , \field Fuel Higher Heating Value
      \note Not currently used.
      \units kJ/kg
      \default 0.0

```

```

A17 , \field Chiller Flow Mode
      \note Sets this chiller to a VariableFlow or ConstantFlow simulation
      \type choice
      \key ConstantFlow
      \key VariableFlow
      \default VariableFlow
A18 , \field Fuel Type
      \required-field
      \type choice
      \key NaturalGas
      \key PropaneGas
      \key Diesel
      \key Gasoline
      \key FuelOil#1
      \key FuelOil#2
      \default NaturalGas
N17 ; \field Sizing Factor
      \note Multiplies the autosized capacity and flow rates
      \type real
      \minimum> 0.0
      \default 1.0

```

An example of this statement in an IDF is:

```

ChillerHeater:Absorption:DirectFired,,
  Big Chiller,                !- Chiller Name
  100000,                     !- Nominal Cooling Capacity {W}
  0.8,                        !- Heating to cooling capacity ratio
  0.97,                       !- Fuel Input to Cooling Output Ratio
  1.25,                       !- Fuel Input to Heating Output Ratio
  0.01,                       !- Electric Input to Cooling Output Ratio
  0.005,                      !- Electric Input to Heating Output Ratio
  Big Chiller Inlet Node,     !- Chilled Water Side Inlet Node
  Big Chiller Outlet Node,    !- Chilled Water Side Outlet Node
  Big Chiller Condenser Inlet Node, !- Condenser Side Inlet Node
  Big Chiller Condenser Outlet Node, !- Condenser Side Outlet Node
  Purchased Heat Inlet Node,  !- Hot Water Side Inlet Node
  Purchased Heat Outlet Node, !- Hot Water Side Outlet Node
  0.000001,                  !- Minimum Part Load Ratio
  1.0,                       !- Maximum Part Load Ratio
  0.6,                       !- Optimum Part Load Ratio
  29,                        !- Design Entering Condenser Water Temperature {C}
  7,                         !- Design Leaving Chilled Water Temperature {C}
  0.0011,                    !- Design Chilled Water Flow Rate {m3/s}
  0.0011,                    !- Design Condenser Water Flow Rate {m3/s}
  0.0043,                    !- Design Hot Water Flow Rate {m3/s}
  GasAbsFlatBiQuad,         !- Cooling Capacity Function of Temperature Curve
  GasAbsFlatBiQuad,         !- Fuel Input to Cooling Output Ratio Function of Temperature Curve
  GasAbsLinearQuad,        !- Fuel Input to Cooling Output Ratio Function of Part Load Ratio Curve
  GasAbsFlatBiQuad,        !- Electric Input to Cooling Output Ratio Function of Temperature Curve
  GasAbsFlatQuad,          !- Electric Input to Cooling Output Ratio Function of Part Load Ratio Curve
  GasAbsInvLinearQuad,     !- Heating Capacity Function of Cooling Capacity Curve
  GasAbsLinearQuad,        !- Fuel Input to Heat Output Ratio During Heating Only Function
  EnteringCondenser,       !- Temperature Curve Input Variable
  WaterCooled,             !- Condenser Type
  2,                       !- Chilled Water Lower Limit Temperature {C}
  0,                       !- Fuel Heating Value {kJ/kg}
  VariableFlow,            !- Chiller Flow Mode
  NaturalGas;              !- Fuel Type

```

Direct Fired Absorption Chiller Outputs

```

HVAC,Average,Chiller Electric Power [W]
HVAC,Sum,Chiller Electric Consumption [J]
Zone,Meter,Electricity:Plant [J]
Zone,Meter,Cooling:Electricity [J]

HVAC,Average,Chiller Gas Consumption Rate [W]
HVAC,Sum,Chiller Gas Consumption [J]
Zone,Meter,Gas:Plant [J]

```

Zone,Meter,Cooling:Gas [J]

HVAC,Average,Chiller Evap Heat Trans Rate [W]

HVAC,Sum,Chiller Evap Heat Trans [J]

Zone,Meter,EnergyTransfer:Plant [J]

Zone,Meter,Chillers:EnergyTransfer [J]

HVAC,Average,Chiller Evap Water Inlet Temp [C]

HVAC,Average,Chiller Evap Water Outlet Temp [C]

HVAC,Average,Chiller Evap Water Mass Flow Rate [kg/s]

HVAC,Average,Chiller Cond Heat Trans Rate [W]

HVAC,Sum,Chiller Cond Heat Trans [J]

Zone,Meter,HeatRejection:EnergyTransfer [J]

The following output is applicable only for air-cooled chillers

HVAC,Average,Chiller Cond Air Inlet Temp [C]

The following three outputs are only available for water-cooled chillers

HVAC,Average,Chiller Cond Water Inlet Temp [C]

HVAC,Average,Chiller Cond Water Outlet Temp [C]

HVAC,Average,Chiller Cond Water Mass Flow Rate [kg/s]

Outputs specific to Direct Fired Absorption Chiller

HVAC,Average,Direct Fired Absorption Chiller Fraction of Period Running

Outputs specific to Direct Fired Absorption Chiller during cooling operation

HVAC,Average,Direct Fired Absorption Chiller Cooling Gas Consumption Rate [W]

HVAC,Sum,Direct Fired Absorption Chiller Cooling Gas Consumption [J]

HVAC,Average,Direct Fired Absorption Chiller Cooling Electric Power [W]

HVAC,Sum,Direct Fired Absorption Chiller Cooling Electric Consumption [J]

HVAC,Average,Direct Fired Absorption Chiller Cooling Part Load Ratio

HVAC,Average,Direct Fired Absorption Chiller Cooling Capacity [W]

HVAC,Average,Direct Fired Absorption Chiller Cooling Fuel COP [W/W]

Outputs specific to Direct Fired Absorption Chiller during heating operation

HVAC,Average,Direct Fired Absorption Chiller Heating Rate [W]

HVAC,Sum,Direct Fired Absorption Chiller Heating Energy [J]

Zone,Meter,Boilers:EnergyTransfer [J]

HVAC,Average,Direct Fired Absorption Chiller Heating Gas Consumption Rate [W]

HVAC,Sum,Direct Fired Absorption Chiller Heating Gas Consumption [J]

Zone,Meter,Heating:Gas [J]

HVAC,Average,Direct Fired Absorption Chiller Heating Electric Power [W]

HVAC,Sum,Direct Fired Absorption Chiller Heating Electric Consumption [J]

Zone,Meter,Heating:Electricity [J]

HVAC,Average,Direct Fired Absorption Chiller Heating Part Load Ratio

HVAC,Average,Direct Fired Absorption Chiller Heating Capacity [W]

HVAC,Average,Direct Fired Absorption Chiller Hot Water Inlet Temp [C]

HVAC,Average,Direct Fired Absorption Chiller Hot Water Outlet Temp [C]

HVAC,Average,Direct Fired Absorption Chiller Hot Water Mass Flow Rate [kg/s]

The "Chiller" output variables are defined above under "Generic Chiller Outputs." The specific "Direct Fired Absorption Chiller" output variables and exceptions to the generic outputs are defined below.

Chiller Electric Power [W]**Chiller Electric Consumption [J]**

These outputs are the electric power input to the chiller when operating in cooling mode, heating mode, or both. This value is not metered, but the separate cooling and heating electric consumption are metered (see below).

Chiller Gas Consumption Rate [W]**Chiller Gas Consumption [J]**

These outputs are the natural gas input to the chiller when operating in cooling mode, heating mode, or both depending on the fuel type entered. This value is not metered, but the separate cooling and heating electric consumption are metered (see below).

Direct Fired Absorption Chiller Fraction of Period Running

This is the average fraction of the time period during which the direct fired absorption chiller-heater was operating in either cooling mode, heating mode, or both.

Direct Fired Absorption Chiller Cooling Gas Consumption Rate [W]**Direct Fired Absorption Chiller Cooling Gas Consumption [J]**

These outputs are the natural gas input to the direct fired absorption chiller to serve cooling operation. Consumption is metered on Cooling:Gas, Gas:Plant, and Gas:Facility.

Direct Fired Absorption Chiller Cooling Electric Power [W]**Direct Fired Absorption Chiller Cooling Electric Consumption [J]**

These outputs are the electricity input to the direct fired absorption chiller to serve cooling operation. Consumption is metered on Cooling:Electricity, Electricity:Plant, and Electricity:Facility.

Direct Fired Absorption Chiller Cooling Capacity [W]

This is the average available cooling capacity for the reported time period.

Direct Fired Absorption Chiller Cooling Part Load Ratio

This is the average cooling load (Chiller Evap Heat Trans Rate [W]) divided by the average available cooling capacity (Direct Fired Absorption Chiller Cooling Capacity [W]) for the reported time period.

Direct Fired Absorption Chiller Cooling Fuel COP

This is the average coefficient of performance for the chiller in cooling operation, calculated as the average cooling load (Chiller Evap Heat Trans Rate [W]) divided by the average gas consumption during cooling (Direct Fired Absorption Chiller Cooling Gas Consumption Rate [W]) for the reported time period. If the chiller cooling gas consumption rate (denominator) is zero, then this output variable is set to zero.

Direct Fired Absorption Chiller Heating Rate [W]**Direct Fired Absorption Chiller Heating Energy [J]**

These outputs are the heating delivered by the direct fired absorption chiller-heater to serve heating operation. Energy is metered on Boilers:EnergyTransfer, EnergyTransfer:Plant, and EnergyTransfer:Facility.

Direct Fired Absorption Chiller Heating Gas Consumption Rate [W]***Direct Fired Absorption Chiller Heating Gas Consumption [J]***

These outputs are the natural gas input to the direct fired absorption chiller-heater to serve heating operation. Consumption is metered on Heating:Gas, Gas:Plant, and Gas:Facility.

Direct Fired Absorption Chiller Heating Electric Power [W]***Direct Fired Absorption Chiller Heating Electric Consumption [J]***

These outputs are the electric power input to the direct fired absorption chiller to serve heating operation. Consumption is metered on Heating:Electricity, Electricity:Plant, and Electricity:Facility.

Direct Fired Absorption Chiller Heating Capacity [W]

This is the average available heating capacity for the reported time period.

Direct Fired Absorption Chiller Heating Part Load Ratio

This is the average heating load (Direct Fired Absorption Chiller Heating Rate [W]) divided by the average available heating capacity (Direct Fired Absorption Chiller Heating Capacity [W]) for the reported time period.

Direct Fired Absorption Chiller Hot Water Inlet Temp [C]***Direct Fired Absorption Chiller Hot Water Outlet Temp [C]******Direct Fired Absorption Chiller Hot Water Mass Flow Rate [kg/s]***

These outputs are the hot water inlet and outlet temperatures and flow rate for the direct fired absorption chiller-heater during heating mode operation.

Boiler:HotWater

The boiler model calculates the performance of fuel oil, gas and electric boilers. Boiler performance is based on nominal thermal efficiency. A normalized efficiency performance curve may be used to more accurately represent the performance of non-electric boilers but is not considered a required input. When using the normalized efficiency performance curve, if all coefficients are not required simply set the unused coefficients to 0. For example, an electric boiler could be modeled by setting the nominal thermal efficiency to a value in the range of 0.96 to 1.0. Coefficient A0 in the normalized efficiency performance curve would equal 1 and all other coefficients would be set to 0. Coefficients for other types of non-electric boilers would set a combination of the available coefficients to non-zero values.


```

Boiler:HotWater,
  \min-fields 11
  \memo This boiler model is an adaptation of the empirical model from the Building
  \memo Loads and System Thermodynamics (BLAST) program. Boiler performance
  \memo curves are generated by fitting catalog data to polynomial equations.
  \memo A constant efficiency boiler may be modeled by leaving the normalized
  \memo boiler efficiency curve name input blank.
A1 , \field Name
  \required-field
  \type alpha
A2 , \field Fuel Type
  \required-field
  \type choice
  \key Electricity
  \key NaturalGas
  \key PropaneGas
  \key FuelOil#1
  \key FuelOil#2
  \key Coal
  \key Diesel
  \key Gasoline
N1 , \field Nominal Capacity
  \type real
  \units W
  \autosizable
  \minimum 0.0
N2 , \field Nominal Thermal Efficiency
  \required-field
  \type real
  \minimum > 0.0
  \maximum 1.0
  \note Based on the higher heating value of fuel.
A3 , \field Normalized Boiler Efficiency Curve Name
  \type object-list
  \object-list AllCurves
  \note Linear, Quadratic and Cubic efficiency curves are solely a function of PLR.
  \note All other efficiency curve types are a function of PLR and boiler outlet water temperature.
  \note Linear =  $C1 + C2*PLR$ 
  \note Quadratic =  $C1 + C2*PLR + C3*PLR^2$ 
  \note Cubic =  $C1 + C2*PLR + C3*PLR^2 + C4*PLR^3$ 
  \note Biquadratic =  $C1 + C2*PLR + C3*PLR^2 + C4*T + C5*T^2 + C6*PLR*T$ 
  \note QuadraticLinear =  $C1 + C2*PLR + C3*PLR^2 + (C4 + C5*PLR + C6*PLR^2)*T$ 
  \note BiCubic =  $C1+C2*PLR+C3*PLR^2+C4*T+C5*T^2+C6*PLR*T+C7*PLR^3+C8*T^3+C9*PLR^2*T+C10*PLR*T^2$ 
  \note TriQuadratic curves are not allowed.
  \note PLR = part-load ratio
  \note T = boiler outlet water temperature.
N3 , \field Design Water Outlet Temperature
  \type real
  \units C
N4 , \field Design Water Flow Rate
  \type real
  \units m3/s
  \autosizable
  \ip-units gal/min
  \minimum 0.0
N5 , \field Minimum Part Load Ratio
  \type real
  \minimum 0.0
  \default 0.0
N6 , \field Maximum Part Load Ratio
  \type real
  \minimum 0.0
  \default 1.0
N7 , \field Optimum Part Load Ratio
  \type real
  \minimum 0.0
  \default 1.0

```

```

A4 , \field Boiler Water Inlet Node Name
    \required-field
    \type alpha
A5 , \field Boiler Water Outlet Node Name
    \required-field
    \type alpha
N8 , \field Water Outlet Upper Temperature Limit
    \type real
    \units C
    \default 99.9
A6 , \field Boiler Flow Mode
    \note Sets this boiler to either a variable or constant flow simulation
    \type choice
    \key ConstantFlow
    \key VariableFlow
    \default VariableFlow
N9 , \field Parasitic Electric Load
    \type real
    \units W
    \minimum 0.0
N10; \field Sizing Factor
    \note Multiplies the autosized capacity and flow rates
    \type real
    \minimum> 0.0
    \default 1.0

```

Field: Name

This required alpha field contains the identifying name for the boiler.

Field: Fuel Type

This required choice field specifies the type of fuel used by the boiler. The fuel type can be Electricity, NaturalGas, PropaneGas, FuelOil#1, FuelOil#2, Coal, Diesel, or Gasoline.

Field: Nominal capacity

This numeric field contains the nominal operating capacity (W) of the boiler. The boiler may be autosized and would require a heating plant sizing object.

Fuel Use Equation

The model is based the following two equations:

$$\textit{TheoreticalFuelUse} = \frac{\textit{BoilerLoad}}{\textit{NominalThermalEfficiency}}$$

$$\textit{FuelUsed} = \frac{\textit{TheoreticalFuelUse}}{\textit{NormalizedBoilerEfficiencyCurveOutput}}$$

Field: Nominal Thermal Efficiency

This required numeric field contains the heating efficiency (as a fraction between 0 and 1) of the boiler's burner. This is the efficiency relative to the higher heating value (HHV) of fuel at a part load ratio of 1.0 and the temperature entered for the Design Boiler Water Outlet Temp. Manufacturers typically specify the efficiency of a boiler using the higher heating value of the fuel. For the rare occurrences when a manufacturers (or particular data set) thermal efficiency is based on the lower heating value (LHV) of the fuel, multiply the thermal efficiency by the lower-to-higher heating value ratio. For example, assume a fuel's lower and higher heating values are approximately 45,450 and 50,000 kJ/kg, respectively. For a manufacturers thermal efficiency rating of 0.90 (based on the LHV), the nominal thermal efficiency entered here is 0.82 (i.e. 0.9 multiplied by 45,450/50,000).

Field: Normalized Boiler Efficiency Curve Name

This alpha field contains the curve name which describes the normalized heating efficiency (as a fraction of nominal thermal efficiency) of the boiler's burner. If this field is left blank, the nominal thermal efficiency is assumed to be constant (i.e., Fuel Used is equal to the Theoretical Fuel Use in the equation above). When a boiler efficiency curve is used, the curve may be any valid curve object with 1 (PLR) or 2 (PLR and boiler outlet water temperature) independent variables. A tri-quadratic curve object is not allowed since it uses 3 independent variables. The linear, quadratic, and cubic curve types may be used when the boiler efficiency is solely a function of boiler part-load ratio (PLR). When this type of curve is used, the boiler should operate at (or very near) the design boiler water outlet temperature. Other curve types may be used when the boiler efficiency is a function of both PLR and boiler water temperature. Examples of valid single and dual independent variable equations are shown below. For all curve types PLR is always the x independent variable. When using 2 independent variables, the boiler outlet water temperature (T_{outlet}) is always the y independent variable.

Linear: $Eff = A0 + A1*PLR$

Quadratic: $Eff = A0 + A1*PLR + A2*PLR^2$

Cubic: $Eff = A0 + A1*PLR + A2*PLR^2 + A3*PLR^3$

BiQuadratic: $Eff = A0 + A1*PLR + A2*PLR^2 + A3*T_w + A4*T_w^2 + A5*PLR*T_w$

QuadraticLinear: $Eff = A0 + A1*PLR + A2*PLR^2 + A3*T_w + A4*PLR*T_w + A5*PLR^2*T_w$

BiCubic: $Eff = A0 + A1*PLR + A2*PLR^2 + A3*T_w + A4*T_w^2 + A5*PLR^2 + A6*T_w^3 + A7*PLR^2*T_w + A8*PLR*T_w^2$

where

Eff = normalized boiler efficiency

PLR = boiler part-load ratio

T_w = boiler (outlet) water temperature [°C]

Field: Design Water Outlet Temperature

This numeric field contains the desired boiler water outlet temperature in Celsius.

Field: Design Water Flow Rate

This numeric field contains the maximum design water volumetric flow rate in m³/sec. This should be the largest flow rate that can be heated to the design outlet temperature. This field is autosizable.

Field: Minimum Part Load Ratio

This numeric field contains the minimum part load ratio. If the ratio of demand to boiler nominal capacity is less than the minimum part load ratio, then the Min PLR will determine the operating PLR. The expected range is between 0 and 1. If this field is left blank, the default value is 0.0.

Field: Maximum Part Load Ratio

This numeric field contains the maximum part load ratio. If the ratio of demand to boiler nominal capacity is greater than the maximum part load ratio, then the Max PLR will determine the operating PLR. This value may exceed 1, but the normal range is between 0 and 1.1. If this field is left blank, the default value is 1.0.

Field: Optimum Part Load Ratio

This numeric field contains the optimum part load ratio. This is the part load ratio at which the boiler performs at its maximum efficiency. If this field is left blank, the default value is 1.0.

Field: Boiler Water Inlet Node Name

This required alpha field contains the water inlet node name.

Field: Boiler Water Outlet Node Name

This required alpha field contains the water outlet node name.

Field: Water Outlet Upper Temperature Limit

This numeric field contains the outlet temperature upper limit. If this field is left blank, the default value is 99.9°C.

Field: Boiler Flow Mode

This choice field determines if the boiler is VariableFlow or ConstantFlow. The default, if not specified, is VariableFlow.

Field: Parasitic Electric Load

This optional numeric field contains the parasitic electric power (W) consumed by a forced draft fan or other electrical device associated with the boiler. This parasitic electric load is consumed whenever the boiler is operating, and the model assumes that this parasitic power does not contribute to heating the water. The minimum value for this field is 0.0, and the default value is also 0.0 if the field is left blank.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. For this component the inputs that would be altered by the sizing factor are: Nominal Capacity and Design Water Flow Rate. Sizing factor allows the user to size a component to meet part of the design load while continuing to use the autosizing feature.

An example of this statement in an IDF is:

```

Boiler:HotWater,
  Condensing Boiler,    !- Boiler Name
  GAS,                  !- Fuel Type
  25000,                !- Nominal Capacity {W}
  0.89,                 !- Nominal Thermal Efficiency
  CondensingBoilerEff, !- Boiler Efficiency Curve Name
  75,                   !- Design Boiler Water Outlet Temp {C}
  0.0021,               !- Max Design Boiler Water Flow Rate {m3/s}
  0.10,                 !- Minimum Part Load Ratio
  1.00,                 !- Maximum Part Load Ratio
  1.00,                 !- Optimum Part Load Ratio
  Boiler Inlet Node,   !- Boiler Water Inlet Node
  Boiler Outlet Node,  !- Boiler Water Outlet Node
  80,                   !- Temp Upper Limit Water Outlet {C}
  ConstantFlow,        !- Boiler Flow Mode
  25.0;                 !- Parasitic Electric Load {W}

Curve:Biquadratic,
  CondensingBoilerEff, !- Name
  1.124970374,          !- Coefficient1 Constant
  0.014963852,          !- Coefficient2 x
  -0.02599835,         !- Coefficient3 x**2
  0.0,                  !- Coefficient4 y
  -1.40464E-6,         !- Coefficient5 y**2
  -0.00153624,         !- Coefficient6 x*y
  0.1,                  !- Minimum Value of x
  1.0,                  !- Maximum Value of x
  30.0,                 !- Minimum Value of y
  85.0;                 !- Maximum Value of y

```

BoilerHotWater Outputs

Outputs available from the boiler:

```
HVAC,Average,Boiler Heating Output Rate [W]
HVAC,Sum,Boiler Heating Output Energy [J]
Zone,Meter,Boilers:EnergyTransfer [J]

HVAC,Average,Boiler Water Inlet Temp [C]
HVAC,Average,Boiler Water Outlet Temp [C]
HVAC,Average,Boiler Water Mass Flow Rate [kg/s]
HVAC,Average,Boiler Parasitic Electric Power [W]
HVAC,Sum,Boiler Parasitic Electric Consumption [J]
HVAC,Average,Boiler Part-Load Ratio
```

One of the following blocks will be applicable based on fuel type:

```
HVAC,Average,Boiler Electric Consumption Rate [W]
HVAC,Sum,Boiler Electric Consumption [J]
Zone,Meter,Electricity:Plant [J]
Zone,Meter,Heating:Electricity [J]

HVAC,Average,Boiler Gas Consumption Rate [W]
HVAC,Sum,Boiler Gas Consumption [J]
Zone,Meter,Gas:Plant [J]
Zone,Meter,Heating:Gas [J]

HVAC,Average,Boiler Propane Consumption Rate [W]
HVAC,Sum,Boiler Propane Consumption [J]
Zone,Meter,Propane:Plant [J]
Zone,Meter,Heating:Propane [J]

HVAC,Average,Boiler FuelOil#1 Consumption Rate [W]
HVAC,Sum,Boiler FuelOil#1 Consumption [J]
Zone,Meter,FuelOil#1:Plant [J]
Zone,Meter,Heating:FuelOil#1 [J]

HVAC,Average,Boiler FuelOil#2 Consumption Rate [W]
HVAC,Sum,Boiler FuelOil#2 Consumption [J]
Zone,Meter,FuelOil#2:Plant [J]
Zone,Meter,Heating:FuelOil#2 [J]

HVAC,Average,Boiler Coal Consumption Rate [W]
HVAC,Sum,Boiler Coal Consumption [J]
Zone,Meter,Coal:Plant [J]
Zone,Meter,Heating:Coal [J]

HVAC,Average,Boiler Diesel Consumption Rate [W]
HVAC,Sum,Boiler Diesel Consumption [J]
Zone,Meter,Diesel:Plant [J]
Zone,Meter,Heating:Diesel [J]

HVAC,Average,Boiler Gasoline Consumption Rate [W]
HVAC,Sum,Boiler Gasoline Consumption [J]
Zone,Meter,Gasoline:Plant [J]
Zone,Meter,Heating:Gasoline [J]
```

Boiler Heating Output Rate [W]

Boiler Heating Output Energy [J]

These outputs are the heating output (load) of the boiler. Energy is metered on Boilers:EnergyTransfer, EnergyTransfer:Plant, and EnergyTransfer:Facility.

Boiler Water Inlet Temp [C]**Boiler Water Outlet Temp [C]****Boiler Water Mass Flow Rate [kg/s]**

These outputs are the hot water inlet and outlet temperatures and flow rate for the boiler.

Boiler Part-Load Ratio

This output is the operating part-load ratio of the boiler. The part-load ratio is calculated as the boiler load divided by the boiler nominal capacity. The part-load ratio is limited by the minimum and maximum part-load ratio inputs specified by the user.

Boiler <FuelType> Consumption Rate [W]**Boiler <FuelType> Consumption [J]**

These outputs are the energy input to the boiler. Valid fuel types are: Electric, Gas (natural gas), Propane, FuelOil#1, FuelOil#2, Coal, Diesel, and Gasoline. Consumption is metered on Heating:<FuelType>, <FuelType>:Plant, and <FuelType>:Facility.

Boiler Parasitic Electric Power [W]**Boiler Parasitic Electric Consumption [J]**

These outputs are the parasitic electric power and parasitic electric consumption associated with the boiler. Used when simulating a forced draft fan or other electric component. Consumption is metered on Heating:Electricity and Electricity:Plant.

Boiler:Steam

The steam boiler model provides a first order approximation of performance for fuel oil, gas and electric boilers. Boiler performance is based on a “theoretical” boiler efficiency (overall efficiency at design operating conditions) and a single quadratic fuel use/ part load ratio curve. This single curve accounts for all combustion inefficiencies and stack losses.

```
Boiler:Steam,
  \memo This boiler model is an adaptation of the empirical model from the Building
  \memo Loads and System Thermodynamics (BLAST) program. Boiler performance
  \memo curves are generated by fitting catalog data to third order
  \memo polynomial equations. A constant efficiency boiler is modeled by setting
  \memo the fuel use coefficients as follows: N9=1, N10=0, N11=0
A1 , \field Name
  \required-field
A2 , \field Fuel Type
  \required-field
  \type choice
  \key Electricity
  \key NaturalGas
  \key PropaneGas
  \key FuelOil#1
  \key FuelOil#2
  \key Coal
  \key Diesel
  \key Gasoline
N1 , \field Maximum Operating Pressure
  \units Kpa
N2 , \field Theoretical Efficiency
  \type real
  \minimum 0.0
  \maximum 1.0
N3 , \field Design Outlet Steam Temperature
  \units C
N4 , \field Nominal Capacity
  \units W
  \autosizable
```

```

N5 , \field Minimum Part Load Ratio
    \minimum 0.0
N6 , \field Maximum Part Load Ratio
    \minimum 0.0
N7 , \field Optimum Part Load Ratio
    \minimum 0.0
N8 , \field Coefficient 1 of Fuel Use Function of Part Load Ratio Curve
N9 , \field Coefficient 2 of Fuel Use Function of Part Load Ratio Curve
N10, \field Coefficient 3 of Fuel Use Function of Part Load Ratio Curve
A3 , \field Water Inlet Node Name
A4 , \field Steam Outlet Node Name
N11; \field Sizing Factor
    \note Multiplies the autosized capacity and flow rates
    \type real
    \minimum> 0.0
    \default 1.0

```

Field: Name

This alpha field contains the identifying name for the Steam Boiler.

Field: Fuel Type

This alpha value specifies the type of fuel used by the boiler. The fuel type can be Electricity, NaturalGas, PropaneGas, FuelOil#1, FuelOil#2, Coal, Diesel, or Gasoline.

Field: Maximum Operating Pressure

This numeric field contains the maximum value of pressure up to which the boiler would operate, or the maximum design pressure. (Pascal)

Field: Theoretical Efficiency

This numeric field contains the heating efficiency (as a fraction between 0 and 1) of the boiler's burner

Field: Design Outlet Steam Temperature

The maximum value of steam temperature the boiler can provide. (Celcius)

Field: Nominal Capacity

This numeric field contains the nominal operating capacity (W) of the boiler.

Field: Minimum Part Load Ratio

This numeric field contains the minimum part load ratio. If the ratio of demand to boiler nominal capacity is less than the minimum part load ratio, then the Min PLR will determine the operating PLR. The expected range is between 0 and 1.

Field: Maximum Part Load Ratio

This numeric field contains the maximum part load ratio. If the ratio of demand to boiler nominal capacity is greater than the maximum part load ratio, then the Max PLR will determine the operating PLR. This value may exceed 1, but the normal range is between 0 and 1.1.

Field: Optimum Part Load Ratio

This numeric field contains the optimum part load ratio. This is the part load ratio at which the boiler performs at its maximum efficiency.

Field: Coefficient 1 of Fuel Use Function of Part Load Ratio Curve

This numeric field contains the fuel use / PLR coefficient1.

Field: Coefficient 2 of Fuel Use Function of Part Load Ratio Curve

This numeric field contains the fuel use / PLR coefficient2.

Field: Coefficient 3 of Fuel Use Function of Part Load Ratio Curve

This numeric field contains the fuel use / PLR coefficient3.

Field: Water Inlet Node Name

This alpha field contains the water inlet node name.

Field: Steam Outlet Node Name

This alpha field contains the steam outlet node name.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. For this component the inputs that would be altered by the sizing factor are: Nominal Capacity. Sizing factor allows the user to size a component to meet part of the design load while continuing to use the autosizing feature.

More information on the technical aspects of steam boiler can be found in the Engineering Reference Document.

An example of a Steam Boiler input statement from an IDF is:

```
Boiler:Steam,
  Steam Boiler Plant Boiler, !- Boiler Name
  NaturalGas,                !- Fuel Type
  160000,                    !-Maximum Boiler Pressure Pascal
  0.8,                        !- Theoretical Boiler Efficiency
  115,                        !- Max Design Outlet Steam Temp
  300000,                    !- Nominal Capacity W
  0.00001,                   !- Minimum Part Load Ratio
  1.0,                        !- Maximum Part Load Ratio
  0.2,                        !- Optimum Part Load Ratio
  0.8,!- Coefficient 1 of the fuel use/part load ratio curve
  0.1,!- Coefficient 2 of the fuel use/part load ratio curve
  0.1,!- Coefficient 3 of the fuel use/part load ratio curve
  Steam Boiler Plant Boiler Inlet Node, !- Boiler Steam Inlet Node
  Steam Boiler Plant Boiler Outlet Node; !- Plant Loop Outlet Node

Boiler:Steam,
  Steam Boiler Plant Boiler, !- Boiler Name
  NaturalGas,                !- Fuel Type
  160000,                    !-Maximum Boiler Pressure Pascal
  0.8,                        !- Theoretical Boiler Efficiency
  115,                        !- Max Design Outlet Steam Temp
  autosize,                  !- Nominal Capacity W
  0.00001,                   !- Minimum Part Load Ratio
  1.0,                        !- Maximum Part Load Ratio
  0.2,                        !- Optimum Part Load Ratio
  0.8,!- Coefficient 1 of the fuel use/part load ratio curve
  0.1,!- Coefficient 2 of the fuel use/part load ratio curve
  0.1,!- Coefficient 3 of the fuel use/part load ratio curve
  Steam Boiler Plant Boiler Inlet Node, !- Boiler Steam Inlet Node
  Steam Boiler Plant Boiler Outlet Node; !- Plant Loop Outlet Node
```

Steam Boiler Outputs

Outputs available from the steam boiler:

HVAC, Average, Boiler Heating Output Rate [W]

HVAC,Sum,Boiler Heating Output Energy [J]
 Zone,Meter,Boilers:EnergyTransfer [J]

HVAC,Average,Boiler Water Inlet Temp [C]
 HVAC,Average,Boiler Steam Outlet Temp [C]
 HVAC,Average,Boiler Water Mass Flow Rate [kg/s]

One of the following blocks will be applicable based on fuel type:

HVAC,Average,Boiler Electric Consumption Rate [W]
 HVAC,Sum,Boiler Electric Consumption [J]
 Zone,Meter,Electricity:Plant [J]
 Zone,Meter,Heating:Electricity [J]

HVAC,Average,Boiler Gas Consumption Rate [W]
 HVAC,Sum,Boiler Gas Consumption [J]
 Zone,Meter,Gas:Plant [J]
 Zone,Meter,Heating:Gas [J]

HVAC,Average,Boiler Propane Consumption Rate [W]
 HVAC,Sum,Boiler Propane Consumption [J]
 Zone,Meter,Propane:Plant [J]
 Zone,Meter,Heating:Propane [J]

HVAC,Average,Boiler FuelOil#1 Consumption Rate [W]
 HVAC,Sum,Boiler FuelOil#1 Consumption [J]
 Zone,Meter,FuelOil#1:Plant [J]
 Zone,Meter,Heating:FuelOil#1 [J]

HVAC,Average,Boiler FuelOil#2 Consumption Rate [W]
 HVAC,Sum,Boiler FuelOil#2 Consumption [J]
 Zone,Meter,FuelOil#2:Plant [J]
 Zone,Meter,Heating:FuelOil#2 [J]

HVAC,Average,Boiler Coal Consumption Rate [W]
 HVAC,Sum,Boiler Coal Consumption [J]
 Zone,Meter,Coal:Plant [J]
 Zone,Meter,Heating:Coal [J]

HVAC,Average,Boiler Diesel Consumption Rate [W]
 HVAC,Sum,Boiler Diesel Consumption [J]
 Zone,Meter,Diesel:Plant [J]
 Zone,Meter,Heating:Diesel [J]

HVAC,Average,Boiler Gasoline Consumption Rate [W]
 HVAC,Sum,Boiler Gasoline Consumption [J]
 Zone,Meter,Gasoline:Plant [J]
 Zone,Meter,Heating:Gasoline [J]

Boiler Heating Output Rate [W]

Boiler Heating Output Energy [J]

These outputs are the heating output (load) of the boiler. Energy is metered on Boilers:EnergyTransfer, EnergyTransfer:Plant, and EnergyTransfer:Facility.

Boiler Condensate Inlet Temp [C]**Boiler Steam Outlet Temp [C]****Boiler Steam Mass Flow Rate [kg/s]**

These outputs are the hot water inlet and Steam outlet temperatures and steam flow rate for the boiler.

Boiler <FuelType> Consumption Rate [W]**Boiler <FuelType> Consumption [J]**

These outputs are the energy input to the boiler. Valid fuel types are: Electric, Gas (natural gas), Propane, FuelOil#1, FuelOil#2, Coal, Diesel, and Gasoline. Consumption is metered on Heating:<FuelType>, <FuelType>:Plant, and <FuelType>:Facility.

Water to Water Heat Pumps

The EnergyPlus has two water-to-water heat pump models, parameter estimation and equation fit, to choose from:

HeatPump:WaterToWater:EquationFit:Cooling**HeatPump:WaterToWater:EquationFit:Heating**

This model is an equation-fit model from the catalog data which resembles a black box with no usage of heat transfer equations. The performance of the heat pump is modeled using curves fitted from the catalog data.

HeatPump:WaterToWater:ParameterEstimation:Cooling**HeatPump:WaterToWater:ParameterEstimation:Heating**

This model is a parameter estimation based model that uses physical parameters generated from the catalog data. The physical parameters are then used to predict the performance of the heat pump using thermodynamic laws and heat transfer equations. The heat pump has a reciprocating compressor that serves both the hot water and the chilled water loop. Note that this model is currently “hardwired” to fluid property R22.

Descriptions and strength of each respective model is available in the following references:

Jin, Hui. 2002. Parameter Estimation Based Models of Water Source Heat Pumps. Phd. Thesis, Department of Mechanical and Aerospace Engineering, Oklahoma State University. (downloadable from <http://www.hvac.okstate.edu/>)

Tang, C. C. 2005. Modeling Packaged Heat Pumps in Quasi-Steady State Energy Simulation Program. M.S. Thesis. Department of Mechanical and Aerospace Engineering, Oklahoma State University. (downloadable from <http://www.hvac.okstate.edu/>)

The Supply side of the heat pump is usually connected to a Ground Heat Exchanger. The figure below shows the layout and piping diagram of the water-to-water heat pump.

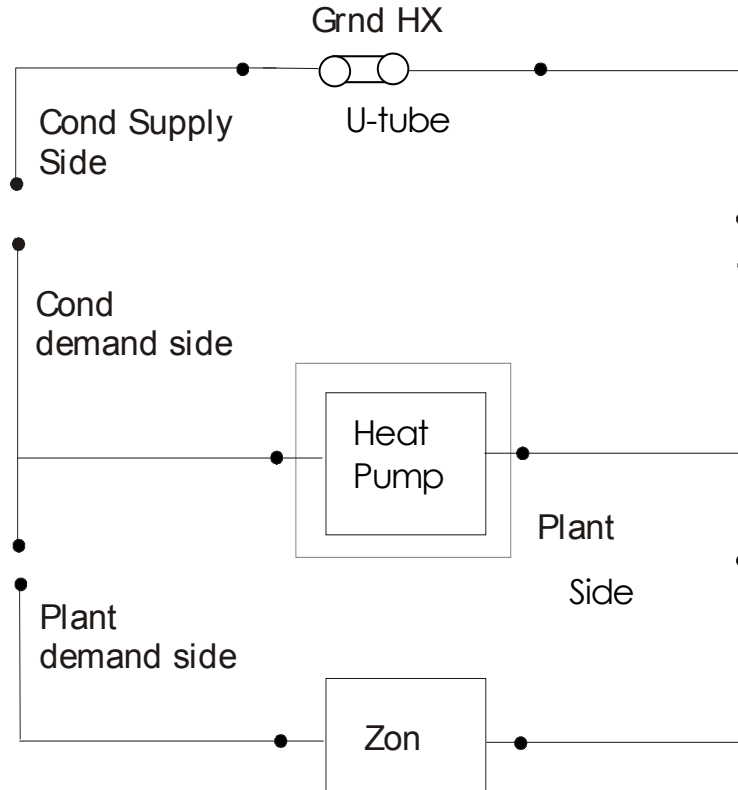


Figure 65. Schematic of EnergyPlus Ground Loop Heat Exchanger

First, the equation fit model objects are described. This model has two sets of coefficients, one for the heating mode and other for the cooling mode.

HeatPump:WaterToWater:EquationFit:Cooling

Field: Name

This alpha field contains the identifying name for the ground source heat pump.

Field: Source Side Inlet Node Name

This alpha field contains the heat pump's source side inlet node name.

Field: Source Side Outlet Node Name

This alpha field contains the heat pump's source side outlet node name.

Field: Load Side Inlet Node Name

This alpha field contains the heat pump's load side inlet node name.

Field: Load Side Outlet Node Name

This alpha field contains the heat pump's load side outlet node name.

Field: Rated Load Side Flow Rate

This numeric field contains the rated volumetric flow rate on the load side of the heat pump in m³/s.

Field: Rated Source Side Flow Rate

This numeric field contains the rated volumetric flow rate on the source side of the heat pump in m³/s.

Field: Rated Cooling Capacity

This numeric field contains the rated cooling capacity of the heat pump in W.

Field: Rated Cooling Power Consumption

This numeric field contains the rated power consumption of the heat pump in W.

Fields: Cooling Capacity Coefficients

Five fields are used to describe the coefficients for the Cooling Capacity curve. More details on how these coefficients are used are described in the Engineering Reference.

Field: Cooling Capacity Coefficient 1-5

These numeric fields contain the five coefficients for the heat pump capacity.

Field: Cooling Compressor Power Coefficients

Five fields are used to describe the coefficients for the Cooling Compressor Power consumption curve. More details on how these coefficients are used are described in the Engineering Reference.

Field: Cooling Compressor Power Coefficient 1-5

These numeric fields contain the five coefficients for the heat pump power consumption.

Field: Cycle Time

This numeric field contains the full on and off cycle time of the heat pump unit in Hour.

The IDD specification for the object:

```
HeatPump:WaterToWater:EquationFit:Cooling,  
  \memo simple water-water heatpump curve-fit model  
  \min-fields 20  
A1, \field Name  
  \required-field  
A2, \field Source Side Inlet Node Name  
  \required-field  
A3, \field Source Side Outlet Node Name  
  \required-field  
A4, \field Load Side Inlet Node Name  
  \required-field  
A5, \field Load Side Outlet Node Name  
  \required-field  
N1, \field Rated Load Side Flow Rate  
  \required-field  
  \type real  
  \minimum> 0.0  
  \units m3/s  
N2, \field Rated Source Side Flow Rate  
  \required-field  
  \type real  
  \minimum> 0.0  
  \units m3/s  
N3, \field Rated Cooling Capacity  
  \required-field  
  \type real  
  \minimum> 0.0  
  \units W  
N4, \field Rated Cooling Power Consumption  
  \required-field  
  \type real  
  \minimum> 0.0  
  \units W  
N5, \field Cooling Capacity Coefficient 1  
  \required-field  
  \type real  
N6, \field Cooling Capacity Coefficient 2  
  \required-field  
  \type real  
N7, \field Cooling Capacity Coefficient 3  
  \required-field  
  \type real  
N8, \field Cooling Capacity Coefficient 4  
  \required-field  
  \type real  
N9, \field Cooling Capacity Coefficient 5  
  \required-field  
  \type real
```

```

N10, \field Cooling Compressor Power Coefficient 1
      \required-field
      \type real
N11, \field Cooling Compressor Power Coefficient 2
      \required-field
      \type real
N12, \field Cooling Compressor Power Coefficient 3
      \required-field
      \type real
N13, \field Cooling Compressor Power Coefficient 4
      \required-field
      \type real
N14, \field Cooling Compressor Power Coefficient 5
      \required-field
      \type real
N15; \field Cycle Time
      \required-field
      \type real
      \units hr
      \minimum> 0.016
      \default .1

```

An idf example:

```

HeatPump:WaterToWater:EquationFit:Cooling,
  GshpCLG,      !- Water to Water Heat Pump Name
  GshpCLG SourceSide Inlet Node,  !- Source Side Inlet Node
  GshpCLG SourceSide Outlet Node, !- Source Side Outlet Node
  GshpCLG LoadSide Inlet Node,    !- Load Side Inlet Node
  GshpCLG LoadSide Outlet Node,   !- Load Side Outlet Node
  1.89E-03,     !- Rated Load Side Flow Rate {m3/s}
  1.89E-03,     !- Rated Source Side Flow Rate {m3/s}
  39890.91,    !- Rated Cooling Capacity {W}
  4790.00,     !- Rated Cooling Power Consumption {W}
  -1.52030596, !- Cooling Capacity Coefficient 1
  3.46625667, !- Cooling Capacity Coefficient 2
  -1.32267797, !- Cooling Capacity Coefficient 3
  0.09395678, !- Cooling Capacity Coefficient 4
  0.038975504, !- Cooling Capacity Coefficient 5
  -8.59564386, !- Cooling Compressor Power Coefficient 1
  0.96265085, !- Cooling Compressor Power Coefficient 2
  8.69489229, !- Cooling Compressor Power Coefficient 3
  0.02501669, !- Cooling Compressor Power Coefficient 4
  -0.20132665, !- Cooling Compressor Power Coefficient 5
  0.1;        !- Heat pump unit's cycle time {hr}

```

HeatPump:WaterToWater:EquationFit:Heating

Field: Name

This alpha field contains the identifying name for the ground source heat pump.

Field: Source Side Inlet Node Name

This alpha field contains the heat pump's source side inlet node name.

Field: Source Side Outlet Node Name

This alpha field contains the heat pump's source side outlet node name.

Field: Load Side Inlet Node Name

This alpha field contains the heat pump's load side inlet node name.

Field: Load Side Outlet Node Name

This alpha field contains the heat pump's load side outlet node name.

Field: Rated Load Side Flow Rate

This numeric field contains the rated volumetric flow rate on the load side of the heat pump in m³/s.

Field: Rated Source Side Flow Rate

This numeric field contains the rated volumetric flow rate on the source side of the heat pump in m³/s.

Field: Rated Heating Capacity

This numeric field contains the rated heating capacity of the heat pump in W.

Field: Rated Heating Power Consumption

This numeric field contains the rated power consumption of the heat pump in W.

Fields: Heating Capacity Coefficients

Five fields are used to describe the coefficients for the Heating Capacity curve. More details on how these coefficients are used are described in the Engineering Reference.

Field: Heating Capacity Coefficient 1-5

These numeric fields contain the five coefficients for the heat pump capacity.

Field: Heating Compressor Power Coefficients

Five fields are used to describe the coefficients for the Heating Compressor Power consumption curve. More details on how these coefficients are used are described in the Engineering Reference.

Field: Heating Compressor Power Coefficient 1-5

These numeric fields contain the five coefficients for the heat pump power consumption.

Field: Cycle Time

This numeric field contains the full on and off cycle time of the heat pump unit in Hour.

The IDD specification for the object:

```
HeatPump:WaterToWater:EquationFit:Heating,
  \memo simple water-water hp curve-fit model
  \min-fields 20
  A1, \field Name
      \required-field
  A2, \field Source Side Inlet Node Name
      \required-field
  A3, \field Source Side Outlet Node Name
      \required-field
  A4, \field Load Side Inlet Node Name
      \required-field
  A5, \field Load Side Outlet Node Name
      \required-field
  N1, \field Rated Load Side Flow Rate
      \required-field
      \type real
      \minimum> 0.0
      \units m3/s
```

```
N2, \field Rated Source Side Flow Rate
    \required-field
    \type real
    \minimum> 0.0
    \units m3/s
N3, \field Rated Heating Capacity
    \required-field
    \type real
    \minimum> 0.0
    \units W
N4, \field Rated Heating Power Consumption
    \required-field
    \type real
    \minimum> 0.0
    \units W
N5, \field Heating Capacity Coefficient 1
    \required-field
    \type real
N6, \field Heating Capacity Coefficient 2
    \required-field
    \type real
N7, \field Heating Capacity Coefficient 3
    \required-field
    \type real
N8, \field Heating Capacity Coefficient 4
    \required-field
    \type real
N9, \field Heating Capacity Coefficient 5
    \required-field
    \type real
N10, \field Heating Compressor Power Coefficient 1
    \required-field
    \type real
N11, \field Heating Compressor Power Coefficient 2
    \required-field
    \type real
N12, \field Heating Compressor Power Coefficient 3
    \required-field
    \type real
N13, \field Heating Compressor Power Coefficient 4
    \required-field
    \type real
N14, \field Heating Compressor Power Coefficient 5
    \required-field
    \type real
N15; \field Cycle Time
    \required-field
    \type real
    \units hr
    \minimum> 0.016
    \default .1
```

An idf example:


```

HeatPump:WaterToWater:EquationFit:Heating,
GshpHeating, !- Water to Water Heat Pump Name
GshpHeating SourceSide Inlet Node, !- Source Side Inlet Node
GshpHeating SourceSide Outlet Node, !- Source Side Outlet Node
GshpHeating LoadSide Inlet Node, !- Load Side Inlet Node
GshpHeating LoadSide Outlet Node, !- Load Side Outlet Node
1.89E-03, !- Rated Load Side Flow Rate {m3/s}
1.89E-03, !- Rated Source Side Flow Rate {m3/s}
39040.92, !- Rated Heating Capacity {W}
5130.00, !- Rated Heating Power Consumption {W}
-3.33491153, !- Heating Capacity Coefficient 1
-0.51451946, !- Heating Capacity Coefficient 2
4.51592706, !- Heating Capacity Coefficient 3
0.01797107, !- Heating Capacity Coefficient 4
0.155797661, !- Heating Capacity Coefficient 5
-8.93121751, !- Heating Compressor Power Coefficient 1
8.57035762, !- Heating Compressor Power Coefficient 2
1.29660976, !- Heating Compressor Power Coefficient 3
-0.21629222, !- Heating Compressor Power Coefficient 4
0.033862378, !- Heating Compressor Power Coefficient 5
0.15; !- Heat pump unit's cycle time {hr}

```

Next, the parameter estimation model objects are described. This model has two sets of parameters, one for the heating mode and other for the cooling mode.

HeatPump:WaterToWater:ParameterEstimation:Cooling

Field: Name

This alpha field contains the identifying name for the ground source heat pump.

Field: Source Side Inlet Node Name

This alpha field contains the heat pump's source side inlet node name.

Field: Source Side Outlet Node Name

This alpha field contains the heat pump's source side outlet node name.

Field: Load Side Inlet Node Name

This alpha field contains the heat pump's load side inlet node name.

Field: Load Side Outlet Node Name

This alpha field contains the heat pump's load side outlet node name.

Field: Nominal COP

This numeric field contains the nominal coefficient of performance of the heat pump.

Field: Nominal Capacity

This numeric field contains the nominal capacity of the heat pump in Watts.

Field: Minimum Part Load Ratio

This numeric field contains the minimum part load ratio of the heat pump usually set to 0.

Field: Maximum Part Load Ratio

This numeric field contains the maximum part load ratio of the heat pump usually set to 1.

Field: Optimum Part Load Ratio

This numeric field contains the optimal part load ratio of the heat pump usually set to 1.

Field: Load Side Flow Rate

This numeric field contains the volumetric flow rate on the load side of the heat pump in m3/s

Field: Source Side Flow Rate

This numeric field contains the volumetric flow rate on the source side of the heat pump in m³/s

Field: Load Side Heat Transfer Coefficient

This numeric field contains Estimated parameter load side heat transfer coefficient W/K.

Field: Source Side Heat Transfer Coefficient

This numeric field contains Estimated parameter source side heat transfer coefficient W/K.

Field: Piston Displacement

This numeric field contains the Estimated parameter displacement of the reciprocating compressor in m³/s.

Field: Compressor Clearance Factor

This numeric field contains the Estimated parameter clearance factor of the reciprocating compressor.

Field: Compressor Suction and Discharge Pressure Drop

This numeric field contains the estimated parameter the pressure drop at compressor suction and discharge in Pascals (N/m²).

Field: Superheating

This numeric field contains the estimated parameter superheat at the evaporator outlet in °C.

Field: Constant Part of Electromechanical Power Losses

This numeric field contains the estimated parameter power loss, which accounts for the loss of work due mechanical and electrical losses in the compressor in Watts.

Field: Loss Factor

This numeric field contains the factor of electromechanical loss that is proportional to the theoretical power percentage.

Field: High Pressure Cut Off

This numeric field contains the design pressure limit of the compressor in Pascals (N/m²).

Field: Low Pressure Cut Off

This numeric field contains the design low-pressure limit of the compressor in Pascals (N/m²).

Field: Cycle Time

This numeric field contains the full on and off cycle time of the heat pump unit in Hour.

The IDD specification for the object:

```

HeatPump:WaterToWater:ParameterEstimation:Cooling,
\memo OSU parameter estimation model
\min-fields 20
A1, \field Name
  \required-field
A2,\field Source Side Inlet Node Name
  \required-field
A3,\field Source Side Outlet Node Name
  \required-field
A4,\field Load Side Inlet Node Name
  \required-field
A5,\field Load Side Outlet Node Name
  \required-field
N1,\field Nominal COP
  \minimum> 0
N2,\field Nominal Capacity
  \units W
  \minimum> 0
N3,\field Minimum Part Load Ratio
  \minimum 0.0
N4,\field Maximum Part Load Ratio
  \minimum 0.0
N5,\field Optimum Part Load Ratio
  \minimum 0.0
N6,\field Load Side Flow Rate
  \units m3/s
  \minimum> 0.0
  \ip-units gal/min
N7,\field Source Side Flow Rate
  \units m3/s
  \minimum> 0.0
  \ip-units gal/min
N8,\field Load Side Heat Transfer Coefficient
  \units W/K
  \minimum> 0
N9,\field Source Side Heat Transfer Coefficient
  \units W/K
  \minimum> 0
N10,\field Piston Displacement
  \units m3/s
  \minimum> 0
N11,\field Compressor Clearance Factor
  \minimum> 0
N12,\field Compressor Suction and Discharge Pressure Drop
  \units Pa
  \minimum> 0
N13,\field Superheating
  \units C
  \minimum> 0
N14,\field Constant Part of Electromechanical Power Losses
  \units W
  \minimum> 0
N15,\field Loss Factor
  \note Used To define electromechanical loss that Is proportional
  \note to the theoretical power %
  \minimum> 0
N16,\field High Pressure Cut Off
  \units Pa
  \minimum 0.0
  \default 500000000
N17,\field Low Pressure Cut Off
  \units Pa
  \minimum 0.0
  \default 0.0
N18;\field Cycle Time
  \units hr
  \minimum> 0.016
  \default .1

```

An idf example:

```

HeatPump:WaterToWater:ParameterEstimation:Cooling,
GshpCLG,                !- Water to Water Heat Pump Name
GshpCLG SourceSide Inlet Node, !- Source Side Inlet Node
GshpCLG SourceSide Outlet Node, !- Source Side Outlet Node
GshpCLG LoadSide Inlet Node, !- Load Side Inlet Node
GshpCLG LoadSide Outlet Node, !- Load Side Outlet Node
3.5,                    !- Nominal COP
45000,                  !- Nominal Capacity {W}
0.0,                    !- Min PLR
1,                      !- Max PLR
1,                      !- optimum PLR
.003,                   !- Load side Flow Rate {m3/s}
.003,                   !- Source Side Flow Rate {m3/s}
7761,                   !- Load side Heat Transfer Coefficient {W/K}
3998,                   !- Source Side Heat Transfer Coefficient {W/K}
.012544,                !- Piston Displacement {m3/s}
.05469,                 !- Compressor Clearance Factor %
92156.2,                !- Compressor Suction And Discharge Pressure Drop {Pa}
4.8907,                 !- Superheating {C}
2803.9,                 !- Constant Part of Electro Mechanical Power Losses {W}
.699,                   !- Loss Factor
0.0,                    !- High Pressure Cut off {Pa}
0.0,                    !- LowPressure Cut off {Pa}
0.1;                    !- Heat pump unit's cycle time {hr}

```

HeatPump:WaterToWater:ParameterEstimation:Heating

Field: Name

This alpha field contains the identifying name for the ground source heat pump.

Field: Source Side Inlet Node Name

This alpha field contains the heat pump's source side inlet node name.

Field: Source Side Outlet Node Name

This alpha field contains the heat pump's source side outlet node name.

Field: Load Side Inlet Node Name

This alpha field contains the heat pump's load side inlet node name.

Field: Load Side Outlet Node Name

This alpha field contains the heat pump's load side outlet node name.

Field: Nominal COP

This numeric field contains the nominal coefficient of performance of the heat pump.

Field: Nominal Capacity

This numeric field contains the nominal capacity of the heat pump in Watts.

Field: Minimum Part Load Ratio

This numeric field contains the minimum part load ratio of the heat pump usually set to 0.

Field: Maximum Part Load Ratio

This numeric field contains the maximum part load ratio of the heat pump usually set to 1.

Field: Optimum Part Load Ratio

This numeric field contains the optimal part load ratio of the heat pump usually set to 1.

Field: Load Side Flow Rate

This numeric field contains the volumetric flow rate on the load side of the heat pump in m3/s

Field: Source Side Flow Rate

This numeric field contains the volumetric flow rate on the source side of the heat pump in m³/s

Field: Load Side Heat Transfer Coefficient

This numeric field contains Estimated parameter load side heat transfer coefficient W/K.

Field: Source Side Heat Transfer Coefficient

This numeric field contains Estimated parameter source side heat transfer coefficient W/K.

Field: Piston Displacement

This numeric field contains the Estimated parameter displacement of the reciprocating compressor in m³/s.

Field: Compressor Clearance Factor

This numeric field contains the Estimated parameter clearance factor of the reciprocating compressor.

Field: Compressor Suction and Discharge Pressure Drop

This numeric field contains the estimated parameter the pressure drop at compressor suction and discharge in Pascals (N/m²).

Field: Superheating

This numeric field contains the estimated parameter superheat at the evaporator outlet in °C.

Field: Constant Part of Electromechanical Power Losses

This numeric field contains the estimated parameter power loss, which accounts for the loss of work due mechanical and electrical losses in the compressor in Watts.

Field: Loss Factor

This numeric field contains the factor of electromechanical loss that is proportional to the theoretical power percentage.

Field: High Pressure Cut Off

This numeric field contains the design pressure limit of the compressor in Pascals (N/m²).

Field: Low Pressure Cut Off

This numeric field contains the design low-pressure limit of the compressor in Pascals (N/m²).

Field: Cycle Time

This numeric field contains the full on and off cycle time of the heat pump unit in Hour.

The IDD specification for the object:

```

HeatPump:WaterToWater:ParameterEstimation:Heating,
  \memo OSU parameter estimation model
  \min-fields 20
A1, \field Name
  \required-field
A2,\field Source Side Inlet Node Name
  \required-field
A3,\field Source Side Outlet Node Name
  \required-field
A4,\field Load Side Inlet Node Name
  \required-field
A5,\field Load Side Outlet Node Name
  \required-field
N1,\field Nominal COP
  \minimum> 0
N2,\field Nominal Capacity
  \units W
  \minimum> 0
N3,\field Minimum Part Load Ratio
  \minimum 0.0
N4,\field Maximum Part Load Ratio
  \minimum 0.0
N5,\field Optimum Part Load Ratio
  \minimum 0.0
N6,\field Load Side Flow Rate
  \units m3/s
  \minimum> 0
  \ip-units gal/min
N7,\field Source Side Flow Rate
  \units m3/s
  \minimum> 0
  \ip-units gal/min
N8,\field Load Side Heat Transfer Coefficient
  \units W/K
  \minimum> 0
N9,\field Source Side Heat Transfer Coefficient
  \units W/K
  \minimum> 0
N10,\field Piston Displacement
  \units m3/s
  \minimum> 0
N11,\field Compressor Clearance Factor
  \minimum> 0
N12,\field Compressor Suction and Discharge Pressure Drop
  \units Pa
  \minimum> 0
N13,\field Superheating
  \units C
  \minimum> 0
N14,\field Constant Part of Electromechanical Power Losses
  \units W
  \minimum> 0
N15,\field Loss Factor
  \note Used To define electromechanical loss that Is proportional
  \note to the theoretical power %
  \minimum> 0
N16,\field High Pressure Cut Off
  \units Pa
  \minimum 0.0
  \default 500000000
N17,\field Low Pressure Cut Off
  \units Pa
  \minimum 0.0
  \default 0.0
N18;\field Cycle Time
  \units hr
  \minimum> 0.016
  \default .1

```

An idf example:

```

HeatPump:WaterToWater:ParameterEstimation:Heating,
GshpHeating,           !- Water to Water Heat Pump Name
GshpHeating SourceSide Inlet Node, !- Source Side Inlet Node
GshpHeating SourceSide Outlet Node, !- Source Side Outlet Node
GshpHeating LoadSide Inlet Node, !- Load Side Inlet Node
GshpHeating LoadSide Outlet Node, !- Load Side Outlet Node
3.5,                   !- Nominal COP
50000,                 !- Nominal Capacity {W}
0.0,                   !- Min PLR
1,                     !- Max PLR
1,                     !- optimum PLR
.003,                  !- Load side Flow Rate {m3/s}
.003,                  !- Source Side Flow Rate {m3/s}
7761,                  !- Load side Heat Transfer Coefficient {W/K}
3998,                  !- Source Side Heat Transfer Coefficient {W/K}
.012544,               !- Piston Displacement {m3/s}
.05469,               !- Compressor Clearance Factor %
92156.2,               !- Compressor Suction And Discharge Pressure Drop {Pa}
4.8907,               !- Superheating {C}
2803.9,               !- Constant Part Of Electro Mechanical Power Losses {W}
.699,                 !- Loss Factor
0.0,                  !- High Pressure Cut off {Pa}
0.0,                  !- LowPressure Cut off {Pa}
0.15;                 !- Heat pump unit's cycle time {hr}

```

Since the heat pump is defined with two separate objects (one for heating, one for cooling), the connections to the condenser has to be done carefully. The example below shows the configuration for parameter estimation objects. The same specifications and configuration also applies to the equation fit model.

Steps to specify the Ground Source Heat Pump

For the heating mode:

- 1) Specify a branch for the Heat pump in hot water loop .
- 2) Include the branch name in the splitter and mixer branches.
- 3) Add a branch in condenser loop and include its name in the respective splitter and mixer.

```

! in hot water loop
BRANCH, Heating GshpHeating Branch,
,
HeatPump:WatertoWater:ParameterEstimatinon:Heating,
GshpHeating,
GshpHeating LoadSide Inlet Node,
GshpHeating LoadSide Outlet Node,
ACTIVE;

!in condenser loop
BRANCH, GshpHeating SourceSide Branch,
,
HeatPump:WatertoWater:ParameterEstimatinon:Heating,
GshpHeating,
GshpHeating SourceSide Inlet Node,
GshpHeating SourceSide Outlet Node,
ACTIVE;

```

Example of Heat Pump Links

For the cooling mode:

- 1) Specify a branch for the Heat pump in chilled water loop .
- 2) Include the branch name in the splitter and mixer branches.

3) Add a branch in condenser loop and include its name in the respective splitter and mixer.

```

! in chilled water loop
BRANCH,GshpCLG1 Chiller Branch,
,
HeatPump:WatertoWater:ParameterEstimatinon:Cooling, GshpCLG1,
GshpCLG LoadSide Inlet Node1,
GshpCLG LoadSide Outlet Node1,
Active;
!in condenser loop
BRANCH, GshpCLG1 Condenser Branch,
,
HeatPump:WatertoWater:ParameterEstimatinon:Cooling, GshpCLG1,
GshpCLG SourceSide Inlet Node1,
GshpCLG SourceSide Outlet Node1,
ACTIVE;
    
```

Water to Water Heat Pump Parameter Estimation Outputs

This section describes the outputs available for the water to water heat pump, parameter estimation model; both cooling and heating.

```

HVAC,Average,GSHP COOLING Electric Power [W]
HVAC,Average,GSHP HEATING Electric Power [W]
HVAC,Sum,GSHP COOLING Electric Consumption [J]
HVAC,Sum,GSHP HEATING Electric Consumption [J]
HVAC,Average,GSHP COOLING Load Side Heat Transfer Rate [W]
HVAC,Average,GSHP HEATING Load Side Heat Transfer Rate [W]
HVAC,Sum,GSHP COOLING Load Side Heat Transferred [J]
HVAC,Sum,GSHP HEATING Load Side Heat Transferred [J]
HVAC,Average,GSHP COOLING Source Side Heat Transfer Rate [W]
HVAC,Average,GSHP HEATING Source Side Heat Transfer Rate [W]
HVAC,Sum,GSHP COOLING Source Side Heat Transferred [J]
HVAC,Sum,GSHP HEATING Source Side Heat Transferred [J]
HVAC,Average,GSHP COOLING Load Side Outlet Temperature [°C]
HVAC,Average,GSHP HEATING Load Side Outlet Temperature [°C]
HVAC,Average,GSHP COOLING Load Side Inlet Temperature [°C]
HVAC,Average,GSHP HEATING Load Side Inlet Temperature [°C]
HVAC,Average,GSHP COOLING Source Side Outlet Temperature [°C]
HVAC,Average,GSHP HEATING Source Side Outlet Temperature [°C]
HVAC,Average,GSHP COOLING Source Side Inlet Temperature [°C]
HVAC,Average,GSHP HEATING Source Side Inlet Temperature [°C]
HVAC,Average,GSHP COOLING Load Side Water Mass Flow Rate[kg/s]
HVAC,Average,GSHP HEATING Load Side Water Mass Flow Rate[kg/s]
HVAC,Average,GSHP COOLING Source Side Water Mass Flow Rate[kg/s]
HVAC,Average,GSHP HEATING Source Side Water Mass Flow Rate[kg/s]
    
```

GSHP COOLING Electric Power [W]

GSHP HEATING Electric Power [W]

These output variables represent the compressor power required to run the heat pump. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

GSHP COOLING Electric Consumption [J]

GSHP HEATING Electric Consumption [J]

These output variables represent the cumulative energy used by the compressor. The values are calculated for each HVAC system time step being simulated, and the results are summed across the reporting period.

GSHP COOLING Load Side Heat Transfer Rate [W]***GSHP HEATING Load Side Heat Transfer Rate [W]***

These output variables represent the heat transfer across the load side coil. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

GSHP COOLING Load Side Heat Transferred [J]***GSHP HEATING Load Side Heat Transferred [J]***

These output variables represent the cumulative heat transfer across the load side coil. The values are calculated for each HVAC system time step being simulated, and the results are summed across the reporting period.

GSHP COOLING Source Side Heat Transfer Rate [W]***GSHP HEATING Source Side Heat Transfer Rate [W]***

These output variables represent the heat transfer across the source side coil. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

GSHP COOLING Source Side Heat Transferred [J]***GSHP HEATING Source Side Heat Transferred [J]***

These output variables represent the cumulative heat transfer across the source side coil. The values are calculated for each HVAC system time step being simulated, and the results are summed across the reporting period.

GSHP COOLING Load Side Outlet Temperature [C]***GSHP HEATING Load Side Outlet Temperature [C]***

These output variables represent the average fluid temperature leaving the load side coil. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

GSHP COOLING Load Side Inlet Temperature [C]***GSHP HEATING Load Side Inlet Temperature [C]***

These output variables represent the average fluid temperature entering the load side coil. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

GSHP COOLING Source Side Outlet Temperature [C]***GSHP HEATING Source Side Outlet Temperature °C]***

These output variables represent the average fluid temperature leaving the source side coil. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

GSHP COOLING Source Side Inlet Temperature [C]***GSHP HEATING Source Side Inlet Temperature [C]***

These output variables represent the average fluid temperature entering the source side coil. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

GSHP COOLING Load Side Water Mass Flow Rate[kg/s]**GSHP HEATING Load Side Water Mass Flow Rate[kg/s]**

These output variables represent the average fluid flow rate through the load side coil. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

GSHP COOLING Source Side Water Mass Flow Rate[kg/s]**GSHP HEATING Source Side Water Mass Flow Rate[kg/s]**

These output variables represent the average fluid flow rate through the source side coil. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

Water to Water Heat Pump Equation Fit Outputs

This section describes the outputs available for the water to water heat pump, equation fit model; both cooling and heating.

```

HVAC,Sum,GSHP Electric Consumption [J]
HVAC,Sum,GSHP Load Side Heat Transferred [J]
HVAC,Sum,GSHP Source Side Heat Transferred [J]
HVAC,Average,GSHP Electric Power [W]
HVAC,Average,GSHP Load Side Heat Transfer Rate [W]
HVAC,Average,GSHP Source Side Heat Transfer Rate [W]
HVAC,Average,GSHP Load Side Outlet Temperature [°C]
HVAC,Average,GSHP Load Side Inlet Temperature [°C]
HVAC,Average,GSHP Source Side Outlet Temperature [°C]
HVAC,Average,GSHP Source Side Inlet Temperature [°C]
HVAC,Average,GSHP Load Side Water Mass Flow Rate[kg/s]
HVAC,Average,GSHP Source Side Water Mass Flow Rate[kg/s]

```

GSHP Electric Consumption [J]

This output variable represents the cumulative energy used by the compressor. The values are calculated for each HVAC system time step being simulated, and the results are summed across the reporting period.

GSHP Load Side Heat Transferred [J]

This output variable represents the cumulative heat transfer across the load side coil. The values are calculated for each HVAC system time step being simulated, and the results are summed across the reporting period.

GSHP Source Side Heat Transferred [J]

This output variable represents the cumulative heat transfer across the source side coil. The values are calculated for each HVAC system time step being simulated, and the results are summed across the reporting period.

GSHP Electric Power [W]

This output variable represents the compressor power required to run the heat pump. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

GSHP Load Side Heat Transfer Rate [W]

This output variable represents the heat transfer across the load side coil. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

GSHP Source Side Heat Transfer Rate [W]

This output variable represents the heat transfer across the source side coil. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

GSHP Load Side Outlet Temperature [C]

This output variable represents the average fluid temperature leaving the load side coil. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

GSHP Load Side Inlet Temperature [C]

This output variable represents the average fluid temperature entering the load side coil. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

GSHP Source Side Outlet Temperature [C]

This output variable represents the average fluid temperature leaving the source side coil. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

GSHP Source Side Inlet Temperature [C]

This output variable represents the average fluid temperature entering the source side coil. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

GSHP Load Side Water Mass Flow Rate [kg/s]

This output variable represents the average fluid flow rate through the load side coil. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

GSHP Source Side Water Mass Flow Rate [kg/s]

This output variable represents the average fluid flow rate through the source side coil. The values are calculated for each HVAC system time step being simulated, and the results are averaged for the time step being reported.

DistrictCooling

When the user is not interested in a plant simulation or there is some centralized source of chilled water, the following object can be used in the input.

```
DistrictCooling,
  A1 , \field Name
      \required-field
  A2 , \field Chilled Water Inlet Node Name
      \required-field
  A3 , \field Chilled Water Outlet Node Name
      \required-field
  N1 ; \field Nominal Capacity
      \required-field
      \units W
      \minimum 0.0
```

Field: Name

This alpha field contains the identifying name for the district cooling (i.e., purchased chilled water).

Field: Chilled Water Inlet Node Name

This alpha field contains the identifying name for the district cooling inlet node.

Field: Chilled Water Outlet Node Name

This alpha field contains the identifying name for the district cooling outlet node.

Field: Nominal Capacity

This numeric field contains the nominal demand (W) that the district cooling will meet.

An example of this statement in an IDF is:

```
DistrictCooling, Purchased Cooling,
  NODE_35,NODE_49,
  68000;
```

DistrictCooling Outputs

```
HVAC,Average, District Chilled Water Rate [W]
HVAC,Sum, District Chilled Water Energy [J]
Zone,Meter, DistrictCooling:Plant [J]
Zone,Meter,Cooling: DistrictCooling [J]

HVAC,Average,District Cooling Rate [W]

HVAC,Average,District Cooling Inlet Temp [C]
HVAC,Average,District Cooling Outlet Temp [C]
HVAC,Average,District Cooling Mass Flow Rate[kg/s]
```

District Chilled Water Rate [W]**District Chilled Water Energy [J]**

These outputs are the energy taken from purchased chilled water. Consumption is metered on Cooling:DistrictCooling, DistrictCooling:Plant, and DistrictCooling:Facility.

District Cooling Rate [W]

This is the useful cooling energy from purchased chilled water. For the current algorithm, this is the same as District Chilled Water Rate.

District Cooling Inlet Temp[C]**District Cooling Outlet Temp[C]****District Cooling Mass Flow Rate[kg/s]**

These outputs are the supply-side plant loop chilled water inlet and outlet temperatures and mass flow rate.

DistrictHeating

When the user is not interested in a plant simulation or there is some centralized source of hot water (district heating), the following object can be used in the input.

```

DistrictHeating,
A1 , \field Name
    \required-field
A2 , \field Hot Water Inlet Node Name
    \required-field
A3 , \field Hot Water Outlet Node Name
    \required-field
N1 ; \field Nominal Capacity
    \required-field
    \units W
    \minimum 0.0

```

Field: Name

This alpha field contains the identifying name for the district heating (i.e., purchased hot water).

Field: Hot Water Inlet Node Name

This alpha field contains the identifying name for the district heating inlet node.

Field: Hot Water Outlet Node Name

This alpha field contains the identifying name for the district heating outlet node.

Field: Nominal Capacity

This numeric field contains the nominal demand (W) that the district heating will meet.

An example of this statement in an IDF is:

```

DistrictHeating,Purchased Heating,
NODE_30,NODE_29,
1000000;

```

DistrictHeating Outputs

```

HVAC,Average,District Hot Water Rate [W]
HVAC,Sum,District Hot Water Energy[J]
Zone,Meter,DistrictHeating:Plant [J]
Zone,Meter,Heating:DistrictHeating [J]

HVAC,Average,District Heating Rate[W]

HVAC,Average,District Heating Inlet Temp[C]
HVAC,Average,District Heating Outlet Temp[C]
HVAC,Average,District Heating Mass Flow Rate[kg/s]

```

District Hot Water Rate [W]**District Hot Water Energy [J]**

These outputs are the energy taken from purchased hot water. Consumption is metered on Heating:DistrictHeating, DistrictHeating:Plant, and DistrictHeating:Facility.

District Heating Rate [W]

This is the useful heating energy from purchased hot water. For the current algorithm, this is the same as Purchased Hot Water Rate.

District Heating Inlet Temp[C]**District Heating Outlet Temp[C]****District Heating Mass Flow Rate[kg/s]**

These outputs are the supply-side plant loop hot water inlet and outlet temperatures and mass flow rate.

Thermal Storage Objects

There are four types of cold thermal storage objects:

- ThermalStorage:Ice:Simple
- ThermalStorage:Ice:Detailed
- ThermalStorage:ChilledWater:Mixed
- ThermalStorage:ChilledWater:Stratified

These objects are typically placed on the supply side of a primary chilled water loop in series or in parallel with one or more chillers. Using the the component set point (PlantEquipmentOperation:ComponentSetpoint) plant operation scheme type, the chiller and storage tank setpoints are used to control operation. Using a SetpointManager:Scheduled object (or other appropriate type of set point manager), the setpoints on the chiller outlet node and the ice storage outlet node can be used to control how the cooling load is shared and when charging of storage occurs. Example setpoints to use for various modes of operation are shown in the table below:

Mode	Chiller Setpoint	Storage Setpoint
Charging ice storage tank	-5C	7C
Cooling with chiller only	7C	99C
Cooling with chiller and storage (fully load chiller before using storage))	7C	7C
Cooling with chiller and storage (chiller carries portion of load, valid if chiller is upstream of storage)	10C	7C

Example files have been developed for three common storage configurations:

- 1) Series – Chiller Upstream: In this configuration, a chiller is placed first on the same branch as the storage unit and both use the **SeriesActive** branch control type.
- 2) Series – Chiller Downstream: In this configuration, a chiller is placed second on the same branch as the storage unit and both use the **SeriesActive** branch control type.
- 3) Parallel: In this configuration, the chiller is on a branch parallel to the storage unit branch when it is not charging. During charging mode, valves will be changed so that the chiller is in series upstream of the storage. To accomplish this in EnergyPlus, the chiller must be modeled using two different chiller objects to represent the same chiller. One chiller object on a parallel branch operates only when storage is not being charged. The other chiller object, in series upstream of the storage unit operates only during charging mode.

Other considerations for applying cold thermal storage objects include:

- In the PlantLoop object, the "Minimum Loop Temperature" must be set equal to or less than the lowest setpoint to be used anywhere in the loop.
- To end the storage charging cycle, use a AvailabilityManager:LowTemperatureTurnOff to shut off the primary chilled water loop when the temperature leaving the storage tank nears the charging mode chiller setpoint indicating that the tank is fully charged. For example, if the chiller is set to provide –5C chilled water during charging, then charging can be shut down when the water temperature leaving the storage unit reaches –4C. When using a primary-secondary loop arrangement, it may be necessary to schedule this availability manager to be active only when the HVAC systems are off to avoid fighting between the demand controls and the availability manager.

ThermalStorage:Ice:Simple

This thermal storage model is based on a simple simulation of an ice storage tank with a fixed capacity. The tank is charged, or frozen, in an ice-on-coil configuration where ice builds up on the outside of the tubes carrying the brine or glycol solution from the chiller. There are two discharge (melt) options, internal or external. Internal melt uses the same fluid tubes for charging and discharging. External melt uses a separate fluid path for discharge such that the outer layers of ice melt first. The ice storage model includes an implied 3-way valve to control the amount of charge/discharge based on the incoming water temperature and the outlet node setpoint temperature. The storage tank is assumed to be fully charged (full of ice) at the beginning of each environment. The tank is then allowed to charge and discharge during the warmup days of the environment. The tank is best controlled using the PlantEquipmentOperation:ComponentSetpoint plant operation scheme, and requires that a setpoint be placed by a set point manager on the ice storage Plant Outlet Node.

The input fields for the object are described in detail below:

Field: Name

This alpha field contains the identifying name for the ice storage tank.

Field: Ice Storage Type

This alpha field specifies the type of ice storage tank to be modeled. There are two options: "IceOnCoilInternal" models ice-on-coil, internal melt. "IceOnCoilExternal" models ice-on-coil, external melt.

Field: Capacity

This numeric field contains the nominal capacity of the ice storage in GJ (Giga is 10^9).

Field: Inlet Node Name

This alpha field specifies the name of the chilled water inlet node.

Field: Outlet Node Name

This alpha field specifies the name of the chilled water outlet node.

Below is the IDD Definition for the object.

```

ThermalStorage:Ice:Simple,
  \min-fields 5
  \memo This ice storage model is a simplified model
  \memo It requires a setpoint placed on the Chilled Water Side Outlet Node
  \memo It should be placed in the chilled water supply side outlet branch
  \memo followed by a pipe.
  \memo Use the PlantEquipmentOperation:ComponentSetpoint plant operation scheme.
A1, \field Name
  \type alpha
  \required-field
A2, \field Ice Storage Type
  \note IceOnCoilInternal = Ice-on-Coil, internal melt
  \note IceOnCoilExternal = Ice-on-Coil, external melt
  \type choice
  \required-field
  \key IceOnCoilInternal
  \key IceOnCoilExternal
N1, \field Capacity
  \required-field
  \type real
  \units GJ
  \ip-units ton-hrs
A3, \field Inlet Node Name
  \type alpha
  \required-field
A4, \field Outlet Node Name
  \type alpha
  \required-field
    
```

Following is an example input for the THERMAL STORAGE:ICE:SIMPLE object.

```

ThermalStorage:Ice:Simple,
  ITS,                !- Ice Storage Name
  IceOnCoilInternal,  !- Ice Storage Type
  1.5,                !- Ice Storage Capacity {GJ}
  ITS Inlet Node,     !- Plant Loop Inlet Node
  ITS Outlet Node;    !- Plant Loop Outlet Node
    
```

Thermal Storage:Ice:Simple Outputs

The following outputs are available for THERMAL STORAGE:ICE:SIMPLE:

```

HVAC,Average,Ice Thermal Storage Load Requested [W]
Zone,Average,Ice Thermal Storage End Fraction[Frac]
HVAC,Average,Ice Thermal Storage Water mass flow rate[kg/s]
HVAC,Average,Ice Thermal Storage Water Inlet Temp[C]
HVAC,Average,Ice Thermal Storage Water Outlet Temp[C]
HVAC,Average,Ice Thermal Storage Cooling Rate[W]
HVAC,Sum,Ice Thermal Storage Cooling Energy[J]
HVAC,Average,Ice Thermal Storage Charging Rate[W]
HVAC,Sum,Ice Thermal Storage Charging Energy[J]
    
```

Ice Thermal Storage Load Requested [W]

The load requested by the plant control scheme. A positive value indicates a cooling load or a request to discharge (melt) the tank. A negative value indicates a request to charge (freeze) the tank.

Ice Thermal Storage End Fraction[Frac]

The fraction of full ice storage which is present at the end of the current HVAC timestep. When reported at a frequency less than detailed, this value is averaged over the reporting period.

Ice Thermal Storage Water mass flow rate[kg/s]

The total water mass flow rate through the ice storage component. Because the component includes an implied 3-way valve, this flow may be all through the tank, all bypassed through the valve, or a mixture of both.

Ice Thermal Storage Water Inlet Temp[C]

The water temperature entering the ice storage component.

Ice Thermal Storage Water Outlet Temp[C]

The water temperature leaving the ice storage component.

Ice Thermal Storage Cooling Rate[W]

The rate of cooling delivered by the ice storage component. A positive value indicates the ice tank is discharging (melting). A zero value indicates the tank is charging or dormant.

Ice Thermal Storage Cooling Energy[J]

The cooling energy delivered by the ice storage component. A positive value indicates the ice tank is discharging (melting). A zero value indicates the tank is charging or dormant.

Ice Thermal Storage Charging Rate[W]

The rate of charging delivered to the ice storage component. A positive value indicates the ice tank is charging (freezing). A zero value indicates the tank is discharging or dormant.

Ice Thermal Storage Charging Energy[J]

The charging energy delivered to the ice storage component. A positive value indicates the ice tank is charging (freezing). A zero value indicates the tank is discharging or dormant.

ThermalStorage:Ice:Detailed

The detailed ice storage model allows the users of EnergyPlus to model more closely specific manufacturers' ice storage units. This is possible due to the use of curve fits to simulate the performance of the ice storage unit during charging and discharging. In this implementation, both charging and discharging are a function of the fraction charged/discharged as well as the log mean temperature difference across the storage unit. More information on the model is provided in the Engineering Reference for EnergyPlus. The remainder of this section describes the input required for the detailed ice storage model and the output that it can produce.

Field: Name

This field is the name of the detailed ice storage system given to it by the user.

Field: Availability Schedule Name

This field is the name of the schedule (ref: Schedule) that determines whether or not the ice storage system is available during a particular time period. This allows the system to be turned off during a particular season. A value of less than or equal to zero indicates that the ice storage system is not available. Any value greater than zero indicates that the system is available.

Field: Capacity

This number is the maximum amount of latent thermal storage available in the ice storage system. This model does not allow the removal or addition of sensible energy from the tank. Thus, it is always assumed to be at the freezing temperature of the storage material. The capacity is expressed in units of GJ.

Field: Inlet Node Name

This is the name of the node that connects the ice storage system to the plant loop. It is the inlet node to the ice storage component. The next field defines the outlet node. Due to presence of an internal bypass in this model, there are other “nodes” that are handled internally within the program. Users do not need to define any nodes other than the inlet and outlet nodes.

Field: Outlet Node Name

This is the name of the other node that connects the ice storage system to the plant loop. It is the outlet node to the ice storage component.

Field: Discharging Curve Object Type

The detailed ice storage model in EnergyPlus takes advantage of the Curve feature of the program. Currently, the only allowed curve fit type for the detailed ice storage model is the QuadraticLinear curve. More information on this curve can be found in the section on Curves.

Field: Discharging Curve Name

This field specifies the name of the actual curve fit to be used to model the discharging process of the detailed ice storage system.

Field: Charging Curve Object Type

The detailed ice storage model in EnergyPlus takes advantage of the Curve feature of the program. Currently, the only allowed curve fit type for the detailed ice storage model is the QuadraticLinear curve. More information on this curve can be found in the section on Curves.

Field: Charging Curve Name

This field specifies the name of the actual curve fit to be used to model the charging process of the detailed ice storage system.

Field: Timestep of the Curve Data

This field defines what timestep was used to produce the curve fits named in the previous inputs. This parameter is important because the curve fit is non-dimensional. Thus, the data used to develop the curve fits were based on a specific length of time. In many cases, this is probably one hour or 1.0. The units for this parameter are hours.

Field: Parasitic Electric Load During Discharging

This field defines the amount of parasitic electric consumption (for controls or other miscellaneous electric consumption associate with the ice storage unit itself) during the discharge phase. This parameter is dimensionless and gets multiplied by the current load on the tank.

Field: Parasitic Electric Load During Charging

This field defines the amount of parasitic electric consumption (for controls or other miscellaneous electric consumption associate with the ice storage unit itself) during the charge phase. This parameter is dimensionless and gets multiplied by the current load on the tank.

Field: Tank Loss Coefficient

This field defines the loss of ice stored during a particular hour. This field is dimensionless (per hour). It is not multiplied by any temperature difference between the tank and the environment in which it might be located.

Field: Freezing Temperature of Storage Medium

This parameter defines the freezing/melting temperature of the ice storage medium in degrees Celsius. For most tanks, this is simply 0.0C (the default value). However, some tanks may use other materials or salts which would change the freezing temperature. This can be changed using this parameter.

```

ThermalStorage:Ice:Detailed,
  \min-fields 14
  \memo This input syntax is intended to describe a thermal storage system that
  \memo includes smaller containers filled with water that are placed in a larger
  \memo tank or series of tanks.
  \memo The model uses polynomial equations to describe the system performance.
  A1 , \field Name
  \required-field
  A2 , \field Availability Schedule Name
  \required-field
  N1 , \field Capacity
  \note This includes only the latent storage capacity
  \units GJ
  \required-field
  A3 , \field Inlet Node Name
  \required-field
  A4 , \field Outlet Node Name
  \required-field
  A5 , \field Discharging Curve Object Type
  A6 , \field Discharging Curve Name
  A7 , \field Charging Curve Object Type
  A8 , \field Charging Curve Name
  N2 , \field Timestep of the Curve Data
  \units hr
  N3 , \field Parasitic Electric Load During Discharging
  \units dimensionless
  N4 , \field Parasitic Electric Load During Charging
  \units dimensionless
  N5 , \field Tank Loss Coefficient
  \note This is the fraction the total storage capacity that is lost or melts
  \note each hour
  \units dimensionless
  N6 ; \field Freezing Temperature of Storage Medium
  \note This temperature is typically 0C for water.
  \note Simply changing this temperature without adjusting the performance
  \note parameters input above is inappropriate and not advised.
  \units C
  \default 0.0

```

An IDF example:

```

ThermalStorage:Ice:Detailed,
  Ice Tank,                !- Ice Storage Name
  ON,                      !- Ice Storage availability schedule
  0.5,                     !- Ice Storage Capacity {GJ}
  Ice Tank Inlet Node,     !- Plant Loop Inlet Node
  Ice Tank Outlet Node,   !- Plant Loop Outlet Node
  QuadraticLinear,        !- Discharging Curve Fit Type
  DischargeCurve,         !- Discharging Curve Name
  QuadraticLinear,        !- Charging Curve Fit Type
  ChargeCurve,            !- Charging Curve Name
  1.0,                    !- Timestep of Curve Fit Data
  0.0001,                 !- Parasitic electric load during discharging
  0.0002,                 !- Parasitic electric load during charging
  0.0003,                 !- Tank loss coefficient
  0.0;                    !- Freezing temperature [C]

```

Detailed Ice Storage Output

Current detailed ice storage output variables are:

System, Average, Detailed Ice Thermal Storage Load Requested [W]
System, Average, Detailed Ice Thermal Storage Fraction Change [Frac]
System, Average, Detailed Ice Thermal Storage End Fraction [Frac]
System, Average, Detailed Ice Thermal Storage Mass Flow Rate [kg/s]
System, Average, Detailed Ice Thermal Storage Bypass Mass Flow Rate [kg/s]
System, Average, Detailed Ice Thermal Storage Tank Mass Flow Rate [kg/s]
System, Average, Detailed Ice Thermal Storage Fluid Inlet Temp [C]
System, Average, Detailed Ice Thermal Storage Blended Outlet Temp [C]
System, Average, Detailed Ice Thermal Storage Tank Outlet Temp [C]
System, Average, Detailed Ice Thermal Storage Cooling/Discharge Rate [W]
System, Sum, Detailed Ice Thermal Storage Cooling/Discharge Energy [J]
System, Average, Detailed Ice Thermal Storage Charging Rate [W]
System, Sum, Detailed Ice Thermal Storage Charging Energy [J]
System, Average, Detailed Ice Thermal Storage Parasitic Electric Power [W]
System, Sum, Detailed Ice Thermal Storage Parasitic Electric Consumption [J]

Detailed Ice Thermal Storage Load Requested [W]

The actual load (absolute value) on the ice storage system during the current timestep

Detailed Ice Thermal Storage Fraction Change [Frac]

The change in the fraction charged during the current timestep (positive for charging, negative for discharging).

Detailed Ice Thermal Storage End Fraction [Frac]

The fraction charge of the ice storage system at the end of the timestep

Detailed Ice Thermal Storage Mass Flow Rate [kg/s]

The mass flow through the ice storage component

Detailed Ice Thermal Storage Bypass Mass Flow Rate [kg/s]

The mass flow through the ice storage component bypass (bypasses the actual unit)

Detailed Ice Thermal Storage Tank Mass Flow Rate [kg/s]

The mass flow through the ice storage unit itself

Detailed Ice Thermal Storage Fluid Inlet Temp [C]

The inlet temperature to the ice storage component

Detailed Ice Thermal Storage Blended Outlet Temp [C]

The outlet temperature of the component after mixing any bypass flow with flow through the ice storage unit

Detailed Ice Thermal Storage Tank Outlet Temp [C]

The outlet temperature of the ice storage unit itself below mixing with any bypass flow

Detailed Ice Thermal Storage Cooling/Discharge Rate [W]

The cooling done (as a rate) by the ice storage unit or its discharge rate

Detailed Ice Thermal Storage Cooling/Discharge Energy [J]

The total cooling done by the ice storage unit or its discharge rate

Detailed Ice Thermal Storage Charging Rate [W]

The charging done (as a rate) to the ice storage unit

Detailed Ice Thermal Storage Charging Energy [J]

The total charging done to the ice storage unit

Detailed Ice Thermal Storage Parasitic Electric Power [W]

The electric power as a result of parasitic loads on the ice storage unit for things like controls or other miscellaneous parts of the ice storage unit itself

Detailed Ice Thermal Storage Parasitic Electric Consumption [J]

The electric consumption as a result of parasitic loads on the ice storage unit for things like controls or other miscellaneous parts of the ice storage unit itself

ThermalStorage:ChilledWater:Mixed

The ThermalStorage:ChilledWater:Mixed object analytically solves the differential equation governing the energy balance of the water tank. The chilled water is “used” by drawing from the “Use Side” of the water tank. The tank is indirectly charged by circulating cold water through the “Source Side” of the water tank.

Control is based on cycling flow through the source side. When the tank temperature rises above a “cut-in” temperature, source side flow is requested. Source side flow will continue until the tank is cooled to below the tank set point or “cut-out” temperature.

For heat gains from the ambient environment, the ambient air temperature can be taken from a schedule, a zone, or the exterior. When used with a zone, the skin gains are removed from the zone heat balance as negative internal heat gains.

Field: Name

The unique name of the ThermalStorage:ChilledWater:Mixed object.

Field: Tank Volume

The volume of the thermal storage tank [m³].

Field: Setpoint Temperature Schedule Name

The reference to the schedule object specifying the chilled water temperature setpoint [°C]. Also known as the “cut-out” temperature.

Field: Deadband Temperature Difference

The delta temperature difference [Δ°C] between the setpoint and the “cut-in” temperature at which the storage tank will request cooling. In other words, the “cut-in” temperature is Setpoint + Deadband.

Field: Minimum Temperature Limit

The temperature [°C] at which the tank water becomes too cold. No source side flow is allowed when the tank temperature is below this limit. The minimum temperature must be lower than the setpoint temperature at all times.

Field: Nominal Cooling Capacity

This field describes the typical cooling capacity that the chilled water tank will provide. Since this is a passive device, the actual cooling capacity depends on water temperatures and flow rates. However, this field is used to describe the chilled water tank’s nominal cooling capacity for supervisory control where plant operation schemes require a cooling capacity to model how equipment is dispatched.

Field: Ambient Temperature Indicator

The Ambient Temperature Indicator specifies how the ambient air temperature will be indicated. The field can be “Schedule”, “Zone”, or “Exterior.” If *Schedule* is used, the Ambient Temperature Schedule Name field provides the values for ambient temperature. If *Zone* is used, the zone air temperature of the zone specified in the Ambient Temperature Zone field provides the ambient temperature. If *Exterior* is used, the outdoor dry-bulb air temperature provides the ambient temperature.

Field: Ambient Temperature Schedule Name

The field contains the name of a schedule object specifying the ambient air temperature around the tank for skin gains. This field is only used if Ambient Temperature Indicator is *Schedule*.

Field: Ambient Temperature Zone Name

The reference to the zone object specifying the ambient air temperature around the tank for skin gains. This field is only used if Ambient Temperature Indicator is *Zone*.

Field: Ambient Temperature Outdoor Air Node Name

This optional alpha field specifies the outdoor air node (OutdoorAir:Node) name used to define the ambient conditions surrounding the chilled water tank. This field is applicable only when the Ambient Temperature Indicator is specified as *Exterior*, otherwise this field should be left blank. The node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air conditions from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air conditions are taken directly from the weather data.

Field: Heat Gain Coefficient from Ambient Temperature

The gain coefficient [W/K] from the ambient air temperature. This coefficient is often referred to as the "UA" for the overall tank thermal performance with respect to heat gains from the tank's skin..

Field: Use Side Inlet Node Name

The inlet node connection to the plant loop for the use side of the chilled water storage tank. Typically the use side draws chilled water from the tank and returns warmer water.

Field: Use Side Outlet Node Name

The outlet node connection to the plant loop for the use side of the chilled water storage tank. Typically the use side chilled water from the tank and returns warmer water.

Field: Use Side Heat Transfer Effectiveness

This field specifies the heat transfer effectiveness between the use side water and the tank water. If the effectiveness is set to 1 then complete heat transfer occurs, simulating perfect mixing of the use side water and the tank water. If the effectiveness is lower, then the use side outlet water temperature will not be as cold as the tank water, simulating a heat exchanger.

Field: Use Side Availability Schedule Name

This field contains the name of an availability schedule for the use side of the water tank. If the schedule's value is 0.0, then the use side is not available and flow will not be requested.

Field: Use Side Design Flow Rate

This field is used to specify the design flow rate through the Use Side of the chilled water tank. The volumetric design flow rate is specified in m³/s. The field can be autosized. If autosized, then the input file should include a Plant Sizing object for the plant loop connected to the Use side. Sizing results are reported in the EIO file.

Field: Source Side Inlet Node Name

The inlet node connection to the plant loop for the source side of the chilled water storage tank. Typically the source side draws somewhat warm water from the tank and returns colder water. The source side volume flow rate is obtained from the plant loop. The magnitude of the flow rates through the source side can be controlled by setting the Maximum Branch Flow Rate field in the BRANCH object that connects the source inlet node.

Field: Source Side Outlet Node Name

The outlet node connection to the plant loop for the source side of the chilled water storage tank. Typically the source side draws somewhat warm water from the tank and returns colder water.

Field: Source Side Heat Transfer Effectiveness

This field specifies the heat transfer effectiveness between the source side water and the tank water. If the effectiveness is set to 1 then complete heat transfer occurs, simulating perfect mixing of the source side water and the tank water. If the effectiveness is lower, then the source side outlet water temperature will not be as cold as the tank water, simulating a heat exchanger.

Field: Source Side Availability Schedule Name

This field contains the name of an availability schedule for the source side of the water tank. If the schedule's value is 0.0, then the source side is not available and flow will not be requested.

Field: Source Side Design Flow Rate

This field is used to specify the design flow rate through the Source Side of the chilled water tank. The volumetric design flow rate is specified in m^3/s . The field can be autosized. If autosized, then the input file should include a Plant Sizing object for the plant loop. Sizing results are reported in the EIO file.

Field: Tank Recovery Time

This field is used to autosize the Source Side Design Flow Rate. The field is used if the previous field is set to autosize and the water tank's source side is on the demand side of a plant loop. This is the time, in hours, that the chilled water tank is to be indirectly cooled from 14.4°C to 9.0°C using the exit temperature of in the associated Plant Sizing object.

The IDD entry for this object follows.

```

ThermalStorage:ChilledWater:Mixed,
A1 , \field Name
    \required-field
    \type alpha
    \reference ChilledWaterStorageNames
N1 , \field Tank Volume
    \type real
    \units m3
    \minimum> 0.0
    \default 0.1
    \ip-units gal
A2 , \field Setpoint Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
N2 , \field Deadband Temperature Difference
    \type real
    \units deltaC
    \minimum> 0.0
    \default 0.5
N3 , \field Minimum Temperature Limit
    \type real
    \units C
N4 , \field Nominal Cooling Capacity
    \type real
    \units W
A3 , \field Ambient Temperature Indicator
    \required-field
    \type choice
    \key Schedule
    \key Zone
    \key Outdoors
A4 , \field Ambient Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
A5 , \field Ambient Temperature Zone Name
    \type object-list
    \object-list ZoneNames
A6 , \field Ambient Temperature Outdoor Air Node Name
    \type alpha
    \note required when field Ambient Temperature Indicator=Outdoors
N5 , \field Heat Gain Coefficient from Ambient Temperature
    \type real
    \units W/K
    \minimum 0.0
A7 , \field Use Side Inlet Node Name
    \type alpha
A8 , \field Use Side Outlet Node Name
    \type alpha
N6 , \field Use Side Heat Transfer Effectiveness
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 1.0
A9 , \field Use Side Availability Schedule Name
    \type alpha
N7 , \field Use Side Design Flow Rate
    \type real
    \autosizable
    \default autosize
    \units m3/s
    \ip-units gal/min
    \minimum 0.0
A10, \field Source Side Inlet Node Name
    \type alpha
A11, \field Source Side Outlet Node Name
    \type alpha

```



```

N8, \field Source Side Heat Transfer Effectiveness
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 1.0
A12, \field Source Side Availability Schedule Name
    \type alpha
N9 , \field Source Side Design Flow Rate
    \type real
    \autosizable
    \default autosize
    \units m3/s
    \ip-units gal/min
    \minimum 0.0
N10; \field Tank Recovery Time
    \type real
    \default 4.0
    \note Parameter for autosizing design flow rates for indirectly cooled water tanks
    \note time required to lower temperature of entire tank from 14.4C to 9.0C
    \units hr
    \minimum> 0.0

```

An example input object follows.

```

ThermalStorage:ChilledWater:Mixed,
Chilled Water Storage Tank 1 ,      !- Name
4.0 ,                                !- Tank Volume
CW-Tank-Temp-Schedule,              !- Setpoint Temperature Schedule Name
3.5,                                !- Deadband Temperature Difference
1.0 ,                                !- Minimum Temperature Limit
25000 ,                              !- Nominal Cooling Capacity
Zone ,                               !- Ambient Temperature Indicator
,                                    !- Ambient Temperature Schedule Name
ZN_1_FLR_1_SEC_5 ,                 !- Ambient Temperature Zone Name
,                                    !- Ambient Temperature Outdoor Air Node Name
5.0 ,                                !- Heat Gain Coefficient from Ambient Temperature
CW Tank Discharge Inlet node,       !- Use Side Inlet Node Name
CW Tank Discharge Outlet node ,     !- Use Side Outlet Node Name
1.0 ,                                !- Use Side Effectiveness
TES Use Schedule,                  !- Use Side Availability Schedule Name
Autosize ,                          !- Use Side Design Flow Rate
CW Tank Charge Inlet Node,          !- Source Side Inlet Node Name
CW Tank Charge Outlet Node,        !- Source Side Outlet Node Name
1.0,                                !- Source Side Effectiveness
TES Charge Schedule,               !- Source Side Availability Schedule Name
Autosize ,                          !- Source Side Design Flow Rate
4.0;                                !- Tank Recovery Time

```

ThermalStorage:ChilledWater:Mixed Outputs

The following output variables are reported for chilled water thermal storage tanks.

Chilled Water Tank Temperature	!- HVAC Average [C]
Chilled Water Final Tank Temperature	!- HVAC Average [C]
Chilled Water Tank Gain Rate	!- HVAC Average [W]
Chilled Water Tank Gain Energy	!- HVAC Sum [J]
Chilled Water Tank Use Flow Rate	!- HVAC Average [kg/s]
Chilled Water Tank Use Inlet Temperature	!- HVAC Average [C]
Chilled Water Tank Use Outlet Temperature	!- HVAC Average [C]
Chilled Water Tank Use Rate	!- HVAC Average [W]
Chilled Water Tank Use Energy	!- HVAC Sum [J]
Chilled Water Tank Source Flow Rate	!- HVAC Average [kg/s]
Chilled Water Tank Source Inlet Temperature	!- HVAC Average [C]
Chilled Water Tank Source Outlet Temperature	!- HVAC Average [C]
Chilled Water Tank Source Rate	!- HVAC Average [W]
Chilled Water Tank Source Energy	!- HVAC Sum [J]

Chilled Water Tank Temperature [C]

The average water tank temperature.

Chilled Water Tank Final Temperature [C]

The final water tank temperature at the end of the system timestep. If reported at the "Detailed" interval, this report variable can be used to verify an exact energy balance on the water storage tank.

Chilled Water Tank Gain Rate [W]

The average heat exchange rate to the storage tank from the surrounding ambient. This is usually positive with surrounding ambient heating the storage tank.

Chilled Water Tank Gain Energy [J]

The energy exchange to the storage tank from the surrounding ambient. This is usually positive with surrounding ambient heating the storage tank.

Chilled Water Tank Use Flow Rate [kg/s]

The use side mass flow rate.

Chilled Water Tank Use Inlet Temperature [C]

The inlet temperature on the use side.

Chilled Water Tank Use Outlet Temperature [C]

The outlet temperature on the use side.

Chilled Water Tank Use Rate [W]

The average heat transfer rate between the use side water and the tank water.

Chilled Water Tank Use Energy [J]

The heat transfer energy between the use side water and the tank water.

Chilled Water Tank Source Flow Rate [kg/s]

The source side mass flow rate.

Chilled Water Tank Source Inlet Temperature [C]

The inlet temperature on the source side.

Chilled Water Tank Source Outlet Temperature [C]

The outlet temperature on the source side.

Chilled Water Tank Source Rate [W]

The average heat transfer rate between the source side water and the tank water.

Chilled Water Tank Source Energy [J]

The heat transfer energy between the source side water and the tank water.

ThermalStorage:ChilledWater:Stratified

The ThermalStorage:ChilledWater:Stratified object divides the water tank into multiple nodes of equal volume. The nodes are coupled by vertical conduction effects, internode fluid flow, and temperature inversion mixing. The object simultaneously solves the differential equations governing the energy balances on the nodes using a numerical method. The system timestep is divided into many small substeps that allow the simulation to capture events that occur on a very short time scale. The chilled water is "used" by drawing from the "Use Side" of the

water tank. The tank is indirectly charged by circulating cold water through the “Source Side” of the water tank.

Control is based on cycling flow through the source side. When the tank temperature rises above a “cut-in” temperature, source side flow is requested. Source side flow will continue until the tank is cooled to below the tank set point or “cut-out” temperature.

For heat gains from the ambient environment, the ambient air temperature can be taken from a schedule, a zone, or the exterior. When used with a zone, the skin gains are removed from the zone heat balance as negative internal heat gains.

Field: Name

The unique name of the ThermalStorage:ChilledWater:Stratified object.

Field: Tank Volume

The volume of the thermal storage tank [m³].

Field: Tank Height

The height [m] of the tank. For the HorizontalCylinder shape (see below) the height of the tank is the measure in the axial direction, i.e., the height if you were to stand the cylinder up on its end.

Field: Tank Shape

The tank shape determines the size and skin losses of the stratified nodes. There are three options: “VerticalCylinder,” “HorizontalCylinder,” and “Other.”

VerticalCylinder describes most upright cylindrical water tanks.

HorizontalCylinder describes a few specialty water tanks and some large commercial storage tanks. *HorizontalCylinder* implies that the tank is divided into nodes of equal mass, but not equal height.

Other describes water storage tanks that have a uniform horizontal cross-section, but are not cylinders, e.g., a cuboid or other shape. The length of the perimeter is then specified by the Tank Perimeter field.

If blank, the default shape is *VerticalCylinder*.

Field: Tank Perimeter

The length of the tank perimeter [m]. This field is only used if Tank Shape is *Other*.

Field: Setpoint Temperature Schedule Name

The reference to the schedule object specifying the chilled water temperature setpoint [°C]. Also known as the “cut-out” temperature.

Field: Deadband Temperature Difference

The delta temperature difference [Δ°C] between the setpoint and the “cut-in” temperature at which the storage tank will request cooling. In other words, the “cut-in” temperature is Setpoint + Deadband.

Field: Temperature Sensor Height

This field is used to describe the location in the tank where the temperature is sensed for control decisions. The program will associate one of the nodes with this height and use that node’s temperature for control decisions. The location is described in meters from the bottom of the tank.

Field: Minimum Temperature Limit

The temperature [°C] at which the tank water becomes too cold. No source side flow is allowed when the tank temperature is below this limit. The minimum temperature must be lower than the setpoint temperature at all times.

Field: Nominal Cooling Capacity

This field describes the typical cooling capacity that the chilled water tank will provide. Since this is a passive device, the actual cooling capacity depends on water temperatures and flow rates. However, this field is used to describe the chilled water tank's nominal cooling capacity for supervisory control where plant operation schemes require a cooling capacity to model how equipment is dispatched.

Field: Ambient Temperature Indicator

The Ambient Temperature Indicator specifies how the ambient air temperature will be indicated. The field can be "Schedule", "Zone", or "Exterior." If *Schedule* is used, the Ambient Temperature Schedule Name field provides the values for ambient temperature. If *Zone* is used, the zone air temperature of the zone specified in the Ambient Temperature Zone field provides the ambient temperature. If *Exterior* is used, the outdoor dry-bulb air temperature provides the ambient temperature.

Field: Ambient Temperature Schedule Name

The field contains the name of a schedule object specifying the ambient air temperature around the tank for skin gains. This field is only used if Ambient Temperature Indicator is *Schedule*.

Field: Ambient Temperature Zone Name

The reference to the zone object specifying the ambient air temperature around the tank for skin gains. This field is only used if Ambient Temperature Indicator is *Zone*.

Field: Ambient Temperature Outside Air Node Name

This optional alpha field specifies the outdoor air node name used to define the ambient conditions surrounding the chilled water tank. This field is applicable only when the Ambient Temperature Indicator is specified as *Exterior*, otherwise this field should be left blank. The node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air conditions from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air conditions are taken directly from the weather data.

Field: Uniform Skin Loss Coefficient per Unit Area to Ambient Temperature

The uniform skin loss coefficient [W/m^2-K] or U-Value of the tank to the ambient air temperature. The uniform skin loss accounts for the tank insulation. The overall losses at any particular tank node can be further modified using the Additional Loss Coefficient fields to account for thermal shorting due to pipe penetrations, tank feet, and any other loss effects.

Field: Use Side Inlet Node Name

The inlet node connection to the plant loop for the use side of the chilled water storage tank. Typically the use side draws chilled water from the tank and returns warmer water.

Field: Use Side Outlet Node Name

The outlet node connection to the plant loop for the use side of the chilled water storage tank. Typically the use side chilled water from the tank and returns warmer water.

Field: Use Side Heat Transfer Effectiveness

This field specifies the heat transfer effectiveness between the use side water and the tank water. If the effectiveness is set to 1 then complete heat transfer occurs, simulating perfect mixing of the use side water and the tank water. If the effectiveness is lower, then the use side outlet water temperature will not be as cold as the tank water, simulating a heat exchanger.

Field: Use Side Availability Schedule Name

This field contains the name of an availability schedule for the use side of the water tank. If the schedule's value is 0.0, then the use side is not available and flow will not be requested.

Field: Use Side Inlet Height

The height of the use side inlet to the tank. If blank, the inlet defaults to the top of the tank. The inlet height cannot be higher than the tank height.

Field: Use Side Outlet Height

The height of the use side outlet from the tank. If blank or **autocalculate**, the inlet defaults to the bottom of the tank. The outlet height cannot be higher than the tank height.

Field: Use Side Design Flow Rate

This field is used to specify the design flow rate through the Use Side of the water tank. The volumetric design flow rate is specified in m^3/s . The field is needed when the Use Side is connected to a plant loop. The field can be autosized. If autosized, then the input file should include a Plant Sizing object for the plant loop. Sizing results are reported in the EIO file.

Field: Source Side Inlet Node Name

The inlet node connection to the plant loop for the source side of the chilled water storage tank. Typically the source side draws somewhat warm water from the tank and returns colder water. The source side volume flow rate is obtained from the plant loop. The magnitude of the flow rates through the source side can be controlled by setting the Maximum Branch Flow Rate field in the BRANCH object that connects the source inlet node.

Field: Source Side Outlet Node Name

The outlet node connection to the plant loop for the source side of the chilled water storage tank. Typically the source side draws somewhat warm water from the tank and returns colder water.

Field: Source Side Heat Transfer Effectiveness

This field specifies the heat transfer effectiveness between the source side water and the tank water. If the effectiveness is set to 1 then complete heat transfer occurs, simulating perfect mixing of the source side water and the tank water. If the effectiveness is lower, then the source side outlet water temperature will not be as cold as the tank water, simulating a heat exchanger.

Field: Source Side Availability Schedule Name

This field contains the name of an availability schedule for the source side of the water tank. If the schedule's value is 0.0, then the source side is not available and flow will not be requested.

Field: Source Side Inlet Height

The height of the source side inlet to the tank. If blank or **autocalculate**, the inlet defaults to the bottom of the tank. The inlet height cannot be higher than the tank height.

Field: Source Side Outlet Height

The height of the source side outlet from the tank. If blank, the inlet defaults to the top of the tank. The outlet height cannot be higher than the tank height.

Field: Source Side Design Flow Rate

This field is optional and is used to specify the design flow rate through the Source Side of the water heater. The volumetric design flow rate is specified in m^3/s . The field is needed when the Source Side is connected to a plant loop. The field can be autosized. If autosized,

then the input file should include a Plant Sizing object for the plant loop. Sizing results are reported in the EIO file.

Field: Tank Recovery Time

This field is used to autosize the Source Side Design Flow Rate. The field is used if the previous field is set to autosize and the water tank's source side is on the demand side of a plant loop. This is the time, in hours, that the chilled water tank is to be indirectly cooled from 14.4C to 9.0C using the exit temperature of in the associated Plant Sizing object.

Field: Inlet Mode

The inlet mode of entering fluid from the use and source sides. There are two options: "Fixed" or "Seeking." In *Fixed* mode, the fluid enters at the fixed heights specified above. In *Seeking* mode, the fluid "seeks out" the stratified node that is closest to the inlet temperature and adds all flow to that node. The *Seeking* mode provides maximum stratification.

Field: Number of Nodes

The number of stratified nodes in the tank. There must be at least one node. The maximum number of nodes is 10, although this limit can be increased by editing the IDD.

Field: Additional Destratification Conductivity

An additional destratification conductivity [W/m-K] is added to the fluid conductivity of water (0.6 W/m-K) to account for vertical conduction effects along the inside of the tank wall, and perhaps other vertical components such as a dip tube pipe or anode rod.

Field: Node 1-10 Additional Loss Coefficient

An additional heat gain coefficient [W/m-K] added to the skin gains for a given node to account for thermal shorting due to pipe penetrations, tank feet, and any other loss effects.

ThermalStorage:ChilledWater:Stratified,

```

A1 , \field Name
    \required-field
    \type alpha
    \reference ChilledWaterStorageNames
N1 , \field Tank Volume
    \required-field
    \type real
    \units m3
    \minimum> 0.0
    \ip-units gal
N2 , \field Tank Height
    \required-field
    \type real
    \units m
    \minimum> 0.0
    \note Height is measured in the axial direction for horizontal cylinders
A2 , \field Tank Shape
    \type choice
    \key VerticalCylinder
    \key HorizontalCylinder
    \key Other
    \default VerticalCylinder
N3 , \field Tank Perimeter
    \type real
    \units m
    \minimum 0.0
    \note Only used if Tank Shape is Other
A3 , \field Setpoint Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
N4 , \field Deadband Temperature Difference
    \type real
    \units deltaC
    \minimum 0.0
    \default 0.0
N5 , \field Temperature Sensor Height
    \units m
    \minimum 0.0
N6 , \field Minimum Temperature Limit
    \type real
    \units C
N7 , \field Nominal Cooling Capacity
    \type real
    \units W
A4 , \field Ambient Temperature Indicator
    \required-field
    \type choice
    \key Schedule
    \key Zone
    \key Outdoors
A5 , \field Ambient Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
A6 , \field Ambient Temperature Zone Name
    \type object-list
    \object-list ZoneNames
A7 , \field Ambient Temperature Outdoor Air Node Name
    \type alpha
    \note required for Ambient Temperature Indicator=Outdoors
N8 , \field Uniform Skin Loss Coefficient per Unit Area to Ambient Temperature
    \type real
    \units W/m2-K
    \minimum 0.0

```

```
A8 , \field Use Side Inlet Node Name
    \type alpha
A9, \field Use Side Outlet Node Name
    \type alpha
N9 , \field Use Side Heat Transfer Effectiveness
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 1.0
A10, \field Use Side Availability Schedule Name
    \type alpha
N10 , \field Use Side Inlet Height
    \type real
    \units m
    \minimum 0.0
    \autocalculatable
    \default autocalculate
    \note Defaults to top of tank
N11, \field Use Side Outlet Height
    \type real
    \units m
    \minimum 0.0
    \default 0.0
    \note Defaults to bottom of tank
N12, \field Use Side Design Flow Rate
    \type real
    \autosizable
    \default autosize
    \units m3/s
    \ip-units gal/min
    \minimum 0.0
A11, \field Source Side Inlet Node Name
    \type alpha
A12, \field Source Side Outlet Node Name
    \type alpha
N13, \field Source Side Heat Transfer Effectiveness
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 1.0
A13, \field Source Side Availability Schedule Name
    \type alpha
N14, \field Source Side Inlet Height
    \type real
    \units m
    \minimum 0.0
    \autocalculatable
    \default autocalculate
    \note Defaults to top of tank
N15, \field Source Side Outlet Height
    \type real
    \units m
    \minimum 0.0
    \default 0.0
    \note Defaults to bottom of tank
N16, \field Source Side Design Flow Rate
    \type real
    \autosizable
    \default autosize
    \units m3/s
    \ip-units gal/min
    \minimum 0.0
```



```

N17, \field Tank Recovery Time
      \type real
      \default 4.0
      \note Parameter for autosizing design flow rates for indirectly cooled water tanks
      \note time required to lower temperature of entire tank from 14.4C to 9.0C
      \units hr
      \minimum> 0.0
A14, \field Inlet Mode
      \type choice
      \key Fixed
      \key Seeking
      \default Fixed
N18, \field Number of Nodes
      \type integer
      \minimum 1
      \maximum 10
      \default 1
N19, \field Additional Destratification Conductivity
      \type real
      \units W/m-K
      \minimum 0.0
      \default 0.0
N20, \field Node 1 Additional Loss Coefficient
      \type real
      \units W/m2-K
      \default 0.0
<up to 10 nodes allowed>

```

An example input object follows.

```

ThermalStorage:ChilledWater:Stratified,
Chilled Water Storage Tank 1 ,      !- Name
4.0 ,                                !- Tank Volume
2.0 ,                                !- Tank Height
VerticalCylinder,                   !- Tank Shape
,                                     !- Tank Perimeter
CW-Tank-Temp-Schedule ,              !- Setpoint Temperature Schedule Name
3.5 ,                                !- Deadband Temperature Difference
1.4 ,                                !- Temperature Sensor Height
1.0 ,                                !- Minimum Temperature Limit
2500,                                !- Nominal Cooling Capacity
Zone,                                 !- Ambient Temperature Indicator
,                                     !- Ambient Temperature Schedule Name
ZN_1_FLR_1_SEC_5 ,                  !- Ambient Temperature Zone Name
,                                     !- Ambient Temperature OutdoorAir:Node Name
4.2,                                 !- Uniform Skin Loss Coefficient Per Unit Area To Ambient Temperature
CW Tank Discharge Inlet node,        !- Use Side Inlet Node Name
CW Tank Discharge Outlet node,       !- Use Side Outlet Node Name
1.0,                                  !- Use Side Effectiveness
ALWAYS_ON,                           !- Use Side Availability Schedule Name
1.85 ,                                !- Use Side Inlet Height
0.15 ,                                !- Use Side Outlet Height
autosize,                             !- Use Side Design Flow Rate
CW Tank Charge Inlet Node,            !- Source Side Inlet Node Name
CW Tank Charge Outlet Node,          !- Source Side Outlet Node Name
1.0,                                  !- Source Side Effectiveness
TES Charge Schedule,                 !- Source Side Availability Schedule Name
0.15,                                 !- Source Side Inlet Height
1.85,                                 !- Source Side Outlet Height
autosize,                             !- Source Side Design Flow Rate
2.0,                                  !- Tank Recovery Time
Seeking,                              !- Inlet Mode
6,                                    !- Number Of Nodes
0.0;                                  !- Additional Destratification Conductivity

```

ThermalStorage:ChilledWater:Stratified Outputs

The following output variables are reported for stratified chilled water thermal storage tanks.

Chilled Water Tank Temperature	!- HVAC Average [C]
Chilled Water Final Tank Temperature	!- HVAC Average [C]
Chilled Water Tank Gain Rate	!- HVAC Average [W]
Chilled Water Tank Gain Energy	!- HVAC Sum [J]
Chilled Water Tank Use Flow Rate	!- HVAC Average [kg/s]
Chilled Water Tank Use Inlet Temperature	!- HVAC Average [C]
Chilled Water Tank Use Outlet Temperature	!- HVAC Average [C]
Chilled Water Tank Use Rate	!- HVAC Average [W]
Chilled Water Tank Use Energy	!- HVAC Sum [J]
Chilled Water Tank Source Flow Rate	!- HVAC Average [kg/s]
Chilled Water Tank Source Inlet Temperature	!- HVAC Average [C]
Chilled Water Tank Source Outlet Temperature	!- HVAC Average [C]
Chilled Water Tank Source Rate	!- HVAC Average [W]
Chilled Water Tank Source Energy	!- HVAC Sum [J]
Chilled Water Tank Node <x> Temperature	!- HVAC Average [C]
Chilled Water Tank Final Node <x> Temperature	!- HVAC Average [C]

Chilled Water Tank Temperature [C]

The average water tank temperature, i.e., the average of all of the node average temperatures.

Chilled Water Tank Final Temperature [C]

The final water tank temperature at the end of the system timestep, i.e., the average of all of the final node temperatures at the end of the system timestep. If reported at the "Detailed" interval, this report variable can be used to verify an exact energy balance on the water storage tank.

Chilled Water Tank Gain Rate [W]

The average heat exchange rate to the storage tank from the surrounding ambient. This is usually positive with surrounding ambient heating the storage tank.

Chilled Water Tank Gain Energy [J]

The energy exchange to the storage tank from the surrounding ambient. This is usually positive with surrounding ambient heating the storage tank.

Chilled Water Tank Use Flow Rate [kg/s]

The use side mass flow rate.

Chilled Water Tank Use Inlet Temperature [C]

The inlet temperature on the use side.

Chilled Water Tank Use Outlet Temperature [C]

The outlet temperature on the use side.

Chilled Water Tank Use Rate [W]

The average heat transfer rate between the use side water and the tank water.

Chilled Water Tank Use Energy [J]

The heat transfer energy between the use side water and the tank water.

Chilled Water Tank Source Flow Rate [kg/s]

The source side mass flow rate.

Chilled Water Tank Source Inlet Temperature [C]

The inlet temperature on the source side.

Chilled Water Tank Source Outlet Temperature [C]

The outlet temperature on the source side.

Chilled Water Tank Source Rate [W]

The average heat transfer rate between the source side water and the tank water.

Chilled Water Tank Source Energy [J]

The heat transfer energy between the source side water and the tank water.

Water Heater Node 1-10 Temperature [C]

The average node temperature.

Water Heater Final Node 1-10 Temperature [C]

The final node temperature at the end of the system timestep.

Group – Water Heaters

Water heater objects are components for storing and heating water. They can be coupled to a plant loop simulation or used stand-alone. Typical water heater applications are for domestic hot water heating, low-temperature radiant space heating, and energy storage for solar hot water systems or waste heat recovery.

When coupled to the plant loop, the water heater has an inlet node and outlet node on the "source side" and an inlet node and outlet node on the "use side". The source side typically draws cold water from the tank and returns warmer water, for instance, from solar hot water systems or waste heat recovery systems. The use side typically draws hot water from the tank and returns cooler water from the cold water supply mains or from the outlet of a heating system. The distinction between source and use sides is merely a convenience for reporting. They can actually be used interchangeably. If so desired, either source side or use side can be used by itself, without the other side being connected to the plant loop.

However, for a water heater that is indirectly heated (e.g. with a separate boiler), the source side can be used to provide remotely heated water to the tank. The source side is configured to operate as a component on the demand side of a plant loop. The design flow rate through the source side can be set by the user or autosized. If autosized, then a Plant Sizing object is needed elsewhere in the input file for the Plant Loop serving the source side. The water heater input includes an additional design parameter that describes how rapidly the tank can recover. The water heaters's Source Side should be on a BRANCH object that is set to "ACTIVE" so that it can request heat from the remote boiler when needed.

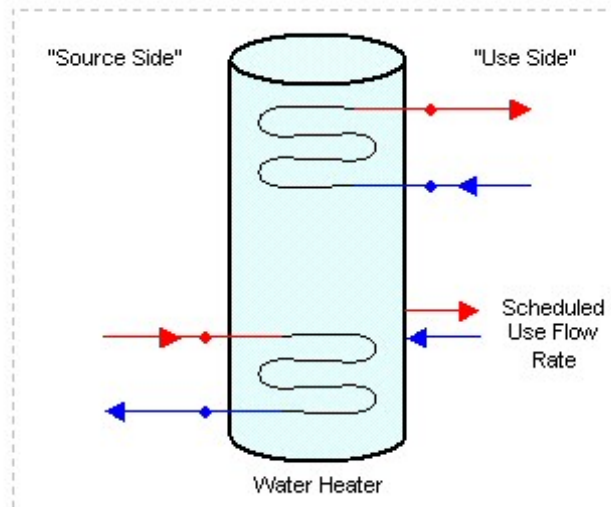


Figure 66. Water Heater Configuration

If the use side only consists of domestic hot water usage, a simple scheduled use flow rate can be specified in lieu of the full plant loop connections. The scheduled use flow rate can be used simultaneously with source side plant connections, but cannot be used with use side plant connections.

For stand-alone operation, there are no node connections to the plant loop on either source or use sides. The scheduled use flow rate determines all fluid exchange with the water tank.

There are currently two water heater objects in EnergyPlus:

- WaterHeater:Mixed
- WaterHeater:Stratified

There is also a compound object that uses the WaterHeater:Mixed as part of its strategy:

- WaterHeater:HeatPump

The WaterHeater:Mixed object simulates a well-mixed, single-node water tank. The WaterHeater:Stratified object simulates a stratified, multi-node water tank. Both water heater objects can be appropriate for simulating many types of water heaters and storage tanks, including gas and electric residential water heaters, and a variety of large commercial water heaters. Both objects share similar features, such as stand-alone operation, on- and off-cycle parasitic loads, and thermal losses to the zone. However, each object has its advantages which may make one water heater object more appropriate than the other depending on the application.

Advantages of **WaterHeater:Mixed**:

- can simulate instantaneous/tankless water heaters
- requires less input than the stratified tank
- faster execution time than the stratified tank
- adequate for modeling gas water heaters with no source connections.

Advantages of **WaterHeater:Stratified**:

- better modeling of electric water heaters with two heating elements
- better modeling of thermal storage applications which rely on stratification to improve heat transfer performance.

Standard Ratings

The EIO file reports the industry standard ratings of Recovery Efficiency and Energy Factor for water heater objects. The rating method is based on the GAMA and 10CFR430 test

procedures. Under certain input parameters, the rating method will not succeed and a warning message will be generated. Problems occur when inputs do not allow the tank to recover to the setpoint temperature within the test period. This can occur if the maximum heater capacity is undersized, or if the deadband temperature difference is large enough that the first draw of the test does not trigger the heater to come on. In either case, the Recovery Efficiency test will not compute properly because recovery to the setpoint was not achieved.

Standard ratings for storage-only water tanks (Heater Maximum Capacity = 0) cannot be calculated and do not report anything in the EIO file.

Water Heater:Mixed

The WaterHeater:Mixed object analytically solves the differential equation governing the energy balance of the water tank. Within a timestep, conditions are solved separately for when the heater element or burner is "on" (on-cycle) and when it is "off" (off-cycle). This approach allows ambient losses and parasitic loads to be divided into on-cycle and off-cycle effects and accounted for in detail.

For losses to the ambient environment, the ambient air temperature can be taken from a schedule, a zone, or the exterior. When used with a zone, a fraction of the skin losses can be added to the zone heat balance as internal heat gains.

Control options allow the heater to cycle or modulate to meet the load. When cycling, the heater element or burner is either on or off. The heater remains fully on while heating the tank up to the setpoint temperature. When the setpoint is reached, the heater turns off. The heater remains off until the tank temperature falls below the "cut-in" temperature, i.e., the setpoint temperature minus the deadband temperature difference. The heater continuously cycles on and off to maintain the tank temperature within the deadband. Most storage-tank water heaters cycle.

When modulating, the heater power varies between the maximum and minimum heater capacities. The heater stays on as long as the required total demand is above the minimum capacity. Below the minimum capacity, the heater will begin to cycle on and off based on the deadband temperature difference. Equipment is usually designed and rated to avoid this condition. Most tankless/instantaneous water heaters modulate.

```

WaterHeater:Mixed,
  A1 , \field Name
        \required-field
        \type alpha
        \reference WaterHeaterNames
  N1 , \field Tank Volume
        \autosizable
        \type real
        \units m3
        \minimum 0.0
        \default 0.0
        \ip-units gal
  A2 , \field Setpoint Temperature Schedule Name
        \type object-list
        \object-list ScheduleNames
  N2 , \field Deadband Temperature Difference
        \type real
        \units deltaC
        \minimum 0.0
        \default 0.0
  N3 , \field Maximum Temperature Limit
        \type real
        \units C
  A3 , \field Heater Control Type
        \type choice
        \key Cycle
        \key Modulate
        \default Cycle

```

```
N4 , \field Heater Maximum Capacity
    \autosizable
    \type real
    \units W
    \minimum 0.0
N5 , \field Heater Minimum Capacity
    \note Only used when Heater Control Type is set to Modulate
    \type real
    \units W
    \minimum 0.0
N6 , \field Heater Ignition Minimum Flow Rate
    \note Not yet implemented
    \type real
    \units m3/s
    \minimum 0.0
    \default 0.0
N7 , \field Heater Ignition Delay
    \note Not yet implemented
    \type real
    \units s
    \minimum 0.0
    \default 0.0
A4 , \field Heater Fuel Type
    \required-field
    \type choice
    \key Electricity
    \key NaturalGas
    \key PropaneGas
    \key FuelOil#1
    \key FuelOil#2
    \key Coal
    \key Diesel
    \key Gasoline
    \key Steam
    \key DistrictHeating
N8 , \field Heater Thermal Efficiency
    \type real
    \minimum> 0.0
    \maximum 1.0
A5 , \field Part Load Factor Curve Name
    \type object-list
    \object-list QuadraticCubicCurves
N9 , \field Off Cycle Parasitic Fuel Consumption Rate
    \type real
    \units W
    \minimum 0.0
    \default 0.0
A6 , \field Off Cycle Parasitic Fuel Type
    \type choice
    \key Electricity
    \key NaturalGas
    \key PropaneGas
    \key FuelOil#1
    \key FuelOil#2
    \key Coal
    \key Diesel
    \key Gasoline
    \key Steam
    \key DistrictHeating
N10, \field Off Cycle Parasitic Heat Fraction to Tank
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0.0
```

```

N11, \field On Cycle Parasitic Fuel Consumption Rate
    \type real
    \units W
    \minimum 0.0
    \default 0.0
A7 , \field On Cycle Parasitic Fuel Type
    \type choice
    \key Electricity
    \key NaturalGas
    \key PropaneGas
    \key FuelOil#1
    \key FuelOil#2
    \key Coal
    \key Diesel
    \key Gasoline
    \key Steam
    \key DistrictHeating
N12, \field On Cycle Parasitic Heat Fraction to Tank
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0.0
A8 , \field Ambient Temperature Indicator
    \required-field
    \type choice
    \key Schedule
    \key Zone
    \key Outdoors
A9 , \field Ambient Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
A10, \field Ambient Temperature Zone Name
    \type object-list
    \object-list ZoneNames
A11, \field Ambient Temperature Outdoor Air Node Name
    \type alpha
    \note required for Ambient Temperature Indicator=Outdoors
N13, \field Off Cycle Loss Coefficient to Ambient Temperature
    \type real
    \units W/K
    \minimum 0.0
N14, \field Off Cycle Loss Fraction to Zone
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 1.0
N15, \field On Cycle Loss Coefficient to Ambient Temperature
    \type real
    \units W/K
    \minimum 0.0
N16, \field On Cycle Loss Fraction to Zone
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 1.0
N17, \field Peak Use Flow Rate
    \type real
    \units m3/s
    \ip-units gal/min
    \minimum 0.0
    \note Only used if Use Side Node connections are blank
A12, \field Use Flow Rate Fraction Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note Only used if Use Side Node connections are blank
A13, \field Cold Water Supply Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note Only used if Use Side Node connections are blank
    \note Defaults to water temperatures calculated by Site:WaterMainsTemperature object

```

```

A14, \field Use Side Inlet Node Name
      \type alpha
A15, \field Use Side Outlet Node Name
      \type alpha
N18, \field Use Side Effectiveness
      \type real
      \minimum 0.0
      \maximum 1.0
      \default 1.0
A16, \field Source Side Inlet Node Name
      \type alpha
A17, \field Source Side Outlet Node Name
      \type alpha
N19, \field Source Side Effectiveness
      \type real
      \minimum 0.0
      \maximum 1.0
      \default 1.0
N20, \field Use Side Design Flow Rate
      \type real
      \autosizable
      \default Autosize
      \units m3/s
      \ip-units gal/min
      \minimum 0.0
N21, \field Source Side Design Flow Rate
      \type real
      \autosizable
      \default Autosize
      \units m3/s
      \ip-units gal/min
      \minimum 0.0
N22; \field Indirect Water Heating Recovery Time
      \type real
      \default 1.5
      \note Parameter for autosizing design flow rates for indirectly heated water tanks
      \note Time required to raise temperature of entire tank from 14.4C to 57.2C
      \units hr
      \minimum> 0.0

```

Field: Name

The name of the WaterHeater:Mixed object.

Field: Tank Volume

The volume of the storage tank [m³]. This field is autosizable if used with a Water Heater:Sizing object. Although this field is allowed to go down to zero, even so-called "tankless" water heaters have some volume of water that is maintained around the heating elements or in the heat exchanger, typically around 0.00379 m³ (1 gallon).

Field: Setpoint Temperature Schedule Name

The reference to the schedule object specifying the hot water temperature setpoint [°C]. Also known as the "cut-out" temperature.

Field: Deadband Temperature Difference

The delta temperature difference [Δ°C] between the setpoint and the "cut-in" temperature at which the heater will turn on. In other words, the "cut-in" temperature is Setpoint – Deadband.

Field: Maximum Temperature Limit

The temperature [°C] at which the tank water becomes dangerously hot and is vented through boiling or an automatic safety. The tank temperature will never exceed the maximum. Any extra heat added to the tank is immediately vented. Note: The maximum temperature must be greater than the setpoint temperature at all times.

Field: Heater Control Type

The control type can be **Cycle** or **Modulate**. Cycle is appropriate for most storage tank-type water heaters. Modulate is appropriate for most instantaneous/tankless water heaters.

Field: Heater Maximum Capacity

The maximum heat rate [W] that can be supplied to the water, probably the same as the "nominal" capacity. This field is autosizable if used with a Water Heater:Sizing object.

Field: Heater Minimum Capacity

The minimum heat rate [W] that can be supplied to the water. This field is only used when the Heater Control Type is **Modulate**. If the total demand rate for heating is less than the minimum, even a modulating water heater will begin to cycle.

Field: Heater Ignition Minimum Flow Rate

NOT YET IMPLEMENTED.

Field: Heater Ignition Delay

NOT YET IMPLEMENTED.

Field: Heater Fuel Type

The type of fuel used for heating. The fuel type can be Electricity, NaturalGas, PropaneGas, FuelOil#1, FuelOil#2, Coal, Diesel, Gasoline, Steam, or DistrictHeating.

Field: Heater Thermal Efficiency

The thermal conversion efficiency from fuel energy to heat energy for the heater element or burner. This is not the same as the overall efficiency of the water heater.

Field: Part Load Factor Curve Name

The reference to the curve object that relates the overall efficiency of the water heater to the Runtime Fraction (if Control Type **Cycle**) or Part Load Ratio (if Control Type **Modulate**). This is an additional multiplier applied to the Heater Thermal Efficiency to compute fuel energy use. The Part Load Factor Curve should not have a value less than 0.1 in the domain from 0 to 1. If the Part Load Factor Curve accounts for ambient losses and/or parasitic fuel consumption, these effects should not also be input into the related fields in this object as that would result in double-counting.

Field: Off-Cycle Parasitic Fuel Consumption Rate

Off-cycle parasitics include parts of the water heater that consume fuel when the heater is off, for example, a pilot light, or stand-by electronic control circuits. The fuel consumption rate [W] is strictly the total fuel that is consumed by all of the off-cycle parasitics.

Field: Off-Cycle Parasitic Fuel Type

The type of fuel used by the off-cycle parasitics. The fuel type can be Electricity, NaturalGas, PropaneGas, FuelOil#1, FuelOil#2, Coal, Diesel, Gasoline, Steam, or DistrictHeating. The fuel type can be the same or different from the Heater Fuel Type.

Field: Off-Cycle Parasitic Heat Fraction to Tank

The fraction of off-cycle parasitic fuel energy that is converted to heat energy that ends up in the tank water. For example, a pilot light would deliver most of its heat to the tank water, as long as the thermal conversion efficiency must be taken into account, so perhaps 0.80 is reasonable. Electronic control circuits, on the other hand, do not add any heat to the tank and should be 0.

Field: On-Cycle Parasitic Fuel Consumption Rate

On-cycle parasitics include parts of the water heater that consume fuel when the heater is on, for example, an induction fan, or stand-by electronic control circuits. The fuel consumption rate [W] is strictly the total fuel that is consumed by all of the on-cycle parasitics.

Field: On-Cycle Parasitic Fuel Type

The type of fuel used by the on-cycle parasitics. The fuel type can be Electricity, NaturalGas, PropaneGas, FuelOil#1, FuelOil#2, Coal, Diesel, Gasoline, Steam, or DistrictHeating. The fuel type can be the same or different from the Heater Fuel Type.

Field: On-Cycle Parasitic Heat Fraction to Tank

The fraction of on-cycle parasitic fuel energy that is converted to heat energy that ends up in the tank water. For example, an induction fan might (maybe) deliver a small fraction of its energy to the tank water for a value of 0.05. Electronic control circuits, on the other hand, do not add any heat to the tank and should be 0.

Field: Ambient Temperature Indicator

The Ambient Temperature Indicator specifies how the ambient air temperature will be indicated. The field can be **Schedule**, **Zone**, or **Outdoors**. If Schedule is used, the Ambient Temperature Schedule field provides the ambient temperature. If ZONE is used, the zone air temperature of the zone specified in the Ambient Temperature Zone field provides the ambient temperature. If EXTERIOR is used, the outdoor dry-bulb air temperature provides the ambient temperature.

Field: Ambient Temperature Schedule Name

The reference to the schedule object specifying the ambient air temperature around the tank for skin losses. This field is only used if Ambient Temperature Indicator is **Schedule**.

Field: Ambient Temperature Zone Name

The reference to the zone object specifying the ambient air temperature around the tank for skin losses. This field is only used if Ambient Temperature Indicator is **Zone**.

Field: Ambient Temperature Outdoor Air Node Name

This optional alpha field specifies the outdoor air node name used to define the ambient conditions surrounding the water heater tank. This field is applicable only when the Ambient Temperature Indicator is specified as OutdoorAir:Node, otherwise this field should be left blank. The node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air conditions from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air conditions are taken directly from the weather data.

Field: Off-Cycle Loss Coefficient to Ambient Temperature

The loss coefficient [W/K] to the ambient air temperature. Often this coefficient is identical to the "UA" for skin losses. However, it can also be used to model the loss effects of the flue in a combustion water heater, in addition to the skin losses.

Field: Off-Cycle Loss Fraction to Zone

If the Ambient Temperature Indicator is **Zone**, this field adds the specified fraction of the off-cycle losses to the zone heat balance as an internal gain.

Field: On-Cycle Loss Coefficient to Ambient Temperature

The loss coefficient [W/K] to the ambient air temperature. Often this coefficient is identical to the "UA" for skin losses. If the loss effects of the flue are being modeled in the Off-Cycle Loss Coefficient, then this field would have a different value accounting only for the skin losses.

Field: On-Cycle Loss Fraction to Zone

If the Ambient Temperature Indicator is **Zone**, this field adds the specified fraction of the on-cycle losses to the zone heat balance as an internal gain.

Field: Peak Use Flow Rate

The peak flow rate [m³/s] of domestic hot water usage for stand-alone operation, i.e., without plant loop node connections. The peak value is multiplied by the Use Flow Rate Fraction Schedule. If there are node connections, this field is not used.

Field: Use Flow Rate Fraction Schedule Name

The reference to the schedule object specifying the current fraction of Peak Volumetric Use Flow Rate of domestic hot water usage for stand-alone operation.

Field: Cold Water Supply Temperature Schedule Name

The reference to the schedule object specifying the cold water temperature [°C] from the supply mains that makes up for the hot water lost down the drain. If blank, water temperatures are calculated by the Site:WaterMainsTemperature object. This field is for stand-alone operation only. If there are node connections, this field is not used.

Field: Use Side Inlet Node Name

The inlet node connection to the plant loop for the use side of the water heater. Typically the use side draws hot water from the tank and returns cooler water.

Field: Use Side Outlet Node Name

The outlet node connection to the plant loop for the use side of the water heater. Typically the use side draws hot water from the tank and returns cooler water.

Field: Use Side Effectiveness

This field specifies the heat transfer effectiveness between the use side water and the tank water. If the effectiveness is set to 1 then complete heat transfer occurs, simulating perfect mixing of the use side water and the tank water. If the effectiveness is lower, then the use side outlet water temperature will not be as hot as the tank water, simulating a heat exchanger.

Field: Source Side Inlet Node Name

The inlet node connection to the plant loop for the source side of the water heater. Typically the source side draws cold water from the tank and returns warmer water. The source side volume flow rate is obtained from the plant loop. The magnitude of the flow rates through the source side can be controlled by setting the Maximum Branch Flow Rate field in the **Branch** object that connects the source inlet node.

Field: Source Side Outlet Node Name

The outlet node connection to the plant loop for the source side of the water heater. Typically the source side draws cold water from the tank and returns warmer water.

Field: Source Side Effectiveness

This field specifies the heat transfer effectiveness between the source side water and the tank water. If the effectiveness is set to 1 then complete heat transfer occurs, simulating perfect mixing of the source side water and the tank water. If the effectiveness is lower, then the source side outlet water temperature will not be as hot as the tank water, simulating a heat exchanger.

Field: Use Side Design Flow Rate

This field is optional and is used to specify the design flow rate through the Use Side of the water heater. The volumetric design flow rate is specified in m^3/s . The field is needed when the Use Side is connected to a plant loop. The field can be autosized. If autosized, then the input file should include a Plant Sizing object for the plant loop. Sizing results are reported in the EIO file.

Field: Source Side Design Flow Rate

This field is optional and is used to specify the design flow rate through the Source Side of the water heater. The volumetric design flow rate is specified in m^3/s . The field is needed when the Source Side is connected to a plant loop. The field can be autosized. If autosized, then the input file should include a Plant Sizing object for the plant loop. Sizing results are reported in the EIO file.

Field: Indirect Water Heating Recovery Time

This field is optional and is used to provide a design parameter for autosizing design flow rates when the water heater is connected to the demand side of a plant loop. The recovery time is expressed in hours. This is the time that the entire volume of the tank can be heated from 14.4°C to 57.2°C (58°F to 135°F) with an inlet temperature defined as the exit temperature in the associated Plant Sizing object. The default is 1.5 hours. The calculation is based on log-mean temperature difference (LMTD) and includes the heat transfer effectiveness factor entered above.

```
WaterHeater:Mixed,                ! Stand-alone electric, outdoor example
  Outdoor Electric Tank,  !- Name
  0.151,  !- Tank Volume {m3}
  Hot Water Setpoint Temp Schedule,  !- Setpoint Temperature Schedule
  2.0,  !- Deadband Temperature Difference {deltaC}
  82.2222,  !- Maximum Temperature Limit {C}
  Cycle,  !- Heater Control Type {Cycle | Modulate}
  11712,  !- Heater Maximum Capacity {W}
  ,  !- Heater Minimum Capacity {W}
  ,  !- Heater Ignition Minimum Flow Rate {m3/s}
  ,  !- Heater Ignition Delay {s}
  ELECTRICITY,  !- Heater Fuel Type
  0.95,  !- Heater Thermal Efficiency
  ,  !- Part Load Factor Curve
  15,  !- Off-Cycle Parasitic Fuel Consumption Rate {W}
  ELECTRICITY,  !- Off-Cycle Parasitic Fuel Type
  0,  !- Off-Cycle Parasitic Heat Fraction To Tank
  15,  !- On-Cycle Parasitic Fuel Consumption Rate {W}
  ELECTRICITY,  !- On-Cycle Parasitic Fuel Type
  0,  !- On-Cycle Parasitic Heat Fraction To Tank
  Outdoors,  !- Ambient Temperature Indicator {Schedule | Zone | Outdoors}
  ,  !- Ambient Temperature Schedule
  ,  !- Ambient Temperature Zone
  2.36,  !- Off-Cycle Loss Coefficient To Ambient Temperature {W/K}
  ,  !- Off-Cycle Loss Fraction To Zone
  2.36,  !- On-Cycle Loss Coefficient To Ambient Temperature {W/K}
  ,  !- On-Cycle Loss Fraction To Zone
  0.000379,  !- Peak Volumetric Use Flow Rate {m3/s}
  Hot Water Demand Schedule,  !- Use Flow Rate Fraction Schedule
  Constant Mains Temp Schedule;  !- Cold Water Supply Temperature Schedule
```

```

WaterHeater:Mixed,                ! Stand-alone electric, tankless example
Tankless,  !- Name
0.003785,  !- Tank Volume {m3}
Hot Water Setpoint Temp Schedule, !- Setpoint Temperature Schedule
,  !- Deadband Temperature Difference {deltaC}
82.2222,  !- Maximum Temperature Limit {C}
Modulate, !- Heater Control Type {Cycle | Modulate}
11712,  !- Heater Maximum Capacity {W}
0,  !- Heater Minimum Capacity {W}
,  !- Heater Ignition Minimum Flow Rate {m3/s}
,  !- Heater Ignition Delay {s}
ELECTRICITY, !- Heater Fuel Type
0.95,  !- Heater Thermal Efficiency
,  !- Part Load Factor Curve
10,  !- Off-Cycle Parasitic Fuel Consumption Rate {W}
ELECTRICITY, !- Off-Cycle Parasitic Fuel Type
0,  !- Off-Cycle Parasitic Heat Fraction To Tank
30,  !- On-Cycle Parasitic Fuel Consumption Rate {W}
ELECTRICITY, !- On-Cycle Parasitic Fuel Type
0,  !- On-Cycle Parasitic Heat Fraction To Tank
Schedule, !- Ambient Temperature Indicator {Schedule | Zone | Outdoors}
Hot Water Ambient Temp Schedule, !- Ambient Temperature Schedule
,  !- Ambient Temperature Zone
,  !- Off-Cycle Loss Coefficient To Ambient Temperature {W/K}
,  !- Off-Cycle Loss Fraction To Zone
,  !- On-Cycle Loss Coefficient To Ambient Temperature {W/K}
,  !- On-Cycle Loss Fraction To Zone
0.000379, !- Peak Volumetric Use Flow Rate {m3/s}
Hot Water Demand Schedule, !- Use Flow Rate Fraction Schedule
;  !- Cold Water Supply Temperature Schedule

```

```

WaterHeater:Mixed,                ! Plant loop connected, gas example
Water Heater,  !- Name
0.454,  !- Tank Volume {m3}
Hot Water Setpoint Temp Schedule, !- Setpoint Temperature Schedule
5.0,  !- Deadband Temperature Difference {deltaC}
82.2222,  !- Maximum Temperature Limit {C}
Cycle, !- Heater Control Type {Cycle | Modulate}
2000,  !- Heater Maximum Capacity {W}
,  !- Heater Minimum Capacity {W}
,  !- Heater Ignition Minimum Flow Rate {m3/s}
,  !- Heater Ignition Delay {s}
NATURALGAS, !- Heater Fuel Type
0.80,  !- Heater Thermal Efficiency
,  !- Part Load Factor Curve
,  !- Off-Cycle Parasitic Fuel Consumption Rate {W}
,  !- Off-Cycle Parasitic Fuel Type
,  !- Off-Cycle Parasitic Heat Fraction To Tank
,  !- On-Cycle Parasitic Fuel Consumption Rate {W}
,  !- On-Cycle Parasitic Fuel Type
,  !- On-Cycle Parasitic Heat Fraction To Tank
Schedule, !- Ambient Temperature Indicator {Schedule | Zone | Outdoors}
Hot Water Ambient Temp Schedule, !- Ambient Temperature Schedule
,  !- Ambient Temperature Zone
5.0,  !- Off-Cycle Loss Coefficient To Ambient Temperature {W/K}
,  !- Off-Cycle Loss Fraction To Zone
5.0,  !- On-Cycle Loss Coefficient To Ambient Temperature {W/K}
,  !- On-Cycle Loss Fraction To Zone
,  !- Peak Volumetric Use Flow Rate {m3/s}
,  !- Use Flow Rate Fraction Schedule
,  !- Cold Water Supply Temperature Schedule
Water Heater Use Inlet Node, !- Use Side Inlet Node
Water Heater Use Outlet Node, !- Use Side Outlet Node
1.0,  !- Use Side Effectiveness
Water Heater Source Inlet Node, !- Source Side Inlet Node
Water Heater Source Outlet Node, !- Source Side Outlet Node
1.0;  !- Source Side Effectiveness

```

```

WaterHeater:Mixed,
  Indirect Water Heater,      !- Name
  1.00,                       !- Tank Volume {m3}
  Hot Water Setpoint Temperature Schedule, !- Setpoint Temperature Schedule
  5.0,                         !- Deadband Temperature Difference {deltaC}
  82.2222,                     !- Maximum Temperature Limit {C}
  Cycle,                       !- Heater Control Type
  0.0,                         !- Heater Maximum Capacity {W}
  ,                             !- Heater Minimum Capacity {W}
  ,                             !- Heater Ignition Minimum Flow Rate {m3/s}
  ,                             !- Heater Ignition Delay {s}
  ELECTRIC,                    !- Heater Fuel Type
  0.8,                         !- Heater Thermal Efficiency
  ,                             !- Part Load Factor Curve
  ,                             !- Off-Cycle Parasitic Fuel Consumption Rate {W}
  ,                             !- Off-Cycle Parasitic Fuel Type
  ,                             !- Off-Cycle Parasitic Heat Fraction To Tank
  ,                             !- On-Cycle Parasitic Fuel Consumption Rate {W}
  ,                             !- On-Cycle Parasitic Fuel Type
  ,                             !- On-Cycle Parasitic Heat Fraction To Tank
  Zone,                        !- Ambient Temperature Indicator
  ,                             !- Ambient Temperature Schedule
  SPACE5-1,                    !- Ambient Temperature Zone
  ,                             !- Ambient Temperature Outside Air Node
  5.0,                         !- Off-Cycle Loss Coefficient To Ambient Temperature {W/K}
  ,                             !- Off-Cycle Loss Fraction To Zone
  5.0,                         !- On-Cycle Loss Coefficient To Ambient Temperature {W/K}
  ,                             !- On-Cycle Loss Fraction To Zone
  ,                             !- Peak Volumetric Use Flow Rate {m3/s}
  ,                             !- Use Flow Rate Fraction Schedule
  ,                             !- Cold Water Supply Temperature Schedule
  SHWSys1 Pump-SHWSys1 Water HeaterNode, !- Use Side Inlet Node
  SHWSys1 Supply Equipment Outlet Node, !- Use Side Outlet Node
  1.0,                          !- Use Side Effectiveness
  Indirect Water Heater SrcSideInletNode, !- Source Side Inlet Node
  Indirect Water Heater SrcSideOutletNode, !- Source Side Outlet Node
  0.9,                          !- Source Side Effectiveness
  autosize,                    !- Use Side Design Flow Rate
  autosize,                    !- Source Side Design Flow Rate
  1.0;                          !- Indirect Water Heating Recovery Time

```

Water Heater:Mixed Output

The following output variables are reported for the WaterHeater:Mixed object:

```

HVAC,Average,Water Heater Tank Temperature [C]
HVAC,Average,Water Heater Final Tank Temperature [C]
HVAC,Average,Water Heater Loss Rate [W]
HVAC,Sum,Water Heater Loss Energy [J]
HVAC,Average,Water Heater Use Flow Rate [kg/s]
HVAC,Average,Water Heater Use Inlet Temperature [C]
HVAC,Average,Water Heater Use Outlet Temperature [C]
HVAC,Average,Water Heater Use Rate [W]
HVAC,Sum,Water Heater Use Energy [J]
HVAC,Average,Water Heater Source Flow Rate [kg/s]
HVAC,Average,Water Heater Source Inlet Temperature [C]
HVAC,Average,Water Heater Source Outlet Temperature [C]
HVAC,Average,Water Heater Source Rate [W]
HVAC,Sum,Water Heater Source Energy [J]
HVAC,Average,Water Heater Off-Cycle Parasitic Heat Rate To Tank [W]
HVAC,Sum,Water Heater Off-Cycle Parasitic Heat Energy To Tank [J]
HVAC,Average,Water Heater On-Cycle Parasitic Heat Rate To Tank [W]
HVAC,Sum,Water Heater On-Cycle Parasitic Heat Energy To Tank [J]
HVAC,Average,Water Heater Total Demand Rate [W]
HVAC,Sum,Water Heater Total Demand Energy [J]
HVAC,Average,Water Heater Heating Rate [W]
HVAC,Sum,Water Heater Heating Energy [J]
HVAC,Average,Water Heater Unmet Demand Rate [W]

```

```

HVAC,Sum,Water Heater Unmet Demand Energy [J]
HVAC,Average,Water Heater Venting Rate [W]
HVAC,Sum,Water Heater Venting Energy [J]
HVAC,Average,Water Heater Net Heat Transfer Rate [W]
HVAC,Sum,Water Heater Net Heat Transfer Energy [J]
HVAC,Sum,Water Heater Cycle On Count []
HVAC,Average,Water Heater Runtime Fraction []
HVAC,Average,Water Heater Part Load Ratio []
HVAC,Average,Water Heater <Fuel Type> Consumption Rate [W]
HVAC,Sum,Water Heater <Fuel Type>Consumption [J]
HVAC,Average,Water Heater Off-Cycle Parasitic <Fuel Type> Consumption Rate [W]
HVAC,Sum,Water Heater Off-Cycle Parasitic <Fuel Type> Consumption [J]
HVAC,Average,Water Heater On-Cycle Parasitic <Fuel Type> Consumption Rate [W]
HVAC,Sum,Water Heater On-Cycle Parasitic <Fuel Type> Consumption [J]
HVAC,Average,Water Heater Water Consumption Rate [m3/s]
HVAC,Sum,Water Heater Water Consumption [m3]

```

Water Heater Tank Temperature [C]

The average water tank temperature.

Water Heater Final Tank Temperature [C]

The final water tank temperature at the end of the system timestep. If reported at the "Detailed" interval, this report variable can be used to verify an exact energy balance on the water heater. Also see the report variable: Water Heater Net Heat Transfer Energy.

Water Heater Loss Rate [W]

The average heat loss rate due to the off- and on-cycle loss coefficients to the ambient temperature.

Water Heater Loss Energy [J]

The heat loss energy due to the off- and on-cycle loss coefficients to the ambient temperature.

Water Heater Use Flow Rate [kg/s]

The use side mass flow rate. If stand-alone, this is the scheduled use flow rate.

Water Heater Use Inlet Temperature [C]

The inlet temperature on the use side.

Water Heater Use Outlet Temperature [C]

The outlet temperature on the use side.

Water Heater Use Rate [W]

The average heat transfer rate between the use side water and the tank water.

Water Heater Use Energy [J]

The heat transfer energy between the use side water and the tank water.

Water Heater Source Flow Rate [kg/s]

The source side mass flow rate. If in stand-alone operation, this is 0.

Water Heater Source Inlet Temperature [C]

The inlet temperature on the source side.

Water Heater Source Outlet Temperature [C]

The outlet temperature on the source side.

Water Heater Source Rate [W]

The average heat transfer rate between the source side water and the tank water.

Water Heater Source Energy [J]

The heat transfer energy between the source side water and the tank water.

Water Heater Off-Cycle Parasitic Heat Rate To Tank [W]

The average heat gain rate to the tank water due to off-cycle parasitics.

Water Heater Off-Cycle Parasitic Heat Energy To Tank [J]

The heat gain energy to the tank water due to off-cycle parasitics.

Water Heater On-Cycle Parasitic Heat Rate To Tank [W]

The average heat gain rate to the tank water due to on-cycle parasitics.

Water Heater On-Cycle Parasitic Heat Energy To Tank [J]

The heat gain energy to the tank water due to on-cycle parasitics.

Water Heater Total Demand Rate [W]

The average heating rate demanded to maintain the setpoint temperature.

Water Heater Total Demand Energy [J]

The heating energy demanded to maintain the setpoint temperature.

Water Heater Heating Rate [W]

The average heating rate supplied by the heater element or burner.

Water Heater Heating Energy [J]

The heating energy supplied by the heater element or burner.

Water Heater Unmet Demand Rate [W]

The average heating rate unmet by the heater element or burner. The difference between the Total Demand Rate and the Heating Rate.

Water Heater Unmet Demand Energy [J]

The heating energy unmet by the heater element or burner. The difference between the Total Demand Energy and the Heating Energy.

Water Heater Venting Rate [W]

The average venting rate to keep the tank below the Maximum Temperature Limit.

Water Heater Venting Energy [J]

The venting energy to keep the tank below the Maximum Temperature Limit.

Water Heater Net Heat Transfer Rate [W]

The average net heat transfer rate when considering all losses and gains.

Water Heater Net Heat Transfer Energy [J]

The net heat transfer energy when considering all losses and gains.

Water Heater Cycle On Count []

The number of times that the heater turned on in the time period.

Water Heater Runtime Fraction []

The fraction of the time period that the heater was running.

Water Heater Part Load Ratio []

The fraction of the Heater Maximum Capacity.

Water Heater <Fuel Type> Consumption Rate [W]

The average fuel consumption rate for the heater element or burner.

Water Heater <Fuel Type> Consumption Energy [J]

The fuel consumption energy for the heater element or burner.

Water Heater Off-Cycle <Fuel Type> Consumption Rate [W]

The average fuel consumption rate for the off-cycle parasitics.

Water Heater Off-Cycle <Fuel Type> Consumption Energy [J]

The fuel consumption energy for the off-cycle parasitics.

Water Heater On-Cycle <Fuel Type> Consumption Rate [W]

The average fuel consumption rate for the on-cycle parasitics.

Water Heater On-Cycle <Fuel Type> Consumption Energy [J]

The fuel consumption energy for the on-cycle parasitics.

Water Heater Water Consumption Rate [m³/s]

The water consumption rate for the use side, if in stand-alone operation.

Water Heater Water Consumption [m³]

The water consumption for the use side, if in stand-alone operation.

Water Heater:Stratified

The WaterHeater:Stratified object divides the water tank into multiple nodes of equal volume. The nodes are coupled by vertical conduction effects, internode fluid flow, and temperature inversion mixing. The object simultaneously solves the differential equations governing the energy balances on the nodes using a numerical method. The system timestep is divided into many small substeps that allow the simulation to capture events that occur on a very short time scale. This approach allows ambient losses and parasitic loads to be divided into on-cycle and off-cycle effects and accounted for in detail.

For losses to the ambient environment, the ambient air temperature can be taken from a schedule, a zone, or the exterior. When used with a zone, a fraction of the skin losses can be added to the zone heat balance as internal heat gains.

The WaterHeater:Stratified object allows two heating elements to be simulated. The two elements can cycle on and off to maintain the node temperature within the deadband. The Heater Priority Control field determines how the heaters work together. There are two options: MasterSlave or Simultaneous. In the MasterSlave option, Heater 1 is the master and Heater 2 is the slave. That is, both heaters are not allowed to turn on at the same time. If the thermostats ask for heat at both Heater 1 and 2, only Heater 1 will turn on. Once Heater 1 has met the set point, it turns off and Heater 2 can turn on, if necessary. In the Simultaneous option, Heater 1 and Heater 2 can turn on and off independently. Autosizing is available for only Heater 1.

```
WaterHeater:Stratified,
A1 , \field Name
    \required-field
    \type alpha
    \reference WaterHeaterNames
A2 , \field End-Use Subcategory
    \type alpha
    \retaincase
    \default General
N1 , \field Tank Volume
    \autosizable
    \required-field
    \type real
    \units m3
    \minimum> 0.0
    \ip-units gal
N2 , \field Tank Height
    \autosizable
    \required-field
    \type real
    \units m
    \minimum> 0.0
    \note Height is measured in the axial direction for horizontal cylinders
A3 , \field Tank Shape
    \type choice
    \key VerticalCylinder
    \key HorizontalCylinder
    \key Other
    \default VerticalCylinder
N3 , \field Tank Perimeter
    \type real
    \units m
    \minimum 0.0
    \note Only used if Tank Shape is Other
N4 , \field Maximum Temperature Limit
    \type real
    \units C
A4 , \field Heater Priority Control
    \type choice
    \key MasterSlave
    \key Simultaneous
    \default MasterSlave
A5 , \field Heater 1 Setpoint Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
N5 , \field Heater 1 Deadband Temperature Difference
    \type real
    \units deltaC
    \minimum 0.0
    \default 0.0
N6 , \field Heater 1 Capacity
    \type real
    \units W
    \minimum 0.0
    \autosizable
N7 , \field Heater 1 Height
    \type real
    \units m
    \minimum 0.0
```

```
A6 , \field Heater 2 Setpoint Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
N8 , \field Heater 2 Deadband Temperature Difference
    \type real
    \units deltaC
    \minimum 0.0
    \default 0.0
N9 , \field Heater 2 Capacity
    \type real
    \units W
    \minimum 0.0
N10, \field Heater 2 Height
    \type real
    \units m
    \minimum 0.0
A7 , \field Heater Fuel Type
    \required-field
    \type choice
    \key Electricity
    \key NaturalGas
    \key PropaneGas
    \key FuelOil#1
    \key FuelOil#2
    \key Coal
    \key Diesel
    \key Gasoline
    \key Steam
    \key DistrictHeating
N11, \field Heater Thermal Efficiency
    \type real
    \minimum> 0.0
    \maximum 1.0
N12, \field Off Cycle Parasitic Fuel Consumption Rate
    \type real
    \units W
    \minimum 0.0
    \default 0.0
A8 , \field Off Cycle Parasitic Fuel Type
    \type choice
    \key Electricity
    \key NaturalGas
    \key PropaneGas
    \key FuelOil#1
    \key FuelOil#2
    \key Coal
    \key Diesel
    \key Gasoline
    \key Steam
    \key DistrictHeating
N13, \field Off Cycle Parasitic Heat Fraction to Tank
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0.0
N14, \field Off Cycle Parasitic Height
    \type real
    \units m
    \minimum 0.0
    \default 0.0
```

```

N15, \field On Cycle Parasitic Fuel Consumption Rate
\type real
\units W
\minimum 0.0
\default 0.0
A9 , \field On Cycle Parasitic Fuel Type
\type choice
\key Electricity
\key NaturalGas
\key PropaneGas
\key FuelOil#1
\key FuelOil#2
\key Coal
\key Diesel
\key Gasoline
\key Steam
\key DistrictHeating
N16, \field On Cycle Parasitic Heat Fraction to Tank
\type real
\minimum 0.0
\maximum 1.0
\default 0.0
N17, \field On Cycle Parasitic Height
\type real
\units m
\minimum 0.0
\default 0.0
A10, \field Ambient Temperature Indicator
\required-field
\type choice
\key Schedule
\key Zone
\key Outdoors
A11, \field Ambient Temperature Schedule Name
\type object-list
\object-list ScheduleNames
A12, \field Ambient Temperature Zone Name
\type object-list
\object-list ZoneNames
A13, \field Ambient Temperature Outdoor Air Node Name
\type alpha
\note required for Ambient Temperature Indicator=Outdoors
N18, \field Uniform Skin Loss Coefficient per Unit Area To Ambient Temperature
\type real
\units W/m2-K
\minimum 0.0
N19, \field Skin Loss Fraction to Zone
\type real
\minimum 0.0
\maximum 1.0
\default 1.0
N20, \field Off Cycle Flue Loss Coefficient to Ambient Temperature
\type real
\units W/K
\minimum 0.0
N21, \field Off Cycle Flue Loss Fraction to Zone
\type real
\minimum 0.0
\maximum 1.0
\default 1.0
N22, \field Peak Use Flow Rate
\type real
\units m3/s
\ip-units gal/min
\minimum 0.0
\note Only used if Use Side Node connections are blank
A14, \field Use Flow Rate Fraction Schedule Name
\type object-list
\object-list ScheduleNames
\note If blank, defaults to 1.0 at all times
\note Only used if use side node connections are blank

```

```

A15, \field Cold Water Supply Temperature Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Only used if use side node connections are blank
      \note Defaults to water temperatures calculated by Site:WaterMainsTemperature object
A16, \field Use Side Inlet Node Name
      \type alpha
A17, \field Use Side Outlet Node Name
      \type alpha
N23, \field Use Side Effectiveness
      \type real
      \minimum 0.0
      \maximum 1.0
      \default 1.0
N24, \field Use Side Inlet Height
      \type real
      \units m
      \minimum 0.0
      \default 0.0
      \note Defaults to bottom of tank
N25, \field Use Side Outlet Height
      \type real
      \units m
      \minimum 0.0
      \autocalculatable
      \default Autocalculate
      \note Defaults to top of tank
A18, \field Source Side Inlet Node Name
      \type alpha
A19, \field Source Side Outlet Node Name
      \type alpha
N26, \field Source Side Effectiveness
      \type real
      \minimum 0.0
      \maximum 1.0
      \default 1.0
N27, \field Source Side Inlet Height
      \type real
      \units m
      \minimum 0.0
      \autocalculatable
      \default Autocalculate
      \note Defaults to top of tank
N28, \field Source Side Outlet Height
      \type real
      \units m
      \minimum 0.0
      \default 0.0
      \note Defaults to bottom of tank
A20, \field Inlet Mode
      \type choice
      \key Fixed
      \key Seeking
      \default Fixed
N29, \field Use Side Design Flow Rate
      \type real
      \autosizable
      \default Autosize
      \units m3/s
      \ip-units gal/min
      \minimum 0.0
N30, \field Source Side Design Flow Rate
      \type real
      \autosizable
      \default Autosize
      \units m3/s
      \ip-units gal/min
      \minimum 0.0

```

```

N31, \field Indirect Water Heating Recovery Time
    \type real
    \default 1.5
    \note Parameter for autosizing design flow rates for indirectly heated water tanks
    \note time required to raise temperature of entire tank from 14.4C to 57.2C
    \units hr
    \minimum> 0.0
N32, \field Number of Nodes
    \type integer
    \minimum 1
    \maximum 10
    \default 1
N33, \field Additional Destratification Conductivity
    \type real
    \units W/m-K
    \minimum 0.0
    \default 0.0
N34, \field Node 1 Additional Loss Coefficient
    \type real
    \units W/m2-K
    \default 0.0
<up to 10 nodes allowed>

```

Field: Name

The name of the WaterHeater:Stratified object.

Field: End-Use Subcategory

Allows you to specify a user-defined end-use subcategory, e.g., "Laundry", "Dish Washing", etc. A new meter for reporting is created for each unique subcategory (ref: Report Meter). Subcategories are also reported in the ABUPS table under the "Water Systems" end-use category. If this field is omitted or blank, the water use will be assigned to the "General" end-use subcategory.

Field: Tank Volume

The actual volume [m3] of fluid in the tank. This field is autosizable if used with a Water Heater:Sizing object. The actual volume is typically not equal to the nominal volume specified by the manufacturer. Actual volume is almost always 10% lower for electric water heaters, and 5% lower for gas water heaters (Burch and Erickson 2004).

Burch, J., and P. Erickson. 2004. "Using Ratings Data to Derive Simulation-Model Inputs for Storage-Tank Water Heaters". *Proceedings of the Solar 2004 Conference, 11-14 July 2004, Portland, Oregon*, American Solar Energy Society (ASES), pp. 393-398.

Field: Tank Height

The height [m] of the tank. For the **HorizontalCylinder** shape (see below) the height of the tank is the measure in the axial direction, i.e., the height if you were to stand the cylinder up on its end. This field is autosizable if used with a Water Heater:Sizing object.

Field: Tank Shape

The tank shape determines the size and skin losses of the stratified nodes. There are three options: **VerticalCylinder**, **HorizontalCylinder**, and **Other**.

VerticalCylinder describes most upright residential water heaters.

HorizontalCylinder describes a few specialty water heaters and large commercial storage tanks. **HorizontalCylinder** can also be used to model an outdoor storage tank located above a solar collector in a thermosiphon configuration. **HorizontalCylinder** implies that the tank is divided into nodes of equal mass, but not equal height.

Other describes water heaters or storage tanks that have a uniform horizontal cross-section, but are not cylinders, e.g., a cuboid or other shape. The length of the perimeter is then specified by the Tank Perimeter field.

If blank, the default shape is **VerticalCylinder**.

Field: Tank Perimeter

The length of the tank perimeter [m]. This field is only used if Tank Shape is **Other**.

Field: Maximum Temperature Limit

The temperature [°C] at which the tank water becomes dangerously hot and is vented through boiling or an automatic safety. The tank temperature will never exceed the maximum. Any extra heat added to the tank is immediately vented. Note: The maximum temperature must be greater than the setpoint temperature at all times.

Field: Heater Priority Control

The heater priority control determines how Heater 1 and Heater 2 work together. There are two options: **MasterSlave** or **Simultaneous**. In the MasterSlave option, Heater 1 is the master and Heater 2 is the slave. In most residential electric water heaters, the heaters operate in a MasterSlave relationship. That is, both heaters are not allowed to turn on at the same time. If the thermostats ask for heat at both Heater 1 and 2, only Heater 1 will turn on. Once Heater 1 has met the set point, it turns off and Heater 2 can turn on, if necessary. In other words, only one heater can be on at any time, and Heater 1 is always has priority over Heater 2.

In the Simultaneous option, Heater 1 and Heater 2 can turn on and off independently.

If blank, the default is **MasterSlave**.

Field: Heater 1 Set Point Temperature Schedule Name

The reference to the schedule object specifying the hot water temperature set point [°C] for Heater 1. Also known as the "cut-out" temperature.

Field: Heater 1 Deadband Temperature Difference

The delta temperature difference [Δ °C] between the set point and the "cut-in" temperature at which Heater 1 will turn on. In other words, the "cut-in" temperature is Set Point – Deadband.

Field: Heater 1 Capacity

The heat rate [W] supplied to the water for Heater 1, probably the same as the "nominal" capacity. For residential electric water heaters, heating elements are usually 4500 W. This field is autosizable if used with a Water Heater:Sizing object.

Field: Heater 1 Height

The height [m] of Heater 1 in the tank.

Field: Heater 2 Set Point Temperature Schedule Name

The reference to the schedule object specifying the hot water temperature set point [°C] for Heater 2. Also known as the "cut-out" temperature.

Field: Heater 2 Deadband Temperature Difference

The delta temperature difference [Δ °C] between the set point and the "cut-in" temperature at which Heater 2 will turn on. In other words, the "cut-in" temperature is Set Point – Deadband.

Field: Heater 2 Capacity

The heat rate [W] supplied to the water for Heater 1, probably the same as the "nominal" capacity. For residential electric water heaters, heating elements are usually 4500 W.

Field: Heater 2 Height

The height [m] of Heater 2 in the tank.

Field: Heater Fuel Type

The type of fuel used for both Heaters 1 and 2. The fuel type can be Electricity, NaturalGas, PropaneGas, FuelOil#1, FuelOil#2, Coal, Diesel, Gasoline, Steam, or DistrictHeating.

Field: Heater Thermal Efficiency

The thermal conversion efficiency from fuel energy to heat energy for the heater element or burner (for both Heaters 1 and 2). This is not the same as the overall efficiency of the water heater.

Field: Off-Cycle Parasitic Fuel Consumption Rate

Off-cycle parasitics include parts of the water heater that consume fuel when the heater is off, for example, a pilot light, or stand-by electronic control circuits. The fuel consumption rate [W] is strictly the total fuel that is consumed by all of the off-cycle parasitics.

Field: Off-Cycle Parasitic Fuel Type

The type of fuel used by the off-cycle parasitics. The fuel type can be Electricity, NaturalGas, PropaneGas, FuelOil#1, FuelOil#2, Coal, Diesel, Gasoline, Steam, or DistrictHeating. The fuel type can be the same or different from the Heater Fuel Type.

Field: Off-Cycle Parasitic Heat Fraction to Tank

The fraction of off-cycle parasitic fuel energy that is converted to heat energy that ends up in the tank water. For example, a pilot light would deliver most of its heat to the tank water, as long as the thermal conversion efficiency must be taken into account, so perhaps 0.80 is reasonable. Electronic control circuits, on the other hand, do not add any heat to the tank and should be 0.

Field: Off-Cycle Parasitic Height

The height [m] where any off-cycle parasitic heat gains are added to the tank.

Field: On-Cycle Parasitic Fuel Consumption Rate

On-cycle parasitics include parts of the water heater that consume fuel when the heater is on, for example, an induction fan, or stand-by electronic control circuits. The fuel consumption rate [W] is strictly the total fuel that is consumed by all of the on-cycle parasitics.

Field: On-Cycle Parasitic Fuel Type

The type of fuel used by the on-cycle parasitics. The fuel type can be Electricity, NaturalGas, PropaneGas, FuelOil#1, FuelOil#2, Coal, Diesel, Gasoline, Steam, or DistrictHeating. The fuel type can be the same or different from the Heater Fuel Type.

Field: On-Cycle Parasitic Heat Fraction to Tank

The fraction of on-cycle parasitic fuel energy that is converted to heat energy that ends up in the tank water. For example, an induction fan might (maybe) deliver a small fraction of its energy to the tank water for a value of 0.05. Electronic control circuits, on the other hand, do not add any heat to the tank and should be 0.

Field: On-Cycle Parasitic Height

The height [m] where any on-cycle parasitic heat gains are added to the tank.

Field: Ambient Temperature Indicator

The Ambient Temperature Indicator specifies how the ambient air temperature will be indicated. The field can be **Schedule**, **Zone**, or **Outdoors**. If Schedule is used, the Ambient

Temperature Schedule value provides the ambient temperature. If Zone is used, the zone air temperature of the zone specified in the Ambient Temperature Zone field provides the ambient temperature. If Outdoors is used, the outdoor dry-bulb air temperature of the outdoor air node specified in the Ambient Temperature OutdoorAir:Node field provides the ambient temperature.

Field: Ambient Temperature Schedule Name

The reference to the schedule object specifying the ambient air temperature around the tank for skin losses. This field is only used if Ambient Temperature Indicator is **Schedule**.

Field: Ambient Temperature Zone

The reference to the zone object specifying the ambient air temperature around the tank for skin losses. This field is only used if Ambient Temperature Indicator is **Zone**.

Field: Ambient Temperature Outdoor Air Node

The reference to the outdoor air node specifying the ambient air temperature around the tank for skin losses. An outdoor air node can be defined by an OutdoorAir:Node object or OutdoorAir:NodeList object. This field is only used if Ambient Temperature Indicator is **Outdoors**.

Field: Uniform Skin Loss Coefficient Per Unit Area to Ambient Temperature

The uniform skin loss coefficient [W/m²-K] or U-Value of the tank to the ambient air temperature. The uniform skin loss accounts for the tank insulation and applies during both off- and on-cycle operation. The overall losses at any particular node can be further modified using the Additional Loss Coefficient fields to account for thermal shorting due to pipe penetrations, water heater feet, and any other loss effects.

Field: Skin Loss Fraction to Zone

If the Ambient Temperature Indicator is **Zone**, this field adds the specified fraction of the skin losses to the zone heat balance as an internal gain.

Field: Off-Cycle Flue Loss Coefficient to Ambient Temperature

The off-cycle flue loss coefficient [W/K] to the ambient air temperature. This field mainly applies to gas water heaters that have a flue.

Field: Off-Cycle Flue Loss Fraction to Zone

If the Ambient Temperature Indicator is **Zone**, this field adds the specified fraction of the off-cycle flue losses to the zone heat balance as an internal gain.

Field: Peak Use Flow Rate

The peak flow rate [m³/s] of domestic hot water usage for stand-alone operation, i.e., without plant loop node connections. The peak value is multiplied by the Use Flow Rate Fraction Schedule. If there are node connections, this field is not used.

Field: Use Flow Rate Fraction Schedule Name

The reference to the schedule object specifying the current fraction of Peak Volumetric Use Flow Rate of domestic hot water usage for stand-alone operation. If blank, the fraction defaults to 1.0 at all times.

Field: Cold Water Supply Temperature Schedule Name

The reference to the schedule object specifying the cold water temperature [°C] from the supply mains that makes up for the hot water lost down the drain. If blank, water temperatures are calculated by the Site:WaterMainsTemperature object. This field is for stand-alone operation only. If there are node connections, this field is not used.

Field: Use Side Inlet Node Name

The inlet node connection to the plant loop for the use side of the water heater. Typically the use side draws hot water from the tank and returns cooler water.

Field: Use Side Outlet Node Name

The outlet node connection to the plant loop for the use side of the water heater. Typically the use side draws hot water from the tank and returns cooler water.

Field: Use Side Effectiveness

This field specifies the heat transfer effectiveness between the use side water and the tank water. If the effectiveness is set to 1 then complete heat transfer occurs, simulating perfect mixing of the use side water and the tank water. If the effectiveness is lower, then the use side outlet water temperature will not be as hot as the tank water, simulating an external heat exchanger that is indirectly coupled to the water heater tank.

Field: Use Side Inlet Height

The height of the use side inlet to the tank. If blank, the inlet defaults to the bottom of the tank. The inlet height cannot be higher than the tank height.

Field: Use Side Outlet Height

The height of the use side outlet from the tank. If blank or **autocalculate**, the inlet defaults to the top of the tank. The outlet height cannot be higher than the tank height.

Field: Source Side Inlet Node

The inlet node connection to the plant loop for the source side of the water heater. Typically the source side draws cold water from the tank and returns warmer water.

Field: Source Side Outlet Node

The outlet node connection to the plant loop for the source side of the water heater. Typically the source side draws cold water from the tank and returns warmer water.

Field: Source Side Effectiveness

This field specifies the heat transfer effectiveness between the source side water and the tank water. If the effectiveness is set to 1 then complete heat transfer occurs, simulating perfect mixing of the source side water and the tank water. If the effectiveness is lower, then the source side outlet water temperature will not be as hot as the tank water, simulating an external heat exchanger that is indirectly coupled to the water heater tank.

Field: Source Side Inlet Height

The height of the source side inlet to the tank. If blank or **autocalculate**, the inlet defaults to the top of the tank. The inlet height cannot be higher than the tank height.

Field: Source Side Outlet Height

The height of the source side outlet from the tank. If blank, the inlet defaults to the bottom of the tank. The outlet height cannot be higher than the tank height.

Field: Inlet Mode

The inlet mode of entering fluid from the use and source sides. There are two options: **Fixed** or **Seeking**. In Fixed mode, the fluid enters at the fixed heights specified above. In Seeking mode, the fluid "seeks out" the stratified node that is closest to the inlet temperature and adds all flow to that node. The Seeking mode provides maximum stratification. The default is **Fixed**.

Field: Use Side Design Flow Rate

This field is optional and is used to specify the design flow rate through the Use Side of the water heater. The volumetric design flow rate is specified in m³/s. The field is needed when the Use Side is connected to a plant loop. The field can be autosized. If autosized, then the input file should include a Plant Sizing object for the plant loop. Sizing results are reported in the EIO file.

Field: Source Side Design Flow Rate

This field is optional and is used to specify the design flow rate through the Source Side of the water heater. The volumetric design flow rate is specified in m³/s. The field is needed when the Source Side is connected to a plant loop. The field can be autosized. If autosized, then the input file should include a Plant Sizing object for the plant loop. Sizing results are reported in the EIO file.

Field: Indirect Water Heating Recovery Time

This field is optional and is used to provide a design parameter for autosizing design flow rates when the water heater is connected to the demand side of a plant loop. The recovery time is expressed in hours. This is the time that the entire volume of the tank can be heated from 14.4°C to 57.2°C (58°F to 135°F) with an inlet temperature defined as the exit temperature in the associated Plant Sizing object. The default is 1.5 hours. The calculation is based on log-mean temperature difference (LMTD) and includes the heat transfer effectiveness factor entered above.

Field: Number Of Nodes

The number of stratified nodes in the tank. There must be at least one node. The maximum number of nodes is 10, although this limit can be increased by editing the IDD.

Field: Additional Destratification Conductivity

An additional destratification conductivity [W/m-K] is added to the fluid conductivity of water (0.6 W/m-K) to account for vertical conduction effects along the inside of the tank wall, and perhaps other vertical components such as the flue, the cold water inlet pipe (dip tube), and the anode rod.

Field: Node 1-10 Additional Loss Coefficient

An additional loss coefficient [W/m-K] added to the skin losses for a given node to account for thermal shorting due to pipe penetrations, water heater feet, and any other loss effects.

```
WaterHeater:Stratified,
  Electric Water Heater,  !- Name
  Water Heater,  !- End-Use Subcategory
  0.1893,  !- Tank Volume {m3}
  1.4,  !- Tank Height {m}
  VerticalCylinder,  !- Tank Shape
  ,  !- Tank Perimeter {m}
  82.2222,  !- Maximum Temperature Limit {C}
  MasterSlave,  !- Heater Priority
  Hot Water Set Point Temp Schedule,  !- Heater 1 Set Point Temperature Schedule
  2.0,  !- Heater 1 Deadband Temperature Difference {deltaC}
  4500,  !- Heater 1 Capacity {W}      (Master)
  1.0,  !- Heater 1 Height {m}
  Hot Water Set Point Temp Schedule,  !- Heater 2 Set Point Temperature Schedule
  5.0,  !- Heater 2 Deadband Temperature Difference {deltaC}
  4500,  !- Heater 2 Capacity {W}      (Slave)
  0.0,  !- Heater 2 Height {m}
```

```

ELECTRICITY, !- Heater Fuel Type
0.98, !- Heater Thermal Efficiency
10, !- Off-Cycle Parasitic Fuel Consumption Rate {W}
ELECTRICITY, !- Off-Cycle Parasitic Fuel Type
0, !- Off-Cycle Parasitic Heat Fraction To Tank
, !- Off-Cycle Parasitic Height {m}
10, !- On-Cycle Parasitic Fuel Consumption Rate {W}
ELECTRICITY, !- On-Cycle Parasitic Fuel Type
0, !- On-Cycle Parasitic Heat Fraction To Tank
, !- On-Cycle Parasitic Height {m}
SCHEDULE, !- Ambient Temperature Indicator
Ambient Temp Schedule, !- Ambient Temperature Schedule
, !- Ambient Temperature Zone
, !- Ambient Temperature Outdoor Air Node
0.846, !- Uniform Skin Loss Coefficient Per Unit Area To Ambient Temperature {W/m2-K}
, !- Skin Loss Fraction To Zone {}
, !- Off-Cycle Flue Loss Coefficient To Ambient Temperature {W/K}
, !- Off-Cycle Flue Loss Fraction To Zone {}
, !- Peak Volumetric Use Flow Rate {m3/s}
, !- Use Flow Rate Fraction Schedule
, !- Cold Water Supply Temperature Schedule
Water Heater Use Inlet Node, !- Use Side Inlet Node
Water Heater Use Outlet Node, !- Use Side Outlet Node
1.0, !- Use Side Effectiveness {}
, !- Use Side Inlet Height {m}
, !- Use Side Outlet Height {m}
, !- Source Side Inlet Node
, !- Source Side Outlet Node
, !- Source Side Effectiveness {}
, !- Source Side Inlet Height {m}
, !- Source Side Outlet Height {m}
FIXED, !- Inlet Mode {FIXED | SEEKING}
6, !- Number Of Nodes
0.1, !- Destratification Conductivity {W/m-K}
0.15, !- Node 1 Additional Loss Coefficient {W/K}
, !- Node 2 Additional Loss Coefficient {W/K}
, !- Node 3 Additional Loss Coefficient {W/K}
, !- Node 4 Additional Loss Coefficient {W/K}
, !- Node 5 Additional Loss Coefficient {W/K}
0.1; !- Node 6 Additional Loss Coefficient {W/K}

```

Water Heater:Stratified Outputs

All of the output variables reported for the WaterHeater:Mixed object also apply to the WaterHeater:Stratified object, with several qualifications noted below:

Water Heater Tank Temperature [C]

The average water tank temperature, i.e., the average of all of the node average temperatures.

Water Heater Final Tank Temperature [C]

The final water tank temperature at the end of the system timestep, i.e., the average of all of the final node temperatures at the end of the system timestep. If reported at the "Detailed" interval, this report variable can be used to verify an exact energy balance on the water heater.

Water Heater Heating Rate [W]

The total average heating rate supplied by Heater 1 plus Heater 2.

Water Heater Heating Energy [J]

The total heating energy supplied by Heater 1 plus Heater 2.

Water Heater Cycle On Count []

The number of times that either Heater 1 or Heater 2 turned on in the time period.

Water Heater Runtime Fraction []

The fraction of the time period that either Heater 1 or Heater 2 was running.

In addition, the WaterHeater:Stratified object also reports the following output variables:

```
HVAC,Average,Water Heater Heating Rate 1 [W]
HVAC,Average,Water Heater Heating Rate 2 [W]
HVAC,Sum,Water Heater Heating Energy 1 [J]
HVAC,Sum,Water Heater Heating Energy 2 [J]
HVAC,Sum,Water Heater Cycle On Count 1 []
HVAC,Sum,Water Heater Cycle On Count 2 []
HVAC,Average,Water Heater Runtime Fraction 1 []
HVAC,Average,Water Heater Runtime Fraction 2 []
HVAC,Average,Water Heater Node <x> Temperature [C]
HVAC,Average,Water Heater Final Node <x> Temperature [C]
```

Water Heater Heating Rate 1 [W]

The average heating rate supplied by Heater 1.

Water Heater Heating Rate 2 [W]

The average heating rate supplied by Heater 2.

Water Heater Heating Energy 1 [J]

The heating energy supplied by Heater 1.

Water Heater Heating Energy 2 [J]

The heating energy supplied by Heater 2.

Water Heater Cycle On Count 1 []

The number of times that Heater 1 turned on in the time period.

Water Heater Cycle On Count 2 []

The number of times that Heater 2 turned on in the time period.

Water Heater Runtime Fraction 1 []

The fraction of the time period that Heater 1 was running.

Water Heater Runtime Fraction 2 []

The fraction of the time period that Heater 2 was running.

Water Heater Node 1-10 Temperature [C]

The average node temperature.

Water Heater Final Node 1-10 Temperature [C]

The final node temperature at the end of the system timestep.

WaterHeater:Sizing

The WaterHeater:Sizing object is used to provide additional input data needed for designing tank volume and/or heater capacity for either the Mixed or Stratified water heaters. This object is only needed if volume or capacity is being automatically sized. There are no output variable associated with this object -- sizing results are reported to the EIO output file and some predefined summary reports.

A source of design input data for use with this object can be found in the current ASHRAE Handbook HVAC Applications chapter on Service Water Heating.

The idd entry for this object follows.

```

WaterHeater:Sizing,
  \min-fields 4
  \memo This input object is used with WaterHeater:Mixed or
  \memo with WaterHeater:Stratified to autosize tank volume and heater capacity
  \memo This object is not needed if water heaters are not autosized.
A1 , \field WaterHeater Name
  \required-field
  \type alpha
  \type object-list
  \object-list WaterHeaterNames
A2 , \field Design Mode
  \type choice
  \key PeakDraw
  \key ResidentialHUD-FHAMinimum
  \key PerPerson
  \key PerFloorArea
  \key PerUnit
  \key PerSolarCollectorArea
N1 , \field Time Storage Can Meet Peak Draw
  \type real
  \units hr
  \note Only used for Design Mode = PeakDraw
  \minimum 0.0
N2 , \field Time for Tank Recovery
  \type real
  \units hr
  \note Only used for Design Mode = PeakDraw
  \minimum 0.0
N3 , \field Nominal Tank Volume for Autosizing Plant Connections
  \type real
  \units m3
  \note Only used if Design Mode = PeakDraw and the water heater also
  \note has autosized flow rates for connections on the demand side of a plant loop
N4 , \field Number of Bedrooms
  \type integer
  \note Only used for Design Mode = ResidentialHUD-FHAMinimum
  \minimum 1
N5 , \field Number of Bathrooms
  \type integer
  \note Only used for Design Mode = ResidentialHUD-FHAMinimum
  \minimum 1
N6 , \field Storage Capacity per Person
  \type real
  \units m3/Person
  \note Only used for Design Mode = PerPerson
  \minimum 0.0
N7 , \field Recovery Capacity per Person
  \type real
  \units m3/hr-person
  \note Only used for Design Mode = PerPerson
  \minimum 0.0
N8 , \field Storage Capacity per Floor Area
  \type real
  \units m3/m2
  \note Only used for Design Mode = PerFloorArea
  \minimum 0.0
N9 , \field Recovery Capacity per Floor Area
  \type real
  \units m3/hr-m2
  \note Only used for Design Mode = PerFloorArea
  \minimum 0.0
N10 , \field Number of Units
  \type real
  \note Only used for Design Mode = PerUnit

```

```

N11 , \field Storage Capacity per Unit
      \units m3
      \type real
      \note Only used for Design Mode = PerUnit
      \minimum 0.0
N12 , \field Recovery Capacity PerUnit
      \units m3/hr
      \type real
      \note Only used for Design Mode = PerUnit
      \minimum 0.0
N13 , \field Storage Capacity per Collector Area
      \units m3/m2
      \type real
      \note Only used for Design Mode = PerSolarCollectorArea
      \minimum 0.0
N14 ; \field Height Aspect Ratio
      \type real
      \note only used if for WaterHeater:Stratified
      \minimum 0.0

```

Field: WaterHeater Name

This field contains the unique name of the water heater being sized. This name should match the name of a Water Heater:Mixed or a Water Heater:Stratified input object defined elsewhere in the input file.

Field: Design Mode

This field describes which of several methods are to be used for sizing the water heater. There are six possible choices and one of the following should be selected:

- **PeakDraw**. This design method uses the design flow rates of all the different demands placed on the water heater. The tank size is based on how long it can meet the demand and how quickly it can recover. The user enters the time in hours that the water heater can meet the demands. Only the hot water uses connected to an individual water heater are included in that water heater's peak draw.
- **ResidentialHUD-FHAMinimum** This design method is based on minimum permissible water heater sizes (established by HUD-FHA in its Minimum Property Standards for One- and Two-Family Living Units, No. 4900.1-1982). The user enters the number of bathrooms and bedrooms in this input object. The smallest allowable water heater sizes are used.
- **PerPerson** This design method scales sizes based on the total number of people in all zones in the building. Each water heater in the model will be sized using the total (peak, design) number of people for the entire model. The number of people is determined from People objects defined elsewhere in the input file
- **PerFloorArea** This design method scales sizes based on the total floor area in all the zones in the building. Each water heater in the model will be sized using all the floor area in the model. The floor areas are determined from the geometry input elsewhere in the input file.
- **PerUnit** This design method scales sizes based on an arbitrary number of units. This can be used, for example, to size based on the number of rooms in a lodging building. The user provides the number of units in an input field in this object.
- **PerSolarCollectorArea** This design method scales tank volume based on the collector area for a solar hot water collector. The collector area is summed for all the collectors in the model and each tank is sized for the total. The collector area is determined from input for Solar Collectors defined elsewhere in the input file.

Field: Time Storage Can Meet Peak Draw

This field provides the time, in hours, that the tank's volume can sustain a peak draw. It is used to size the tank's volume which is the simple product of peak draw volume flow rate and

the draw time. There is no assurance that the water will be at the desired temperature for the entire draw. This field is only used if the Design Mode is “**PeakDraw**.” The water heater must be connected to a full plant loop, be on the supply side, and the plant loop needs a Plant Sizing object.

Field: Time for Tank Recovery

This field provides the the time, in hours, that tank’s heater needs to recover the volume of the tank. The temperatures used to define recovery are a starting temperature of 14.4°C (58°F) and a final temperature of 57.2°C (135°F). This field is only used if the Design Mode is “**PeakDraw**.”

Field: Nominal Tank Volume for Autosizing Plant Connections

This field is used in case the water heater is indirectly heated by its source side connections and they are also autosized. Because of the complexity of such a water heater and the timing for when sizing calculation happen inside EnergyPlus, the Source side connection flow rates need to be reported before the tank’s volume can be sized to meet Peak Draw. This input field is used to provide a nominal tank volume to use temporarily while the flow connections are sized. This field is only used if the Design Mode is “**PeakDraw**” and the water heater has autosized plant connections on the demand side.

Field: Number of Bedrooms

This field is used to enter the numer of bedrooms in the model. This field is only used if the Design Mode is “**ResidentialHUD-FHAMinimum**.”

Field: Number of Bathrooms

This field is used to enter the number of bathrooms in the model. This field is only used if the Design Mode is “**ResidentialHUD-FHAMinimum**.”

Field: Storage Capacity per Person

This field is used to enter the tank’s storage volume on per-person basis. The units are m³/person. This field is only used if the Design Mode is “**PerPerson**.”

Field: Recovery Capacity per Person

This field is used to enter the recovery capacity per person in units of m³/person/hr. This is the volume of water the heater can recover in one hour per person. Recovery is heating water from a starting temperature of 14.4°C (58°F) to a final temperature of 57.2°C (135°F). This field is only used if the Design Mode is “**PerPerson**.”

Field: Storage Capacity per Floor Area

This field is used to enter the tank’s storage volume on a per-floor-area basis. The units are m³ /m² (water/floor area). This field is only used if the Design Mode is “**PerFloorArea**.”

Field: Recovery Capacity per Floor Area

This field is used to enter the recovery capacity per floor area in units of m³/m²/hr. This is the volume water the heater can recover in an hour per floor area. Recovery is heating water from a starting temperature of 14.4°C (58°F) to a final temperature of 57.2°C (135°F). This field is only used if the Design Mode is “**PerFloorArea**.”

Field: Number of Units

This field is used to enter the number of Units for use in sizing on per-Unit basis with the next two fields. This field is only used if the Design Mode is “**PerUnit**.” This can be used to account for any arbitrary item such as lodging rooms, desks, water fixtures, restrooms, etc.

Field: Storage Capacity per Unit

This field is used to enter the tanks' storage volume on per-Unit basis. The units are m³/Unit. The number of Units is entered in the previous field. This field is only used if the Design Mode is "PerUnit."

Field: Recovery Capacity per Unit

This field is used to enter the recover capacity per Unit in units of m³/Unit/hr. This is the volume of water the heater can recover in an hour per Unit. Recovery is heating water from a starting temperature of 14.4°C (58°F) to a final temperature of 57.2°C (135°F). This field is only used if the Design Mode is "PerUnit."

Field: Storage Capacity per Collector Area

This field is used to enter the tank's storage volume on per-solar-collector-area basis. The units are m³/m². This field is only used if the Design Mode is "PerSolarCollectorArea."

Field: Height Aspect Ratio

This field is used to scale the height of a stratified tank to preserve relative geometry for different size tanks. The Height Aspect Ratio is defined as the length scale in the vertical direction (height) divided by the length scale in the horizontal direction (diameter). This field is only used if the water heater being sized is a Water Heater:Stratified, the tank height has been set to Autosize, and the tank shape is set to **VerticalCylinder**. This field can be used with any Design Mode.

WaterHeater:HeatPump

The heat pump water heater (HPWH) is a compound object consisting of a water heater tank (e.g., WaterHeater:Mixed), a direct expansion (DX) "coil" (i.e., an air-to-water DX compression system which includes a water heating coil, air coil, compressor, and water pump), and a fan to provide air flow across the air coil associated with the DX compression system. These objects work together to model a system which heats water using zone air, outdoor air, or a combination of zone and outdoor air as the primary heat source. Numerous configurations of tank location, inlet air source, and DX coil compressor location can be modeled, with one common configuration shown below.

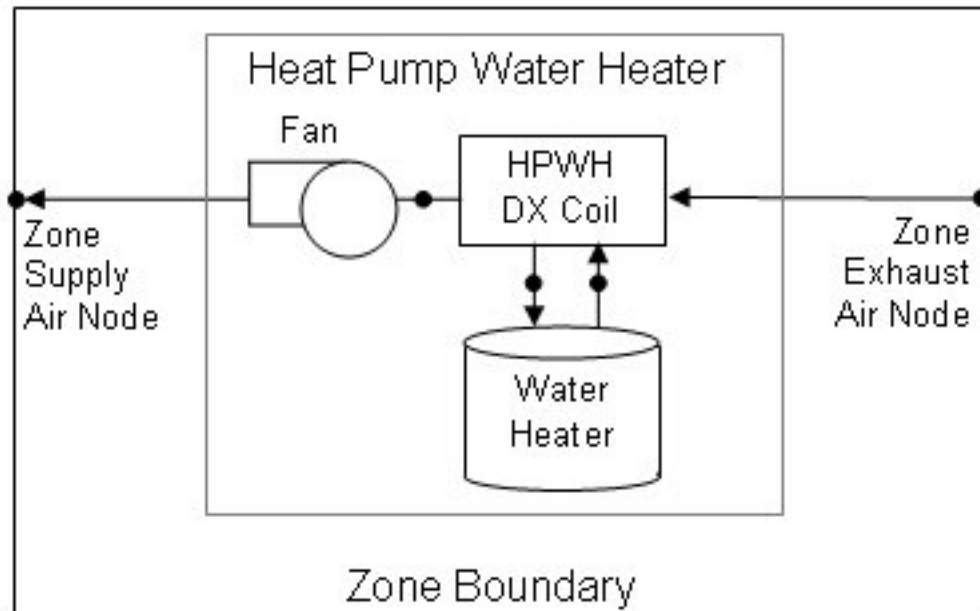


Figure 67. Schematic diagram for a heat pump water heater located in a zone

In this model, the heat pump water heater's DX coil is considered the primary heat source and the water tank's heater (element or burner) provides supplemental heat as necessary. The model also assumes that the heat pump's fan and water pump cycle on and off with the compressor.

To model a heat pump water heater, the input data file must include some combination of the following objects depending on the configuration to be modeled:

- WaterHeater:HeatPump (required)
- WaterHeater:Mixed (required)
- Coil:WaterHeating:AirToWaterHeatPump (required)
- Fan:OnOff (required)
- ZoneHVAC:EquipmentList (when the HPWH draws some or all of its air from the zone, the heat pump water heater type and name must be in this list)
- ZoneHVAC:EquipmentConnections (when the HPWH draws some or all of its air from the zone, the HPWH air inlet and outlet node names must be provided in this object)
- OutdoorAir:NodeList (for HPWHs that use outdoor air as all or part of the heat source, the HPWH outdoor air node name must be provided in this list)

The input fields for the compound object are described in detail below:

Field: Name

This alpha field contains a unique user-assigned name for an instance of a heat pump water heater. Any reference to this heat pump water heater by another object will use this name.

Field: Availability Schedule Name

This alpha field contains the name of the schedule (ref: Schedule) that denotes whether the heat pump compressor is available to operate during a given time period. A schedule value equal to 0 denotes that the heat pump compressor is off for that time period. A value other than 0 denotes that the heat pump compressor is available to operate during that time period. During times when the heat pump compressor is scheduled off, the heater (element or

burner) in the water tank object operates based on its tank set point temperature schedule and the heat pump's parasitic electric power is also off for that time period.

Field: Compressor Setpoint Temperature Schedule Name

This alpha field contains the name of the schedule (ref: Schedule) that specifies the set point (or "cut-out") temperature for the heat pump compressor. Temperature values used in this schedule should be in degrees Celsius. The heat pump compressor cycles off when the tank water reaches this set point temperature. Once the heat pump compressor cycles off, the tank water temperature floats downward until it falls below the set point temperature minus the dead band temperature difference defined below (i.e., the "cut-in" temperature). At this point, the heat pump compressor cycles on and remains on until the heat pump compressor set point temperature is reached.

Field: Dead Band Temperature Difference

This numeric field contains the dead band temperature difference in degrees Celsius. The heat pump compressor "cut-in" temperature is defined as the compressor set point temperature defined above minus this dead band temperature difference. The heat pump compressor cycles on when the water temperature in the tank falls below the "cut-in" temperature. The heat pump compressor remains on until the water temperature in the tank rises above the compressor set point ("cut-out") temperature defined above. The dead band temperature difference must be greater than 0°C and less than or equal to 20°C. If this field is left blank, the default value is 5°C.

In this model, the heat pump water heater's DX compression system is considered the primary heat source and the water tank's heater (element or burner) provides supplemental heat as necessary. Therefore, the cut-in temperature for the heat pump compressor (set point minus dead band temperature difference) is usually higher than the set point temperature for the heater (element or burner) in the associated water heater tank object. At times when the water heater tank set point temperature is greater than the cut-in temperature of the heat pump compressor, the heat pump compressor is disabled and the tank's heater is used to heat the water.

Field: Condenser Water Inlet Node Name

This alpha field contains the name of the inlet water node for the heat pump's water heating coil (condenser). This node name must also be specified in the water heater tank object as the source outlet node name, and in the DX coil object as the condenser water inlet node name.

Field: Condenser Water Outlet Node Name

This alpha field contains the name of the outlet water node for the heat pump's water heating coil (condenser). This node name must also be specified in the water heater tank object as the source inlet node name, and in the DX coil object as the condenser water outlet node name.

Field: Condenser Water Flow Rate

This numeric field contains the heat pump's condenser water flow rate in cubic meters per second. It is the actual condenser water flow rate to be simulated, which may differ from the rated condenser water volumetric flow rate specified for the heat pump's DX coil (Ref. Coil:WaterHeating:AirToWaterHeatPump). This water flow rate must be greater than 0 or this field is autocalculatable. If autocalculated (field value = **autocalculate**), the condenser water flow rate is set equal to the rated heating capacity of the heat pump's DX coil multiplied by $4.487E-8$ m³/s/W. When this flow rate is different from the Rated Condenser Water Volumetric Flow Rate specified in the heat pump's DX coil object (Ref. Coil:WaterHeating:AirToWaterHeatPump), the user should also specify a Total Heating

Capacity Modifier Curve Name (function of water flow fraction) and a Heating COP Modifier Curve Name (function of water flow fraction) in the associated DX coil object to account for differences in capacity and power consumption at the off-rated water flow rate.

Field: Evaporator Air Flow Rate

This numeric field contains the air flow rate across the heat pump's air coil (evaporator) in cubic meters per second. It is the actual air flow rate to be simulated, which may differ from the rated evaporator air volumetric flow rate specified for the heat pump's DX coil (Ref. Coil:WaterHeating:AirToWaterHeatPump). Values must be greater than 0 or this field is autocalculatable. If autocalculated (field value = **autocalculate**), the evaporator air flow rate is set equal to the rated heating capacity of the heat pump's DX coil multiplied by $5.035E-5$ m³/s/W. When this flow rate is different from the Rated Evaporator Air Volumetric Flow Rate specified in the heat pump's DX coil object (Ref. Coil:WaterHeating:AirToWaterHeatPump), the user should also specify a Total Heating Capacity Modifier Curve Name (function of air flow fraction) and a Heating COP Modifier Curve Name (function of air flow fraction) in the associated DX coil object to account for differences in capacity and power consumption at the off-rated air flow rate.

Field: Inlet Air Configuration

This choice field defines the configuration of the air flow path through the heat pump air coil (evaporator) and fan section. Valid entries are **Schedule**, **ZoneAirOnly**, **OutdoorAirOnly**, or **ZoneAndOutdoorAir**. If 'Schedule' is selected, names for an inlet air temperature schedule and an inlet air humidity schedule must be defined in the fields below. If 'ZoneAirOnly' is selected, the corresponding zone name must be entered in the Inlet Air Zone Name field below. If 'ZoneAndOutdoorAir' is selected, the corresponding Inlet Air Zone Name, Inlet Air Mixer Node Name, Outlet Air Splitter Node Name, and an Inlet Air Mixer Schedule Name must be entered in the corresponding fields below.

Field: Air Inlet Node Name

This alpha field contains the name of the node from which the heat pump water heater draws its inlet air. If the Inlet Air Configuration field defined above is set to 'ZoneAirOnly' or 'ZoneAndOutdoorAir', then this node name should be the name of a zone air exhaust node (Ref. ZoneHVAC:EquipmentConnections). If the Inlet Air Configuration field is set to 'OutdoorAirOnly', this node name should be left blank. If the Inlet Air Configuration field is set to 'Schedule', this node name should simply be a unique name that allows the user to receive output on conditions at this node for verification purposes.

Field: Air Outlet Node Name

This alpha field contains the name of the node to which the heat pump water heater sends its outlet air. If the Inlet Air Configuration field defined above is set to 'ZoneAirOnly' or 'ZoneAndOutdoorAir', then this node name should be the name of a zone air inlet node (Ref. ZoneHVAC:EquipmentConnections). If the Inlet Air Configuration field is set to 'OutdoorAirOnly', this node name should be left blank. If the Inlet Air Configuration field is set to 'Schedule', this node name should simply be a unique name that allows the user to receive output on conditions at this node for verification purposes.

Field: Outdoor Air Node Name

This alpha field contains the name of the node from which the heat pump water heater draws its outdoor air. If the Inlet Air Configuration field defined above is set to 'ZoneAirOnly' or 'Schedule', this node name should be left blank. If the Inlet Air Configuration field is set to 'ZoneAndOutdoorAir' or 'OutdoorAirOnly', this node name should be the name of an outdoor air node (Ref. OutdoorAir:NodeList).

Field: Exhaust Air Node Name

This alpha field contains the name of the node to which the heat pump water heater sends its exhaust air. If the Inlet Air Configuration field defined above is set to 'ZoneAirOnly' or 'Schedule', this node name should be left blank. If the Inlet Air Configuration field is set to 'ZoneAndOutdoorAir' or 'OutdoorAirOnly', then this node name should be a unique name that allows the user to receive output on conditions at this node for verification purposes.

Field: Inlet Air Temperature Schedule Name

This alpha field contains the name of a schedule used to define the dry-bulb temperature of the inlet air to the heat pump air coil (evaporator) and fan section. Schedule values should be in degrees Celsius. This field is only used when the Inlet Air Configuration defined above is specified as 'Schedule', otherwise leave this field blank.

Field: Inlet Air Humidity Schedule Name

This alpha field contains the name of a schedule used to define the humidity of the inlet air to the heat pump evaporator and fan section. Schedule values must be entered as relative humidity fraction from 0 to 1 (e.g., a schedule value of 0.5 means 50%RH). This field is only used when the Inlet Air Configuration defined above is specified as 'Schedule', otherwise leave this field blank.

Field: Inlet Air Zone Name

This alpha field contains the name of the zone from which the heat pump evaporator and fan section draws some or all of its inlet air. This field is only used when the Inlet Air Configuration defined above is specified as 'ZoneAirOnly' or 'ZoneAndOutdoorAir'.

Field: Tank Object Type

This alpha (choice) field contains the type of water heater tank used by this heat pump water heater. Currently, the only valid choice is WaterHeater:Mixed.

Field: Tank Name

This alpha field contains the name of the specific water heater tank (WaterHeater:Mixed object) used by this heat pump water heater.

Field: Tank Use Side Inlet Node Name

This alpha field contains the name of the use side inlet node of the water heater tank used by this heat pump water heater. This name must match the Use Side Inlet Node Name in the water heater tank object (Ref. WaterHeater:Mixed). This field is required if the water heater tank use side nodes are connected to a plant loop, otherwise leave this field blank.

Field: Tank Use Side Outlet Node Name

This alpha field contains the name of the use side outlet node of the water heater tank used by this heat pump water heater. This name must match the Use Side Outlet Node Name in the water heater tank object (Ref. WaterHeater:Mixed). This field is required if the water heater tank use side nodes are connected to a plant loop, otherwise leave this field blank.

Field: DX Coil Object Type

This alpha (choice) field contains the type of DX coil used by this heat pump water heater. Currently, the only valid choice is Coil:WaterHeating:AirToWaterHeatPump.

Field: DX Coil Name

This alpha field contains the name of the specific DX coil (Coil:WaterHeating:AirToWaterHeatPump object) used by this heat pump water heater.

Field: Minimum Inlet Air Temperature for Compressor Operation

This numeric field contains the minimum inlet air dry-bulb temperature entering the air coil (evaporator) and fan section, in degrees Celsius, below which the heat pump compressor does not operate. The minimum inlet air dry-bulb temperature should be greater than or equal to 5°C. If this field is left blank, the default value is 10°C.

Field: Compressor Location

This alpha (choice) field contains the location of the heat pump compressor and the air temperature for this location is used to control operation of the compressor's crankcase heater in the Coil:WaterHeating:AirToWaterHeatPump object. Valid entries are **Schedule**, **Zone**, or **Outdoors**. If 'Schedule' is selected, a compressor ambient temperature schedule name must be defined in the field below; otherwise, the field below should be left blank. If 'Zone' is selected, the crankcase heater operation is controlled based on the air temperature in the zone defined in the field Inlet Air Zone Name, and the Inlet Air Configuration must be 'ZoneAirOnly' or 'ZoneAndOutdoorAir'. If 'Outdoors' is selected, crankcase heater operation is controlled based on the outdoor air temperature.

Field: Compressor Ambient Temperature Schedule Name

This alpha field contains the name of a schedule that defines the ambient air temperature surrounding the heat pump compressor, which is used to control the compressor's crankcase heater operation. This field is only used when the compressor location field defined above is specified as 'Schedule', otherwise it should be left blank.

Field: Fan Object Type

This alpha (choice) field contains the type of fan used by this heat pump water heater. Currently, the only valid choice is Fan: OnOff.

Field: Fan Name

This alpha field contains the name of the specific fan (Fan:OnOff object) used by this heat pump water heater.

Field: Fan Placement

This alpha (choice) field defines the placement of the fan in the heat pump water heater. Valid choices are **BlowThrough** (fan upstream of the air coil) and **DrawThrough** (fan downstream of the air coil). If this field is left blank, the default value is DrawThrough.

Field: On Cycle Parasitic Electric Load

This numeric field contains the on-cycle parasitic electric power in Watts. This is the parasitic electric power consumed by controls or other electrical devices associated with the heat pump water heater. This parasitic electric load is consumed whenever the heat pump compressor is operating and the model assumes that this parasitic power does not contribute to heating the water. This parasitic load does, however, affect the zone air heat balance when the heat pump water heater sends some or all of its outlet air to a zone (i.e., Inlet Air Configuration field specified as 'ZoneAirOnly' or 'ZoneAndOutdoorAir') and the Parasitic Heat Rejection Location field is specified as 'Zone'. The minimum value for this field is 0.0, and the default value is also 0.0 if this field is left blank.

Field: Off Cycle Parasitic Electric Load

This numeric field contains the off-cycle parasitic electric power in Watts. This is the parasitic electric power consumed by controls or other electrical devices associated with the heat pump compressor. This parasitic electric load is consumed whenever the heat pump water heater is available but the compressor is not operating, and the model assumes that this parasitic power does not contribute to heating the water. This parasitic load does, however, affect the zone air heat balance when the heat pump water heater sends some or all of its outlet air to a zone (i.e., Inlet Air Configuration field specified as 'ZoneAirOnly' or

'ZoneAndOutdoorAir') and the Parasitic Heat Rejection Location field is specified as 'Zone'. The minimum value for this field is 0.0, and the default value is also 0.0 if this field is left blank.

Field: Parasitic Heat Rejection Location

This alpha (choice) field determines where the on-cycle and off-cycle parasitic heat is rejected. Valid choices are Zone and Exterior. If 'Zone' is selected, both the on-cycle and off-cycle parasitic heat is rejected to the zone defined in the field Inlet Air Zone Name, and the Inlet Air Configuration must be 'ZoneAirOnly' or 'ZoneAndOutdoorAir'. If 'Outdoors' is selected, this parasitic heat is rejected outdoors (does not impact the zone air heat balance) regardless of the specified Inlet Air Configuration. If this field is left blank, the default value is 'Outdoors'.

Field: Inlet Air Mixer Node Name

This optional alpha field defines the name of the HVAC node which represents the mixture of outdoor air and zone air that enters the heat pump air coil (evaporator) and fan section. The model mixes outdoor air with zone air and places the result on this inlet air mixer node based on the Inlet Air Mixer Schedule defined below. When the schedule value is equal to 0, 100% zone air enters the evaporator coil and fan section of the heat pump water heater. When the schedule value is equal to 1, 100% outdoor air enters the evaporator coil and fan section. This node name must be provided if the Inlet Air Configuration field above is specified as 'ZoneAndOutdoor Air', otherwise this field should be left blank.

Field: Outlet Air Splitter Node Name

This alpha field defines the name of the air node to which the heat pump air coil (evaporator) and fan sends all of its outlet air. The supply air flow downstream of this node is split between the zone and outdoors based on the Inlet Air Mixer schedule defined below. When the schedule value is equal to 0, the entire outlet air stream is diverted to the zone. When the schedule value is equal to 1, the entire outlet air stream is exhausted to outdoors. This node name must be provided if the Inlet Air Configuration field above is specified as 'Zone and Outdoor Air', otherwise this field should be left blank.

Field: Inlet Air Mixer Schedule Name

This alpha field defines the name of the schedule (ref: Schedule) that denotes whether the heat pump draws its inlet air from the zone, outdoors, or a combination of zone and outdoor air. A schedule value equal to 0 indicates that the heat pump draws its inlet air from the zone. A schedule value equal to 1 denotes that the heat pump draws its inlet air from outdoors. Values between 0 and 1 denote a mixture of zone and outdoor air proportional to the schedule value. The Inlet Air Mixer schedule controls both the inlet air mixer and outlet air splitter nodes in unison to ensure that the operation of the heat pump does not contribute to zone pressurization or depressurization. For example if the Inlet Air Mixer schedule value is 0.4, then the inlet air mixer node is composed of 40% outdoor air and 60% zone air. For this same case, the outlet air splitter directs 60% of the HPWH outlet air back to the zone and 40% of the outlet air flow is exhausted outdoors. This schedule name must be provided if the Inlet Air Configuration field is specified as 'Zone and Outdoor Air', otherwise this field should be left blank.

Below is the IDD Definition for the WaterHeater:HeatPump compound object.

```

WaterHeater:HeatPump,
  \min-fields 31
  \memo This object models an air-source heat pump for water heating.
  \memo WaterHeater:HeatPump is a compound object that references other component objects -
  \memo Coil:WaterHeating:AirToWaterHeatPump, Fan:OnOff, WaterHeater:Mixed
A1 , \field Name
  \required-field
  \type alpha
  \note Unique name for this instance of a heat pump water heater.
A2 , \field Availability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
  \note Schedule values of 0 denote the heat pump compressor is off and the parasitic electric
  \note energy is also off.
A3, \field Compressor Setpoint Temperature Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
  \note Defines the cut-out temperature where the heat pump compressor turns off.
  \note The heat pump compressor setpoint temperature should always be greater
  \note than the water tank's heater (element or burner) setpoint temperature.
N1 , \field Dead Band Temperature Difference
  \type real
  \units deltaC
  \minimum> 0.0
  \maximum 20
  \default 5.0
  \note Setpoint temperature minus the dead band temperature difference defines
  \note the cut-in temperature where the heat pump compressor turns on.
  \note The water tank's heater (element or burner) setpoint temperature
  \note should always be less than the heat pump compressor cut-in temperature.
A4 , \field Condenser Water Inlet Node Name
  \required-field
  \type alpha
  \note Should match the field Source Outlet Node Name in the water heater tank object.
  \note Should also match the Condenser Water Inlet Node Name in the associated
  \note DX coil object.
A5 , \field Condenser Water Outlet Node Name
  \required-field
  \type alpha
  \note Should match the field Source Inlet Node Name in water heater tank object.
  \note Should also match the Condenser Water Outlet Node Name in the associated
  \note DX Coil object.
N2 , \field Condenser Water Flow Rate
  \type real
  \units m3/s
  \minimum> 0
  \autocalculatable
  \note Actual water flow rate through the heat pump's water coil (condenser).
  \note If autocalculated, the water flow rate is set equal to 4.487E-8 m3/s/W times
  \note the rated heating capacity of the heat pump's DX coil.
N3 , \field Evaporator Air Flow Rate
  \type real
  \units m3/s
  \minimum> 0
  \autocalculatable
  \note Actual air flow rate across the heat pump's air coil (evaporator).
  \note If autocalculated, the air flow rate is set equal to 5.035E-5 m3/s/W times
  \note the rated heating capacity of the heat pump's DX coil.
A6 , \field Inlet Air Configuration
  \required-field
  \type choice
  \key Schedule
  \key ZoneAirOnly
  \key OutdoorAirOnly
  \key ZoneAndOutdoorAir
  \note Defines the configuration of the airflow path through the air coil and fan section.

```



```

A7 , \field Air Inlet Node Name
    \type alpha
    \note Zone air exhaust node name if Inlet Air Configuration is ZoneAirOnly or
    \note ZoneAndOutdoorAir.
    \note Simply a unique Node Name if Inlet Air Configuration is Schedule.
    \note Otherwise, leave field blank.
A8 , \field Air Outlet Node Name
    \type alpha
    \note Zone Air Inlet Node Name if Inlet Air Configuration is ZoneAirOnly or
    \note ZoneAndOutdoorAir.
    \note Simply a unique Node Name if Inlet Air Configuration is Schedule.
    \note Otherwise, leave field blank.
A9 , \field Outdoor Air Node Name
    \type alpha
    \note Outdoor air node name if inlet air configuration is ZoneAndOutdoorAir
    \note or OutdoorAirOnly, otherwise leave field blank.
A10, \field Exhaust Air Node Name
    \type alpha
    \note Simply a unique Node Name if Inlet Air Configuration is ZoneAndOutdoorAir
    \note or OutdoorAirOnly, otherwise leave field blank.
A11, \field Inlet Air Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note Used only if Inlet Air Configuration is Schedule, otherwise leave blank.
    \note Schedule values should be degrees C.
A12, \field Inlet Air Humidity Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note Used only if Inlet Air Configuration is Schedule, otherwise leave blank.
    \note Schedule values are entered as a fraction (e.g. 0.5 is equal to 50%RH)
A13, \field Inlet Air Zone Name
    \type object-list
    \object-list ZoneNames
    \note Used only if Inlet Air Configuration is ZoneAirOnly or ZoneAndOutdoorAir.
    \note Otherwise, leave field blank.
A14, \field Tank Object Type
    \required-field
    \type choice
    \key WaterHeater:Mixed
    \default WaterHeater:Mixed
    \note Specify the type of water heater tank used by this heat pump water heater.
A15, \field Tank Name
    \required-field
    \type object-list
    \object-list WaterHeaterNames
    \note Needs to match the name used in the corresponding Water Heater object.
A16, \field Tank Use Side Inlet Node Name
    \type alpha
    \note Used only when the heat pump water heater is connected to a plant loop,
    \note otherwise leave blank. Needs to match the name used in the corresponding
    \note Water Heater object when connected to a plant loop.
A17, \field Tank Use Side Outlet Node Name
    \type alpha
    \note Used only when the heat pump water heater is connected to a plant loop,
    \note otherwise leave blank. Needs to match the name used in the corresponding
    \note Water Heater object when connected to a plant loop.
A18, \field DX Coil Object Type
    \required-field
    \type choice
    \key Coil:WaterHeating:AirToWaterHeatPump
    \default Coil:WaterHeating:AirToWaterHeatPump
    \note Specify the type of DX coil used by this heat pump water heater. The only
    \note valid choice is Coil:WaterHeating:AirToWaterHeatPump.
A19, \field DX Coil Name
    \required-field
    \type object-list
    \object-list HeatPumpWaterHeaterDXCoils
    \note Must match the name used in the corresponding Coil:WaterHeating:AirToWaterHeatPump object.

```

```

N4 , \field Minimum Inlet Air Temperature for Compressor Operation
    \type real
    \units C
    \minimum 5
    \default 10
    \note Heat pump compressor will not operate when the inlet air dry-bulb temperature
    \note is below this value.
A20, \field Compressor Location
    \required-field
    \type choice
    \key Schedule
    \key Zone
    \key Outdoors
    \note If Zone is selected, Inlet Air Configuration must be ZoneAirOnly or
    \note ZoneAndOutdoorAir. If Schedule is selected, then you must provide a
    \note Compressor Ambient Temperature Schedule Name below.
A21, \field Compressor Ambient Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note Used only if Compressor Location is Schedule, otherwise leave field blank.
A22, \field Fan Object Type
    \required-field
    \type choice
    \key Fan:OnOff
    \default Fan:OnOff
    \note Specify the type of fan used by this heat pump water heater. The only
    \note valid choice is Fan:OnOff.
A23, \field Fan Name
    \required-field
    \type object-list
    \object-list FansOnOff
    \note Needs to match the name used in the corresponding Fan:OnOff object.
A24, \field Fan Placement
    \type choice
    \key BlowThrough
    \key DrawThrough
    \default DrawThrough
    \note BlowThrough means the fan is located before the air coil (upstream).
    \note DrawThrough means the fan is located after the air coil (downstream).
N5 , \field On Cycle Parasitic Electric Load
    \type real
    \units W
    \minimum 0.0
    \default 0.0
    \note Parasitic electric power consumed when the heat pump compressor operates.
    \note Does not contribute to water heating but can impact the zone air heat balance.
N6 , \field Off Cycle Parasitic Electric Load
    \type real
    \units W
    \minimum 0.0
    \default 0.0
    \note Parasitic electric power consumed when the heat pump compressor is off.
    \note Does not contribute to water heating but can impact the zone air heat balance.
    \note Off-cycle parasitic power is 0 when the availability schedule is 0.
A25, \field Parasitic Heat Rejection Location
    \type choice
    \key Zone
    \key Outdoors
    \default Outdoors
    \note This field determines if the parasitic electric load impacts the zone air
    \note heat balance. If Zone is selected, Inlet Air Configuration must be
    \note ZoneAirOnly or ZoneAndOutdoorAir.
A26, \field Inlet Air Mixer Node Name
    \type alpha
    \note Required only if Inlet Air Configuration is ZoneAndOutdoorAir, otherwise
    \note leave field blank.
A27, \field Outlet Air Splitter Node Name
    \type alpha
    \note Required only if Inlet Air Configuration is ZoneAndOutdoorAir, otherwise
    \note leave field blank.

```

```

A28; \field Inlet Air Mixer Schedule Name
\type object-list
\object-list ScheduleNames
\note Required only if Inlet Air Configuration is ZoneAndOutdoorAir, otherwise
\note leave field blank. Schedule values define whether the heat pump draws its
\note inlet air from the zone, outdoors or a combination of zone and outdoor air.
\note A schedule value of 0 denotes inlet air is drawn only from the zone.
\note A schedule value of 1 denotes inlet air is drawn only from outdoors.
\note Schedule values between 0 and 1 denote a mixture of zone and outdoor air
\note proportional to the schedule value.

```

Following is an example input for the Heat Pump:Water Heater compound object and the other required component objects that it references.

```

WaterHeater:HeatPump,
  Zone4HeatPumpWaterHeater,      !- Heat Pump Name
  HeatPumpWaterHeaterSch,       !- Availability Schedule Name
  HPWHTempSch,                   !- Heat Pump Compressor Set Point Temperature Schedule Name
  2.0,                           !- Dead Band Temperature Difference {deltaC}
  Zone4WaterInletNode,          !- Condenser Water Inlet Node Name
  Zone4WaterOutletNode,        !- Condenser Water Outlet Node Name
  autocalculate,                !- Condenser Water Volumetric Flow Rate {m3/s}
  autocalculate,                !- Evaporator Air Volumetric Flow Rate {m3/s}
  Zone Air Only,                !- Inlet Air Configuration
  Zone4AirOutletNode,          !- Heat Pump Air Inlet Node Name
  Zone4AirInletNode,           !- Heat Pump Air Outlet Node Name
  ,                              !- OutdoorAir:Node Name
  ,                              !- Exhaust Air Node Name
  ,                              !- Inlet Air Temperature Schedule Name
  ,                              !- Inlet Air Humidity Schedule Name
  SPACE4-1,                     !- Inlet Air Zone Name
  WaterHeater:Mixed,            !- Water Heater Tank Type
  Zone4HPWHTank,                !- Water Heater Tank Name
  ,                              !- Water Heater Tank Use Side Inlet Node Name
  ,                              !- Water Heater Tank Use Side Outlet Node Name
  Coil:WaterHeating:AirToWaterHeatPump, !- DX Coil Type
  Zone4HPWHDXCoil,              !- DX Coil Name
  5.0,                           !- Minimum Inlet Air Temperature for Heat Pump Compressor Operation {C}
  Zone,                          !- Compressor Location
  ,                              !- Compressor Ambient Temperature Schedule Name
  Fan:OnOff,                    !- Fan Type
  Zone4HPWHFan,                 !- Fan Name
  DrawThrough,                  !- Fan Placement
  15.0,                          !- On-Cycle Parasitic Electric Load {W}
  5.0,                           !- Off-Cycle Parasitic Electric Load {W}
  Zone;                          !- Parasitic Heat Rejection Location

```

```

WaterHeater:Mixed,
  Zone4HPWHTank,           !- Name
  0.3785,                  !- Tank Volume {m3}
  Hot Water Setpoint Temp Schedule, !- Setpoint Temperature Schedule
  2.0,                    !- Deadband Temperature Difference {deltaC}
  82.2222,                !- Maximum Temperature Limit {C}
  Cycle,                  !- Heater Control Type
  5000,                   !- Heater Maximum Capacity {W}
  0,                      !- Heater Minimum Capacity {W}
  ,                       !- Heater Ignition Minimum Flow Rate {m3/s}
  ,                       !- Heater Ignition Delay {s}
  ELECTRICITY,            !- Heater Fuel Type
  0.95,                   !- Heater Thermal Efficiency
  ,                       !- Part Load Factor Curve
  10,                    !- Off-Cycle Parasitic Fuel Consumption Rate {W}
  ELECTRICITY,            !- Off-Cycle Parasitic Fuel Type
  0,                      !- Off-Cycle Parasitic Heat Fraction To Tank
  30,                    !- On-Cycle Parasitic Fuel Consumption Rate {W}
  ELECTRICITY,            !- On-Cycle Parasitic Fuel Type
  0,                      !- On-Cycle Parasitic Heat Fraction To Tank
  ZONE,                   !- Ambient Temperature Indicator
  ,                       !- Ambient Temperature Schedule
  SPACE4-1,              !- Ambient Temperature Zone
  2.0,                   !- Off-Cycle Loss Coefficient To Ambient Temperature {W/K}
  1.0,                   !- Off-Cycle Loss Fraction To Zone
  2.0,                   !- On-Cycle Loss Coefficient To Ambient Temperature {W/K}
  1.0,                   !- On-Cycle Loss Fraction To Zone
  0.00379,               !- Peak Volumetric Use Flow Rate {m3/s}
  Hot Water Demand Schedule, !- Use Flow Rate Fraction Schedule
  ,                       !- Cold Water Supply Temperature Schedule
  ,                       !- Use Side Inlet Node
  ,                       !- Use Side Outlet Node
  ,                       !- Use Side Effectiveness
  Zone4WaterOutletNode,  !- Source Side Inlet Node
  Zone4WaterInletNode,   !- Source Side Outlet Node
  0.95;                  !- Source Side Effectiveness

```

```

Coil:WaterHeating:AirToWaterHeatPump,
  Zone4HPWHDXCcoil,      !- Coil Name
  4000.0,                !- Heating Capacity {W}
  3.2,                   !- Rated COP {W/W}
  0.6956,                !- Rated SHR (gross)
  19.7,                  !- Rated Evaporator Inlet Air Dry-Bulb Temperature {C}
  13.5,                  !- Rated Evaporator Inlet Air Wet-Bulb Temperature {C}
  57.5,                  !- Rated Condenser Inlet Water Temperature {C}
  autocalculate,        !- Rated Evaporator Air Volumetric Flow Rate {m3/s}
  autocalculate,        !- Rated Condenser Water Volumetric Flow Rate {m3/s}
  No,                    !- Evaporator Fan Power Included in Rated COP
  No,                    !- Condenser Pump Power Included in Rated COP
  No,                    !- Condenser Pump Heat Included in Rated Heating Capacity and Rated COP
  150.0,                 !- Condenser Water Pump Power {W}
  0.1,                   !- Fraction of Condenser Pump Heat to Water
  Zone4AirOutletNode,    !- Evaporator Air Inlet Node Name
  Zone4DXCoilAirOutletNode, !- Evaporator Air Outlet Node Name
  Zone4WaterInletNode,   !- Condenser Water Inlet Node Name
  Zone4WaterOutletNode,  !- Condenser Water Outlet Node Name
  100.0,                 !- Crankcase Heater Capacity {W}
  5.0,                   !- Maximum Ambient Temperature for Crankcase Heater Operation {C}
  WetBulbTemperature,    !- Evaporator Air Temperature Type for Curve Objects
  HPWHHeatingCapFTemp,   !- Heating Capacity Modifier Curve Name (function of temperature)
  ,                       !- Heating Capacity Modifier Curve Name (function of air flow fraction)
  ,                       !- Heating Capacity Modifier Curve Name (function of water flow fraction)
  HPWHHeatingCOPFTemp,   !- Heating COP Modifier Curve Name (function of temperature)
  ,                       !- Heating COP Modifier Curve Name (function of air flow fraction)
  ,                       !- Heating COP Modifier Curve Name (function of water flow fraction)
  HPWHPLFFPLR;          !- Part Load Fraction Correlation Name (function of part load ratio)

```

Fan:OnOff,		
Zone4HPWHFan,	!-	Fan Name
HeatPumpWaterHeaterSch,	!-	Available Schedule
0.7,	!-	Fan Total Efficiency
100.0,	!-	Delta Pressure {Pa}
0.2685,	!-	Max Flow Rate {m3/s}
0.9,	!-	Motor Efficiency
1.0,	!-	Motor In Airstream Fraction
Zone4DXCoilAirOutletNode,	!-	Fan_Inlet_Node
Zone4AirInletNode;	!-	Fan_Outlet_Node

WaterHeater:HeatPump Outputs

HVAC,Average,Heat Pump Water Heater Compressor Part-Load Ratio
HVAC,Average,Heat Pump Water Heater On-Cycle Parasitic Electric Power [W]
HVAC,Sum,Heat Pump Water Heater On-Cycle Parasitic Elec Consumption [J]
HVAC,Average,Heat Pump Water Heater Off-Cycle Parasitic Electric Power [W]
HVAC,Sum,Heat Pump Water Heater Off-Cycle Parasitic Elec Consumption [J]

Heat Pump Water Heater Compressor Part-Load Ratio

This output is the average part-load ratio of the heat pump water heater's compressor (as well as its water pump and fan) for the timestep being reported. This output is independent of the "Water Heater Part Load Ratio" (Ref. Water Heater Outputs) which represents the part-load ratio of the supplemental heater (element or burner) in the water tank. When the water tank's (supplemental) heater set point temperature is higher than the cut-in temperature of the heat pump water heater's compressor, the heat pump compressor is disabled and the water tank's heater (element or burner) is used to heat the water. During these times the Heat Pump Water Heater Compressor Part-Load Ratio is equal to 0.

Heat Pump Water Heater On-Cycle Parasitic Electric Power [W]

Heat Pump Water Heater On-Cycle Parasitic Elec Consumption [J]

Heat Pump Water Heater Off-Cycle Parasitic Electric Power [W]

Heat Pump Water Heater Off-Cycle Parasitic Elec Consumption [J]

These outputs are the parasitic electric power and consumption associated with the heat pump water heater. Specific outputs represent parasitic electrical usage during the compressor/fan on and off cycles. These outputs represent electronic controls or other electric component. The model assumes that the parasitic power does not contribute to heating the water, but it can impact the zone air heat balance depending on user inputs. The parasitic electric consumption outputs are also added to a report meter with Resource Type = Electricity, End Use Key = DHW, Group Key = Plant (ref. Report Meter).

Group – Condenser Equipment

Equipment Types

In each CondenserEquipmentList, various equipment types and names must be given. Each type-name pair must then have a corresponding equipment definition. This subsection lists the various equipment types that are available and examples from an IDF. Where appropriate, notes and comments on the input structure are provided.

CoolingTower:SingleSpeed

Cooling towers are components that may be assigned to condenser loops. The cooling tower is modeled as a counterflow heat exchanger with a single-speed fan (induced draft configuration) based on Merkel's theory. The user must define tower performance via one of two methods: design heat transfer coefficient-area product (UA) and design water flow rate,

or nominal tower capacity at a specific rating point. Regardless of which method is chosen, the design airflow rate and corresponding fan power must be specified. The model will also account for tower performance in the “free convection” regime, when the tower fan is off but the water pump remains on and heat transfer still occurs (albeit at a low level). If the user wants the model to account for “free convection”, they must specify the corresponding airflow rate and heat transfer coefficient-area product (UA), or the nominal tower capacity during this mode of operation.

The cooling tower seeks to maintain the temperature of the water exiting the cooling tower at (or below) a set point. The set point schedule value is defined by the field “Condenser Loop Temperature Setpoint Node Name or Reference” for the CondenserLoop object. The model first checks to determine the impact of “free convection”, if specified by the user, on the tower exiting water temperature. If the exiting water temperature based on “free convection” is at or below the set point, then the tower fan is not turned on. If the exiting water temperature based on “free convection” is below the set point, the tower will operate in FluidBypass mode – portion of the water goes through the tower media and gets cooled while the remaining water flow gets bypassed, two water flows then mix together trying to meet the water setpoint temperature. If the exiting water temperature remains above the set point after “free convection” is modeled, then the tower fan is turned on to reduce the exiting water temperature to the set point. If the capacity control is FanCycling, the model assumes that part-load operation is represented by a simple linear interpolation between two steady-state regimes (i.e., tower fan on for the entire simulation timestep and tower fan off for the entire simulation timestep). Cyclic losses are not taken into account. If the capacity control is FluidBypass, the model determines the fraction of water flow to be bypassed while the remaining water goes through the tower cooling media and gets cooled, then the two water flows mix to meet the setpoint temperature. In this case, the fan runs at full speed for the entire timestep.

Cooling towers here are “wet” and consume water through evaporation, drift, and blowdown. The model can be used to predict water consumed by the towers. The last six input fields are optional and provide methods of controlling details of the water consumption calculations. The user can specify connections to the rest of the buildings water system by providing the name of a water storage tanks (i.e. WaterUse:Storage objects).

The IDD specification for the single-speed cooling tower is given below.

```

CoolingTower:SingleSpeed,
  \min-fields 9
  \memo This tower model is based on Merkel's theory, which is also the basis
  \memo for the tower model in ASHRAE's HVAC1 Toolkit. The closed-circuit cooling tower
  \memo is modeled as a counter flow heat exchanger with a single-speed fan drawing air
  \memo through the tower (induced-draft configuration).
  \memo Added fluid bypass as an additional capacity control. 8/2008.
A1 , \field Name
  \required-field
  \type alpha
  \note Tower Name
A2 , \field Water Inlet Node Name
  \required-field
  \type alpha
  \note Name of tower water inlet node
A3 , \field Water Outlet Node Name
  \required-field
  \type alpha
  \note Name of tower water outlet node
N1 , \field Design Water Flow Rate
  \type real
  \units m3/s
  \minimum > 0.0
  \autosizable
  \note Leave field blank if tower performance input method is NominalCapacity
  \ip-units gal/min

```

```

N2 , \field Design Air Flow Rate
    \required-field
    \type real
    \units m3/s
    \minimum> 0.0
    \autosizable
N3 , \field Fan Power at Design Air Flow Rate
    \required-field
    \type real
    \units W
    \minimum> 0.0
    \autosizable
    \ip-units W
N4 , \field U-Factor Times Area Value at Design Air Flow Rate
    \type real
    \units W/K
    \minimum> 0.0
    \maximum 2100000.0
    \autosizable
    \note Leave field blank if tower performance input method is NominalCapacity
N5 , \field Air Flow Rate in Free Convection Regime
    \type real
    \units m3/s
    \minimum 0.0
    \default 0.0
    \autosizable
N6 , \field U-Factor Times Area Value at Free Convection Air Flow Rate
    \type real
    \units W/K
    \minimum 0.0
    \maximum 300000.0
    \default 0.0
    \autosizable
A4 , \field Performance Input Method
    \type Choice
    \key UFactorTimesAreaAndDesignWaterFlowRate
    \key NominalCapacity
    \default NominalCapacity
    \note User can define tower thermal performance by specifying the tower UA
    \note and the Design Air Flow Rate, or by specifying the tower nominal capacity
N7 , \field Nominal Capacity
    \type real
    \units W
    \minimum> 0.0
    \note Nominal tower capacity with entering water at 35C (95F), leaving water at
    \note 29.44C (85F), entering air at 25.56C (78F) wet-bulb temperature and 35C (95F)
    \note dry-bulb temperature. Design water flow rate assumed to be 5.382E-8 m3/s per watt
    \note (3 gpm/ton). Nominal tower capacity times (1.25) gives the actual tower
    \note heat rejection at these operating conditions.
N8 , \field Free Convection Capacity
    \type real
    \units W
    \minimum 0.0
    \note Tower capacity in free convection regime with entering water at 35C (95F),
    \note leaving water at 29.44C (85F), entering air at 25.56C (78F) wet-bulb temperature
    \note and 35C (95F) dry-bulb temperature. Design water flow rate assumed to be
    \note 5.382E-8 m3/s per watt of nominal tower capacity (3 gpm/ton). Tower free
    \note convection capacity times (1.25) gives the actual tower heat rejection at these
    \note operating conditions.
A5 , \field Evaporation Loss Mode
    \type choice
    \key LossFactor
    \key SaturatedExit
N9 , \field Evaporation Loss Factor
    \type real
    \units percent/K
    \note Rate of water evaporation from the cooling tower and lost to the outdoor air [%/K]
    \note Evaporation loss is calculated as percentage of the circulating condenser water rate
    \note Value entered here is percent-per-degree K of temperature drop in the condenser water
    \note Typical values are from 0.15 to 0.27 [%/K].
    \default 0.2

```

```

N10, \field Drift Loss Percent
      \type real
      \default 0.008
      \units percent
      \note Rate of drift loss as a percentage of circulating condenser water flow rate
      \note Typical values are between 0.002 and 0.2% The default value is 0.008%
A6 , \field Blowdown Calculation Mode
      \type choice
      \key ConcentrationRatio
      \key ScheduledRate
N11, \field Blowdown Concentration Ratio
      \type real
      \minimum 2.0
      \default 3.0
      \note Characterizes the rate of blowdown in the cooling tower.
      \note Blowdown is water intentionally drained from the tower in order to offset the build up
      \note of solids in the water that would otherwise occur because of evaporation.
      \note Ratio of solids in the blowdown water to solids in the make up water.
      \note Typical values for tower operation are 3 to 5. The default value is 3.
A7 , \field Blowdown Makeup Water Usage Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Makeup water usage due to blowdown results from occasionally draining a small amount
      \note of water in the tower basin to purge scale or other contaminants to reduce their
      \note concentration in order to maintain an acceptable level of water quality.
      \note Schedule values should reflect water usage in m3/s.
A8 , \field Supply Water Storage Tank Name
      \type object-list
      \object-list WaterStorageTankNames
A9 , \field Outdoor Air Inlet Node Name
      \type alpha
      \note Enter the name of an outdoor air node
A10, \field Capacity Control
      \type choice
      \key FanCycling
      \key FluidBypass
      \default FanCycling
N12; \field Sizing Factor
      \note Multiplies the autosized capacity and flow rates
      \type real
      \minimum> 0.0
      \default 1.0

```

Field: Name

This alpha field contains the identifying name for the cooling tower.

Field: Water Inlet Node Name

This alpha field contains the identifying name for the cooling tower's water inlet node.

Field: Water Outlet Node Name

This alpha field contains the identifying name for the cooling tower's water outlet node.

Field: Design Water Flow Rate

This numeric field contains the design water flow rate through the tower in m³/s. This value is the flow rate of the condenser loop water being cooled by the tower (not the flow rate of water being sprayed on the outside of the heat exchange coil). If the input field "Performance Input Method" is specified as "UFactorTimesAreaAndDesignWaterFlowRate", then a water flow rate greater than zero must be defined or the field can be autosized. If autosized, a Plant Sizing object must be defined and the design water flow rate is derived from the design load to be rejected by the condenser loop and the design loop delta T (Ref. Plant Sizing and Input for Design Calculations and Component Autosizing). If "Performance Input Method" is specified as "NominalCapacity", then this field must be left blank since the model

automatically assumes a water flow rate of 5.382E-8 m³/s per watt (3 gpm/ton) of tower capacity specified in the field “Nominal Capacity”.

Field: Design Air Flow Rate

This numeric field contains the design air flow rate induced by the tower fan in m³/s. A value greater than zero must be defined regardless of the tower performance input method. Alternately, this field can be autosized. If autosized, the design air flow rate is calculated as follows:

$$\text{Design Air Flow Rate} = \frac{0.5 \rho_{\text{air}} (\text{Fan power at Design Air Flow Rate})}{190}$$

where a fan pressure rise of 190 Pascals and total fan efficiency of 0.5 are assumed.

Field: Fan Power at Design Air Flow Rate

This numeric field contains the fan power (in watts) at the design air flow rate specified in the previous field. A value greater than zero must be specified regardless of the tower performance input method, or this field can be autosized. If autosized, the fan power is calculated as follows:

If “Performance Input Method” is specified as “*UFactorTimesAreaAndDesignWaterFlowRate*”, then

$$\text{Fan power} = 0.0105 \cdot \rho_{\text{water}} \cdot C_{p,\text{water}} \cdot \text{Design Water Flow Rate} \cdot \text{Design Loop } \Delta T$$

is used.

If “Performance Input Method” is specified as “*NominalCapacity*”, then

$$\text{Fan power} = 0.0105 \cdot \text{Tower Nominal Capacity}$$

is used.

Field: U-Factor Times Area Value at Design Air Flow Rate

This numeric field contains the heat transfer coefficient-area product (UA) in watts per degree Celsius corresponding to the design air and water flow rates specified above. If the input field “Performance Input Method” is specified as “*UFactorTimesAreaAndDesignWaterFlowRate*”, then a UA value greater than zero but less than or equal to 300,000 must be defined, or the field can be autosized. If autosized, a Plant Sizing object must be defined and the design tower UA value is derived from the design load to be rejected by the condenser loop and the design loop delta T (Ref. Plant Sizing and Input for Design Calculations and Component Autosizing), assuming a tower water inlet temperature of 35C and tower inlet air at 35C drybulb/25.6C wetbulb. If “Performance Input Method” is specified as “*NominalCapacity*”, then this field must be left blank since the model automatically calculates the tower UA based on the tower capacity specified in the field “Nominal Capacity”.

Field: Air Flow Rate in Free Convection Regime

This numeric field contains the air flow rate (m³/s) when the tower is in the “free convection” regime (water flow exists but tower fan is turned off). This value must be less than the value specified for the field “Design Air Flow Rate”. This field may be autosized, in which case it is set to 10% of the “Design Air Flow Rate”. If the user does not wish to model “free convection” and is using the Performance Input Method “*UFactorTimesAreaAndDesignWaterFlowRate*”, then this field should be set to 0.0. If the user specifies the U-Factor Times Area Value at Free Convection Air Flow Rate or Free Convection Capacity as a value greater than zero, then the free convection air flow rate must be specified greater than 0.0.

Field: U-Factor Times Area Value at Free Convection Air Flow Rate

This numeric field contains the heat transfer coefficient-area product ($W/^\circ C$) when the tower is in the “free convection” regime (water flow exists but tower fan is turned off). This value must be less than the value specified for the field “U-Factor Times Area Value at Design Air Flow Rate”. This field may be autosized, in which case it is set to 10% of the “U-Factor Times Area Value at Design Air Flow Rate”. If the user does not wish to model “free convection” and is using the Performance Input Method “UFactorTimesAreaAndDesignWaterFlowRate”, then this field should be set to 0.0. If “Performance Input Method” is specified as “NominalCapacity”, then this field must be left blank since the model automatically calculates the tower UA based on the tower capacity specified in the field “Free Convection Capacity”.

Field: Performance Input Method

This alpha field contains the method by which the user will specify tower performance: “UFactorTimesAreaAndDesignWaterFlowRate” or “NominalCapacity”. If this field is left blank in the input data file, the default input method is assumed to be “NominalCapacity”. If the method “” is selected, then the user must enter design UA values, design water flow rates and air flow rates as described for the previous input fields. If the method “NominalCapacity” is selected then the fields “Design Water Flow Rate”, “U-Factor Times Area Value at Design Air Flow Rate” and “U-Factor Times Area Value at Free Convection Air Flow Rate” must be left blank, but the fields “Nominal Capacity” and “Free Convection Capacity” must be entered as described below.

Field: Nominal Capacity

This numeric input field contains the “nominal” heat rejection capacity of the cooling tower in watts, with entering water at 35C (95F), leaving water at 29.4C (85F), entering air at 25.6C (78F) wetbulb and 35C (95F) drybulb temperatures. The design water flow rate is assumed to be $5.382E-8$ m³/s per watt of nominal capacity (3 gpm/ton). 125% of this nominal tower capacity gives the actual tower heat rejection at these operating conditions (based on historical assumption that the tower must dissipate 0.25W of compressor heat for every watt of heat removed by the evaporator).

Field: Free Convection Capacity

This numeric input field contains the “nominal” heat rejection capacity of the cooling tower in watts when the tower is in the “free convection” regime (water flow exists but tower fan is turned off), with entering water at 35C (95F), leaving water at 29.4C (85F), entering air at 25.6C (78F) wetbulb and 35C (95F) drybulb temperatures. The design water flow rate is assumed to be $5.382E-8$ m³/s per watt of nominal tower capacity (input field above). 125% of this free convection tower capacity gives the actual tower heat rejection at these operating conditions (based on historical assumption that the tower must dissipate 0.25W of compressor heat for every watt of heat removed by the evaporator). The value specified for this field must be less than the value specified for the field “Tower Nominal Capacity”. If the user does not wish to model “free convection”, then this field should be set to 0.0. If the user specifies a value greater than zero, then the “Air Flow Rate in Free Convection Regime” field must contain a value greater than zero.

Field: Evaporation Loss Mode

This field is used to choose which method is used to model the amount of water evaporated by the cooling tower. There are two options: **LossFactor** or **SaturatedExit**. The default is SaturatedExit. The user-defined loss factor is entered in the following field. By assuming that the air leaving the tower is saturated, the evaporation can be directly calculated using moist air engineering calculations with data available within the cooling tower model (and does not require additional user input).

Field: Evaporation Loss Factor

This field is used to specify the rate of water evaporated from the cooling tower and lost to the outside air [percent/K]. This field is only used if the Evaporation Calculation Mode is set to **LossFactor**. The evaporation loss is then calculated as a fraction of the circulating condenser water flow and varies with the temperature change in the condenser water. The value entered here is in units of percent-per-degree Kelvin. The evaporation rate will equal this value times each degree Kelvin of temperature drop in the condenser water. Typical values are from 0.15 to 0.27 [percent/K]. The default is 0.2.

Field: Drift Loss Percent

This field is used to specify the rate of water lost to the exiting air as entrained droplets [%]. The drift loss is a percent of the condenser water flow. Typical values for towers with efficient drift eliminators are between 0.002 and 0.2% of the condenser water flow rate. The default value is 0.008%.

Field: Blowdown Calculation Mode

This field specifies which method is used to determine blowdown rates. There two options **ConcentrationRatio** or **ScheduledRate**. The choice will determine which of the two models below is used. The default is ConcentrationRatio.

Field: Blowdown Concentration Ratio

This field is used to dynamically adjust the rate of blowdown in the cooling tower as a function of the rate of evaporation. Blowdown is water intentionally drained from the tower in order to offset the build up of solids in the water that would otherwise occur because of evaporation. The value entered here is dimensionless. It can be characterized as the ratio of solids in the blowdown water to solids in the make up water. Typical values for tower operation are 3 to 5. The default value is 3.

Field: Blowdown Makeup Water Usage Schedule Name

This alpha field contains the name of the schedule used to define the amount of water (m^3/s) flushed from the basin on a periodic basis to purge the tower of mineral scale build-up and other contaminants. This schedule is only used if the Blowdown Calculation Mode is set to ScheduledRate. The amount of water use due to blowdown depends on the makeup water quality and is specific to each geographical location. Typical values range from 0.0002 to 0.0013 m^3/s (17.3 to 112.3 m^3/day). This water usage is in addition to the amount of water lost to the atmosphere due to evaporation and/or drift. Since blowdown occurs when the basin water contaminant concentration is high, blowdown only occurs when the cooling tower is active and water is flowing through the tower (regardless of the water usage defined by this schedule).

Field: Supply Water Storage Tank Name

This field is optional. It is used to describe where the tower obtains water used for evaporative cooling. If blank or omitted, then the tower will obtain water directly from the mains. If the name of a WaterUse:Storage object is used here, then the tower will obtain its water from that tank. If a tank is specified, the tower will attempt to obtain all the water it uses from the tank. However if the tank cannot provide all the water the tower needs, then the tower will still operate and obtain the rest of the water it needs from the mains (referred to as 'Starved' water).

Field: Outdoor Air Inlet Node Name

This optional alpha field specifies the outdoor air node name used to define the conditions of the air entering the cooling tower. If this field is left blank, the outdoor air conditions entering the cooling tower are taken directly from the weather data. If this field is not blank, the node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air conditions from the weather

data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air conditions are taken directly from the weather data.

Field: Capacity Control

This alpha field contains the cooling capacity control for the cooling tower. Two choices are available: **FanCycling** and **FluidBypass**. During part-load conditions, there are two ways to maintain the exiting water temperature at the setpoint: either cycling the tower fan, or bypassing portion of the tower water with a three-way valve. For FluidBypass, the tower fan still runs at full speed for the entire timestep, but only portion of the water flow goes through the cooling tower media to get cooled while the remaining portion of the water flow gets bypassed. Two water flows then mix at the common water sump to meet the setpoint temperature.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. Sizing factor allows the user to size a component to meet part of the design load while continuing to use the autosizing feature. For this component the inputs that would be altered by the sizing factor are:

1. Design Water Flow Rate;
2. Design Air Flow Rate;
3. Fan Power at Design Air Flow Rate;
4. U-Factor Times Area Value at Design Air Flow Rate;
5. Air Flow Rate in Free Convection Regime;
6. U-Factor Times Area Value at Free Convection Air Flow Rate.

Note that the U-Factor Times Area Value at Design Air Flow Rate is not *multiplied* by the Sizing Factor. Instead the design tower load is multiplied by the sizing factor and the design UA then calculated as usual. The U-Factor Times Area Value at Free Convection Air Flow Rate is set to 10% of the new design Tower UA.

Three examples of an IDF specification for this object are shown below:

```
CoolingTower:SingleSpeed,
My Tower,                ! Tower name
Condenser Tower Inlet Node, ! Tower inlet water node name
Condenser Tower Outlet Node, ! Tower outlet water node name
.0011,                   ! Design water flow rate, m3/s
16.0,                    ! Design air flow rate, m3/s
10000.,                  ! Fan power at design air flow, W
3500.,                   ! Tower UA at design flow rates, W/C
0.0,                     ! Air flow rate for free convection, m3/s
0.0,                     ! Tower UA at free convection air flow, W/C
UFactorTimesAreaAndDesignWaterFlowRate, ! Tower Performance Input Method
,                          ! Tower Nominal Capacity
,                          ! Tower Free Convection Capacity
,                          ! Evaporation Loss Mode
,                          ! Evaporation Loss Factor
,                          ! Drift Loss Percent
,                          ! Blowdown Calculation Mode
,                          ! Blowdown Concentration Ratio
,                          ! Schedule Name for Makeup Water Usage due to Blowdown
,                          ! Name of Water Storage Tank for Supply
,                          ! Outdoor Air Inlet Node Name
FluidBypass;             ! Capacity Control
```

```

CoolingTower:SingleSpeed,
My Tower,          ! Tower name
Condenser Tower Inlet Node, ! Tower inlet water node name
Condenser Tower Outlet Node, ! Tower outlet water node name
,                  ! Design water flow rate, m3/s
autosize,          ! Design air flow rate, m3/s
1000.,             ! Fan power at design air flow, W
,                  ! Tower UA at design flow rates, W/C
autosize,          ! Air flow rate for free convection, m3/s
,                  ! Tower UA at free convection air flow, W/C
NominalCapacity,  ! Tower Performance Input Method
95250.,           ! Tower Nominal Capacity
9525.;            ! Tower Free Convection Capacity

CoolingTower:SingleSpeed,
Big Tower,        !- Tower Name
Condenser Tower Inlet Node, !- Water Inlet Node Name
Condenser Tower Outlet Node, !- Water Outlet Node Name
autosize,         !- Design Water Flow Rate {m3/s}
autosize,         !- Design Air Flow Rate {m3/s}
autosize,         !- Fan Power at Design Air Flow Rate {W}
autosize,         !- Tower UA Value at Design Air Flow Rate {W/K}
0,               !- Air Flow Rate in Free Convection Regime {m3/s}
0,               !- Tower UA Value at Free Convection Air Flow Rate {W/K}
UFactorTimesAreaAndDesignWaterFlowRate, !- Tower Performance Input Method
,               !- Tower Nominal Capacity
,               !- Tower Free Convection Capacity
SaturatedExit,  !- Evaporation Loss Mode
,               !- Evaporation Loss Factor [percent/K]
0.008,         !- Drift Loss Percent
ConcentrationRatio, !- Blowdown Calculation Mode
3.0,           !- Blowdown Concentration Ratio
,               !- Schedule Name for Makeup Water Usage due to Blowdown
Recovery Tank; !- Name of Water Storage Tank for Supply

```

CoolingTower:SingleSpeed Outputs

```

HVAC,Average,Tower Fan Electric Power [W]
HVAC,Sum,Tower Fan Electric Consumption [J]
Zone,Meter,HeatRejection:Electricity [J]

HVAC,Average,Tower Heat Transfer [W]
HVAC,Average,Tower Water Inlet Temp [C]
HVAC,Average,Tower Water Outlet Temp [C]
HVAC,Average,Tower Water Mass Flow Rate [kg/s]
HVAC,Average,Tower External Water Use Rate [m3/s]
HVAC,Average,Tower Fluid Bypass Fraction

```

Tower Fan Electric Power [W]

Tower Fan Electric Consumption [J]

These outputs are the electric power input to the tower fans. Consumption is metered on HeatRejection:Electricity, Electricity:Plant, and Electricity:Facility.

Tower Heat Transfer [W]

This is the rate at which heat is removed from the condenser water loop by the tower.

Tower Water Inlet Temp [C]***Tower Water Outlet Temp [C]******Tower Water Mass Flow Rate [kg/s]***

These outputs are the tower water inlet and outlet temperatures, and mass flow rate of the circulating condenser water loop.

Tower Water Make Up Rate [m3/s]***Tower Water Make Up [m3]***

These outputs are the water consumed by the wet cooling tower for external water sprays used to augment heat transfer. This is the total of evaporation, drift, and blowdown.

Tower Water Evaporation Rate [m3/s]***Tower Water Evaporation [m3]******Tower Water Drift Rate [m3/s]******Tower Water Drift [m3]******Tower Water Blowdown Rate [m3/s]******Tower Water Blowdown [m3]***

These outputs provide the breakdown of the different components of water use during cooling tower operation.

If a water storage tank is used to provide water to the tower, then the following output variables will also be available.

Tower Water From Storage Tank Rate [m3/s]***Tower Water From Storage Tank [m3]***

These are the rate and volume of water provided by the Water Storage Tank.

Tower Water Starved By Storage Tank Rate [m3/s]***Tower Water Starved By Storage Tank [m3]***

These are the rate and volume of water the Storage Tank connections was not able to provide. The starved water is assumed to come from the mains. The tower's operation is not affected by a lack of storage tank water.

CoolingTower:TwoSpeed

The two-speed cooling tower is modeled in a similar fashion to the single-speed tower. The cooling tower is modeled as a counterflow heat exchanger with a two-speed fan (induced draft configuration) based on Merkel's theory. The user must define tower performance via one of two methods: heat transfer coefficient-area product (UA) and design water flow rate, or nominal tower capacity at a specific rating point. Regardless of which method is chosen, the airflow rate and corresponding fan power at both high and low fan speed must be specified. The model will also account for tower performance in the "free convection" regime, when the tower fan is off but the water pump remains on and heat transfer still occurs (albeit at a low level). If the user wants the model to account for "free convection", they must specify the corresponding air flow rate and heat transfer coefficient-area product (UA), or the nominal tower capacity during this mode of operation.

The cooling tower seeks to maintain the temperature of the water exiting the cooling tower at (or below) a set point. The set point schedule value is defined by the field "Condenser Loop Temperature Setpoint Node Name or Reference" for the CondenserLoop object. The model first checks to determine the impact of "free convection", if specified by the user, on the tower

exiting water temperature. If the exiting water temperature based on “free convection” is at or below the set point, then the tower fan is not turned on. If the exiting water temperature remains above the set point after “free convection” is modeled, then the tower fan is turned on at low speed to reduce the exiting water temperature. If operating the tower fan at low speed does not reduce the exiting water temperature to the set point, then the tower fan is increased to its high speed.

The model assumes that part-load operation is represented by a simple linear interpolation between two steady-state regimes (i.e., tower fan at high speed for the entire simulation timestep and tower fan at low speed for the entire simulation timestep, or tower fan at low speed for the entire simulation timestep and tower fan off for the entire simulation timestep). Cyclic losses are not taken into account.

Cooling towers here are “wet” and consume water through evaporation, drift, and blowdown. The model can be used to predict water consumed by the towers. The last six input fields are optional and provide methods of controlling details of the water consumption calculations. The user can specify connections to the rest of the buildings water system by providing the name of a WaterUse:Storage object.

The IDD specification for the two-speed cooling tower is given below.

```

CoolingTower:TwoSpeed,
  \min-fields 12
  \memo This tower model is based on Merkel's theory, which is also the basis
  \memo for the tower model in ASHRAE's HVAC1 Toolkit. The closed-circuit cooling tower
  \memo is modeled as a counter flow heat exchanger with a two-speed fan drawing air
  \memo through the tower (induced-draft configuration).
A1, \field Name
  \required-field
  \type alpha
  \note Tower Name
A2 , \field Water Inlet Node Name
  \required-field
  \type alpha
  \note Name of tower Water Inlet Node
A3 , \field Water Outlet Node Name
  \required-field
  \type alpha
  \note Name of tower Water Outlet Node
N1 , \field Design Water Flow Rate
  \type real
  \units m3/s
  \minimum> 0.0
  \autosizable
  \note Leave field blank if Tower Performance Input Method is NominalCapacity
  \ip-units gal/min
N2 , \field Air Flow Rate at High Fan Speed
  \required-field
  \type real
  \units m3/s
  \minimum> 0.0
  \autosizable
N3 , \field Fan Power at High Fan Speed
  \required-field
  \type real
  \units W
  \minimum> 0.0
  \autosizable
  \ip-units W

```

```

N4 , \field U-Factor Times Area Value at High Fan Speed
    \type real
    \units W/K
    \minimum> 0.0
    \maximum 2100000.0
    \autosizable
    \note Leave field blank if Tower Performance Input Method is NominalCapacity
N5 , \field Air Flow Rate at Low Fan Speed
    \required-field
    \type real
    \units m3/s
    \minimum> 0.0
    \autosizable
    \note Low speed air flow rate must be less than high speed air flow rate
    \note Low speed air flow rate must be greater than free convection air flow rate
N6 , \field Fan Power at Low Fan Speed
    \required-field
    \type real
    \units W
    \minimum> 0.0
    \autosizable
    \ip-units W
N7 , \field U-Factor Times Area Value at Low Fan Speed
    \type real
    \units W/K
    \minimum> 0.0
    \maximum 300000.0
    \autosizable
    \note Leave field blank if tower Performance Input Method is NominalCapacity
    \note Low speed tower UA must be less than high speed tower UA
    \note Low speed tower UA must be greater than free convection tower UA
N8 , \field Air Flow Rate in Free Convection Regime
    \type real
    \units m3/s
    \minimum 0.0
    \default 0.0
    \autosizable
N9 , \field U-Factor Times Area Value at Free Convection Air Flow Rate
    \type real
    \units W/K
    \minimum 0.0
    \maximum 300000.0
    \default 0.0
    \autosizable
    \note Leave field blank if Tower Performance Input Method is NominalCapacity
A4 , \field Performance Input Method
    \type Choice
    \key UFactorTimesAreaAndDesignWaterFlowRate
    \key NominalCapacity
    \default NominalCapacity
    \note User can define tower thermal performance by specifying the tower U-factor times area
    \note and the design air flow rates, or by specifying the tower nominal capacity
N10, \field High Speed Nominal Capacity
    \type real
    \units W
    \minimum> 0.0
    \note Nominal tower capacity with entering water at 35C (95F), leaving water at
    \note 29.44C (85F), entering air at 25.56C (78F) wet-bulb temperature and 35C (95F)
    \note dry-bulb temperature, with the tower fan operating at high speed. Design water
    \note flow rate assumed to be 5.382E-8 m3/s per watt(3 gpm/ton). Nominal tower capacity
    \note times (1.25) gives the actual tower heat rejection at these operating conditions.
N11, \field Low Speed Nominal Capacity
    \type real
    \units W
    \minimum> 0.0
    \note Nominal tower capacity with entering water at 35C (95F), leaving water at
    \note 29.44C (85F), entering air at 25.56C (78F) wet-bulb temperature and 35C (95F)
    \note dry-bulb temperature, with the tower fan operating at low speed. Design water flow
    \note rate assumed to be 5.382E-8 m3/s per watt of tower high-speed nominal capacity
    \note (3 gpm/ton). Nominal tower capacity times (1.25) gives the actual tower heat
    \note rejection at these operating conditions.

```



```

N12, \field Free Convection Capacity
\type real
\units W
\minimum 0.0
\note Tower capacity in free convection regime with entering water at 35C (95F),
\note leaving water at 29.44C (85F), entering air at 25.56C (78F) wet-bulb temperature
\note and 35C (95F) dry-bulb temperature. Design water flow rate assumed to be
\note 5.382E-8 m3/s per watt of tower high-speed nominal capacity (3 gpm/ton). Tower
\note free convection capacity times (1.25) gives the actual tower heat rejection at
\note these operating conditions.
A5 , \field Evaporation Loss Mode
\type choice
\key LossFactor
\key SaturatedExit
N13, \field Evaporation Loss Factor
\type real
\units percent/K
\note Rate of water evaporated from the cooling tower and lost to the outdoor air [%/K]
\note Evaporation loss is calculated as percentage of the circulating condenser water rate
\note Value entered here is percent-per-degree K of temperature drop in the condenser water
\note Typical values are from 0.15 to 0.27 [%/K].
\default 0.2
N14, \field Drift Loss Percent
\type real
\units percent
\default 0.008
\note Rate of drift loss as a percentage of circulating condenser water flow rate
\note Typical values are between 0.002 and 0.2% The default value is 0.008%
A6 , \field Blowdown Calculation Mode
\type choice
\key ConcentrationRatio
\key ScheduledRate
N15, \field Blowdown Concentration Ratio
\type real
\minimum 2.0
\default 3.0
\note Characterizes the rate of blowdown in the cooling tower.
\note Blowdown is water intentionally drained from the tower in order to offset the build up
\note of solids in the water that would otherwise occur because of evaporation.
\note Ratio of solids in the blowdown water to solids in the make up water.
\note Typical values for tower operation are 3 to 5. The default value is 3.
A7 , \field Blowdown Makeup Water Usage Schedule Name
\type object-list
\object-list ScheduleNames
\note Makeup water usage due to blowdown results from occasionally draining some amount
\note of water in the tower basin to purge scale or other contaminants to reduce their
\note concentration in order to maintain an acceptable level of water quality.
\note Schedule values should reflect water usage in m3/s.
A8 , \field Supply Water Storage Tank Name
\type object-list
\object-list WaterStorageTankNames
A9 , \field Outdoor Air Inlet Node Name
\type alpha
\note Enter the name of an outdoor air node
N16; \field Sizing Factor
\note Multiplies the autosized capacity and flow rates
\type real
\minimum> 0.0
\default 1.0

```

Field: Name

This alpha field contains the identifying name for the cooling tower.

Field: Water Inlet Node Name

This alpha field contains the identifying name for the cooling tower's water inlet node.

Field: Water Outlet Node Name

This alpha field contains the identifying name for the cooling tower's water outlet node.

Field: Design Water Flow Rate

This numeric field contains the design water flow rate through the tower in m³/s. This value is the flow rate of the condenser loop water being cooled by the tower (not the flow rate of water being sprayed on the outside of the heat exchange coil). If the input field “Performance Input Method” is specified as “UFactorTimesAreaAndDesignWaterFlowRate”, then a water flow rate greater than zero must be defined or the field can be autosized. If autosized, a Plant Sizing object must be defined and the design water flow rate is derived from the design load to be rejected by the condenser loop and the design loop delta T (Ref. Plant Sizing and Input for Design Calculations and Component Autosizing). If “Performance Input Method” is specified as “NominalCapacity”, then this field must be left blank since the model automatically assumes a design water flow rate of 5.382E-8 m³/s per watt (3 gpm/ton) of tower capacity specified in the field “Tower High-Speed Nominal Capacity”.

Field: Air Flow Rate at High Fan Speed

This numeric field contains the tower air flow rate at high fan speed in m³/s. A value greater than zero must be defined regardless of the tower performance input method. Alternately, this field can be autosized. If autosized, the design air flow rate is calculated as follows:

$$\text{Air Flow Rate at High Fan Speed} = \frac{0.5 \rho_{\text{air}} (\text{Fan Power at High Fan Speed})}{190}$$

where a fan pressure rise of 190 Pascals and total fan efficiency of 0.5 are assumed.

Field: Fan Power at High Fan Speed

This numeric field contains the fan power (in Watts) at the high-speed air flow rate specified in the previous field. A value greater than zero must be specified regardless of the tower performance input method, or this field can be autosized. If autosized, the fan power is calculated as follows:

If “Performance Input Method” is specified as “UFactorTimesAreaAndDesignWaterFlowRate”, then

$$\text{Fan power}_{\text{High Fan Speed}} = 0.0105 \cdot \rho_{\text{water}} \cdot C_{p,\text{water}} \cdot \text{Design Water Flow Rate} \cdot \text{Design Loop } \Delta T$$

is used.

If “Performance Input Method” is specified as “NominalCapacity”, then

$$\text{Fan power}_{\text{High Fan Speed}} = 0.0105 \cdot \text{Tower High – Speed Nominal Capacity}$$

is used.

Field: U-Factor Times Area Value at High Fan Speed

This numeric field contains the heat transfer coefficient-area product (UA) in watts per degree Celsius corresponding to the high-speed air flow rate and design water flow rate specified above. If the input field “Performance Input Method” is specified as “UFactorTimesAreaAndDesignWaterFlowRate”, then a UA value greater than zero but less than or equal to 300,000 must be defined, or the field can be autosized. If autosized, a Plant Sizing object must be defined and the tower UA value at high fan speed is derived from the design load to be rejected by the condenser loop and the design loop delta T (Ref. Plant Sizing and Input for Design Calculations and Component Autosizing), assuming a tower water inlet temperature of 35C and tower inlet air at 35C drybulb/25.6C wetbulb. If “Performance Input Method” is specified as “NominalCapacity”, then this field must be left blank since the model automatically calculates the tower UA based on the capacity specified in the field “High-Speed Nominal Capacity”.

Field: Air Flow Rate at Low Fan Speed

This numeric field contains the tower air flow rate at low fan speed in m^3/s . This value must be greater than zero, less than the value specified for the field “Air Flow Rate at High Fan Speed”, and greater than the value specified for the field “Air Flow Rate in Free Convection Regime”. This field may be autosized, in which case it is set to 50% of the “Air Flow Rate at High Fan Speed”.

Field: Fan Power at Low Fan Speed

This numeric field contains the fan power (in Watts) at the low-speed air flow rate specified in the previous field. This value must be specified greater than zero or the field may be autosized, in which case it is set to 16% of the “Fan Power at High Fan Speed”.

Field: U-Factor Times Area Value at Low Fan Speed

This numeric field contains the heat transfer coefficient-area product (UA) in watts per degree Celsius corresponding to the design water flow rate and low-speed air flow rate specified above. If the input field “Performance Input Method” is specified as “UFactorTimesAreaAndDesignWaterFlowRate”, this value must be greater than zero but less than or equal to 300,000, less than the value specified for the field “U-Factor Times Area Value at High Fan Speed”, and greater than the value specified for the field “U-Factor Times Area Value at Free Convection Air Flow Rate”. This field may be autosized, in which case it is set to 60% of the “U-Factor Times Area Value at High Fan Speed”. If “Performance Input Method” is specified as “NominalCapacity”, then this field must be left blank since the model automatically calculates the tower UA based on the tower capacity specified in the field “Low Speed Nominal Capacity”.

Field: Air Flow Rate in Free Convection Regime

This numeric field contains the air flow rate (m^3/s) when the tower is in the “free convection” regime (water flow exists but tower fan is turned off). This value must be less than the value specified for the field “Air Flow Rate at Low Fan Speed”. This field may be autosized, in which case it is set to 10% of the “Air Flow Rate at High Fan Speed”. If the user does not wish to model “free convection” and is using the Performance Input Method “UFactorTimesAreaAndDesignWaterFlowRate”, then this field should be set to 0.0. If the user specifies the U-Factor Times Area Value at Free Convection Air Flow Rate or Free Convection Capacity as a value greater than zero, then the free convection air flow rate must be specified greater than 0.0.

Field: U-Factor Times Area Value at Free Convection Air Flow Rate

This numeric field contains the heat transfer coefficient-area product ($\text{W}/^\circ\text{C}$) when the tower is in the “free convection” regime (water flow exists but tower fan is turned off). This value must be less than the value specified for the field “U-Factor Times Area Value at Low Fan Speed”. This field may be autosized, in which case it is set to 10% of the “U-Factor Times Area Value at High Fan Speed”. If the user does not wish to model “free convection” and is using the Performance Input Method “UFactorTimesAreaAndDesignWaterFlowRate”, then this field should be set to 0.0. If “Performance Input Method” is specified as “NominalCapacity”, then this field must be left blank since the model automatically calculates the tower UA based on the tower capacity specified in the field “Free Convection Capacity”.

Field: Performance Input Method

This alpha field contains the method by which the user will specify tower performance: “UFactorTimesAreaAndDesignWaterFlowRate” or “NominalCapacity”. If this field is left blank in the input data file, the default input method is assumed to be “NominalCapacity”. If the method “UFactorTimesAreaAndDesignWaterFlowRate” is selected, then the user must enter UA values, design water flow rate and air flow rates as described for the previous input fields. If the method “NominalCapacity” is selected then the fields “Design Water Flow Rate”, “U-Factor Times Area Value at High Fan Speed”, “U-Factor Times Area Value at Low Fan

Speed” and “U-Factor Times Area Value at Free Convection Air Flow Rate” must be left blank, but the fields “High Speed Nominal Capacity”, “Low Speed Nominal Capacity” and “Free Convection Capacity” must be entered as described below.

Field: High Speed Nominal Capacity

This numeric input field contains the “nominal” heat rejection capacity of the cooling tower in watts under high-speed fan operation, with entering water at 35C (95F), leaving water at 29.4C (85F), entering air at 25.6C (78F) wetbulb and 35C (95F) drybulb temperatures. The design water flow rate is assumed to be $5.382E-8$ m³/s per watt of high-speed nominal capacity (3 gpm/ton). 125% of this nominal tower capacity gives the actual tower heat rejection at these operating conditions (based on historical assumption that the tower must dissipate 0.25W of compressor heat for every watt of heat removed by the evaporator).

Field: Low Speed Nominal Capacity

This numeric input field contains the “nominal” heat rejection capacity of the cooling tower in watts under low-speed fan operation, with entering water at 35C (95F), leaving water at 29.4C (85F), entering air at 25.6C (78F) wetbulb and 35C (95F) drybulb temperatures. The design water flow rate is assumed to be $5.382E-8$ m³/s per watt of high-speed nominal tower capacity (input field above). 125% of this nominal tower capacity gives the actual tower heat rejection at these operating conditions (based on historical assumption that the tower must dissipate 0.25W of compressor heat for every watt of heat removed by the evaporator). The value specified for this field must be greater than zero but less than the value specified for the field “High-Speed Nominal Capacity”.

Field: Free Convection Capacity

This numeric input field contains the “nominal” heat rejection capacity of the cooling tower in watts when the tower is in the “free convection” regime (water flow exists but tower fan is turned off), with entering water at 35C (95F), leaving water at 29.4C (85F), entering air at 25.6C (78F) wetbulb and 35C (95F) drybulb temperatures. The design water flow rate is assumed to be $5.382E-8$ m³/s per watt of high-speed nominal tower capacity (input field above). 125% of this free convection tower capacity gives the actual tower heat rejection at these operating conditions (based on historical assumption that the tower must dissipate 0.25W of compressor heat for every watt of heat removed by the evaporator). The value specified for this field must be less than the value specified for the field “Tower Low-Speed Nominal Capacity”. If the user does not wish to model “free convection”, then this field should be set to 0.0. If the user specifies a value greater than zero, then the “Air Flow Rate in Free Convection Regime” field must contain a value greater than zero.

Field: Evaporation Loss Mode

This field is used to choose which method is used to model the amount of water evaporated by the cooling tower. There are two options: ‘LossFactor’ or ‘SaturatedExit’. The default is SaturatedExit. The user-defined loss factor is entered in the following field. By assuming that the air leaving the tower is saturated, the evaporation can be directly calculated using moist air engineering calculations with data available within the cooling tower model (and does not require additional user input).

Field: Evaporation Loss Factor

This field is used to specify the rate of water evaporated from the cooling tower and lost to the outside air [percent/K]. This field is only used if the Evaporation Calculation Mode is set to LossFactor. The evaporation loss is then calculated as a fraction of the circulating condenser water flow and varies with the temperature change in the condenser water. The value entered here is in units of percent-per-degree Kelvin. The evaporation rate will equal this value times each degree Kelvin of temperature drop in the condenser water. Typical values are from 0.15 to 0.27 [percent/K]. The default is 0.2.

Field: Drift Loss Percent

This field is used to specify the rate of water lost to the exiting air as entrained droplets [%]. The drift loss is a percent of the condenser water flow. Typical values for towers with efficient drift eliminators are between 0.002 and 0.2% of the condenser water flow rate. The default value is 0.008%.

Field: Blowdown Calculation Mode

This field specifies which method is used to determine blowdown rates. There two options ConcentrationRatio or ScheduledRate. The choice will determine which of the two models below is used. The default is ConcentrationRatio

Field: Blowdown Concentration Ratio

This field is used to dynamically adjust the rate of blowdown in the cooling tower as a function of the rate of evaporation. Blowdown is water intentionally drained from the tower in order to offset the build up of solids in the water that would otherwise occur because of evaporation. The value entered here is dimensionless. It can be characterized as the ratio of solids in the blowdown water to solids in the make up water. Typical values for tower operation are 3 to 5. The default value is 3.

Field: Blowdown Makeup Water Usage Schedule Name

This alpha field contains the name of the schedule used to define the amount of water (m^3/s) flushed from the basin on a periodic basis to purge the tower of mineral scale build-up and other contaminants. This schedule is only used if the Blowdown Calculation mode is set to ScheduledRate. The amount of water use due to blowdown depends on the makeup water quality and is specific to each geographical location. Typical values range from 0.0002 to 0.0013 m^3/s (17.3 to 112.3 m^3/day). This water usage is in addition to the amount of water lost to the atmosphere due to evaporation and/or drift. Since blowdown occurs when the basin water contaminant concentration is high, blowdown only occurs when the cooling tower is active and water is flowing through the tower (regardless of the water usage defined by this schedule).

Field: Supply Water Storage Tank Name

This field is optional. It is used to describe where the tower obtains water used for evaporative cooling. If blank or omitted, then the tower will obtain water directly from the mains. If the name of a WaterUse:Storage object is used here, then the tower will obtain its water from that tank. If a tank is specified, the tower will attempt to obtain all the water it uses from the tank. However if the tank cannot provide all the water the tower needs, then the tower will still operate and obtain the rest of the water it needs from the mains (referred to as 'Starved' water).

Field: Outdoor Air Inlet Node Name

This optional alpha field specifies the outdoor air node name used to define the conditions of the air entering the cooling tower. If this field is left blank, the outdoor air conditions entering the cooling tower are taken directly from the weather data. If this field is not blank, the node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air conditions from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air conditions are taken directly from the weather data.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. Sizing factor allows the user to size a component to meet part of the design load while continuing to

use the autosizing feature. For this component the inputs that would be altered by the sizing factor are:

1. Design Water Flow Rate;
2. Air Flow Rate at High Fan Speed;
3. Fan Power at High Fan Speed;
4. U-Factor Times Area Value at High Fan Speed;
5. Air Flow Rate at Low Fan Speed;
6. Fan Power at Low Fan Speed;
7. U-Factor Times Area Value at Low Fan Speed;
8. Air Flow Rate in Free Convection Regime;
9. U-Factor Times Area Value at Free Convection Air Flow Rate.

Note that the U-Factor Times Area Value at High Fan Speed is not *multiplied* by the Sizing Factor. Instead the design tower load is multiplied by the sizing factor and the design UA then calculated as usual. The U-Factor Times Area Value at Low Fan Speed is set to 60% of the full load design UA. The U-Factor Times Area Value at Free Convection Air Flow Rate is set to 10% of the design Tower UA.

Three examples of an IDF specification for this object are shown below:

```
CoolingTower:TwoSpeed,
  My Tower,                ! Tower name
  Condenser Tower Inlet Node, ! Water inlet node name
  Condenser Tower Outlet Node, ! Water outlet node name
  .0011,                   ! Design water flow rate, m3/s
  16.0,                    ! Air flow rate at high fan speed, m3/s
  10000,                   ! Fan power at high fan speed, W
  3500.,                   ! Tower UA at high fan speed, W/C
  8.0,                     ! Air flow rate at low fan speed, m3/s
  1600,                    ! Fan power at low fan speed, W
  2100.,                   ! Tower UA at low fan speed, W/C
  1.6,                     ! Air flow rate for free convection, m3/s
  350,                     ! Tower UA at free convection air flow, W/C
  UFactorTimesAreaAndDesignWaterFlowRate; ! Tower performance input method
```

```
CoolingTower:TwoSpeed,
  My Tower,                ! Tower name
  Condenser Tower Inlet Node, ! Water inlet node name
  Condenser Tower Outlet Node, ! Water outlet node name
  ,                          ! Design water flow rate, m3/s
  autosize,                 ! Air flow rate at high fan speed, m3/s
  1000,                     ! Fan power at high fan speed, W
  ,                          ! Tower UA at high fan speed, W/C
  autosize,                 ! Air flow rate at low fan speed, m3/s
  160,                      ! Fan power at low fan speed, W
  ,                          ! Tower UA at low fan speed, W/C
  autosize,                 ! Air flow rate for free convection, m3/s
  ,                          ! Tower UA at free convection air flow, W/C
  NominalCapacity,         ! Tower performance input method
  95250.,                  ! Tower high-speed nominal capacity, W
  57150.,                  ! Tower low-speed nominal capacity, W
  9525.;                   ! Tower free convection capacity, W
```

```

CoolingTower:TwoSpeed,
Big Tower1,  !- Tower Name
Condenser Tower 1 Inlet Node,  !- Water Inlet Node Name
Condenser Tower 1 Outlet Node,  !- Water Outlet Node Name
,  !- Design Water Flow Rate {m3/s}
8.0,  !- Design High Speed Air Flow Rate {m3/s}
500,  !- Fan Power at Design High Speed Air Flow Rate {W}
,  !- Tower UA Value at Design High Speed Air Flow Rate {W/K}
4.0,  !- Design Low Speed Air Flow Rate {m3/s}
125,  !- Fan Power at Design Low Speed Air Flow Rate {W}
,  !- Tower UA Value at Design Low Speed Air Flow Rate {W/K}
0.8,  !- Air Flow Rate in Free Convection Regime {m3/s}
,  !- Tower UA Value at Free Convection Air Flow Rate {W/K}
NominalCapacity,  !- Tower Performance Input Method
20000.0,  !- Tower High Speed Nominal Capacity
10000.0,  !- Tower Low Speed Nominal Capacity
2000.0,  !- Tower Free Convection Nominal Capacity
SaturatedExit,  !- Evaporation Loss Mode
,  !- Evaporation Loss Factor [%/C]
0.008 ,  !- Drift Loss Percent
ConcentrationRatio,  !- Blowdown Calculation Mode
3.0,  !- Blowdown Concentration Ratio
,  !- Schedule Name for Makeup Water Usage due to Blowdown
Recovery Tank;  !- Name of Water Storage Tank for Supply

```

Cooling Tower:Two Speed Outputs

```

HVAC,Average,Tower Fan Electric Power [W]
HVAC,Sum,Tower Fan Electric Consumption [J]
Zone,Meter,HeatRejection:Electricity [J]

HVAC,Average,Tower Heat Transfer [W]

HVAC,Average,Tower Water Inlet Temp [C]
HVAC,Average,Tower Water Outlet Temp [C]
HVAC,Average,Tower Water Mass Flow Rate [kg/s]

```

Tower Fan Electric Power [W]

Tower Fan Electric Consumption [J]

These outputs are the electric power input to the tower fans. Consumption is metered on HeatRejection:Electricity, Electricity:Plant, and Electricity:Facility.

Tower Heat Transfer [W]

This is the rate at which heat is removed from the condenser water loop by the tower.

Tower Water Inlet Temp [C]

Tower Water Outlet Temp [C]

Tower Water Mass Flow Rate [kg/s]

These outputs are the tower water inlet and outlet temperatures, and mass flow rate.

Tower Water Make Up Rate [m3/s]

Tower Water Make Up [m3]

These outputs are the water consumed by the wet cooling tower for external water sprays used to augment heat transfer. This is the total of evaporation, drift, and blowdown.

Tower Water Evaporation Rate [m3/s]***Tower Water Evaporation [m3]******Tower Water Drift Rate [m3/s]******Tower Water Drift [m3]******Tower Water Blowdown Rate [m3/s]******Tower Water Blowdown [m3]***

These outputs provide the breakdown of the different components of water use during cooling tower operation.

If a water storage tank is used to provide water to the tower, then the following output variables will also be available.

Tower Water From Storage Tank Rate [m3/s]***Tower Water From Storage Tank [m3]***

These are the rate and volume of water provided by the Water Storage Tank.

Tower Water Starved By Storage Tank Rate [m3/s]***Tower Water Starved By Storage Tank [m3]***

These are the rate and volume of water the Storage Tank connections was not able to provide. The starved water is assumed to come from the mains. The tower's operation is not affected by a lack of storage tank water.

Cooling Tower:Variable Speed

The variable speed tower model is based on empirical curve fits of manufacturer's performance data or field measurements. The user specifies tower performance at design conditions, and empirical curves are used to determine the approach temperature and fan power at off-design conditions. The user defines tower performance by entering the inlet air wet-bulb temperature, tower range, and tower approach temperature at the design conditions. The corresponding water flow rate (within $\pm 25\%$ of the tower's rated water mass flow rate), air flow rate, and fan power must also be specified. The model will account for tower performance in the "free convection" regime, when the tower fan is off but the water pump remains on and heat transfer still occurs (albeit at a low level). Basin heater operation and makeup water usage (due to evaporation, drift, and blowdown) are also modeled.

The cooling tower seeks to maintain the temperature of the water exiting the cooling tower at (or below) a set point. The set point schedule is defined by the field "Condenser Loop Temperature Setpoint Node Name or Reference" for the CondenserLoop object. The model first checks to determine the impact of "free convection" on the tower exiting water temperature. If the exiting water temperature based on "free convection" is at or below the set point, then the variable-speed tower fan is not turned on. If the exiting water temperature is above the set point after "free convection" is modeled, then the variable-speed tower fan is turned on to reduce the exiting water temperature. Tower fan power is calculated based on the tower air flow rate required to achieve the exiting water set point temperature.

Cooling towers here are "wet" and consume water through evaporation, drift, and blowdown. The model can be used to predict water consumed by the towers. The last six input fields are optional and provide methods of controlling details of the water consumption calculations. The user can specify connections to the rest of the buildings water system by providing the name of a WaterUse:Storage object.

The IDD specification for the variable speed cooling tower is given below.


```

CoolingTower:VariableSpeed,
  \min-fields 15
  \memo This tower model is based on purely empirical algorithms derived from manufacturer's
  \memo performance data or field measurements. The user can select from two existing
  \memo algorithms (CoolTools or YorkCalc), or they can enter their own correlation for
  \memo approach temperature by using a variable speed tower model coefficient object.
A1 , \field Name
  \required-field
  \type alpha
  \note Tower Name
A2 , \field Water Inlet Node Name
  \required-field
  \type alpha
  \note Name of tower water inlet node
A3 , \field Water Outlet Node Name
  \required-field
  \type alpha
  \note Name of tower water outlet node
A4 , \field Model Type
  \type choice
  \key CoolToolsCrossFlow
  \key CoolToolsUserDefined
  \key YorkCalc
  \key YorkCalcUserDefined
  \default YorkCalc
  \note Determines the coefficients and form of the equation for calculating
  \note approach temperature
A5 , \field Model Coefficient Name
  \type object-list
  \object-list VariableSpeedTowerCoefficient
  \note Name of the tower model coefficient object.
  \note Used only when tower Model Type is either CoolToolsUserDefined or YorkCalcUserDefined.
N1 , \field Design Inlet Air Wet-Bulb Temperature
  \type real
  \units C
  \default 25.6
  \minimum 20.0
  \note Enter the tower's design inlet air wet-bulb temperature
N2 , \field Design Approach Temperature
  \type real
  \units C
  \default 3.9
  \minimum > 0
  \note Enter the approach temperature corresponding to the design inlet air
  \note wet-bulb temperature and design range temperature.
  \note Design approach temp = outlet water temperature minus inlet air wet-bulb temperature
  \note at design conditions.
N3 , \field Design Range Temperature
  \type real
  \units C
  \default 5.6
  \minimum > 0
  \note Enter the range temperature corresponding to the design inlet air
  \note wet-bulb temperature and design approach temperature.
  \note Design range = inlet water temperature minus outlet water temperature
  \note at design conditions.
N4 , \field Design Water Flow Rate
  \required-field
  \type real
  \units m3/s
  \minimum > 0.0
  \autosizable
  \ip-units gal/min
  \note Water flow rate through the tower at design conditions
N5 , \field Design Air Flow Rate
  \required-field
  \type real
  \units m3/s
  \minimum > 0.0
  \autosizable
  \note Design (maximum) air flow rate through the tower

```

```

N6 , \field Design Fan Power
    \required-field
    \type real
    \units W
    \minimum> 0.0
    \autosizable
    \ip-units W
    \note Enter the fan power at design (max) air flow through the tower
    \note Standard conversion for horsepower is 1 HP = 745.7 W
A6 , \field Fan Power Ratio Function of Air Flow Rate Ratio Curve Name
    \type object-list
    \object-list CubicCurves
    \note  $FPR = a + b*AFR + c*AFR**2 + d*AFR**3$ 
    \note FPR = fraction of the design fan power
    \note AFR = fraction of the design air flow rate
    \note If left blank, then fan power is assumed to be proportional to
    \note (air flow rate ratio)^3
N7 , \field Minimum Air Flow Rate Ratio
    \type real
    \minimum 0.2
    \maximum 0.5
    \default 0.2
    \note Enter the minimum air flow rate ratio. This is typically determined by the variable
    \note speed drive that controls the fan motor speed. Valid entries are from 0.2 to 0.5.
N8 , \field Fraction of Tower Capacity in Free Convection Regime
    \type real
    \minimum 0.0
    \maximum 0.2
    \default 0.125
    \note Enter the fraction of tower capacity in the free convection regime. This is the
    \note fraction of the tower capacity, at the current inlet air wet-bulb temperature,
    \note that is available when the tower fan is off. Manufacturers typically estimate the
    \note free convection capacity at approximately 10-15%. Values are entered as a fraction
    \note and can range from 0 to 0.2.
N9 , \field Basin Heater Capacity
    \type real
    \units W/K
    \minimum 0.0
    \default 0.0
    \note This heater maintains the basin water temperature at the basin heater setpoint
    \note temperature when the outdoor air temperature falls below the setpoint temperature.
    \note The basin heater only operates when water is not flowing through the tower.
N10, \field Basin Heater Setpoint Temperature
    \type real
    \units C
    \minimum 2.0
    \default 2.0
    \note Enter the outdoor dry-bulb temperature when the basin heater turns on
A7 , \field Basin Heater Operating Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note Schedule values greater than 0 allow the basin heater to operate whenever the outdoor
    \note air dry-bulb temperature is below the basin heater setpoint temperature.
    \note If a schedule name is not entered, the basin heater is allowed to operate
    \note throughout the entire simulation.
A8 , \field Evaporation Loss Mode
    \type choice
    \key LossFactor
    \key SaturatedExit
N11, \field Evaporation Loss Factor
    \type real
    \units percent/K
    \note Rate of water evaporated from the cooling tower and lost to the outdoor air [%/K]
    \note Evaporation loss is calculated as percentage of the circulating condenser water rate
    \note Value entered here is percent-per-degree K of temperature drop in the condenser water
    \note Typical values are from 0.15 to 0.27 [percent/K].
    \default 0.2

```

```

N12, \field Drift Loss Percent
      \type real
      \units percent
      \note Rate of drift loss as a percentage of circulating condenser water flow rate
      \note Typical values are between 0.002 and 0.2% The default value is 0.008%
A9 , \field Blowdown Calculation Mode
      \type choice
      \key ConcentrationRatio
      \key ScheduledRate
N13, \field Blowdown Concentration Ratio
      \type real
      \minimum 2.0
      \default 3.0
      \note Characterizes the rate of blowdown in the cooling tower.
      \note Blowdown is water intentionally drained from the tower in order to offset the build up
      \note of solids in the water that would otherwise occur because of evaporation.
      \note Ratio of solids in the blowdown water to solids in the make up water.
      \note Typical values for tower operation are 3 to 5. The default value is 3.
A10, \field Blowdown Makeup Water Usage Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Makeup water usage due to blowdown results from occasionally draining a small amount
      \note of water in the tower basin to purge scale or other contaminants to reduce their
      \note concentration in order to maintain an acceptable level of water quality.
      \note Schedule values should reflect water usage in m3/s.
A11, \field Supply Water Storage Tank Name
      \type object-list
      \object-list WaterStorageTankNames
A12, \field Outdoor Air Inlet Node Name
      \type alpha
      \note Enter the name of an outdoor air node
N14; \field Sizing Factor
      \note Multiplies the autosized capacity and flow rates
      \type real
      \minimum > 0.0
      \default 1.0

```

Field: Name

This alpha field contains the identifying name for the variable speed cooling tower.

Field: Water Inlet Node Name

This alpha field contains the identifying name for the cooling tower's water inlet node.

Field: Water Outlet Node Name

This alpha field contains the identifying name for the cooling tower's water outlet node.

Field: Model Type

This alpha field contains the type of empirical model used to simulate the tower's thermal performance (approach temperature). Valid choices for this field are "CoolToolsCrossFlow", "CoolToolsUserDefined", "YorkCalc", or "YorkCalcUserDefined". "CoolToolsCrossFlow" and "YorkCalc" are empirical models with the equation form and model coefficients already defined within EnergyPlus. If "CoolToolsUserDefined" or "YorkCalcUserDefined" is selected, the user must specify a valid Model Coefficient Name in the next input field to reference an appropriate CoolingTowerPerformance:CoolTools or CoolingTowerPerformance:YorkCalc object. If a user-defined model type is selected and the specified Model Coefficient Name is not found in the input data file (idf), then a severe message is issued and the simulation will terminate.

Field: Model Coefficient Name

This alpha field contains the identifying name for the object(s) CoolingTowerPerformance:CoolTools or CoolingTowerPerformance:YorkCalc . A single model coefficient object may be used to define coefficients for multiple variable speed cooling tower objects (i.e., the same name may be used in this input field for more than one variable

speed tower). This field is only used when the field Tower Model Type described above is set to “CoolToolsUserDefined” or “YorkCalcUserDefined”, and should be left blank otherwise.

Field: Design Inlet Air Wet-Bulb Temperature

This numeric field specifies the inlet air wet-bulb temperature (°C) at design conditions. This design temperature should correspond with the design values for range temperature, approach temperature, water flow rate, and air flow rate specified in the following fields. The minimum value for this field is 20°C and the default value is 25.6°C if this field is left blank.

Field: Design Approach Temperature

This numeric field specifies the tower approach temperature (°C) at design conditions. The approach temperature is the outlet water temperature minus the inlet air wet-bulb temperature. The design approach temperature should correspond with the design values for inlet air wet-bulb temperature, range temperature, water flow rate, and air flow rate specified for this tower. The value for this field must be greater than 0°C and the default value is 3.9°C if this field is left blank.

Field: Design Range Temperature

This numeric field specifies the range temperature (°C) at design conditions. The range temperature is defined as the inlet water temperature minus the outlet water temperature. The design range temperature should correspond with the design values for inlet air wet-bulb temperature, approach temperature, water flow rate, and air flow rate specified for this tower. The value for this field must be greater than 0°C and the default value is 5.6°C if this field is left blank.

Field: Design Water Flow Rate

This numeric field contains the design water flow rate through the tower in m³/s. The value entered should be within ±25% of the tower’s rated water mass flow rate as specified by the manufacturer if Model Type is “CoolToolsCrossFlow” or “YorkCalc”. This constraint may be different for Model Type “CoolToolsUserDefined” or “YorkCalcUserDefined” (ref. CoolingTowerPerformance:CoolTools or CoolingTowerPerformance:YorkCalc).

This value is the flow rate of the condenser loop water being cooled by the tower. A value greater than zero must be specified or this field can be autosized. A Plant Sizing object must be defined if the field is autosized and the design water flow rate is then derived from the design load to be rejected by the condenser loop and the design loop delta T (Ref. Plant Sizing and Input for Design Calculations and Component Autosizing). The design water flow rate should correspond with the design values specified for the inlet air wet-bulb temperature, approach temperature, range temperature, and air flow rate. When this field is not autosized, the condenser loop flow rate specified in other objects should be within ±25% of the tower’s rated water flow rate (different range is permissible if Model Type is “User Defined”).

Field: Design Air Flow Rate

This numeric field contains the design (maximum) air flow rate through the tower in m³/s. A value greater than zero must be specified or this field can be autosized. Autosizing of this field does not require a Plant Sizing object since the design air flow rate is assumed to be the design fan power multiplied by a total fan efficiency of 0.5 and divided by a fan pressure rise of 190 Pascals. A correction for altitude is also included as follows:

$$\text{Design Air Flow Rate} = \frac{0.5(\text{Fan power at Design Air Flow Rate})}{190} \left(\frac{101325}{P_{atm}} \right)$$

Field: Design Fan Power

This numeric field contains the fan power in watts at the design (maximum) air flow rate through the tower. A value greater than zero must be specified or this field can be autosized. If autosized, a Plant Sizing object must be defined and the fan power is calculated as follows:

$$\text{Design fan power} = 0.0105 \cdot \rho_{\text{water}} \cdot C_{p,\text{water}} \cdot \text{Design Water Flow Rate} \cdot \text{Design Loop } \Delta T$$

Field: Fan Power Ratio Function of Air Flow Rate Ratio Curve Name

This alpha field contains the curve object name for fan power ratio (fan power/design fan power) as a function of air flow rate ratio (air flow rate/design air flow rate) [ref. Performance Curves]. The curve object must be a cubic curve and should be normalized to 1.0 at an air flow rate ratio of 1.0. If this field is left blank, a theoretical fan curve is assumed where fan power ratio is directly proportional to the air flow rate ratio cubed.

Field: Minimum Air Flow Rate Ratio

This numeric field contains the minimum air flow rate ratio. The tower fan is allowed to operate between the ratio defined here and a maximum air flow rate ratio of 1.0 (which corresponds to the design [maximum] tower air flow rate). Below this value, the tower is assumed to operate either in the “free convection” regime with the tower fan off, or the tower fan is cycled on/off to maintain the exiting water set point temperature. The minimum air flow rate ratio must be greater than or equal to 0.2 and less than or equal to 0.5, with a default value of 0.2 if the field is left blank.

Field: Fraction of Tower Capacity in Free Convection Regime

This numeric field contains the fraction of tower capacity available in the free convection regime (i.e., when the tower fan is off but water continues to flow through the tower). The tower fan does not operate when the free convection tower capacity is able to meet or exceed the exiting water set point temperature. The air flow rate through the tower in the free convection regime is assumed to be this same fraction of the tower design air flow rate. The fraction of tower capacity in free convection regime must be greater than or equal to 0 and less than or equal to 0.2, with a default value of 0.125 if this field is left blank.

Field: Basin Heater Capacity

This numeric field contains the capacity of the tower’s electric basin heater in watts per degree Kelvin. This field is used in conjunction with the Basin Heater Setpoint Temperature described in the following field. The basin heater electric power is equal to this field multiplied by the difference between the basin heater set point temperature and the outdoor dry-bulb temperature. The basin heater only operates when the tower fan is off and water is not flowing through the tower, regardless of the basin heater schedule described below. The basin heater capacity must be greater than or equal to zero, with a default value of zero if this field is left blank.

Field: Basin Heater Setpoint Temperature

This numeric field contains the set point temperature (°C) for the basin heater described in the previous field. The basin heater is active when the outdoor air dry-bulb temperature falls below this setpoint temperature, as long as the tower fan is off and water is not flowing through the tower. This set point temperature must be greater than or equal to 2°C, and the default value is 2°C if this field is left blank.

Field: Basin Heater Operating Schedule Name

This alpha field contains the name of the basin heater operating schedule. The basin heater operating schedule is assumed to be an on/off schedule and the heater is available to operate any time the schedule value is greater than 0. The basin heater operates when scheduled on and the outdoor air dry-bulb temperature is below the set point temperature

described in the previous field. If this field is left blank, the basin heater is available to operate throughout the simulation. Regardless of this schedule, the basin heater may only operate when the cooling tower fan is off and water is not flowing through the tower.

Field: Evaporation Loss Mode

This field is used to choose which method is used to model the amount of water evaporated by the cooling tower. There are two options: 'LossFactor' or 'SaturatedExit'. The default is SaturatedExit. The user-defined loss factor is entered in the following field. By assuming that the air leaving the tower is saturated, the evaporation can be directly calculated using moist air engineering calculations with data available within the cooling tower model (and does not require additional user input).

Field: Evaporation Loss Factor

This field is used to specify the rate of water evaporated from the cooling tower and lost to the outside air [percent/K]. This field is only used if the Evaporation Calculation Mode is set to LossFactor. The evaporation loss is then calculated as a fraction of the circulating condenser water flow and varies with the temperature change in the condenser water. The value entered here is in units of percent-per-degree Kelvin. The evaporation rate will equal this value times each degree Kelvin of temperature drop in the condenser water. Typical values are from 0.15 to 0.27 [percent/K]. The default is 0.2.

Field: Drift Loss Percent

This numeric field contains the percent (%) of design water flow rate lost to the atmosphere at the design air flow rate due to drift, which is water droplets that are entrained in the airstream as it passes through the tower. Drift is assumed to vary directly with tower air flow rate ratio, and is in addition to the amount of water lost to the atmosphere due to evaporation and/or blowdown. Typical values for water usage due to drift are from 0.05 to 0.2% of the total water circulation rate with currently-available drift eliminators from tower manufacturers. The value entered in this field must be greater than or equal to zero, and the default is zero if the field is left blank.

Field: Blowdown Calculation Mode

This field specifies which method is used to determine blowdown rates. There two options 'ConcentrationRatio' or 'ScheduledRate'. The choice will determine which of the two models below is used. The default is ConcentrationRatio.

Field: Blowdown Concentration Ratio

This field is used to dynamically adjust the rate of blowdown in the cooling tower as a function of the rate of evaporation. Blowdown is water intentionally drained from the tower in order to offset the build up of solids in the water that would otherwise occur because of evaporation. The value entered here is dimensionless. It can be characterized as the ratio of solids in the blowdown water to solids in the make up water. Typical values for tower operation are 3 to 5. The default value is 3.

Field: Blowdown Makeup Water Usage Schedule Name

This alpha field contains the name of the schedule used to define the amount of water (m^3/s) flushed from the basin on a periodic basis to purge the condenser loop of mineral scale build-up and other contaminants. The amount of water use due to blowdown depends on the makeup water quality and is specific to each geographical location. Typical values range from 0.0002 to 0.0013 m^3/s (17.3 to 112.3 m^3/day). This water usage is in addition to the amount of water lost to the atmosphere due to evaporation and/or drift. Since blowdown occurs when the basin water contaminant concentration is high, blowdown only occurs when the cooling tower is active and water is flowing through the tower (regardless of the water usage defined by this schedule).

Field: Supply Water Storage Tank Name

This field is optional. It is used to describe where the tower obtains water used for evaporative cooling. If blank or omitted, then the tower will obtain water directly from the mains. If the name of a WaterUser:Storage object is used here, then the tower will obtain its water from that tank. If a tank is specified, the tower will attempt to obtain all the water it uses from the tank. However if the tank cannot provide all the water the tower needs, then the tower will still operate and obtain the rest of the water it needs from the mains (referred to as 'Starved' water).

Field: Outdoor Air Inlet Node Name

This optional alpha field specifies the outdoor air node name used to define the conditions of the air entering the cooling tower. If this field is left blank, the outdoor air conditions entering the cooling tower are taken directly from the weather data. If this field is not blank, the node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air conditions from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air conditions are taken directly from the weather data.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. Sizing factor allows the user to size a component to meet part of the design load while continuing to use the autosizing feature. For this component the inputs that would be altered by the sizing factor are:

1. Design Water Flow Rate;
2. Design Air Flow Rate;
3. Design Fan Power.

An example IDF specification for this object is shown below:

```
CoolingTower:VariableSpeed,
  Big Tower1, !- Tower Name
  Condenser 1 Inlet Node, !- Water Inlet Node Name
  Condenser 1 Outlet Node, !- Water Outlet Node Name
  YorkCalc, !- Tower Model Type
  , !- Tower Model Coefficient Name
  25.5556, !- Design Inlet Air Wet-Bulb Temperature {C}
  3.8889, !- Design Approach Temperature {C}
  5.5556, !- Design Range Temperature {C}
  0.0015, !- Design Water Flow Rate {m3/s}
  1.6435, !- Design Air Flow Rate {m3/s}
  275, !- Design Fan Power {W}
  FanRatioCurve, !- Fan Power Ratio as a function of Air Flow Rate Ratio Curve Name
  0.2, !- Minimum Air Flow Rate Ratio
  0.125, !- Fraction of Tower Capacity in Free Convection Regime
  450.0, !- Basin Heater Capacity {W/K}
  4.5, !- Basin Heater Set Point Temperature {C}
  BasinSchedule, !- Basin Heater Operating Schedule Name
  SaturatedExit, !- Evaporation Loss Mode
  , !- Evaporation Loss Factor
  0.05, !- Makeup Water Usage due to Drift {&}
  ScheduledRate, !- Blowdown Calculation Mode
  BlowDownSchedule, !- Schedule Name for Makeup Water Usage due to Blowdown
  ; !- Name of Water Storage Tank for Supply
```

Cooling Tower:Variable Speed Outputs

```
HVAC,Average,Tower Fan Electric Power [W]
HVAC,Sum,Tower Fan Electric Consumption [J]
Zone,Meter,HeatRejection:Electricity [J]
```

```

HVAC,Average,Tower Fan Part-Load Ratio

HVAC,Average,Tower Heat Transfer [W]

HVAC,Average,Tower Water Inlet Temp [C]
HVAC,Average,Tower Water Outlet Temp [C]
HVAC,Average,Tower Water Mass Flow Rate [kg/s]

Zone,Meter,Water:Facility [m3]
Zone,Meter,Water:Plant [m3]
Zone,Meter,HeatRejection:Water [m3]
HVAC,Sum,Tower Water Make Up [m3]
Zone,Meter,MainsWater:Plant [m3]
Zone,Meter,HeatRejection:MainsWater [m3]
HVAC,Sum,Tower Water Make Up Mains Draw [m3]
HVAC,Average,Tower Water Evaporation Rate [m3/s]
HVAC,Sum,Tower Water Evaporation [m3]
HVAC,Average,Tower Water Drift Rate [m3/s]
HVAC,Sum,Tower Water Drift [m3]
HVAC,Average,Tower Water Blowdown Rate [m3/s]
HVAC,Sum,Tower Water Blowdown [m3]

HVAC,Average,Tower Air Flow Rate Ratio

IF specified:
HVAC,Average,Tower Basin Heater Electric Power [W]
HVAC,Sum,Tower Basin Heater Electric Consumption [J]

```

Tower Fan Electric Power [W]***Tower Fan Electric Consumption [J]***

These outputs are the electric power input to the tower fan. Consumption is metered on HeatRejection:Electricity, Electricity:Plant, and Electricity:Facility.

Tower Fan Part-Load Ratio

This is the on/off cycling rate of the tower fan when free convection cannot meet the set point temperature and the tower capacity at the minimum air flow rate ratio drives the tower exiting water temperature below the set point temperature. The fan part-load ratio is calculated as the ratio of the exiting water temperature in the free convection regime minus the exiting water temperature set point divided by the exiting water temperature in the free convection regime minus the exiting water temperature at the minimum air flow rate ratio. If tower air flow is at or above the minimum air flow rate ratio, then the tower fan part-load ratio is 1.0.

Tower Heat Transfer [W]

This is the rate at which heat is removed from the condenser water loop by the tower.

Tower Water Inlet Temp [C]***Tower Water Outlet Temp [C]******Tower Water Mass Flow Rate [kg/s]***

These outputs are the tower water inlet and outlet temperatures, and mass flow rate of the circulating condenser water loop.

Tower Air Flow Rate Ratio

This is the ratio of air flow through the tower to the design air flow rate. During times when the tower can maintain the condenser loop set point temperature using free convection (when the fan is not operating), the air flow rate ratio is assumed to be equal to the field Fraction of Tower Capacity in Free Convection Regime. During times when the fan cycles on/off to maintain the outlet water set point temperature, the air flow rate ratio is calculated as the

summation of Fan Part-Load Ratio multiplied by the Minimum Air Flow Rate Ratio and (1.0 - Fan Part-Load Ratio) multiplied by the fraction of Tower Capacity in Free Convection Regime.

Tower Basin Heater Electric Power [W]

Tower Basin Heater Electric Consumption [J]

These outputs are the electric power input to the tower basin heater. Consumption is metered on HeatRejection:Electricity, Electricity:Plant, and Electricity:Facility.

Tower Water Make Up Rate [m3/s]

Tower Water Make Up [m3]

These outputs are the water consumed by the wet cooling tower for external water sprays used to augment heat transfer. This is the total of evaporation, drift, and blowdown.

Tower Water Evaporation Rate [m3/s]

Tower Water Evaporation [m3]

Tower Water Drift Rate [m3/s]

Tower Water Drift [m3]

Tower Water Blowdown Rate [m3/s]

Tower Water Blowdown [m3]

These outputs provide the breakdown of the different components of water use during cooling tower operation.

If a water storage tank is used to provide water to the tower, then the following output variables will also be available.

Tower Water From Storage Tank Rate [m3/s]

Tower Water From Storage Tank [m3]

These are the rate and volume of water provided by the Water Storage Tank.

Tower Water Starved By Storage Tank Rate [m3/s]

Tower Water Starved By Storage Tank [m3]

These are the rate and volume of water the Storage Tank connections was not able to provide. The starved water is assumed to come from the mains. The tower's operation is not affected by a lack of storage tank water.

CoolingTowerPerformance:CoolTools

Variable speed cooling towers can be modeled by EnergyPlus with user-selectable performance based on the CoolTools correlation, YorkCalc correlation, or user-defined coefficients for either the CoolTools or YorkCalc correlations. The empirical CoolTools tower correlation uses a set of 35 coefficients to model the thermal performance (approach temperature) of a cooling tower based on four independent variables. If the user specifies Model Type = CoolToolsCrossFlow in the CoolingTower:VariableSpeed object, then the 35 coefficients derived for the CoolTools simulation model are used and these coefficients are already defined within EnergyPlus. If the user specifies Model Type = CoolToolsUserDefined, then the user must enter a CoolingTowerPerformance:CoolTools object to define the 35 coefficients that will be used by the CoolTools correlation.

The user must specify a name for the model coefficient object, and this name must be used in the CoolingTower:VariableSpeed object (field Model Coefficient Name) to tell the program to use these coefficients. Next, the user enters the minimum and maximum values for inlet air wet-bulb temperature, range temperature, approach temperature, and water mass flow rate

ratio to specify the valid range for which the model coefficients were derived. For all of these variables, the program issues warnings if the actual values are beyond the minimum/maximum values specified. For inlet air wet-bulb temperature and water mass flow rate ratio, the values of these variables used in the calculation of approach temperature are limited to be within the valid minimum/maximum range specified. For approach and range, the warnings are issued if the values are beyond the specified minimum/maximum range but the actual values are still used.

The CoolTools correlation has four independent variables: inlet air wet-bulb temperature (Twb), tower range temperature (Tr), water flow rate ratio (FRwater), and air flow rate ratio (FRair). Temperatures are in units of °C and flow rate ratios are dimensionless (actual flow rate divided by design flow rate). Using these independent variables, tower approach temperature (°C) is calculated as follows:

$$\begin{aligned} \text{Approach} = & \text{Coeff}(1) + \text{Coeff}(2) \cdot \text{FRair} + \text{Coeff}(3) \cdot (\text{FRair})^2 + \\ & \text{Coeff}(4) \cdot (\text{FRair})^3 + \text{Coeff}(5) \cdot \text{FRwater} + \\ & \text{Coeff}(6) \cdot \text{FRair} \cdot \text{FRwater} + \text{Coeff}(7) \cdot (\text{FRair})^2 \cdot \text{FRwater} + \\ & \text{Coeff}(8) \cdot (\text{FRwater})^2 + \text{Coeff}(9) \cdot \text{FRair} \cdot (\text{FRwater})^2 + \\ & \text{Coeff}(10) \cdot (\text{FRwater})^3 + \text{Coeff}(11) \cdot \text{Twb} + \text{Coeff}(12) \cdot \text{FRair} \cdot \text{Twb} + \\ & \text{Coeff}(13) \cdot (\text{FRair})^2 \cdot \text{Twb} + \text{Coeff}(14) \cdot \text{FRwater} \cdot \text{Twb} + \\ & \text{Coeff}(15) \cdot \text{FRair} \cdot \text{FRwater} \cdot \text{Twb} + \text{Coeff}(16) \cdot (\text{FRwater})^2 \cdot \text{Twb} + \\ & \text{Coeff}(17) \cdot (\text{Twb})^2 + \text{Coeff}(18) \cdot \text{FRair} \cdot (\text{Twb})^2 + \\ & \text{Coeff}(19) \cdot \text{FRwater} \cdot (\text{Twb})^2 + \text{Coeff}(20) \cdot (\text{Twb})^3 + \text{Coeff}(21) \cdot \text{Tr} + \\ & \text{Coeff}(22) \cdot \text{FRair} \cdot \text{Tr} + \text{Coeff}(23) \cdot \text{FRair} \cdot \text{FRair} \cdot \text{Tr} + \\ & \text{Coeff}(24) \cdot \text{FRwater} \cdot \text{Tr} + \text{Coeff}(25) \cdot \text{FRair} \cdot \text{FRwater} \cdot \text{Tr} + \\ & \text{Coeff}(26) \cdot (\text{FRwater})^2 \cdot \text{Tr} + \text{Coeff}(27) \cdot \text{Twb} \cdot \text{Tr} + \\ & \text{Coeff}(28) \cdot \text{FRair} \cdot \text{Twb} \cdot \text{Tr} + \text{Coeff}(29) \cdot \text{FRwater} \cdot \text{Twb} \cdot \text{Tr} + \\ & \text{Coeff}(30) \cdot (\text{Twb})^2 \cdot \text{Tr} + \text{Coeff}(31) \cdot (\text{Tr})^2 + \text{Coeff}(32) \cdot \text{FRair} \cdot (\text{Tr})^2 + \\ & \text{Coeff}(33) \cdot \text{FRwater} \cdot (\text{Tr})^2 + \text{Coeff}(34) \cdot \text{Twb} \cdot (\text{Tr})^2 + \text{Coeff}(35) \cdot (\text{Tr})^3 \end{aligned}$$

This object allows the user to specify model coefficients for use with the CoolTools correlation shown above. It is recommended that a broad set of cooling tower performance data be used to generate these model coefficients. The data set used to create the model coefficients should cover the entire range of water and air flow rate ratios and inlet air wet-bulb, range, and approach temperatures expected during the simulation.

The IDD definition is shown below:

```

CoolingTowerPerformance:CoolTools,
  \min-fields 44
  \memo This object is used to define coefficients for the approach temperature
  \memo correlation for a variable speed cooling tower when tower Model Type is
  \memo specified as CoolToolsUserDefined in the object CoolingTower:VariableSpeed.
A1 , \field Name
  \required-field
  \type alpha
  \reference VariableSpeedTowerCoefficient
N1 , \field Minimum Inlet Air Wet-Bulb Temperature
  \required-field
  \type real
  \units C
  \note Minimum valid inlet air wet-bulb temperature for this approach
  \note temperature correlation.
N2 , \field Maximum Inlet Air Wet-Bulb Temperature
  \required-field
  \type real
  \units C
  \note Maximum valid inlet air wet-bulb temperature for this approach
  \note temperature correlation.

```

```

N3 , \field Minimum Range Temperature
    \required-field
    \type real
    \units C
    \note Minimum valid range temperature for this approach temperature
    \note correlation.
N4 , \field Maximum Range Temperature
    \required-field
    \type real
    \units C
    \note Maximum valid range temperature for this approach temperature
    \note correlation.
N5 , \field Minimum Approach Temperature
    \required-field
    \type real
    \units C
    \note Minimum valid approach temperature for this correlation.
N6 , \field Maximum Approach Temperature
    \required-field
    \type real
    \units C
    \note Maximum valid approach temperature for this correlation.
N7 , \field Minimum Water Flow Rate Ratio
    \required-field
    \type real
    \note Minimum valid water flow rate ratio for this approach
    \note temperature correlation.
N8 , \field Maximum Water Flow Rate Ratio
    \required-field
    \type real
    \note Maximum valid water flow rate ratio for this approach
    \note temperature correlation.
N9 , \field Coefficient 1
    \required-field
    \type real

```

-- ALL 35 coefficient fields are required --

Field: Name

This alpha field contains the identifying name for the variable speed cooling tower model coefficients.

Field: Minimum Inlet Air Wet-Bulb Temperature

This numeric field contains the minimum inlet air wet-bulb temperature to be used by the model (approach temperature correlation). Inlet air wet-bulb temperatures less than this value will not be used; instead, the minimum inlet air wet-bulb temperature specified here will be used by the correlation and a warning will be issued.

Field: Maximum Inlet Air Wet-Bulb Temperature

This numeric field contains the maximum inlet air wet-bulb temperature to be used by the model (approach temperature correlation). Inlet air wet-bulb temperatures greater than this value will not be used; instead, the maximum inlet air wet-bulb temperature specified here will be used by the correlation and a warning will be issued.

Field: Minimum Range Temperature

This numeric field contains the minimum range temperature (inlet water temperature minus outlet water temperature) to be used by the empirical model. If the range temperature is less than this value the actual range temperature is still passed to the empirical model but a warning will be issued.

Field: Maximum Range Temperature

This numeric field contains the maximum range temperature (inlet water temperature minus outlet water temperature) to be used by the empirical model. If the range temperature is

greater than this value the actual range temperature is still passed to the empirical model but a warning will be issued.

Field: Minimum Approach Temperature

This numeric field contains the minimum approach temperature (outlet water temperature minus inlet air wet-bulb temperature) to be used by the empirical model. If the calculated approach temperature is less than this value then the calculated value is still used but a warning will be issued.

Field: Maximum Approach Temperature

This numeric field contains the maximum approach temperature (outlet water temperature minus inlet air wet-bulb temperature) to be used by the empirical model. If the calculated approach temperature is greater than this value then the calculated value is still used but a warning will be issued.

Field: Minimum Water Flow Rate Ratio

This numeric field contains the minimum water flow rate ratio (ratio of actual water flow rate to rated water flow rate) to be used by the empirical model. Water flow rate ratios less than this value will not be used; instead, the minimum water flow rate ratio specified here will be used by the model and a warning will be issued.

Field: Maximum Water Flow Rate Ratio

This numeric field contains the maximum water flow rate ratio (ratio of actual water flow rate to rated water flow rate) to be used by the empirical model. Water flow rate ratios greater than this value will not be used; instead, the maximum water flow rate ratio specified here will be used by the model and a warning will be issued.

Field: Coefficient 1 to 35

These numeric fields contain the coefficients to be used by the CoolTools approach temperature correlation shown above.

An example IDF specification for this object is shown below:

```
CoolingTowerPerformance:CoolTools,
CoolTools CrossFlow Default Model, !- Tower Model Coefficient Name
-1.0, !- Minimum Inlet Air Wet-Bulb Temperature {C}
26.6667, !- Maximum Inlet Air Wet-Bulb Temperature {C}
1.1111, !- Minimum Range Temperature {C}
11.1111, !- Maximum Range Temperature {C}
1.1111, !- Minimum Approach Temperature {C}
11.1111, !- Maximum Approach Temperature {C}
0.75, !- Minimum Water Flow Rate Ratio
1.25, !- Maximum Water Flow Rate Ratio
0.52049709836241, !- Coefficient 1
-10.617046395344, !- Coefficient 2
10.7292974722538, !- Coefficient 3
-2.74988377158227, !- Coefficient 4
4.73629943913743, !- Coefficient 5
-8.25759700874711, !- Coefficient 6
1.57640938114136, !- Coefficient 7
6.51119643791324, !- Coefficient 8
1.50433525206692, !- Coefficient 9
-3.2888529287801, !- Coefficient 10
0.0257786145353773, !- Coefficient 11
0.182464289315254, !- Coefficient 12
-0.0818947291400898, !- Coefficient 13
-0.215010003996285, !- Coefficient 14
0.0186741309635284, !- Coefficient 15
```

0.0536824177590012,	!- Coefficient 16
-0.00270968955115031,	!- Coefficient 17
0.00112277498589279,	!- Coefficient 18
-0.00127758497497718,	!- Coefficient 19
0.0000760420796601607,	!- Coefficient 20
1.43600088336017,	!- Coefficient 21
-0.5198695909109,	!- Coefficient 22
0.117339576910507,	!- Coefficient 23
1.50492810819924,	!- Coefficient 24
-0.135898905926974,	!- Coefficient 25
-0.152577581866506,	!- Coefficient 26
-0.0533843828114562,	!- Coefficient 27
0.00493294869565511,	!- Coefficient 28
-0.00796260394174197,	!- Coefficient 29
0.000222619828621544,	!- Coefficient 30
-0.0543952001568055,	!- Coefficient 31
0.00474266879161693,	!- Coefficient 32
-0.0185854671815598,	!- Coefficient 33
0.00115667701293848,	!- Coefficient 34
0.000807370664460284;	!- Coefficient 35

CoolingTowerPerformance:CoolTools

No additional cooling tower report variables are output when this object is used.

CoolingTowerPerformance:YorkCalc

Variable speed cooling towers can be modeled by EnergyPlus with user-selectable performance based on the CoolTools correlation, YorkCalc correlation, or user-defined coefficients for either the CoolTools or YorkCalc correlations. The empirical YorkCalc tower correlation uses a set of 27 coefficients to model the thermal performance (approach temperature) of a variable speed cooling tower based on three independent variables. If the user specifies Tower Model Type = YorkCalc in the CoolingTower:VariableSpeed object, then the 27 coefficients derived for the YorkCalc simulation model are used and these coefficients are already defined within EnergyPlus. If the user specifies Tower Model Type = YorkCalcUserDefined, then the user must enter a CoolingTowerPerformance:YorkCalc object to define the 27 coefficients that will be used by the YorkCalc correlation.

The user must specify a name for the model coefficient object, and this name must be used in the CoolingTower:VariableSpeed object (field Model Coefficient Name) to tell the program to use these coefficients. Next, the user enters the minimum and maximum values for inlet air wet-bulb temperature, range temperature, approach temperature, and water mass flow rate ratio to specify the valid range for which the model coefficients were derived. The user also specifies the maximum valid liquid-to-gas ratio. For all of these variables, the program issues warnings if the actual values are beyond the minimum/maximum values specified. For inlet air wet-bulb temperature and water mass flow rate ratio, the values of these variables used in the calculation of approach temperature are limited to be within the valid minimum/maximum range specified. For approach, range, and liquid-to-gas ratio the warnings are issued if the values are beyond the specified minimum/maximum range but the actual values are still used.

The YorkCalc correlation has three independent variables: inlet air wet-bulb temperature (Twb), tower range temperature (Tr), and the liquid-to-gas ratio (ratio of water flow rate ratio to air flow rate ratio = LGRatio). Temperatures are in units of °C and liquid-to-gas ratio is dimensionless. Using these independent variables, an approach temperature (°C) is calculated as follows:

$$\begin{aligned} \text{Approach} = & \text{Coeff}(1) + \text{Coeff}(2) \cdot \text{Twb} + \text{Coeff}(3) \cdot \text{Twb}^2 + \text{Coeff}(4) \cdot \text{Tr} + \\ & \text{Coeff}(5) \cdot \text{Twb} \cdot \text{Tr} + \text{Coeff}(6) \cdot \text{Twb}^2 \cdot \text{Tr} + \text{Coeff}(7) \cdot \text{Tr}^2 + \\ & \text{Coeff}(8) \cdot \text{Twb} \cdot \text{Tr}^2 + \text{Coeff}(9) \cdot \text{Twb}^2 \cdot \text{Tr}^2 + \text{Coeff}(10) \cdot \text{LGRatio} + \end{aligned}$$

$$\begin{aligned}
& \text{Coeff}(11) \cdot \text{Twb} \cdot \text{LGRatio} + \text{Coeff}(12) \cdot \text{Twb}^2 \cdot \text{LGRatio} + \\
& \text{Coeff}(13) \cdot \text{Tr} \cdot \text{LGRatio} + \text{Coeff}(14) \cdot \text{Twb} \cdot \text{Tr} \cdot \text{LGRatio} + \\
& \text{Coeff}(15) \cdot \text{Twb}^2 \cdot \text{Tr} \cdot \text{LGRatio} + \text{Coeff}(16) \cdot \text{Tr}^2 \cdot \text{LGRatio} + \\
& \text{Coeff}(17) \cdot \text{Twb} \cdot \text{Tr}^2 \cdot \text{LGRatio} + \text{Coeff}(18) \cdot \text{Twb}^2 \cdot \text{Tr}^2 \cdot \text{LGRatio} + \\
& \text{Coeff}(19) \cdot \text{LGRatio}^2 + \text{Coeff}(20) \cdot \text{Twb} \cdot \text{LGRatio}^2 + \\
& \text{Coeff}(21) \cdot \text{Twb}^2 \cdot \text{LGRatio}^2 + \text{Coeff}(22) \cdot \text{Tr} \cdot \text{LGRatio}^2 + \\
& \text{Coeff}(23) \cdot \text{Twb} \cdot \text{Tr} \cdot \text{LGRatio}^2 + \text{Coeff}(24) \cdot \text{Twb}^2 \cdot \text{Tr} \cdot \text{LGRatio}^2 + \\
& \text{Coeff}(25) \cdot \text{Tr}^2 \cdot \text{LGRatio}^2 + \text{Coeff}(26) \cdot \text{Twb} \cdot \text{Tr}^2 \cdot \text{LGRatio}^2 + \\
& \text{Coeff}(27) \cdot \text{Twb}^2 \cdot \text{Tr}^2 \cdot \text{LGRatio}^2
\end{aligned}$$

This object allows the user to specify model coefficients for use with the YorkCalc correlation shown above. It is recommended that a broad set of cooling tower performance data be used to generate these model coefficients. The data set used to create the model coefficients should cover the entire range of water and air flow rate ratios and inlet air wet-bulb, range, and approach temperatures expected during the simulation.

The IDD definition is shown below:

```

CoolingTowerPerformance:YorkCalc
  \min-fields 37
  \memo This object is used to define coefficients for the approach temperature
  \memo correlation for a variable speed cooling tower when tower Model Type is
  \memo specified as YorkCalcUserDefined in the object CoolingTower:VariableSpeed.
A1 , \field Name
  \required-field
  \type alpha
  \reference VariableSpeedTowerCoefficient
N1 , \field Minimum Inlet Air Wet-Bulb Temperature
  \required-field
  \type real
  \units C
  \note Minimum valid inlet air wet-bulb temperature for this approach
  \note temperature correlation.
N2 , \field Maximum Inlet Air Wet-Bulb Temperature
  \required-field
  \type real
  \units C
  \note Maximum valid inlet air wet-bulb temperature for this approach
  \note temperature correlation.
N3 , \field Minimum Range Temperature
  \required-field
  \type real
  \units C
  \note Minimum valid range temperature for this approach temperature
  \note correlation.
N4 , \field Maximum Range Temperature
  \required-field
  \type real
  \units C
  \note Maximum valid range temperature for this approach temperature
  \note correlation.
N5 , \field Minimum Approach Temperature
  \required-field
  \type real
  \units C
  \note Minimum valid approach temperature for this correlation.

```

```

N6 , \field Maximum Approach Temperature
    \required-field
    \type real
    \units C
    \note Maximum valid approach temperature for this correlation.
N7 , \field Minimum Water Flow Rate Ratio
    \required-field
    \type real
    \note Minimum valid water flow rate ratio for this approach
    \note temperature correlation.
N8 , \field Maximum Water Flow Rate Ratio
    \required-field
    \type real
    \note Maximum valid water flow rate ratio for this approach
    \note temperature correlation.
N9 , \field Maximum Liquid to Gas Ratio
    \required-field
    \type real
    \note Maximum liquid (water) to gas (air) ratio for this approach
    \note temperature correlation.
N10, \field Coefficient 1
    \required-field
    \type real
-- All 27 coefficient fields are required. --

```

Field: Name

This alpha field contains the identifying name for the variable speed cooling tower model coefficients.

Field: Minimum Inlet Air Wet-Bulb Temperature

This numeric field contains the minimum inlet air wet-bulb temperature to be used by the model (approach temperature correlation). Inlet air wet-bulb temperatures less than this value will not be used; instead, the minimum inlet air wet-bulb temperature specified here will be used by the correlation and a warning will be issued.

Field: Maximum Inlet Air Wet-Bulb Temperature

This numeric field contains the maximum inlet air wet-bulb temperature to be used by the model (approach temperature correlation). Inlet air wet-bulb temperatures greater than this value will not be used; instead, the maximum inlet air wet-bulb temperature specified here will be used by the model and a warning will be issued.

Field: Minimum Range Temperature

This numeric field contains the minimum range temperature (inlet water temperature minus outlet water temperature) to be used by the empirical model. If the range temperature is less than this value the actual range temperature is still passed to the empirical model but a warning will be issued.

Field: Maximum Range Temperature

This numeric field contains the maximum range temperature (inlet water temperature minus outlet water temperature) to be used by the empirical model. If the range temperature is greater than this value the actual range temperature is still passed to the empirical model but a warning will be issued.

Field: Minimum Approach Temperature

This numeric field contains the minimum approach temperature (outlet water temperature minus inlet air wet-bulb temperature) to be used by the empirical model. If the calculated approach temperature is less than this value then the calculated value is still used but a warning will be issued.

Field: Maximum Approach Temperature

This numeric field contains the maximum approach temperature (outlet water temperature minus inlet air wet-bulb temperature) to be used by the empirical model. If the calculated approach temperature is greater than this value then the calculated value is still used but a warning will be issued.

Field: Minimum Water Flow Rate Ratio

This numeric field contains the minimum water flow rate ratio (ratio of actual water flow rate to rated water flow rate) to be used by the empirical model. Water flow rate ratios less than this value will not be used; instead, the minimum water flow rate ratio specified here will be used by the model and a warning will be issued.

Field: Maximum Water Flow Rate Ratio

This numeric field contains the maximum water flow rate ratio (ratio of actual water flow rate to rated water flow rate) to be used by the empirical model. Water flow rate ratios greater than this value will not be used; instead, the maximum water flow rate ratio specified here will be used by the model and a warning will be issued.

Field: Maximum Liquid to Gas Ratio

This numeric field contains the maximum liquid-to-gas ratio (ratio of actual water flow rate ratio [capped to be within the minimum/maximum water flow rate ratio defined above as necessary] to actual air flow rate ratio) to be used by the empirical model. If the liquid-to-gas ratio is greater than this value the actual liquid to gas ratio is still passed to the empirical model but a warning will be issued.

Field: Coefficient 1 to 27

These numeric fields contain the coefficients to be used by the YorkCalc approach temperature correlation shown above.

An example IDF specification for this object is shown below:

```

CoolingTowerPerformance:YorkCalc
YorkCalc Default Tower Model, !- Tower Model Coefficient Name
  -34.4,                !- Minimum Inlet Air Wet-Bulb Temperature {C}
  26.6667,             !- Maximum Inlet Air Wet-Bulb Temperature {C}
  1.1111,              !- Minimum Range Temperature {C}
  22.2222,             !- Maximum Range Temperature {C}
  1.1111,              !- Minimum Approach Temperature {C}
  40.0,                !- Maximum Approach Temperature {C}
  0.75,                !- Minimum Water Flow Rate Ratio
  1.25,                !- Maximum Water Flow Rate Ratio
  8.0,                 !- Maximum Liquid to Gas Ratio
  -0.359741205,        !- Coefficient 1
  -0.055053608,        !- Coefficient 2
  0.0023850432,        !- Coefficient 3
  0.173926877,         !- Coefficient 4
  -0.0248473764,       !- Coefficient 5
  0.00048430224,       !- Coefficient 6
  -0.005589849456,     !- Coefficient 7
  0.0005770079712,     !- Coefficient 8
  -0.00001342427256,   !- Coefficient 9
  2.84765801111111,    !- Coefficient 10
  -0.121765149,        !- Coefficient 11
  0.0014599242,        !- Coefficient 12
  1.680428651,         !- Coefficient 13
  -0.0166920786,       !- Coefficient 14
  -0.0007190532,       !- Coefficient 15
  -0.025485194448,     !- Coefficient 16

```


0.0000487491696,	!- Coefficient 17
0.00002719234152,	!- Coefficient 18
-0.0653766255555556,	!- Coefficient 19
-0.002278167,	!- Coefficient 20
0.0002500254,	!- Coefficient 21
-0.0910565458,	!- Coefficient 22
0.00318176316,	!- Coefficient 23
0.000038621772,	!- Coefficient 24
-0.0034285382352,	!- Coefficient 25
0.00000856589904,	!- Coefficient 26
-0.000001516821552;	!- Coefficient 27

CoolingTowerPerformance:YorkCalc Outputs

No additional cooling tower report variables are output when this object is used.

FluidCooler: SingleSpeed

Fluid coolers are components that may be assigned to condenser loops. The Fluid cooler is modeled as a cross flow heat exchanger (both streams unmixed) with single-speed fans (induced draft configuration). The user must define fluid cooler performance via one of the two methods: design heat transfer coefficient-area product (UA) and design water flow rate, or nominal fluid cooler capacity at a specific rating point. Regardless of which method is chosen, the design airflow rate and corresponding fan power must be specified.

The fluid cooler seeks to maintain the temperature of the water exiting the fluid cooler at (or below) a set point. The set point schedule value is defined by the field “Condenser Loop Temperature Setpoint Node Name or Reference” for the CondenserLoop object. The model assumes that part-load operation is represented by a simple linear interpolation between two steady-state regimes (i.e., fluid cooler fan on for the entire simulation timestep and fluid cooler fan off for the entire simulation timestep). Cyclic losses are not taken into account.

Field: Name

This alpha field contains the identifying name for the Fluid Cooler.

Field: Water Inlet Node Name

This alpha field contains the identifying name for the Fluid Cooler’s water inlet node.

Field: Water Outlet Node Name

This alpha field contains the identifying name for the Fluid Cooler’s water outlet node.

Field: Performance Input Method

This alpha field contains the method by which the user will specify fluid cooler performance: “UFactorTimesAreaAndDesignWaterFlowRate” or “NominalCapacity”.

Field: U-factor Times Area Value at Design Air Flow Rate

This numeric field contains the heat transfer coefficient-area product (UA) in watts per degree Celsius corresponding to the design air and water flow rates specified above. If the input field “Performance Input Method” is specified as “UFactorTimesAreaAndDesignWaterFlowRate”, then a UA value greater than zero but less than or equal to 300,000 must be defined, or the field can be autosized. If autosized, a Plant Sizing object must be defined and the design fluid cooler UA value is derived from the design load to be rejected by the condenser loop and the design loop delta T (Ref. Plant Sizing and Input for Design Calculations and Component Autosizing), the fluid cooler inlet air dry-bulb and wetbulb temperature are taken from the input. If “Performance Input Method” is specified as “NominalCapacity”, then this field must be left blank since the model automatically calculates the fluid cooler UA based on the fluid cooler capacity and nominal conditions specified in input file.

Field: Nominal Capacity

This numeric input field contains the “nominal” heat rejection capacity of the fluid cooler in watts, Nominal conditions i.e. entering air dry-bulb temperature, entering air wet-bulb temperature, Entering water temperature and leaving water temperature should be provided in the input.

Field: Design Entering Water Temperature

This numeric field contains entering water temperature at nominal conditions.

Field: Design Entering Air Temperature

This numeric field contains entering air dry-bulb temperature at nominal conditions.

Field: Design Entering Air Wet-bulb Temperature

This numeric field contains entering air wetbulb temperature at nominal conditions.

Field: Design Water Flow Rate

This numeric field contains the design water flow rate through the fluid cooler in m^3/s . This value is the flow rate of the condenser loop water being cooled by the fluid cooler. If the input field “Performance Input Method” is specified as “UFactorTimesAreaAndDesignWaterFlowRate”, then a water flow rate greater than zero must be defined or the field can be autosized. If autosized, a Plant Sizing object must be defined and the design water flow rate is derived from the design load to be rejected by the condenser loop and the design loop delta T (Ref. Plant Sizing and Input for Design Calculations and Component Autosizing). If “Performance Input Method” is specified as “NominalCapacity”, then this field must be specified as the flow rate for which the nominal capacity is given.

Field: Design Air Flow Rate

This numeric field contains the design air flow rate induced by the fluid cooler fan in m^3/s . A value greater than zero must be defined regardless of the fluid cooler performance input method. Alternately, this field can be autosized. See Engineering ref. for fluid cooler autosizing.

Field: Fan Power at Design Air Flow Rate

This numeric field contains the fan power (in watts) at the design air flow rate specified in the previous field. A value greater than zero must be specified regardless of the performance input method, or this field can be autosized. See Engineering ref. for fluid cooler autosizing.

Field: Fluid Name

This alpha field contains the fluid name. This name will be validated against Fluid Names (ref: Fluid Properties section below) in the input file.

Field: Fluid Glycol Concentration

This numeric field contains the fluid glycol concentration in percentage.

Field: Outdoor Air Inlet Node Name

This optional alpha field specifies the outdoor air node name used to define the conditions of the air entering the fluid cooler. If this field is left blank, the outdoor air conditions entering the fluid cooler are taken directly from the weather data. If this field is not blank, the node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air conditions from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air conditions are taken directly from the weather data.

The IDD specification for the single-speed Fluid Cooler is given below.

```

Fluidcooler:SingleSpeed,
  \min-fields 9
  \memo This fluidcooler model is based on Merkel's theory, which is also the basis
  \memo for the fluidcooler model in ASHRAE's HVAC1 Toolkit. The closed-circuit Fluid Cooler
  \memo is modeled as a counterflow heat exchanger with a single-speed fan drawing air
  \memo through the fluidcooler (induced-draft configuration).
A1 , \field Name
  \required-field
  \type alpha
  \note fluidcooler name
A2 , \field Water Inlet Node Name
  \required-field
  \type alpha
  \note Name of fluidcooler water inlet node
A3 , \field Water Outlet Node Name
  \required-field
  \type alpha
  \note Name of fluidcooler water outlet node
A4 , \field Performance Input Method
  \type Choice
  \key UAandDesignWaterFlowRate
  \key NominalCapacity
  \default NominalCapacity
  \note User can define fluidcooler thermal performance by specifying the fluidcooler UA
  \note and the Design Air Flow Rate, or by specifying the fluidcooler nominal capacity
N1 , \field U-factor Times Area Value at Design Air Flow Rate
  \type real
  \units W/K
  \minimum> 0.0
  \maximum 2100000.0
  \autosizable
  \note Leave field blank if fluidcooler Performance Input Method is NOMINAL CAPACITY
N2 , \field Nominal Capacity
  \type real
  \units W
  \minimum> 0.0
  \note Nominal fluidcooler capacity
N3 , \field Design Entering Water Temperature
  \type real
  \units C
  \minimum> 0.0
  \ip-units F
N4 , \field Design Entering Air Temperature
  \type real
  \units C
  \minimum> 0.0
  \ip-units F
N5 , \field Design Entering Air Wet-bulb Temperature
  \type real
  \units C
  \minimum> 0.0
  \ip-units F
N6 , \field Design Water Flow Rate
  \type real
  \units m3/s
  \minimum> 0.0
  \autosizable
  \ip-units gal/min
N7 , \field Design Air Flow Rate
  \required-field
  \type real
  \units m3/s
  \minimum> 0.0
  \autosizable
N8 , \field Fan Power at Design Air Flow Rate
  \required-field
  \type real
  \units W
  \minimum> 0.0
  \autosizable
  \ip-units W

```

```

A5, \field Fluid Name
    \note (water, ethylene glycol, etc.)
    \type object-list
    \object-list GlycolConcentrations
    \required-field
    \default water
N9, \field Fluid Glycol Concentration
    \required-field
    \type real
    \units percent
    \minimum 0
    \maximum 100
    \note with the rewrite of fluid properties this parameter is no longer needed
A6 ; \field Outdoor Air Inlet Node Name
    \type alpha
    \note Enter the name of an outdoor air node
    
```

An IDF specification for this object is shown below:

```

Fluidcooler:SingleSpeed,
    Big FLUIDCOOLER1,           !- FLUIDCOOLER Name
    Condenser FLUIDCOOLER 1 Inlet Node, !- Water Inlet Node Name
    Condenser FLUIDCOOLER 1 Outlet Node, !- Water Outlet Node Name
    NominalCapacity,           !- FluidCooler Performance Input Method
    ,                           !- FluidCooler UA Value at Design Air Flow Rate {W/K}
    58601.,                     !- FluidCooler Nominal Capacity {W}
    51.67,                      !- Design Entering Water temperature {C}
    35,                         !- Design Entering Air temperature {C}
    25.6,                       !- Design Entering Air Wet-bulb temperature {C}
    0.001388,                   !- Design Water Flow Rate{m3/s}
    9.911,                      !- Design Air Flow Rate {m3/s}
    autosize,                   !- Fan Power at Design Air Flow Rate {W}
    ethyleneGlycol40Percent,    !- Fluid name
    40;                          !- fluid/glycol concentration {percent}
    
```

Fluidcooler:SingleSpeed Outputs

```

HVAC,Average,Fluid Cooler Fan Electric Power [W]
HVAC,Sum,Fluid Cooler Fan Electric Consumption [J]
Zone,Meter,HeatRejection:Electricity [J]
HVAC,Average,Fluid Cooler Heat Transfer [W]
HVAC,Average,Fluid Cooler Water Inlet Temp [C]
HVAC,Average,Fluid Cooler Water Outlet Temp [C]
HVAC,Average,Fluid Cooler Water Mass Flow Rate [kg/s]
HVAC,Average,Fluid Cooler External Water Use Rate [m3/s]
    
```

Fluid Cooler Fan Electric Power [W]

The electric power consumption of the fluid cooler fans.

Fluid Cooler Fan Electric Consumption [J]

Fan energy use. Consumption is metered on HeatRejection:Electricity, Electricity:Plant, and Electricity:Facility.

Fluid Cooler Heat Transfer [W]

This is the rate at which heat is removed from the condenser water loop by the fluid cooler.

Fluid Cooler Water Inlet Temperature [C]

The loop temperature at the fluid cooler inlet.

Fluid Cooler Water Outlet Temperature [C]

The loop temperature at the fluid cooler outlet.

Fluid Cooler Water Mass Flow Rate [kg/s]

The loop mass flow rate of the circulating condenser water loop.

Fluidcooler:TwoSpeed

The two-speed fluid cooler is modeled in a similar fashion to the single-speed fluid cooler. The fluid cooler is modeled as a cross flow heat exchanger (both stream unmixed) with two-speed fans (induced draft configuration). The user must define fluid cooler performance via one of two methods: heat transfer coefficient-area product (UA) and design water flow rate, or nominal fluid cooler capacity at a specific rating point. Regardless of which method is chosen, the airflow rate and corresponding fan power at both high and low fan speed must be specified. The Fluid Cooler seeks to maintain the temperature of the water exiting the Fluid Cooler at (or below) a set point. The set point schedule is defined by the field “Condenser Loop Temperature Setpoint Node Name or Reference” for the CondenserLoop object. The model first runs at low speed and calculates the fluid cooler exiting water temperature. If the exiting water temperature based on “low speed” is at or below the set point, then the fluid cooler fan runs at this speed or below this speed. If the exiting water temperature remains above the set point after “low speed” is modeled, then the fluid cooler fan runs at high speed to reduce the exiting water temperature.

The model assumes that part-load operation is represented by a simple linear interpolation between two steady-state regimes (i.e., fluid cooler fan at high speed for the entire simulation timestep and fluid cooler fan at low speed for the entire simulation timestep.). Cyclic losses are not taken into account.

Field: Name

This alpha field contains the identifying name for the fluid cooler.

Field: Water Inlet Node Name

This alpha field contains the identifying name for the fluid cooler’s water inlet node.

Field: Water Outlet Node Name

This alpha field contains the identifying name for the fluid cooler’s water outlet node.

Field: Performance Input Method

This alpha field contains the method by which the user will specify fluid cooler performance: “UFactorTimesAreaAndDesignWaterFlowRate” or “NominalCapacity”.

Field: U-factor Times Area Value at High Fan Speed

This numeric field contains the heat transfer coefficient-area product (UA) in watts per degree Celsius corresponding to the high-speed air flow rate and design water flow rate specified above. If the input field “Performance Input Method” is specified as “UFactorTimesAreaAndDesignWaterFlowRate”, then a UA value greater than zero but less than or equal to 300,000 must be defined, or the field can be autosized. If autosized, a Plant Sizing object must be defined and the fluid cooler UA value at high fan speed is derived from the design load to be rejected by the condenser loop and the design loop delta T (Ref. Plant Sizing and Input for Design Calculations and Component Autosizing), fluid cooler water inlet temperature, fluid cooler inlet air drybulb and wetbulb are provided in the input. If “Performance Input Method” is specified as “NominalCapacity”, then this field must be left blank since the model automatically calculates the fluid cooler UA based on the capacity specified in the field “High Speed Nominal Capacity” and nominal conditions.

Field: U-factor Times Area Value at Low Fan Speed

This numeric field contains the heat transfer coefficient-area product (UA) in watts per degree Celsius corresponding to the design water flow rate and low-speed air flow rate specified above. If the input field “Performance Input Method” is specified as “UFactorTimesAreaAndDesignWaterFlowRate”, this value must be greater than zero but less than or equal to 300,000, less than the value specified for the field “U-factor Times Area Value at High Fan Speed”. This field may be autosized, in which case it is set to 60% of the

“U-factor Times Area Value at High Fan Speed”. If “Performance Input Method” is specified as “NominalCapacity”, then this field must be left blank since the model automatically calculates the fluid cooler UA based on the fluid cooler capacity specified in the field “Low Speed Nominal Capacity”.

Field: High Speed Nominal Capacity

This numeric input field contains the “nominal” heat rejection capacity of the fluid cooler in watts under high-speed fan operation, with nominal (design) inputs entering water temperature, leaving water temperature, entering air temperature and entering air wet-bulb temperature. The design water flow rate is also provided in the input.

Field: Low Speed Nominal Capacity

This numeric input field contains the “nominal” heat rejection capacity of the Fluid Cooler in watts under low-speed fan operation, with nominal (design) inputs entering water temperature, leaving water temperature, entering air temperature and entering air wet-bulb temperature. The design water flow rate is also provided in the input. The value specified for this field must be greater than zero but less than the value specified for the field “High Speed Nominal Capacity”.

Field: Design Entering Water Temperature

This numeric field contains entering water temperature at nominal conditions.

Field: Design Entering Air Temperature

This numeric field contains entering air dry-bulb temperature at nominal conditions.

Field: Design Entering Air Wet-bulb temperature

This numeric field contains entering air wet-bulb temperature at nominal conditions.

Field: Design Water Flow Rate

This numeric field contains the design water flow rate through the fluid cooler in m^3/s . This value is the flow rate of the condenser loop water being cooled by the fluid cooler. If the input field “Performance Input Method” is specified as “UFactorTimesAreaAndDesignWaterFlowRate”, then a water flow rate greater than zero must be defined or the field can be autosized. If autosized, a Plant Sizing object must be defined and the design water flow rate is derived from the design load to be rejected by the condenser loop and the design loop delta T (Ref. Plant Sizing and Input for Design Calculations and Component Autosizing). If “Performance Input Method” is specified as “NominalCapacity”, then this field must be specified as the flow rate for which the nominal capacity is given.

Field: Air Flow Rate at High Fan Speed

This numeric field contains the fluid cooler air flow rate at high fan speed in m^3/s . A value greater than zero must be defined regardless of the fluid cooler performance input method. Alternately, this field can be autosized. See Engineering ref. for fluid cooler autosizing.

Field: Fan Power at High Fan Speed

This numeric field contains the fan power (in Watts) at the high-speed air flow rate specified in the previous field. A value greater than zero must be specified regardless of the fluid cooler performance input method, or this field can be autosized. See Engineering ref. for fluid cooler autosizing.

Field: Air Flow Rate at Low Fan Speed

This numeric field contains the fluid cooler air flow rate at low fan speed in m^3/s . This value must be greater than zero, less than the value specified for the field “Air Flow Rate at High

Fan Speed”. This field may be autosized, in which case it is set to 50% of the “Air Flow Rate at High Fan Speed”.

Field: Fan Power at Low Fan Speed

This numeric field contains the fan power (in Watts) at the low-speed air flow rate specified in the previous field. This value must be specified greater than zero or the field may be autosized, in which case it is set to 16% of the “Fan Power at High Fan Speed”.

Field: Fluid Name

This alpha field contains the fluid name. This name will be validated against Fluid Names (ref: Fluid Properties section below) in the input file.

Field: Fluid Glycol Concentration

This numeric field contains the fluid/glycol concentration in percentage.

Field: Outdoor Air Inlet Node Name

This optional alpha field specifies the outdoor air node name used to define the conditions of the air entering the Fluid Cooler. If this field is left blank, the outdoor air conditions entering the Fluid Cooler are taken directly from the weather data. If this field is not blank, the node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air conditions from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air conditions are taken directly from the weather data.

The IDD specification for the two-speed Fluid Cooler is given below.

```
Fluidcooler:TwoSpeed,
  \min-fields 12
  \memo This fluidcooler model is based on Merkel's theory, which is also the basis
  \memo for the fluidcooler model in ASHRAE's HVAC1 Toolkit. The closed-circuit FLUID COOLER
  \memo is modeled as a counterflow heat exchanger with a two-speed fan drawing air
  \memo through the fluidcooler (induced-draft configuration).
A1 , \field Name
  \required-field
  \type alpha
  \note fluidcooler name
A2 , \field Water Inlet Node Name
  \required-field
  \type alpha
  \note Name of fluidcooler water inlet node
A3 , \field Water Outlet Node Name
  \required-field
  \type alpha
  \note Name of fluidcooler water outlet node
A4 , \field Performance Input Method
  \type Choice
  \key UAandDesignWaterFlowRate
  \key NominalCapacity
  \default NominalCapacity
  \note User can define fluidcooler thermal performance by specifying the fluidcooler UA
  \note and the Design Air Flow Rate, or by specifying the fluidcooler nominal capacity
```

```

N1 , \field U-factor Times Area Value at High Fan Speed
    \type real
    \units W/K
    \minimum> 0.0
    \maximum 2100000.0
    \autosizable
    \note Leave field blank if fluidcooler Performance Input Method is NominalCapacity
N2 , \field U-factor Times Area Value at Low Fan Speed
    \type real
    \units W/K
    \minimum> 0.0
    \maximum 300000.0
    \autosizable
    \note Leave field blank if fluidcooler Performance Input Method is NominalCapacity
    \note Low speed fluidcooler UA must be less than high speed fluidcooler UA
    \note Low speed fluidcooler UA must be greater than free convection fluidcooler UA
N3, \field High-Speed Nominal Capacity
    \type real
    \units W
    \minimum> 0.0
    \note Nominal fluidcooler capacity
N4, \field Low-Speed Nominal Capacity
    \type real
    \units W
    \minimum> 0.0
    \note Nominal fluidcooler capacity times (1.25) gives the actual fluidcooler
    \note heat rejection at these operating conditions.
N5 , \field Design Entering Water Temperature
    \type real
    \units C
    \minimum> 0.0
    \ip-units F
N6 , \field Design Entering Air Temperature
    \type real
    \units C
    \minimum> 0.0
    \ip-units F
N7 , \field Design Entering Air Wet-bulb Temperature
    \type real
    \units C
    \minimum> 0.0
    \ip-units F
N8 , \field Design Water Flow Rate
    \type real
    \units m3/s
    \minimum> 0.0
    \autosizable
    \ip-units gal/min
N9 , \field Air Flow Rate at High Fan Speed
    \required-field
    \type real
    \units m3/s
    \minimum> 0.0
    \autosizable
N10 , \field Fan Power at High Fan Speed
    \required-field
    \type real
    \units W
    \minimum> 0.0
    \autosizable
    \ip-units W
N11 , \field Air Flow Rate at Low Fan Speed
    \required-field
    \type real
    \units m3/s
    \minimum> 0.0
    \autosizable
    \note Low speed air flow rate must be less than high speed air flow rate
    \note Low speed air flow rate must be greater than free convection air flow rate

```



```

N12 , \field Fan Power at Low Fan Speed
      \required-field
      \type real
      \units W
      \minimum> 0.0
      \autosizable
      \ip-units W
A5,   \field Fluid Name
      \note (water, ethylene glycol, etc.)
      \type object-list
      \object-list GlycolConcentrations
      \required-field
      \default water
N13, \field Fluid Glycol Concentration
      \required-field
      \type real
      \units percent
      \minimum 0
      \maximum 100
      \note with the rewrite of fluid properties this parameter is no longer needed
A6 ; \field Outdoor Air Inlet Node Name
      \type alpha

```

Examples of an IDF specification for this object are shown below:

```

Fluidcooler:TwoSpeed,
  Big FLUIDCOOLER1,          !- FLUIDCOOLER Name
  Condenser FLUIDCOOLER 1 inlet Node, !- Water Inlet Node Name
  Condenser FLUIDCOOLER 1 Outlet Node, !- Water Outlet Node Name
  NominalCapacity,          !- FluidCooler Performance Input Method
  ,                          !- FluidCooler UA Value at High speed Air Flow Rate {W/K}
  ,                          !- FluidCooler UA Value at low speed Air Flow Rate {W/K}
  58601.,                   !- FluidCooler High speed Nominal Capacity {W}
  28601.,                   !- FluidCooler Low speed Nominal Capacity {W}
  51.67,                    !- Design Entering Water temperature {C}
  40.56,                    !- Design Leaving Water temperature {C}
  35,                       !- Design Entering Air temperature {C}
  25.6,                     !- Design Entering Air Wet-bulb temperature {C}
  0.001388,                 !- Design Water Flow Rate {m3/s}
  9.911,                    !- High speed Air Flow Rate {m3/s}
  autosize,                 !- Fan Power at High speed Air Flow Rate {W}
  autosize,                 !- Low speed Air Flow Rate {m3/s}
  autosize,                 !- Fan Power at low speed Air Flow Rate {W}
  ethyleneGlycol40Percent, !- Fluid name
  40;                       !- fluid/glycol concentration {percent}

```

Fluidcooler:TwoSpeed Outputs

```

HVAC,Average,Fluid cooler Fan Electric Power [W]
HVAC,Sum,Fluid cooler Fan Electric Consumption [J]
Zone,Meter,HeatRejection:Electricity [J]
HVAC,Average,Fluid cooler Heat Transfer [W]
HVAC,Average,Fluid cooler Water Inlet Temp [C]
HVAC,Average,Fluid cooler Water Outlet Temp [C]
HVAC,Average,Fluid cooler Water Mass Flow Rate [kg/s]

```

Fluid Cooler Fan Electric Power [W]

Average fan electric power consumed.

Fluid Cooler Fan Electric Consumption [J]

Total energy used by the fan. Consumption is metered on HeatRejection:Electricity, Electricity:Plant, and Electricity:Facility.

Fluid Cooler Heat Transfer [W]

This is the rate at which heat is removed from the condenser water loop by the fluid cooler.

Fluid Cooler Water Inlet Temperature [C]

Loop temperature at the fluid cooler inlet.

Fluid Cooler Water Outlet Temperature [C]

Loop temperature at the fluid cooler outlet.

Fluid Cooler Water Mass Flow Rate [kg/s]

Loop mass flow rate through the fluid cooler.

GroundHeatExchanger:Vertical

The Energy Plus Ground loop heat exchanger is a condenser component. This serves the condenser supply side in addition to the cooling towers and other condensing components. The following figure shows the Ground Heat Exchanger in the Energy Plus simulation environment.

The heat exchanger response is defined by a G-function. This is a non-dimensional function that is used to calculate the response to square heat pulses of different duration. (This function is not the same as 'G-factors' referred to in the ASHRAE Applications Handbook). This continuous function is specified by a series of data pairs (LNTTS_i, GFNC_i) where,

- LNTTS_i is the non-dimensional time: $\ln(T/T_s)$
- GFNC_i is the G-function value

The G-function is different for each borehole field configuration (i.e. a 4x4 field has a different response than a 80x80 field) and the borehole thermal resistance. It is also dependant on the ratio of borehole spacing to depth. G-function values, for accurate simulation, have to be calculated for each specific heat exchanger design. This can be done using some commercial ground loop heat exchanger design tool and the like. A reference data set, containing examples input data for 1x2, 4x4 and 8x8 configurations and for both standard and thermally enhanced grout, have also been provided. These data are provided as examples only.

Further details of the implementation of this model can be found in:

Murugappan, A. *Implementing Ground Source Heat Pump and Ground Loop Heat Exchanger Models in the EnergyPlus Simulation Environment*. M.S. Thesis, Oklahoma State University, December 2002.

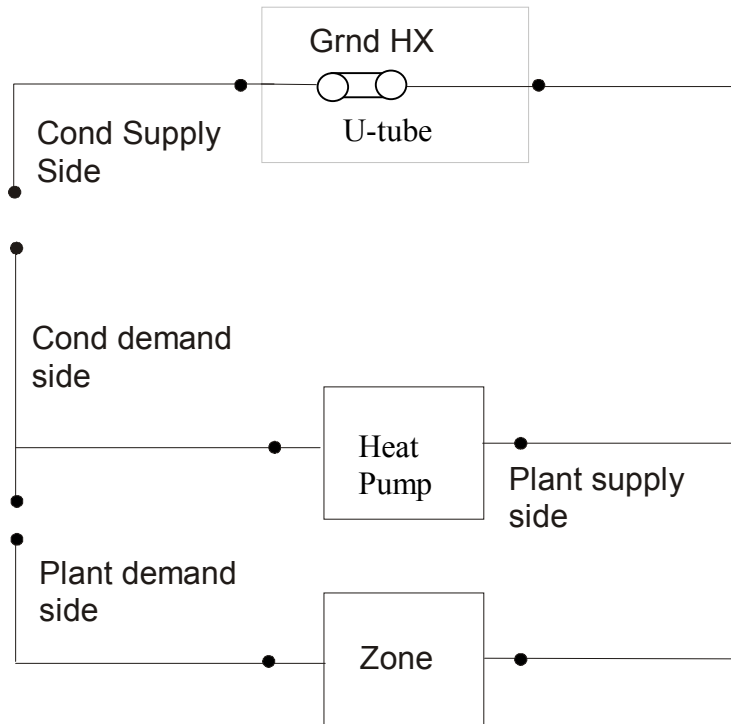


Figure 68. Schematic of EnergyPlus Ground Loop Heat Exchanger

The data definition for the ground loop heat exchanger from the Energy+.idd is shown below. The syntax to the specification of Borehole, U-tube and ground are illustrated in the example following.

```

GroundHeatExchanger:Vertical,
  \min-fields 24
  \memo Variable short time step vertical ground heat exchanger model based on
  \memo Yavuztruk, C., J.D.Spitler. 1999. A Short Time Step response Factor Model for
  \memo Vertical Ground Loop Heat Exchangers
  A1, \field Name
      \required-field
  A2, \field Inlet Node Name
      \required-field
  A3, \field Outlet Node Name
      \required-field
  N1, \field Maximum Flow Rate
      \units m3/s
      \minimum> 0.0
      \ip-units gal/min
  N2, \field Number of Bore Holes
      \minimum> 0.0
  N3, \field Bore Hole Length
      \units m
      \minimum> 0.0
  N4, \field Bore Hole Radius
      \units m
      \minimum> 0.0
  N5, \field Ground Thermal Conductivity
      \units W/m-K
      \minimum> 0.0
  N6, \field Ground Thermal Heat Capacity
      \units J/m3-K
      \minimum> 0.0
    
```

```

N7, \field Fluid Thermal Heat Capacity
    \units J/kg-K
    \minimum> 0.0
    \note same order
N8, \field Ground Temperature
    \units C
    \minimum> 0.0
N9, \field Design Flow Rate
    \units m3/s
    \minimum> 0.0
    \ip-units gal/min
N10, \field Grout Thermal Conductivity
    \units W/m-K
    \minimum> 0.0
N11, \field Pipe Thermal Conductivity
    \units W/m-K
    \minimum> 0.0
N12, \field Fluid Thermal Conductivity
    \units W/m-K
    \minimum> 0.0
N13, \field Fluid Density
    \units kg/m3
    \minimum> 0.0
N14, \field Fluid Viscosity
    \note (Dynamic Viscosity)
    \units N-s/m2
    \minimum> 0.0
N15, \field Pipe Out Diameter
    \units m
    \minimum> 0.0
    \ip-units in
N16, \field U-Tube Distance
    \units m
    \minimum> 0.0
N17, \field Pipe Thickness
    \units m
    \minimum> 0.0
    \ip-units in
N18, \field Maximum Length of Simulation
    \minimum> 0.0
N19, \field Number of Data Pairs of the G Function
    \minimum> 0.0
N20, \field G-Function Ln(T/Ts) Value 1
    \type real
N21, \field G-Function G Value 1
    \type real
--reduced for brevity --

```

Field: Name

This alpha field contains the identifying name for the ground heat exchanger (GHE).

Field: Inlet Node Name

This alpha field contains the ground heat exchanger inlet node name.

Field: Outlet Node Name

This alpha field contains the ground heat exchanger outlet node name.

Field: Maximum Flow Rate

This numeric field contains the GHE maximum design flow rate in cubic meters per seconds.

Field: Number of Bore Holes

This numeric field contains the number of bore holes in the GHE installation.

Field: Bore Hole Length

This numeric field contains the length of the borehole in meters.

Field: Bore Hole Radius

This numeric field contains the radius of the borehole in meters.

Field: Ground Thermal Conductivity

This numeric field contains the thermal conductivity of the ground in W/m-K.

FieldSet: Ground Thermal Heat Capacity

This numeric field contains the thermal heat capacity of the Ground. J/m³-K

Field: Fluid Thermal Heat Capacity

This numeric field contains the specific heat capacity of the U-tube fluid in J/kg-K.

Field: Ground Temperature

This numeric field contains the far field temperature of the ground in °C

Field: Design Flow Rate

This numeric field contains the design volumetric flow rate of the GHE.

Field: Grout Thermal Conductivity

This numeric field contains the thermal conductivity of the filler material in W/m-K.

Field: Pipe Thermal Conductivity

This numeric field contains the thermal conductivity of the pipe in W/m-K.

Field: Fluid Thermal Conductivity

This numeric field contains the thermal conductivity of the U-tube fluid in W/m-K.

Field: Fluid Density

This numeric field contains the density of the U-tube fluid in kilograms per cubic meter.

Field: Fluid Viscosity

This numeric field contains the viscosity of the U-tube fluid in N.s/m².

Field: Pipe Out Diameter

This numeric field contains the outer diameter of the U-tube (pipe) in meters.

Field: U-Tube Distance

This numeric field contains the distance between the two legs of the U-tube in meters.

Field: Pipe Thickness

This numeric field contains the outer diameter of the U-tube (pipe) in meters.

Field: Maximum Length of Simulation

This numeric field contains the maximum number of years of simulation to be carried out.

Field: Number of Data Pairs of the G Function

The borehole response is defined by a non-dimensional 'G-function'. This is specified as a series of data points giving values of non-dimensional time vs G-function value (LNTTS1, GFUNC1), (LNTTS2, GFUNC2), (LNTTS3, GFUNC3) (LNTTS_n, GFUNC_n), This numeric field contains the number of data pairs to be read in (*n*).

Field: G-Function $\ln(T/T_s)$ Value <x>

This numeric field contains the natural log of time/steady state time: $\ln(T/T_s)$

Field: G-Function 'G' Value <x>

This numeric field contains the G-function value of the corresponding LNTTS.

The following is an example input:

```

GroundHeatExchanger:Vertical,
  Vertical Ground Heat Exchanger,  !- Ground Heat Exchanger Name
  GHE Inlet Node,                 !- GHE Inlet Node
  GHE Outlet Node,                !- GHE Outlet Node
  0.00330000,                     !- Max GHE FlowRate {m3/s}
  120,                             !- Number of Boreholes
  76.2,                           !- Bore Hole Length {m}
  .635080E-01,                    !- Bore Hole Radius {m}
  .692626E+00,                    !- K of Ground {W/mK}
  .234700E+07,                    !- rhoCp of Ground {J/m3k}
  .418211E+04,                    !- Cp of Fluid {J/m3k}
  13.375,                         !- Temp. of Ground {C}
  0.0033,                         !- Design GHE Vol Flowrate {m3/s}
  .692626E+00,                    !- K of Grout {W/mK}
  .391312E+00,                    !- K of Pipe {W/mK}
  .602636E+00,                    !- K of Fluid {W/mK}
  9.98200E+02,                    !- Rho of Fluid {Kg/m3}
  9.87958E-04,                    !- Mu of Fluid {N-s/m2}
  2.66667E-02,                    !- Pipe Out Diameter {m}
  2.53977E-02,                    !- U-Tube Distance {m}
  2.41285E-03,                    !- Pipe Thickness {m}
  2,                               !- Maximum length of simulation in years
  35,                             !- Number of data pairs of the G function
  ! The G-function is defined by the following data pairs
  -15.2996, -0.348322, ! LNTTS1, GFNC1
  -14.201,  0.022208, ! LNTTS2, GFNC2
  -13.2202, 0.412345, ! LNTTS3, GFNC3
  -12.2086, 0.867498, ! LNTTS4, GFNC4
  -11.1888, 1.357839, ! LNTTS5, GFNC5
  -10.1816, 1.852024, ! LNTTS6, GFNC6
  -9.1815,  2.345656, ! LNTTS7, GFNC7
  -8.6809,  2.593958, ! LNTTS8, GFNC8
  -8.5,     2.679,    ! etc, etc.
  -7.8,     3.023,
  -7.2,     3.32,
  -6.5,     3.681,
  -5.9,     4.071,
  -5.2,     4.828,
  -4.5,     6.253,
  -3.963,   7.894,
  -3.27,    11.82,
  -2.864,   15.117,
  -2.577,   18.006,
  -2.171,   22.887,
  -1.884,   26.924,
  -1.191,   38.004,
  -0.497,   49.919,
  -0.274,   53.407,
  -0.051,   56.632,
  0.196,    59.825,
  0.419,    62.349,
  0.642,    64.524,
  0.873,    66.412,
  1.112,    67.993,
  1.335,    69.162,

```

1.679,	70.476,	
2.028,	71.361,	
2.275,	71.79,	
3.003,	72.511;	!- 35 PAIRS

GroundHeatExchanger:Pond

The pond heat exchanger model represents a shallow pond with submerged hydronic tubes through which the heat transfer fluid is circulated. The model represents a 'shallow' pond in that no attempt is made to model any stratification effects that may be present in deeper ponds.

This type of heat exchanger is intended to be connected to the supply side of a condenser loop, and can be used with any type of plant loop. The pond may be specified as the only heat exchanger on the condenser loop (as shown in Figure 69) or it may be connected in parallel with other condenser loop heat exchangers (such as cooling towers, ground surface heat exchangers) as shown in the second figure below.

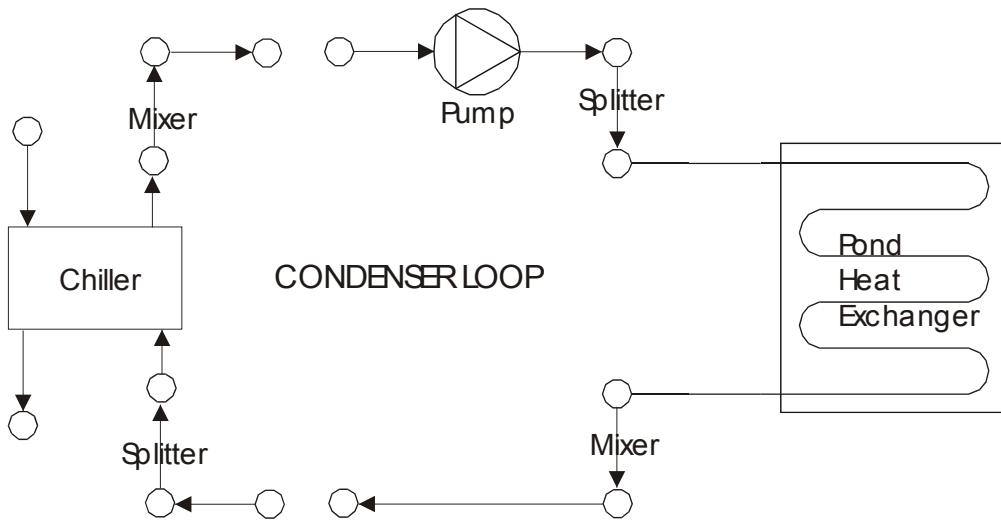


Figure 69. Example of Pond Ground Heat Exchanger as only heat exchanger on condenser loop

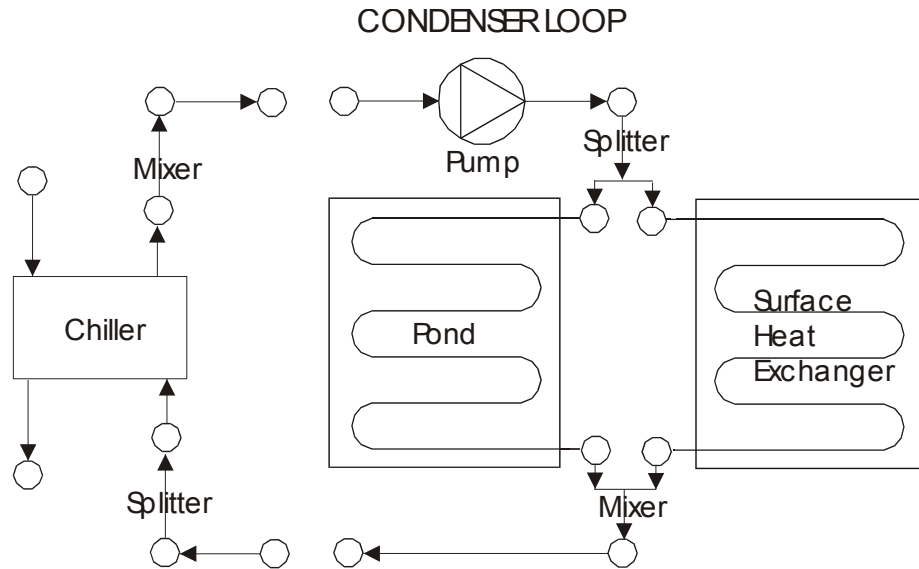


Figure 70. Pond Ground Heat Exchanger with other heat exchangers on condenser loop

Field: Name

This alpha field contains the identifying name for the outside pond heat exchanger.

Field: Fluid Inlet Node Name

This alpha field contains the fluid inlet node name.

Field: Fluid Outlet Node Name

This alpha field contains the fluid outlet node name.

Field: Fluid Name

This alpha field contains the fluid name. This name will be validated against Fluid Names (ref: Fluid Properties section below) in the input file.

Field: Fluid Glycol Concentration

This numeric field contains the fluid/glycol concentration in percentage.

Field: Pond Depth

This numeric field contains the pond depth {m}.

Field: Pond Area

This numeric field contains the pond area {m²}.

Field: Hydronic Tubing Inside Diameter

This numeric field contains the hydronic tubing inside diameter {m}.

Field: Hydronic Tubing Outside Diameter

This numeric field contains the hydronic tubing outside diameter {m}.

Field: Hydronic Tubing Thermal Conductivity

This numeric field contains the hydronic tubing thermal conductivity in W/mK.

Field: Ground Thermal Conductivity

This numeric field contains the ground thermal conductivity in W/m²K.

Field: Number of Tubing Circuits

This numeric field contains the number of hydronic tubing circuits, total in parallel in this pond..

Field: Length of Each Tubing Circuit

This numeric field contains length {m} of each hydronic tubing circuit.

```

GroundHeatExchanger:Pond,
  \memo A model of a shallow pond with immersed pipe loops.
  \memo Typically used in hybrid geothermal systems and included in the condenser loop.
  \memo This component may also be used as a simple solar collector.
A1 , \field Name
    \required-field
A2 , \field Fluid Inlet Node Name
    \type alpha
    \required-field
A3 , \field Fluid Outlet Node Name
    \required-field
    \type alpha
A4 , \field Fluid Name
    \note (Water, ethylene glycol, etc.)
    \type object-list
    \object-list GlycolConcentrations
    \required-field
    \default Water
N1 , \field Fluid Glycol Concentration
    \required-field
    \type real
    \units percent
    \minimum 0
    \maximum 100
    \note with the rewrite of fluid properties this parameter is no longer needed
N2 , \field Pond Depth
    \required-field
    \type real
    \units m
    \minimum> 0
N3 , \field Pond Area
    \required-field
    \type real
    \units m2
    \minimum> 0
N4 , \field Hydronic Tubing Inside Diameter
    \required-field
    \type real
    \units m
    \minimum> 0
    \ip-units in
N5 , \field Hydronic Tubing Outside Diameter
    \required-field
    \type real
    \units m
    \minimum> 0
    \ip-units in
N6 , \field Hydronic Tubing Thermal Conductivity
    \required-field
    \type real
    \units W/m-K
    \minimum> 0

```

```
N7 , \field Ground Thermal Conductivity
      \required-field
      \type real
      \units W/m2-K
      \minimum> 0
N8 , \field Number of Tubing Circuits
      \required-field
      \type integer
      \minimum 1
N9 ; \field Length of Each Tubing Circuit
      \required-field
      \type real
      \units m
      \minimum 0
```

An example of the IDF is shown below.

```
GroundHeatExchanger:Pond,
  Pond 1,
Condenser Tower 1 Inlet Node,      ! Inlet_Node
Condenser Tower 1 Outlet Node,! Outlet_Node
Water,                              ! Fluid Name
0.0,                                ! Concentration
0.5,                                ! Depth
200.0,                              ! Area
0.02,                               ! Tube ID
0.025,                              ! Tube OD
0.4,                                ! Pipe Conductivity
1.0,                                ! Ground Conductivity
10,                                 ! Number of Circuits
50.0;                               ! Length of Each Circuit
```

Pond Heat Exchanger Outputs

```
HVAC,Average,Pond Ground Heat Exchanger Heat Transfer Rate[W]
HVAC,Sum,Pond Ground Heat Exchanger Energy[J]
HVAC,Average,Pond Ground Heat Exchanger Mass Flow Rate[kg/s]
HVAC,Average,Pond Ground Heat Exchanger Inlet Temp[C]
HVAC,Average,Pond Ground Heat Exchanger Outlet Temp[C]
HVAC,Average,Pond Ground Heat Exchanger Bulk Temp[C]
```

Pond Ground Heat Exchanger Heat Transfer Rate [W]

Pond Ground Heat Exchanger Energy [J]

These outputs are the pond ground heat exchanger heat transfer rate and total energy exchange for the timestep.

Pond Ground Heat Exchanger Mass Flow Rate [kg/s]

Pond Ground Heat Exchanger Inlet Temp [C]

Pond Ground Heat Exchanger Outlet Temp [C]

These outputs are the pond fluid inlet and outlet temperatures and mass flow rate.

Pond Ground Heat Exchanger Bulk Temp [C]

This output is the pond bulk temperature.

GroundHeatExchanger:Surface

The surface heat exchanger model is to simulate hydronic surface ground heat exchangers. This includes pavement surfaces with embedded pipes for snow-melting or heat rejection from hybrid ground source heat pump systems.

The heat exchanger may be ground coupled or not. In the latter case the bottom surface is exposed to the wind but not solar gains. This type of heat exchanger is intended to be connected to the supply side of a condenser loop, and can be used with any type of plant loop. The surface heat exchanger may be specified as the only heat exchanger on the condenser loop (as shown in the first figure below) or it may be connected in parallel with other condenser loop heat exchangers (such as cooling towers, ground surface heat exchangers) as shown in the second figure below.

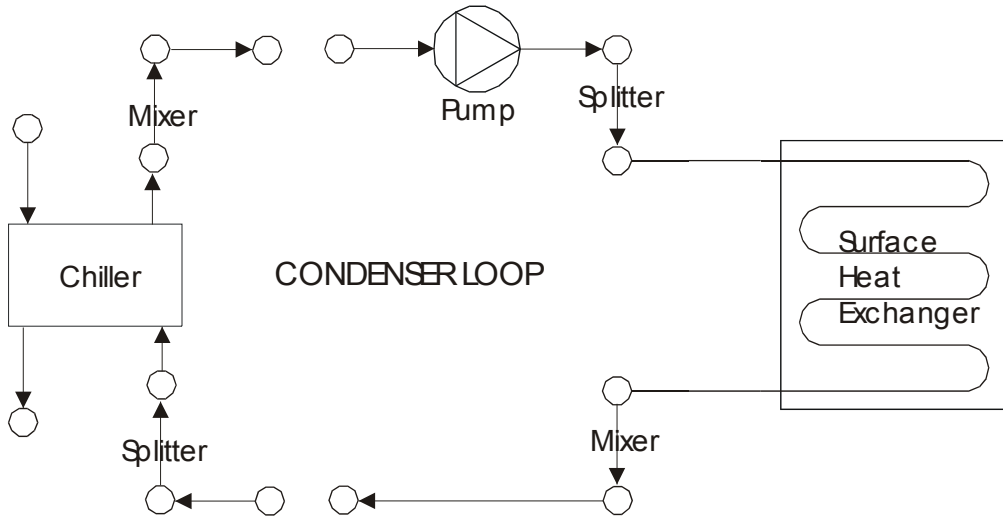


Figure 71. Example of Surface Ground Heat Exchanger as only heat exchanger on condenser loop

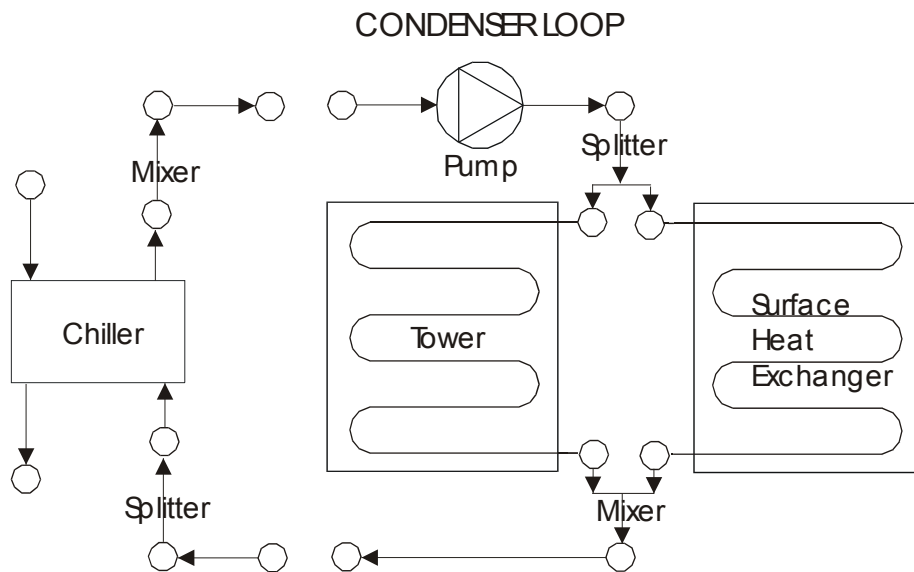


Figure 72. Surface Ground Heat Exchanger with other heat exchangers on condenser loop

Field: Name

This alpha field contains the identifying name for the outside panel heat exchanger.

Field: Construction Name

This alpha field contains the construction name. It must contain a valid "Construction" name that is usual for Surfaces. (Ref: Group – Surface Construction Elements).

Field: Fluid Inlet Node Name

This alpha field contains the fluid inlet node name.

Field: Fluid Outlet Node Name

This alpha field contains the fluid outlet node name.

Field: Fluid Name

This alpha field contains the fluid name. This name will be validated against Fluid Names (ref: Fluid Properties section below) in the input file.

Field: Hydronic Tubing Inside Diameter

This numeric field contains the hydronic tubing inside diameter in m.

Field: Number of Tubing Circuits

This numeric field contains the number of hydronic tubing circuits.

Field: Hydronic Tube Spacing

This numeric field contains the hydronic tube spacing in m.

Field: Surface Length

This numeric field contains the surface length in m.

Field: Surface Width

This numeric field contains the surface width in m.

Field: Lower Surface Environment

This alpha field expresses the lower surface exposure: Exposed or Ground.

```

GroundHeatExchanger:Surface,
    \memo A hydronic surface/panel consisting of a multi-layer construction with embedded rows of
tubes.
    \memo Typically used in hybrid geothermal systems and included in the condenser loop.
    \memo This component may also be used as a simple solar collector.
    \memo The bottom surface may be defined as ground-coupled or exposed to wind (eg. bridge deck).
A1 , \field Name
    \required-field
A2 , \field Construction Name
    \required-field
    \type object-list
    \object-list ConstructionNames
A3 , \field Fluid Inlet Node Name
    \type alpha
    \required-field
A4 , \field Fluid Outlet Node Name
    \required-field
    \type alpha
A5, \field Fluid Name
    \note (Water, ethylene glycol, etc.)
    \type object-list
    \object-list GlycolConcentrations
    \required-field
    \default Water
N1 , \field Hydronic Tubing Inside Diameter
    \type real
    \units m
    \minimum> 0
    \ip-units in

```

```

N2 , \field Number of Tubing Circuits
    \type integer
    \minimum 1
N3 , \field Hydronic Tube Spacing
    \type real
    \units m
    \minimum> 0.0
N4 , \field Surface Length
    \type real
    \units m
    \minimum> 0.0
N5 , \field Surface Width
    \type real
    \units m
    \minimum> 0.0
A6 ; \field Lower Surface Environment
    \type choice
    \key Ground
    \key Exposed
    \default Ground

```

An example of this statement in an IDF is shown below:

```

GroundHeatExchanger:Surface,
SURFACE 1,
Outside Surface Construction,
Condenser Tower 1 Inlet Node,      ! Inlet_Node
Condenser Tower 1 Outlet Node,! Outlet_Node
Water,                             ! Fluid Name
0.02,                              ! Tube ID
10.0,                              ! Tube Circuits
0.3,                               ! Tube Spacing
10.0,                              ! Surface Length
20.0,                              ! Surface Width
Exposed;                          ! Lower Surface Environment

```

Surface Heat Exchanger Outputs

```

HVAC,Average,Surface Ground Heat Exchanger Heat Transfer Rate[W]
HVAC,Average,Surface Ground Heat Exchanger Surface Heat Transfer Rate[W]
HVAC,Sum,Surface Ground Heat Exchanger Energy[J]
HVAC,Average,Surface Ground Heat Exchanger Mass Flow Rate[kg/s]
HVAC,Average,Surface Ground Heat Exchanger Inlet Temp[C]
HVAC,Average,Surface Ground Heat Exchanger Outlet Temp[C]
HVAC,Average,Surface Ground Heat Exchanger Top Surface Temp[C]
HVAC,Average,Surface Ground Heat Exchanger Bottom Surface Temp[C]
HVAC,Average,Surface Ground Heat Exchanger Top Surface Flux [J/m2]
HVAC,Average,Surface Ground Heat Exchanger Bottom Surface Flux[J/m2]
HVAC,Sum,Surface Ground Heat Exchanger Surface Energy[J]
HVAC,Average,Surface Ground Heat Exchanger Source Temp[C]

```

Surface Ground Heat Exchanger Heat Transfer Rate [W]

Surface Ground Heat Exchanger Surface Heat Transfer Rate [W]

Surface Ground Heat Exchanger Energy [J]

These outputs are the source heat transfer rate, surface heat transfer rate and the total source energy input for the timestep.

Surface Ground Heat Exchanger Mass Flow Rate [kg/s]

Surface Ground Heat Exchanger Inlet Temp [C]

Surface Ground Heat Exchanger Outlet Temp [C]

These outputs are the surface heat exchanger fluid inlet and outlet temperatures and mass flow rate.

Surface Ground Heat Exchanger Top Surface Temp [C]**Surface Ground Heat Exchanger Bottom Surface Temp [C]**

These outputs are the surface heat exchanger top and bottom surface temperatures.

Surface Ground Heat Exchanger Top Surface Flux [J/m²]**Surface Ground Heat Exchanger Bottom Surface Flux [J/m²]**

These outputs are the surface heat exchanger top and bottom surface flux.

Surface Ground Heat Exchanger Surface Energy [J]

This is the total surface energy exchange for the timestep.

Surface Ground Heat Exchanger Source Temp [C]

This is the surface heat exchanger source temperature.

HeatExchanger:Hydronic

This component is intended to be used in a condenser loop to simulate the effect of coupling the condenser and plant loops directly. For example, to bypass a chiller and couple the chilled water loop to the condenser loop so that the chilled water loop uses a cooling tower as its cooling source. This component is accordingly connected to both plant and condenser water loops (in a similar way to a chiller). The component acts to switch on and off the specified chiller/heat pump according to specified criteria (either a setpoint schedule, outside drybulb or wetbulb temperatures). The heat exchanger may be operated either in ideal or UA-effectiveness mode. In the UA-effectiveness mode the actual heat transfer between loops is calculated according to the UA-effectiveness method assuming counter flow. In ideal mode the maximum possible heat transfer is calculated. In this case, if both fluids are the same type and the loop flow rates are the same, operation is if the loops are directly coupled.

The specified plant component (chiller) is switched off and coupling enabled when either the drybulb, wetbulb or condenser loop temperature falls below the scheduled temperature. Any setpoint schedule can be specified. The usual way to operate a chiller would be to specify the schedule the same as the chilled water loop temperature and operate in 'loop' mode. In this way the loops would be connected when condenser water was available at or below the chilled water temperature.

The data definition for the free cooling heat exchanger from the Energy+.idd is shown below.

```
HeatExchanger:Hydronic,
    \memo A fluid/fluid heat exchanger designed to couple the plant loop to the condenser loop.
    \memo May be set as an ideal heat exchanger to emulate complete coupling of the loops.
    \memo May also be used as a 'real' heat exchanger using an U-Factor Times Area-Effectiveness
model.
    \memo For controlled free cooling a component on another branch (e.g. chiller) can
    \memo be switched on/off.
A1 , \field Name
    \required-field
A2 , \field Controlled Component Name
    \required-field
    \type alpha
A3 , \field Controlled Component Object Type
    \required-field
    \type alpha
```

```

A4 , \field Setpoint Schedule Name
      \type alpha
A5 , \field Condenser Inlet Node Name
      \type alpha
      \required-field
A6 , \field Condenser Outlet Node Name
      \type alpha
      \required-field
A7 , \field Plant Inlet Node Name
      \type alpha
      \required-field
A8 , \field Plant Outlet Node Name
      \type alpha
      \required-field
A9 , \field Condenser Loop Fluid Name
      \type object-list
      \object-list GlycolConcentrations
      \required-field
      \default Water
A10, \field Plant Loop Fluid Name
      \type object-list
      \object-list GlycolConcentrations
      \required-field
      \default Water
A11, \field Free Cooling Control Mode
      \type choice
      \required-field
      \key WetBulbTemperature
      \key DryBulbTemperature
      \key Schedule
      \key Loop
      \default Loop
A12, \field Heat Exchanger Setpoint Schedule Name
      \type alpha
A13, \field Heat Exchange Mode
      \type choice
      \required-field
      \key Ideal
      \key UFactorTimesAreaEffectiveness
      \default Ideal
N1 , \field U-Factor Times Area Value
      \type real
      \units W/K
      \minimum> 0.0
N2 , \field Condenser Side Flow Rate
      \type real
      \minimum> 0.0
      \units m3/s
      \ip-units gal/min
N3 , \field Plant Side Flow Rate
      \type real
      \minimum> 0.0
      \units m3/s
      \ip-units gal/min
A14, \field Controlled Component Condenser Inlet Node Name
      \type alpha
      \required-field
A15, \field Controlled Component Condenser Outlet Node Name
      \type alpha
      \required-field
A16, \field Controlled Component Plant Inlet Node Name
      \type alpha
      \required-field
A17, \field Controlled Component Plant Outlet Node Name
      \type alpha
      \required-field

```

Field: Name

This alpha field contains the unique identifying name of this component.

Field: Controlled Component Name

This alpha field contains the unique identifying name of the component under the control of the heat exchanger (e.g. the corresponding chiller).

Field: Controlled Component Object Type

This alpha field contains the 'type' of the component under the control of the heat exchanger (e.g. Chiller:ConstantCOP).

Field: Setpoint Schedule Name

This alpha field contains the name of the setpoint schedule that is being used to control the heat exchanger.

Field: Condenser Inlet Node Name

This alpha field contains the name of the inlet node on the condenser loop.

Field: Condenser Outlet Node Name

This alpha field contains the name of the outlet node on the condenser loop.

Field: Plant Inlet Node Name

This alpha field contains the name of the inlet node on the plant loop.

Field: Plant Outlet Node Name

This alpha field contains the name of the outlet node on the plant loop.

Field: Condenser Loop Fluid Name

This alpha field contains the name of the fluid used in the condenser loop. The default is **Water**. This fluid name must be the same as defined in the loop specification and its data must be available from the input file.

Field: Plant Loop Fluid Name

This alpha field contains the name of the fluid used in the plant loop. The default is **Water**. This fluid name must be the same as defined in the loop specification and its data must be available from the input file.

Field: Free Cooling Control Mode

This alpha field determines the control mode. Free cooling (coupling) is enabled depending on the comparison of the scheduled temperature with the temperature defined here (drybulb, wetbulb or condenser loop). For example, specifying outside wetbulb here, free cooling would be enabled if the wetbulb temperature fell below the scheduled temperature. Options are: **DryBulbTemperature**, **WetBulbTemperature**, **Schedule**, or **Loop**. The default is Loop.

Field: Heat Exchanger Setpoint Schedule Name

This alpha field contains the name of the setpoint schedule for the heat exchanger.

Field: Heat Exchange Mode

The heat exchanger can operate as either an ideal heat exchanger (the max possible energy is transferred across the loops) or as specified by the UA and effectiveness. The options are correspondingly **Ideal** and **UFactorTimesAreaEffectiveness**. Effectiveness is calculated assuming counter-flow. The default is Ideal.

Field: U-Factor Times Area Value

This numerical field is used to specify the overall UA {W/K} for use in the calculation of actual heat transfer when in UFactorTimesAreaEffectiveness mode.

Field: Condenser Side Flow Rate

This numerical field is used to specify the design flow rate {m³/s} of this component on the condenser side. This would normally be the same as the loop/cooling tower flow rate.

Field: Plant Side Flow Rate

This numerical field is used to specify the design flow rate {m³/s} of this component on the plant side. This would normally be the same as the loop/chiller flow rate.

Field: Controlled Component Condenser Inlet Node Name

This alpha field contains the name of the inlet node on the condenser loop for the component being controlled by the heat exchanger.

Field: Controlled Component Condenser Outlet Node Name

This alpha field contains the name of the outlet node on the condenser loop for the component being controlled by the heat exchanger.

Field: Controlled Component Plant Inlet Node Name

This alpha field contains the name of the inlet node on the plant loop for the component being controlled by the heat exchanger.

Field: Controlled Component Plant Outlet Node Name

This alpha field contains the name of the outlet node on the plant loop for the component being controlled by the heat exchanger.

An example of the model's input from an idf file is shown below.

```
HeatExchanger:Hydronic,
  Free Cooler,                ! component name
  Main Chiller,               ! controlled component
  Chiller:ConstantCOP,       ! controlled component type
  CW Loop Temp Schedule,     ! controlled component setpoint schedule
  Free Cooler Condenser Inlet Node,  !- Condenser Inlet Node Name
  Free Cooler Condenser Outlet Node, !- Condenser Outlet Node Name
  Free Cooler Inlet Node,    !- Chilled Water Inlet Node Name
  Free Cooler Outlet Node,   !- Chilled Water Outlet Node Name
  Water,                     ! Condenser loop fluid name (water, glycol, etc.)
  Water,                     ! plant loop fluid name (water, ethylene glycol, etc.)
  Loop,                      ! Free cooling control mode
                              ! (outside wetbulb, outside drybulb, setpoint schedule)
  Free Cooling Schedule,     ! This schedule name is no longer used
  Ideal,                    ! Heat exchange mode
  150000.0, !100.0,         ! Heat exchanger UA
  0.0086,                   ! Heat exchanger condenser side design flow rate.
  0.0086,                   ! Heat exchanger plant side design flow rate.
  Main Chiller Condenser Inlet Node, !- Controlled equipment condenser side inlet node
  Main Chiller Condenser Outlet Node, !- Controlled equipment condenser side outlet node
  Main Chiller Inlet Node,    !- Controlled equipment plant side inlet node
  Main Chiller Outlet Node;  !- Controlled equipment plant side outlet node  HEAT
```

HeatExchanger:Hydronic Outputs

```
HVAC,Average,Free Cooling Heat Exchanger Heat Transfer Rate[W]
HVAC,SUM,Free Cooling Heat Exchanger Heat Transfer Energy[J]
HVAC,Average,Free Cooling Heat Exchanger Condenser Side Mass Flow rate[kg/s]
HVAC,Average,Free Cooling Heat Exchanger Plant Side Mass Flow rate[kg/s]
HVAC,Average,Free Cooling Heat Exchanger Condenser Side Inlet Temp[C]
HVAC,Average,Free Cooling Heat Exchanger Condenser Side Outlet Temp[C]
HVAC,Average,Free Cooling Heat Exchanger Plant Side Inlet Temp[C]
HVAC,Average,Free Cooling Heat Exchanger Plant Side Outlet Temp[C]
HVAC,Sum,Debug Free Cooling Heat Exchanger Coupling Status[]
```

Free Cooling Heat Exchanger Heat Transfer Rate [W]

The heat transfer rate between the plant and condenser loops via the heat exchanger.

Free Cooling Heat Exchanger Heat Transfer Energy [J]

The heat transfer energy between the plant and condenser loops via the heat exchanger in Joules. This is on Metered on EnergyTransfer with an End Use of FreeCooling.

Free Cooling Heat Exchanger Condenser Side Mass Flow rate [kg/s]***Free Cooling Heat Exchanger Plant Side Mass Flow rate [kg/s]***

The flow rates in each loop.

Free Cooling Heat Exchanger Condenser Side Inlet Temp[C]***Free Cooling Heat Exchanger Condenser Side Outlet Temp[C]******Free Cooling Heat Exchanger Plant Side Inlet Temp[C]******Free Cooling Heat Exchanger Plant Side Outlet Temp[C]***

The inlet and outlet temperatures on each side of the component.

HeatExchanger:Plate

This component is intended to couple two condenser loops, so that the effect of connecting heating/cooling equipments in series in a branch can be achieved, as is the case required by some hybrid systems. The component is connected to the supply side of one condenser loop and to the demand side of the second condenser loop. The coupling and uncoupling of two loops is achieved based on control equipment defined in the input file. The heat exchanger can be a single component on a branch or can be connected to any other condenser equipment. The heat transfer is calculated as in the case of hydronic free cooling heat exchanger. The figure below shows a typical hybrid system, which uses a Plate heat exchanger to couple two condenser loops.

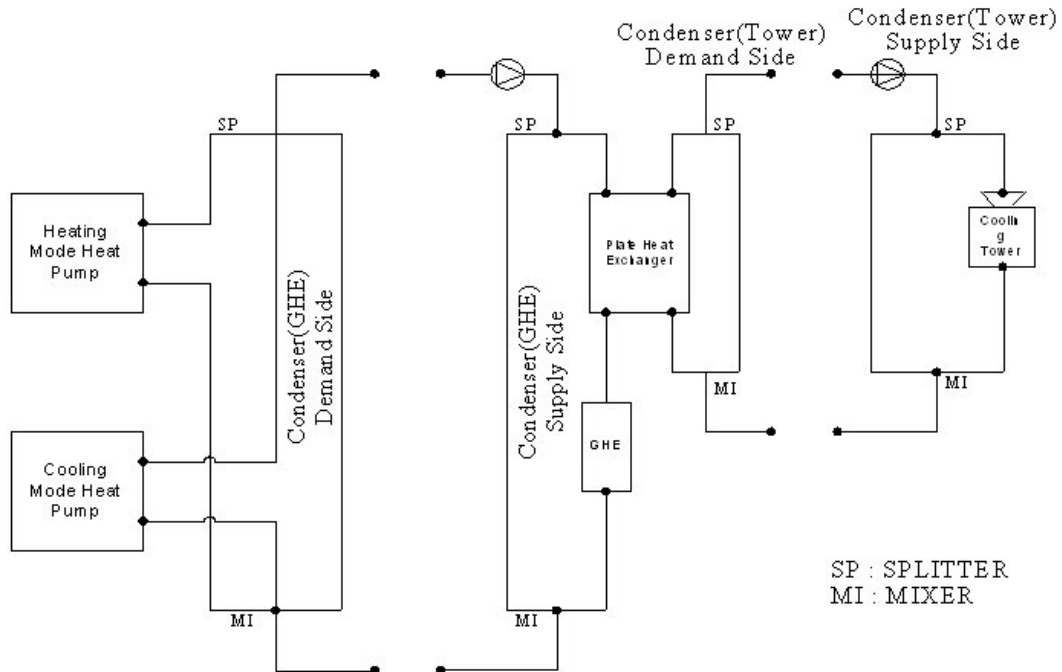


Figure 73. Plate Heat Exchanger (hybrid)

The data definition for the plate cooling heat exchanger from the Energy+.idd is shown below.

```
HeatExchanger:Plate,
  \memo A fluid/fluid heat exchanger designed to couple one condenser loop to another condenser
loop.
  \memo May be set as an ideal heat exchanger to emulate complete coupling of the loops.
  \memo May also be used as a 'real' heat exchanger using an U-Factor Times Area-Effectiveness
model.
  \memo For controlled free cooling a component in series (e.g. chiller) can be switched on/off.
  A1 , \field Name
  \type alpha
  \required-field
  A2 , \field Controlled Component Name
  \type alpha
  \required-field
  A3 , \field Controlled Component Object Type
  \type alpha
  \required-field
  A4 , \field Demand Side Inlet Node Name
  \type alpha
  \required-field
  A5 , \field Demand Side Outlet Node Name
  \type alpha
  \required-field
  A6 , \field Supply Side Inlet Node Name
  \type alpha
  \required-field
  A7 , \field Supply Side Outlet Node Name
  \type alpha
  \required-field
  A8, \field Demand Side Loop Fluid Name
  \type object-list
  \object-list GlycolConcentrations
  \required-field
  \default Water
```

```

A9, \field Supply Side Loop Fluid Name
    \type object-list
    \object-list GlycolConcentrations
    \required-field
    \default Water
A10, \field Heat Exchange Mode
    \type choice
    \required-field
    \key Ideal
    \key UFactorTimesAreaEffectiveness
    \default Ideal
N1 , \field U-Factor Times Area Value
    \type real
    \minimum> 0.0
N2 , \field Demand Side Flow Rate
    \type real
    \minimum> 0.0
    \units m3/s
    \ip-units gal/min
N3 ; \field Supply Side Flow Rate
    \type real
    \minimum> 0.0
    \units m3/s
    \ip-units gal/min

```

Field: Name

This alpha field contains the unique identifying name of this component.

Field: Controlled Component Name

This alpha field is the name of the component, which allows the plate heat exchanger to decide whether the loops have to be coupled or not. If this component is ON, the loops are coupled else the loops are uncoupled.

Field: Controlled Component Object Type

This alpha field tells the type of the component with the name given in the previous field.

Field: Demand Side Inlet Node Name

This alpha field contains the name of the inlet node on the condenser demand side connected to the heat exchanger.

Field: Demand Side Outlet Node Name

This alpha field contains the name of the outlet node on the condenser demand side connected to the heat exchanger.

Field: Supply Side Inlet Node Name

This alpha field contains the name of the inlet node on the Condenser supply side connected to the heat exchanger.

Field: Supply Side Outlet Node Name

This alpha field contains the name of the outlet node on the Condenser supply side connected to the heat exchanger.

Field: Demand Side Loop Fluid Name

This alpha field contains the name of the fluid used in the Demand side of heat exchanger. The default is **Water**. This fluid name must be the same as defined in the loop specification and its data must be available from the input file.

Field: Supply Side Loop Fluid Name

This alpha field contains the name of the fluid used in the Supply side of heat exchanger. The default is **Water**. This fluid name must be the same as defined in the loop specification and its data must be available from the input file.

Field: Heat Exchange Mode

The heat exchanger can operate as either an ideal heat exchanger (the max possible energy is transferred across the loops) or as specified by the UA and effectiveness. The options are correspondingly **Ideal** and **UFactorTimesAreaEffectiveness**. Effectiveness is calculated assuming counter-flow. The default is Ideal.

Field: U-Factor Times Area Value

This numerical field is used to specify the overall UA for use in the calculation of actual heat transfer when in UFactorTimesAreaEffectiveness mode.

Field: Demand Side Flow Rate

This numerical field is used to specify the design flow rate of this component on the Demand side. This would normally be the same as the loop/cooling tower flow rate.

Field: Supply Side Flow Rate

This numerical field is used to specify the design flow rate of this component on the Supply side. This would normally be the same as the loop flow rate.

An example of the model's input from an idf file is shown below.

```
HeatExchanger:Plate,
  Plate Heat Exchanger,      !- Name of free cooling heat exchanger
  Cooling Tower,            !- Controlled component name
  CoolingTower:SingleSpeed, !- Controlled component type
  PHE Demand Inlet Node,    !- Condenser Side fluid Inlet Node
  PHE Demand Outlet Node,   !- Condenser Side fluid Outlet Node
  PHE Supply Inlet Node,    !- Plant side fluid inlet node
  PHE Supply Outlet Node,   !- Plant side fluid outlet node
  Water,                    !- Condenser loop fluid name (water, ethylene glycol, etc.)
  Water,                    !- plant loop fluid name (water, ethylene glycol, etc.)
  UFactorTimesAreaEffectiveness, !- Heat exchange mode
  571,                      !- UA
  0.000505,                 !- condenser side flow rate {m3/s}
  0.000505;                 !- plant side flow rate {m3/s}
```

HeatExchanger:Plate Outputs

```
HVAC,Average,Plate Heat Exchanger Heat Transfer Rate[W]
HVAC,Average, Plate Heat Exchanger Demand Side Mass Flow rate[kg/s]
HVAC,Average, Plate Heat Exchanger Supply Side Mass Flow rate[kg/s]
HVAC,Average, Plate Heat Exchanger Demand Side Inlet Temp[C]
HVAC,Average, Plate Heat Exchanger Demand Side Outlet Temp[C]
HVAC,Average, Plate Heat Exchanger Supply Side Inlet Temp[C]
HVAC,Average, Plate Heat Exchanger Supply Side Outlet Temp[C]
```

Plate Heat Exchanger Heat Transfer Rate [W]

The heat transfer rate between the loops connected via the heat exchanger.

Plate Heat Exchanger Demand Side Mass Flow rate [kg/s]**Plate Heat Exchanger Supply Side Mass Flow rate [kg/s]**

The flow rates in each loop.

Plate Heat Exchanger Demand Side Inlet Temp[C]**Plate Heat Exchanger Demand Side Outlet Temp[C]****Plate Heat Exchanger Supply Side Inlet Temp[C]****Plate Heat Exchanger Supply Side Outlet Temp[C]**

The inlet and outlet temperatures on each side of the component.

HeatExchanger:WatersideEconomizer

The heat exchanger model designed primarily to support the simulation of plant waterside economizers, but is also suitable for other plant applications. Three types of heat exchangers can be selected: 1.) Plate frame, 2.) Single pass counter-flow and 3.) Single pass parallel-flow. The heat transfer rate is calculated using the UA-effectiveness method. An appropriate effectiveness-NTU correlation is used for each type of heat exchanger. The maximum possible heat transfer rate can be used in the simulation by specifying an **Ideal** heat exchanger. For this case an effectiveness of 1.0 is used.

The data definition for the water-to-water heat exchanger is shown below.

```
HeatExchanger:WatersideEconomizer,
    \memo A fluid/fluid heat exchanger designed to model plant waterside economizers
    \min-fields 13
A1 , \field Name
    \required-field
A2 , \field Heat Exchanger Type
    \type choice
    \required-field
    \key PlateFrame
    \key CounterFlow
    \key ParallelFlow
    \key Ideal
A3 , \field Availability Schedule Name
    \note default is that heat exchanger is on
    \type object-list
    \object-list ScheduleNames
A4 , \field Chilled Water Inlet Node Name
    \type alpha
    \required-field
A5 , \field Chilled Water Outlet Node Name
    \type alpha
    \required-field
A6 , \field Condenser Inlet Node Name
    \type alpha
    \required-field
A7 , \field Condenser Outlet Node Name
    \type alpha
    \required-field
A8, \field Chilled Water Loop Fluid Name
    \type object-list
    \object-list GlycolConcentrations
    \required-field
    \default Water
A9 , \field Condenser Loop Fluid Name
    \type object-list
    \object-list GlycolConcentrations
    \required-field
    \default Water
```

```

N1 , \field Chilled Water Side Maximum Flow Rate
    \type real
    \required-field
    \minimum> 0.0
    \units m3/s
    \ip-units gal/min
    \autosizable
N2 , \field Condenser Side Maximum Flow Rate
    \type real
    \required-field
    \minimum> 0.0
    \units m3/s
    \ip-units gal/min
    \autosizable
N3, \field Heat Exchanger U-Factor Times Area Value
    \type real
    \required-field
    \units W/k
    \minimum> 0.0
    \autosizable
N4 ; \field Minimum Temperature Difference to Activate Heat Exchanger
    \note Minimum temp difference between chilled water side heat exchanger inlet and condenser
    \note side heat exchanger inlet required to turn on heat exchanger.
    \type real
    \minimum> 0.0
    \maximum 50
    \default 0.001
    \units deltaC

```

Field: Name

This alpha field contains the unique identifying name of this component.

Field: Heat Exchanger Type

This alpha field identifies the type of heat exchanger. Heat exchanger type is specified by one of the following key words:

PlateFrame: specifies a plate-frame heat exchanger. The effectiveness will be calculated using a plate frame heat exchanger correlation. Currently this type of heat exchanger is approximated as cross flow with both streams unmixed

CounterFlow: specifies a counter-flow shell and tube heat exchanger. The effectiveness will be calculated using a counter-flow shell and tube heat exchanger correlation.

ParallelFlow: specifies a parallel-flow shell and tube heat exchanger. The effectiveness will be calculated using a parallel-flow shell and tube heat exchanger correlation.

Ideal: specifies an ideal heat exchanger. The effectiveness will be set to '1.0' and the specified UA will be ignored. The heat transfer rate will be calculated as the maximum possible heat transfer rate.

Field: Availability Schedule Name

Name of the availability schedule for this heat exchanger.

Field: Chilled Water Inlet Node Name

This alpha field contains the name of the heat exchanger inlet node connected to chilled water . In typical water side economizer applications this is the Plant loop.

Field: Chilled Water Outlet Node Name

This alpha field contains the name of the heat exchanger outlet node connected to chilled water . In typical water side economizer applications this is the Plant loop.

Field: Condenser Inlet Node Name

This alpha field contains the name of the heat exchanger inlet node connected to the condenser . In typical water side economizer applications this is the Condenser loop.

Field: Condenser Outlet Node Name

This alpha field contains the name of the heat exchanger outlet node connected to the condenser . In typical water side economizer applications this is the Condenser loop.

Field: Chilled Water Loop Fluid Name

This alpha field contains the Fluid circulating in Chilled Water Loop. The default is Water.

Field: Condenser Loop Fluid Name

This alpha field contains the Fluid circulating in the Condenser Loop. For air cooled condenser this field has to be set to Air. The default is Water.

Field: Chilled Water Side Maximum Flow Rate

This numerical field is used to specify the design (maximum) flow rate {m³/s} for the side of the heat exchanger connected to chilled water loop.

Field: Condenser Side Maximum Flow Rate

This numerical field is used to specify the design (maximum) flow rate {m³/s} for the side of the heat exchanger connected to the Condenser Loop.

Field: Heat Exchanger U-Factor Times Area Value

This numerical field is used to specify the overall U-Factor Times Area (UA) {W/K} for use in the calculation of the heat exchanger effectiveness using the appropriate Δ-NTU correlation. If **Ideal** is specified as the heat exchanger type, the effectiveness will be set to 1.0. When set to autosize Heat Exchanger U-Factor Times Area Value is calculated based on an effectiveness of 1.0

Field: Minimum Temperature Difference to Activate Heat Exchanger

This numerical field is the minimum temperature difference between chilled water side heat exchanger inlet and condenser side heat exchanger inlet required to turn on heat exchanger.

An example of the model's input from an idf file is shown below.

```
HeatExchanger:WatersideEconomizer,
    Integrated Economizer HX,           !- Heat Exchanger Name
    CounterFlow,                       !- Heat Exchanger Type
    AirCooled,                         !- Heat Exchanger Condenser Type
    CW Pump Outlet Node,               !- Loop1 Inlet Node Name
    Economizer Outlet Node,           !- Loop1 Outlet Node Name
    ,                                   !- Loop2 Inlet Node Name
    ,                                   !- Loop2 Outlet Node Name
    Water,                             !- Loop1 Fluid Name
    Air,                               !- Loop2 Fluid Name
    autosize,                          !- Loop1 Max Flow rate
    autosize,                          !- Loop2 Max Flow rate
    150000.0;                          !- HX UA Value
```

HeatExchanger:WatersideEconomizer Outputs

```
HVAC,Average, Economizer Heat Exchanger Heat Transfer Rate[W]
HVAC,SUM, Economizer Heat Exchanger Heat Transfer Energy[J]
HVAC,Average, Economizer Heat Exchanger Condenser Side Mass Flow rate[kg/s]
HVAC,Average, Economizer Heat Exchanger Plant Side Mass Flow rate[kg/s]
HVAC,Average, Economizer Heat Exchanger Condenser Side Inlet Temp[C]
HVAC,Average, Economizer Heat Exchanger Condenser Side Outlet Temp[C]
HVAC,Average, Economizer Heat Exchanger Plant Side Inlet Temp[C]
HVAC,Average, Economizer Heat Exchanger Plant Side Outlet Temp[C]
```

Economizer Heat Exchanger Heat Transfer Rate [W]

The heat transfer rate between the plant and condenser loops via the heat exchanger.

Economizer Heat Exchanger Heat Transfer Energy [J]

The heat transfer energy between the plant and condenser loops via the heat exchanger in Joules. This is on Metered on EnergyTransfer with an End Use of FreeCooling.

Economizer Heat Exchanger Condenser Side Mass Flow rate [kg/s]***Economizer Heat Exchanger Plant Side Mass Flow rate [kg/s]***

The flow rates in each loop.

Economizer Heat Exchanger Condenser Side Inlet Temp[C]***Economizer Heat Exchanger Condenser Side Outlet Temp[C]******Economizer Heat Exchanger Plant Side Inlet Temp[C]******Economizer Heat Exchanger Plant Side Outlet Temp[C]***

The inlet and outlet temperatures on each side of the component.

Group – Plant-Condenser Flow Control

The connector list described earlier determines how the branches of a particular loop will be hooked together. These connections can be classified either as a separation of a single stream into several outlet streams (splitter) or the merging of several streams into a single outlet stream (mixer). Due to the limitation per branch of a single splitter and a single mixer, the connector list can only have two pieces of equipment as a maximum. The names defined for either/both the splitter or/and the mixer refer then to “component” definitions as described below.

Connector:Splitter, Connector:Mixer

```
Connector:Splitter,
\min-fields 3
  \extensible:1 Just duplicate last field and \ comments (changing numbering, please)
  \memo Split one air/water stream into N outlet streams. Branch names cannot be duplicated
  \memo within a single Splitter list.
A1, \field Name
    \required-field
A2, \field Inlet Branch Name
    \required-field
    \type object-list
    \object-list Branches
A3, \field Outlet Branch 1 Name
    \required-field
    \type object-list
    \object-list Branches
A4, \field Outlet Branch 2 Name
    \type object-list
    \object-list Branches
reduced for brevity, object is extensible
```

```

Connector:Mixer,
  \min-fields 3
  \extensible:1 Just duplicate last field and \ comments (changing numbering, please)
  \memo Mix N inlet air/water streams into one. Branch names cannot be duplicated within
  \memo a single mixer list.
A1 , \field Name
  \required-field
A2 , \field Outlet Branch Name
  \required-field
  \type object-list
  \object-list Branches
A3 , \field Inlet Branch 1 Name
  \required-field
  \type object-list
  \object-list Branches
A4 , \field Inlet Branch 2 Name
  \type object-list
  \object-list Branches
reduced for brevity, object is extensible

```

The format of both the **Connector:Splitter** and **Connector:Mixer** statements is similar. Both begin with an identifying name followed by the branch name of the “single side” of the component. In the case of the splitter, this is the inlet since the inlet stream is broken into several outlet streams. In the case of the mixer, this is the outlet since several streams are mixed together to form a single outlet. The remaining list of up to 50 names is simply the branch names of the outlet legs in the case of the splitter and inlet legs in the case of the mixer. No control logic is assume in these components—a determination of how much air to split in which direction using the splitter must be defined by other components.

Connector:Splitter

Field: Name

This alpha field contains the identifying name for the Splitter.

Field: Inlet Branch Name

This alpha field contains the identifying name for the Splitter Inlet Branch.

Field: Outlet Branch <x> Name

This alpha field contains the identifying names for the Splitter Outlet Branches and you enter as many outlet branches as needed.

Connector:Mixer

Field: Name

This alpha field contains the identifying name for the Mixer.

Field: Outlet Branch Name

This alpha field contains the identifying name for the Mixer Outlet Branch.

Field: Inlet Branch <x> Name

This alpha field contains the identifying names for the Mixer Inlet Branches and you enter as many inlet branch names as needed..

An example of these statements in an IDF is:

```
Connector:Splitter,  
    CW Loop Splitter,  
    CW Pump Branch,  
    Little Chiller Branch,  
    Big Chiller Branch,  
    Purchased Cooling Branch,  
    Supply Bypass Branch;  
Connector:Mixer,  
    CW Loop Mixer,  
    Cooling Supply Outlet,  
    Little Chiller Branch,  
    Big Chiller Branch,  
    Purchased Cooling Branch,  
    Supply Bypass Branch;
```

TemperingValve

This object is used for special cases where plant flow control is needed to make efficient use of thermal storage. In certain solar hot water and heat recovery situations, a thermal storage tank may become warmer than is necessary or allowable for safe use of the hot water. Although real installations of a tempering, or anti-scald valve, would more commonly mix a new stream of mains water with the hot water to achieve a desired outlet temperature, this is difficult to model directly within EnergyPlus because plant loops need to be closed circuits. For many installations where the water entering the splitter is directly from the mains, such as make up water entering a water heater tank, the modeling provided with this object should be thermodynamically equivalent.

The TemperingValve object models a temperature-controlled diversion valve. It models a valve on a bypass pipe that can open to divert flow around one or more plant components. It can only be used on one of two branches between a Splitter and a Mixer. The figure below shows the use of the tempering valve with a Water Heater:Mixed component on "Stream 2." The tempering valve acts to divert flow through the branch it is on in order to adjust the temperature at the outlet of the mixer. If the temperature at Stream 2 Source Node is warmer than the setpoint and the inlet flow is cooler than the setpoint, then a controller determines how much flow should bypass the storagew tank to achieve the desired setpoint.

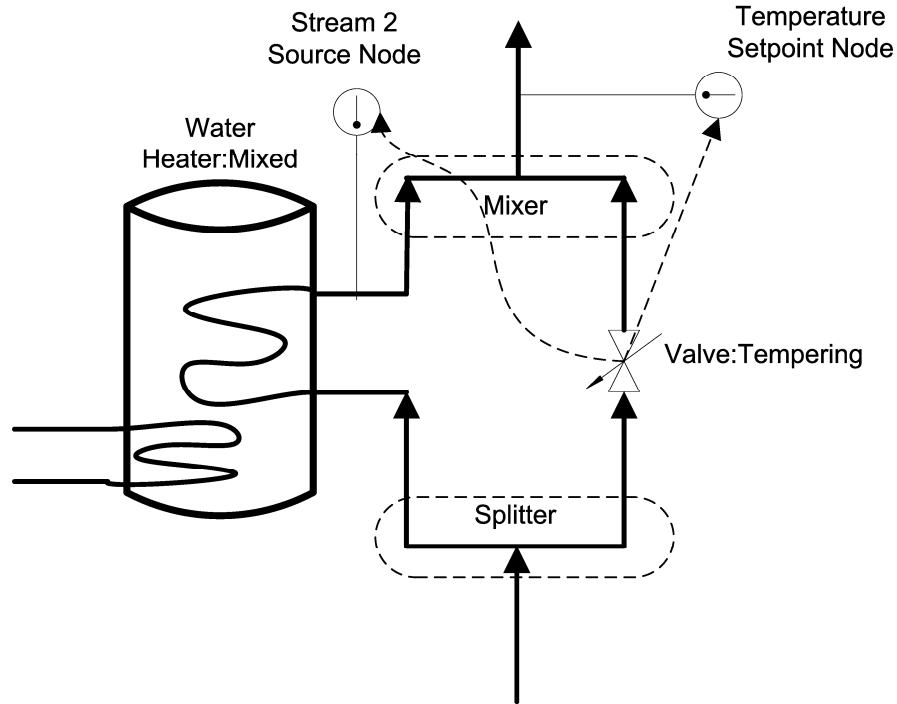


Figure 74. Tempering Valve Schematic

The TemperingValve is an **Active** component and the other path should have only **Passive** components. Only two paths in the splitter/mixer can be used; bypasses are not allowed. No other Connector:Splitter and Connector:Mixer pair can be used on the supply side of the plant loop.

Field: Name

This field should contain an unique name for each TemperingValve object

Field: Inlet Node Name

This field should contain the name of node which is the inlet for the valve.

Field: Outlet Node Name

This field should contain the name of node which is the outlet for the valve

Field: Stream 2 Source Node Name

This field should contain the name of node that is the inlet to the Mixer object for the second stream containing the component whose flow is being diverted.

Field: Temperature Setpoint Node Name

This field should contain the name of a node that has a temperature setpoint assigned to it. A separate set point manager object is needed to provide a set point on the node listed here.

Field: Pump Outlet Node Name

This field should contain the name of the node that is the outlet for the pump that is one the same plant loop. This is node is used to sense the total flow rate.

The idd entry for this object is:

```

TemperingValve,
  A1, \field Name
      \required-field
      \type alpha
  A2, \field Inlet Node Name
      \required-field
      \type alpha
      \note Name of a Node
  A3, \field Outlet Node Name
      \required-field
      \type alpha
      \note Name of a Node
  A4, \field Stream 2 Source Node Name
      \required-field
      \type alpha
      \note Name of a Node
  A5, \field Temperature Setpoint Node Name
      \required-field
      \type alpha
      \note Name of a Node
  A6; \field Pump Outlet Node Name
      \required-field
      \type alpha

```

This object is demonstrated in the example file called `SolarCollectorFlatPlateWater.idf`. An example of this object is:

```

TemperingValve,
    DHW Anti-Scald Diverter,
    DHW Anti-Scald Inlet Node, ! Inlet Node Name
    DHW Anti-Scald Outlet Node, ! Outlet Node Name
    SHW Storage Tank Use Outlet Node, ! Stream 2 Source Node Name
    DHW Instantaneous Boost Outlet Node, ! Temperature Setpoint Node Name
    DHW Use Side Pump Outlet; ! pump outlet node

```

Tempering Valve Outputs

Use report variables for System Nodes for flow and temperature results.

Group – Air Distribution

AirLoopHVAC

Air loops along with zone equipment form the entire forced air heating and cooling system (air side). The main statement for defining an air loop is the *AirLoopHVAC* object described here. As with the main plant and condenser statements, several of the items in the *AirLoopHVAC* object definition are actually names that refer to other objects in the input file. After the *AirLoopHVAC* object name, four such list pointers are encountered: for controllers, system availability, branches, and connectors. The Controller List defines how the air loop will respond due to various inputs (control signals). The Availability Manager List refers to methods for controlling when a system is operational. This may be as simple as a schedule to define when the system is shutdown. The Branch List lists the branches that comprise the primary air system. Finally, the Connector List lists the connections between the branches. The branches and connections together define the primary air system topology.

The only numeric input is the design primary air flow rate. This item is input just before the BranchList name.

The next series of names refer to nodes for the various inlet and outlet points of the air loop. The air loop starts where the zone equipment ends. This is a single point consisting of the return air duct once all of the zone return air streams have been collected. While in reality, there is really only one point, for clarity within the simulation components and consistency with the other HVAC loop sections, this point in the systems is defined as two points: one that resides with the zone equipment simulation and one that is acted upon by the air loop simulation. Both node names must be entered into the input file, and both nodes must have

unique names. Similarly, the end points of the air loop that also correspond to the beginning points of the zone equipment loop must also be defined. These consist of names referencing lists of up to three pairs of node names as shown below. Up to three air loop outlets are allowed to accommodate the simulation of three deck systems.

Field: Name

This field is a unique, user assigned name for a single instance of an AirLoopHVAC object. Any other object referencing this AirLoopHVAC will use this name.

Field: Controller List Name

This field is the name of a ControllerList object. A Controller List is simply a list of controllers giving both controller name and type. This Controller List specifies all the controllers that will act on this primary air loop. The order of the controllers in the list is significant: controllers are simulated sequentially in the order given in the Controller List.

Field: Availability Manager List Name

This field is the name of a AvailabilityManagerList object. A Availability Manager List is a list of Availability Managers giving both Availability Manager type and name. The availability managers in the list apply to this primary air loop. That is, they determine when and if this air loop is on or off, overriding the control provided by the central fan on/off schedule.

Field: Design Supply Air Flow Rate

This is the system primary air design volumetric flow rate in cubic meters per second.

Field: Branch List Name

This field is the object name of a BranchList object (see BranchList and Branch). The BranchList named here specifies all the branches composing the primary air system. These branches, together with the Connectors listed in the ConnectorList, define the primary air system topology.

Field: Connector List Name

This field is the name of ConnectorList object. This ConnectorList object lists all the Connectors (by type and name) that are included in this primary air system. These Connectors, together with the Branches in the BranchList, define the topology of the primary air system.

Field: Supply Side Inlet Node Name

The name of the air entrance node of this primary air system. This is the inlet node for return air for this air system.

Field: Demand Side Outlet Node Name

The name of the air outlet node for the zone equipment group (ZoneHVAC:EquipmentConnections objects) attached to the primary air system. This should be the outlet node of a AirLoopHVAC:ZoneMixer in the AirLoopHVAC:ReturnPath for the zone equipment group attached to this primary air system.

Field: Demand Side Inlet Node Names

This field can be the name of a node which is the air inlet node for the zone equipment group (see ZoneHVAC:EquipmentConnections objects) attached to this primary air system. Or, this field can be the name of a node list containing one or more nodes (up to 3). These nodes should be the inlet nodes to the AirLoopHVAC:ZoneSplitter or AirLoopHVAC:SupplyPlenum in each of the AirLoopHVAC:SupplyPaths for the zone equipment groups attached to this primary air system. For single duct systems, there is only one node name in this list. For two and three duct systems, the order of the nodes in this list must correspond with the order of the nodes in the Supply Side Outlet Node Names list.

Field: Supply Side Outlet Node Names

This field can be the name of a node which is the air outlet node for each supply duct of this primary air system. Or, this field can be the name of a node list containing one or more nodes (up to 3). The list can contain the names of up to three nodes. For single duct systems, there is only one node name in this list. For two and three duct systems, the order of the nodes in this list must correspond with the order of the nodes in the Demand Side Inlet Node Names list.

The IDD specification:

```
AirLoopHVAC,
  \min-fields 10
  \memo Defines a central forced air system
A1, \field Name
  \required-field
  \type alpha
  \reference AirPrimaryLoops
A2, \field Controller List Name
  \note Enter the name of an AirLoopHVAC:ControllerList object.
  \type object-list
  \object-list ControllerLists
A3, \field Availability Manager List Name
  \note Enter the name of an AvailabilityManagerAssignmentList object.
  \type object-list
  \object-list SystemAvailabilityManagerLists
N1, \field Design Supply Air Flow Rate
  \default 0
  \units m3/s
  \autosizable
A4, \field Branch List Name
  \note Name of a BranchList containing all the branches in this air loop
  \required-field
  \type object-list
  \object-list BranchLists
A5, \field Connector List Name
  \note Name of a ConnectorList containing all the splitters and mixers in the loop
  \type object-list
  \object-list ConnectorLists
A6, \field Supply Side Inlet Node Name
  \note Name of inlet node where return air enters the supply side of the air loop
  \required-field
A7, \field Demand Side Outlet Node Name
  \note Name of outlet node where return air leaves the demand side and enters the supply side.
  \required-field
A8, \field Demand Side Inlet Node Names
  \note Name of a Node or NodeList containing the inlet node(s) supplying air to zone equipment.
  \required-field
A9; \field Supply Side Outlet Node Names
  \note Name of a Node or NodeList containing the outlet node(s) supplying air to the demand side.
  \required-field
```

An example of this statement in an IDF is:

```
AirLoopHVAC,
Main Dual Duct Air Loop,          ! Primary Air Loop Name
Dual Duct System 1 Controllers,   ! Controller List
Dual Duct System 1 Schedule List , ! System Availability Manager List
1.3 ,                             ! Primary air design volumetric flow rate
Dual Duct Air Loop Branches ,     ! Air Loop Branch List Name
Dual Duct Connectors ,           ! Air Loop Connector List Name
Supply Fan Inlet Node ,          ! ReturnAir AirLoop Inlet Node
Return Air Mixer Outlet ,        ! ZoneEquipGroup Outlet Node
Zone Equipment Inlet Node List , ! SupplyAirPath ZoneEquipGroup Inlet Nodes
Air Loop Outlet Node List ;      ! AirLoop Outlet Nodes
```

AirLoopHVAC Outputs

```
HVAC,Average,Air Loop System Cycle On/Off Status
```

Air Loop System Cycle On/Off Status

This field is the availability status of an AirLoopHVAC. This status flag is a result of the calculations made by the System Availability Manager(s) listed in a System Availability Manager List. When a single availability manager is used in a System Availability Manager List, this is also the availability status reported by the specific availability manager (Ref. System Availability Manager Outputs). When multiple availability managers are used in a System Availability Manager List, the loop availability status is determine by the rules associated with AirLoopHVACs (see rules described for Group – System Availability Managers). The control status outputs are represented using integers 0 through 3.. These integers represent *NoAction* (0), *ForceOff* (1), *CycleOn* (2), and *CycleOnZoneFansOnly* (3). Since the status output is averaged, the output result may not correspond to the values described here when report variable frequencies other than detailed are used. Use the “detailed” reporting frequency (Ref. Report Variable) to view the availability status at each simulation timestep.

A map for Air Loop input syntax is shown in the following diagram.

Air Loop Input Structure/Map

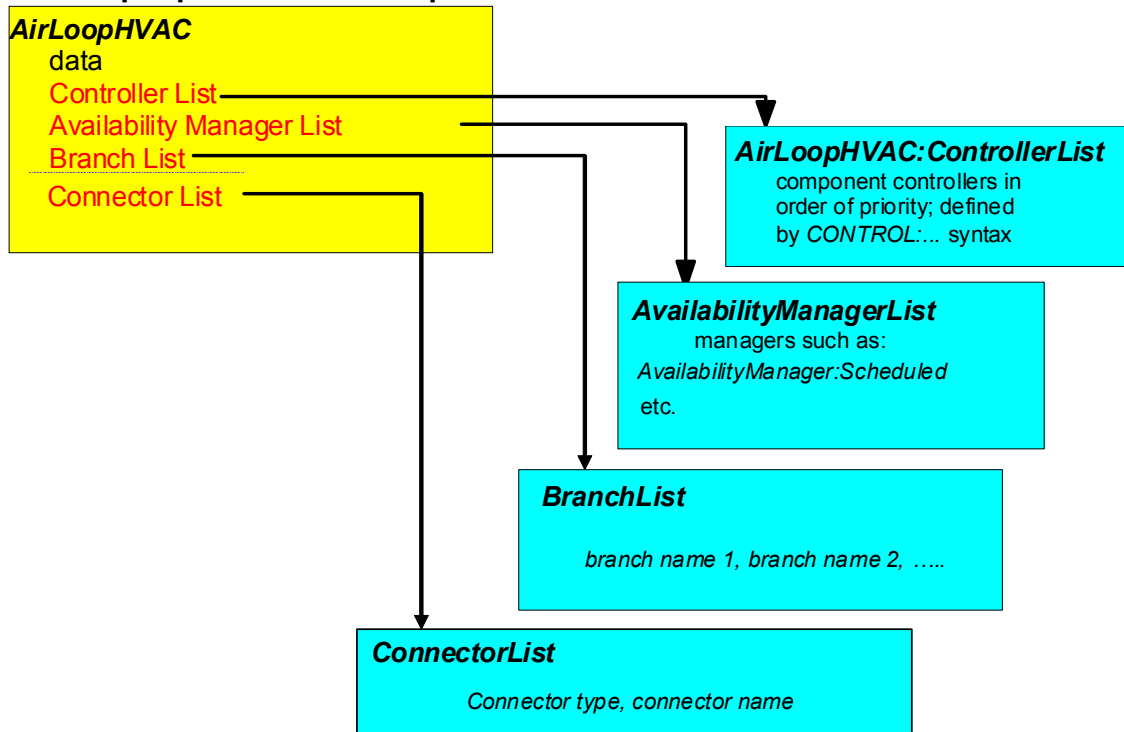


Figure 75. Air Loop Input Syntax Map

AirLoopHVAC:ControllerList

The syntax for the AirLoopHVAC:ControllerList definition is shown below. As with other lists in EnergyPlus input, the object title and identifying name are followed by type-name pairs. In this case, the types are controller types. The order in which controllers appear on this list also define the priority as described below. The identifying name refers back to the name recorded in the AirLoopHVAC statement.

Field: Name

The user designated unique name of an instance of a Controller List. Any object referencing this Controller List will do so using this name.

Field Set (Object Type, Controller Name) up to 8

After the identifying name, input for the controller list consists of up to 8 pairs of data items: a controller type and a controller name. The first controller listed has the highest priority, the second the second highest priority, and so forth.

Field: Controller <x> Object Type

The type of controller. This should be a key word defining a class of controllers such as Controller:WaterCoil.

Field: Controller <x> Name

The name of a controller object (such as a Controller:WaterCoil) defined elsewhere in the input file.

The IDD specification:

```
AirLoopHVAC:ControllerList,
  \memo List controllers in order of control sequence
A1 , \field Name
    \required-field
    \type alpha
    \reference ControllerLists
A2 , \field Controller 1 Object Type
    \required-field
    \type choice
    \key Controller:WaterCoil
    \key Controller:OutdoorAir
A3 , \field Controller 1 Name
    \required-field
    \type object-list
    \object-list AirLoopControllers
A4 , \field Controller 2 Object Type
    \type choice
    \key Controller:WaterCoil
    \key Controller:OutdoorAir
-- etc to # of controller sets entered
```

An example of this statement in an IDF is:

```
AirLoopHVAC:ControllerList,
  Dual Duct System 1 Controllers,
  Controller:WaterCoil, Main Cooling Coil Controller,
  Controller:WaterCoil, Main Heating Coil Controller;
```

The AvailabilityManagerAssignmentList defines the applicable managers used for an AirLoopHVAC or PlantLoop. The priority of availability managers is based on a set of rules and are specific to the type of loop. The output from each Availability Manager is an availability status flag. This flag can have the values *NoAction*, *ForceOff*, *CycleOn*, or *CycleOnZoneFansOnly* (used only for air loops). The availability status flags for the Availability Managers referenced by an air or plant loop are used to set the availability status flag for each loop. For the air loops, *ForceOff* takes precedence: if any of the loop's availability managers are showing status *ForceOff*, the loop status will be *ForceOff*. Next in precedence is *CycleOnZoneFansOnly*, followed by *CycleOn*, and *NoAction*. For the plant loops, there is no precedence among the Availability Manager status flag values. Instead, the first availability manager giving a status flag value other than *NoAction* sets the status for the loop. The Availability Managers are executed in Availability Manager List order.

Special rules also apply for which managers may be listed in a Availability Manager list. The Hybrid Ventilation Control Manager (object: AvailabilityManager:HybridVentilation) is a special type of manager and is never specified in a Availability Manager List (it is used stand-alone for a specific air loop). All other types of availability managers may be listed in the Availability Manager List used for AirLoopHVACs. For Plant Loops, the Night Cycle and Night

Ventilation managers (objects: AvailabilityManager:NightCycle and AvailabilityManager:NightVentilation) are not allowed in the Availability Manager List.

Field: Name

The name of the AvailabilityManagerAssignmentList object. This is referenced by AirLoopHVAC and PlantLoop objects.

Field Set (Availability Manager Object Type, Name)

Managers are listed by pairs of data items: *Availability Manager Object Type* and *Availability Manager Name*. The managers are simulated down the list and calculate a control status for use by the AirLoopHVAC or PlantLoop. The priority of each manager used for a specific loop is based on the rules described above. Availability managers are not currently used for condenser loops. The availability managers, along with the AirLoopHVAC and PlantLoop object, report the control status calculated each simulation timestep. These report variables can be used to prioritize the managers according to the required control strategy. Six managers are accommodated in the list by default, however, this IDD specification is extensible. Additional pairs may be added by directly editing the IDD.

Field: Availability Manager <x> Object Type

The key word defining the type of manager, e.g. AvailabilityManager:NightCycle.

Field: Availability Manager<x> Name

The name of a AvailabilityManager object defined elsewhere in the input file.

The IDD specification:

```
AvailabilityManagerAssignmentList,
  \min-fields 3
  \extensible:2 - repeat last two fields, remembering to remove ; from "inner" fields.
A1 , \field Name
     \type alpha
     \required-field
     \reference SystemAvailabilityManagerLists
A2 , \field Availability Manager 1 Object Type
     \required-field
     \type choice
     \key AvailabilityManager:Scheduled
     \key AvailabilityManager:ScheduledOn
     \key AvailabilityManager:ScheduledOff
     \key AvailabilityManager:NightCycle
     \key AvailabilityManager:DifferentialThermostat
     \key AvailabilityManager:HighTemperatureTurnOff
     \key AvailabilityManager:HighTemperatureTurnOn
     \key AvailabilityManager:LowTemperatureTurnOff
     \key AvailabilityManager:LowTemperatureTurnOn
     \key AvailabilityManager:NightVentilation
A3 , \field Availability Manager 1 Name
     \required-field
     \type object-list
     \object-list SystemAvailabilityManagers
-- etc to # of system availability manager sets entered
```

An example of this statement in an IDF is:

```

AvailabilityManagerAssignmentList,
Collector Loop Availability Manager List,  !- Name
AvailabilityManager:HighTemperatureTurnOff,  !- System Availability Manager Type 1
High Temperature Turn Off Availability Manager,  !- System Availability Manager Name 1
AvailabilityManager:LowTemperatureTurnOn ,  !- System Availability Manager Type 2
Low Temperature Turn On Availability Manager,  !- System Availability Manager Name 2
AvailabilityManager:DifferentialThermostat,  !- System Availability Manager Type 3
Differential Thermostat Availability Manager;  !- System Availability Manager Name 3

```

AirLoopHVAC:OutdoorAirSystem

The Outside Air System (object AirLoopHVAC:OutdoorAirSystem) is a subsystem of an AirLoopHVAC. It handles the mixed air portion of the primary air system: the system relief air, the outside air inlet, and any components and controllers associated with the system relief air and outside air streams. From the perspective of the primary air loop the Outside Air System is treated as a single component. As a subsystem, it can contain one or more components and controllers.

The input for the Outside Air System consists of a system name, a controller list name, an equipment list name, and an availability manager list name. The controller list simply lists, by type and unique name, all the controllers in the subsystem. The controllers will be simulated in list order. The equipment list lists all the components in the subsystem, by type and name. The equipment is simulated in list order. Finally, the availability manager list gives the type and name of the availability managers used by the subsystem.

The equipment inlet/outlet must be sequential with no loops - the simulation can only handle a straight-through air path, both on the primary air side and on the secondary air side, if any. Heat exchanger secondary air inlets need to be independent of the primary air stream – usually relief air is used.

Field: Name

The unique, user assigned name for a single instance of an Outside Air System. Any other object referencing this Outside Air System will use this name.

Field: Name: Controller List Name

This field is the name of a AirLoopHVAC:ControllerList object. A AirLoopHVAC:ControllerList is simply a list of controllers giving both controller name and type. This Controller List specifies all the controllers that will act on this outside air system. The order of the controllers in the list is significant: controllers are simulated sequentially in the order given in the Controller List. Typically the Controller List would contain a Controller:OutdoorAir. If there are chilled water or hot water coils in the outdoor air system, each such coil will need a Controller:WaterCoil.

Field: Outdoor Air Equipment List Name

This field is the name of an AirLoopHVAC:OutdoorAirSystem:EquipmentList object. An AirLoopHVAC:OutdoorAirSystem:EquipmentList is simply a list of components giving both component name and type. This Outdoor Air Equipment List specifies all the components that will be simulated in this outside air system. The order of the components in the list is significant: components are simulated sequentially in the order given in the Outdoor Air Equipment List. Typically the equipment list would contain at least an OutdoorAir:Mixer. If there is more than one component, the components must be listed in order from the outside air to the OutdoorAir:Mixer (the OutdoorAir:Mixer is last).

Field: Availability Manager List Name

This field is the name of a AvailabilityManagerAssignmentList object. An Availability Manager List is a list of Availability Managers giving both Availability Manager Object Type and Name. **Use of this input is optional.** This field may be omitted; it is not currently used by the program.

The full IDD specification follows:

```

AirLoopHVAC:OutdoorAirSystem,
  \min-fields 3
A1, \field Name
  \required-field
  \type alpha
A2, \field Controller List Name
  \note Enter the name of an AirLoopHVAC:ControllerList object.
  \required-field
  \type object-list
  \object-list ControllerLists
A3, \field Outdoor Air Equipment List Name
  \note Enter the name of an AirLoopHVAC:OutdoorAirSystem:EquipmentList object.
  \required-field
  \type object-list
  \object-list AirLoopOAEquipmentLists
A4; \field Availability Manager List Name
  \note Enter the name of an AvailabilityManagerAssignmentList object.
  \type object-list
  \object-list SystemAvailabilityManagerLists

```

An IDF example, including the AirLoopHVAC, and the controller and equipment lists.

```

AirLoopHVAC,Typical Terminal Reheat 1,
  Reheat System 1 Controllers,
  Reheat System 1 Avail List,
  1.3,
  Air Loop Branches,,
  Air Loop Inlet Node, Return Air Mixer Outlet,
  Zone Equipment Inlet Node, Air Loop Outlet Node;

AirLoopHVAC:ControllerList,
  Reheat System 1 Controllers,
  Controller:WaterCoil, Main Cooling Coil Controller;

BranchList, Air Loop Branches,
  Air Loop Main Branch;

Branch, Air Loop Main Branch,
  1.3,
  AirLoopHVAC:OutdoorAirSystem, OA Sys 1,
  Air Loop Inlet Node, Mixed Air Node,PASSIVE
  Fan:ConstantVolume, Supply Fan 1,
  Mixed Air Node, Cooling Coil Air Inlet Node, ACTIVE,
  Coil:Cooling:Water:DetailedGeometry, Detailed Cooling Coil,
  Cooling Coil Air Inlet Node, Air Loop Outlet Node, PASSIVE;

AvailabilityManagerAssignmentList, Reheat System 1 Avail List,
  AvailabilityManager:Scheduled, Reheat System 1 Avail;

AvailabilityManager:Scheduled, Reheat System 1 Avail,
  FanAndCoilAvailSched;

```

```
AirLoopHVAC:OutdoorAirSystem,
  OA Sys 1,
  OA Sys 1 Controllers,
  OA Sys 1 Equipment;

AirLoopHVAC:ControllerList,
  OA Sys 1 Controllers,
  Controller:OutdoorAir, OA Controller 1;

AirLoopHVAC:OutdoorAirSystem:EquipmentList,
  OA Sys 1 Equipment,
  HeatExchanger:AirToAir:FlatPlate,OA Heat Recovery 1,
  OutdoorAir:Mixer, OA Mixing Box 1;
```

Outdoor Air System Outputs

The impact of using outside air/mechanical ventilation is described in the section: Outdoor Air Ventilation Report Variables.

AirLoopHVAC:OutdoorAirSystem:EquipmentList

Used to specify the components in the outdoor air system. The components will be simulated in the order in which they occur in the list.

Field: Name

The user designated unique name of an instance of an Air Loop Equipment List. Any object referencing this Air Loop Equipment List will do so using this name.

Field Set (Component Object Type,, Component Name) up to 8

After the identifying name, the list consists of up to 8 pairs of data items:

Field: Component <x> Object Type

This field specifies the keyword for the type of component used.

Field: Component <x> Name

This field is the unique name of the component specified in the previous field. This named object must appear in the IDF.

The IDD specification:

```
AirLoopHVAC:OutdoorAirSystem:EquipmentList,
  \memo List equipment in simulation order
  A1 , \field Name
  \required-field
  \type alpha
  \reference AirLoopOAEquipmentLists
  A2 , \field Component 1 Object Type
  \required-field
  A3 , \field Component 1 Name
  \required-field
  A4 , \field Component 2 Object Type
  A5 , \field Component 2 Name
  -- etc to # of sets entered
```

An example from an IDF:

```
AirLoopHVAC:OutdoorAirSystem:EquipmentList,
  OA Sys 1 Equipment,
  HeatExchanger:AirToAir:FlatPlate,OA Heat Recovery 1,
  OutdoorAir:Mixer, OA Mixing Box 1;
```

OutdoorAir:Node

The OutdoorAir:Node object declares an HVAC system node for outdoor air conditions. The program automatically sets the air conditions at these nodes to correspond to the ambient

environmental conditions at the beginning of every timestep. The outdoor air node is typically used as the inlet air node to an HVAC component such as the OutdoorAir:Mixer object. Multiple OutdoorAir:Node objects can be used in an input file, however, duplicate node names are not allowed.

The *Height Above Ground* field is used to adjust the weather file air conditions, e.g., outdoor dry-bulb and wet-bulb air temperatures, for atmospheric variation with height. This variation can become a significant factor when modeling tall buildings. See the Engineering Reference section on Atmospheric Variation for a description of the algorithm for variation of atmospheric properties with height. A blank entry or a value less than zero for this field indicates that the height will be ignored and the weather file conditions will be used.

OutdoorAir:Node and **OutdoorAir:NodeList** both set a node to outdoor air conditions. **OutdoorAir:Node** modifies the weather file conditions if a height has been specified. **OutdoorAir:NodeList** does not have a height input and always uses the weather file conditions without modification. The same node name may not be used with both of these objects.

Field: Name

The unique name for this outdoor air node.

Field: Height Above Ground

The height [m] of the node above ground level. A value greater than zero allows the weather file conditions, e.g., outdoor dry-bulb and wet-bulb air temperatures, to be adjusted according to atmospheric variation with height.

A blank entry or value less than zero indicates that the height will be ignored and the weather file conditions will be used.

The IDD specification:

```
OutdoorAir:Node,
  \memo This object sets the temperature and humidity conditions
  \memo for an outdoor air node. It allows the height above ground to be
  \memo specified. This object may be used more than once.
  \memo The same node name may not appear in both an OutdoorAir:Node object and
  \memo an OutdoorAir:NodeList object.
A1, \field Name
  \required-field
  \type alpha
N1 ; \field Height Above Ground
  \note A value less than zero indicates that the height will be ignored and the weather file
  conditions will be used.
  \type real
  \units m
  \default -1.0
```

An example IDF:

```
OutdoorAir:Node,
  OA Node 1; !- Name

OutdoorAir:Node,
  Floor 10 Outdoor air Inlet Node, !- Name
  30.0; !- Height Above Ground {m}
```

OutdoorAir:Node outputs:

The ambient dry-bulb air temperature and flow rate at the outdoor air node can be monitored using the system node output variables:

```
HVAC,Average,System Node Temp[C]
```

```
HVAC,Average,System Node MassFlowRate[kg/s]
```

e.g.

```
Report Variable,
Floor 10 Outdoor air Inlet Node,
System Node Temp,
Hourly;
```

OutdoorAir:NodeList

The program needs to know which HVAC system nodes are inlets for outdoor air. Knowing this, the program can set the conditions at these nodes to the outdoor conditions at the start of each major timestep. The OutdoorAir:NodeList provides the means for specifying which nodes are outdoor air nodes.

The input is flexible: there may be one or more OutdoorAir:NodeList in each input file. Each list contains up to 25 names. The names can be the name of a unique HVAC system node, or the name of a Node List which will contain the actual node names. Duplicate node names are ignored.

OutdoorAir:Node and **OutdoorAir:NodeList** both set a node to outdoor air conditions. **OutdoorAir:Node** modifies the weather file conditions if a height has been specified. **OutdoorAir:NodeList** does not have a height input and always uses the weather file conditions without modification. The same node name may not be used with both of these objects.

Field: Node or NodeList name

The name of an HVAC system node or of a NodeList object. There can be up to 25 names.

The IDD specification:

```
OutdoorAir:NodeList,
  \memo This object sets the temperature and humidity conditions
  \memo for an outdoor air node using the weather data values.
  \memo to vary outdoor air node conditions with height above ground
  \memo use OutdoorAir:Node instead of this object.
  \memo This object may be used more than once.
  \memo The same node name may not appear in both an OutdoorAir:Node object and
  \memo an OutdoorAir:NodeList object.
A1 , \field Node or NodeList Name 1
    \required-field
    \type alpha
A2 , \field Node or NodeList Name 2
    \type alpha
A3 , \field Node or NodeList Name 3
    \type alpha
-- etc to # of node or node lists entered
```

An example IDF:

```
OutdoorAir:NodeList,
  OutsideAirInletNodes;

NodeList,OutsideAirInletNodes,
  Outdoor air Inlet Node;
```

OutdoorAir:Mixer

The OutdoorAir:Mixer is the most common component used in an outdoor air system. The outdoor air mixer has 2 inlet air streams: the system return air and the outdoor air. It has 2 outlet air streams: the system relief air and the mixed air. This is a passive component. It takes the inlet mass flows and conditions plus the relief air mass flow and calculates the

mixed air flow rate and conditions (as well as the relief air conditions). The inlet and relief mass flow must be set outside the component – most commonly by an outdoor air controller. The OutdoorAir:Mixer can also be used in compound components such as a fan coil unit.

Input for this object is very simple: a unique name plus the node names of the 2 inlet nodes and the 2 outlet nodes.

Field: Name

A unique user assigned name for a particular outdoor air mixer component. Any reference to this component by another object will use this name.

Field: Mixed Air Node Name

The name of the HVAC system node which is the outlet for the mixed air stream.

Field: Outdoor Air Stream Node Name

The name of the HVAC system node which is the inlet for the outdoor air stream.

Field: Relief Air Stream Node Name

The name of the HVAC system node which is the outlet for the system relief air.

Field: Return Air Stream Node Name

The name of the HVAC system node which is the inlet for the return air stream.

The IDD specification:

```

OutdoorAir:Mixer,
  \memo Node names cannot be duplicated within a single OutdoorAir:Mixer object.
A1, \field Name
  \required-field
  \type alpha
  \reference OutdoorAirMixers
A2, \field Mixed Air Node Name
  \note Name of Mixed Air Node
  \required-field
A3, \field Outdoor Air Stream Node Name
  \note Name of Outdoor Air Stream Node
  \required-field
A4, \field Relief Air Stream Node Name
  \note Name of Relief Air Stream Node
  \required-field
A5; \field Return Air Stream Node Name
  \note Name of Return Air Stream Node
  \required-field
    
```

An IDF example:

```

OutdoorAir:Mixer,
  ZonelWindACOAMixer,           ! name
  ZonelWindACOAMixerOutletNode, ! mixer outlet node
  ZonelWindACOAINode,          ! mixer OA node
  ZonelWindACExhNode,         ! mixer relief node
  ZonelWindACAirInletNode;    ! mixer inlet node
    
```

Group – Airflow Network

Overview

The Airflow Network model provides the ability to simulate multizone airflows driven by wind and also by a forced air distribution system. The model can also simulate the heat and moisture gains or losses from the air distribution system itself (e.g., ductwork). When modeling an air distribution system, the current version of the Airflow Network model is

restricted to a single forced air system (i.e., AirLoopHVAC object) with a constant volume supply air fan (Fan:ConstantVolume or Fan:OnOff). The capabilities of the model are to:

- Simulate zone pressures due to envelope leakage and forced air distribution during HVAC system fan operation
- Simulate node pressures in a forced air distribution system during HVAC system fan operation
- Calculate multizone airflows due to forced air, wind, and surface leakage, including adjacent zones and outdoors, during HVAC system fan operation
- Simulate distribution system airflows, including supply and return air leaks, during HVAC system fan operation
- Simulate air distribution system node temperatures and humidity ratios during HVAC system fan operation
- Calculate duct conduction losses during HVAC system fan operation
- Calculate vapor diffusion losses of ducts during HVAC system fan operation
- Calculate sensible and latent loads on the surrounding zones due to supply and return air leaks in the air distribution system during HVAC system fan operation
- Simulate zone pressures due to envelope leakage driven by wind when the HVAC system fan is off or if no air distribution system is specified
- Calculate multizone airflows due to wind and surface leakage, including adjacent zones and outdoors when the HVAC system fan is off or if no air distribution system is specified
- Allow zone exhaust fans to be included as part of the airflow network
- For airflow networks with a forced air distribution system, calculate zone sensible and latent loads for two different supply air fan operation modes as required: cycling fan, cycling compressor (CyclingFanAndCompressor) and continuous fan, cycling compressor (ContinuousFanWithCyclingCompressor)

Summary of Objects

Before describing the Airflow Network input objects in detail, we list all of the objects and then give a short description of what the objects do.

The Airflow Network input objects are:

AirflowNetwork:SimulationControl
AirflowNetwork:Multizone:Zone
AirflowNetwork:Multizone:Surface
AirflowNetwork:MultiZone:Component:SimpleOpening
AirflowNetwork:MultiZone:Component:DetailedOpening
AirflowNetwork:MultiZone:Surface:Crack
AirflowNetwork:MultiZone:ReferenceCrackConditions
AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea
AirflowNetwork:MultiZone:Component:ZoneExhaustFan
AirflowNetwork:MultiZone:ExternalNode
AirflowNetwork:MultiZone:WindPressureCoefficientArray
AirflowNetwork:MultiZone:WindPressureCoefficientValues
AirflowNetwork:Distribution:Node
AirflowNetwork:Distribution:Component:Leak
AirflowNetwork:Distribution:Component:LeakageRatio
AirflowNetwork:Distribution:Component:Duct
AirflowNetwork:Distribution:Component:ConstantPressureDrop
AirflowNetwork:Distribution:Component:ConstantVolumeFan
AirflowNetwork:Distribution:Component:Coil
AirflowNetwork:Distribution:Component:HeatExchanger
AirflowNetwork:Distribution:Component:TerminalUnit

AirflowNetwork:Distribution:Linkage

- **AirflowNetwork:SimulationControl** defines basic run parameters for the air flow calculations and specifies whether wind pressure coefficients are input by the user or, for rectangular buildings, calculated by the program.
- The **AirflowNetwork:Multizone:Zone** object specifies the ventilation control that applies to all of the openable exterior and interior windows and doors in the corresponding thermal zone. Surface-level ventilation control can be used to override the zone-level ventilation control if required (see **AirflowNetwork:Multizone:Surface** object below).
- **AirflowNetwork:Multizone:Surface** object indicates whether a heat transfer surface (wall, window, etc.) has a crack or opening and references an **AirflowNetwork:MultiZone:Surface:Crack**, **AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea**, **AirflowNetwork:MultiZone:Component:SimpleOpening**, **AirflowNetwork:MultiZone:Component:DetailedOpening** or **AirflowNetwork:MultiZone:Component:ZoneExhaustFan** object that gives the air flow characteristics of that crack, opening, or zone exhaust fan. The **AirflowNetwork:Multizone:Surface** object can also be used to specify individual ventilation control for openable exterior and interior windows and doors.
- **AirflowNetwork:MultiZone:ReferenceCrackConditions** is used to normalize crack information that is based on measurements of crack air flow.
- **AirflowNetwork:Distribution:Node** represents air distribution system nodes for the **AirflowNetwork** model. A set of an **AirLoopHVAC** and **ZoneHVAC:EquipmentList** nodes is a subset of the **AirflowNetwork:Distribution:Nodes**.
- **AirflowNetwork:Distribution:Component** objects consist of **Leak**, **LeakageRatio**, **Duct**, **ConstantPressureDrop**, **ConstantVolumeFan**, **Coil**, and **TerminalUnit**. The components provide a relationship between pressure and airflow. The **Leak** and **Leakage** components can be used to simulate supply and/or return leaks in an air distribution system. The **Duct** and **ConstantPressureDrop** components can be used to deliver forced air into conditioned spaces. The components **ConstantVolumeFan**, **Coil**, and **TerminalUnit** reference normal **EnergyPlus** objects. The **Airflow Network** model gets information from these objects to perform an airflow network simulation.
- **AirflowNetwork:Distribution:Linkage** object represents a connection between two node objects and an **AirflowNetwork** component. The node objects can be an **AirflowNetwork:Distribution:Node**, **AirflowNetwork:MultiZone:ExternalNode** or **AirflowNetwork:Multizone:Zone**.

If you input wind pressure coefficients, **AirflowNetwork:Multizone:Surface** also has an associated **AirflowNetwork:MultiZone:ExternalNode** that, via the **AirflowNetwork:Multizone:WindPressureCoefficientArray** and **AirflowNetwork:MultiZone:WindPressureCoefficientValues** objects, gives the wind pressure distribution vs. wind direction for that node and, implicitly, for the cracks and openings in the exterior surfaces associated with that node.

Figure 76 shows the relationships among **AirflowNetwork:Multizone** objects and between **AirflowNetwork:Multizone** objects and regular **EnergyPlus** objects. In this figure an arrow from object A to object B means A references B, i.e., one of the inputs in A is the name of object B. For example, one input for **AirflowNetwork:Multizone:Surface** is the name of a heat transfer surface, and another is the name of a crack or opening object. The arrow between **AirflowNetwork:Multizone:Surface** and **AirflowNetwork:MultiZone:ExternalNode** is shown dashed to indicate that this reference is not used when wind pressure coefficients are calculated by the program rather than being input by the user.

Figure 76 also shows the relationships among **AirflowNetwork:Distribution** objects and between **AirflowNetwork:Distribution** objects and regular **EnergyPlus** objects. The **AirflowNetwork:Distribution:Linkage** objects link two nodes from

AirflowNetwork:Distribution:Node and/or AirflowNetwork:Multizone:Zone objects with a component defined in the object AirflowNetwork:Distribution:Component. The solid arrows show a reference from object A to object B. The dashed arrows indicate the components which can be used in a linkage object. The red arrows pointing to the Zone object indicate the components that interact with the zone air. For example, the temperature in a zone where a supply leak terminates is used to calculate duct leakage energy loss. The temperature in a zone where a duct component is located is also used to calculate duct conduction loss.

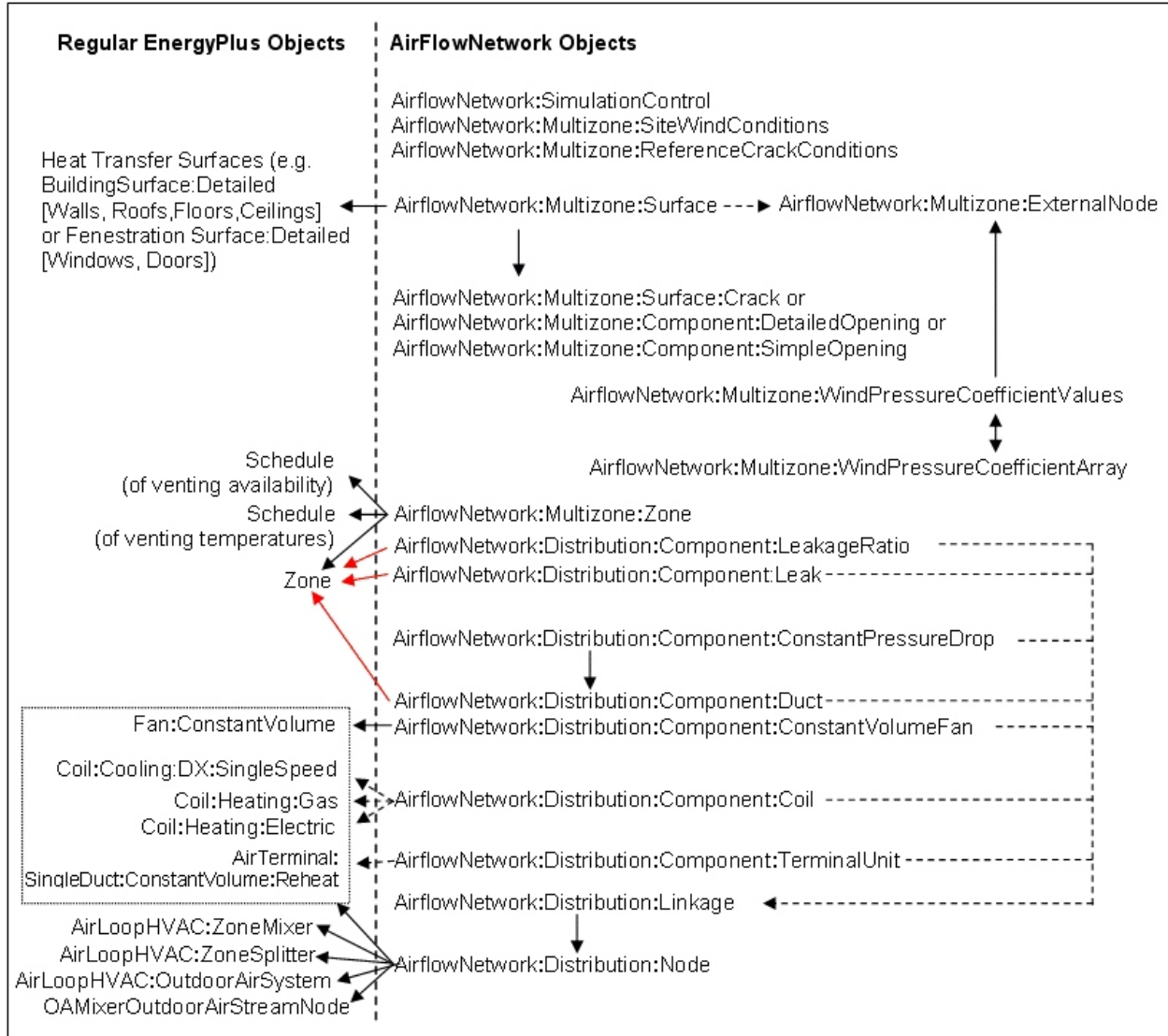


Figure 76. Relationships among AirflowNetwork objects (right-hand side) and between AirflowNetwork objects and regular EnergyPlus objects. An arrow from object A to object B means that A references B.

Much of the information needed for the air flow calculation is automatically extracted from the building description for thermal modeling. This includes things like the volume and neutral height of the zones, and the orientation and location of the building surfaces that contain cracks or openings through which air flows. From all of this information the program creates a “pressure-flow network” that is solved each timestep using iterative solution methods to obtain the unknown pressures and air flows.

Figure 77 shows a plan view of a very simple air flow network that you can construct using the above AirflowNetwork objects. There are three thermal zones, Zone-1, Zone-2 and Zone-3. There are openable exterior windows—Window-1, Window-2 and Window-3—and

openable interior doors—Door-12 and Door-23. Two External Nodes are indicated. ExternalNode-1 is associated with the façade that contains Window-1 and Window-2. ExternalNode-2 is associated with the façade containing Window-3.

One possible air flow pattern is shown in this figure. The actual air flow pattern in a particular timestep, and the size of the flows, depends on many factors, such as (1) What is the wind pressure distribution seen by the exterior windows? (2) Are the exterior windows open or closed, and if open, how far are they open? (3) Are the interior doors open or closed? (4) What are the air temperature differences between zones and between zones and the outdoor air (which affect buoyancy flows)?

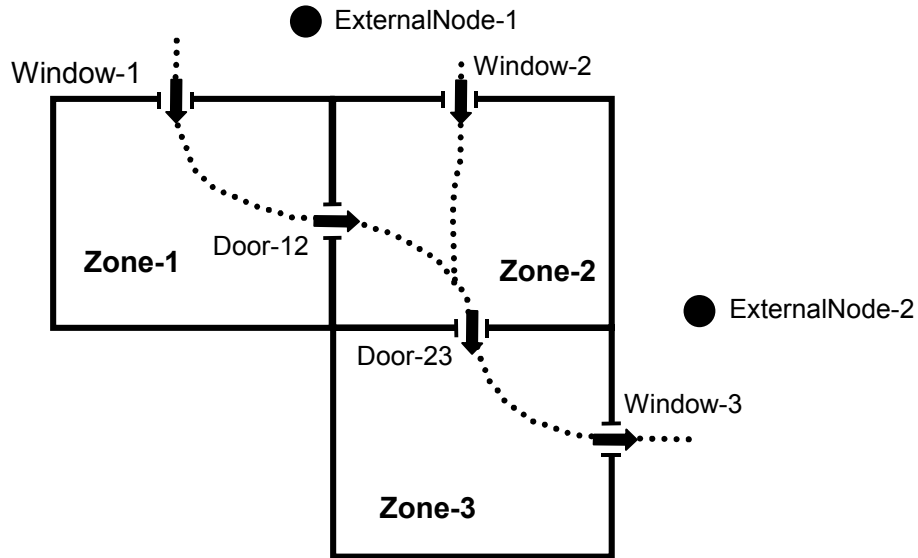


Figure 77. Plan view of a simple air flow network showing a possible air flow pattern in which all of the windows and doors are open.

Figure 77 shows a possible air flow pattern in which all of the windows and doors are open. Associated with the external nodes are wind pressure coefficient distributions as a function of wind direction that are input using two `AirflowNetwork:Multizone:Wind Pressure Coefficient` objects. The nature of the air flows through the windows and doors is specified using `AirflowNetwork:MultiZone:Component:DetailedOpening` and `AirflowNetwork:MultiZone:Component:SimpleOpening` objects. The Airflow Network model calculates the flows each system timestep depending on various factors, including wind direction and speed, size and vertical position of openings, outdoor air temperature, and zone air temperatures.

Airflow Network Example Files

`AirflowNetwork3zVent.idf`
`AirflowNetwork3zVentAutoWPC.idf`
`AirflowNetwork_Simple_House.idf`
`AirflowNetwork_Simple_SmallOffice.idf`
`AirflowNetwork_Multizone_House.idf`
`AirflowNetwork_Multizone_House_TwoSpeed.idf`
`AirflowNetwork_Multizone_SmallOffice.idf`
`AirflowNetwork_Multizone_SmallOffice_CoilHXAssistedDX.idf`
`AirflowNetwork_Multizone_SmallOffice_HeatRecoveryHXSL.idf`
`CrossVent_1Zone_AirflowNetwork.idf`

DisplacementVent_Nat_AirflowNetwork.idf

HybridVentilationControl.idf

What the Airflow Network Model Can and Cannot Do

Here is a list of some of the things that the Airflow Network calculation can and cannot model.

Can Do

- 1)** Air flow through cracks in exterior or interzone surfaces.
- 2)** Air flow through cracks around windows and doors when closed.
- 3)** Natural ventilation (i.e., air flow through open or partially open exterior windows and doors).
- 4)** Zone level control of natural ventilation (all windows/doors in a zone that are defined with a component opening object have identical controls).
- 5)** Individual surface control of natural ventilation for a subsurface (window, door, or glassdoor).
- 6)** Modulation of natural ventilation to prevent large zone air temperature swings.
- 7)** Interzone air flow (i.e., air flow through open interzone windows and doors, and through cracks in interzone surfaces).
- 8)** Dependence of air flow on buoyancy effects and wind pressure.
- 9)** Dependence of wind pressure on wind speed, wind direction and surface orientation.
- 10)** Supply and return air leaks in an air distribution system.
- 11)** Account for the effect of supply-air and/or return-air leakage on zone pressure when a forced air distribution system is present and is operating.
- 12)** When duct leakage is modeled and the HVAC system is on, interzone airflow or infiltration/exfiltration can occur due to changes in zone pressure.
- 13)** Bi-directional flow through large vertical openings. See discussion below under AirflowNetwork:MultiZone:Component:DetailedOpening and AirflowNetwork:Multizone:Component:SimpleOpening.
- 14)** Calculate air flows and pressures in ducts or other components of a forced air distribution system.
- 15)** Calculate zone loads when the supply air fan cycles on and off during a system timestep using the CyclingFanAndCompressor fan operation mode (Fan:OnOff).
- 16)** Determine the impact of zone exhaust fans on air flows, pressures, air temperatures/humidity levels and energy consumption.

Cannot Do or Restricted

- 1)** The model is restricted to using a constant volume fan (Fan:ConstantVolume and Fan:OnOff) and cannot model variable volume fan equipment.
- 2)** Air circulation and/or air temperature stratification within a thermal zone. For example, you should not try to divide a high space, such as an atrium, into subzones separated by artificial horizontal surfaces that have cracks or openings with the expectation that AirflowNetwork will give you a realistic temperature in each subzone and/or a realistic air flow between subzones.
- 3)** The model is restricted to eleven types of coils that can be in the air distribution system (Coil:Cooling:DX:SingleSpeed, Coil:Heating:Gas, Coil:Heating:Electric, Coil:Heating:DX:SingleSpeed, Coil:Cooling:Water, Coil:Heating:Water, Coil:Cooling:Water:DetailedGeometry, Coil:Cooling:DX:TwoStageWithHumidityControlMode, Coil:Cooling:DX:MultiSpeed, Coil:Heating:DX:MultiSpeed, and Coil:Heating:Desuperheater).

- 4) The model is restricted to a single type of air distribution equipment terminal units (AirTerminal:SingleDuct:ConstantVolume:Reheat).
- 5) Pollutant transport cannot currently be modeled.
- 6) Supply and return leaks are not allowed in an AirLoopHVAC. They can only be modeled in the Zone Equipment portion of the air loop (i.e., return leaks may be modeled between the zone return node and the zone mixer inlet or the zone mixer outlet and the zone equipment loop outlet; and supply leaks may be modeled between the zone equipment loop inlet and the AirLoopHVAC:ZoneSplitter inlet node or the AirLoopHVAC:ZoneSplitter outlet node and the zone supply node).
- 7) An air distribution system must be located inside the building (i.e., the ducts must pass through zones within the building).
- 8) Zone exhaust fans must be defined in ZoneHVAC:EquipmentConnections objects.

The input specifications consist of five main sections: **AirflowNetwork:SimulationControl object**, **AirflowNetwork multizone data objects**, **AirflowNetwork distribution node objects**, **AirflowNetwork distribution component objects**, and **AirflowNetwork distribution linkage objects**. Each of these object types is described in detail below.

AirflowNetwork:SimulationControl

The basic run parameters for this model are defined in this unique object which has the following input specifications:

Field: Name

This is a unique character string associated with this instance of the AirflowNetwork:SimulationControl object. At this time, only one AirflowNetwork:SimulationControl object can be specified in an input data file (idf).

Field: AirflowNetwork Control

The following selections are available to control the Airflow Network simulation:

MultizoneWithDistribution: Multizone air flow calculations are performed during all simulation timesteps, including the impacts of the air distribution system when a HVAC system fan is operating. Any **ZoneInfiltration**, **ZoneVentilation**, **ZoneMixing** and **ZoneCrossMixing** objects specified in the input data file are not simulated.

MultizoneWithoutDistribution: Multizone air flow calculations are performed during all simulation timesteps, but the air distribution system portion of the network is not modeled even if it is specified in the input data file. Any **ZoneInfiltration**, **ZoneVentilation**, **ZoneMixing** and **ZoneCrossMixing** objects specified in the input data file are not simulated.

MultizoneWithDistributionOnlyDuringFanOperation: Multizone air flow calculations, including the impacts of the air distribution system, are only performed when the HVAC system fan is operating. Any **ZoneInfiltration**, **ZoneVentilation**, **ZoneMixing** and **ZoneCrossMixing** objects specified in the input data file are used when the HVAC system fan is OFF (if none are specified, then no air flow calculations are performed when the fan is OFF).

NoMultizoneOrDistribution: No multizone air flow calculations (with or without the air distribution system portion of the network) are performed during the simulation. Any **ZoneInfiltration**, **ZoneVentilation**, **ZoneMixing** and **ZoneCrossMixing** objects specified in the input data file are simulated (if none are specified, then no air flow calculations are performed). Note: Having an input data file with no AirflowNetwork:SimulationControl objects gives the same impact – no multizone air flow calculations. However, this choice is provided as a convenience to the user to easily disable the multizone air flow calculations for an input data file that already contains AirflowNetwork objects.

Field: Wind Pressure Coefficient Type

Determines whether the wind pressure coefficients are input by the user or calculated. The choices are **Input** or **SurfaceAverageCalculation**, with the default being SurfaceAverageCalculation.

If INPUT, you must enter an AirflowNetwork:MultiZone:WindPressureCoefficientArray object, one or more AirflowNetwork:MultiZone:ExternalNode objects, and one or more AirflowNetwork:MultiZone:WindPressureCoefficientValues objects.

The second choice, SurfaceAverageCalculation, should only be used for **rectangular** buildings. In this case surface-average wind pressure coefficients vs. wind direction are calculated by the program for the four vertical facades and the roof based on user entries for “Building Type,” “Azimuth Angle of Long Axis of Building,” and “Ratio of Building Width Along Short Axis to Width Along Long Axis” (see description of these fields below). With this choice you do **not** have to enter any of the following objects: AirflowNetwork:MultiZone: Wind Pressure Coefficient Array, AirflowNetwork:MultiZone:ExternalNode and AirflowNetwork:MultiZone:WindPressureCoefficientValues.

Field: AirflowNetwork Wind Pressure Coefficient Array Name

This is the name of the AirflowNetwork:MultiZone:WindPressureCoefficientArray object that contains wind directions corresponding to the wind pressure coefficients given in the AirflowNetwork:MultiZone:WindPressureCoefficientValues objects.

A value need be entered only if Wind Pressure Coefficient Type = INPUT (see description of previous field).

Field: Height Selection for Local Wind Speed Calculation

Determines whether the local wind speed is calculated based on either given external node heights or surface opening heights. The choices are **ExternalNode** or **OpeningHeight**, with the default being OpeningHeight. The local outdoor wind speed calculation procedure is given in the section of “Local Wind Speed Calculation” in the Engineering Reference. The calculation procedure requires the height input.

If **ExternalNode**, the heights given in the AirflowNetwork:MultiZone:ExternalNode objects are used to calculate local wind speeds. Used only if Wind Pressure Coefficient Type = INPUT (see description of previous field).

If **OpeningHeight**, the number of the AirflowNetwork:MultiZone:ExternalNode objects has to be equal to the number of external surfaces defined in the AirflowNetwork:MultiZone:Surface objects. The centroids in the z direction of the AirflowNetwork:MultiZone:Surface objects are the heights used in the local wind speed calculation. The input is required if Wind Pressure Coefficient Type = INPUT (see description of previous field).

If Wind Pressure Coefficient Type = **SurfaceAverageCalculation**, a value in this field is not required and a blank may be entered. The default choice is used internally to generate the AirflowNetwork:MultiZone:ExternalNode objects

Field: Building Type

Used only if Wind Pressure Coefficient Type = SurfaceAverageCalculation. The choices for Building Type are LowRise and HighRise, with the default being LowRise.

LowRise corresponds to a rectangular building whose height is less than three times the width of the footprint (w_{short} in Figure 78) and is less than three times the length of the footprint (w_{long} in the same figure).

HighRise corresponds to a rectangular building whose height is more than three times the width of the footprint (w_{short} in Figure 78) or is more than three times the length of the footprint (w_{long} in the same figure).

Field: Maximum Number of Iterations

The maximum number of iterations allowed in finding an AirflowNetwork solution. If the number of iterations at each simulation timestep is above the maximum number of iterations defined by this field, the program could not find the solution and a Severe error is issued and the program is aborted. The default value is 500.

Field: Initialization Type

Designates which method is used for AirflowNetwork initialization. The choices for Initialization Type are LinearInitializationMethod and ZeroNodePressures, with the default being ZeroNodePressures.

Field: Relative Airflow Convergence Tolerance

The solution is assumed to have converged when $\left| \frac{\sum \dot{m}_i}{\sum |\dot{m}_i|} \right|$ is less than the value specified for this input field. This convergence criteria is equivalent to the ratio of the absolute value of the sum of all network airflows ($\left| \sum \dot{m}_i \right|$) to the sum of network airflow magnitudes ($\sum |\dot{m}_i|$). The default value is 1.0×10^{-4} .

Field: Absolute Airflow Convergence Tolerance

The solution is assumed to have converged when the summation of the absolute value of all network airflows ($\sum |\dot{m}_i|$) is less than the value specified for this input field. The default value is 1.0×10^{-6} .

Field: Convergence Acceleration Limit

If the ratio of successive pressure corrections is less than this limit, use Steffensen acceleration algorithm (Ref. AirflowNetwork Model in the EnergyPlus Engineering Reference). The range for this field is -1 to 1, with the default value being -0.5.

Field: Azimuth Angle of Long Axis of Building

Gives the orientation of a rectangular building for calculating wind pressure coefficients. This is the smaller of the angles, measured clockwise, between North and the long axis of the building (see Figure 78). Used only if Wind Pressure Coefficient Type = SurfaceAverageCalculation. The range for this input is 0 to 180, with the default value being 0.

Field: Ratio of Building Width Along Short Axis to Width Along Long Axis

This is the aspect ratio of a rectangular footprint. It is given by the width of the footprint along its short axis divided by the width along the long axis (see Figure 78). If the footprint is square, the value of this field is 1.0. Used only if Wind Pressure Coefficient Type = SurfaceAverageCalculation. The range for this input is > 0 to 1, with the default value being 1.

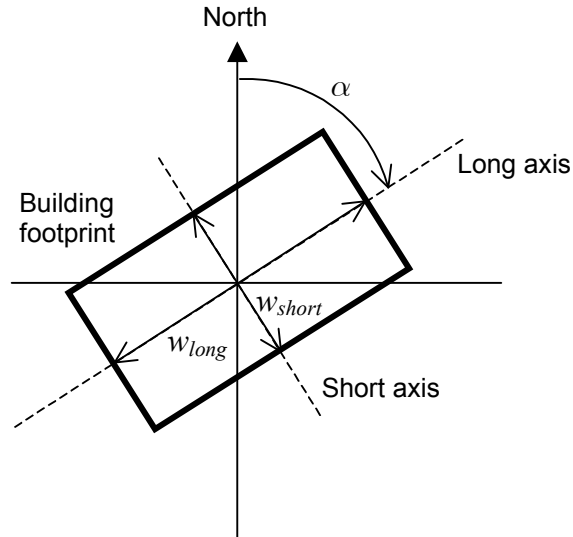


Figure 78. Footprint of a rectangular building showing variables used by the program to calculate surface-average wind pressure coefficients. The angle α is the “Azimuth Angle of Long Axis of Building.”
 W_{short}/W_{long} is the “Ratio of Building Width Along Short Axis to Width Along Long Axis.”

Below is the input data dictionary description for the AirflowNetwork:SimulationControl object.

```

AirflowNetwork:SimulationControl,
  \min-fields 13
  \unique-object
  \memo This object defines the global parameters used in an AirflowNetwork simulation.
A1 , \field Name
  \required-field
  \note Enter a unique name for this object.
A2 , \field AirflowNetwork Control
  \type choice
  \key MultizoneWithDistribution
  \key MultizoneWithoutDistribution
  \key MultizoneWithDistributionOnlyDuringFanOperation
  \key NoMultizoneOrDistribution
  \default NoMultizoneOrDistribution
  \note NoMultizoneOrDistribution: Only perform Simple calculations (objects ZoneInfiltration,
  \note ZoneVentilation, ZoneMixing and ZoneCrossMixing);
  \note MultizoneWithoutDistribution: Use AirflowNetwork objects to simulate multizone
  \note Airflows driven by wind during simulation time,
  \note and objects of ZoneInfiltration, ZoneVentilation, ZoneMixing and ZoneCrossMixing are ignored;
  \note MultizoneWithDistributionOnlyDuringFanOperation: Perform distribution system
  \note calculations during system fan on time
  \note and Simple calculations during system Fan off time;
  \note MultizoneWithDistribution: Perform distribution system calculations during system
  \note fan on time and multizone Airflow driven by wind during system fan off time.
A3 , \field Wind Pressure Coefficient Type
  \type choice
  \key Input
  \key SurfaceAverageCalculation
  \default SurfaceAverageCalculation
  \note Input: User must enter AirflowNetwork:MultiZone:WindPressureCoefficientArray,
  \note AirflowNetwork:MultiZone:ExternalNode, and
  \note AirflowNetwork:MultiZone:WindPressureCoefficientValues objects.
  \note SurfaceAverageCalculation: used only for rectangular buildings.
  \note If SurfaceAverageCalculation is selected,
  \note AirflowNetwork:MultiZone:WindPressureCoefficientArray, AirflowNetwork:MultiZone:ExternalNode,
  \note and AirflowNetwork:MultiZone:WindPressureCoefficientValues objects are not used.

```

```

A4 , \field AirflowNetwork Wind Pressure Coefficient Array Name
      \type object-list
      \object-list WPCSetNames
      \note Used only if Wind Pressure Coefficient Type = Input, otherwise this field may be left blank.
A5 , \field Height Selection for Local Wind Speed Calculation
      \type choice
      \key ExternalNode
      \key OpeningHeight
      \default OpeningHeight
      \note If ExternalNode is selected, the heights given in the
      \note AirflowNetwork:MultiZone:ExternalNode object will be used.
      \note If OpeningHeight is selected, the surface opening heights (centroid) will be used to
      \note calculate local wind speed
      \note This field is ignored when the choice of the Wind Pressure Coefficient Type field is
      \note SurfaceAverageCalculation.
A6 , \field Building Type
      \note Used only if Wind Pressure Coefficient Type = SurfaceAverageCalculation,
      \note otherwise this field may be left blank.
      \type choice
      \key LowRise
      \key HighRise
      \default LowRise
N1 , \field Maximum Number of Iterations
      \type integer
      \units dimensionless
      \default 500
      \minimum > 10
      \maximum 30000
      \note Determines the maximum number of iterations used to converge on a solution. If this limit
      \note is exceeded, the program terminates.
A7 , \field Initialization Type
      \type choice
      \key LinearInitializationMethod
      \key ZeroNodePressures
      \default ZeroNodePressures
N2 , \field Relative Airflow Convergence Tolerance
      \type real
      \units dimensionless
      \default 1.E-4
      \minimum > 0
      \note This tolerance is defined as the absolute value of the sum of the mass Flow Rates
      \note divided by the sum of the absolute value of the mass Flow Rates. The mass Flow Rates
      \note described here refer to the mass Flow Rates at all Nodes in the AirflowNetwork model.
      \note The solution converges when both this tolerance and the tolerance in the next field
      \note (Absolute Airflow Convergence Tolerance) are satisfied.
N3 , \field Absolute Airflow Convergence Tolerance
      \type real
      \units kg/s
      \default 1.E-6
      \minimum > 0
      \note This tolerance is defined as the absolute value of the sum of the mass flow rates. The mass
      \note flow rates described here refer to the mass flow rates at all nodes in the AirflowNetwork
      \note model. The solution converges when both this tolerance and the tolerance in the previous
      \note field (Relative Airflow Convergence Tolerance) are satisfied.
N4 , \field Convergence Acceleration Limit
      \type real
      \units dimensionless
      \note Used only for AirflowNetwork:SimulationControl
      \minimum -1
      \maximum 1
      \default -0.5
N5 , \field Azimuth Angle of Long Axis of Building
      \type real
      \units deg
      \minimum 0.0
      \maximum 180.0
      \default 0.0
      \note Degrees clockwise from true North.
      \note Used only if Wind Pressure Coefficient Type = SurfaceAverageCalculation.

```

```
N6 ; \field Ratio of Building Width Along Short Axis to Width Along Long Axis
\type real
\minimum> 0.0
\maximum 1.0
\default 1.0
\note Used only if Wind Pressure Coefficient Type = SurfaceAverageCalculation.
```

An IDF example is shown below:

```
AirflowNetwork:SimulationControl,
AirflowNetwork_All,      !- Name
MultiZoneWithDistribution, !- AirflowNetwork Control
Input,                   !- Wind Pressure Coefficient Type
Every 30 Degrees,        !- AirflowNetwork Wind Pressure Coefficient Array Name
OpeningHeight,           !- Height Selection for Local Wind Speed Calculation
LowRise,                 !- Building Type
500,                     !- Maximum Number of Iterations {dimensionless}
ZeroNodePressures,      !- Initialization Type
1.0E-05,                 !- Relative Airflow Convergence Tolerance {dimensionless}
1.0E-06,                 !- Absolute Airflow Convergence Tolerance {kg/s}
-0.5,                   !- Convergence Acceleration Limit {dimensionless}
0.0,                     !- Azimuth Angle of Long Axis of Building {deg}
1.0;                     !- Ratio of Building Width Along Short Axis to Width Along Long Axis
```

AirflowNetwork:Multizone data objects are used to calculate multizone airflows. This section describes the input requirements for the following objects:

- AirflowNetwork:MultiZone:Zone

AirflowNetwork:Multizone data objects are used to calculate multizone airflows. This section describes the input requirements for the following objects:

- AirflowNetwork:MultiZone:Zone
- AirflowNetwork:MultiZone:Surface
- AirflowNetwork:MultiZone:Surface:Crack
- AirflowNetwork:MultiZone:ReferenceCrackConditions
- AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea
- AirflowNetwork:MultiZone:Component:DetailedOpening
- AirflowNetwork:MultiZone:Component:SimpleOpening
- AirflowNetwork:MultiZone:Component:ZoneExhaustFan
- AirflowNetwork:MultiZone:ExternalNode
- AirflowNetwork:MultiZone:WindPressureCoefficientArray
- AirflowNetwork:MultiZone:WindPressureCoefficientValues

A detailed description for each of these objects is provided below.

AirflowNetwork:Multizone:Zone

This object allows control of natural ventilation through exterior and interior openings in a zone, where “opening” is defined as an openable window or door. (Note that only window, door or glass door subsurfaces in a zone that are specified using AirflowNetwork:MultiZone:Component:DetailedOpening or AirflowNetwork:Multizone:Component:SimpleOpening and have an associated AirflowNetwork:Multizone:Surface object are considered to be openings). The control will be applied in the same way to all of the openings in the zone.

This object is required to perform Airflow Network calculations. Note that ventilation control for all openings is provided at the zone level as default and individual ventilation control of a surface opening can be used to override the zone-level control (see the AirflowNetwork:Multizone:Surface object description below).

Field: Zone Name

The name of the EnergyPlus thermal zone corresponding to the AirflowNetwork zone.

Field: Ventilation Control Mode

Specifies the type of zone-level natural ventilation control.

Let T_{out} equal the outdoor air temperature, T_{zone} equal the previous timestep's zone air temperature, T_{set} equal the Vent Temperature Schedule value, H_{zone} equal the specific enthalpy of zone air from the previous timestep, and H_{out} equal the specific enthalpy of outdoor air. Then the four allowed choices for Ventilation Control Mode are:

NoVent: All of the zone's openable windows and doors are closed at all times independent of indoor or outdoor conditions. The Venting Availability Schedule is ignored in this case. This is the default value for this field.

Temperature: All of the zone's openable windows and doors are opened if $T_{zone} > T_{out}$ **and** $T_{zone} > T_{set}$ **and** Venting Availability Schedule (see below) allows venting.

Enthalpy: All of the zone's openable windows and doors are opened if $H_{zone} > H_{out}$ **and** $T_{zone} > T_{set}$ **and** Venting Availability Schedule allows venting.

Constant: Whenever this object's Venting Availability Schedule allows venting, all of the zone's openable windows and doors are open, independent of indoor or outdoor conditions. Note that "Constant" here means that the size of each opening is fixed while venting; the air flow through each opening can, of course, vary from timestep to timestep.

Field: Ventilation Control Zone Temperature Setpoint Schedule Name

The name of a schedule of zone air temperature set points that controls the opening of windows and doors in the thermal zone to provide natural ventilation. This setpoint is the temperature above which all the openable windows and doors in the zone will be opened if the conditions described in the previous field Ventilation Control Mode are met.

The Ventilation Control Zone Temperature Setpoint Schedule Name applies only to windows and doors in the zone that are specified using AirflowNetwork:MultiZone:Component:DetailedOpening or AirflowNetwork:MultiZone:Component:SimpleOpening and have an associated AirflowNetwork:MultiZone:Surface object.

(The discussion under the field Window/Door Opening Factor in the AirflowNetwork:MultiZone:Surface object describes how the actual opening area of a window or door in a particular timestep is determined.)

Modulation of Openings

The following five fields can be used to modulate the window/door openings when Ventilation Control Mode = Temperature or Enthalpy. These fields determine a factor between 0 and 1 that multiplies the opening factor of each window and door in the zone according to the control action shown in Figure 79 for Ventilation Control Mode = Temperature and in Figure 80 for Ventilation Control Mode = Enthalpy. Modulation of the openings can reduce the large temperature swings that can occur if the windows/doors are open too far when they are venting, especially when there is a large inside-outside temperature difference.

The modulation takes the following form when Ventilation Control Mode = Temperature:

$$T_{zone} - T_{out} \leq [\text{Lower Value on Inside/Outside Temperature Difference for Modulating the Venting Open Factor}] \rightarrow \text{Multiplication factor} = 1.0$$

$$[\text{Lower Value on Inside/Outside Temperature Difference for Modulating the Venting Open Factor}] < T_{zone} - T_{out} < [\text{Upper Value on Inside/Outside Temperature Difference for Modulating the Venting Open Factor}] \rightarrow \text{Multiplication factor} < 1.0$$

Open Factor] → Multiplication factor varies linearly from 1.0 to [Limit Value on Multiplier for Modulating Venting Open Factor]

$T_{\text{zone}} - T_{\text{out}} \geq$ [Upper Value on Inside/Outside Temperature Difference for Modulating the Venting Open Factor] → Multiplication factor = [Limit Value on Multiplier for Modulating Venting Open Factor]

One way of “tuning” the following modulation control parameters is to perform a sensitivity analysis for winter and/or summer design days to determine what combination of values causes the biggest reduction in zone air temperature fluctuations due to venting.

Note that the default values for the following fields are such that, if none of the fields are specified, the default values are assigned.

Field: Minimum Venting Open Factor

See Figure 79 or Figure 80. This field applies only if Ventilation Control Mode = Temperature or Enthalpy. This value may be from zero to 1.0, with the default being 0.0.

Field: Indoor and Outdoor Temperature Difference Lower Limit For Maximum Venting Open Factor

See Figure 79. This field applies only if Ventilation Control Mode = Temperature. This value may be from zero to less than 100°C, with the default being 0°C. The value for this field must be less than the value specified for the following field.

Field: Indoor and Outdoor Temperature Difference Upper Limit for Minimum Venting Open Factor

See Figure 79. This field applies only if Ventilation Control Mode = Temperature. This value must be greater than 0°C, with the default being 100°C. The value for this field must be greater than the value specified for the previous field.

Field: Indoor and Outdoor Enthalpy Difference Lower Limit For Maximum Venting Open Factor

See Figure 80. This field applies only if Ventilation Control Mode = Enthalpy. This value may be from zero to less than 300,000 J/kg, with the default being 0 J/kg. The value for this field must be less than the value specified for the following field.

Field: Indoor and Outdoor Enthalpy Difference Upper Limit for Minimum Venting Open Factor

See Figure 80. This field applies only if Ventilation Control Mode = Enthalpy. This value must be greater than zero, with the default being 300,000 J/kg. The value for this field must be greater than the value specified for the previous field.

Field: Venting Availability Schedule Name

The name of a schedule that specifies when venting is available. A zero or negative schedule value means venting is not allowed. A value greater than zero means venting can occur if other venting control conditions (specified by Ventilation Control Mode and Vent Temperature Schedule Name) are satisfied. This schedule name should not be confused with Vent Temperature Schedule Name.

If a Venting Availability Schedule Name is not specified, it is assumed that venting is always available.

Using Venting Availability Schedule allows you to turn off venting at certain times of the day (at night, for example), of the week (on weekends, for example), or of the year (during the winter, for example).

If used with Ventilation Control Mode = Constant, the ventilation rate is constant only when this schedule allows venting; otherwise the ventilation rate is set to zero.

If Ventilation Control Mode = NoVent, this schedule has no effect.

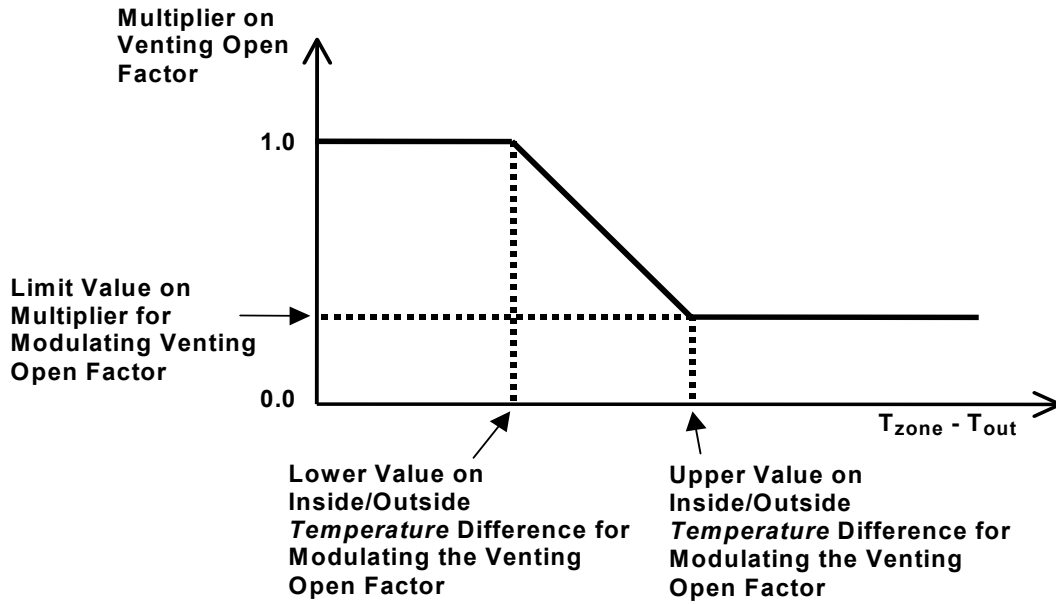


Figure 79. Modulation of venting area according to inside-outside temperature difference.

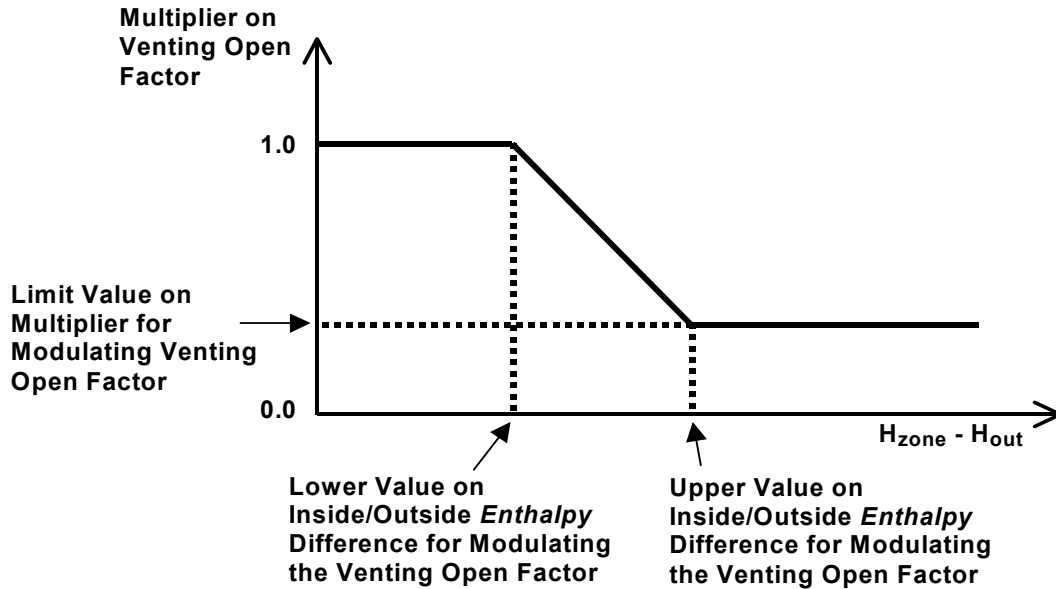


Figure 80. Modulation of venting area according to inside-outside enthalpy difference.

Note: In order to establish an airflow network, each AirflowNetwork:Multizone:Zone object must have at least two surfaces defined with AirflowNetwork:Multizone:Surface objects, so that air can flow from one

zone into other zones (or to outdoors) through the network (air mass flow conserved). In addition, for all AirflowNetwork:Multizone:Surface objects facing the same Zone (ref. BuildingSurface:Detailed), at least two different environments must be defined for the other side of these surfaces (e.g., an external node and an adjacent zone, two adjacent zones, or two external nodes).

Below is the input data dictionary description for the AirflowNetwork:Multizone:Zone object.

```

AirflowNetwork:MultiZone:Zone,
  \min-fields 8
  \memo This object is used to simultaneously control a thermal zone's window and door openings,
  \memo both exterior and interior.
A1, \field Zone Name
  \required-field
  \type object-list
  \object-list ZoneNames
  \note Enter the zone name where ventilation control is required.
A2, \field Ventilation Control Mode
  \type choice
  \key Temperature
  \key Enthalpy
  \key Constant
  \key NoVent
  \default NoVent
  \note When Ventilation Control Mode = Temperature or Enthalpy, the following
  \note fields are used to modulate the Ventilation Open Factor for all
  \note window and door openings in the zone according to the zone's
  \note indoor-outdoor temperature or enthalpy difference.
  \note Constant: controlled by field Venting Schedule Name.
  \note NoVent: control will not open window or door during simulation (Ventilation Open Factor = 0).
A3, \field Ventilation Control Zone Temperature Setpoint Schedule Name
  \type object-list
  \object-list ScheduleNames
  \note Used only if Ventilation Control Mode = Temperature or Enthalpy.
N1, \field Minimum Venting Open Factor
  \type real
  \units dimensionless
  \minimum 0.0
  \maximum 1.0
  \default 0.0
  \note Used only if Ventilation Control Mode = Temperature or Enthalpy.
N2, \field Indoor and Outdoor Temperature Difference Lower Limit For Maximum Venting Open Factor
  \type real
  \units deltaC
  \minimum 0.0
  \maximum< 100.0
  \default 0.0
  \note Applicable only if Ventilation Control Mode = Temperature.
  \note This value must be less than the corresponding upper value (next field).

```

```

N3, \field Indoor and Outdoor Temperature Difference Upper Limit for Minimum Venting Open Factor
\type real
\units deltaC
\minimum> 0.0
\default 100.0
\note Applicable only if Ventilation Control Mode = Temperature.
\note This value must be greater than the corresponding lower value (previous field).
N2, \field Indoor and Outdoor Enthalpy Difference Lower Limit For Maximum Venting Open Factor
\type real
\units deltaJ/kg
\minimum 0.0
\maximum< 300000.0
\default 0.0
\note Applicable only if Ventilation Control Mode = Enthalpy.
\note This value must be less than the corresponding upper value (next field).
N3, \field Indoor and Outdoor Enthalpy Difference Upper Limit for Minimum Venting Open Factor
\type real
\units deltaJ/kg
\minimum> 0.0
\default 300000.0
\note Applicable only if Ventilation Control Mode = Enthalpy.
\note This value must be greater than the corresponding lower value (previous field).

```

```

A4; \field Venting Availability Schedule Name
\type object-list
\object-list ScheduleNames
\note Non-zero Schedule value means venting is allowed if other venting control conditions are
\note satisfied. A zero (or negative) Schedule value means venting is not allowed under any
\note The Schedule values should be greater than or equal to 0 and less than or equal to 1.
\note circumstances. If this Schedule is not specified then venting is allowed if
\note other venting control conditions are satisfied.
\note Not used if Ventilation Control Mode = NoVent.

```

An IDF example is shown below:

```

AirflowNetwork:MultiZone:Zone,
RESISTIVE_ZONE,           !- Name of Associated Thermal Zone
Temperature,              !- Ventilation Control Mode
WindowVentSched,         !- Vent Temperature Schedule Name
0.3,                     !- Limit Value on Multiplier for Modulating Venting Open Factor
                          !- {dimensionless}
5.0,                     !- Lower Value on Inside/Outside Temperature Difference for
                          !- Modulating the Venting Open Factor {deltaC}
10.0,                    !- Upper Value on Inside/Outside Temperature Difference for
                          !- Modulating the Venting Open Factor {deltaC}
0.0,                     !- Lower Value on Inside/Outside Enthalpy Difference for Modulating
                          !- the Venting Open Factor {J/kg}
300000.0,                !- Upper Value on Inside/Outside Enthalpy Difference for Modulating
                          !- the Venting Open Factor {J/kg}
VentingSched;            !- Venting Availability Schedule Name

```

AirflowNetwork:Multizone:Surface

The AirflowNetwork:Multizone:Surface object specifies the properties of a surface “linkage” through which air flows. This linkage is always associated with a heat transfer surface (wall, roof, floor, or a ceiling) or subsurface (door, glass door, or window) with both faces exposed to air. The linkage specifies two connected nodes: two zone nodes defined in AirflowNetwork:MultiZone:Zone objects based on inside and outside face environment for an interior surface, or a zone node defined in an AirflowNetwork:MultiZone:Zone object based on inside face environment and an external node defined in an AirflowNetwork:MultiZone:ExternalNode object for an exterior surface. The associated leakage component for this surface can be a crack (or surface effective leakage area) in an exterior or interior heat transfer surface or subsurface, or an exterior or interior window, door

or glass door (heat transfer subsurface) that can be opened to allow air flow. The allowed surface air leakage components are:

- AirflowNetwork:MultiZone:Surface:Crack
- AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea
- AirflowNetwork:MultiZone:Component:DetailedOpening
- AirflowNetwork:MultiZone:Component:SimpleOpening
- AirflowNetwork:MultiZone:Component:ZoneExhaustFan

The two “opening” components are used to modulate openness based on required conditions.

The AirflowNetwork:Multizone:Surface object allows a heat transfer surface or subsurface to have one crack (or one surface effective leakage area object), or a subsurface (i.e., window, door or glass door) to have one opening (detailed or simple).

An interior heat transfer surface (BuildingSurface:Detailed) whose surface name is used as the input for the Outside Boundary Condition Object field represents a floor without ground contact and is not allowed as an AirflowNetwork:Multizone:Surface. A heat transfer surface defined in the BuildingSurface:Detailed:ExteriorNaturalVentedCavity is also not allowed.

Field: Surface Name

This is the name of the corresponding surface (wall, roof, ceiling, floor, window, door or glass door).

Information on this surface is used by the program as follows:

- (1) For a linkage associated with an exterior heat transfer surface: air flow through this linkage is between the outside environment and the thermal zone to which the surface belongs.
- (2) For a linkage associated with an interior (i.e., interzone) heat transfer surface: air flow through this linkage is between the thermal zones separated by the surface (i.e., the thermal zone associated with the inside face environment and the thermal zone associated with the outside face environment).
- (3) This heat transfer surface determines the height of the linkage, which is used in calculating buoyancy-related flow through the linkage.

Note: It is possible to define an interzone surface twice in EnergyPlus, once in each of the zones that the surface separates. Previously this was a requirement of EnergyPlus (prior to version 2.0), but now it is optional and the user also has the option of only defining the surface once (EnergyPlus defines the second surface automatically within the program). For each interzone surface, use only one (of possible two) interzone surface names in the AirflowNetwork:Multizone:Surface object for “Surface Name.” **Do not** enter two AirflowNetwork:Multizone:Surface objects corresponding to the two possible interzone names. This would cause the air flow through the surface to be counted twice.

Field: Leakage Component Name

The name of the AirflowNetwork:MultiZone:Surface:Crack, AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea, AirflowNetwork:MultiZone:Component:SimpleOpening, AirflowNetwork:MultiZone:Component:DetailedOpening or AirflowNetwork:MultiZone:Component:ZoneExhaustFan object associated with this air flow linkage.

If the name of an AirflowNetwork:MultiZone:Component:DetailedOpening or AirflowNetwork:MultiZone:Component:SimpleOpening is given here, then the Surface Name in the previous field must be that of a window, door or glass door heat transfer subsurface. Otherwise an error message will be reported.

If the name of an AirflowNetwork:MultiZone:Surface:Crack object or AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea object is given here, the program will position the crack at the average height of the associated heat transfer surface or subsurface. The user can define multiple heat transfer surfaces (e.g., split a wall into several surfaces) to be more precise in establishing the crack location. Similarly, the user can define multiple heat transfer surfaces if a wall, for example, has multiple cracks or openings that need to be defined individually.

If the name of an AirflowNetwork:MultiZone:Component:ZoneExhaustFan is given here, then the Surface Name in the previous field must be that of an exterior heat transfer surface. The zone name defined in the Zone Name field for this heat transfer surface must be the same zone name defined in the ZoneHVAC:EquipmentConnections object (which references a ZoneHVAC:EquipmentList containing the name of the corresponding zone exhaust fan). Otherwise an error message will be reported. When this zone exhaust fan is operating for a simulation timestep, all surface-level controls described below are ignored for that timestep.

Field: External Node Name

The name of the associated AirflowNetwork:MultiZone:ExternalNode object, which determines the wind pressure coefficients for the heat transfer surface. Used only if Surface Name is for an exterior surface.

If Wind Pressure Coefficient Type = SurfaceAverageCalculation in the AirflowNetwork:SimulationControl object, this field is not used and a blank may be entered. If the surface is an interior (i.e., interzone) surface, leave this field blank.

Field: Window/Door Opening Factor, or Crack Factor

If this linkage is associated with an AirflowNetwork:MultiZone:Component:DetailedOpening or AirflowNetwork:MultiZone:Component:SimpleOpening object (which means it is an openable window or door), then this field is called “Window/Door Opening Factor” and represents the value of the Opening Factor that is in effect when the Vent Temperature Schedule (defined in the AirflowNetwork:MultiZone:Zone object) indicates that this window or door is open.

The AirflowNetwork model uses a combination of factors to determine the actual opening area for a window or door when it is venting. For example, consider a window that is 1.5m high and 2.0m wide (excluding frame). Assume that the AirflowNetwork:MultiZone:Component:DetailedOpening for this window has Type of Large Vertical Opening = 1 (non-pivoting window), Height Factor = 0.5 and Width Factor = 0.8. Then when the window is fully open, the opening area = height of opening (0.5x1.5) times width of opening (0.8x2.0) = 0.75x1.6 = 1.2 m². If the Window/Door Opening Factor is 0.75, then the opening area = 0.75x1.2 = 0.9 m².

If, in addition, the window is in a thermal zone for which opening modulation has been specified (ref: AirflowNetwork:MultiZone:Zone) and the multiplication factor due to modulation is 0.3 in a particular timestep, then the actual opening factor that timestep = 0.3x0.75 = 0.225 and the actual opening area that timestep = 0.3x0.9 = 0.27 m².

If this linkage is associated with an AirflowNetwork:MultiZone:Surface:Crack object, the following crack air flow equation is used.

$$Q = (\text{Crack Factor}) * C_T * C_Q (\Delta P)^n$$

Where

Q = air mass flow (kg/s)

C_Q = air mass flow coefficient (kg/s @ 1 Pa)

C_T = reference condition temperature correction factor (dimensionless). See AirflowNetwork:MultiZone:Surface:Crack object.

ΔP = pressure difference across crack (Pa)

n = air flow exponent (dimensionless)

The following fields control venting. They are used only when Name of Associated Heat Transfer Surface is that of an openable exterior or interior window, door or glass door. They only apply to openings, and do not apply to surface cracks, effective leakage area or zone exhaust fans. If none of these fields is specified, or if Ventilation Control Mode = ZoneLevel, venting is controlled by the AirflowNetwork:Multizone:Zone object for the thermal zone containing the window or door (ref: AirflowNetwork:Multizone:Zone Data).

Field: Ventilation Control Mode

Specifies the type of surface-level natural ventilation control.

Let T_{out} equal the outdoor air temperature, T_{zone} equal the previous timestep's zone air temperature, T_{set} equal the Vent Temperature Schedule value, H_{zone} equal the specific enthalpy of zone air from the previous timestep, and H_{out} equal the specific enthalpy of outdoor air. Then the four allowed choices for Ventilation Control Mode are:

NoVent: The openable window or door associated with this surface is closed at all times independent of indoor or outdoor conditions. The Venting Availability Schedule is ignored in this case.

Temperature: The openable window or door associated with this surface is opened if $T_{zone} > T_{out}$ and $T_{zone} > T_{set}$ and Venting Availability Schedule (see below) allows venting.

Enthalpy: The openable window or door associated with this surface is opened if $H_{zone} > H_{out}$ and $T_{zone} > T_{set}$ and Venting Availability Schedule allows venting.

Constant: Whenever this object's Venting Availability Schedule allows venting, the openable window or door associated with this surface is open, independent of indoor or outdoor conditions. Note that "Constant" here means that the size of this opening is fixed while venting; the air flow through this opening can, of course, vary from timestep to timestep.

ZoneLevel: Venting of the window or door is not controlled individually, but is controlled instead at the zone level. This means that the venting is determined by the AirflowNetwork:Multizone:Zone object for the thermal zone containing the window or door (ref: AirflowNetwork:Multizone:Zone object). This is the default value for this field.

AdjacentTemperature: This choice is used for an interior surface only. The openable interior window or door associated with this surface is opened if $T_{zone} > T_{adjacent\ zone}$ and $T_{zone} > T_{set}$ and Venting Availability Schedule (see below) allows venting, where $T_{adjacent\ zone}$ is the adjacent zone temperature.

AdjacentEnthalpy: This choice is also used for an interior surface only. The interior openable window or door associated with this surface is opened if $H_{zone} > H_{adjacent\ zone}$ and $T_{zone} > T_{set}$ and Venting Availability Schedule allows venting, where $H_{adjacent\ zone}$ is the adjacent zone specific enthalpy.

Field: Ventilation Control Zone Temperature Setpoint Schedule Name

The name of a schedule of zone air temperature set points that controls the opening of a window or door associated with this surface to provide natural ventilation. This setpoint is the temperature above which this openable window or door will be opened if the conditions described in the previous field Ventilation Control Mode are met.

The Ventilation Control Zone Temperature Setpoint Schedule applies only to a window or door attached to this surface that is specified using

AirflowNetwork:MultiZone:Component:DetailedOpening or
 AirflowNetwork:MultiZone:Component:SimpleOpening.

(The discussion under the field Window/Door Opening Factor in this object describes how the actual opening area of a window or door in a particular timestep is determined.)

Modulation of Openings

The following five fields can be used to modulate this window/door opening when Ventilation Control Mode = Temperature or Enthalpy. These fields determine a factor between 0 and 1 that multiplies the opening factor of this window or door according to the control action shown in Figure 79 for Ventilation Control Mode = Temperature and in Figure 80 for Ventilation Control Mode = Enthalpy. Modulation of this opening can reduce the large temperature swings that can occur if the window/door is open too far when it is venting, especially when there is a large inside-outside temperature difference.

The modulation takes the following form when Ventilation Control Mode = Temperature:

$T_{\text{zone}} - T_{\text{out}} \leq [\text{Lower Value on Inside/Outside Temperature Difference for Modulating the Venting Open Factor}] \rightarrow \text{Multiplication factor} = 1.0$

$[\text{Lower Value on Inside/Outside Temperature Difference for Modulating the Venting Open Factor}] < T_{\text{zone}} - T_{\text{out}} < [\text{Upper Value on Inside/Outside Temperature Difference for Modulating the Venting Open Factor}] \rightarrow \text{Multiplication factor varies linearly from 1.0 to } [\text{Limit Value on Multiplier for Modulating Venting Open Factor}]$

$T_{\text{zone}} - T_{\text{out}} \geq [\text{Upper Value on Inside/Outside Temperature Difference for Modulating the Venting Open Factor}] \rightarrow \text{Multiplication factor} = [\text{Limit Value on Multiplier for Modulating Venting Open Factor}]$

One way of “tuning” the following modulation control parameters is to perform a sensitivity analysis for winter and/or summer design days to determine what combination of values causes the biggest reduction in zone air temperature fluctuations due to venting.

Note that the default values for the following fields are such that, if none of the fields are specified, modulation will not occur.

Field: Minimum Venting Open Factor

See Figure 79 or Figure 80. This field applies only if Ventilation Control Mode = Temperature or Enthalpy. This value may be from zero to 1.0, with the default being 0.0.

Field: Indoor and Outdoor Temperature Difference Lower Limit For Maximum Venting Open Factor

See Figure 79. This field applies only if Ventilation Control Mode = Temperature. This value may be from zero to less than 100°C, with the default being 0°C. The value for this field must be less than the value specified for the following field.

Field: Indoor and Outdoor Temperature Difference Upper Limit for Minimum Venting Open Factor

See Figure 79. This field applies only if Ventilation Control Mode = Temperature. This value must be greater than 0°C, with the default being 100°C. The value for this field must be greater than the value specified for the previous field.

Field: Indoor and Outdoor Enthalpy Difference Lower Limit For Maximum Venting Open Factor

See Figure 80. This field applies only if Ventilation Control Mode = Enthalpy. This value may be from zero to less than 300,000 J/kg, with the default being 0 J/kg. The value for this field must be less than the value specified for the following field.

Field: Indoor and Outdoor Enthalpy Difference Upper Limit for Minimum Venting Open Factor

See Figure 80. This field applies only if Ventilation Control Mode = Enthalpy. This value must be greater than zero, with the default being 300,000 J/kg. The value for this field must be greater than the value specified for the previous field.

Field: Venting Availability Schedule Name

The name of a schedule that specifies when venting is available. A zero or negative schedule value means venting is not allowed. A value greater than zero means venting can occur if other venting control conditions (specified by Ventilation Control Mode and Vent Temperature Schedule Name) are satisfied. This schedule name should not be confused with Vent Temperature Schedule Name.

If a Venting Availability Schedule Name is not specified, it is assumed that venting is always available.

Using Venting Availability Schedule allows you to turn off venting at certain times of the day (at night, for example), week (on weekends, for example), or year (during the winter, for example).

If used with Ventilation Control Mode = Constant, the ventilation rate is constant only when this schedule allows venting; otherwise the ventilation rate is set to zero.

If Ventilation Control Mode = NoVent, this schedule has no effect.

Note: In order to establish an airflow network, each AirflowNetwork:Multizone:Zone object must have at least two surfaces defined with AirflowNetwork:Multizone:Surface objects, so that air can flow from one zone into other zones (or to outdoors) through the network (air mass flow conserved). In addition, for all AirflowNetwork:Multizone:Surface objects facing the same Zone Name (ref. BuildingSurface:Detailed), at least two different environments must be defined for the other side of these surfaces (e.g., an external node and an adjacent zone, two adjacent zones, or two external nodes).

Below is the input data dictionary description for the AirflowNetwork:Multizone: Surface object.

```

AirflowNetwork:MultiZone:Surface,
  \min-fields 4
  \memo This object specifies the properties of a surface linkage through which air flows.
  \memo Airflow Report: Node 1 as an inside face zone;
  \memo Node 2 as an outside face zone or external node.
A1, \field Surface Name
  \required-field
  \type object-list
  \object-list SurfAndSubSurfNames
  \note Enter the name of a heat transfer surface.
A2, \field Leakage Component Name
  \required-field
  \type object-list
  \object-list SurfaceAirflowLeakageNames
  \note Enter the name of an Airflow Network leakage component. A leakage component is
  \note one of the following AirflowNetwork:Multizone objects:
AirflowNetwork:MultiZone:Component:DetailedOpening,
  \note AirflowNetwork:MultiZone:Component:SimpleOpening, AirflowNetwork:MultiZone:Surface:Crack,
  \note AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea, or
  \note AirflowNetwork:MultiZone:Component:ZoneExhaustFan.
  \note When the zone exhaust fan name is entered, any surface control fields below A3 are
  \note ignored when the zone exhaust fan turns on.
A3, \field External Node Name
  \type object-list
  \object-list ExternalNodeNames
  \note Used if Wind Pressure Coefficient Type = Input in the AirflowNetwork:SimulationControl object,
  \note otherwise this field may be left blank.
N1, \field Window/Door Opening Factor, or Crack Factor
  \required-field
  \type real
  \units dimensionless
  \minimum > 0.0
  \maximum 1.0
  \default 1.0
  \note This field specifies a multiplier for a crack, window, or door.
A4, \field Ventilation Control Mode
  \type choice
  \key Temperature
  \key Enthalpy
  \key Constant
  \key NoVent
  \key ZoneLevel
  \key AdjacentTemperature
  \key AdjacentEnthalpy
  \default ZoneLevel
  \note When Ventilation Control Mode = Temperature or Enthalpy, the following
  \note fields are used to modulate the Ventilation Open Factor for a
  \note window or door opening according to the parent zone's
  \note indoor-outdoor temperature or enthalpy difference.
  \note When Ventilation Control Mode = AdjacentTemperature or AdjacentEnthalpy, the following
  \note fields are used to modulate the Ventilation Open Factor for an interior
  \note window or door opening according to temperature or enthalpy difference
  \note between the parent zone and the adjacent zone.
  \note Constant: controlled by field Venting Schedule Name.
  \note NoVent: control will not open window or door during simulation (Ventilation Open Factor = 0).
  \note ZoneLevel: control will be controlled by AirflowNetwork:MultiZone:Zone
  \note Mode.
A5, \field Ventilation Control Zone Temperature Setpoint Schedule Name
  \type object-list
  \object-list ScheduleNames
  \note Used only if Ventilation Control Mode = Temperature or Enthalpy.
N2, \field Minimum Venting Open Factor
  \type real
  \units dimensionless
  \minimum 0.0
  \maximum 1.0
  \default 0.0
  \note Used only if Ventilation Control Mode = Temperature or Enthalpy.

```

```

N3, \field Indoor and Outdoor Temperature Difference Lower Limit For Maximum Venting Open Factor
\note Applicable only if Ventilation Control Mode = Temperature
\type real
\units deltaC
\minimum 0.0
\maximum< 100
\default 0.0
N4, \field Indoor and Outdoor Temperature Difference Upper Limit for Minimum Venting Open Factor
\type real
\units deltaC
\minimum> 0.0
\default 100.0
\note Applicable only if Ventilation Control Mode = Temperature.
\note This value must be greater than the corresponding lower value (previous field).
N5, \field Indoor and Outdoor Enthalpy Difference Lower Limit For Maximum Venting Open Factor
\type real
\units deltaJ/kg
\minimum 0.0
\maximum< 300000.0
\default 0.0
\note Applicable only if Ventilation Control Mode = Enthalpy.
\note This value must be less than the corresponding upper value (next field).
N6, \field Indoor and Outdoor Enthalpy Difference Upper Limit for Minimum Venting Open Factor
\type real
\units deltaJ/kg
\minimum> 0.0
\default 300000.0
\note Applicable only if Ventilation Control Mode = Enthalpy.
\note This value must be greater than the corresponding lower value (previous field).
A6; \field Venting Availability Schedule Name
\type object-list
\object-list ScheduleNames
\note Non-zero schedule value means venting is allowed if other venting control conditions are
\note satisfied. A zero (or negative) schedule value means venting is not allowed under any
\note circumstances. The schedule values should be greater than or equal to 0 and less than or
\note equal to 1. If this schedule is not specified then venting is allowed if
\note other venting control conditions are satisfied.
\note Not used if Ventilation Control Mode = NoVent or ZoneLevel.

```

IDF examples are provided below:

```

AirflowNetwork:MultiZone:Surface,
  Zn001:Wall001,      !- Name of Associated Heat Transfer Surface
  CR-1,              !- Leakage Component Name
  SFacade,           !- External Node Name
  1.0;               !- Window/Door Opening Factor, or Crack Factor {dimensionless}

AirflowNetwork:MultiZone:Surface,
  Zn001:Wall001:Win001, !- Name of Associated Heat Transfer Surface
  WiOpen1,          !- Leakage Component Name
  SFacade,          !- External Node Name
  0.5;              !- Window/Door Opening Factor, or Crack Factor {dimensionless}

AirflowNetwork:MultiZone:Surface,
  Zn003:Wall003,      !- Name of Associated Heat Transfer Surface
  Zone3 Exhaust Fan, !- Leakage Component Name
  EFacade,           !- External Node Name
  1.0;               !- Window/Door Opening Factor, or Crack Factor {dimensionless}

```

```

AirflowNetwork:MultiZone:Surface,
  Zn001:Wall001:Win002,    !- Name of Associated Heat Transfer Surface
  WiOpen2,                !- Leakage Component Name
  WFacade,                !- External Node Name
0.5;                      !- Window/Door Opening Factor, or Crack Factor {dimensionless}
  Temperature,            !- Ventilation Control Mode
  WindowVentSched,        !- Vent Temperature Schedule Name
  0.3,                    !- Limit Value on Multiplier for Modulating Venting Open Factor
                          !- {dimensionless}
  5.0,                    !- Lower Value on Inside/Outside Temperature Difference for
                          !- Modulating the Venting Open Factor {deltaC}
  10.0,                   !- Upper Value on Inside/Outside Temperature Difference for
                          !- Modulating the Venting Open Factor {deltaC}
  0.0,                    !- Lower Value on Inside/Outside Enthalpy Difference for Modulating
                          !- the Venting Open Factor {J/kg}
  300000.0,               !- Upper Value on Inside/Outside Enthalpy Difference for Modulating
                          !- the Venting Open Factor {J/kg}
  VentingSched;           !- Venting Availability Schedule Name

```

AirflowNetwork:MultiZone:ReferenceCrackConditions

This object specifies the reference conditions for temperature, humidity, and pressure which correspond to the AirflowNetwork:MultiZone:Surface:Crack object.

Field: Name

The name of this Reference Crack Conditions object. This name is referenced by an AirflowNetwork:MultiZone:Surface:Crack object.

Field: Reference Temperature

The reference temperature in °C under which the Surface Crack Data were obtained. The default value is 20°C.

Field: Reference Barometric Pressure

The reference barometric pressure in Pa under which the Surface Crack Data were obtained. The default value is 101325 Pa.

Field: Reference Humidity Ratio

The reference humidity ratio in kg/kg under which the Surface Crack Data were obtained. The default value is 0 kg/kg.

Below is the input data dictionary description for the AirflowNetwork:MultiZone:ReferenceCrackConditions object.


```

AirflowNetwork:MultiZone:ReferenceCrackConditions,
  \min-fields 4
  \memo This object specifies the conditions under which the air mass flow coefficient was measured.
A1 , \field Name
  \required-field
  \type alpha
  \reference ReferenceCrackConditions
  \note Enter a unique name for this object.
N1 , \field Reference Temperature
  \type real
  \units C
  \default 20
  \note Enter the reference temperature under which the surface crack data were obtained.
N2 , \field Reference Barometric Pressure
  \type real
  \units Pa
  \default 101325
  \minimum 31000
  \maximum 120000
  \type real
  \ip-units inHg
  \note Enter the reference barometric pressure under which the surface crack data were obtained.
N3 ; \field Reference Humidity Ratio
  \type real
  \units kg/kg
  \default 0
  \note Enter the reference humidity ratio under which the surface crack data were obtained.
    
```

An IDF example is provided below:

```

AirflowNetwork:MultiZone:ReferenceCrackConditions,
  ReferenceCrackConditions,      !- Name of Reference Crack Conditions
  20.0,                          !- Reference Temperature for Crack Data {C}
  101325,                        !- Reference Barometric Pressure for Crack Data {Pa}
  0.0;                           !- Reference Humidity Ratio for Crack Data {kg/kg}
    
```

AirflowNetwork:MultiZone:Surface:Crack

This object specifies the properties of air flow through a crack and the associated measurement conditions. The following power law form is used that gives air flow through the crack as a function of the pressure difference across the crack:

$$Q = (\text{Crack Factor}) * C_T * C_Q (\Delta P)^n$$

Where

Q = air mass flow (kg/s)

C_Q = air mass flow coefficient (kg/s-Paⁿ @ 1 Pa)

C_T = reference condition temperature correction factor (dimensionless)

ΔP = pressure difference across crack (Pa)

n = air flow exponent (dimensionless)

$$C_T = \left[\frac{\rho_o}{\rho} \right]^{n-1} \left[\frac{v_o}{v} \right]^{2n-1}$$

where

ρ = Air density at the specific air temperature and humidity ratio conditions [kg/m³]

v = Air kinetic viscosity at the specific air temperature condition [m²/s]

ρ_o = Air density at the reference air conditions provided by the object AirflowNetwork:MultiZone:ReferenceCrackConditions specified in the field Reference Crack Conditions [kg/m³]

ν_o = Air kinetic viscosity at the reference air temperature provided by the object AirflowNetwork:MultiZone:ReferenceCrackConditions specified in the field Reference Crack Conditions [m²/s]

Note: The correction factor shown above is use for this particular component as specified.

Field: Name

This is a name for this AirflowNetwork:MultiZone:Surface:Crack object. It is referenced by an AirflowNetwork:Multizone:Surface object.

Field: Air Mass Flow Coefficient at Reference Conditions

The value of the air mass flow coefficient, C_Q , in the crack air flow equation. It has units of kg/s at 1Pa. This value must be greater than zero.

Field: Air Mass Flow Exponent

The value of the exponent, n , in the crack air flow equation. The valid range is 0.5 to 1.0, with the default value being 0.65.

Field: Reference Crack Conditions

The name of the AirflowNetwork:MultiZone:ReferenceCrackConditions object which specifies the conditions under which the air mass flow coefficient was measured. If the user omits this field and only one AirflowNetwork:MultiZone:ReferenceCrackConditions object is defined in the input data file, then those reference crack conditions will be used. If the user omits this field and either zero or more than one AirflowNetwork:MultiZone:ReferenceCrackConditions objects are defined in the input data file, then the default conditions for the AirflowNetwork:Multizone: Reference Crack Conditions object will be used.

Below is the input data dictionary description for the AirflowNetwork:MultiZone:Surface:Crack object.

```
AirflowNetwork:MultiZone:Surface:Crack,
  \min-fields 3
  \memo This object specifies the properties of airflow through a crack.
A1 , \field Name
  \required-field
  \type alpha
  \reference SurfaceAirflowLeakageNames
  \note Enter a unique name for this object.
N1 , \field Air Mass Flow Coefficient at Reference Conditions
  \type real
  \required-field
  \units kg/s
  \minimum> 0
  \note Enter the air mass flow coefficient at the conditions defined
  \note in the Reference Crack Conditions object.
  \note Defined at 1 Pa pressure difference across this crack.
```

```

N2 , \field Air Mass Flow Exponent
    \type real
    \units dimensionless
    \minimum 0.5
    \maximum 1.0
    \default 0.65
    \note Enter the air mass flow exponent for the surface crack.
A2 ; \field Reference Crack Conditions
    \type object-list
    \object-list ReferenceCrackConditions
    \note Select a AirflowNetwork:MultiZone:ReferenceCrackConditions name associated with
    \note the air mass flow coefficient entered above.

```

An IDF example is shown below:

```

AirflowNetwork:MultiZone:Surface:Crack,
CR-1,                !- Name of Surface Crack Component
0.01,                !- Air Mass Flow Coefficient at Reference Conditions {kg/s}
0.667,              !- Air Mass Flow Exponent {dimensionless}
ReferenceCrackConditions; !- Reference Crack Conditions

```

AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea

The effective leakage area (ELA) object is used to define surface air leakage. It has five fields. The relationship between pressure and airflow may be expressed as:

$$\dot{m} = ELA * C_d \sqrt{2\rho} * (\Delta P_r)^{0.5-n} (\Delta P)^n$$

where

\dot{m} = Air mass flow rate [kg/s]

ELA = Effective leakage area [m²]

ρ = Air density [kg/m³]

ΔP_r = Reference pressure difference [Pa]

ΔP = Pressure difference across this component [Pa]

C_d = Discharge coefficient [dimensionless]

n = Air mass flow exponent [dimensionless]

Field: Name

This is a name for this AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea object. It is referenced by an AirflowNetwork:MultiZone:Surface object.

Field: Effective Leakage Area

This numeric field is used to input the effective leakage area in square meters. The effective leakage area is used to characterize openings for infiltration calculations (ASHRAE Handbook of Fundamentals, 1997, pp 25.18). This value must be greater than zero.

Field: Discharge Coefficient

This numeric field is used to input the discharge coefficient. This value must be greater than zero, with a default value of 1.0.

Field: Reference Pressure Difference

This numeric field is used to input the reference pressure difference [Pa]. This value must be greater than zero, with a default value of 4.0 Pa.

Field: Air Mass Flow Exponent

This numeric field is used to input the pressure difference exponent. The valid range of the exponent is from 0.5 to 1.0, with a default value of 0.65.

Note: There are two common sets of reference conditions: $C_d = 1.0$ and $\Delta P = 4$ Pa, or $C_d = 0.6$ and $\Delta P = 10$ Pa

Below is the input data dictionary description for the AirflowNetwork:MultiZone: Surface Effective Leakage Area object.

```
AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea,
  \min-fields 5
  \memo This object is used to define surface air leakage.
A1 , \field Name
  \required-field
  \type alpha
  \reference SurfaceAirflowLeakageNames
  \note Enter a unique name for this object.
N1 , \field Effective Leakage Area
  \required-field
  \type real
  \units m2
  \minimum > 0
  \note Enter the effective leakage area.
N2 , \field Discharge Coefficient
  \type real
  \units dimensionless
  \minimum > 0
  \default 1.0
  \note Enter the coefficient used in the air mass flow equation.
N3 , \field Reference Pressure Difference
  \type real
  \units Pa
  \minimum > 0
  \default 4.0
  \note Enter the pressure difference used to define the air mass flow coefficient and exponent.
N4 ; \field Air Mass Flow Exponent
  \units dimensionless
  \type real
  \default .65
  \minimum 0.5
  \maximum 1.0
  \note Enter the exponent used in the air mass flow equation.
```

An IDF example is shown below:

```
AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea,
  SurfaceELR,           !- Name of surface effective leakage area component
  0.07,                 !- Effective leakage area {dimensionless}
  1.00,                 !- Discharge coefficient {dimensionless}
  4.0,                  !- Reference pressure difference {Pa}
  0.65;                 !- Air mass flow exponent {dimensionless}
```

AirflowNetwork:MultiZone:Component:DetailedOpening

This object specifies the properties of air flow through windows and doors (window, door and glass door heat transfer subsurfaces) when they are closed or open. The fields are similar to those for AirflowNetwork:MultiZone:SurfaceCrack object when the window or door is closed, but additional fields are required to describe the air flow characteristics when the window or door is open. These additional fields include opening type, opening dimensions, degree of opening, and opening schedule.

The AirflowNetwork model assumes that open windows or doors are vertical or close to vertical; for this reason they are called “Large Vertical Openings.” Such openings can have air flow moving simultaneously in two different directions depending on stack effects and wind conditions (for example, flow from inside to outside at the top of a window and from outside to inside at the bottom). AirflowNetwork models such two-directional flow, but only for vertical openings.

It is assumed that the air flow through a window opening is unaffected by the presence of a shading device such as a shade or blind on the window. Also, the calculation of conductive heat transfer and solar gain through a window or door assumes that the window or door is closed.

The AirflowNetwork model does not have a model for bi-directional flow through large horizontal openings. For this reason, **AirflowNetwork:MultiZone:Component:DetailedOpening should not be used for horizontal openings**. The best modeling technique in this case is to put an AirflowNetwork:MultiZone:Surface:Crack object in a horizontal surface and use a large air mass flow coefficient. Crack flow is assumed to be uni-directional in any given timestep (but can reverse flow direction from timestep to timestep).

A subsurface multiplier may be used to represent multiple subsurfaces and calculates total air flow when the subsurface (window, glassdoor, or door) is either closed or open. The total airflow across the surface is equal to the airflow based on the surface geometry multiplied by the subsurface multiplier.

Field: Name

The name of this AirflowNetwork:MultiZone:Component:DetailedOpening object. It is referenced by an AirflowNetwork:MultiZone:Surface object.

Field: Air Mass Flow Coefficient When Opening is Closed

Crack flow is assumed when the window or door is closed. The units for this air mass flow coefficient ($C_{Q, unit\ length}$) are different from the units for C_Q (kg/s at 1 Pa pressure difference) defined in an AirflowNetwork:MultiZone:Surface:Crack object. There is no default but the entered value must be greater than zero. The program will automatically generate four cracks around the perimeter of the window or door—one along the bottom, one along the top, and one on each side. The temperature correction factor used in the AirflowNetwork:MultiZone:Surface:Crack object is not used for this component to calculate air mass flow rate.

Field: Air Mass Flow Exponent When Opening Is Closed

Crack flow is assumed when the window or door is closed. In this case, the value of this field is the exponent, n , in the crack air flow equation. The valid range for this exponent is 0.5 to 1.0, with the default value being 0.65.

Field: Type of Rectangular Large Vertical Opening (LVO)

This alpha field specifies the type of rectangular window or door. (Open windows or doors are also called Large Vertical Openings (LVOs). The choices for the opening type are **NonPivoted** (LVO Type 1) and **HorizontallyPivoted** (LVO Type 2) with the default being **NonPivoted**. The NonPivoted type represents a regular window or door. The HorizontallyPivoted type represents a window with a horizontal axis ((i.e., a horizontally-pivoting window) and cannot be used for a door.

Field: Extra Crack Length or Height of Pivoting Axis

Specifies window or door characteristics that depend on the LVO type.

For LVO Type 1 (rectangular non-pivoted windows and doors) this field is the extra crack length in meters due to multiple openable parts, if present. “Extra” here means in addition to

the length, calculated by the program, of the cracks on the top, bottom and sides of the window/door.

For LVO Type 2 (rectangular horizontally-pivoted windows) this field gives the height of the pivoting axis measured from the bottom of the glazed part of the window (m).

Field: Number of Sets of Opening Factor Data

This is the number of the following sets of data for opening factor, discharge coefficient, width factor, height factor, and start height factor. From two to four of these sets must be defined. The first set should be for Opening Factor = 0.0 and the last set should be for Opening Factor = 1.0. For example, if only two sets are defined, the first set should be for Opening Factor = 0.0 and the second set should be for Opening Factor = 1.0, as shown below in the IDF example below.

An “opening factor” refers to the amount that a window or door is opened. The program linearly interpolates each timestep between the values of discharge coefficient, width factor, etc., in these sets using the opening factor for the window or door for the timestep. (See discussion under the field Window/Door Opening Factor in the AirflowNetwork:Multizone:Zone object for a description of how the AirflowNetwork model determines the time-step value of the opening factor.)

Field Group: Opening Factor, Discharge Coefficient, Width Factor, Height Factor, Start Height Factor

Each field is described for as many groups as required in the previous field (number of sets of opening factor data). As the final field has specific requirements, this field (n) will be described.

Field: Opening Factor 11

The first opening factor of a window or door. This value must be 0.0. The default value is also 0.0.

For LVO Type 1 (rectangular non-pivoted window or door), the Opening Factor corresponds to the fraction of window or door that is opened.

For LVO Type 2 (rectangular horizontally-pivoted windows), the Opening Factor is determined by the window opening angle. For example, an opening angle of 45° corresponds to an Opening Factor of 0.50 since the maximum opening angle is 90°.

Field: Discharge Coefficient for Opening Factor 1

The discharge coefficient of the window or door for Opening Factor 1. The range is greater than 0.0 to less than or equal to 1.0. The default value is 0.001. The Discharge Coefficient indicates the fractional effectiveness for air flow through a window or door at that Opening Factor.

Note: In the following, “window width” and “window height” are glazing dimensions; they do not include the frame, if present.

Field: Width Factor for Opening Factor 1

The Width Factor of the rectangular window or door for Opening Factor 1. The Width Factor is the opening width divided by the window or door width (see Figure 81). The range is 0.0 to 1.0. The default value is 0.0. Note that the width factor applies to rectangular windows or doors where the width is assumed constant along the entire height of the opening.

Field: Height Factor for Opening Factor 1

The Height Factor of the rectangular window or door for Opening Factor 1. The Height Factor is the opening height divided by the window or door height (see Figure 81). The range is 0.0

to 1.0. The default value is 0.0. Note that the height factor applies to rectangular windows or doors where the height is assumed constant along the entire width of the opening.

Field: Start Height Factor for Opening Factor 1

The Start Height Factor of the window or door for Opening Factor 1. The Start Height Factor is the Start Height divided by the window or door height (see Figure 81). The range is 0.0 to 1.0. The default is 0. Start Height is the distance between the bottom of the window or door and the bottom of the window or door opening. The sum of the Height Factor and the Start Height Factor must be less than 1.0 in order to have the opening within the window or door dimensions.

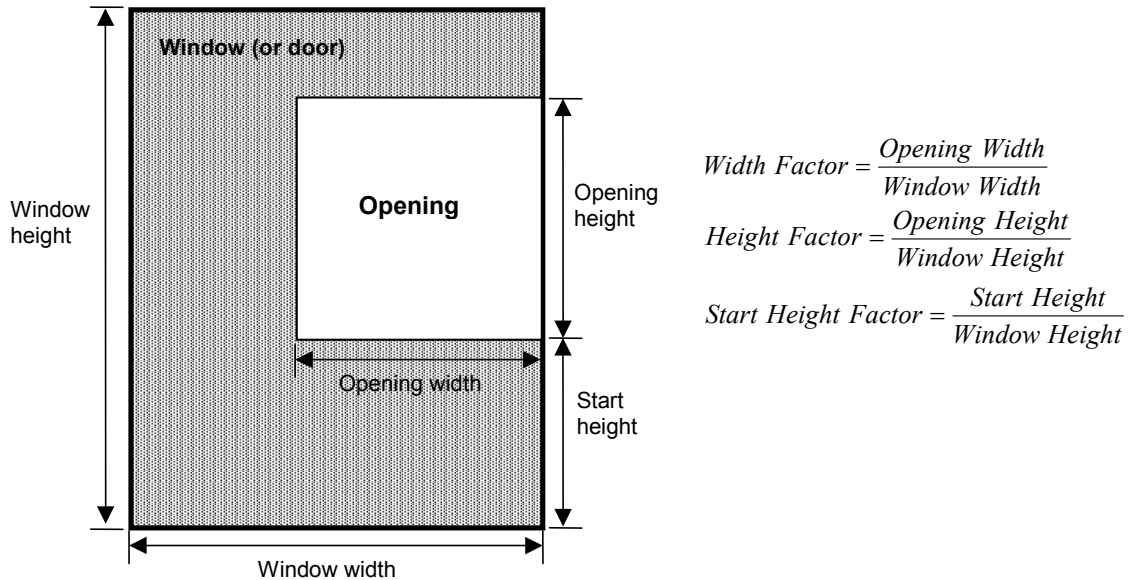


Figure 81. Window (or door) showing geometrical factors associated with an opening through which air flows.

Field: Opening Factor <n>

When Number of Sets of Opening Factor Data = n, the value of Opening Factor n must be set to 1.0.

Field: Discharge Coefficient for Opening Factor <n>

The discharge coefficient of the window or door for Opening Factor n. The range is greater than 0.0 to less than or equal to 1.0. The default value is 1.0.

Field: Width Factor for Opening Factor <n>

The Width Factor of the rectangular window or door for Opening Factor n. The Width Factor is the opening width divided by the window or door width (see Figure 81). The range is 0.0 to 1.0. The default value is 1.0.

Field: Height Factor for Opening Factor <n>

The Height Factor of the rectangular window or door for Opening Factor n. The Height Factor is the opening height divided by the window or door height (see Figure 81). The range is 0.0 to 1.0. The default value is 1.0.

Field: Start Height Factor for Opening Factor <n>

The Start Height Factor of the window or door for Opening Factor n. The Start Height Factor is the Start Height divided by the window or door height (see Figure 81). The range is 0.0 to 1.0. The default is 0.

When the opening factor value (as described under the field Window/Door Opening Factor in the AirflowNetwork:Multizone:Surface object) is between two Opening Factor field values, the values of Discharge Coefficient, Width Factor, Height Factor, and Start Height Factor are linearly interpolated.

Below is the input data dictionary description for the object.

```

AirflowNetwork:MultiZone:Component:DetailedOpening,
  \min-fields 16
  \memo This object specifies the properties of airflow through windows and doors (window, door and
  \memo glass door heat transfer subsurfaces) when they are closed or open.
A1 , \field Name
  \required-field
  \type alpha
  \reference SurfaceAirflowLeakageNames
  \note Enter a unique name for this object.
N1 , \field Air Mass Flow Coefficient When Opening is Closed
  \required-field
  \type real
  \units kg/s-m
  \minimum > 0
  \note Defined at 1 Pa per meter of crack length. Enter the coefficient used in the following
  \note equation:
  \note Mass Flow Rate = Air Mass Flow Coefficient * (dP)^Air Mass Flow Exponent.
  \note Used only when opening (window or door) is closed.
N2 , \field Air Mass Flow Exponent When Opening is Closed
  \units dimensionless
  \type real
  \minimum 0.5
  \maximum 1.0
  \default 0.65
  \note Enter the exponent used in the following equation:
  \note Mass Flow Rate = Air Mass Flow Coefficient * (dP)^Air Mass Flow Exponent.
  \note Used only when opening (window or door) is closed.
A2 , \field Type of Rectangular Large Vertical Opening (LVO)
  \type choice
  \key NonPivoted
  \key HorizontallyPivoted
  \note Select the type of vertical opening: Non-pivoted opening or Horizontally pivoted opening.
  \default NonPivoted
N3 , \field Extra Crack Length or Height of Pivoting Axis
  \type real
  \units m
  \minimum 0
  \default 0
  \note Extra crack length is used for LVO Non-pivoted type with multiple openable parts.
  \note Height of pivoting axis is used for LVO Horizontally pivoted type.
  \note Specifies window or door characteristics that depend on the LVO type.
  \note For Non-pivoted Type (rectangular windows and doors), this field is the extra crack length
  \note in meters due to multiple openable parts, if present. Extra here means in addition
  \note to the length of the cracks on the top, bottom and sides of the window/door.
  \note For Horizontally pivoted Type, this field gives the height of the
  \note pivoting axis measured from the bottom of the glazed part of the window (m).
N4 , \field Number of Sets of Opening Factor Data
  \required-field
  \type integer
  \minimum 2
  \maximum 4
  \note Enter the number of the following sets of data for opening factor,
  \note discharge coefficient, width factor, height factor, and start height factor.

```



```

N5 , \field Opening Factor 1
    \type real
    \units dimensionless
    \minimum 0
    \maximum 0
    \default 0
    \note This value must be specified as 0.
N6 , \field Discharge Coefficient for Opening Factor 1
    \type real
    \units dimensionless
    \minimum> 0
    \maximum 1
    \default 0.001
    \note The Discharge Coefficient indicates the fractional effectiveness
    \note for air flow through a window or door at that Opening Factor.
N7 , \field Width Factor for Opening Factor 1
    \type real
    \units dimensionless
    \minimum 0
    \maximum 1
    \default 0
    \note The Width Factor is the opening width divided by the window or door width.
N8 , \field Height Factor for Opening Factor 1
    \type real
    \units dimensionless
    \minimum 0
    \maximum 1
    \default 0
    \note The Height Factor is the opening height divided by the window or door height.
N9 , \field Start Height Factor for Opening Factor 1
    \type real
    \units dimensionless
    \minimum 0
    \maximum 1
    \default 0
    \note The Start Height Factor is the Start Height divided by the window or door height.
    \note Start Height is the distance between the bottom of the window or door and the
    \note bottom of the window or door opening. The sum of the Height Factor and the Start Height
    \note Factor must be less than 1.0 in order to have the opening within the window or door
    \note dimensions.
<repeat to Number of Sets of Opening Factor Data>

```

An IDF example is shown below:

```

AirflowNetwork:MultiZone:Component:DetailedOpening,
WiOpen1,           !- Detailed Opening Name
0.001,            !- Air Mass Flow Coefficient When Opening is Closed {kg/s-m}
0.667,            !- Air Mass Flow Exponent When Opening is Closed {dimensionless}
NonPivoted,       !- Type of Large Vertical Opening (LVO)
0.0,              !- Extra crack length for LVO type 1 with multiple openable parts,
                 !- or Height of pivoting axis for LVO type 2 {m}
2,                !- Number of Sets of Opening Factor Data
0.0,              !- Opening factor 1 {dimensionless}
0.5,              !- Discharge coefficient for opening factor 1 {dimensionless}
0.0,              !- Width factor for opening factor 1 {dimensionless}
1.0,              !- Height factor for opening factor 1 {dimensionless}
0.0,              !- Start height factor for opening factor 1 {dimensionless}
1.0, 0.6, 1.0, 1.0, 0.0; !- Set of values for opening factor 2

```

AirflowNetwork:MultiZone:Component:SimpleOpening

This object specifies the properties of air flow through windows, doors and glass doors (heat transfer subsurfaces) when they are closed or open. The AirflowNetwork model assumes that open windows or doors are vertical or close to vertical. The second and third fields are similar to those for AirflowNetwork:MultiZone:Surface:Crack, when the window or door is closed, but additional information is required to describe the air flow characteristics when the window or door is open. This additional information is specified in the last two fields. Compared to the

object `AirflowNetwork:MultiZone:Component:DetailedOpening`, which requires more inputs at different opening factors, this object needs comparatively less inputs. For this reason it is called a simple opening. This opening also allows for the possibility of two-way flow due to temperature and resulting density differences. Therefore, it is possible to have a positive pressure difference at the top of the opening, and a negative pressure difference at the bottom (or vice versa) when the neutral height is between the bottom and top heights of the associated surface. This object's openness can also be modulated based on the same opening factor control as an `AirflowNetwork:MultiZone:Component:DetailedOpening` object. However, the opening factor is only applied to the subsurface width. The opening width is equal to opening factor multiplied by the subsurface width.

A subsurface multiplier may be used to represent multiple subsurfaces and calculates total air flow when the subsurface (window, glassdoor, or door) is either closed or open. The total airflow across the surface is equal to the airflow based on the surface geometry multiplied by the subsurface multiplier.

Field: Name

This is a name for this `AirflowNetwork:MultiZone:Component:SimpleOpening` object. It is referenced by an `AirflowNetwork:MultiZone:Surface` object.

Field: Air Mass Flow Coefficient When Opening is Closed

The value of the air mass flow coefficient, $C_{Q,unit\ length}$, in the simple opening air flow equation. It has units of kg/s-m at 1Pa. The temperature correction factor is not applied for mass flow calculation.

Field: Air Mass Flow Exponent When Opening is Closed

The value of the exponent, n , in the crack air flow equation. The valid range is 0.5 to 1.0, with the default value being 0.65.

Field: Minimum Density Difference for Two-Way Flow

This numeric field is used to input the minimum density difference above which two-way flow may occur due to stack effect. Density differences less than this value result in one-way flow. The minimum value for this field is greater than zero.

Field: Discharge Coefficient

This numeric field is used to input the discharge coefficient. This value must be greater than zero.

Below is the input data dictionary description for the object.

```
AirflowNetwork:MultiZone:Component:SimpleOpening,
  \min-fields 5
  \memo This object specifies the properties of air flow through windows and doors (window, door and
  \memo glass door heat transfer subsurfaces) when they are closed or open.
A1 , \field Name
  \required-field
  \type alpha
  \reference SurfaceAirflowLeakageNames
  \note Enter a unique name for this object.
N1 , \field Air Mass Flow Coefficient When Opening is Closed
  \required-field
  \type real
  \minimum> 0
  \units kg/s-m
  \note Defined at 1 Pa pressure difference. Enter the coefficient used in the following equation:
  \note Mass Flow Rate = Air Mass Flow Coefficient * (dP)^Air Mass Flow Exponent.
  \note Used only when opening (window or door) is closed.
```

```
N2 , \field Air Mass Flow Exponent When Opening is Closed
    \units dimensionless
    \type real
    \default .65
    \minimum 0.5
    \maximum 1.0
    \note Enter the exponent used in the following equation:
    \note Mass Flow Rate = Air Mass Flow Coefficient * (dP)^Air Mass Flow Exponent.
    \note Used only when opening (window or door) is closed.
N3 , \field Minimum Density Difference for Two-Way Flow
    \required-field
    \units kg/m3
    \type real
    \minimum > 0
    \note Enter the minimum density difference above which two-way flow may occur due to stack effect.
N4 ; \field Discharge Coefficient
    \required-field
    \units dimensionless
    \type real
    \minimum > 0
    \note The Discharge Coefficient indicates the fractional effectiveness
    \note for air flow through a window or door at that Opening Factor.
```

An IDF example is shown below:

```
AirflowNetwork:MultiZone:Component:SimpleOpening,
WiOpen2,           !- Simple Opening Name
0.001,             !- Air Mass Flow Coefficient When Opening Is Closed {kg/s-m}
0.650,            !- Air Mass Flow Exponent When Opening Is Closed {dimensionless}
0.0001,           !- Minimum density difference for two-way flow (kg/m3)
1.0;              !- Discharge coefficient (dimensionless)
```

AirflowNetwork:MultiZone:Component:ZoneExhaustFan

This object specifies the properties of air flow through an exterior heat transfer surface with a zone exhaust fan. The zone exhaust fan turns on or off based on the availability schedule defined in the corresponding ZONE EXHAUST FAN object. When the exhaust fan mass flow rate is greater than zero, the airflow network model treats this object as a constant volume fan. When the fan is off based on the availability schedule, the model treats this object as a crack.

When the fan is on, the air mass flow rate modeled for the airflow network is based on the value defined in the Max Flow Rate field of the ZONE EXHAUST FAN object. The airflow direction is from the corresponding zone to outdoors.

When the fan is off, the following power law form is used that gives air flow through the crack as a function of the pressure difference across the crack:

$$Q = (\text{Crack Factor}) * C_T * C_Q (\Delta P)^n$$

Where

Q = air mass flow (kg/s)

C_Q = air mass flow coefficient (kg/s-Paⁿ @ 1 Pa)

C_T = reference condition temperature correction factor (dimensionless)

ΔP = pressure difference across crack (Pa)

n = air flow exponent (dimensionless)

$$C_T = \left[\frac{\rho_o}{\rho} \right]^{n-1} \left[\frac{\nu_o}{\nu} \right]^{2n-1}$$

where

ρ = Air density at the specific air temperature and humidity ratio conditions [kg/m³]

ν = Air kinetic viscosity at the specific air temperature condition [m²/s]

ρ_o = Air density at the reference air conditions provided by the object AirflowNetwork:MultiZone:ReferenceCrackConditions specified in the field Reference Crack Conditions [kg/m³]

ν_o = Air kinetic viscosity at the reference air temperature provided by the object AirflowNetwork:MultiZone:ReferenceCrackConditions specified in the field Reference Crack Conditions [m²/s]

Note: The correction factor shown above is used when the exhaust fan is off. The airflow direction is based on the pressure difference between the zone and outdoors.

Field: Name

This is the name for this instance of the AirflowNetwork:MultiZone:Component:ZoneExhaustFan object. This name must be the same name defined in the Fan:ZoneExhaust object. It is referenced by an AirflowNetwork:Multizone:Surface object.

Field: Air Mass Flow Coefficient When the Zone Exhaust Fan is Off at Reference Conditions

The value of the air mass flow coefficient, C_Q , in the crack air flow equation. It has units of kg/s at 1Pa. This value must be greater than zero. The value is used when the fan is off.

Field: Air Mass Flow Exponent When the Zone Exhaust Fan is Off

The value of the exponent, n , in the crack air flow equation. The valid range is 0.5 to 1.0, with the default value being 0.65. The value is used when the fan is off.

Field: Reference Crack Conditions

The name of the AirflowNetwork:MultiZone:ReferenceCrackConditions object which specifies the conditions under which the air mass flow coefficient was measured. If the user omits this field and only one AirflowNetwork:MultiZone:ReferenceCrackConditions object is defined in the input data file, then those reference crack conditions will be used. If the user omits this field and either zero or more than one AirflowNetwork:MultiZone:ReferenceCrackConditions objects are defined in the input data file, then the default conditions for the AirflowNetwork:Multizone: Reference Crack Conditions object will be used.

Below is the input data dictionary description for the AirflowNetwork:Multizone:Component Zone Exhaust Fan object.

```

AirflowNetwork:MultiZone:Component:ZoneExhaustFan,
  \min-fields 3
  \memo This object specifies the additional properties for a zone exhaust fan
  \memo to perform multizone airflow calculations.
A1 , \field Name
  \required-field
  \type alpha
  \reference ZoneEquipmentLists
  \note Enter the name of the zone exhaust fan.
N1 , \field Air Mass Flow Coefficient When the Zone Exhaust Fan is Off at Reference Conditions
  \required-field
  \type real
  \units kg/s
  \minimum > 0
  \note Enter the air mass flow coefficient at the conditions defined
  \note in the Reference Crack Conditions object.
  \note Defined at 1 Pa pressure difference. Enter the coefficient used in the following
  \note equation:
  \note Mass Flow Rate = Air Mass Flow Coefficient * (dP)^Air Mass Flow Exponent.
  \note Used only when the fan is off.
N2 , \field Air Mass Flow Exponent When the Zone Exhaust Fan is Off
  \units dimensionless
  \type real
  \minimum 0.5
  \maximum 1.0
  \default 0.65
  \note Enter the exponent used in the following equation:
  \note Mass Flow Rate = Air Mass Flow Coefficient * (dP)^Air Mass Flow Exponent.
  \note Used only when the fan is off.
A2 ; \field Reference Crack Conditions
  \type object-list
  \object-list ReferenceCrackConditions
  \note Select a AirflowNetwork:MultiZone:ReferenceCrackConditions name associated with
  \note the air mass flow coefficient entered above.

```

An IDF example is shown below:

```

AirflowNetwork:MultiZone:Component:ZoneExhaustFan,
  Zone3 Exhaust Fan,      !- Zone Exhaust Fan Name
  0.01,                  !- Air Mass Flow Coefficient at Reference Conditions during fan off {kg/s}
  0.667;                 !- Air Mass Flow Exponent during fan off {dimensionless}
  ReferenceCrackConditions; !- Reference Crack Conditions

```

AirflowNetwork:MultiZone:ExternalNode

External nodes in the AirflowNetwork model define environmental conditions outside of the building. These conditions include wind pressure coefficients that vary from façade to façade and can be highly dependent on the building geometry.

AirflowNetwork:MultiZone:ExternalNode objects do **not** have to be entered if Wind Pressure Coefficient Type = SurfaceAverageCalculation in the AirflowNetwork:SimulationControl object.

Field: Name

The external node name is associated with a particular building façade. This name is referenced by the External Node Name field of an AirflowNetwork:MultiZone:WindPressureCoefficientValues object (which gives wind pressure coefficients for the façade as a function of angle of wind incident on the façade) and by the External Node Name field of an AirflowNetwork:MultiZone:Surface object.

Field: External Node Height

Designates the reference height, in meters, used to calculate relative pressure. The default value is 0 meters.

Field: Wind Pressure Coefficient Values Object Name

The name of a specific AirflowNetwork:MultiZone:WindPressureCoefficientValues object (which gives wind pressure coefficients for the façade as a function of angle of wind incident on the façade).

Below is the input data dictionary description for the AirflowNetwork:Multizone: External Node object.

```
AirflowNetwork:MultiZone:ExternalNode,
  \min-fields 3
  \memo This object defines outdoor environmental conditions outside of the building.
A1 , \field Name
  \required-field
  \type alpha
  \reference ExternalNodeNames
  \note Enter a unique name for this object.
  \note This node name will be referenced by a particular building facade.
N1 ; \field External Node Height
  \required-field
  \type real
  \units m
  \default 0.0
  \note Designates the reference height used to calculate relative pressure.
A2 , \field Wind Pressure Coefficient Values Object Name
  \required-field
  \type object-list
  \object-list WPCValueNames
  \note Enter the name of the AirflowNetwork:MultiZone:WindPressureCoefficientValues object.
```

IDF examples are provided below:

```
AirflowNetwork:MultiZone:ExternalNode,
  NFacade,           !- Name
  1.524,             !- External Node Height {m}
  NFacade_WPCValue;  !- Wind Pressure Coefficient Values Object Name

AirflowNetwork:MultiZone:ExternalNode,
  EFacade,           !- Name
  1.524,             !- External Node Height {m}
  EFacade_WPCValue;  !- Wind Pressure Coefficient Values Object Name

AirflowNetwork:MultiZone:ExternalNode,
  SFacade,           !- Name
  1.524,             !- External Node Height {m}
  SFacade_WPCValue;  !- Wind Pressure Coefficient Values Object Name

AirflowNetwork:MultiZone:ExternalNode,
  WFacade,           !- Name
  1.524,             !- External Node Height {m}
  WFacade_WPCValue;  !- Wind Pressure Coefficient Values Object Name

AirflowNetwork:MultiZone:ExternalNode,
  Horizontal,        !- Name
  3.028,             !- External Node Height {m}
  Horizontal_WPCValue; !- Wind Pressure Coefficient Values Object Name
```

AirflowNetwork:MultiZone:WindPressureCoefficientArray

The reference height and wind directions are first specified under the AirflowNetwork:MultiZone:WindPressureCoefficientArray object. The user may specify up to 36 different wind directions in ascending order. These are then referenced by AirflowNetwork:MultiZone:WindPressureCoefficientValues objects defined for each AirflowNetwork:MultiZone:ExternalNode.

The AirflowNetwork:MultiZone:WindPressureCoefficientArray object is unique and needs to be entered only if Wind Pressure Coefficient Type = INPUT in the AirflowNetwork:SimulationControl object. If Wind Pressure Coefficient Type = SurfaceAverageCalculation, this object is not required.

Field: Name

The name of this AirflowNetwork:MultiZone:WindPressureCoefficientArray object. This name is referenced by each AirflowNetwork:MultiZone:WindPressureCoefficientValues object which, for each AirflowNetwork:MultiZone:ExternalNode, gives the wind pressure coefficients at each of the wind directions listed in the AirflowNetwork:MultiZone:WindPressureCoefficientArray. This name is also referenced by the AirflowNetwork:SimulationControl object, indicating that this AirflowNetwork:MultiZone:WindPressureCoefficientArray and the pressure coefficients in the associated AirflowNetwork:MultiZone:WindPressureCoefficientValues objects will be used in the air flow simulation.

Field: Wind Direction 1-Wind Direction N

Each field references the wind direction corresponding to the first through the Nth WPC value in each of the AirflowNetwork:MultiZone:WindPressureCoefficientValues objects. *N* can be as high as 36.

Below is the input data dictionary description for the object.

```
AirflowNetwork:MultiZone:WindPressureCoefficientArray,
  \min-fields 3
  \memo Used only if Wind Pressure Coefficient (WPC) Type = Input in the
AirflowNetwork:SimulationControl
  \memo object. Number of WPC Values in the corresponding
AirflowNetwork:MultiZone:WindPressureCoefficientValues
  \memo object must be the same as the number of wind directions specified for
  \memo this AirflowNetwork:MultiZone:WindPressureCoefficientArray object.
A1 , \field Name
  \required-field
  \reference WPCSetNames
  \type alpha
  \note Enter a unique name for the object.
N1 , \field Wind Direction 1
  \required-field
  \type real
  \units deg
  \minimum 0.0
  \maximum 360.0
  \note Enter the wind direction corresponding to the 1st WPC Array value.
N2 , \field Wind Direction 2
  \required-field
  \type real
  \units deg
  \minimum 0.0
  \maximum 360.0
  \note Enter the wind direction corresponding to the 2nd WPC Array value.
--continues up to 36 wind directions --
```

An IDF example is provided below:

```

AirflowNetwork:MultiZone:WindPressureCoefficientArray,
  Every 30 Degrees,      !- WPC Array Name
  0,                    !- Wind Direction #1 {deg}
  30,                   !- Wind Direction #2 {deg}
  60,                   !- Wind Direction #3 {deg}
  90,                   !- Wind Direction #4 {deg}
  120,                  !- Wind Direction #5 {deg}
  150,                  !- Wind Direction #6 {deg}
  180,                  !- Wind Direction #7 {deg}
  210,                  !- Wind Direction #8 {deg}
  240,                  !- Wind Direction #9 {deg}
  270,                  !- Wind Direction #10 {deg}
  300,                  !- Wind Direction #11 {deg}
  330;                  !- Wind Direction #12 {deg}

```

AirflowNetwork:MultiZone:WindPressureCoefficientValues

This object specifies up to 36 wind pressure coefficients (WPCs) for an AirflowNetwork:MultiZone:ExternalNode. These coefficients are defined for each of the wind directions defined in the unique AirflowNetwork:MultiZone:WindPressureCoefficientArray object. In the air flow calculation, interpolation of the specified WPC values is done for time-step values of wind direction.

AirflowNetwork:MultiZone:WindPressureCoefficientValues objects need to be entered only if the Wind Pressure Coefficient Type = INPUT in the AirflowNetwork:SimulationControl object. If Wind Pressure Coefficient Type = SurfaceAverageCalculation, this object is not required and is not used.

Field: Name

The name of this WindPressureCoefficientValues object. This name can be referenced by multiple AirflowNetwork:MultiZone:ExternalNode objects.

Field: WindPressureCoefficientArray Name

Name of the associated AirflowNetwork:MultiZone:WindPressureCoefficientArray, which lists the wind direction corresponding to each wind pressure coefficient value in this AirflowNetwork:MultiZone:WindPressureCoefficientValues object.

Field: Wind Pressure Coefficient Value 1 to Wind Pressure Coefficient Value N

The WPC (wind pressure coefficient) value for the building façade indicated by the External Node Name field above. This WPC value corresponds to the first wind direction in the AirflowNetwork:MultiZone:WindPressureCoefficientArray. Note that WPC values can be positive, negative or zero.

Obtaining WPC values

WPC values can be obtained from wind tunnel measurements, CFD calculations, or from published values for different building shapes.

For **rectangular buildings** EnergyPlus will automatically calculate surface-averaged Cp values for the walls and roof of the building if you specify Wind Pressure Coefficient Type = SurfaceAverageCalculation in the AirflowNetwork:SimulationControl object. In this case you do not have to enter any AirflowNetwork:MultiZone:WindPressureCoefficientValues objects.

Wind pressure coefficients are reported in the eplusout.eio either from inputs using "INPUT" as the choice for the Wind Pressure Coefficient Type field defined in the AirflowNetwork:SimulationControl object, or from internal calculation using SurfaceAverageCalculation as the choice for the Wind Pressure Coefficient Type field defined in the same object. Below is an output example from the eplusout.eio file:


```

AirflowNetwork Model:Wind Direction, 0.0,30.0,60.0,90.0,120.0,150.0,180.0,210.0,240.0,270.0,300.0,330.0
! <AirflowNetwork Model:Wind Pressure Coefficients, WPC Name, Wind Pressure Coefficients #1 to n
(dimensionless)>
AirflowNetwork Model:Wind Pressure Coefficients, NFACADE, 0.60,0.48,4.00E-002,-0.56,-0.56,-0.42,-0.37,-
0.42,-0.56,-0.56,4.00E-002,0.48
AirflowNetwork Model:Wind Pressure Coefficients, EFACADE, -0.56,4.00E-002,0.48,0.60,0.48,4.00E-002,-0.56,-
0.56,-0.42,-0.37,-0.42,-0.56
AirflowNetwork Model:Wind Pressure Coefficients, SFACADE, -0.37,-0.42,-0.56,-0.56,4.00E-
002,0.48,0.60,0.48,4.00E-002,-0.56,-0.56,-0.42
AirflowNetwork Model:Wind Pressure Coefficients, WFACADE, -0.56,-0.56,-0.42,-0.37,-0.42,-0.56,-0.56,4.00E-
002,0.48,0.60,0.48,4.00E-002

```

Below is the input data dictionary description for the object.

```

AirflowNetwork:MultiZone:WindPressureCoefficientValues,
  \min-fields 4
  \memo Used only if Wind Pressure Coefficient (WPC) Type = INPUT in the
AirflowNetwork:SimulationControl
  \memo object. The number of WPC numeric inputs must correspond to the number of wind direction
  \memo inputs in the AirflowNetwork:Multizone:WindPressureCoefficientArray object.
A1 , \field Name
  \required-field
  \type object-list
  \reference WPCValueNames
  \note Enter a unique name for this object.
A2 , \field WindPressureCoefficientArray Name
  \required-field
  \type object-list
  \object-list WPCSetNames
  \note Enter the name of the AirflowNetwork:Multizone:WindPressureCoefficientArray object.
N1 , \field Wind Pressure Coefficient Value 1
  \required-field
  \type real
  \units dimensionless
  \note Enter the WPC Value corresponding to the 1st wind direction.
N2 , \field Wind Pressure Coefficient Value 2
  \required-field
  \type real
  \units dimensionless
--continues up to 36 wind directions and corresponds to the number of wind directions in the
Referenced AirflowNetwork:MultiZone:WindPressureCoefficientArray object.

```

An IDF example is provided below:

```

AirflowNetwork:MultiZone:WindPressureCoefficientValues,
NFacade_WPCValue,      !- Name
Every 30 Degrees,     !- AirflowNetwork:MultiZone:WindPressureCoefficientArray Name
0.60,                 !- Wind Pressure Coefficient Value 1 {dimensionless}
0.48,                 !- Wind Pressure Coefficient Value 2 {dimensionless}
0.04,                 !- Wind Pressure Coefficient Value 3 {dimensionless}
-0.56,                !- Wind Pressure Coefficient Value 4 {dimensionless}
-0.56,                !- Wind Pressure Coefficient Value 5 {dimensionless}
-0.42,                !- Wind Pressure Coefficient Value 6 {dimensionless}
-0.37,                !- Wind Pressure Coefficient Value 7 {dimensionless}
-0.42,                !- Wind Pressure Coefficient Value 8 {dimensionless}
-0.56,                !- Wind Pressure Coefficient Value 9 {dimensionless}
-0.56,                !- Wind Pressure Coefficient Value 10 {dimensionless}
0.04,                 !- Wind Pressure Coefficient Value 11 {dimensionless}
0.48;                 !- Wind Pressure Coefficient Value 12 {dimensionless}

```

The previous sections of this AirflowNetwork model discussion describe input objects used for multizone airflow calculations. The following sections describe input objects used for air distribution system simulations. These objects work when control option “MultiZone with Distribution” or “MultiZone with Distribution Only During Fan Operation” is defined in the AirflowNetwork Control field in the AirflowNetwork:SimulationControl object.

The first section presents the input object for distribution system nodes. Although thermal zones are required to perform air distribution system simulations, the thermal zones are already defined in the multizone input section (described previously), so that there is no need to repeat the inputs for thermal zones when modeling an air distribution system. The same is also true for surface air leakage. This section has only one object: `AirflowNetwork:Distribution:Node`.

AirflowNetwork:Distribution:Node

The `AirflowNetwork:Distribution:Node` object is used to represent air distribution system nodes for the `AirflowNetwork` model. The EnergyPlus nodes defined in an `AirLoopHVAC` are a subset of the nodes used to simulate the distribution system using the `AirflowNetwork` model. For example, the inlet node of a fan and the outlet node of a coil defined in an `AirLoopHVAC` must be defined as nodes using the `AirflowNetwork:Distribution:Node` object. A set of EnergyPlus Zone Equipment nodes is also a subset of the `AirflowNetwork:Distribution:Nodes`. For example, zone inlet and outlet nodes must be defined as nodes using the `AirflowNetwork:Distribution:Node` object. In addition, although mixers and splitters are defined as objects with inlet and outlet nodes within EnergyPlus, the `AirflowNetwork:Distribution:Node` object treats mixers and splitters as single nodes. The node objects are referenced by `AirflowNetwork:Distribution:Linkage` objects.

In summary, all nodes used to define an `AirLoopHVAC` (except splitters, mixers, and outdoor air systems which are treated as single nodes) and its connections to a thermal zone must be specified as `AirflowNetwork:Distribution:Nodes`. If distribution system air leaks are to be modeled, additional `AirflowNetwork:Distribution:Nodes` may be defined along with `AirflowNetwork:Distribution:Components` (e.g., leak or leak ratio) to define the air leakage characteristics.

Note: Supply and return leaks are not allowed in an `AirLoopHVAC`. They can only be modeled in the Zone Equipment Loop (i.e., return leaks may be modeled between the zone return node and the zone mixer inlet or the zone mixer outlet and the zone equipment loop outlet; and supply leaks may be modeled between the zone equipment loop inlet and the `AirLoopHVAC:ZoneSplitter` inlet node or the `AirLoopHVAC:ZoneSplitter` outlet node and the zone supply node).

Field: Name

The name of an air distribution system node. This node name is referenced by an `AirflowNetwork:Distribution:Linkage` and in the output listing. Each node should have a unique name within the `AirflowNetwork:Distribution:Node` objects (however, the node name may be used elsewhere as regular EnergyPlus node names such as the fan inlet node or coil outlet node).

Field:Component Name or Node Name

Designates node names defined in another EnergyPlus object, so that the `AirflowNetwork:Distribution:Node` object is able to get input parameters and node conditions from the associated EnergyPlus node or object. The actual node name is entered here and represents a node already defined in an `AirLoopHVAC` or zone equipment loop. This field is left blank if the EnergyPlus Node Type field below is entered as Mixer, Splitter, Outdoor air System, or Other.

Field: Component Object Type or Node Type

This choice field distinguishes the node type for the EnergyPlus node or object name defined above. Five node types are available:

- **AirLoopHVAC:ZoneMixer**: Represents an `AirLoopHVAC:ZoneMixer` object defined in EnergyPlus

- **AirLoopHVAC:ZoneSplitter:** Represents an AirLoopHVAC:ZoneSplitter object defined in EnergyPlus
- **AirLoopHVAC:OutdoorAirSystem:** Represents an AirLoopHVAC:OutdoorAirSystem object used in EnergyPlus
- **OAMixerOutdoorAirStreamNode:** Represents an external node name specified as an Outdoor Air Stream Node Name in the OutdoorAir:Mixer object when the AirLoopHVAC:OutdoorAirSystem object is used.
- **OutdoorAir:NodeList:** Represents an external node name defined in the OutdoorAir:NodeList object when the AirLoopHVAC:OutdoorAirSystem object and an exhaust energy recovery system (air-to-air heat exchanger) are used.
- **OutdoorAir:** Represents an external node name defined in the OutdoorAir:Node object when the AirLoopHVAC:OutdoorAirSystem and an exhaust energy recovery system (air-to-air heat exchanger) are used.
- **Other:** Represents a type not already defined above.

Note: Both the OutdoorAir:NodeList and OutdoorAir:Node node types represent a node to outdoor air conditions. Either one of these node types can be used to represent an external node when an air-to-air heat exchanger is used to recover energy from the exhaust air stream as part of an AirLoopHVAC:OutdoorAirSystem object. Node type OAMixerOutdoorAirStreamNode does not represent an external node when an OutdoorAir:NodeList or OutdoorAir:Node object is specified. If no exhaust heat recovery system (i.e., air-to-air heat exchanger) is specified in the AirLoopHVAC:OutdoorAirSystem, the node type OAMixerOutdoorAirStreamNode represents an external node.

Field: Node Height

Designates the reference height in meters used to calculate relative pressure. The default value is 0 meters.

Below is the input data dictionary description for the AirflowNetwork:Distribution:Node object.

```
AirflowNetwork:Distribution:Node,
  \min-fields 4
  \memo This object represents an air distribution node in the AirflowNetwork model.
A1 , \field Name
  \required-field
  \type alpha
  \reference AirflowNetwork NodeNames
  \note Enter a unique name for this object.
A2 , \field Component Name or Node Name
  \type alpha
  \note Designates node names defined in another object. The node name may occur in air branches.
  \note Enter a node name to represent a node already defined in an air loop.
  \note Leave this field blank if the Node or Object Type field below is entered as
AirLoopHVAC:ZoneMixer,
  \note AirLoopHVAC:ZoneSplitter, AirLoopHVAC:OutdoorAirSystem, or Other.
```

```

A3 , \field Component Object Type or Node Type
    \type choice
    \key AirLoopHVAC:ZoneMixer
    \key AirLoopHVAC:ZoneSplitter
    \key AirLoopHVAC:OutdoorAirSystem
    \key OAMixerOutdoorAirStreamNode
    \key OutdoorAir:NodeList
    \key OutdoorAir:Node
    \key Other
    \default Other
    \note Designates Node type for the Node or Component Name defined in the field above.
    \note AirLoopHVAC:ZoneMixer -- Represents a AirLoopHVAC:ZoneMixer object.
    \note AirLoopHVAC:ZoneSplitter -- Represents a AirLoopHVAC:ZoneSplitter object.
    \note AirLoopHVAC:OutdoorAirSystem -- Represents an AirLoopHVAC:OutdoorAirSystem object.
    \note OAMixerOutdoorAirStreamNode -- Represents an external node used in the
    \note OutdoorAir:NodeList -- Represents an external node when a heat exchanger is used
    \note before the OutdoorAir:Mixer
    \note OutdoorAir:Node -- Represents an external node when a heat exchanger is used before
    \note the OutdoorAir:Mixer
    \note Other -- none of the above, the Node name already defined in the previous field is
    \note part of an air loop.
N1 ; \field Node Height
    \type real
    \units m
    \default 0.0
    \note Enter the reference height used to calculate the relative pressure.
    
```

IDF examples are provided below:

```

AirflowNetwork:Distribution:Node,
    EquipmentInletNode,      !- Name
    Zone Equipment Inlet Node, !- Component Name or Node Name
    Other,                   !- Component Object Type or Node Type
    3.0;                     !- Node Height {m}

AirflowNetwork:Distribution:Node,
    SupplyMainNode,         !- Name
    ,                       !- Component Name or Node Name
    Other,                   !- Component Object Type or Node Type
    3.0;                     !- Node Height {m}

AirflowNetwork:Distribution:Node,
    MainSplitterNode,      !- Name
    ,                       !- Component Name or Node Name
    AirLoopHVAC:ZoneSplitter, !- Component Object Type or Node Type
    3.0;                   !- Node Height {m}
    
```

```

AirflowNetwork:Distribution:Node,
    MainSplitterNode,      !- Name of Node
    ,                       !- Name of Associated EnergyPlus Node or Object
    AirLoopHVAC:ZoneSplitter, !- EnergyPlus Object or Node Type
    3.0;                   !- Node Height {m}
    
```

The next section describes AirflowNetwork Distribution Components, with 7 available types listed below. All required fields for each component represent a relationship between pressure difference and airflow. The components are referenced in AirflowNetwork:Distribution:Linkage objects.

- AirflowNetwork:Distribution:Component:Leak
- AirflowNetwork:Distribution:Component:LeakageRatio
- AirflowNetwork:Distribution:Component:Duct
- AirflowNetwork:Distribution:Component:ConstantVolumeFan
- AirflowNetwork:Distribution:Component:Coil
- AirflowNetwork:Distribution:Component:HeatExchanger

- AirflowNetwork:Distribution:Component:TerminalUnit
- AirflowNetwork:Distribution:Component:ConstantPressureDrop

AirflowNetwork:Distribution:Component:Leak

This component may be also called a power law component and is used to represent a supply or return air leak in an air distribution system. Its relationship between pressure difference and airflow may be expressed as:

$$\dot{m} = C_T C (\Delta P)^n$$

where

\dot{m} = Air mass flow rate through the component [kg/s]

C = Air mass flow coefficient (kg/s at 1 Pa pressure difference)

ΔP = Total pressure loss across the element [Pa]

n = Air mass flow exponent

C_T = Temperature correction factor

$$C_T = \left[\frac{\rho_o}{\rho} \right]^{n-1} \left[\frac{\nu_o}{\nu} \right]^{2n-1}$$

where

ρ = Air density at the specific air temperature and humidity ratio conditions [kg/m³]

ν = Air kinetic viscosity at the specific air temperature condition [m²/s]

ρ_o = Air density at air conditions of 20°C, 0 kg/kg and 101325 Pa [kg/m³]

ν_o = Air kinetic viscosity at an air temperature of 20°C [m²/s]

Note: The correction factor shown above is use for this particular component as specified.

Field: Name

A unique name identifying a supply or return air leak in an air distribution system. This unique name will be referenced by an AirflowNetwork:Distribution:Linkage object to represent a component leak.

Field: Air Mass Flow Coefficient

This numeric field is defined as the air mass flow coefficient at 1 Pa pressure difference across this component. Valid entries must be greater than zero.

Field: Air Mass Flow Exponent

This numeric field is defined as the pressure difference exponent across the component. Valid entries are from 0.5 to 1.0, with the default value being 0.65.

Below is the input data dictionary description for the AirflowNetwork:Distribution: Component Leak object.

```

AirflowNetwork:Distribution:Component:Leak,
  \min-fields 3
  \memo This object defines the characteristics of a supply or return air leak.
A1 , \field Name
  \required-field
  \type alpha
  \reference AirflowNetworkComponentNames
  \note Enter a unique name for this object.
N1 , \field Air Mass Flow Coefficient
  \required-field
  \type real
  \units kg/s
  \minimum > 0
  \note Defined at 1 Pa pressure difference across this component.
  \note Enter the coefficient used in the following equation:
  \note Mass Flow Rate = Air Mass Flow Coefficient * (dP)^Air Mass Flow Exponent
N2 ; \field Air Mass Flow Exponent
  \type real
  \units dimensionless
  \minimum 0.5
  \maximum 1.0
  \default 0.65
  \note Enter the exponent used in the following equation:
  \note Mass Flow Rate = Air Mass Flow Coefficient * (dP)^Air Mass Flow Exponent

```

An IDF example is provided below:

```

AirflowNetwork:Distribution:Component:Leak,
  MainSupplyLeak,      !- Name of Supply or Return Leak
  0.0001,              !- Air Mass Flow Coefficient {kg/s}
  0.65;                !- Air Mass Flow Exponent {dimensionless}

AirflowNetwork:Distribution:Component:Leak,
  ZoneSupplyLeak,     !- Name of Supply or Return Leak
  0.01,               !- Air Mass Flow Coefficient {kg/s}
  0.65;              !- Air Mass Flow Exponent {dimensionless}

```

AirflowNetwork:Distribution:Component:LeakageRatio

The leakage ratio component is generally used to define supply and return leaks with respect to a constant fan flow. This object requires 5 inputs. The relationship between pressure and airflow may be expressed as a power law element:

$$\dot{m} = C_{equ} (\Delta P)^n$$

where

ρ = Air density [kg/m³]

ΔP = Total pressure loss across the element [Pa]

n = Air mass flow exponent

C_{equ} = Equivalent air mass flow coefficient

$$C_{equ} = r * Q_r * \rho * (\Delta P_r)^{-n}$$

where

r = Effective leakage ratio [dimensionless]

Q_r = Maximum airflow rate [m³/s]

ΔP_r = Reference pressure difference [Pa]

n = Air mass flow exponent [dimensionless]

Field: Name

A unique name identifying a supply or return air leak (ratio with respect to the constant volume fan flow rate) in an air distribution system. This unique name will be referenced in an AirflowNetwork:Distribution:Linkage object to represent a component.

Field: Effective Leakage Ratio

This numeric field is used to input the effective leakage ratio. This value must be greater than zero and less than or equal to 1. The effective leakage ratio is used to characterize supply and return leaks with respect to the constant fan flow (supply or return air leak flow rate divided by the maximum air flow rate for the fan).

Field: Maximum Flow Rate

This numeric field is used to input the maximum flow rate for a constant volume fan [m^3/s]. This value must be greater than $0 \text{ m}^3/\text{s}$.

Field: Reference Pressure Difference

This numeric field is used to input the reference pressure difference [Pa]. This value must be greater than 0 Pa.

Field: Air Mass Flow Exponent

This numeric field is used to input the pressure difference exponent. The value of the exponent can be from 0.5 to 1.0, with the default value being 0.65.

Note: The reference pressure difference is defined as the difference between pressures of originate and terminate nodes for supply and return leaks. In general, it may require that a simulation be performed with an initial guess for reference pressure difference using design day conditions. After obtaining pressures at the leakage nodes, more realistic reference pressure differences can be entered. It should be pointed out that since pressures at the nodes vary with temperature and other conditions, the effective leakage ratio is only an estimate. In other words, the exact leakage ratio may not be available.

Below is the input data dictionary description for the AirflowNetwork:Distribution: Component Leakage Ratio object.

```

AirflowNetwork:Distribution:Component:LeakageRatio,
  \min-fields 5
  \memo This object is used to define supply and return air leaks with respect to the fan's maximum
  \memo air flow rate.
A1 , \field Name
  \required-field
  \type alpha
  \reference AirflowNetworkComponentNames
  \note Enter a unique name for this object.
N1 , \field Effective Leakage Ratio
  \type real
  \units dimensionless
  \minimum > 0.0
  \maximum 1.0
  \note Defined as a ratio of leak flow rate to the maximum flow rate.
N2 , \field Maximum Flow Rate
  \required-field
  \units m3/s
  \type real
  \minimum > 0.0
  \note Enter the maximum air flow rate in this air loop.
N3 , \field Reference Pressure Difference
  \required-field
  \units Pa
  \type real
  \minimum > 0.0
  \note Enter the pressure corresponding to the Effective leakage ratio entered above.
N4 ; \field Air Mass Flow Exponent
  \units dimensionless
  \type real
  \default 0.65
  \minimum 0.5
  \maximum 1.0
  \note Enter the exponent used in the air mass flow equation.
    
```

An IDF example is provided below:

```

AirflowNetwork:Distribution:Component:LeakageRatio,
  Zone1ELA,           !- Name of Effective Leakage Ratio
  0.043527,          !- Effective Leakage Ratio {dimensionless}
  1.0,              !- Maximum Flow Rate {m3/s}
  4.0,              !- Reference Pressure Difference {Pa}
  0.65;             !- Air Mass Flow Exponent {dimensionless}
    
```

AirflowNetwork:Distribution:Component:Duct

This object represents a duct component and requires 9 input fields, one alpha field and 8 numeric fields. The relationship between pressure and airflow across the component may be expressed as (2001 ASHRAE Handbook of Fundamentals, Chapter 34):

$$\dot{m} = \sqrt{\frac{2\rho A^2 \Delta P}{fL/D + \sum C_d}}$$

where

\dot{m} = Mass flow rate of air through the component [kg/s]

ρ = Air density [kg/m³]

A = Cross sectional area [m²]

ΔP = Total pressure loss across the component [Pa]

L = Duct length [m]

D = Hydraulic diameter [m]

C_d = Dynamic loss coefficient due to fitting [dimensionless]

f = Friction factor

The friction factor can be calculated using the nonlinear Colebrook equation (ASHRAE Handbook of Fundamentals, 1997. p. 2.9, Eq. 29b)

$$\frac{1}{\sqrt{f}} = 1.44 + 2 * \log\left(\frac{D}{\varepsilon}\right) - 2 * \log\left(1 + \frac{9.3}{\text{Re} * \varepsilon / D * \sqrt{f}}\right)$$

where

ε = Surface roughness [m]

Re = Reynolds number = $\frac{\rho V D}{\mu}$

Field: Name

A unique name for an AirflowNetwork duct component in an air distribution system. This unique name will be referenced by an AirflowNetwork:Distribution:Linkage object to represent a component.

Field: Duct Length

This numeric field is used to input duct length [m]. This value must be greater than zero.

Field: Hydraulic Diameter

This numeric field is used to input hydraulic diameter, which is defined as:

$$D_h = \frac{4A}{P}$$

where

D_h = Hydraulic diameter [m]

A = Duct cross sectional area [m²]

P = Perimeter of cross section [m]

Field: Cross Section Area

This numeric field is used to input cross section area [m²]. The model assumes that this element has no area change along its length. Otherwise, effective cross sectional area is required.

Field: Surface Roughness

This numeric field is used to input surface roughness [m]. This value must be greater than zero, and the default value is 0.0009 m.

Field: Coefficient for Local Dynamic Loss Due to fitting

This numeric field is defined as a coefficient for dynamic loss [dimensionless]. It represents dynamic loss due to fittings (such as an elbow).

Field: Overall Heat Transmittance Coefficient (U-Factor) from Air to Air

This numeric field is defined as the overall heat transmittance coefficient (U value, W/m²-K) from air to air, including film coefficients at both surfaces.

Field: Overall Moisture Transmittance Coefficient from Air to Air

This numeric field is defined as the overall moisture transmittance coefficient (kg/m^2) from air to air, including film coefficients at both surfaces.

Below is the input data dictionary description for the AirflowNetwork:Distribution: Component Duct object.

```

AirflowNetwork:Distribution:Component:Duct,
  \min-fields 8
  \memo This object defines the relationship between pressure and air flow through the duct.
A1 , \field Name
  \required-field
  \type alpha
  \reference AirflowNetworkComponentNames
  \note Enter a unique name for this object.
N1 , \field Duct Length
  \required-field
  \type real
  \units m
  \minimum> 0.0
  \note Enter the length of the duct.
N2 , \field Hydraulic Diameter
  \required-field
  \type real
  \units m
  \minimum> 0.0
  \note Enter the hydraulic diameter of the duct.
  \note Hydraulic diameter is defined as 4 multiplied by cross section area divided by perimeter
N3 , \field Cross Section Area
  \required-field
  \type real
  \units m2
  \minimum> 0.0
  \note Enter the cross section area of the duct.
N4 , \field Surface Roughness
  \type real
  \units m
  \default 0.0009
  \minimum> 0.0
  \note Enter the inside surface roughness of the duct.
N5 , \field Coefficient for Local Dynamic Loss Due to Fitting
  \type real
  \units dimensionless
  \default 0.0
  \minimum 0.0
  \note Enter the coefficient used to calculate dynamic losses of fittings (e.g. elbows).
N6 , \field Overall Heat Transmittance Coefficient (U-Factor) from Air to Air
  \Note including film coefficients at both surfaces
  \type real
  \units W/m2-K
  \minimum> 0.0
  \default 0.772
  \note Enter the overall U-value for this duct.
  \note Default value of 0.772 is equivalent to 1.06 m2-K/W (R6) duct insulation with
  \note film coefficients for outside and inside equal to 5 and 25 W/m2-K, respectively.
N7 ; \field Overall Moisture Transmittance Coefficient from Air to Air
  \type real
  \units kg/m2
  \minimum> 0.0
  \default 0.001
  \note Enter the overall moisture transmittance coefficient
  \note including moisture film coefficients at both surfaces.

```

An IDF example is provided below:

```
AirflowNetwork:Distribution:Component:Duct,
MainTruck1,           !- Name of Duct Component
3.0,                 !- Duct Length {m}
0.6,                 !- Hydraulic Diameter {m}
0.2827,              !- Cross Section Area {m2}
0.0009,              !- Surface Roughness {m}
0.01,                !- Coefficient for local dynamic loss due to fitting {dimensionless}
0.772,               !- Overall heat transmittance coefficient (U value) from air to air
                    !- {W/m2-K}
0.0001;              !- Overall moisture transmittance coefficient from air to air {kg/m2}
```

AirflowNetwork:Distribution:Component:ConstantVolumeFan

This component represents a constant volume fan in the air distribution system (AirLoopHVAC). The air flow rate and air conditions (temperature and humidity) are obtained from the associated Fan:ConstantVolume or Fan:OnOff object.

Field: Fan Name

The name identifying an AirflowNetwork constant volume fan in an air distribution system. This name must be the same as the name of the associated Fan:ConstantVolume or Fan:OnOff object. This name will be referenced by an AirflowNetwork:Distribution:Linkage object to represent a component.

Field: Supply Fan Object Type

This choice field defines the type of fan. The only valid choices are Fan:OnOff and Fan:ConstantVolume, with the default being Fan:ConstantVolume. Both cycling and continuous fan operating modes are allowed for Fan:OnOff. Only the continuous fan operating mode is allowed for Fan:ConstantVolume.

Note: Make sure that the volumetric air flow rates for the fan, coils, and parent components (e.g., unitary system or furnace) are the same so that fan energy and air distribution system losses/gains are properly calculated.

Below is the input data dictionary description for the AirflowNetwork:Distribution: Component Constant Volume Fan object.

```
AirflowNetwork:Distribution:Component:ConstantVolumeFan,
  \min-fields 2
  \memo This object defines the name of the constant volume supply Air Fan used in an Air loop.
A1 , \field Fan Name
    \required-field
    \type alpha
    \object-list FansCVandOnOff
    \reference AirflowNetworkComponentNames
    \note Enter the name of the constant volume fan in the primary air loop.
A2 ; \field Supply Fan Object Type
    \type choice
    \key Fan:OnOff
    \key Fan:ConstantVolume
    \default Fan:ConstantVolume
```

An IDF example is provided below:

```
AirflowNetwork:Distribution:Component:ConstantVolumeFan,
Supply Fan 1,         !- Name of Constant Volume Fan
Fan:ConstantVolume; !- Supply fan type
```

AirflowNetwork:Distribution:Component:Coil

This component represents a cooling or heating coil. The main purpose for this object is to get calculated values (air flow and temperature/humidity conditions) from the associated coil models.

Field: Coil Name

The name identifying an AirflowNetwork cooling coil or heating coil defined in an air loop. This name must be the same name as the associated coil object. This unique name will be referenced by an AirflowNetwork:Distribution:Linkage object to represent a component.

Field: Coil Object Type

This field requires input of the coil type used in the AirflowNetwork model. The available choices are:

- Coil:Cooling:DX:SingleSpeed
- Coil:Heating:Gas
- Coil:Heating:Electric
- Coil:Heating:DX:SingleSpeed
- Coil:Cooling:Water
- Coil:Heating:Water
- Coil:Cooling:Water:DetailedGeometry
- Coil:Cooling:DX:TwoStageWithHumidityControlMode
- Coil:Cooling:DX:MultiSpeed
- Coil:Heating:DX:MultiSpeed
- Coil:Heating:Desuperheater

Field: Air Path Length

This numeric field is used to input air path length for the coil [m]. This value must be greater than 0 meters.

Field: Air Path Hydraulic Diameter

This numeric field is used to input hydraulic diameter of a coil's air path, which is defined as:

$$D_h = \frac{4A}{P}$$

where

D_h = Hydraulic diameter [m]

A = Duct cross section area [m²]

P = Perimeter of cross section [m]

For this component, the relationship between airflow and pressure is similar to the component AirflowNetwork:Distribution:Component:Duct. However, the model assumes very small surface roughness (10^{-4}) and no local dynamic loss due to fittings for this component. Therefore, this component only requires two numerical fields. Heat and moisture exchange from surroundings is ignored.

Note: Make sure that the volumetric air flow rates for the fan, coils, and parent components (e.g., unitary system or furnace) are the same so that fan energy and air distribution system losses/gains are properly calculated.

Below is the input data dictionary description for the object.

```

AirflowNetwork:Distribution:Component:Coil,
  \min-fields 4
  \memo This object defines the name of a coil used in an air loop.
A1 , \field Coil Name
  \required-field
  \type alpha
  \reference AirflowNetworkComponentNames
  \note Enter the name of a cooling or heating coil in the primary Air loop.
A2 , \field Coil Object Type
  \required-field
  \type choice
  \key Coil:Cooling:DX:SingleSpeed
  \key Coil:Heating:Gas
  \key Coil:Heating:Electric
  \key Coil:Heating:DX:SingleSpeed
  \key Coil:Cooling:Water
  \key Coil:Heating:Water
  \key Coil:Cooling:Water:DetailedGeometry
  \key Coil:Cooling:DX:TwoStageWithHumidityControlMode
  \key Coil:Cooling:DX:MultiSpeed
  \key Coil:Heating:DX:MultiSpeed
  \key Coil:Heating:Desuperheater
  \note Select the type of coil corresponding to the name entered in the field above.
N1 , \field Air Path Length
  \required-field
  \type real
  \units m
  \minimum> 0
  \note Enter the air path length (depth) for the coil.
N2 ; \field Air Path Hydraulic Diameter
  \required-field
  \units m
  \type real
  \minimum> 0
  \note Enter the hydraulic diameter of this coil. The hydraulic diameter is
  \note defined as 4 multiplied by the cross section area divided by perimeter.

```

An IDF example is provided below:

```

AirflowNetwork:Distribution:Component:Coil,
  ACDXCoil 1,           !- Name of Associated EnergyPlus Coil
  Coil:Cooling:DX:SingleSpeed,  !- EnergyPlus Coil Type
  0.1,                 !- Air Path Length {m}
  1.00;                !- Air Path Hydraulic Diameter {m}

AirflowNetwork:Distribution:Component:Coil,
  HP Heating Coil 1,   !- Name of Associated EnergyPlus Coil
  Coil:Heating:DX:SingleSpeed,  !- EnergyPlus Coil Type
  0.1,                 !- Air Path Length {m}
  1.00;                !- Air Path Hydraulic Diameter {m}

```

AirflowNetwork:Distribution:Component:HeatExchanger

This component represents an air-to-air heat exchanger typically used in combination with a cooling coil to enhance dehumidification or in an outside air system to recover energy from exhaust air to pretreat incoming outdoor ventilation air. The cooling coils with enhanced dehumidification are defined in the two objects `CoilSystem:Cooling:DX:HeatExchangerAssisted` and `CoilSystem:Cooling:Water:HeatExchangerAssisted` using one of three heat exchanger objects specified below. The exhaust air energy recovery system also has the same restriction using the one of three heat exchanger objects. The main purpose for this object is to obtain calculated values (air flow and temperature/humidity conditions) from the associated heat exchanger models for the airflow network calculations.

Field: Heat Exchanger Name

The name identifying an AirflowNetwork heat exchanger defined in an air loop. This name must be the same name that is used in the associated heat exchanger object. This unique name will be referenced by an AirflowNetwork:Distribution:Linkage object to represent a component.

Field: Heat Exchanger Object Type

This field requires input of the heat exchanger type. The available choices are:

- HeatExchanger:AirToAir:FlatPlate
- HeatExchanger:AirToAir:SensibleAndLatent
- HeatExchanger:Desiccant:BalancedFlow

Field: Air Path Length

This numeric field is used to input air path length for the heat exchanger coil [m]. This value must be greater than 0 meters.

Field: Air Path Hydraulic Diameter

This numeric field is used to input hydraulic diameter of a heat exchanger coil's air path, which is defined as:

$$D_h = \frac{4A}{P}$$

where

D_h = Hydraulic diameter [m]

A = Duct cross section area [m²]

P = Perimeter of cross section [m]

For this component, the relationship between airflow and pressure is similar to the component AirflowNetwork:Distribution:Component:Duct. However, the model assumes very small surface roughness (10^{-4}) and no local dynamic loss due to fittings for this component. Therefore, this component only requires two numerical fields. Heat and moisture exchange from surroundings are ignored.

Note: When a heat exchanger is used as a component of either CoilSystem:Cooling:DX:HeatExchangerAssisted or CoilSystem:Cooling:Water:HeatExchangerAssisted, the heat exchanger acts as two components in an air primary loop. For example, an air-to-air heat exchanger has a component connected to the supply air side (equivalent to a supply coil) and a component connected to exhaust air side (equivalent to an exhaust coil). The desiccant heat exchanger has a component connected to regeneration air side (equivalent to a regeneration air coil) and a component connected to process air side (equivalent to a process air coil). Therefore, each air-to-air heat exchanger used in this configuration requires two linkage objects (instead of only one linkage object as required for other AirflowNetwork components).

When a heat exchanger is used in an exhaust air energy recovery system (i.e., in an AirLoopHVAC:OutdoorAirSystem object to recover waste heat from exhaust air to pretreat incoming outdoor ventilation air), the heat exchanger is treated as a single component. The AirflowNetwork model only connects the two nodes associated with the incoming outdoor ventilation air, while the two exhaust nodes are not defined as part of the AirflowNetwork model. Therefore, each heat exchanger component used in an exhaust air energy recovery system has only one linkage object, similar to AirflowNetwork coil components.

Below is the input data dictionary description for the AirflowNetwork:Distribution:Component:HeatExchanger object.

```
AirflowNetwork:Distribution:Component:HeatExchanger,
  \min-fields 4
  \memo This object defines the name of an air-to-air heat exchanger used in an air loop.
A1 , \field HeatExchanger Name
    \required-field
    \type alpha
    \reference AirflowNetworkComponentNames
    \note Enter the name of an air-to-air heat exchanger in the primary Air loop.
A2 , \field HeatExchanger Object Type
    \required-field
    \type choice
    \key HeatExchanger:AirToAir:FlatPlate
    \key HeatExchanger:AirToAir:SensibleAndLatent
    \key HeatExchanger:Desiccant:BalancedFlow
    \note Select the type of heat exchanger corresponding to the name entered in the field above.
N1 , \field Air Path Length
    \required-field
    \type real
    \units m
    \minimum > 0
    \note Enter the air path length (depth) for the heat exchanger.
N2 ; \field Air Path Hydraulic Diameter
    \required-field
    \units m
    \type real
    \minimum > 0
    \note Enter the hydraulic diameter of this heat exchanger. The hydraulic diameter is
    \note defined as 4 multiplied by the cross section area divided by perimeter.
```

An IDF example is provided below:

```
AirflowNetwork:Distribution:Component:HeatExchanger,
  OA Heat Recovery 1,      !- HeatExchanger Name
  HeatExchanger:AirToAir:SensibleAndLatent, !- HeatExchanger Object Type
  0.1,                    !- Air Path Length {m}
  1.00;                   !- Air Path Hydraulic Diameter {m}

AirflowNetwork:Distribution:Component:HeatExchanger,
  Desiccant Heat Exchanger 1, !- HeatExchanger Name
  HeatExchanger:Desiccant:BalancedFlow, !- HeatExchanger Object Type
  0.1,                    !- Air Path Length {m}
  1.00;                   !- Air Path Hydraulic Diameter {m}
```

AirflowNetwork:Distribution:Component:TerminalUnit

This component represents a terminal unit for reheating the incoming supply air. The main purpose is to get calculated values from the terminal unit models.

Field: Terminal Unit Name

A name identifying an AirflowNetwork terminal unit defined in a zone equipment list. This name must be the same as the associated terminal unit object. This unique name will be referenced by an AirflowNetwork:Distribution:Linkage object to represent a component.

Field: Terminal Unit Object Type

This field requires input of the terminal unit type used in the AirflowNetwork model. The only available type is AirTerminal:SingleDuct:ConstantVolume:Reheat.

Field: Air Path Length

This numeric field is used to input the air path length for the terminal unit [m]. This value must be greater than 0 meters.

Field: Air Path Hydraulic Diameter

This numeric field is used to input hydraulic diameter for the terminal unit's air path, which is defined as:

$$D_h = \frac{4A}{P}$$

where

D_h = Hydraulic diameter [m]

A = Duct cross section area [m²]

P = Perimeter of cross section [m]

It should be noted that the relationship for this component between airflow and pressure is similar to the component `AirflowNetwork:Distribution:Component:Duct`. However, the model assumes very small surface roughness (10^{-4}) and no local dynamic loss due to fittings for this component. Therefore, this component only requires two numerical fields. Heat and moisture exchange from surroundings is ignored.

Note: The `AirflowNetwork:Distribution:Component:TerminalUnit` object is used to represent an `AirTerminal:SingleDuct:ConstantVolume:Reheat` object in an `AirflowNetwork` simulation. The `AirflowNetwork:Distribution:Component:TerminalUnit` should not be used to represent any other air terminal unit types. When the `ZoneHVAC:EquipmentList` object specifies an `AirTerminal:SingleDuct:Uncontrolled` object, the `AirflowNetwork:Distribution:Component:Duct` object should be used instead.

Below is the input data dictionary description for the object.

```
AirflowNetwork:Distribution:Component:TerminalUnit,
  \min-fields 4
  \memo This object defines the name of a terminal unit in an air loop.
A1 , \field Terminal Unit Name
  \required-field
  \type alpha
  \reference AirflowNetworkComponentNames
  \note Enter the name of a terminal unit in the AirLoopHVAC.
A2 , \field Terminal Unit Object Type
  \required-field
  \type choice
  \key AirTerminal:SingleDuct:ConstantVolume:Reheat
  \note Select the type of terminal unit corresponding to the name entered in the field above.
N1 , \field Air Path Length
  \required-field
  \type real
  \units m
  \minimum> 0
  \note Enter the air path length (depth) for the terminal unit.
```

```
N2 ; \field Air Path Hydraulic Diameter
  \required-field
  \units m
  \type real
  \minimum> 0
  \note Enter the hydraulic diameter of this terminal unit. The hydraulic diameter is
  \note defined as 4 multiplied by the cross section area divided by perimeter.
```

An IDF example is provided below:


```
AirflowNetwork:Distribution:Component:TerminalUnit,
  Reheat Zone 1,                !- Name of Associated Energyplus Terminal Unit
  AirTerminal:SingleDuct:ConstantVolume:Reheat, !- EnergyPlus Terminal Unit Type
  0.1,                          !- Air Path Length {m}
  0.44;                          !- Air Path Hydraulic Diameter {m}
```

AirflowNetwork:Distribution:Component:ConstantPressureDrop

This component represents a constant pressure drop component. It is generally used to simulate a constant pressure drop filter. The mathematical equation may be written as:

$$\Delta P = const$$

Field: Name

A unique name identifying an AirflowNetwork constant pressure drop component in an air distribution system. This unique name will be referenced by an AirflowNetwork:Distribution:Linkage object to represent a component.

Field: Pressure Difference across the Component

This numeric field is used to input the pressure difference across the element [Pa].

Note: This object should be used with caution. Each node connected to this object can not be a node for a mixer or splitter, a node in an AirLoopHVAC, or a node in a zone configuration loop. It is recommended that duct components be specified at both ends of this object.

Below is the input data dictionary description for the object.

```
AirflowNetwork:Distribution:Component:ConstantPressureDrop,
  \min-fields 2
  \memo This object defines the characteristics of a constant pressure drop component (e.g. filter).
  \memo Each node connected to this object can not be a node of mixer, splitter, a node of air primary
  \memo loop, or zone equipment loop. It is recommended to connect to a duct component at both ends.
A1 , \field Name
  \required-field
  \type alpha
  \reference AirflowNetworkComponentNames
  \note Enter a unique name for this object.
N1 ; \field Pressure Difference Across the Component
  \required-field
  \units Pa
  \type real
  \minimum> 0.0
  \note Enter the pressure drop across this component.
```

An IDF example is provided below:

```
AirflowNetwork:Distribution:Component:ConstantPressureDrop,
SupplyCPDComp, ! Name of Constant Pressure Drop Component
1.0;          ! Pressure Difference Across the Component [Pa]
```

AirflowNetwork:Distribution:Linkage

The AirflowNetwork:Distribution:Linkage represents a connection between two AirflowNetwork:Distribution:Node objects and an AirflowNetwork component defined above. In addition, the relative height from node height to linkage height for each node is required.

Field: Name

The name identifies the linkage for later reference and in the output listing. Each linkage should have a unique name.

Field: Node 1 Name

Designates a node name where airflow starts. The node name should be defined in an AirflowNetwork:Distribution:Node object.

Field: Node 2 Name

Designates a node name where airflow ends. The node name should be defined in an AirflowNetwork:Distribution:Node object.

Field: Component Name

Designates an AirflowNetwork component name associated with the two nodes. The component name should be one of the AirflowNetwork:Distribution:Component... object names.

Field: Thermal Zone Name

Designates a thermal zone where the linkage is located. The information provides the ambient conditions for duct elements to calculate duct conduction losses (only used if component is AirflowNetwork:Distribution:Component:Duct).

Below is the input data dictionary description for the AirflowNetwork:Distribution: Linkage object.

```
AirflowNetwork:Distribution:Linkage,
  \min-fields 4
  \memo This object defines the connection between two nodes and a component.
A1 , \field Name
  \required-field
  \type alpha
  \note Enter a unique name for this object.
  \reference AirflowNetwork LinkageNames
A2 , \field Node 1 Name
  \required-field
  \type alpha
  \object-list AirflowNetwork NodeNames
  \object-list ZoneNames
  \note Enter the name of zone or AirflowNetwork Node.
A3 , \field Node 2 Name
  \required-field
  \type alpha
  \object-list AirflowNetwork NodeNames
  \object-list ZoneNames
  \note Enter the name of zone or AirflowNetwork Node.
A4 , \field Component Name
  \required-field
  \type object-list
  \object-list AirflowNetworkComponentNames
  \note Enter the name of an AirflowNetwork component. A component is one of the
  \note following AirflowNetwork:Distribution:Component objects: Leak, LeakageRatio,
  \note Duct, ConstantVolumeFan, Coil, TerminalUnit, ConstantPressureDrop or HeatExchanger.
A5 ; \field Thermal Zone Name
  \type object-list
  \object-list ZoneNames
  \note Only used if component = AirflowNetwork:Distribution:Component:Duct
  \note The zone name is where AirflowNetwork:Distribution:Component:Duct is exposed. Leave this field
blank if the duct
  \note conduction loss is ignored.
```

An IDF example is provided below:

```

AirflowNetwork:Distribution:Linkage,
Main Link 1,                !- Name of Linkage
EquipmentInletNode,        !- Node 1 Name
SupplyMainNode,            !- Node 2 Name
MainTruck1,                 !- Component Name
Attic Zone,                 !- Thermal Zone Name

```

AirflowNetwork Outputs

The AirflowNetwork nodes in the following output variables includes zones defined in AirflowNetwork:Multizone:Zone objects, external nodes defined in AirflowNetwork:MultiZone:ExternalNode objects, and nodes defined in AirflowNetwork:Distribution:Node objects.

The AirflowNetwork linkage used in following output variables includes surfaces defined in AirflowNetwork:Multizone:Surface objects, and linkages defined in AirflowNetwork:Distribution:Linkage objects. The surface linkages represent airflows through surface cracks or openings between two zones or between a zone and outdoors. The distribution linkages represent airflows in an air distribution system.

```

HVAC,Average,AirflowNetwork Node Temperature [C]
HVAC,Average,AirflowNetwork Node Humidity Ratio [kg/kg]
HVAC,Average,AirflowNetwork Node Total Pressure [Pa]
HVAC,Average,AirflowNetwork Wind Pressure [Pa]
HVAC,Average,AirflowNetwork Mass Flow Rate from Node 1 to 2 [kg/s]
HVAC,Average,AirflowNetwork Mass Flow Rate from Node 2 to 1 [kg/s]
HVAC,Average,AirflowNetwork Volume Flow Rate from Node 1 to 2 [m3/s]
HVAC,Average,AirflowNetwork Volume Flow Rate from Node 2 to 1 [m3/s]
HVAC,Average,AirflowNetwork Linkage Pressure Difference [Pa]
HVAC,Average,Window/Door Venting Opening Factor
HVAC,Average,Opening Factor Multiplier for Venting Modulation []
HVAC,Average,Inside Temp Setpoint for AirflowNetwork Venting [C]
HVAC,Average,Venting Availability []
HVAC,Average,AirflowNetwork Infiltration Sensible Gain Rate [W]
HVAC,Sum,AirflowNetwork Infiltration Sensible Gain [J]
HVAC,Average,AirflowNetwork Mixing Sensible Gain Rate [W]
HVAC,Sum,AirflowNetwork Mixing Sensible Gain [J]
HVAC,Average,AirflowNetwork Infiltration Sensible Loss Rate [W]
HVAC,Sum,AirflowNetwork Infiltration Sensible Loss [J]
HVAC,Average,AirflowNetwork Mixing Sensible Loss Rate [W]
HVAC,Sum,AirflowNetwork Mixing Sensible Loss [J]
HVAC,Average,AirflowNetwork Infiltration Latent Gain Rate [W]
HVAC,Sum,AirflowNetwork Infiltration Latent Gain [J]
HVAC,Average,AirflowNetwork Infiltration Latent Loss Rate [W]
HVAC,Sum,AirflowNetwork Infiltration Latent Loss [J]
HVAC,Average,AirflowNetwork Mixing Latent Gain Rate [W]
HVAC,Sum,AirflowNetwork Mixing Latent Gain [J]
HVAC,Average,AirflowNetwork Mixing Latent Loss Rate [W]
HVAC,Sum,AirflowNetwork Mixing Latent Loss [J]
HVAC,Average,AirflowNetwork Duct Leak Sensible Gain Rate [W]
HVAC,Sum,AirflowNetwork Duct Leak Sensible Gain [J]
HVAC,Average,AirflowNetwork Duct Leak Sensible Loss Rate [W]
HVAC,Sum,AirflowNetwork Duct Leak Sensible Loss [J]
HVAC,Average,AirflowNetwork Duct Leak Latent Gain Rate [W]
HVAC,Sum,AirflowNetwork Duct Leak Latent Gain [J]
HVAC,Average,AirflowNetwork Duct Leak Latent Loss Rate [W]
HVAC,Sum,AirflowNetwork Duct Leak Latent Loss [J]
HVAC,Average,AirflowNetwork Duct Conduction Sensible Gain Rate [W]
HVAC,Sum,AirflowNetwork Duct Conduction Sensible Gain [J]
HVAC,Average,AirflowNetwork Duct Conduction Sensible Loss Rate [W]
HVAC,Sum,AirflowNetwork Duct Conduction Sensible Loss [J]
HVAC,Average,AirflowNetwork Duct Diffusion Latent Gain Rate [W]
HVAC,Sum,AirflowNetwork Duct Diffusion Latent Gain [J]

```

```

HVAC,Average,AirflowNetwork Duct Diffusion Latent Loss Rate [W]
HVAC,Sum,AirflowNetwork Duct Diffusion Latent Loss [J]
HVAC,Average,AirflowNetwork Distribution Sensible Gain Rate [W]
HVAC,Sum,AirflowNetwork Distribution Sensible Gain [J]
HVAC,Average,AirflowNetwork Distribution Sensible Loss Rate [W]
HVAC,Sum,AirflowNetwork Distribution Sensible Loss [J]
HVAC,Average,AirflowNetwork Distribution Latent Gain Rate [W]
HVAC,Sum,AirflowNetwork Distribution Latent Gain [J]
HVAC,Average,AirflowNetwork Distribution Latent Loss Rate [W]
HVAC,Sum,AirflowNetwork Distribution Latent Loss [J]
HVAC,Sum,AirflowNetwork Zone Infiltration Volume [m3]
HVAC,Sum,AirflowNetwork Zone Infiltration Mass [kg]
HVAC,Average,AirflowNetwork Zone Infiltration Air Change Rate [ach]
HVAC,Sum,AirflowNetwork Zone Mixing Volume [m3]
HVAC,Sum,AirflowNetwork Zone Mixing Mass [kg]

```

The following are reported only when a Fan:OnOff object is used:

```

HVAC,Average,AirflowNetwork Average Zone Pressure [Pa]
HVAC,Average,AirflowNetwork Zone Pressure During ON cycle [Pa]
HVAC,Average,AirflowNetwork Zone Pressure During OFF cycle [Pa]
HVAC,Average,AirflowNetwork Average Mass Flow Rate from Node 1 to 2 [kg/s]
HVAC,Average,AirflowNetwork Average Mass Flow Rate from Node 2 to 1 [kg/s]
HVAC,Average,AirflowNetwork Average Volume Flow Rate from Node 1 to 2 [m3/s]
HVAC,Average,AirflowNetwork Average Volume Flow Rate from Node 2 to 1 [m3/s]
HVAC,Average,AirflowNetwork Surface Average Pressure Difference [Pa]
HVAC,Average,AirflowNetwork Surface Pressure Difference During ON cycle [Pa]
HVAC,Average,AirflowNetwork Surface Pressure Difference During OFF cycle [Pa]

```

AirflowNetwork Node Temperature [C]

This is the AirflowNetwork node temperature output in degrees C. When a Fan:OnOff object is used and is scheduled to operate in the cycling fan operation mode, this value for AirflowNetwork:Distribution:Node objects reflects the temperature when the fan is operating (ON).

AirflowNetwork Node Humidity Ratio [kg/kg]

This is the AirflowNetwork node humidity ratio output in kg/kg. When a Fan:OnOff object is used and is scheduled to operate in the cycling fan operation mode, this value for AirflowNetwork:Distribution:Node objects reflects the humidity ratio when the fan is operating (ON).

AirflowNetwork Node Total Pressure [Pa]

This is the AirflowNetwork node total pressure in Pa with respect to outdoor barometric pressure. The total pressure is the sum of static pressure, dynamic pressure, and elevation impact at the node's relative height. When a Fan:OnOff object is used and is scheduled to operate in the cycling fan operation mode, the value for AirflowNetwork:Distribution:Node objects reflects the total pressure when the fan is operating (ON). The total pressures for nodes associate with AirflowNetwork:Multizone:Zone objects are reported in different output variables (below).

AirflowNetwork Average Zone Pressure [Pa]

This is the AirflowNetwork average zone total pressure in Pa with respect to outdoor barometric pressure. This output is only available when a Fan:OnOff object is used in the air distribution system. The average zone pressure is weighted by the system fan part-load ratio using the calculated zone pressures during the fan on and off periods for the system timestep. The system fan part-load ratio is defined as the ratio of the air distribution system mass flow rate (average for the simulation timestep) to the system design mass flow rate.

Average zone pressure = (Zone pressure during on cycle * Part-load ratio) + Zone pressure during off cycle * (1.0 – Part-load ratio)

AirflowNetwork Zone Pressure During ON cycle [Pa]

This is the AirflowNetwork zone total pressure in Pa with respect to outdoor barometric pressure when the air distribution system fan is operating (ON). This output is only available when a Fan:OnOff object is used in the air distribution system. When the fan part-load ratio is equal to 0.0, this pressure value will be zero because the air distribution system is not simulated when the fan is off for the entire timestep.

AirflowNetwork Zone Pressure During OFF cycle [Pa]

This is the AirflowNetwork zone total pressure in Pa with respect to outdoor barometric pressure when the air distribution system fan is not operating (OFF). This output is only available when a Fan:OnOff object is used in the air distribution system. Even if the fan part-load ratio is equal to 1.0, the pressure calculated as if the fan were not operating (OFF) is reported.

AirflowNetwork Wind Pressure [Pa]

This is the AirflowNetwork wind pressure output in Pa. The wind pressure depends on several factors, including wind speed, wind direction, the wind-pressure coefficient (C_p) values for the AirflowNetwork:MultiZone:ExternalNode associated with the heat transfer surface and the site wind conditions.

When Wind Pressure Coefficient Type = “Input” in the AirflowNetwork:SimulationControl object, the output represents external node pressures driven by wind defined in an AirflowNetwork:MultiZone:ExternalNode object. When Wind Pressure Coefficient Type = “SurfaceAverageCalculation” in AirflowNetwork:SimulationControl, the program assumes five external nodes:

- FACADE1 Representing north orientation
- FACADE2 Representing east orientation
- FACADE3 Representing south orientation
- FACADE4 Representing west orientation
- ROOF Representing horizontal orientation

In this case, the output represents the wind pressures for the five external nodes defined above.

AirflowNetwork Mass Flow Rate from Node 1 to 2 [kg/s]

This is the AirflowNetwork linkage mass flow rate output in kg/s in the direction from Node 1 to Node 2. It reports surface airflows through a crack or opening, and through linkages defined in an AirflowNetwork:Distribution:Linkage object. The surface linkage is divided into two types of surfaces, exterior surface and interior surface. Node 1 for an exterior surface linkage is a thermal zone and Node 2 is an external node. The value of AirflowNetwork Mass Flow Rate from Node 1 to 2 represents the flow rate from a thermal zone to outdoors. The flow direction through an interior surface crack or opening is defined from a thermal zone defined by a surface’s Zone Name (Node 1) to an adjacent thermal zone defined by a surface’s OutsideFaceEnvironment (Node 2). For an AirflowNetwork:Distribution:Linkage object, the value represents the air mass flow rate flowing from Node 1 to Node 2.

It should be pointed out that in general, each linkage has one directional flow at any given time, either from Node 1 to 2 or from Node 2 to 1. However, there are two components which may have flows in both directions simultaneously: AirflowNetwork:MultiZone:Component:DetailedOpening and AirflowNetwork:MultiZone:Component:SimpleOpening.

When a Fan:OnOff object is used, the air mass flow rates reported for the AirflowNetwork:Distribution:Linkage objects are the values when the fan is operating (ON). It is assumed that the air mass flow rates when the fan is off are zero for the distribution system air linkage objects. The air mass flow rates for the AirflowNetwork:Multizone:Surface object are reported in different output variables (below).

AirflowNetwork Mass Flow Rate from Node 2 to 1 [kg/s]

This is the AirflowNetwork linkage mass flow rate output in kg/s in the direction from Node 2 to Node 1. It reports airflows from surfaces through a crack or opening, and from linkages defined in an AirflowNetwork:Distribution:Linkage object. Node 1 and Node 2 for a surface or subsurface are defined in the same manner as AirflowNetwork Mass Flow Rate from Node 1 to 2.

When a Fan:OnOff object is used, the air mass flow rates reported for the AirflowNetwork:Distribution:Linkage objects are the values when the fan is operating (ON). It is assumed that the air mass flow rates when the fan is off are zero for the distribution system air linkage objects. The air mass flow rates for the AirflowNetwork:Multizone:Surface object are reported in different output variables (below).

AirflowNetwork Average Mass Flow Rate from Node 1 to 2 [kg/s]

This is the AirflowNetwork linkage average mass flow rate in kg/s in the direction from Node 1 to Node 2 defined in the AirflowNetwork:Multizone:Surface objects. This output is only available when a Fan:OnOff object is used in the air distribution system. The average mass flow rate is weighted by the system fan part-load ratio using the calculated air mass flow rates during the fan on and off periods for the system timestep. The system fan part-load ratio is defined as the ratio of the air distribution system mass flow rate (average for the simulation timestep) to the system design mass flow rate.

Average surface mass flow rate = (Surface mass flow rate during on cycle * Part-load ratio) + Surface mass flow rate during off cycle * (1.0 – Part-load ratio)

AirflowNetwork Average Mass Flow Rate from Node 2 to 1 [kg/s]

This is the AirflowNetwork linkage average mass flow rate in kg/s in the direction from Node 2 to Node 1 defined in the AirflowNetwork:Multizone:Surface objects. This output is only available when a Fan:OnOff object is used in the air distribution system. The average mass flow rate is weighted by the system fan part-load ratio using the calculated air mass flow rates during the fan on and off periods for the system timestep. The system fan part-load ratio is defined as the ratio of the air distribution system mass flow rate (average for the simulation timestep) to the system design mass flow rate.

AirflowNetwork Volume Flow Rate from Node 1 to 2 [m³/s]

This is the AirflowNetwork linkage volume flow rate output in m³/s in the direction from the Node 1 to Node 2. It is defined in the same manner as AirflowNetwork Mass Flow Rate from Node 1 to 2.

When a Fan:OnOff object is used, the air volume flow rates reported for the AirflowNetwork:Distribution:Linkage objects are the values when the fan is operating (ON). It is assumed that the air volume flow rates when the fan is off are zero for the distribution system air linkage objects. The air volume flow rates for the AirflowNetwork:Multizone:Surface object are reported in different output variables (below).

AirflowNetwork Volume Flow Rate from Node 2 to 1 [m³/s]

This is the AirflowNetwork linkage volume flow rate output in m³/s in the direction from Node 2 to Node 1. It is defined in the same manner as AirflowNetwork Mass Flow Rate from Node 2 to 1.

When a Fan:OnOff object is used, the air volume flow rates reported for the AirflowNetwork:Distribution:Linkage objects are the values when the fan is operating (ON). It is assumed that the air volume flow rates when the fan is off are zero for the distribution system air linkage objects. The air volume flow rates for the AirflowNetwork:Multizone:Surface object are reported in different output variables (below).

AirflowNetwork Average Volume Flow Rate from Node 1 to 2 [m³/s]

This is the AirflowNetwork linkage average volume flow rate in m³/s in the direction from Node 1 to Node 2 defined in the AirflowNetwork:Multizone:Surface objects. This output is only available when a Fan:OnOff object is used. The average volume flow rate is weighted by the system fan part-load ratio using the calculated air volume flow rates during the fan on and off periods for the system timestep.

Average surface volume flow rate = (Surface volume flow rate during on cycle * Part-load ratio) + Surface volume flow rate during off cycle * (1.0 – Part-load ratio)

AirflowNetwork Average Volume Flow Rate from Node 2 to 1 [m³/s]

This is the AirflowNetwork linkage average volume flow rate in m³/s in the direction from Node 2 to Node 1 defined in the AirflowNetwork:Multizone:Surface objects. This output is only available when a Fan:OnOff object is used. The average volume flow rate is weighted by the system fan part-load ratio using the calculated air volume flow rates during the fan on and off periods for the system timestep.

AirflowNetwork Linkage Pressure Difference [Pa]

This is the pressure difference across a linkage in Pa. The linkage includes both objects: AirflowNetwork:Multizone:Surface and AirflowNetwork: Distribution:Linkage.

When a Fan:OnOff object is used, the pressure differences reported for the AirflowNetwork:Distribution:Linkage objects are the values calculated when the fan is operating (ON). It is assumed that the pressure differences when the fan is off are zero for the distribution system air linkage objects. The pressure differences defined in the AirflowNetwork:Multizone:Surface are reported in different output variables (below).

AirflowNetwork Surface Average Pressure Difference [Pa]

This is the average pressure difference across a linkage in Pa for the AirflowNetwork:Multizone:Surface objects only when a Fan:OnOff object is used. The average pressure difference is weighted by the system fan part-load ratio using the calculated pressure differences during the fan on and off periods for the system timestep. The system fan part-load ratio is defined as the ratio of the air distribution system mass flow rate (average for the simulation timestep) to the system design mass flow rate.

Surface Average Pressure Difference = (Surface Average Pressure Difference during on cycle * Part-load ratio) + Surface Average Pressure Difference during off cycle * (1.0 - Part-load ratio)

AirflowNetwork Surface Pressure Difference During ON cycle [Pa]

This is the pressure difference across a linkage in Pa for the AirflowNetwork:Multizone:Surface objects only when the air distribution system fan is operating (ON). This output is only available when a Fan:OnOff object is used. When the fan part-load ratio is equal to 0.0, this pressure difference value will be zero because the air distribution system is not simulated when the fan is off for the entire timestep.

AirflowNetwork Surface Pressure Difference During OFF cycle [Pa]

This is the pressure difference across a linkage in Pa for the AirflowNetwork:Multizone:Surface objects only when the air distribution system fan is not operating (OFF). This output is only available when a Fan:OnOff object is used. Even if the fan part-load ratio is equal to 1.0, the pressure difference calculated as if the fan were not operating (OFF) is reported.

Window/Door Venting Opening Factor []

The current time-step value of the venting opening factor for a particular window or door. When the window or door is venting, this is the input value of the opening factor (see AirflowNetwork:Multizone:Surface, Window/Door Opening Factor) times the multiplier for

venting modulation (see description of next output variable, “Opening Factor Multiplier for AirflowNetwork Venting Modulation”). For example, if the input Window/Door opening factor is 0.5 and the modulation multiplier is 0.7, then the value of this output variable will be $0.5 \times 0.7 = 0.35$.

Opening Factor Multiplier for AirflowNetwork Venting Modulation []

This is the multiplier on a window or door opening factor when venting modulation is in effect. See “Modulation of Openings” under AirflowNetwork:Multizone:Zone for a description of how the multiplier is determined.

When modulation is in effect the value of the multiplier is between 0.0 and 1.0. When modulation does not apply the value of the multiplier may be -1.0. When modulation applies but the surface is not venting, the value is -1.0. This is summarized in the following table. In this table, “Zone” means a thermal zone for which AirflowNetwork:Multizone:Zone has been specified. See AirflowNetwork: Multizone:Zone for definition of “Ventilation Control Mode.”

Table 22. Value of opening factor multiplier for different venting conditions.

Is surface in a Zone?	Ventilation Control Mode	Is surface venting?	Value of opening factor multiplier
Yes	Temperature	Yes	0.0 to 1.0
		No	-1.0
	Enthalpy	Yes	0.0 to 1.0
		No	-1.0
	Constant	Yes	1.0
	NoVent	No	-1.0

Inside Temp Setpoint for AirflowNetwork Venting [C]

The time-step value of the venting setpoint temperature for the zone to which the surface belongs. This setpoint is determined from the Vent Temperature Schedule input (ref: AirflowNetwork:Multizone:Zone).

Venting Availability []

A value of 1.0 means venting through the surface can occur if venting control conditions are satisfied. A value of 0.0 means venting through the surface cannot occur under any circumstances. This value is determined by the Venting Availability Schedule input (ref: AirflowNetwork:Multizone:Zone or AirflowNetwork:Multizone: Surface).

AirflowNetwork Infiltration Sensible Gain Rate [W]

The average convective sensible heat gain rate, in Watts, to the zone air corresponding to the Zone Infiltration Volume averaged over the reporting period. This value is calculated for each timestep when the outdoor dry-bulb temperature is higher than the zone temperature; otherwise, the sensible gain rate is set to 0.

When a Fan:OnOff object is used, this reported value is weighted by the system run time fraction using the calculated infiltration sensible gain rate during the system on and off cycles for the reporting period:

$$\text{Infiltration Sensible Gain Rate} = (\text{Infiltration Sensible Gain Rate during on cycle} * \text{Run time fraction}) + \text{Infiltration Sensible Gain Rate during off cycle} * (1.0 - \text{Run time fraction})$$

AirflowNetwork Infiltration Sensible Gain [J]

The average convective sensible heat gain, in Joules, to the zone air corresponding to the Zone Infiltration Volume averaged over the reporting period. This value is calculated for each timestep when the outdoor dry-bulb temperature is higher than the zone temperature; otherwise, the sensible gain rate is set to 0.

When a Fan:OnOff object is used, the reported value is weighted by the system run time fraction using the calculated infiltration sensible gain during the system on and off cycles for the reporting period:

Infiltration Sensible Gain = (Infiltration Sensible Gain during on cycle * Run time fraction) + Infiltration Sensible Gain during off cycle * (1.0 – Run time fraction)

AirflowNetwork Infiltration Sensible Loss Rate [W]

The average convective sensible heat loss rate, in Watts, to the zone air corresponding to the Zone Infiltration Volume averaged over the reporting period.

When a Fan:OnOff object is used, the reported value is weighted by the system run time fraction using the calculated infiltration sensible loss rate during the system on and off cycles for the reporting period:

Infiltration Sensible Loss Rate = (Infiltration Sensible Loss Rate during on cycle * Run time fraction) + Infiltration Sensible Loss Rate during off cycle * (1.0 – Run time fraction)

AirflowNetwork Infiltration Sensible Loss [J]

The average convective sensible heat loss, in Joules, to the zone air corresponding to the Zone Infiltration Volume averaged over the reporting period.

When a Fan:OnOff object is used, the reported value is weighted by the system run time fraction using the calculated infiltration sensible loss rate during the system on and off cycles for the reporting period:

Infiltration Sensible Loss = (Infiltration Sensible Loss during on cycle * Run time fraction) + Infiltration Sensible Loss during off cycle * (1.0 – Run time fraction)

AirflowNetwork Infiltration Latent Gain Rate [W]

The average convective latent heat gain rate, in Watts, to the zone air corresponding to the Zone Infiltration Volume averaged over the reporting period, when the outdoor humidity ratio is higher than the zone air humidity ratio.

When a Fan:OnOff object is used, the reported value is weighted by the system run time fraction using the calculated infiltration latent gain rate during the system on and off cycles for the reporting period:

Infiltration Latent Gain Rate = (Infiltration Latent Gain Rate during on cycle * Run time fraction) + Infiltration Latent Gain Rate during off cycle * (1.0 – Run time fraction)

AirflowNetwork Infiltration Latent Gain [J]

The total convective latent heat gain, in Joules, to the zone air corresponding to the Zone Infiltration Volume summed over the reporting period.

When a Fan:OnOff object is used, the reported value is weighted by the system run time fraction using the calculated infiltration latent gain during the system on and off cycles for the reporting period:

Infiltration Latent Gain = (Infiltration Latent Gain during on cycle * Run time fraction) + Infiltration Latent Gain during off cycle * (1.0 – Run time fraction)

AirflowNetwork Infiltration Latent Loss Rate [W]

The average convective latent heat loss rate, in Watts, to the zone air corresponding to the Zone Infiltration Volume averaged over the reporting period.

When a Fan:OnOff object is used, the reported value is weighted by the system run time fraction using the calculated infiltration latent loss rate during the system on and off cycles for the reporting period:

Infiltration Latent Loss Rate = (Infiltration Latent Gain Loss Rate during on cycle * Run time fraction) + Infiltration Latent Loss Rate during off cycle * (1.0 – Run time fraction)

AirflowNetwork Infiltration Latent Loss [J]

The total convective latent heat loss, in Joules, to the zone air corresponding to the Zone Infiltration Volume summed over the reporting period.

When a Fan:OnOff object is used, the reported value is weighted by the system run time fraction using the calculated infiltration latent loss during the system on and off cycles for the reporting period:

Infiltration Latent Loss = (Infiltration Latent Gain Loss during on cycle * Run time fraction) + Infiltration Latent Loss during off cycle * (1.0 – Run time fraction)

AirflowNetwork Mixing Sensible Gain Rate [W]

The average convective sensible heat gain rate, in Watts, to the zone air corresponding to the Zone Mixing Volume averaged over the reporting period. The mixing-volume is defined as incoming volume flow from other adjacent zones where the air temperature is higher than the temperature in this zone. For example, there are two zones (Zone 2 and Zone 3) adjacent to this zone (Zone 1). Zone 1 receives airflows from both Zone 2 and Zone 3. The air temperature is 21°C in Zone 1. The air temperatures are 20°C in Zone 2 and 22°C in Zone 3. The sensible gain rate only includes heat gain from Zone 3 with respect to Zone 1. The energy received from Zone 2 is considered as a sensible loss, instead of a gain, because the air temperature in Zone 2 is lower than in Zone 1.

When a Fan:OnOff object is used, the reported value is weighted by the system run time fraction using the calculated mixing sensible gain rate during the system on and off cycles for the reporting period:

Mixing Sensible Gain Rate = (Mixing Sensible Gain Rate during on cycle * Run time fraction) + Mixing Sensible Gain Rate during off cycle * (1.0 – Run time fraction)

AirflowNetwork Mixing Sensible Loss Rate [W]

The average convective sensible heat loss rate, in Watts, to the zone air corresponding to the Zone Mixing Volume averaged over the reporting period.

When a Fan:OnOff object is used, the reported value is weighted by the system run time fraction using the calculated mixing sensible loss rate during the on and off cycles for the reporting period:

Mixing Sensible Loss Rate = (Mixing Sensible Loss Rate during on cycle * Run time fraction) + Mixing Sensible Loss Rate during off cycle * (1.0 – Run time fraction)

AirflowNetwork Mixing Sensible Gain [J]

The total convective sensible heat gain, in Joules, to the zone air corresponding to the Zone Mixing Volume summed over the reporting period.

When a Fan:OnOff object is used, the reported value is weighted by the system run time fraction using the calculated mixing sensible gain during the on and off cycles for the reporting period:

Mixing Sensible Gain = (Mixing Sensible Gain during on cycle * Run time fraction) + Mixing Sensible Gain during off cycle * (1.0 – Run time fraction)

AirflowNetwork Mixing Sensible Loss [J]

The total convective sensible heat loss, in Joules, to the zone air corresponding to the Zone Mixing Volume summed over the reporting period.

When a Fan:OnOff object is used, the reported value is weighted by the system run time fraction using the calculated mixing sensible loss during the on and off cycles for the reporting period:

Mixing Sensible Loss = (Mixing Sensible Loss during on cycle * Run time fraction) + Mixing Sensible Loss during off cycle * (1.0 – Run time fraction)

AirflowNetwork Mixing Latent Gain Rate [W]

The average convective latent heat gain rate, in Watts, to the zone air corresponding to the Zone Mixing Volume averaged over the reporting period.

When a Fan:OnOff object is used, the reported value is weighted by the system run time fraction using the calculated mixing latent gain rate during the on and off cycles for the reporting period:

Mixing Latent Gain Rate = (Mixing Latent Gain Rate during on cycle * Run time fraction) + Mixing Latent Gain Rate during off cycle * (1.0 – Run time fraction)

AirflowNetwork Mixing Latent Gain [J]

The total convective latent heat gain, in Joules, to the zone air corresponding to the Zone Mixing Volume summed over the reporting period.

When a Fan:OnOff object is used, the reported value is weighted by the system run time fraction using the calculated mixing latent gain during the on and off cycles for the reporting period:

Mixing Latent Gain = (Mixing Latent Gain during on cycle * Run time fraction) + Mixing Latent Gain during off cycle * (1.0 – Run time fraction)

AirflowNetwork Mixing Latent Loss Rate [W]

The average convective latent heat loss rate, in Watts, to the zone air corresponding to the Zone Mixing Volume averaged over the reporting period.

When a Fan:OnOff object is used, the reported value is weighted by the system run time fraction using the calculated mixing latent loss rate during the on and off cycles for the reporting period:

Mixing Latent Loss Rate = (Mixing Latent Loss Rate during on cycle * Run time fraction) + Mixing Latent Loss Rate during off cycle * (1.0 – Run time fraction)

AirflowNetwork Mixing Latent Loss [J]

The total convective latent heat loss, in Joules, to the zone air corresponding to the Zone Mixing Volume summed over the reporting period.

When a Fan:OnOff object is used, the reported value is weighted by the system run time fraction using the calculated mixing latent loss during the on and off cycles for the reporting period:

Mixing Latent Loss = (Mixing Latent Loss during on cycle * Run time fraction) + Mixing Latent Loss during off cycle * (1.0 – Run time fraction)

AirflowNetwork Duct Leak Sensible Gain Rate [W]

This is the average sensible heat gain rate, in Watts, to a specific zone due to supply air leaks from the forced air distribution system. This value is averaged over the reporting period. A sensible heat gain occurs when duct air is warmer than zone air. It should be pointed out that when multiple supply air leaks are present in a single zone, the output value is the summation of all the supply air leak gains in this zone. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Duct Leak Sensible Gain [J]

This is the total sensible heat gain, in Joules, to a specific zone due to supply air leaks summed over the reporting period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Duct Leak Sensible Loss Rate [W]

This is the average sensible heat loss rate, in Watts, to a specific zone due to supply air leaks from the forced air distribution system. This value is averaged over the reporting period. A sensible heat loss occurs when duct air is cooler than zone air. It should be pointed out that when multiple supply air leaks are present in this zone, the output value is the summation of all the supply air leak losses in this zone. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Duct Leak Sensible Loss [J]

This is the total sensible heat loss, in Joules, to a specific zone due to supply air leaks summed over the reporting period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Duct Leak Latent Gain Rate [W]

This is the average latent heat gain rate, in Watts, to a specific zone due to supply air leaks from the forced air distribution system for the reported time period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Duct Leak Latent Gain [J]

This is the total latent heat gain, in Joules, to a specific zone due to supply air leaks summed over the reporting period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Duct Leak Latent Loss Rate [W]

This is the average latent heat loss rate, in Watts, to a specific zone due to supply air leaks from the forced air distribution system for the reported time period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Duct Leak Latent Loss [J]

This is the total latent heat loss, in Joules, to a specific zone due to supply air leaks summed over the reporting period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Duct Conduction Sensible Gain Rate [W]

This is the average sensible heat gain rate, in Watts, of duct conduction to a specific zone where the ducts are located. This value is averaged over the reporting period. A sensible heat gain occurs when duct air is warmer than the zone air. It should be pointed out that when ducts are located in different zones, the total duct conduction loss should be the summation of the duct conduction losses in these zones. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Duct Conduction Sensible Gain [J]

This is the total sensible heat gain, in Joules, to a specific zone due to duct conduction summed over the reporting period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Duct Conduction Sensible Loss Rate [W]

This is the average sensible heat loss rate, in Watts, of duct conduction to a specific zone where the ducts are located. This value is averaged over the reporting period. A sensible

heat loss occurs when duct air is cooler than the zone air. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Duct Conduction Sensible Loss [J]

This is the total sensible heat loss, in Joules, to a specific zone due to duct conduction summed over the reporting period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Duct Diffusion Latent Gain Rate [W]

This is the average latent heat gain rate, in Watts, of vapor diffusion through the walls of the air distribution system to a specific zone where the ducts are located. This value is averaged over the reporting period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Duct Diffusion Latent Gain [J]

This is the total latent heat gain, in Joules, to a specific zone due to duct vapor diffusion summed over the reporting period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Duct Diffusion Latent Loss Rate [W]

This is the average latent heat loss rate, in Watts, of duct vapor diffusion to a specific zone where the ducts are located. This value is averaged over the reporting period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Duct Diffusion Latent Loss [J]

This is the total latent heat loss, in Joules, to a specific zone due to duct vapor diffusion summed over the reporting period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Distribution Sensible Gain Rate [W]

This is the average total sensible heat gain rate, in Watts, in a specific zone caused by the forced air distribution system. The total sensible gain rate is the sum of duct leakage sensible gain rate and duct conduction sensible gain rate. This value is averaged over the reporting period. The multizone airflow sensible gain rate is excluded in this output report variable. The output of multizone airflow sensible gain is reported in the previously-described output variables AirflowNetwork Infiltration Sensible Gain Rate and AirflowNetwork Mixing Sensible Gain Rate. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Distribution Sensible Gain [J]

This is the total sensible heat gain, in Joules, in a specific zone caused by the forced air distribution system. The total sensible gain is the sum of duct leakage sensible gain and duct conduction sensible gain. This value is summed over the reporting period. The multizone airflow sensible gain is excluded in this output report variable. The output of multizone airflow sensible gain is reported in the previously-described output variables AirflowNetwork Infiltration Sensible Gain and AirflowNetwork Mixing Sensible Gain. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Distribution Sensible Loss Rate [W]

This is the average total sensible heat loss rate, in Watts, in a specific zone caused by the forced air distribution system. The total sensible loss rate is the sum of duct leakage sensible loss rate and duct conduction sensible loss rate. This value is averaged over the reporting period. The multizone airflow sensible loss rate is excluded in this output report variable. The output of multizone airflow sensible loss rate is reported in the previously-described output variables AirflowNetwork Infiltration Sensible Loss Rate and AirflowNetwork Mixing Sensible Loss Rate. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Distribution Sensible Loss [J]

This is the total sensible heat loss, in Joules, in a specific zone caused by the forced air distribution system. The total sensible loss is the sum of duct leakage sensible loss and duct conduction sensible loss. This value is summed over the reporting period. The multizone airflow sensible loss is excluded in this output report variable. The output of multizone airflow sensible loss is reported in the previously-described output variables AirflowNetwork Infiltration Sensible Loss and AirflowNetwork Mixing Sensible Loss. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Distribution Latent Gain Rate [W]

This is the average total latent heat gain rate, in Watts, in a specific zone caused by the forced air distribution system. The total latent gain rate is the sum of duct leakage latent gain rate and duct conduction latent gain rate. This value is averaged over the reporting period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Distribution Latent Gain [J]

This is the total latent heat gain, in Joules, in a specific zone caused by the forced air distribution system. The total latent gain is the sum of duct leakage latent gain and duct diffusion latent gain. This value is summed over the reporting period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Distribution Latent Loss Rate [W]

This is the average total latent heat loss rate, in Watts, in a specific zone caused by the forced air distribution system. The total latent loss rate is a sum of duct leakage latent loss rate and duct diffusion latent loss rate. This value is averaged over the reporting period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Distribution Latent Loss [J]

This is the total latent heat loss, in Joules, in a specific zone caused by the forced air distribution system. The total latent loss is the sum of duct leakage latent loss and duct diffusion latent loss. This value is summed over the reporting period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

NOTE: The following report variables should not be confused with similar report variables for the infiltration, mixing, and cross mixing objects (Ref. Infiltration Output, Mixing Output, or Cross Mixing Output). The report variables described below refer to infiltration, mixing, and cross-mixing when an Airflow Network Simulation is performed. The following report variables are always used to describe infiltration, mixing, and cross mixing when the AirflowNetwork Control field in the AirflowNetwork:SimulationControl object is set to “MultizoneWithoutDistribution” or “MultizoneWithDistribution”. In this case the report variables for the infiltration, mixing, and cross mixing objects will always be 0.

In contrast, the following report variables are only used to describe infiltration, mixing, and cross mixing when the AirflowNetwork Control field in the AirflowNetwork:SimulationControl object is set to “MultizoneAirflowWithDistributionOnlyDuringFanOperation” and the fan is operating. When the fan is not operating, the report variables for the infiltration, mixing, and cross mixing objects are used.

In the case where the AirflowNetwork Control field in the AirflowNetwork:SimulationControl object is set to “NoMultizoneOrDistribution”, the following report variables are not used and the report variables for the infiltration, mixing, and cross mixing objects are used instead.

AirflowNetwork Infiltration Sensible Gain [J]

The total convective sensible heat gain, in Joules, to the zone air corresponding to the Zone Infiltration Volume summed over the reporting period. This value is calculated for each

timestep when the outdoor dry-bulb temperature is higher than the zone temperature, otherwise the sensible gain is set to 0. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Infiltration Sensible Loss [J]

The total convective sensible heat loss, in Joules to the zone air corresponding to the Zone Infiltration Volume summed over the reporting period. When a Fan:OnOff object is used, the reported value is for the system on cycle.

AirflowNetwork Zone Infiltration Volume [m3]

The volume of outdoor air flow into the zone from window/door openings and cracks in the exterior surfaces of the zone (i.e., the sum of ventilation and crack flows from the exterior into the zone). Note that AirflowNetwork Zone Infiltration Volume will be zero if all of the flows through the zone's exterior surfaces are out of the zone. When a Fan:OnOff object is used, the reported value is weighted by the system fan part-load ratio using the infiltration volume calculated during the fan on and off periods for the simulation timestep.

AirflowNetwork Zone Infiltration Mass [kg]

The mass of air corresponding to the AirflowNetwork Zone Infiltration Volume. When a Fan:OnOff object is used, the reported value is weighted by the system fan part-load ratio using the infiltration mass calculated during the fan on and off periods for the simulation timestep.

AirflowNetwork Zone Infiltration Air Change Rate [ach]

The number of air changes per hour produced by outdoor air flow into the zone from window/door openings and cracks in the exterior surfaces of the zone (i.e. the sum of ventilation and crack flows from the exterior into the zone). Note that, like Zone Infiltration Volume, Zone Infiltration Air Change Rate will be zero if all flows through the zone's exterior surfaces are out of the zone. When a Fan:OnOff object is used, the reported value is weighted by the system fan part-load ratio using the infiltration air change rate calculated during the fan on and off periods for the simulation timestep.

AirflowNetwork Zone Mixing Volume [m3]

This is a measure of interzone air flow for each thermal zone. It is the volume of air flow into the zone from adjacent zones through window/door openings and cracks in the interior heat transfer surfaces of the zone. This variable does not include flows that are from the zone to adjacent zones. Note that Zone Mixing Volume will be zero if all flows through the zone's interior surfaces are out of the zone. When a Fan:OnOff object is used, the reported value is weighted by the system fan part-load ratio using the mixing volume calculated during the fan on and off periods for the simulation timestep.

AirflowNetwork Zone Mixing Mass [kg]

The mass of air corresponding to the AirflowNetwork Zone Mixing Volume. When a Fan:OnOff object is used, the reported value is weighted by the system fan part-load ratio using the mixing mass calculated during the fan on and off periods for the simulation timestep.

Group – Zone Equipment

There are five main zone equipment statements that must be used to describe a block of zone equipment as shown in the below figure “Zone Equipment Input Syntax Map”.

Types of Zone equipment are listed below and shown below in figure “Zone Equipment”.

Table 23. Available Zone Equipment Types

Air Distribution Equipment	AirTerminal:SingleDuct:Uncontrolled AirTerminal:SingleDuct:ConstantVolume:Reheat AirTerminal:SingleDuct:VAV:Reheat AirTerminal:SingleDuct:VAV:NoReheat AirTerminal:SingleDuct:VAV:Reheat:VariableSpeedFan AirTerminal:DualDuct:ConstantVolume AirTerminal:DualDuct:VAV Powered Induction Units (Series and Parallel)
Zone Forced Air Units	ZoneHVAC:IdealLoadsAirSystem ZoneHVAC:FourPipeFanCoil ZoneHVAC:WindowAirConditioner Unit Ventilator/Heater Air-to-Air Heat Pumps Unitary Systems (heat only and heat/cool) Furnaces (heat only and heat/cool) Energy Recovery Ventilator:Stand Alone AirLoopHVAC:UnitaryCoolOnly
Radiative/Convective Units	Baseboard Heaters Low Temp Radiant Systems High Temp Radiant System

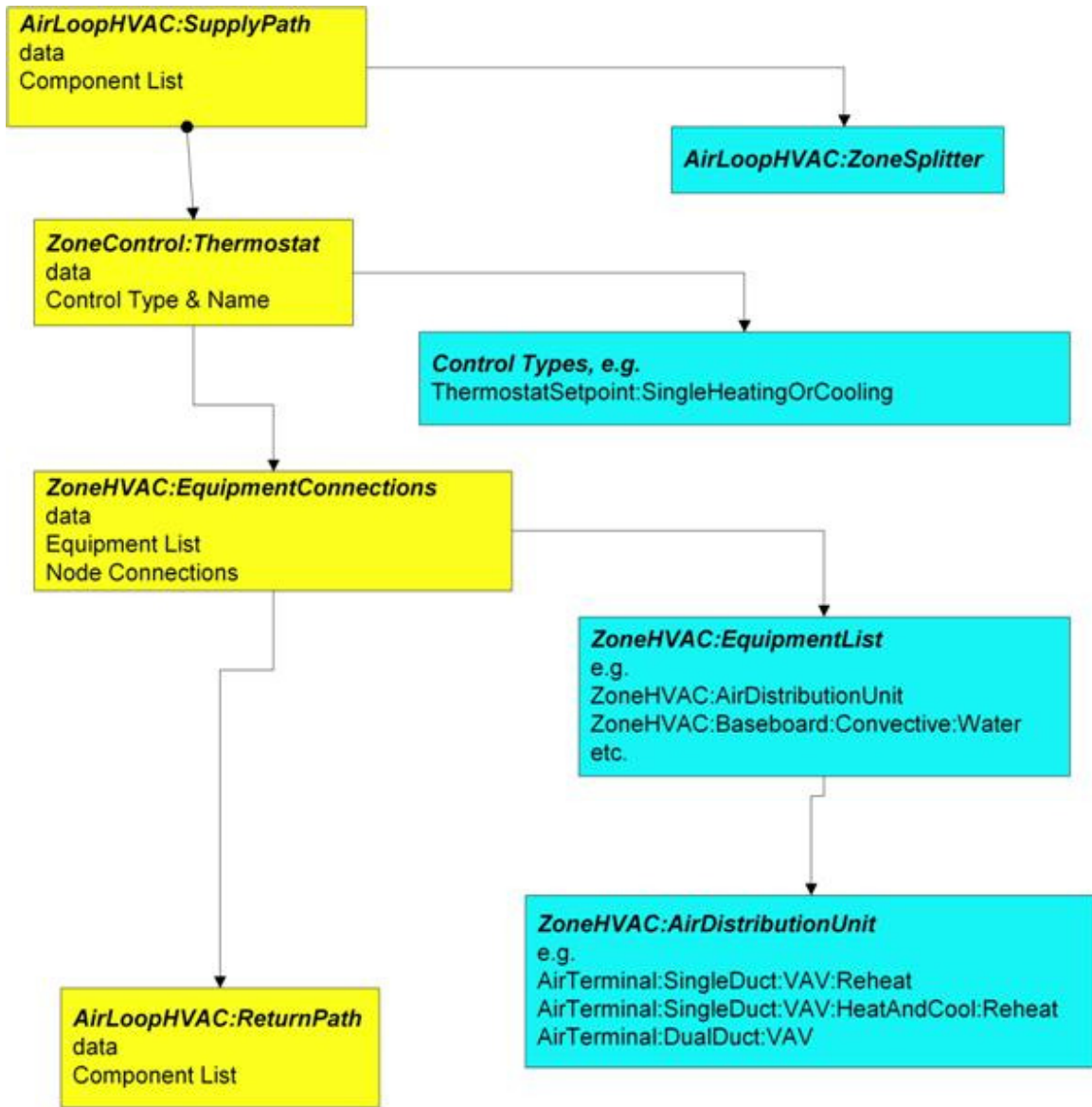


Figure 82. Zone Equipment Input Syntax Map

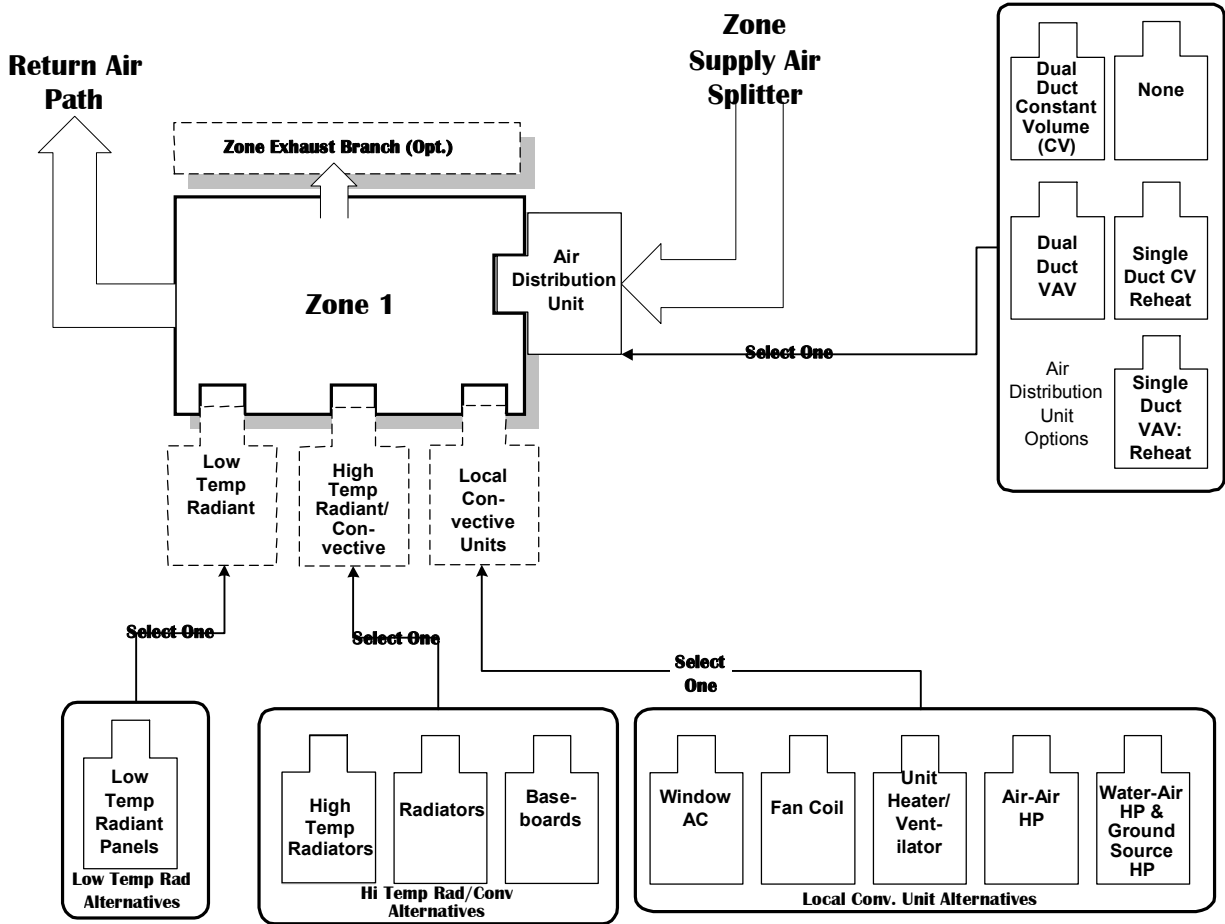


Figure 83. Representative Zone Equipment

The following figure (Air Loop/Zone Equipment Node Diagram) illustrates the connection between the zone equipment and the air loop systems.

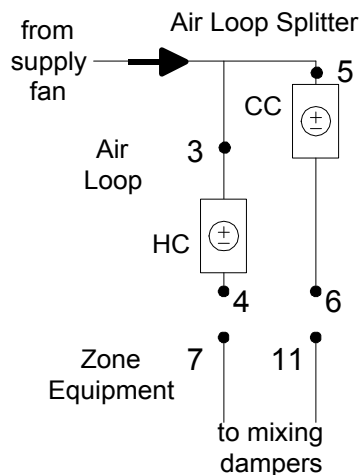


Figure 84. Air Loop/Zone Equipment Node Diagram

Each zone served by an HVAC system must have three additional statements to complete the zone equipment specification. An ZoneHVAC:AirDistributionUnit allows equipment typically found within the zone inlet ductwork (such as dampers, reheat coils, etc.) to be

attached to the supply air stream for a particular zone. A ZoneControl statement will allow the conditions in the zone to be managed. Finally, a ZoneHVAC:EquipmentConnections statement describes all of the pertinent information about the zone from an HVAC perspective. Each of these statements is described in more detail below.

ZoneHVAC:AirDistributionUnit

The ZoneHVAC:AirDistributionUnit object gives further information on what air loop equipment (air terminal units) will be serving a particular zone. The ZoneHVAC:AirDistributionUnit is the part of the system that is supplied from a common main air handler simulated in the Air Loop Simulation and includes the equipment that controls or tempers the air going to each individual zone according to the desired thermostatic control. The current options for ZoneHVAC:AirDistributionUnit terminal unit types are:

```
AirTerminal:DualDuct:ConstantVolume
AirTerminal:DualDuct:VAV
AirTerminal:SingleDuct:ConstantVolume:Reheat
AirTerminal:SingleDuct:VAV:Reheat
AirTerminal:SingleDuct:VAV:NoReheat
AirTerminal:SingleDuct:SeriesPIU:Reheat
AirTerminal:SingleDuct:ParallelPIU:Reheat
AirTerminal:SingleDuct:ConstantVolume:FourPipeInduction
AirTerminal:SingleDuct:VAV:Reheat:VariableSpeedFan
AirTerminal:SingleDuct:VAV:HeatAndCool:Reheat
AirTerminal:SingleDuct:VAV:HeatAndCool:NoReheat
```

Connections between the air distribution unit, the supply air duct, and the zone are specified in the input syntax for the air distribution unit and the AirLoopHVAC:ZoneSplitter. The input syntax also explicitly defines an outlet identifier. This implies a connection to a zone through a NodeList for zone inlets (see the ZoneHVAC:EquipmentConnections statement). The air distribution unit is limited to one combined component-controller unit; because controls are normally based on the zone thermostat and can work in parallel or series in complex fashion. Since the control and the flow resolution can be complex, each air distribution unit is unique in addressing these combinations and therefore only one is allowed per zone.

The Air Distribution unit also allows the user to specify leaks in the supply air duct system. These inputs are used in the EnergyPlus Simplified Duct Leakage Model (SDLM). This model simulates a specific configuration: supply leaks to a return plenum in a commercial VAV or CV system. The system must have a constant static pressure setpoint. Within these limitations SDLM allows the user to easily evaluate the energy penalty due to duct leakage.

Field: Name

Unique identifying name of the air distribution unit.

Field: Air Distribution Unit Outlet Node Name

Outlet node name for the air distribution unit to the attached zone.

Field: Air Terminal Object Type

Single combined component/controller unit for that attached zone. Selection of components as listed above.

Field: Air Terminal Name

The unique identifying component name.

Field: Nominal Upstream Leakage Fraction

This is the leakage upstream of the terminal unit as a fraction of the design flow rate through the unit. It is the leakage fraction at the design flow rate. It is used to calculate a leakage flow rate which is then held constant while the system air flow varies. This input is optional; the default is zero.

Field: Constant Downstream Leakage Fraction

This is the leakage downstream of the terminal unit as a fraction of the current flow rate through the terminal unit. This fraction is held constant, so the leakage flow rate will vary proportionally with the supply air flow rate. This input is optional; the default is zero.

```

ZoneHVAC:AirDistributionUnit,
  \min-fields 4
  \memo A typical set of components for an air distribution unit will
  \memo consist of a single component Air Distribution Unit (ADU)
A1 , \field Name
  \required-field
  \reference AirDistributionUnits
A2 , \field Air Distribution Unit Outlet Node Name
  \required-field
A3 , \field Air Terminal Object Type
  \type choice
  \key AirTerminal:DualDuct:ConstantVolume
  \key AirTerminal:DualDuct:VAV
  \key AirTerminal:SingleDuct:ConstantVolume:Reheat
  \key AirTerminal:SingleDuct:VAV:Reheat
  \key AirTerminal:SingleDuct:VAV:NoReheat
  \key AirTerminal:SingleDuct:SeriesPIU:Reheat
  \key AirTerminal:SingleDuct:ParallelPIU:Reheat
  \key AirTerminal:SingleDuct:ConstantVolume:FourPipeInduction
  \key AirTerminal:SingleDuct:VAV:Reheat:VariableSpeedFan
  \key AirTerminal:SingleDuct:VAV:HeatAndCool:Reheat
  \key AirTerminal:SingleDuct:VAV:HeatAndCool:NoReheat
  \required-field
A4 , \field Air Terminal Name
  \required-field
N1 , \field Nominal Upstream Leakage Fraction
  \note fraction at system design Flow; leakage flow constant, leakage fraction
  \note varies with variable system Flow Rate.
  \type real
  \minimum 0
  \maximum 0.3
  \default 0
N2 ; \field Constant Downstream Leakage Fraction
  \type real
  \minimum 0
  \maximum 0.3
  \default 0

```

Two example IDF excerpts (one with duct leakage, one without):

```

ZoneHVAC:AirDistributionUnit,
  SPACE1-1 ATU,           !- Air Distribution Unit Name
  SPACE1-1 In Node,      !- Air Dist Unit Outlet Node Name
  SINGLE DUCT:VAV:REHEAT, !- KEY--System Component Type 1
  SPACE1-1 VAV Reheat;   !- Component Name 1

ZoneHVAC:AirDistributionUnit,
  SPACE4-1 ATU,           !- Air Distribution Unit Name
  SPACE4-1 In Node,      !- Air Dist Unit Outlet Node Name
  SINGLE DUCT:VAV:REHEAT, !- KEY--System Component Type 1
  SPACE4-1 VAV Reheat,   !- Component Name 1
  0.05,                  !- upstream nominal leakage fraction
  0.07;                  !- downstream constant leakage fraction

```

ZoneHVAC:EquipmentConnections

Finally, the ZoneHVAC:EquipmentConnections statement defines the remaining details about each thermal zone from an HVAC perspective (besides the controls which were defined above). As with other statements, the first two items in this object are the keyword and an identifying name which links the zone back to its geometrical input, internal gains, etc. and other statements in the HVAC section of the input. The next three items are names of lists (equipment, air inlet nodes, and air exhaust nodes) that are described in more detail below.

Note that if there are no air exhaust nodes from the zone that field is left blank. And if there are no air inlet nodes, that field is left blank. Finally, two node names are necessary to complete the zone-HVAC description. The first node is the main air node for the zone upon which the air heat balance is performed. The other node begins the return air path from the zone.

Note that all nodes mentioned in the ZoneHVAC:EquipmentConnections input must be unique. That is, all nodes in all the ZoneHVAC:EquipmentConnections statements referenced by the “Zone Air Inlet Nodes”, “Zone Air Exhaust Nodes”, “Zone Air Node Name” and “Zone Return Air Node Name” cannot have any node name appearing more than once.

Field: Zone Name

Name links this equipment list back to the heat balance for the zone.

Field: Zone Conditioning Equipment List Name

List of zone equipment for this zone in a ZoneHVAC:EquipmentList object. This list will consist of air distribution units or other direct convection or radiant equipment, i.e. window air conditioner, baseboard, fan coils, etc.

Field: Zone Air Inlet Node or NodeList Name

There can be more than one air inlet node depending on how many pieces of equipment are in the ZoneHVAC:EquipmentList. Generally there will be one air inlet node for each piece of zone equipment that delivers conditioned air to the zone. Components such as electric or hot water baseboards and radiant systems do not require zone air inlet nodes. If there is only one node – its name can be put in this field. If there is more than one node, this must be the name of a node list object (a node list object can also contain only one node name). If this field is not required (as in the baseboard system), it should be blank.

Field: Zone Air Exhaust Node or NodeList Name

List of exhaust nodes leaving the zone for exhaust fans, zone energy recovery, etc. However these nodes are also used as sources of zone air for zone components such as fan coil units, unit heaters and ventilators, and window air conditioners. For each such component attached to a zone there should be a unique zone exhaust node acting as the inlet node to the component. If there is only one node – its name can be put in this field. If there is more than one node, this must be the name of a node list object (a node list object can also contain only one node name). If there are no air exhaust nodes, this field should be blank.

Field: Zone Air Node Name

The conditions at this node represent the average state of the air in the zone. For zones modeled as fully mixed the conditions at this node are assumed to represent the air in the entire zone. This field is required for all ZoneHVAC:EquipmentConnections statements.

Field: Zone Return Air Node Name

The name of the return air node which attaches the zone to the return air path described above. Even if there is no return air or no return air path a unique name must be entered in this field. The conditions at this node represent the state of the air leaving the zone including any heat gain from light-heat-to-return.

```

ZoneHVAC:EquipmentConnections,
A1 , \field Zone Name
      \required-field
      \type object-list
      \object-list ZoneNames
A2 , \field Zone Conditioning Equipment List Name
      \note Enter the name of a ZoneHVAC:EquipmentList object.
      \required-field
A3 , \field Zone Air Inlet Node or NodeList Name
A4 , \field Zone Air Exhaust Node or NodeList Name
A5 , \field Zone Air Node Name
      \required-field
A6 ; \field Zone Return Air Node Name
      \required-field

```

An example of this statement in an IDF is:

```

ZoneHVAC:EquipmentConnections,
SPACE3-1,           !- Zone Name
SPACE3-1 Eq,       !- List Name: Zone Equipment
SPACE3-1 In Nodes, !- List Name: Zone Air Inlet Nodes
,                 !- List Name: Zone Air Exhaust Nodes
SPACE3-1 Node,     !- Zone Air Node Name
SPACE3-1 Out Node; !- Zone Return Air Node Name

```

ZoneHVAC:EquipmentList

The first list encountered in the ZoneHVAC:EquipmentConnections statement is the ZoneHVAC:EquipmentList. As with most lists in the EnergyPlus input scheme, there is the defining keyword and an identifying name. In the case of the zone equipment list, each item in the list has four fields associated with it. The first two are the typical type keyword and identifying name pair. The remaining two items help define the cooling and heating priority of that piece of equipment, respectively. The priorities should be integers with a “1” being the highest priority, a “2” being the next highest priority, etc. Since there are separate inputs for heating and cooling, equipment can be prioritized appropriately for the different conditioning seasons. Note that an ZoneHVAC:AirDistributionUnit or AirTerminal:SingleDuct:Uncontrolled must be listed in this statement if there is a forced air system serving the zone from the air loop.

Field: Name

Unique identifying name.

Field Set (Zone Equipment: Object Type, Name, Cooling Priority, Heating Priority)

This set is used together in order to prioritize the equipment for heating and cooling. The #1 priority equipment will try to meet the entire demand with its capacity and then pass the results on to the #2 and so on for both heating and cooling. This field set is extensible by duplicating the last four fields.

Field: Zone Equipment <x> Object Type

Type of zone equipment such as air distribution unit, baseboard, window air conditioner, etc. The current legal types are listed in the following table:

Table 24. Legal Zone Equipment Types (ZoneHVAC:EquipmentList)

Legal Zone Equipment Types
AirTerminal:SingleDuct:Uncontrolled
Fan:ZoneExhaust
WaterHeater:HeatPump
ZoneHVAC:AirDistributionUnit
ZoneHVAC:Baseboard:Convective:Electric
ZoneHVAC:Baseboard:Convective:Water
ZoneHVAC:Baseboard:RadiantConvective:Water
ZoneHVAC:EnergyRecoveryVentilator
ZoneHVAC:FourPipeFanCoil
ZoneHVAC:HighTemperatureRadiant
ZoneHVAC:IdealLoadsAirSystem
ZoneHVAC:LowTemperatureRadiant:ConstantFlow
ZoneHVAC:LowTemperatureRadiant:Electric
ZoneHVAC:LowTemperatureRadiant:VariableFlow
ZoneHVAC:PackagedTerminalAirConditioner
ZoneHVAC:PackagedTerminalHeatPump
ZoneHVAC:UnitHeater
ZoneHVAC:UnitVentilator

Field: Zone Equipment <x> Name

Name of the zone equipment used in the object definition of its type.

Field: Zone Equipment <x> Cooling Priority

Sets the first, second, third, etc. cooling priority for the piece of equipment described. First is highest priority.

Field: Zone Equipment <x> Heating Priority

Sets the first, second, third, etc. heating priority for the piece of equipment described. First is highest priority.

The IDD for the ZoneHVAC:EquipmentList object:

```

ZoneHVAC:EquipmentList,
  \extensible:4 Duplicate the four fields Zone Equipment Object Type through Heating Priority
  \memo List equipment in simulation order. Note that an ZoneHVAC:AirDistributionUnit or
  \memo AirTerminal:SingleDuct:Uncontrolled object must be listed in this statement if there is a
forced
  \memo air system serving the zone from the air loop.
A1 , \field Name
  \required-field
  \reference ZoneEquipmentLists
A2 , \field Zone Equipment 1 Object Type
  \type choice
  \key ZoneHVAC:AirDistributionUnit
  \key AirTerminal:SingleDuct:Uncontrolled
  \key ZoneHVAC:WindowAirConditioner
  \key ZoneHVAC:PackagedTerminalHeatPump
  \key ZoneHVAC:PackagedTerminalAirConditioner
  \key ZoneHVAC:FourPipeFanCoil
  \key ZoneHVAC:UnitVentilator
  \key ZoneHVAC:UnitHeater
  \key ZoneHVAC:IdealLoadsAirSystem
  \key ZoneHVAC:Baseboard:RadiantConvective:Water
  \key ZoneHVAC:Baseboard:Convective:Water
  \key ZoneHVAC:Baseboard:Convective:Electric
  \key ZoneHVAC:HighTemperatureRadiant
  \key ZoneHVAC:LowTemperatureRadiant:VariableFlow
  \key ZoneHVAC:LowTemperatureRadiant:ConstantFlow
  \key ZoneHVAC:LowTemperatureRadiant:Electric
  \key ZoneHVAC:VentilatedSlab
  \key Fan:ZoneExhaust
  \key ZoneHVAC:EnergyRecoveryVentilator
  \key WaterHeater:HeatPump
  \required-field
A3 , \field Zone Equipment 1 Name
  \required-field
N1 , \field Zone Equipment 1 Cooling Priority
  \required-field
  \type integer
  \minimum 1
  \note 1=highest, 2=next, etc
N2 , \field Zone Equipment 1 Heating Priority
  \required-field
  \type integer
  \minimum 1
  \note 1=highest, 2=next, etc
-- reduced for brevity - 18 allowed in basic IDD -- extensible

```

An example of this statement in an IDF is:

```

ZoneHVAC:EquipmentList, Zone1Equipment,
  ZoneHVAC:AirDistributionUnit, Zone1DualDuct, 1, 1;

```

The Zone Inlets and Zone Exhaust are specified in a normal NodeList statement, named such that the ZoneHVAC:EquipmentConnections can find them.

For example, in the IDF:

```

NodeList,
  Zone1Inlets,
  Zone 1 Reheat Air Outlet Node;

NodeList,
  Zone2Inlets,
  Zone 2 Reheat Air Outlet Node;

NodeList,
  Zone3Inlets,
  Zone 3 Reheat Air Outlet Node;

```


Group – Air Distribution Equipment

The systems described in the Air Distribution Units (ADU's) are shown below. These single description ADU's contain the reference to the components and the actual controls in one block of input. The idea is that the control volume is drawn tightly around the controls and loosely around the components. This allows complex interactions to take place between all of the components that respond to the Zone Thermostatic Control output. The coils that are referenced in the ADU's are explained fully in the "Coils" section of this manual.

AirTerminal:SingleDuct:Uncontrolled

Central system air is usually supplied to a zone through a terminal unit such as a single duct VAV reheat box. Sometimes, however, it is desirable to supply central system air directly to a zone without any zone level control or tempering. An example would be a single zone reheat system.

The control zone receives supply air directly from the central system since the supply air temperature has been adjusted to control the temperature in the control zone. The slave zones then have baseboards or reheat coils to allow some temperature adjustment. The AirTerminal:SingleDuct:Uncontrolled object creates the capability of supplying central system air directly to a zone. Its input consists of the object name, an availability (on/off) schedule, and a node name. This node is both a zone inlet node and an outlet node of the AirLoopHVAC:ZoneSplitter.

For the objects to work correctly, it is important in any systems including Direct Air objects for the sum of the maximum zone air flow rates to be equal to the maximum central system flow rate. The zone maximum flow rates are specified in the zone terminal unit or direct air inputs. The central air system flow rate is specified in the AirLoopHVAC input and also in the air loop branch and central fan inputs.

Field: Name

A unique user assigned name for each AirTerminal:SingleDuct:Uncontrolled component. Any other component that needs to use this direct air component will refer to it by this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the component can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the direct air component can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the direct air component must be off for the hour

Field: Zone Supply Air Node Name

The name of the node to which the direct air component is supplying air. This should be one of the supply air nodes for the zone the direct air component is serving. This node should also be an outlet node of a AirLoopHVAC:ZoneSplitter component.

Field: Maximum Air Flow Rate

The design maximum volume flow rate (m^3/sec) specified for the AirTerminal:SingleDuct:Uncontrolled object. This field is autosizable.

The IDD definition is shown below.

```

AirTerminal:SingleDuct:Uncontrolled,
  \min-fields 4
  A1, \field Name
  \required-field
  A2, \field Availability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
  A3, \field Zone Supply Air Node Name
  \required-field
  N1; \field Maximum Air Flow Rate
  \required-field
  \units m3/s
  \minimum 0.0
  \autosizable

```

An example input follows.

```

AirTerminal:SingleDuct:Uncontrolled,
  Zone1DirectAir,
  FanAndCoilAvailSched,
  Zone 1 Inlet Node,
  0.47;
AirTerminal:SingleDuct:Uncontrolled,
  Zone2DirectAir,
  FanAndCoilAvailSched,
  Zone 2 Inlet Node,
  0.36;
AirTerminal:SingleDuct:Uncontrolled,
  Zone3DirectAir,
  FanAndCoilAvailSched,
  Zone 3 Inlet Node,
  0.47;

```

AirTerminal:SingleDuct:ConstantVolume:Reheat

The AirTerminal:SingleDuct:ConstantVolume:Reheat or terminal reheat system is a constant volume reheat system. The systems cooling capabilities are provided by way of cooling coil that supplies cooling to the entire supply air volume. The cooling coil is controlled by a controller setpoint specified for the cooling coil. Zone control is accomplished by heating (reheating) the airflow into each zone as determined by the zone thermostat. Currently the reheat can be supplied by a electric, gas, or hot water coil that tries to meet the zone demand.

Field: Name

Unique name for the terminal reheat Air Distribution Unit (ADU).

Field: Availability Schedule Name

Schedule that this component will operate or is available to operate.

Field: Air Outlet Node Name

The outlet node from the ADU to the zone. This is the same node as the reheat component air outlet node.

Field: Air Inlet Node Name

The air-inlet node name that connects the air splitter to the individual zone ADU. This is the same node as the reheat component air inlet node.

Field: Maximum Air Flow Rate

The design constant volume flow rate (m³/sec) specified for the terminal reheat ADU.

Control Fields:

The last several fields for this object describe the type of reheat coil that is being used and how it is controlled. Most of the fields pertain to the hot water coil since the gas and electric coil are much more simplified.

Field: Hot Water or Steam Inlet Node Name

For the hot water reheat coil there is a node on the water side that would control the flow to the coil capacity to allow the coil to meet the zone demand. This control location is the name of the control node for the terminal reheat ADU. For the gas and electric coil this is left blank.

Field: Reheat Coil Object Type

The valid reheat component objects currently available are:

```
Coil:Heating:Water
Coil:Heating:Electric
Coil:Heating:Gas
Coil:Heating:Steam
```

Field: Reheat Coil Name

Reheat Coil Object name being simulated with this ADU. Applicable for all coils.

Field: Maximum Hot Water or Steam Flow Rate

This field is 0 for gas and electric coils. Set to the maximum design water flow (m³/sec) for the hot water coil

Field: Minimum Hot Water or Steam Flow Rate

This field is zero for gas and electric coils. Set to the minimum design water flow (m³/sec) for the hot water coil, normally set to be a shut off valve that is set to zero.

Field: Convergence Tolerance

The coil is controlled by knowing the zone demand determined by the zone thermostat and setting the outlet conditions to meet this demand. For the electric and gas coils, this is set exactly since the coil model solution can be inverted. With the hot water coil that uses an effectiveness-NTU method, the solution cannot be inverted directly. Therefore, to determine the correct mass flow rate for the hot water the solution is solved for by iteration. The iterative solution uses an interval halving routine and needs a termination criteria that is set with the Convergence Tolerance parameter. This control offset is set to a decimal fraction of the zone demand as the criteria, i.e. 0.001. The default for the field is 0.001.

The IDD specification is:

```
AirTerminal:SingleDuct:ConstantVolume:Reheat,
A1 , \field Name
    \required-field
A2 , \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A3, \field Air Outlet Node Name
    \required-field
A4, \field Air Inlet Node Name
    \required-field
```

```

N1, \field Maximum Air Flow Rate
    \units m3/s
    \minimum 0.0
    \autosizable
A5, \field Hot Water or Steam Inlet Node Name
    \note Not used when reheat coil type is gas or electric
    \deprecated
A6, \field Reheat Coil Object Type
    \type choice
    \key Coil:Heating:Water
    \key Coil:Heating:Electric
    \key Coil:Heating:Gas
    \key Coil:Heating:Steam
A7, \field Reheat Coil Name
    \type object-list
    \object-list HeatingCoilName
N2, \field Maximum Hot Water or Steam Flow Rate
    \note Not used when reheat coil type is gas or electric
    \units m3/s
    \minimum 0.0
    \autosizable
    \ip-units gal/min
N3, \field Minimum Hot Water or Steam Flow Rate
    \note Not used when reheat coil type is gas or electric
    \units m3/s
    \minimum 0.0
    \default 0.0
    \ip-units gal/min
N4; \field Convergence Tolerance
    \type real
    \minimum> 0.0
    \default 0.001

```

An IDF example:

```

AirTerminal:SingleDuct:ConstantVolume:Reheat,
  Reheat Zone 1, !- Name of System
  FanAndCoilAvailSched, !- Availability schedule for VAV System
  Zone 1 Reheat Air Outlet Node, !- Unit Air Outlet Node
  Zone 1 Reheat Air Inlet Node, !- Unit Air Inlet Node
  0.59, !- Maximum air flow rate {m3/s}
  , !- Control node
  COIL:Gas:Heating, !- Reheat Component Object
  Reheat Coil Zone 1, !- Name of Reheat Component
  0.0, !- Max Reheat Water Flow {m3/s}
  0.0, !- Min Reheat Water Flow {m3/s}
  0.001; !- Convergence Tolerance

```

AirTerminal:SingleDuct:VAV:Reheat

AirTerminal:SingleDuct:VAV:Reheat - Variable air volume (VAV) systems control the dry-bulb temperature inside a zone by varying the supply air volume instead of the air temperature. At full cooling the VAV damper is fully open supplying the specified maximum air flow rate. As the cooling load decreases, the damper closes until it reaches the minimum stop specified by the zone minimum air flow fraction.

VAV systems can be used for interior or perimeter zones with a common fan system, air temperature control, and reheating devices. The VAV concept may vary according to the VAV box locations, air temperature controls and types of heating elements. Heating can usually be provided by use of reheat coils or thermostatic baseboard.

Field: Name

Unique name for the AirTerminal:SingleDuct:VAV:Reheat Air Distribution Unit (ADU).

Field: Availability Schedule Name

Schedule that this component will operate or is available to operate.

Field: Damper Air Outlet Node Name

The VAV damper outlet node. This is the outlet node of the damper and the inlet node of the reheat coil.

Field: Air Inlet Node Name

The air inlet node name that connects the air splitter to the individual zone ADU. This is *not* the same as the air inlet node of the reheat component: it is upstream of that node. This is the inlet node to the terminal unit and the damper

Field: Maximum Air Flow Rate

The design maximum volume flow rate (m³/sec) specified for VAV ADU.

Field: Zone Minimum Air Flow Method

This field is used to select how the program will determine the minimum flow rate to the zone while the system is operating. The minimum flow rate is modeled as a fraction of the maximum flow rate. There are two choices: Constant and Scheduled. If Constant is entered, then the program will use the value for minimum flow fraction entered in the following field. If Scheduled is entered, then the program will obtain the value for minimum flow fraction from the schedule named in the field below called Minimum Air Flow Fraction Schedule Name.

Field: Constant Minimum Air Flow Fraction

The minimum flow rate to the zone while the system is operating, specified as a fraction of the maximum air flow rate. The minimum zone fraction is normally specified to meet the minimum ventilation requirement for the occupants. The reheat coil operates only when the damper is at this minimum flow rate when Damper Heating Action is set to Normal (the default). This field is used if the previous field is set to Constant. If the previous field is set to Scheduled (and the field Maximum Hot Water or Steam Flow Rate is set to autosize), then this field is optional and can be used to separately control the air flow rate used for sizing normal-action reheat coils.

Field: Minimum Air Flow Fraction Schedule Name

The name of a schedule that determines the value of the minimum air flow fraction. The schedule should contain fractions from 0.0 to 1.0. These values will define the minimum flow rate to the zone while the system is operating, specified as a fraction of the maximum air flow rate. The reheat coil operates only when the damper is at this minimum flow rate when Damper Heating Action is set to Normal (the default). This field is used if the previous field is set to Scheduled. If the previous field is left blank (and the field Maximum Hot Water or Steam Flow Rate is set to autosize), then the air flow rate used for sizing normal-action reheat coils is the average of the minimum and maximum values in this schedule. The air flow rate used for reheat coil sizing is reported with other component sizing information as "Reheat Coil Sizing Air Volume Flow Rate."

Control Fields:

The last several fields for this object describe the type of reheat coil that is being used and how it is controlled. Most of the fields pertain to the hot water coil since the gas and electric coil are much more simplified.

Field: Hot Water or Steam Inlet Node Name

For the hot water reheat coil there is a node on the water side that would control the flow to the coil capacity to allow the coil to meet the zone demand. This control location is the name of the control node for the terminal reheat ADU. For the gas and electric coils, or if there is no reheat coil, this is left blank.

Field: Reheat Coil Object Type

The valid reheat component objects currently available are:

```
Coil:Heating:Water  
Coil:Heating:Electric  
Coil:Heating:Gas  
Coil:Heating:Steam
```

If there is no reheat coil, use Single Duct:VAV:NoReheat instead of this object.

Field: Reheat Coil Name

Reheat Coil Object name being simulated with this ADU. Applicable for all coils. If there is no reheat coil, use object AirTerminal:SingleDuct:VAV:NoReheat instead of this object.

Field: Maximum Hot Water or Steam Flow Rate

This field is 0 for gas and electric coils. Set to the maximum design water flow (m³/sec) for the hot water coil. If there is no reheat coil, this is left blank.

Field: Minimum Hot Water or Steam Flow Rate

This field is zero for gas and electric coils. Set to the minimum design water flow (m³/sec) for the hot water coil, normally set to be a shut off valve that is set to zero. If there is no reheat coil, this is left blank.

Field: Convergence Tolerance

The coil is controlled by knowing the zone demand determined by the zone thermostat and setting the outlet conditions to meet this demand. For the electric and gas coils, this is set exactly since the coil model solution can be inverted. With the hot water coil that uses an effectiveness-NTU method, the solution cannot be inverted directly. Therefore, to determine the correct mass flow rate for the hot water the solution is solved for by iteration. The iterative solution uses an interval halving routine and needs a termination criteria that is set with the Convergence Tolerance parameter. This control offset is set to a decimal fraction of the zone demand as the criteria, i.e. 0.001. The default for the field is 0.001.

Field: Damper Heating Action

During heating operation, there are two control options for the damper controlling the air flow in the VAV terminal unit as the zone moves above or below the zone setpoint. With both control options, the damper is at the minimum air flow rate whenever the zone temperature is between the cooling and heating setpoints.

With **Normal** (the default) action, the damper will remain at the minimum air flow rate during heating operation. As the heating load increases, the water flow rate in the reheat coil will be increased to maintain temperature in the zone until the maximum water flow rate is reached.

With **Reverse**, as the heating load increases, the unit starts at minimum air flow and minimum hot water flow. The hot water flow is increased until it reaches maximum flow, then the air damper starts to open to meet the load. This option is used if the minimum air flow rate is not adequate to serve the peak heating load.

The IDD specification is:

```

AirTerminal:SingleDuct:VAV:Reheat,
A1, \field Name
    \required-field
A2 , \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A3, \field Damper Air Outlet Node Name
    \note the outlet node of the damper and the inlet node of the reheat coil
    \note this is an internal node to the terminal unit and connects the damper and reheat coil
    \required-field
A4, \field Air Inlet Node Name
    \note the inlet node to the terminal unit and the damper
    \required-field
N1, \field Maximum Air Flow Rate
    \units m3/s
    \minimum 0.0
    \autosizable
A5 \field Zone Minimum Air Flow Input Method
    \type choice
    \key Constant
    \key Scheduled
N2, \field Constant Minimum Air Flow Fraction
    \note This field is used if the field Zone Minimum Air Flow Input Method is Constant
    \note If the field Zone Minimum Air Flow Input Method is Scheduled, then this field
    \note is optional; if a value is entered, then it is used for sizing normal-action reheat coils.
A6, \field Minimum Air Flow Fraction Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note This field is used if the field Zone Minimum Air Flow Input Method is Scheduled
    \note Schedule values are fractions, 0.0 to 1.0.
    \note If the field Constant Minimum Air Flow Fraction is blank, then the average of the
    \note minimum and maximum schedule values is used for sizing normal-action reheat coils.
A7, \field Hot Water or Steam Inlet Node Name
    \note Not used when reheat coil type is gas or electric
    \deprecated
A8, \field Reheat Coil Object Type
    \type choice
    \key Coil:Heating:Water
    \key Coil:Heating:Electric
    \key Coil:Heating:Gas
    \key Coil:Heating:Steam
A9, \field Reheat Coil Name
    \type object-list
    \object-list HeatingCoilName
N3, \field Maximum Hot Water or Steam Flow Rate
    \note Not used when reheat coil type is gas or electric
    \units m3/s
    \minimum 0.0
    \autosizable
    \ip-units gal/min
N4, \field Minimum Hot Water or Steam Flow Rate
    \note Not used when reheat coil type is gas or electric
    \units m3/s
    \minimum 0.0
    \default 0.0
    \ip-units gal/min
A10, \field Air Outlet Node Name
    \note the outlet node of the terminal unit and the reheat coil
N5, \field Convergence Tolerance
    \type real
    \minimum> 0.0
    \default 0.001
A11; \field Damper Heating Action
    \type choice
    \key Normal
    \key Reverse
    \default Normal

```

An IDF example:

```

AirTerminal:SingleDuct:VAV:Reheat,
SPACE2-1 VAV Reheat,  !- Name of System
ReheatCoilAvailSched,  !- Availability schedule for VAV System
SPACE2-1 Zone Coil Air In Node,  !- Damper Air Outlet Node
SPACE2-1 ATU In Node,  !- Unit Air Inlet Node
autosize,  !- Maximum air flow rate {m3/s}
Constant,  !- Zone Minimum Air Flow Input Method
0.3,  !- Constant Minimum Air Flow Fraction
,  !- Minimum Air Flow Fraction Schedule Name
,  !- Control node
COIL:Gas:Heating,  !- Reheat Component Object
SPACE2-1 Zone Coil,  !- Name of Reheat Component
0.0,  !- Max Reheat Water Flow {m3/s}
0.0,  !- Min Reheat Water Flow {m3/s}
SPACE2-1 In Node,  !- Unit Air Outlet Node
0.001,  !- Convergence Tolerance
Reverse;  !- Damper Heating Action

COIL:Heating:Gas,
SPACE2-1 Zone Coil,  !- Coil Name
ReheatCoilAvailSched,  !- Available Schedule
0.8,  !- Gas Burner Efficiency of the Coil
autosize,  !- Nominal Capacity of the Coil {W}
SPACE2-1 Zone Coil Air In Node,  !- Coil_Air_Inlet_Node
SPACE2-1 In Node;  !- Coil_Air_Outlet_Node

```

AirTerminal:SingleDuct:VAV:Reheat:VariableSpeedFan

The VAV terminal unit with variable-speed fan and reheat coil is an air system terminal unit consisting of a variable speed fan in series with a heating coil. These units are usually employed in underfloor air distribution (UFAD) systems where the air is supplied at low static pressure through an underfloor plenum. The fan is used to control the flow of conditioned air that enters the space. When the fan is off the plenum pressure drives the minimum air flow through the terminal unit. At maximum cooling the fan runs at its maximum speed. At full heating the fan runs at its heating maximum – usually less than the cooling maximum flow rate. Thus this unit has two separate maximum flow rates – one for heating and one for cooling.

For cooling, control is maintained simply by varying the fan speed. For heating, the unit first tries to meet the heating load by varying the heating coil output while keeping the air flow at minimum (fan off). If this is not adequate the fan turns on and operates in variable flow mode up to the heating maximum flow rate.

This unit is modeled in EnergyPlus as a compound component – a variable speed fan and a heating coil in series in the air stream. The unit is blow through – the fan is upstream of the heating coil.

Field: Name

A unique user assigned name for a particular VS fan VAV reheat terminal unit. Any reference to this unit by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the unit can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Maximum Cooling Air Flow Rate

The maximum volumetric air flow rate through the unit in cubic meters per second when the thermostat is calling for cooling. Normally this is the same as the unit's fan maximum volumetric flow rate.

Field: Maximum Heating Air Flow Rate

The maximum volumetric air flow rate through the unit in cubic meters per second when the thermostat is calling for heating.

Field: Zone Minimum Air Flow Fraction

The minimum flow rate to the zone while the system is operating, specified as a fraction of the maximum air flow rate. For this unit this is the flow rate when the fan is off.

Field: Air Inlet Node Name

The name of the HVAC system node that is the air inlet node for the terminal unit. This is also the air inlet node for the unit's fan.

Field: Air Outlet Node Name

The name of the HVAC system node that is the air outlet node of the unit. This same node will be the unit heating coil's air outlet node. This node is also a zone inlet node.

Field: Heating Coil Air Inlet Node Name

The name of the HVAC system node that is the air inlet node of the unit's heating coil. The same node is the outlet node of the unit's fan. This is an internal node of this compound component.

Field: Hot Water or Steam Inlet Node Name

The name of the HVAC system node which regulates the flow of hot water through the unit's hot water heating coil. This should be the same node as the water inlet node of the hot water coil. For gas or electric coils this field should be left blank.

Field: Fan Object Type

The type of fan in the terminal unit. At this time the only type of fan allowed is *Fan:VariableVolume*.

Field: Fan Name

The name of the particular fan object in this terminal unit.

Field: Heating Coil Object Type

The type of heating coil in the terminal unit. The valid choices are:

Coil:Heating:Water Coil:Heating:Electric Coil:Heating:Gas Coil:Heating:Steam

Field: Heating Coil Name

The name of the heating coil object contained in this terminal unit.

Field: Maximum Hot Water or Steam Flow Rate

The maximum hot water volumetric flow rate in m³/sec through the unit's heating coil. If the heating coil is not a hot water coil this field should be left blank.

Field: Minimum Hot Water or Steam Flow Rate

The minimum hot water volumetric flow rate in m³/sec through the unit's heating coil. If the heating coil is not a hot water coil this field should be left blank.

Field: Heating Convergence Tolerance

The control tolerance for the unit heating output. The unit is controlled by matching the unit output to the zone demand. The model must be numerically inverted to obtain a specified

output. The convergence tolerance is the error tolerance used to terminate the numerical inversion procedure. Basically this is the fraction:

$$\frac{|Q_{unit,out} - Q_{zone\ load}|}{Q_{zone\ load}} \leq \textit{ConvergenceTolerance}$$

The default is 0.001.

The full IDD specification follows:

```

AirTerminal:SingleDuct:VAV:Reheat:VariableSpeedFan,
A1, \field Name
    \required-field
A2 , \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
N1, \field Maximum Cooling Air Flow Rate
    \required-field
    \type real
    \units m3/s
    \autosizable
    \minimum 0.0
N2, \field Maximum Heating Air Flow Rate
    \required-field
    \type real
    \units m3/s
    \autosizable
    \minimum 0.0
N3, \field Zone Minimum Air Flow Fraction
    \required-field
    \note fraction of cooling air flow rate
A3, \field Air Inlet Node Name
    \note same as fan inlet node
    \type alpha
    \required-field
    \deprecated
A4, \field Air Outlet Node Name
    \note same as heating coil air outlet node
    \note same as zone inlet node
    \type alpha
    \required-field
    \deprecated
A5, \field Heating Coil Air Inlet Node Name
    \note same as fan outlet node
    \type alpha
    \required-field
    \deprecated
A6, \field Hot Water or Steam Inlet Node Name
    \note Not used when heating coil type is gas or electric
    \type alpha
    \deprecated
A7, \field Fan Object Type
    \required-field
    \type choice
    \key Fan:VariableVolume

```

A8,	\field Fan Name \required-field \type object-list \object-list FansVAV
A9,	\field Heating Coil Object Type \type choice \key Coil:Heating:Water \key Coil:Heating:Electric \key Coil:Heating:Gas \key Coil:Heating:Steam
A10,	\field Heating Coil Name \type object-list \object-list HeatingCoilName
N4,	\field Maximum Hot Water or Steam Flow Rate \note Not used when heating coil type is gas or electric \type real \units m3/s \autosizable \ip-units gal/min
N5,	\field Minimum Hot Water or Steam Flow Rate \note Not used when heating coil type is gas or electric \type real \units m3/s \minimum 0.0 \default 0.0 \ip-units gal/min
N6;	\field Heating Convergence Tolerance \type real \minimum> 0.0 \default 0.001

An IDF example:

```
AirTerminal:SingleDuct:VAV:Reheat:VariableSpeedFan,
SPACE2-1 VAV Reheat,      !- Name of System
ReheatCoilAvailSched,    !- System Availability schedule
autosize,                !- Maximum cooling air volume flow rate
autosize,                !- Maximum heating air volume flow rate
0.05,                   !- Zone Minimum Air Flow Fraction
SPACE2-1 ATU In Node,    !- Unit supply air inlet node
SPACE2-1 In Node,       !- Unit supply air outlet node
SPACE2-1 Zone Coil Air In Node, !- heating coil air inlet node
SPACE2-1 Zone Coil Water In Node, !- Hot water control node
FAN:SIMPLE:VariableVolume, !- Fan object
SPACE2-1 Zone Fan,      !- Fan name
COIL:Water:SimpleHeating, !- Heating coil object
SPACE2-1 Zone Coil,     !- Heating coil name
autosize,               !- Max hot water flow
0.0,                   !- Min hot water flow
0.001;                 !- Heating Convergence Tolerance
```

```
Coil:Heating:Water,
SPACE2-1 Zone Coil,      !- Coil Name
ReheatCoilAvailSched,   !- Available Schedule
autosize,               !- UA of the Coil {W/K}
autosize,               !- Max Water Flow Rate of Coil {m3/s}
SPACE2-1 Zone Coil Water In Node, !- Coil_Water_Inlet_Node
SPACE2-1 Zone Coil Water Out Node, !- Coil_Water_Outlet_Node
SPACE2-1 Zone Coil Air In Node, !- Coil_Air_Inlet_Node
SPACE2-1 In Node;      !- Coil_Air_Outlet_Node
```

```

Fan:VariableVolume,
SPACE2-1 Zone Fan,      !- Fan Name
FanAvailsched,         !- Available Schedule
0.7,                   !- Fan Total Efficiency
125.0,                 !- Delta Pressure {Pa}
autosize,              !- Max Flow Rate {m3/s}
0.0,                   !- Min Flow Rate {m3/s}
0.9,                   !- Motor Efficiency
1.0,                   !- Motor In Airstream Fraction
0.00153028,           !- FanCoefficient 1
0.00520806,           !- FanCoefficient 2
1.1086242,            !- FanCoefficient 3
-.11635563,           !- FanCoefficient 4
0.000,                 !- FanCoefficient 5
SPACE2-1 ATU In Node,  !- Fan_Inlet_Node
SPACE2-1 Zone Coil Air In Node; !- Fan_Outlet_Node

```

AirTerminal:SingleDuct:VAV:Reheat:VariableSpeedFan Outputs

There are no outputs for the VS fan VAV reheat terminal units.

AirTerminal:SingleDuct:VAV:HeatAndCool:Reheat

Variable air volume (VAV) systems typically control the dry-bulb temperature inside a zone by varying the supply air volume instead of the supply air temperature (ref: AirTerminal:SingleDuct:VAV:NoReheat). Reheat coils may be required to avoid overcooling (ref: AirTerminal:SingleDuct:VAV:Reheat).

This terminal unit is slightly different from the Single Duct:VAV:Reheat terminal unit. Both operate the same in cooling mode: the damper opens as needed to provide additional sensible cooling to the zone. The difference between the two is in heating mode. For the Single Duct VAV Reheat terminal unit, the air flow rate is reduced to the minimum value (max air flow rate x zone minimum air flow fraction) when zone heating is required and the reheat coil output is modulated to meet the zone heating load. For the AirTerminal:SingleDuct:VAV:HeatAndCool:Reheat terminal unit, the air flow rate in heating mode is increased to meet higher zone heating loads (similar to what is done in cooling mode). If additional heat is required (beyond what the terminal unit can provide with its damper fully open), then the reheat coil is modulated as needed to meet the additional heating load.

This terminal unit model was originally developed and tested for use with the changeover-bypass VAV unitary system.

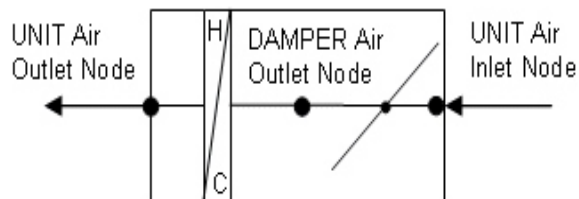


Figure 85. Single Duct VAV Heat and Cool Reheat Schematic

Field: Name

Unique user-defined name for this Air Distribution Unit (ADU).

Field: Availability Schedule Name

This alpha field defines the name of the schedule (ref: Schedule) that denotes whether or not this component is available to operate during a given time period. If a schedule value is greater than zero then the system is available to operate; otherwise, the system is unavailable for that time period.

Field: Damper Air Outlet Node Name

This alpha field defines the name of the VAV damper air outlet node. This is the outlet node of the damper and the inlet node of the reheat coil.

Field: Air Inlet Node Name

This alpha field defines the name of the air inlet node that connects the air splitter to the individual zone ADU. This is *not* the same as the air inlet node of the reheat component: it is upstream of that node. This is the inlet node to the terminal unit and the damper.

Field: Maximum Air Flow Rate

This numeric field defines the design maximum volumetric flow rate (m³/sec) specified for this VAV ADU. This flow rate must be greater than 0 or can be autosized.

Field: Zone Minimum Air Flow Fraction

This numeric field defines the minimum air volumetric flow rate to the zone while the system is operating, specified as a fraction of the maximum air flow rate. The minimum zone fraction is normally specified to meet the minimum ventilation requirement for the occupants. The reheat coil operates as needed to maintain the heating set point specified in the Zone Control:Thermostatic object. This value must be between 0 and 1.

Control Fields:

The last several fields for this terminal reheat component describe the type of reheat coil that is being used and how it is controlled. Most of the fields pertain to the hot water coil since the gas and electric coil are much more simplified.

Field: Hot Water or Steam Inlet Node Name

For the hot water reheat coil there is a node on the water side that would control the water flow rate to allow the coil to meet the zone demand. This control location is the name of the control node for this terminal reheat ADU. For the gas and electric coils this field is left blank.

Field: Reheat Coil Object Type

The valid reheat component objects currently available are:

```
Coil:Heating:Water
Coil:Heating:Electric
Coil:Heating:Gas
Coil:Heating:Steam
```

If no reheat coil is required, use AirTerminal:SingleDuct:VAV:HeatAndCool:NoReheat instead of this object.

Field: Reheat Coil Name

Unique coil name being simulated with this ADU. Applicable for all coils. If there is no reheat coil, use AirTerminal:SingleDuct:VAV:HeatAndCool:NoReheat instead of this object.

Field: Maximum Hot Water or Steam Flow Rate

This field is ignored for gas or electric reheat coils. If using a hot water or steam reheat coil, set to the maximum design water or steam volumetric flow rate (m³/sec) for the hot water or steam coil. This flow rate can be autosized.

Field: Minimum Hot Water or Steam Flow Rate

This field is ignored for gas and electric coils. Set to the minimum design water volumetric flow rate (m³/sec) for the hot water or steam coil, normally set to be a shut-off valve that is set to zero.

Field: Air Outlet Node Name

This is the air outlet node for the ADU and is then connected to the zone. This is the same node as the air outlet node of the reheat component.

Field: Convergence Tolerance

The coil is controlled by knowing the zone demand determined by the zone thermostat and setting the outlet conditions to meet this demand. For the electric and gas coils, this is set exactly since the coil model solution can be inverted and this field is not used. With the hot water coil that uses an effectiveness-NTU method, the solution cannot be inverted directly. Therefore, to determine the correct mass flow rate for the hot water the solution is solved by iteration. The iterative solution uses an interval-halving routine and needs a termination criteria that is set with this Convergence Tolerance parameter. This control offset is set to a decimal fraction of the zone demand. The default value for this field is 0.001.

The IDD specification is shown below:

```

AirTerminal:SingleDuct:VAV:HeatAndCool:Reheat,
  \min-fields 12
A1, \field Name
  \required-field
A2 , \field Availability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
A3, \field Damper Air Outlet Node Name
  \required-field
  \note the outlet node of the damper and the inlet node of the reheat coil
  \note this is an internal node to the terminal unit and connects the damper and reheat coil
A4, \field Air Inlet Node Name
  \required-field
  \note the inlet node to the terminal unit and the damper
N1, \field Maximum Air Flow Rate
  \units m3/s
  \minimum> 0.0
  \autosizable
N2, \field Zone Minimum Air Flow Fraction
  \required-field
  \minimum 0.0
  \maximum 1.0
  \note fraction of maximum air flow
A5, \field Hot Water or Steam Inlet Node Name
  \note Not used when reheat coil type is gas or electric
  \deprecated
A6, \field Reheat Coil Object Type
  \type choice
  \key Coil:Heating:Water
  \key Coil:Heating:Electric
  \key Coil:Heating:Gas
  \key Coil:Heating:Steam
A7, \field Reheat Coil Name
  \type object-list
  \object-list HeatingCoilName
N3, \field Maximum Hot Water or Steam Flow Rate
  \note Not used when reheat coil type is gas or electric
  \units m3/s
  \minimum 0.0
  \autosizable
  \ip-units gal/min

```

```

N4, \field Minimum Hot Water or Steam Flow Rate
    \note Not used when reheat coil type is gas or electric
    \units m3/s
    \minimum 0.0
    \default 0.0
    \ip-units gal/min
A8, \field Air Outlet Node Name
    \note the outlet node of the terminal unit and the reheat coil
N5; \field Convergence Tolerance
    \type real
    \minimum > 0.0
    \default 0.001

```

An IDF example is provided below:

```

AirTerminal:SingleDuct:VAV:HeatAndCool:Reheat,
Zone 1 VAV System,           !- Name of System
FanAndCoilAvailSched,       !- System Availability schedule
Zone 1 Reheat Air Inlet Node, !- DAMPER Air Outlet Node
Zone 1 VAV Inlet Node,       !- UNIT Air Inlet Node
0.583,                       !- Maximum air flow rate {m3/s}
0.25,                        !- Zone Minimum Air Flow Fraction
,                             !- Control node
Coil:Heating:Electric,       !- Reheat Component Object
Reheat Coil Zone 1,          !- Name of Reheat Component
0.0,                         !- Max Reheat Water Flow {m3/s}
0.0,                         !- Min Reheat Water Flow {m3/s}
Zone 1 Reheat Air Outlet Node, !- UNIT Air Outlet Node
0.001;                       !- Convergence Tolerance

Coil:Heating:Electric,
Reheat Coil Zone 1,          !- Coil Name
FanAndCoilAvailSched,       !- Available Schedule
1.0,                        !- Efficiency of the Coil
3000.0,                     !- Nominal Capacity of the Coil {W}
Zone 1 Reheat Air Inlet Node, !- Coil_Air_Inlet_Node
Zone 1 Reheat Air Outlet Node; !- Coil_Air_Outlet_Node

```

AirTerminal:SingleDuct:VAV:HeatAndCool:Reheat Outputs

System,Average,Damper Position

Field: Damper Position

This output field is the damper position required to meet the zone load. This is the average value over the simulation timestep being reported. The damper position is defined as the terminal unit air mass flow rate divided by the terminal unit's maximum air mass flow rate.

AirTerminal:SingleDuct:VAV:NoReheat

Variable air volume (VAV) systems control the dry-bulb temperature inside a zone by varying the supply air volume instead of the air temperature. At full cooling the VAV damper is fully open supplying the specified maximum air flow rate. As the cooling load decreases, the damper closes until it reaches the minimum stop specified by the zone minimum air flow fraction.

VAV systems can be used for interior or perimeter zones with a common fan system and air temperature control. The VAV concept may vary according to the VAV box locations and air temperature controls. Heating can be provided if necessary by use of baseboard.

Field: Name

Unique name for the VAV Air Distribution Unit (ADU).

Field: Availability Schedule Name

Schedule that this component will operate or is available to operate.

Field: Air Outlet Node Name

The VAV damper and Unit outlet node.

Field: Air Inlet Node Name

The air inlet node name that connects the air splitter to the individual zone ADU.

Field: Maximum Air Flow Rate

The design maximum volume flow rate (m³/sec) specified for VAV ADU. This is autosizable.

Field: Zone Minimum Air Flow Fraction

The minimum flow rate to the zone while the system is operating, specified as a fraction of the maximum air flow rate. The minimum zone fraction is normally specified to meet the minimum ventilation requirement for the occupants. The reheat coil operates only when the damper is at this minimum flow rate when Damper Heating Action is set to Normal (the default).

The IDD specification is:

```
AirTerminal:SingleDuct:VAV:NoReheat,
A1, \field Name
    \required-field
A2, \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A3, \field Air Outlet Node Name
    \required-field
A4, \field Air Inlet Node Name
    \required-field
N1, \field Maximum Air Flow Rate
    \units m3/s
    \minimum 0.0
    \autosizable
N2, \field Zone Minimum Air Flow Fraction
    \required-field
    \note fraction of maximum air flow
```

An IDF example:

```
AirTerminal:SingleDuct:VAV:NoReheat,
Zone 1 VAV System, !- Name of System
FanAndCoilAvailSched, !- Availability schedule for VAV System
Zone 1 NoReheat Air Outlet Node, !- Damper Outlet Node
Zone 1 Damper Inlet Node, !- Damper Inlet Node
0.47, !- Maximum air flow rate {m3/s}
0.5; !- Min air flow fraction
```

AirTerminal:SingleDuct:VAV:HeatAndCool:NoReheat

Variable air volume (VAV) systems typically control the dry-bulb temperature inside a zone by varying the supply air volume instead of the supply air temperature (ref: AirTerminal:SingleDuct:VAV:NoReheat). Reheat coils may be required to avoid overcooling (ref: AirTerminal:SingleDuct:VAV:Reheat).

This terminal unit is slightly different from the AirTerminal:SingleDuct:VAV:NoReheat terminal unit. Both operate the same in cooling mode: the damper opens as needed to provide additional sensible cooling to the zone. The difference between the two is in heating mode. For the Single Duct VAV NoReheat terminal unit, the air flow rate is reduced to the minimum value (max air flow rate x zone minimum air flow fraction) when zone heating is required. For the AirTerminal:SingleDuct:VAV:HeatAndCool:NoReheat terminal unit, the air flow rate in heating mode is increased to meet higher zone heating loads (similar to what is done in cooling mode).

This terminal unit model was originally developed and tested for use with the changeover-bypass VAV unitary system. This object may be used when the central heating coil is sufficient to maintain the heating set point temperature. Additional heating may be provided, if necessary, by use of Single Duct:VAVHeatandCool:Reheat or Baseboard Heater objects.

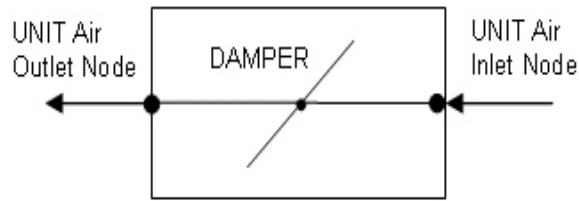


Figure 86. Single Duct VAV Heat and Cool NoReheat Schmatic

Field: Name

Unique user-defined name for this Air Distribution Unit (ADU).

Field: Availability Schedule Name

This alpha field defines the name of the schedule (ref: Schedule) that denotes whether or not this component is available to operate during a given time period. If a schedule value is greater than zero then the system is available to operate; otherwise, the system is unavailable for that time period.

Field: Air Outlet Node Name

This alpha field defines the name of the VAV damper air outlet node.

Field: Air Inlet Node Name

This alpha field defines the name of the air inlet node that connects the air splitter to the individual zone ADU.

Field: Maximum Air Flow Rate

This numeric field defines the design maximum volume flow rate (m^3/sec) specified for this VAV ADU. This flow rate must be greater than 0 or can be autosized.

Field: Zone Minimum Air Flow Fraction

This numeric field defines the minimum air volume flow rate to the zone while the system is operating, specified as a fraction of the maximum air flow rate. The minimum zone fraction is normally specified to meet the minimum ventilation requirement for the occupants. This value must be between 0 and 1.

The IDD specification is shown below:

```
AirTerminal:SingleDuct:VAV:HeatAndCool:NoReheat,
  \min-fields 6
A1, \field Name
  \required-field
A2, \field Availability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
A3, \field Air Outlet Node Name
  \required-field
A4, \field Air Inlet Node Name
  \required-field
```

```

N1, \field Maximum Air Flow Rate
    \units m3/s
    \minimum> 0.0
    \autosizable
N2; \field Zone Minimum Air Flow Fraction
    \required-field
    \minimum 0.0
    \maximum 1.0
    \note fraction of maximum air flow

```

An IDF example is provided below:

```

AirTerminal:SingleDuct:VAV:HeatAndCool:NoReheat,
Zone 3 VAV System,           !- Name of System
FanAndCoilAvailSched,       !- System Availability schedule
Zone 3 Reheat Air Outlet Node, !- UNIT Air Outlet Node
Zone 3 VAV Inlet Node,       !- UNIT Air Inlet Node
0.584,                       !- Maximum air flow rate {m3/s}
0.25;                         !- Zone Minimum Air Flow Fraction

```

AirTerminal:SingleDuct:VAV:HeatAndCool:NoReheat Outputs

```
System,Average,Damper Position
```

Field: Damper Position

This output field is the damper position required to meet the zone load. This is the average value over the simulation timestep being reported. The damper position is defined as the terminal unit air mass flow rate divided by the terminal unit's maximum air mass flow rate.

AirTerminal:SingleDuct:SeriesPIU:Reheat

The series powered induction unit is an air system terminal unit that mixes varying amounts of secondary (recirculated) air and primary (conditioned supply) air to produce a fixed flow of air to a zone. The unit contains a small fan that acts to induce the secondary air and a heating coil for heating the mixed secondary and primary air. The fan runs at a constant volume flow rate whenever the unit is on. The fan is downstream of the primary and secondary air inlets. The variable mixing is accomplished by a damper in the unit's primary air supply inlet duct. This damper can move from fully open (100% primary air, 0% secondary air) to a minimum stop that is specified in the input description. At full cooling the damper will be fully open. At minimum cooling and for heating the damper will be at the minimum stop and the secondary air flow will be at its maximum.

The EnergyPlus model of the series PIU terminal unit is composed of three components: a zone mixer, a constant volume fan, and a heating coil (hot water, electric, or gas).

Field: Name

A unique user assigned name for a particular series powered induction terminal unit. Any reference to this unit by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the unit can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Maximum Air Flow Rate

The maximum volumetric air flow rate through the unit in cubic meters per second. Since this is a constant air volume unit, this is also the design, rated air flow rate of the unit.

Field: Maximum Primary Air Flow Rate

The maximum volumetric air flow rate of primary air through the unit in cubic meters per second. This is the primary air flow rate at full cooling load when the primary air damper is fully open. Usually this quantity is the same as the total unit flow rate, but it can be less.

Field: Minimum Primary Air Flow Fraction

The minimum volumetric air flow rate of primary air through the unit expressed as a fraction of the maximum volumetric air flow rate of primary air. This input can be 0.0.

Field: Supply Air Inlet Node Name

The name of the HVAC system node from which the unit draws its primary or supply air

Field: Secondary Air Inlet Node Name

The name of the HVAC system node from which the unit draws its secondary or recirculated air.

Field: Outlet Node Name

The name of the HVAC system node to which the unit sends its outlet air. This should be one of the inlet air nodes of the zone which is being served.

Field: Reheat Coil Air Inlet Node Name

The name of the HVAC system node which is the inlet node of the unit's heating coil. This is also the outlet node of the unit's fan.

Field: Zone Mixer Name

The name of an zone mixer component (object: AirLoopHVAC:ZoneMixer) which composes part of the unit. Note that some of the input for the mixer will duplicate input fields of the powered induction unit. One of the zone mixer inlet nodes should be the same as the supply air inlet node of the PIU; the other inlet node of the zone mixer should be the same as the secondary air inlet node of the PIU. The outlet node of the zone mixer should be the same as the inlet node of the PIU fan.

Field: Fan Name

The name of a fan component which composes part of the unit. Note that the fan's maximum flow rate should be the same as the maximum air flow rate of the PIU and the type of fan object must be Fan:ConstantVolume. The fan's inlet node should be the same as the zone mixer's outlet node. The fan's outlet node should be the same as the heating coil's air inlet node.

Field: Reheat Coil Object Type

The type of coil in the PIU. The valid choices are:

```
Coil:Heating:Water  
Coil:Heating:Electric  
Coil:Heating:Gas  
Coil:Heating:Steam
```

In other words the PIU may have a hot water, gas, electric or steam reheat coil.

Field: Reheat Coil Name

The name of the heating coil component which composes part of the unit. Note that the heating coil's air inlet node is the same as the fan outlet node and the heating coil's air outlet node is the same as the PIU outlet node.

Field: Maximum Hot Water or Steam Flow Rate

The maximum hot water volumetric flow rate in m³/sec through the unit's heating coil. If the heating coil is gas or electric this field should be blank.

Field: Minimum Hot Water or Steam Flow Rate

The minimum hot water volumetric flow rate in m³/sec through the unit's heating coil. If the heating coil is gas or electric this field should be blank.

Field: Hot Water or Steam Inlet Node Name

The name of the HVAC system node which regulates the flow of hot water through the unit. This should be the same node as the water inlet node of the unit's hot water coil. For gas or electric heating coils, this input should be blank.

Field: Convergence Tolerance

The control tolerance for the unit heating output. The unit is controlled by matching the unit output to the zone demand. For units with water coils, the model must be numerically inverted to obtain a specified output. The convergence tolerance is the error tolerance used to terminate the numerical inversion procedure. Basically this is the fraction:

$$\frac{|Q_{PIU,out} - Q_{zone\ load}|}{Q_{zone\ load}} \leq ConvergenceTolerance$$

For gas or electric heating coils, this input should be left blank. The default is 0.001.

The full IDD specification follows:

```

AirTerminal:SingleDuct:SeriesPIU:Reheat,
  A1, \field Name
      \required-field
      \type alpha
  A2 , \field Availability Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
  N1, \field Maximum Air Flow Rate
      \required-field
      \type real
      \units m3/s
      \autosizable
  N2, \field Maximum Primary Air Flow Rate
      \required-field
      \type real
      \units m3/s
      \autosizable

```

```

N3, \field Minimum Primary Air Flow Fraction
    \required-field
    \type real
    \autosizable
A3, \field Supply Air Inlet Node Name
    \type alpha
A4, \field Secondary Air Inlet Node Name
    \type alpha
A5, \field Outlet Node Name
    \type alpha
A6, \field Reheat Coil Air Inlet Node Name
    \type alpha
A7, \field Zone Mixer Name
    \type alpha
A8, \field Fan Name
    \note Fan type must be Fan:ConstantVolume
    \type object-list
    \object-list FansCV
A9, \field Reheat Coil Object Type
    \type choice
    \key Coil:Heating:Water
    \key Coil:Heating:Electric
    \key Coil:Heating:Gas
    \key Coil:Heating:Steam
A10, \field Reheat Coil Name
    \type object-list
    \object-list HeatingCoilName
N4, \field Maximum Hot Water or Steam Flow Rate
    \note Not used when reheat coil type is gas or electric
    \type real
    \units m3/s
    \autosizable
    \ip-units gal/min
N5, \field Minimum Hot Water or Steam Flow Rate
    \note Not used when reheat coil type is gas or electric
    \type real
    \units m3/s
    \minimum 0.0
    \default 0.0
    \ip-units gal/min
A11, \field Hot Water or Steam Inlet Node Name
    \note Not used when reheat coil type is gas or electric
    \type alpha
    \deprecated
N6; \field Convergence Tolerance
    \type real
    \minimum > 0.0
    \default 0.001

```

An IDF example:

```

AirTerminal:SingleDuct:SeriesPIU:Reheat,
Zone 1 SPIU ATU,           ! Name of air terminal unit
FanAndCoilAvailSched,    ! Availability schedule for series PIU ATU
0.47,                     ! Total volume flow rate through ATU
0.47,                     ! Maximum primary air flow rate through terminal unit
0.3,                      ! Minimum primary air flow rate (fraction of max)
Zone 1 PIU Pri Air Inlet Node, ! Air Terminal unit supply air inlet node
Zone 1 PIU Sec Air Inlet Node, ! Air Terminal unit secondary air inlet node
Zone 1 PIU Air Outlet Node,   ! Air Terminal unit outlet node
Zone 1 Reheat Air Inlet Node, ! Reheat coil air inlet node (fan outlet node)
Zone 1 PIU Mixer,           ! Air terminal unit mixer name
Zone 1 PIU Fan,             ! Air terminal unit fan name
COIL:Heating:Water,        ! type of air terminal unit reheat coil
Reheat Coil Zone 1,        ! name of air terminal unit reheat coil
0.0013,                   ! Max Reheat Water Flow {Flow: m3/sec}
0.0,                      ! Min Reheat Water Flow {Flow: m3/sec}
Zone 1 Reheat Water Inlet Node, ! Control node
0.001;                    ! Convergence tolerance

```

AirTerminal:SingleDuct:SeriesPIU:Reheat Outputs

HVAC,Average,PIU Heating Rate[W]
 HVAC,Sum,PIU Heating Energy[J]
 HVAC,Average,PIU Sensible Cooling Rate[W]
 HVAC,Sum,PIU Sensible Cooling Energy[J]

PIU Heating Rate[W]

This field reports the dry air heating addition rate of the series PIU terminal unit to the zone it is serving in Watts. This is determined by outlet and zone air conditions and the mass flow rate through the terminal unit.

PIU Heating Energy[J]

This field reports the dry air heat addition of the series PIU terminal unit to the zone it is serving in Joules over the timestep being reported. This is determined by outlet and zone air conditions, the mass flow rate through the terminal unit, and the timestep.

PIU Sensible Cooling Rate[W]

This field reports the dry air sensible heat extraction rate of the series PIU terminal unit from the zone it is serving in Watts. This is determined by the outlet and zone conditions and the mass flow rate through the terminal unit.

PIU Sensible Cooling Energy[J]

This field reports the dry air sensible heat extraction of the series PIU terminal unit from the zone it is serving in Joules over the timestep being reported. This is determined by outlet and zone air conditions, the mass flow rate through the terminal unit, and the timestep.

AirTerminal:SingleDuct:ParallelPIU:Reheat

The parallel powered induction unit is an air system terminal unit that mixes varying amounts of secondary (recirculated) air and primary (conditioned supply) air to produce a variable total flow of air to a zone. The unit contains a small fan that acts to induce the secondary air and a heating coil for heating the mixed secondary and primary air. The secondary and primary air streams enter the unit in parallel. The fan sits in the secondary air stream and runs only when secondary air is needed. The primary air inlet contains a damper that can move from fully open (maximum primary air) to a minimum stop (minimum primary air).

At full cooling load the primary air damper is fully open and the fan is off. The primary air flow is at maximum and there is little or no secondary air flow. As the cooling load decreases, the primary air damper gradually closes and the secondary air flow remains close to zero. At some point, usually when the primary air flow has reached the minimum, the fan switches on and secondary air is induced. The heating coil will switch on as needed to meet any heating demand.

The EnergyPlus model of the parallel PIU terminal unit is composed of three components: a constant volume fan, a zone mixer, and a heating coil (hot water, electric, or gas).

Field: Name

A unique user assigned name for a particular parallel powered induction terminal unit. Any reference to this unit by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the unit can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Maximum Primary Air Flow Rate

The maximum volumetric air flow rate of primary air through the unit in cubic meters per second. This is the primary air flow rate at full cooling load when the primary air damper is fully open.

Field: Maximum Secondary Air Flow Rate

The maximum volumetric air flow rate of primary air through the unit in cubic meters per second. This flow rate can be any amount but is commonly less than the maximum primary air flow rate.

Field: Minimum Primary Air Flow Fraction

The minimum volumetric air flow rate of primary air through the unit expressed as a fraction of the maximum volumetric air flow rate of primary air. This input can be 0.0.

Field: Fan On Flow Fraction

The fraction of the primary air flow at which fan turns on. In the parallel PIU the fan operation is intermittent. If the primary air flow is above this fraction of the maximum, the fan is off. Otherwise it is on.

Field: Supply Air Inlet Node Name

The name of the HVAC system node from which the unit draws its primary or supply air

Field: Secondary Air Inlet Node Name

The name of the HVAC system node from which the unit draws its secondary or recirculated air.

Field: Outlet Node Name

The name of the HVAC system node to which the unit sends its outlet air. This should be one of the inlet air nodes of the zone which is being served.

Field: Reheat Coil Air Inlet Node Name

The name of the HVAC system node which is the inlet node of the unit's heating coil. This is also the outlet node of the unit's zone mixer.

Field: Zone Mixer Name

The name of an zone mixer component (object: AirLoopHVAC:ZoneMixer) which composes part of the unit. Note that some of the input for the mixer will duplicate input fields of the powered induction unit. One of the zone mixer inlet nodes should be the same as the supply air inlet node of the PIU; the other inlet node of the zone mixer should be the same as the air outlet node of the fan. The outlet node of the zone mixer should be the same as the inlet node of the heating coil.

Field: Fan Name

The name of a fan component which composes part of the unit. Note that the fan's maximum flow rate should be the same as the maximum secondary air flow rate of the PIU and the type of fan object must be Fan:ConstantVolume. The fan's inlet node should be the same as the PIU secondary air inlet node. The fan's outlet node should be the same as one of the zone mixer's inlet nodes.

Field: Reheat Coil Object Type

The type of coil in the PIU. The valid choices are:

```
Coil:Heating:Water  
Coil:Heating:Electric  
Coil:Heating:Gas
```

Coil:Heating:Steam

In other words the PIU may have a hot water, gas, electric or steam reheat coil.

Field: Reheat Coil Name

The name of the heating coil component which composes part of the unit. Note that the heating coil’s air inlet node is the same as the zone mixer’s outlet node and the heating coil’s air outlet node is the same as the PIU outlet node.

Field: Maximum Hot Water or Steam Flow Rate

The maximum hot water volumetric flow rate in m³/sec through the unit’s heating coil. If the heating coil is gas or electric this field should be blank.

Field: Minimum Hot Water or Steam Flow Rate

The minimum hot water volumetric flow rate in m³/sec through the unit’s heating coil. If the heating coil is gas or electric this field should be blank.

Field: Hot Water or Steam Inlet Node Name

The name of the HVAC system node which regulates the flow of hot water through the unit. This should be the same node as the water inlet node of the unit’s hot water coil. For gas or electric heating coils, this input should be blank.

Field: Convergence Tolerance

The control tolerance for the unit heating output. The unit is controlled by matching the unit output to the zone demand. For units with water coils, the model must be numerically inverted to obtain a specified output. The convergence tolerance is the error tolerance used to terminate the numerical inversion procedure. Basically this is the fraction:

$$\frac{|Q_{PIU,out} - Q_{zone\ load}|}{Q_{zone\ load}} \leq ConvergenceTolerance$$

For gas or electric heating coils, this input should be left blank. The default is 0.001.

The full IDD specification follows:

```
AirTerminal:SingleDuct:ParallelPIU:Reheat,
A1, \field Name
    \required-field
    \type alpha
A2, \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
N1, \field Maximum Primary Air Flow Rate
    \required-field
    \type real
    \units m3/s
    \autosizable
N2, \field Maximum Secondary Air Flow Rate
    \required-field
    \type real
    \units m3/s
    \autosizable
N3, \field Minimum Primary Air Flow Fraction
    \required-field
    \type real
    \autosizable
```



```

N4, \field Fan On Flow Fraction
    \required-field
    \type real
    \autosizable
    \note the fraction of the primary air flow at which fan turns on
A3, \field Supply Air Inlet Node Name
    \type alpha
A4, \field Secondary Air Inlet Node Name
    \type alpha
A5, \field Outlet Node Name
    \type alpha
A6, \field Reheat Coil Air Inlet Node Name
    \type alpha
    \note mixer outlet node
A7, \field Zone Mixer Name
    \type alpha
A8, \field Fan Name
    \note Fan type must be Fan:ConstantVolume
    \type object-list
    \object-list FansCV
A9, \field Reheat Coil Object Type
    \type choice
    \key Coil:Heating:Water
    \key Coil:Heating:Electric
    \key Coil:Heating:Gas
    \key Coil:Heating:Steam
A10, \field Reheat Coil Name
    \type object-list
    \object-list HeatingCoilName
N5, \field Maximum Hot Water or Steam Flow Rate
    \note Not used when reheat coil type is gas or electric
    \type real
    \units m3/s
    \autosizable
    \ip-units gal/min
N6, \field Minimum Hot Water or Steam Flow Rate
    \note Not used when reheat coil type is gas or electric
    \type real
    \units m3/s
    \minimum 0.0
    \default 0.0
    \ip-units gal/min
A11, \field Hot Water or Steam Inlet Node Name
    \note Not used when reheat coil type is gas or electric
    \type alpha
    \deprecated
N7; \field Convergence Tolerance
    \type real
    \minimum > 0.0
    \default 0.001

```

An IDF example:

```

AirTerminal:SingleDuct:ParallelPIU:Reheat,
Zone 3 PPIU ATU,           ! Name of air terminal unit
FanAndCoilAvailSched,     ! Availability schedule for series PIU ATU
0.47,                     ! Maximum primary air flow rate through terminal unit
0.375,                    ! Maximum secondary air flow rate through the terminal unit
0.1,                      ! Minimum primary air flow rate (fraction of max)
0.1,                      ! fan on flow fraction
Zone 3 PIU Pri Air Inlet Node, ! Air Terminal unit supply air inlet node
Zone 3 PIU Sec Air Inlet Node, ! Air Terminal unit secondary air inlet node
Zone 3 PIU Air Outlet Node,   ! Air Terminal unit outlet node
Zone 3 Reheat Air Inlet Node, ! Reheat coil air inlet node (fan outlet node)
Zone 3 PIU Mixer,           ! Air terminal unit mixer name
Zone 3 PIU Fan,             ! Air terminal unit fan name
Coil:Heating:Water,        ! type of air terminal unit reheat coil
Reheat Coil Zone 3,        ! name of air terminal unit reheat coil
0.0013,                   ! Max Reheat Water Flow {Flow: m3/sec}
0.0,                      ! Min Reheat Water Flow {Flow: m3/sec}
Zone 3 Reheat Water Inlet Node, ! Control node
0.001;                    ! Convergence tolerance

```

AirTerminal:SingleDuct:ParallelPIU:Reheat Outputs

```

HVAC,Average,PIU Heating Rate[W]
HVAC,Sum,PIU Heating Energy[J]
HVAC,Average,PIU Sensible Cooling Rate[W]
HVAC,Sum,PIU Sensible Cooling Energy[J]

```

PIU Heating Rate[W]

This field reports the dry air heating addition rate of the parallel PIU terminal unit to the zone it is serving in Watts. This is determined by outlet and zone air conditions and the mass flow rate through the terminal unit.

PIU Heating Energy[J]

This field reports the dry air heat addition of the parallel PIU terminal unit to the zone it is serving in Joules over the timestep being reported. This is determined by outlet and zone air conditions, the mass flow rate through the terminal unit, and the timestep.

PIU Sensible Cooling Rate[W]

This field reports the sensible heat extraction rate of the parallel PIU terminal unit from the zone it is serving in Watts. This is determined by the outlet and zone conditions and the mass flow rate through the terminal unit.

PIU Sensible Cooling Energy[J]

This field reports the dry air sensible heat extraction of the parallel PIU terminal unit from the zone it is serving in Joules over the timestep being reported. This is determined by outlet and zone air conditions, the mass flow rate through the terminal unit, and the timestep.

AirTerminal:SingleDuct:ConstantVolume:FourPipeInduction

The four pipe induction terminal unit provides local hot water heating or chilled water cooling of induced zone air which then mixes with centrally conditioned supply air. An air conditioning system consisting of these terminal units is effectively a mixed central air / local hydronic system. The centrally conditioned air supplied to the induction terminal units is constant volume at quite high pressure. The central air is discharged through a nozzle in the terminal unit, inducing a flow of room air over a hydronic heating/cooling coil. The coil is connected either to a single inlet and outlet pipe (2 pipe unit) or to 2 inlets and 2 outlets (4 pipe unit). The heated or cooled induced air mixes with the centrally conditioned air before being discharged into the zone. The terminal units are usually expected to do only sensible cooling – any dehumidification is done by the central air conditioning system.

The EnergyPlus model of the four pipe induction terminal unit is a compound component consisting of a hot water heating coil, a chilled water cooling coil, and an air mixer. The unit has two inlet air streams: the centrally conditioned supply air and the induced air from the zone. The induced air passes first through the heating coil, then through the cooling coil and finally through the mixer. The central supply air goes directly into the mixer. The water flow through the hot or cold water coil is varied to meet the zone air conditioning requirement. Note that EnergyPlus models the four pipe induction terminal unit as having separate heating and cooling coils whereas real units have only a single coil used for both heating and cooling. Note also that the four pipe induction unit model can be used to model a two pipe unit by simply adjusting the heating and cooling coil schedules so that the heating coil is off when the cooling coil is on and vice versa.

Field: Name

A unique user assigned name for a particular four pipe induction terminal unit. Any reference to this unit by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the unit can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Maximum Total Air Flow Rate

The maximum volumetric air flow rate discharged from the unit in cubic meters per second. Since this is a constant air volume unit, this is also the design, rated air flow rate of the unit. Note that this is the total discharge flow rate – including both central supply and induced air.

Field: Induction Ratio

The ratio of induced air flow rate to primary supply air flow rate. The default is 1.0 –the supply air induces an equal amount of zone air.

Field: Supply Air Inlet Node Name

The name of the HVAC system node from which the unit draws its primary or supply air

Field: Induced Air Inlet Node Name

The name of the HVAC system node from which the unit draws its secondary or recirculated air. This should be the same node as one of the zone exhaust nodes.

Field: Air Outlet Node Name

The name of the HVAC system node to which the unit sends its outlet air. This should be one of the inlet air nodes of the zone which is being served.

Field: Hot Water Inlet Node Name

The name of the HVAC system node which regulates the flow of hot water through the unit. This should be the same node as the water inlet node of the unit's hot water coil.

Field: Cold Water Inlet Node Name

The name of the HVAC system node which regulates the flow of cold water through the unit. This should be the same node as the water inlet node of the unit's chilled water coil.

Field: Heating Coil Object Type

The type of heating coil in the terminal unit. The choices are:

Coil:Heating:Water

In other words the unit may have a hot water coil only.

Field: Heating Coil Name

The name of the heating coil component which composes part of the unit. Note that the heating coil's air inlet node is the same as the terminal unit's induced air inlet node. The heating coil's air outlet node is the same as the cooling coil's air inlet node.

Field: Maximum Hot Water Flow Rate

The maximum hot water volumetric flow rate in m³/sec through the unit's heating coil.

Field: Minimum Hot Water Flow Rate

The minimum hot water volumetric flow rate in m³/sec through the unit's heating coil.

Field: Heating Convergence Tolerance

The control tolerance for the unit heating output. The unit is controlled by matching the unit output to the zone demand. The model must be numerically inverted to obtain a specified output. The convergence tolerance is the error tolerance used to terminate the numerical inversion procedure. Basically this is the fraction:

$$\frac{|Q_{unit,out} - Q_{zone\ load}|}{Q_{zone\ load}} \leq \text{ConvergenceTolerance}$$

The default is 0.001.

Field: Cooling Coil Object Type

The type of cooling coil in the terminal unit. The choices are:

Coil:Cooling:Water

Coil:Cooling:Water:DetailedGeometry

In other words the unit must use only the water cooling coils.

Field: Cooling Coil Name

The name of the cooling coil component which composes part of the unit. Note that the cooling coil's air inlet node is the same as the heating coil's air outlet node. The cooling coil's air outlet node is the same as one of the zone mixer's inlets.

Field: Maximum Cold Water Flow Rate

The maximum cold water volumetric flow rate in m³/sec through the unit's cooling coil.

Field: Minimum Cold Water Flow Rate

The minimum cold water volumetric flow rate in m³/sec through the unit's cooling coil.

Field: Cooling Convergence Tolerance

The control tolerance for the unit cooling output. The unit is controlled by matching the unit output to the zone demand. The model must be numerically inverted to obtain a specified output. The convergence tolerance is the error tolerance used to terminate the numerical inversion procedure. Basically this is the fraction:

$$\frac{|Q_{unit,out} - Q_{zone\ load}|}{Q_{zone\ load}} \leq \text{ConvergenceTolerance}$$

The default is 0.001.

Field: Zone Mixer Name

The name of an zone mixer component (object: AirLoopHVAC:ZoneMixer) which composes part of the terminal unit. Note that some of the zone mixer's inputs will duplicate some of the terminal unit's inputs. One of the zone mixer inlet nodes should be the same as the supply air inlet node of the terminal unit; the other inlet node of the zone mixer should be the same as the cooling coil air outlet node. The outlet node of the zone mixer should be the same as the outlet node of the terminal unit.

The full IDD specification follows:

```

AirTerminal:SingleDuct:ConstantVolume:FourPipeInduction,
A1, \field Name
    \required-field
    \type alpha
A2, \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
N1, \field Maximum Total Air Flow Rate
    \required-field
    \type real
    \units m3/s
    \autosizable
    \minimum 0.0
N2, \field Induction Ratio
    \required-field
    \type real
    \maximum 1.0
    \minimum 0.0
    \default 1.0
    \note ratio of induced air flow rate to primary air flow rate
A3, \field Supply Air Inlet Node Name
    \type alpha
    \required-field
A4, \field Induced Air Inlet Node Name
    \type alpha
    \required-field
    \note should be a zone exhaust node, also the heating coil inlet node
A5, \field Air Outlet Node Name
    \type alpha
    \required-field
    \note should be a zone inlet node
A6, \field Hot Water Inlet Node Name
    \note Not used when heating coil type is gas or electric
    \type alpha
    \deprecated
A7, \field Cold Water Inlet Node Name
    \type alpha
    \deprecated
A8, \field Heating Coil Object Type
    \type choice
    \key Coil:Heating:Water
A9, \field Heating Coil Name
    \type object-list
    \object-list HeatingCoilName
N3, \field Maximum Hot Water Flow Rate
    \note Not used when heating coil type is gas or electric
    \type real
    \units m3/s
    \autosizable
    \ip-units gal/min

```

```

N4, \field Minimum Hot Water Flow Rate
    \note Not used when heating coil type is gas or electric
    \type real
    \units m3/s
    \minimum 0.0
    \default 0.0
    \ip-units gal/min
N5, \field Heating Convergence Tolerance
    \type real
    \minimum> 0.0
    \default 0.001
A10, \field Cooling Coil Object Type
    \type choice
    \key Coil:Cooling:Water
    \key Coil:Cooling:Water:DetailedGeometry
A11, \field Cooling Coil Name
    \type object-list
    \object-list CoolingCoilName
N6, \field Maximum Cold Water Flow Rate
    \type real
    \units m3/s
    \autosizable
    \ip-units gal/min
N7, \field Minimum Cold Water Flow Rate
    \type real
    \units m3/s
    \minimum 0.0
    \default 0.0
    \ip-units gal/min
N8, \field Cooling Convergence Tolerance
    \type real
    \minimum> 0.0
    \default 0.001
A12; \field Zone Mixer Name
    \type object-list
    \object-list ZoneMixers

```

An IDF example:

```

AirTerminal:SingleDuct:ConstantVolume:FourPipeInduction,
SPACE2-1 FPIU,          !- Name of System
ReheatCoilAvailSched,  !- System Availability schedule
autosize,              !- Maximum total air volume flow rate
1.0,                  !- Induction ratio
SPACE2-1 ATU Supply Node, !- Terminal unit supply air inlet node
SPACE2-1 ATU Induc Node, !- Terminal unit induced air inlet node
SPACE2-1 In Node,      !- Terminal unit air outlet node
SPACE2-1 HW Coil Water In Node, !- Hot water control node
SPACE2-1 CW Coil Water In Node, !- Cold water control node
COIL:Heating:Water,    !- Heating coil object
SPACE2-1 HW Coil,      !- Heating coil name
autosize,              !- Max hot water flow
0.0,                  !- Min hot water flow
0.001,                !- Heating Convergence Tolerance
COIL:Cooling:Water,    !- Cooling coil object
SPACE2-1 CW Coil,      !- Cooling coil name
autosize,              !- Max cold water flow
0.0,                  !- Min cold water flow
0.001,                !- Cooling Convergence Tolerance
SPACE2-1 ATU Mixer;    !- Zone mixer component name

```

```

COIL:Heating:Water,
SPACE2-1 HW Coil,          !- Coil Name
ReheatCoilAvailSched,     !- Available Schedule
autosize,                  !- UA of the Coil {W/K}
autosize,                  !- Max Water Flow Rate of Coil {m3/s}
SPACE2-1 HW Coil Water In Node, !- Coil_Water_Inlet_Node
SPACE2-1 HW Coil Water Out Node, !- Coil_Water_Outlet_Node
SPACE2-1 ATU Induc Node, !- Coil_Air_Inlet_Node
SPACE2-1 HW Coil Air Out Node; !- Coil_Air_Outlet_Node

```

```

COIL:Cooling:Water,
SPACE2-1 CW Coil,          !- Coil Name
CWCoilAvailSched,         !- Availability Schedule
autosize,                  !- UA of the Coil
autosize,                  !- Max Water Flow Rate of Coil
,                           !- Leaving Relative Humidity of Coil
SPACE2-1 CW Coil Water In Node, !- Coil_Water_Inlet_Node
SPACE2-1 CW Coil Water Out Node, !- Coil_Water_Outlet_Node
SPACE2-1 HW Coil Air Out Node, !- Coil_Air_Inlet_Node
SPACE2-1 CW Coil Air Out Node; !- Coil_Air_Outlet_Node

AirLoopHVAC:ZoneMixer,
SPACE2-1 ATU Mixer,        !- Mixer Name
SPACE2-1 In Node,          !- Outlet_Node
SPACE2-1 ATU Supply Node,  !- Inlet_Node_1
SPACE2-1 CW Coil Air Out Node; !- Inlet_Node_2

```

AirTerminal:SingleDuct:ConstantVolume:FourPipeInduction Outputs

There are no specific outputs for the four pipe induction terminal units.

AirTerminal:SingleDuct:ConstantVolume:CooledBeam

The Cooled Beam system is a mixed air-hydronic system. A central, single-duct forced-air system supplies conditioned ventilation air to the zones. Sensible cooling is done by chilled water circulating through ceiling mounted cooled beam units. Chilled water flow rate through the cooled beam units is varied to meet the zone sensible cooling load. Any dehumidification is done by the central ventilation air system. Heating is usually accomplished with hot water radiators. Thermodynamically, the cooled beam system resembles the four-pipe induction unit.

To model a typical cooled beam system the user will need to define a conventional central constant volume forced air system. This system will normally be 100% outside air delivered at a fixed supply temperature (which could be reset by schedule or by outside air temperature). On the supply side of this air loop there will be the usual central AC equipment: outside air mixer, fan, heating and cooling coil. On the zone equipment (demand) side of the loop, the chilled beams will be represented as terminal units. Additional zone equipment (such as baseboard heaters) will be needed to handle heating loads.

Although the cooled beam equipment in a zone is treated by the program as a single terminal unit, the actual installation will have multiple beams in each zone. The program (in its sizing calculation for the system) figures out how many beams of what length are needed to meet the zone design load.

Field: Name

A unique user assigned name for a particular chilled beam unit. Any reference to this unit by another object will use this name.

Field: Unit Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the unit can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be

on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Cooled Beam Type

Two types of units are modeled: *Active* or *Passive*. In the active unit, primary air is supplied through the beam, inducing some secondary zone air into contact with the coil. This unit acts as an active convector. The passive unit is simply a passive, finned convector. Primary air is supplied through a normal diffuser.

Field: Supply Air Inlet Node Name

The name of the HVAC system node from which the unit draws its primary or supply air. Note that this field should be specified for both types of unit, even though supply air does not pass through the passive unit.

Field: Supply Air Outlet Node Name

The name of the air node that connects this terminal unit to the zone. The will be the same as one of the zone inlet nodes. The name of this node must be entered even if the actual beams are passive and is not actually supplying air to the zone.

Field: Chilled Water Inlet Node Name

The name of the chilled water inlet node.

Field: Chilled Water Outlet Node Name

The name of the chilled water outlet node.

Field: Supply Air Volumetric Flow Rate

This is the air flow rate in cubic meters per second of the supply air entering the zone. This input would normally be autosized based on the ventilation requirement (see Zone Sizing).

Field: Maximum Total Chilled Water Volumetric Flow Rate

The maximum chilled water flow rate (in cubic meters per second) for the unit. This input would normally be autosized based on the zone design load.

Field: Number of Beams

The number of individual cooled beam units in the zone. Normally this unit would be autocalculated by the program based upon the previous field and the nominal flow rate for a single beam unit (set by the program to 0.07 kg/s).

Field: Beam Length

The length of an individual beam in meters. Normally this will be autocalculated by the program based upon the number of beam units and the zone design sensible cooling load. 1 to 4 meters is a typical length range.

Field: Design Inlet Water Temperature

The nominal or design inlet water temperature in degrees Celsius. The default is 15C.

Field: Design Outlet Water Temperature

The nominal or design outlet water temperature in degrees Celsius. The default is 17C.

The following inputs are parameters used to characterize the performance of the chilled beam units. Values for a given unit can be obtained from the manufacturer. The parameters are used in the following equations.

$P_{beam} = A \cdot K \cdot \Delta T$	beam cooling output per unit length W/m
$K = \alpha \cdot \Delta T^{n1} \cdot v \rho^{n2} \cdot \omega^{n3}$	coil heat transfer coefficient W/(m ² K)
$v \rho = (Q_{in} / \alpha_o) \cdot \rho_{air}$	room air mass flow rate across coil kg/(m ² s)

$$q_{in} = K_1 \bullet \Delta T^n + K_{in} \bullet q_{pr}$$

room air volumetric flow rate across coil per
unit length m³/(s-m)

ΔT is the room air –water temperature difference (average water temperature is used) in degrees C.

ω is the water velocity in m/s.

q_{pr} is the supply air flow rate per unit length m³/(s-m)

Field: Coil Surface Area per Coil Length

Surface area on the air side of the beam per unit beam length. The units are square meters per meter. The default is 5.422. This is A in the above equations.

Field: Model Parameter α (a)

This is α in the above equations. The default is 15.3

Field: Model Parameter n_1

This is n_1 in the above equations. The default is 0.

Field: Model Parameter n_2

This is n_2 in the above equations. The default is 0.84.

Field: Model Parameter n_3

This is n_3 in the above equations. The default is 0.12.

Field: Model Parameter α_0 (a)

This is α_0 in the above equations. It is the free area of the coil in plan view (for the air flow) per unit beam length. The units are square meters per meter. The default is 0.171.

Field: Model Parameter K_1 (K1)

This is K_1 in the above equations. The default is 0.005.

Field: Model Parameter n

This is n in the above equations. The default is 0.4.

Field: Coefficient of Induction K_{in} (Kin)

The coefficient of induction K_{in} in the above equations. The default is 2.0 for active beams and 0.0 for passive beams.

Field: Pipe Inside Diameter

The water pipe inside diameter in meters. The default is 0.0145.

The IDD definition of the object is:

```
AirTerminal:SingleDuct:ConstantVolume:CooledBeam,
  \min-fields 23
A1 , \field Name
    \type alpha
    \required-field
A2 , \field Availability Schedule Name
    \type object-list
    \object-list ScheduleNames
    \required-field
A3 , \field Cooled Beam Type
    \type choice
    \required-field
    \key Active
    \key Passive
```

```

A4 , \field Supply Air Inlet Node Name
    \type alpha
    \required-field
A5 , \field Supply Air Outlet Node Name
    \type alpha
    \required-field
A6 , \field Chilled Water Inlet Node Name
    \type alpha
    \required-field
A7 , \field Chilled Water Outlet Node Name
    \type alpha
    \required-field
N1 , \field Supply Air Volumetric Flow Rate
    \type real
    \units m3/s
    \minimum 0.0
    \autosizable
    \default autosize
N2, \field Maximum Total Chilled Water Volumetric Flow Rate
    \type real
    \units m3/s
    \minimum 0.0
    \autosizable
    \default autosize
N3 , \field Number of Beams
    \note Number of individual beam units in the zone
    \type integer
    \minimum > 0
    \autosizable
    \default autosize
N4 , \field Beam Length
    \note Length of an individual beam unit
    \type real
    \units m
    \minimum > 0.0
    \autosizable
    \default autosize
N5 , \field Design Inlet Water Temperature
    \type real
    \units C
    \minimum 0.0
    \default 15.0
N6 , \field Design Outlet Water Temperature
    \type real
    \units C
    \minimum 0.0
    \default 17.0
N7 , \field Coil Surface Area per Coil Length
    \type real
    \units m2/m
    \minimum 0.0
    \default 5.422
N8 , \field Model Parameter a
    \type real
    \minimum 0.0
    \default 15.3
N9 , \field Model Parameter n1
    \type real
    \minimum 0.0
    \default 0.0
N10, \field Model Parameter n2
    \type real
    \minimum 0.0
    \default 0.84
N11, \field Model Parameter n3
    \type real
    \minimum 0.0
    \default 0.12

```

```

N12, \field Model Parameter a0
      \note Free area of the coil in plan view per unit beam length
      \type real
      \units m2/m
      \minimum 0.0
      \default 0.171
N13, \field Model Parameter K1
      \type real
      \minimum 0.0
      \default 0.0057
N14, \field Model Parameter n
      \type real
      \minimum 0.0
      \default 0.4
N15, \field Coefficient of Induction Kin
      \type real
      \autocalculatable
      \minimum 0.0
      \maximum 4.0
      \default Autocalculate
N16; \field Leaving Pipe Inside Diameter
      \type real
      \units m
      \minimum> 0.0
      \default 0.0145

```

An example input is:

```

AirTerminal:SingleDuct:ConstantVolume:CooledBeam,
SPACE2-1 CB,                !- Name
CWCoilAvailSched,          !- Availability Schedule Name
Active,                    !- Cooled Beam Type
SPACE2-1 ATU Supply Node,  !- Supply Air Inlet Node Name
SPACE2-1 In Node,          !- Supply Air Outlet Node Name
SPACE2-1 CW Coil Water In Node, !- Chilled Water Inlet Node Name
SPACE2-1 CW Coil Water Out Node, !- Chilled Water Outlet Node Name
,                            !- Supply Air Volumetric Flow Rate
,                            !- Maximum Total Chilled Water Volumetric Flow Rate
,                            !- Number of Beams
,                            !- Beam Length
,                            !- Design Inlet Water Temperature
,                            !- Design Outlet Water temperature
,                            !- Coil Surface Area per Coil Length
,                            !- Model Parameter a
,                            !- Model Parameter n1
,                            !- Model Parameter n2
,                            !- Model Parameter n3
,                            !- Model Parameter a0
,                            !- Model Parameter K1
,                            !- Model Parameter n
,                            !- Coefficient of Induction Kin
;                            !- Leaving Pipe Inside Diameter

```

AirTerminal:SingleDuct:ConstantVolume:CooledBeam Outputs

```

HVAC,Sum,Cooled Beam Cooling Energy [J]
HVAC,Average,Cooled Beam Cooling Rate[W]
HVAC,Sum,Cooled Beam Supply Air Cooling Energy [J]
HVAC,Average,Cooled Beam Supply Air Cooling Rate [W]
HVAC,Sum,Cooled Beam Supply Air Heating Energy [J]
HVAC,Average,Cooled Beam Supply Air Heating Rate [W]

```

Cooled Beam Cooling Rate [W]

Sensible cooling by the beams in the zone, exclusive of any cooling or heating done by the supply air.

Cooled Beam Cooling Energy [J]

Sensible cooling by the beams in the zone, exclusive of any cooling or heating done by the supply air.

Cooled Beam Supply Air Cooling Rate [W]

Sensible cooling by the supply air to the zone, exclusive of any cooling done by the beams.

Cooled Beam Supply Air Cooling Energy [J]

Sensible cooling by the supply air to the zone, exclusive of any cooling done by the beams.

Cooled Beam Supply Air Heating Rate [W]

Heating by the supply air to the zone, exclusive of any cooling done by the beams.

Cooled Beam Supply Air Heating Energy [J]

Heating by the supply air to the zone, exclusive of any cooling done by the beams.

AirTerminal:DualDuct:ConstantVolume

The AirTerminal:DualDuct:ConstantVolume simulation or the typical Multizone is described by this Air Distribution Unit (ADU). Multizone systems condition all the air in a central apparatus and distribute it to the conditioned zones through two parallel ducts. One duct carries cold air and the other warm air, providing air sources for both heating and cooling at all times. In each conditioned zone, a mixing valve responsive to a room thermostat mixes the warm and cold air in proper proportions to satisfy the prevailing heating or cooling load of the space. The Multizone ADU is the specific component that leads to the zone containing the mixer and the mixing damper and then connecting to the zone. The total airflow to each room is kept constant while the proportion of hot air to cold air is adjusted to maintain the temperature in each zone at the desired level.

Field: Name

Unique name for the Multizone ADU.

Field: Availability Schedule Name

Schedule that this component will operate or is available to operate.

Field: Air Outlet Node Name

The outlet node from the ADU to the zone.

Field: Hot Air Inlet Node Name

The air-inlet node name that connects the hot air splitter to the individual zone ADU.

Field: Cold Air Inlet Node Name

The air-inlet node name that connects the cold air splitter to the individual zone ADU.

Field: Maximum Air Flow Rate

The design constant volume flow rate (m^3/sec) specified for that Multizone ADU.

The IDD specification is:

```

AirTerminal:DualDuct:ConstantVolume,
A1 , \field Name
    \required-field
A2 , \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A3 , \field Air Outlet Node Name
    \required-field
A4 , \field Hot Air Inlet Node Name
    \required-field
A5 , \field Cold Air Inlet Node Name
    \required-field
N1 ; \field Maximum Air Flow Rate
    \required-field
    \units m3/s
    \minimum 0.0
    \autosizable

```

An IDF example:

```

AirTerminal:DualDuct:ConstantVolume,
Zone2MixDamp, !- Name
FanAndCoilAvailSched, !- Availability Schedule
Zone 2 Dual Duct Outlet, !- Unit Air Outlet Node
Zone 2 Dual Duct Hot Inlet, !- Unit Hot Air Inlet Node
Zone 2 Dual Duct Cold Inlet, !- Unit Cold Air Inlet Node
0.36; !- Max Air Flow Rate {m3/s}

```

AirTerminal:DualDuct:VAV

AirTerminal:DualDuct:VAV (i.e., Dual duct variable air volume (DDVAV)) systems are used to obtain zone temperature control by mixing the cold and warm air in various volume combinations. The fan is sized for the anticipated maximum coincident hot or cold volume, not the sum of the instantaneous peaks. This system has an advantage of a true single path VAV system, except for warm port leakage. When cold air is modulated for control before mixing, it operates similar to the VAV induction when mixing occurs without hot deck reheat. It is similar to a reheat system when mixing occurs while the hot deck is using the reheat coil. It uses more energy than a true VAV system, but less than a constant volume dual duct system.

Field: Name

Unique name for the AirTerminal:DualDuct:VAV Air Distribution Unit (ADU).

Field: Availability Schedule Name

Schedule that this component will operate or is available to operate.

Field: Air Outlet Node Name

The outlet node from the ADU to the zone.

Field: Hot Air Inlet Node Name

The air-inlet node name that connects the hot air splitter to the individual zone ADU.

Field: Cold Air Inlet Node Name

The air-inlet node name that connects the cold air splitter to the individual zone ADU.

Field: Maximum Damper Air Flow Rate

The design maximum volume flow rate (m³/sec) specified for DDVAV ADU.

Field: Zone Minimum Air Flow Fraction

The minimum flow rate to the zone while the system is operating, specified as a fraction of the Max Damper Air Flow Rate. The minimum zone fraction is normally specified to meet the minimum ventilation requirement for the occupants.

The IDD specification is:

```
AirTerminal:DualDuct:VAV,
A1 , \field Name
      \required-field
A2 , \field Availability Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
A3 , \field Air Outlet Node Name
      \required-field
A4 , \field Hot Air Inlet Node Name
      \required-field
A5 , \field Cold Air Inlet Node Name
      \required-field
N1 , \field Maximum Damper Air Flow Rate
      \required-field
      \units m3/s
      \minimum 0.0
      \autosizable
N2 ; \field Zone Minimum Air Flow Fraction
      \required-field
      \note fraction of maximum air flow
      \maximum 1.0
      \minimum 0.0
      \default 0.2
```

An IDF example:

```
AirTerminal:DualDuct:VAV,
ZoneMixDamp, !- Name
FanAndCoilAvailSched, !- Availability Schedule
Zone 1 Dual Duct Outlet, !- Unit Air Outlet Node
Zone 1 Dual Duct Hot Inlet, !- Unit Hot Air Inlet Node
Zone 1 Dual Duct Cold Inlet, !- Unit Cold Air Inlet Node
0.47, !- Max Damper Air Flow Rate {m3/s}
0.3; !- Zone Minimum Air Flow Fraction
```

Group – Zone Forced Air Units**ZoneHVAC:IdealLoadsAirSystem**

The simplest piece of zone equipment is the ZoneHVAC:IdealLoadsAirSystem component. ZoneHVAC:IdealLoadsAirSystem is used in situations where the user wishes to study the performance of a building with an ideal system. In such a case, the Ideal Loads Air System is usually the sole conditioning component: the user does not need to specify air loops, water loops, etc. All that is needed for the ideal system are zone controls, zone equipment configurations, and the purchased air components.

This component can be operated as either a component with infinite heating and cooling capacity or as a component with finite heating and cooling capacity. For infinite capacity, the user should specify the purchased air name, the zone supply air node name, the heating supply air temp, the cooling supply air temp, the heating supply air humidity ratio and the cooling supply air humidity ratio. The program will supply, without limit, the necessary heating or cooling supply air at the specified conditions to meet the zone heating or cooling load.

For finite capacity the user should specify the aforementioned fields plus heating limit (set to **Limit**), maximum heating air flow rate, cooling limit (set to **Limit**) and maximum cooling air flow rate. The program will now limit the heating and cooling supply air flow rates to the user specified limits. These maximum flow rates are also autosizable: the user can specify

autosize as the input value and the program will calculate a value based on the design day maximums.

For either mode – infinite or limited capacity – the user can also specify on/off schedules for heating and cooling and an outdoor air flow rate (set the outdoor air field to **OutdoorAir**). The outdoor air flow rate will also accept *autosize* as an input. Then the outdoor air flow rate will be calculated based on the user's zone sizing input.

This component can be thought of as an ideal unit that mixes air at the zone return condition with the specified amount of outdoor air and then adds or removes heat & moisture at 100% efficiency in order to produce a supply air stream at the specified conditions.

Note: Every zone served by a ideal loads air system component should have a return air node, even though this node is not connected to anything.

Note: The outdoor air flow rate is never allowed to be greater than the supply air flow rate.

Field: Name

A unique user assigned name for each ideal loads air system component. Any other component that needs to use this ideal loads air system component will refer to it by this name.

Field: Zone Supply Air Node Name

The name of the outlet air node of the purchased air object. This should be the same as one of the supply air nodes for the zone the purchased air component is serving.

Field: Heating Supply Air Temperature

The constant air temperature (degrees C) of the air used for heating the zone.

Field: Cooling Supply Air Temperature

The constant air temperature (degrees C) of the air used for cooling the zone.

Field: Heating Supply Air Humidity Ratio

The constant humidity ratio (kg of water per kg of dry air) of the hot supply air.

Field: Cooling Supply Air Humidity Ratio

The constant humidity ratio (kg of water per kg of dry air) of the hot supply air.

Field: Heating Limit

The input must be either **Limit** or **NoLimit**. **Limit** means that there will be a maximum heating supply air flow rate which should be specified in the next input field. **NoLimit** (the default) means that there will not be any limit on the heating supply air flow rate and the subsequent field will be ignored.

Field: Maximum Heating Air Flow Rate

The maximum heating supply air flow rate in cubic meters per second if heating limit is set to **Limit**. This field is ignored if heating limit is set to **NoLimit**.

Field: Cooling Limit

The input must be either **Limit** or **NoLimit**. **Limit** means that there will be a maximum cooling supply air flow rate which should be specified in the next input field. **NoLimit** (the default) means that there will not be any limit on the cooling supply air flow rate and the subsequent field will be ignored.

Field: Maximum Cooling Air Flow Rate

The maximum cooling supply air flow rate in cubic meters per second if cooling limit is set to **Limit**. This field is ignored if cooling limit is set to **NoLimit**.

Field: Outdoor Air

The input must be either **OutdoorAir** or **NoOutdoorAir**. **OutdoorAir** means that there will be a fixed amount of outdoor air (specified in the next input field) mixed with zone return air to make up the heating or cooling supply air stream. **NoOutdoorAir** (the default) means that there will be no outdoor air mixed with the zone return air and the next input field will be ignored.

Cautionary Note: The Ideal Loads Air System component does not control zone humidity levels. The Ideal Loads Air System component total cooling load is simply the enthalpy change between the mixed air condition (return air plus outdoor air, if specified) and the user-specified supply air condition for the current load. The latent load is the total load less the sensible load and may be positive or negative.

Field: Outdoor Air Flow Rate

The flow rate in cubic meters per second of air at outside conditions that will be mixed with zone return air to comprise the heating or cooling supply air stream. This field is ignored if outdoor air is set to **NoOutdoorAir**. This field can be set to *autosize*, in which case the outdoor air flow rate will be based on the user's zone sizing input.

Field: Heating Availability Schedule Name

The name of a schedule (ref: Schedule) that denotes whether the heating supply air will be available for the hour. A schedule value greater than 0 (usually 1 is used) indicates that heating supply air is available during the hour. A value less than or equal to 0 (usually 0 is used) denotes that heating supply air is not available for the hour.

Field: Cooling Availability Schedule Name

The name of a schedule (ref: Schedule) that denotes whether the cooling supply air will be available for the hour. A schedule value greater than 0 (usually 1 is used) indicates that cooling supply air is available during the hour. A value less than or equal to 0 (usually 0 is used) denotes that cooling supply air is not available for the hour.

```

ZoneHVAC:IdealLoadsAirSystem,
  \min-fields 12
A1 , \field Name
    \required-field
A2 , \field Zone Supply Air Node Name
    \required-field
N1 , \field Heating Supply Air Temperature
    \required-field
    \units C
    \minimum> 0
    \maximum< 100

```



```

N2 , \field Cooling Supply Air Temperature
      \required-field
      \units C
      \minimum> -100
      \maximum< 50
N3 , \field Heating Supply Air Humidity Ratio
      \required-field
      \units kg-H2O/kg-air
      \minimum> 0
N4 , \field Cooling Supply Air Humidity Ratio
      \required-field
      \units kg-H2O/kg-air
      \minimum> 0
A3 , \field Heating Limit
      \type choice
      \key Limit
      \key NoLimit
      \default NoLimit
N5 , \field Maximum Heating Air Flow Rate
      \units m3/s
      \minimum 0.0
      \autosizable
      \default Autosize
A4 , \field Cooling Limit
      \type choice
      \key Limit
      \key NoLimit
      \default NoLimit
N6 , \field Maximum Cooling Air Flow Rate
      \units m3/s
      \minimum 0.0
      \autosizable
      \default Autosize
A5 , \field Outdoor Air
      \type choice
      \key OutdoorAir
      \key NoOutdoorAir
      \default NoOutdoorAir
N7 , \field Outdoor Air Flow Rate
      \units m3/s
      \minimum 0.0
      \autosizable
      \default Autosize
A6 , \field Heating Availability Schedule Name
      \type object-list
      \object-list ScheduleNames
A7 ; \field Cooling Availability Schedule Name
      \type object-list
      \object-list ScheduleNames

```

An example of this statement in an IDF is:

```

ZoneHVAC:IdealLoadsAirSystem,
Zone2Air,  !- Purchased Air Name
  NODE_2,  !- Zone Supply Air Node Name
  50,      !- Heating Supply Air Temp {C}
  13,      !- Cooling Supply Air Temp {C}
  0.009,   !- Heating Supply Air Humidity Ratio {kg-H2O/kg-air}
  0.009,   !- Cooling Supply Air Humidity Ratio {kg-H2O/kg-air}
  LIMIT,   !- heating limit
  autosize, !- Maximum heating air flow rate
  LIMIT,   !- cooling limit
  autosize, !- Maximum cooling air flow rate
  OutdoorAir, !- outdoor air
  autosize, !- Outdoor air flow rate
  HeatingAvailSched, !- heating availability schedule
  CoolingAvailSched; !- cooling availability schedule

```

ZoneHVAC:IdealLoadsAirSystem Outputs

```
HVAC,Sum,Ideal Loads Air Heating Energy[J]
```

HVAC, Average, Ideal Loads Air Heating Rate[W]
 HVAC, Sum, Ideal Loads Air Sensible Cooling Energy[J]
 HVAC, Average, Ideal Loads Air Sensible Cooling Rate[W]
 HVAC, Sum, Ideal Loads Air Total Cooling Energy[J]
 HVAC, Average, Ideal Loads Air Total Cooling Rate[W]

Ideal Loads Air Heating Energy[J]

The energy needed to raise the temperature of the mixed outside and return air stream to the specified temperature of the supply air stream. Any energy needed for moisture addition or removal is ignored.

Ideal Loads Air Heating Rate[W]

The rate at which energy is added to the mixed outside and return air stream to raise its temperature to the specified temperature of the supply air stream. Any energy needed for moisture addition or removal is ignored.

Ideal Loads Air Sensible Cooling Energy[J]

The energy removed from the mixed outside and return air stream in order to lower its temperature to the specified temperature of the supply air stream. Any energy needed for moisture addition or removal is ignored.

Ideal Loads Air Sensible Cooling Rate[W]

The rate at which energy is removed from the mixed outside and return air stream in order to lower its temperature to the specified temperature of the supply air stream. Any energy needed for moisture addition or removal is ignored.

Ideal Loads Air Total Cooling Energy[J]

The total energy (sensible and latent) removed from the mixed outside and return air stream in order to bring the mixed air stream to the specified temperature and humidity ratio of the supply air stream.

Ideal Loads Air Total Cooling Rate[W]

The rate at which total energy (sensible and latent) is removed from the mixed outside and return air stream in order to bring the mixed air stream to the specified temperature and humidity ratio of the supply air stream.

ZoneHVAC:FourPipeFanCoil

The fan coil units are zone equipment units which are assembled from other components. Fan coils contain an outdoor air mixer, a fan, a simple heating coil and a cooling coil. These components are described elsewhere in this document. The fan coil input simply requires the names of these four components, which have to be described elsewhere in the input. The input also requires the name of an availability schedule, maximum airflow rate, an outdoor airflow rate, and maximum and minimum hot and cold water volumetric flow rates. The unit is connected to the zone inlet and exhaust nodes and the outdoor air by specifying unit inlet, outlet, outdoor air and exhaust (relief) air node names. Note that the unit air inlet node should be the same as a zone exhaust node and the unit outlet node should be the same as a zone inlet node. The fan coil unit is connected to a hot water loop (demand side) through its hot water coil and to a chilled water loop (demand side) through its cooling coil.

The unit is controlled to meet the zone (remaining) heating or cooling demand. If there is a heating demand, the cooling coil is off and the hot water flow through the heating coil is throttled to meet the demand. The hot water control node must be specified (same as the hot water coil inlet node) as well as maximum and minimum possible hot water volumetric flow rates. If there is a cooling demand from the zone, the hot water coil is off and the chilled water flow through the cooling coil is throttled to meet the load. The cooling coil control node must be specified (same as the cooling coil inlet node) and the maximum and minimum

chilled water volumetric flow rates must be given. Finally both heating and cooling require a convergence tolerance, which denotes how closely the fan coil unit will meet the heating or cooling load. The tolerance is always relative to the zone load.

Field: Name

A unique user assigned name for an instance of a Fan Coil unit. Any reference to this Fan Coil unit by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the fan coil unit can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Maximum Supply Air Flow Rate

The maximum volumetric airflow rate (m^3/sec) through the fan coil unit. Since this is a constant air volume unit, this is also the design, rated airflow rate of the unit.

Field: Maximum Outdoor Air Flow Rate

If the fan coil unit uses outdoor air, this field specifies the outdoor air volumetric flow rate (m^3/sec). This flow rate should be less than or equal to the maximum airflow rate. A value of zero specifies no outdoor air. Note that the outdoor airflow rate is fixed: it cannot change during the simulation

Field: Air Inlet Node Name

The name of the HVAC system node from which the fan coil unit draws its indoor air. This should be one of zone exhaust nodes for the zone which the fan coil unit is serving.

Field: Air Outlet Node Name

The name of the HVAC system node to which the fan coil unit sends its outlet air. This should be one of the inlet air nodes of the zone which is being served.

Field: Outdoor Air Node Name

The name of the HVAC system node from which the fan coil unit draws its outdoor air. This should be the same node as the outdoor air node of the unit's outdoor air mixer (object: OutdoorAir:Mixer).

Field: Air Relief Node Name

The name of the HVAC system node to which the fan coil unit exhausts its relief air. This should be the same node as the relief air node of the unit's outdoor air mixer.

Field: Cold Water Inlet Node Name

The name of the HVAC system node which regulates the flow of cold water through the fan coil unit. This should be the same node as the water inlet node for the unit's cooling coil.

Field: Hot Water Inlet Node Name

The name of the HVAC system node which regulates the flow of hot water through the fan coil unit. This should be the same node as the water inlet node of the unit's hot water coil.

Field: Outdoor Air Mixer Name

The name of an outdoor air mixer component (object: OutdoorAir:Mixer) which composes part of the fan coil unit. Note that some of the input for the outdoor air mixer will duplicate input fields of the fan coil unit. The outdoor air node of the outdoor air mixer should be the same as the outdoor air node of the fan coil unit. The relief air node of the outdoor air mixer should be the same as the relief air node of the fan coil unit. In addition, the return air node of

the outdoor air mixer should be the same node as the air inlet node of the fan coil unit. In addition, the outdoor air mixer's mixed air node should be the same as the inlet air node of the fan coil unit's fan.

Field: Fan Name

The name of a constant volume fan component that composes part of the fan coil unit. Note that the fan's maximum flow rate should be the same as the maximum airflow rate of the fan coil unit and the type of fan object must be Fan:ConstantVolume. The fan's inlet node should be the same as the outdoor air mixer's mixed air node. The fan's outlet node should be the same as the cooling coil's air inlet node.

Field: Cooling Coil Name

The name of the cooling coil component that composes part of the fan coil unit. The cooling coil air inlet node should be the same as the fan outlet node. The cooling coil air outlet node should be the same as the heating coil air inlet node.

Only the following coil types can be used:

```
Coil:Cooling:Water
Coil:Cooling:Water:DetailedGeometry
CoilSystem:Cooling:Water:HeatExchangerAssisted
```

Field: Maximum Cold Water Flow Rate

The maximum cold water volumetric flow rate (m³/sec) through the fan coil unit's cooling coil.

Field: Minimum Cold Water Flow Rate

The minimum cold water volumetric flow rate (m³/sec) through the fan coil unit's cooling coil.

Field: Cooling Convergence Tolerance

The convergence tolerance for the control of the unit cooling output. The unit is controlled by matching the unit output to the zone demand. For units with water coils, the model must be numerically inverted to obtain a specified output. The cooling convergence tolerance is the error tolerance used to terminate the numerical inversion procedure. Basically this is the fraction:

$$\frac{|Q_{fancoil,out} - Q_{zoneload}|}{Q_{zoneload}} \leq CoolingConvergenceTolerance$$

Field: Heating Coil Name

The name of the heating coil component that composes part of the fan coil unit. The heating coil air inlet node should be the same as the cooling coil outlet node. The heating coil air outlet node should be the same as the fan coil air outlet node.

Only the following coil type can be used:

```
Coil:Heating:Water
```

Field: Maximum Hot Water Flow Rate

The maximum hot water volumetric flow rate (m³/sec) through the fan coil unit's heating coil.

Field: Minimum Hot Water Flow Rate

The minimum hot water volumetric flow rate (m³/sec) through the fan coil unit's heating coil.

Field: Heating Convergence Tolerance

The convergence tolerance for the control of the unit heating output. The unit is controlled by matching the unit output to the zone demand. For units with water coils, the model must be

numerically inverted to obtain a specified output. The heating convergence tolerance is the error tolerance used to terminate the numerical inversion procedure. Basically this is the fraction:

$$\frac{|Q_{fancoil,out} - Q_{zoneload}|}{Q_{zoneload}} \leq HeatingConvergenceTolerance$$

Field: Cooling Coil Object Type

This field specifies the type of chilled water cooling coil to be modeled for this fan coil unit. Only the following coil types can be used:

Coil:Cooling:Water
 Coil:Cooling:Water:DetailedGeometry
 CoilSystem:Cooling:Water:HeatExchangerAssisted

The input requirements for these chilled water coil objects are described elsewhere in this document.

The input data dictionary definition of the unit is as follows.

```
ZoneHVAC:FourPipeFanCoil,
  \min-fields 21
A1 , \field Name
  \required-field
A2 , \field Availability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
N1 , \field Maximum Supply Air Flow Rate
  \required-field
  \autosizable
  \units m3/s
N2 , \field Maximum Outdoor Air Flow Rate
  \required-field
  \autosizable
  \units m3/s
A3 , \field Air Inlet Node Name
  \required-field
A4 , \field Air Outlet Node Name
  \required-field
A5 , \field Outdoor Air Node Name
  \required-field
A6 , \field Air Relief Node Name
  \required-field
A7 , \field Cold Water Inlet Node Name
  \required-field
A8 , \field Hot Water Inlet Node Name
  \required-field
A9 , \field Outdoor Air Mixer Name
  \required-field
  \type object-list
  \object-list OutdoorAirMixers
A10, \field Fan Name
  \required-field
  \note Fan type must be Fan:ConstantVolume
  \type object-list
  \object-list FansCV
A11, \field Cooling Coil Name
  \required-field
  \type object-list
  \object-list CoolingCoilsWater
```

```

N3 , \field Maximum Cold Water Flow Rate
    \required-field
    \autosizable
    \units m3/s
    \ip-units gal/min
N4 , \field Minimum Cold Water Flow Rate
    \default 0.0
    \units m3/s
    \ip-units gal/min
N5 , \field Cooling Convergence Tolerance
    \type real
    \minimum> 0.0
    \default 0.001
A12, \field Heating Coil Name
    \required-field
    \type object-list
    \object-list HeatingCoilsWater
N6 , \field Maximum Hot Water Flow Rate
    \required-field
    \autosizable
    \units m3/s
    \ip-units gal/min
N7 , \field Minimum Hot Water Flow Rate
    \default 0.0
    \units m3/s
    \ip-units gal/min
N8 , \field Heating Convergence Tolerance
    \type real
    \minimum> 0.0
    \default 0.001
A13; \field Cooling Coil Object Type
    \required-field
    \type choice
    \key Coil:Cooling:Water
    \key Coil:Cooling:Water:DetailedGeometry
    \key CoilSystem:Cooling:Water:HeatExchangerAssisted

```

An example input for a fan coil unit, including its constituent components, is shown below.

```

ZoneHVAC:FourPipeFanCoil,
  Zone1FanCoil, ! Name
  FanAndCoilAvailSched, ! on/off schedule
  0.84, ! air flow rate in m3/s
  0.05, ! outdoor air flow rate in m3/s
  Zone1FanCoilAirInletNode, ! air inlet node to fancoil; also a zone exhaust node
  Zone1FanCoilAirOutletNode, ! air outlet node of fancoil; also a zone inlet node
  Zone1FanCoilOAINode, ! fancoil outdoor air inlet node
  Zone1FanCoilExhNode, ! fancoil relief air node
  Zone1FanCoilChWInletNode, ! fancoil chilled water control node
  Zone1FanCoilHWInletNode, ! fancoil hot water control node
  Zone1FanCoilOAMixer, ! name of outdoor air mixer in fancoil
  Zone1FanCoilFan, ! name of fan in fancoil
  Zone1FanCoilCoolingCoil, ! name of cooling coil in fancoil
  0.001, ! max chilled water flow rate m3/s
  0.0, ! min chilled water flow rate m3/s
  0.001, ! tolerance on chilled water control
  Zone1FanCoilHeatingCoil, ! name of heating coil in fancoil
  0.0005, ! max hot water flow rate m3/s
  0.0, ! min hot water flow rate m3/s
  0.001, ! Heating Convergence Tolerance
  Coil:Cooling:Water; ! Cooling coil type

```

```

OutdoorAir:Mixer,
  Zone1FanCoilOAMixer, ! name
  Zone1FanCoilOAMixerOutletNode, ! mixer outlet node
  Zone1FanCoilOAMixerInletNode, ! mixer OA node
  Zone1FanCoilExhNode, ! mixer relief node
  Zone1FanCoilAirInletNode; ! mixer inlet node

Fan:ConstantVolume,
  Zone1FanCoilFan, ! name
  FanAndCoilAvailSched, ! fan on/off schedule
  0.5, ! total efficiency
  75.0, ! pressure rise in Pascals (typical fan coil value)
  0.84, ! flow rate in m3/s
  0.9, ! motor efficiency
  1.0, ! motor in air stream fraction
  Zone1FanCoilOAMixerOutletNode, ! fancoil fan inlet node
  Zone1FanCoilFanOutletNode; ! fancoil fan outlet node

Coil:Cooling:Water,
  Zone1FanCoilCoolingCoil, !- Name
  FanAndCoilAvailSched, !- Availability Schedule Name
  autosize, !- Design Water Flow Rate {m3/s}
  autosize, !- Design Air Flow Rate {m3/s}
  autosize, !- Design Inlet Water Temperature {C}
  autosize, !- Design Inlet Air Temperature {C}
  autosize, !- Design Outlet Air Temperature {C}
  autosize, !- Design Inlet Air Humidity Ratio {kg-H2O/kg-air}
  autosize, !- Design Outlet Air Humidity Ratio {kg-H2O/kg-air}
  Zone1FanCoilChWInletNode, !- Water Inlet Node Name
  Zone1FanCoilChWOutletNode, !- Water Outlet Node Name
  Zone1FanCoilFanOutletNode, !- Air Inlet Node Name
  Zone1FanCoilCCOutletNode, !- Air Outlet Node Name
  SimpleAnalysis, !- Type of Analysis
  CrossFlow; !- Heat Exchanger Configuration

Coil:Heating:Water,
  Zone1FanCoilHeatingCoil, !- Name
  FanAndCoilAvailSched, !- Availability Schedule Name
  autosize, !- U-Factor Times Area Value {W/K}
  autosize, !- Maximum Water Flow Rate {m3/s}
  Zone1FanCoilHWInletNode, !- Water Inlet Node Name
  Zone1FanCoilHWOutletNode, !- Water Outlet Node Name
  Zone1FanCoilCCOutletNode, !- Air Inlet Node Name
  Zone1FanCoilAirOutletNode, !- Air Outlet Node Name
  UFactorTimesAreaAndDesignWaterFlowRate, !- Performance Input Method
  autosize, !- Nominal Capacity {W}
  82.2, !- Design Inlet Water Temperature {C}
  16.6, !- Design Inlet Air Temperature {C}
  71.1, !- Design Outlet Water Temperature {C}
  32.2; !- Design Outlet Air Temperature {C}

```

Fan Coil Outputs

```

HVAC,Average,Fan Coil Heating Rate[W]
HVAC,Sum,Fan Coil Heating Energy[J]
HVAC,Average,Fan Coil Total Cooling Rate[W]
HVAC,Sum,Fan Coil Total Cooling Energy[J]
HVAC,Average,Fan Coil Sensible Cooling Rate[W]
HVAC,Sum,Fan Coil Sensible Cooling Energy[J]
HVAC,Average,Fan Coil Electric Power[W]
HVAC,Sum,Fan Coil Electric Consumption[J]

```

Fan Coil Heating Rate[W]

This field reports the dry air heating addition rate of the fan coil unit to the zone it is serving in Watts. This is determined by outlet and zone air conditions and the mass flow rate through the unit.

Fan Coil Heating Energy[J]

This field is the dry air heat addition of the fan coil unit to the zone it is serving in Joules over the timestep being reported. This is determined by outlet and zone air conditions, the mass flow rate through the unit, and the timestep.

Fan Coil Total Cooling Rate[W]

This field is the total (sensible and latent) heat extraction rate of the fan coil unit from the zone it is serving in Watts. This is determined by the outlet and zone conditions and the mass flow rate through the unit.

Fan Coil Total Cooling Energy[J]

This field is the total (sensible and latent) heat extraction of the fan coil unit from the zone it is serving in Joules over the timestep being reported. This is determined by outlet and zone air conditions, the mass flow rate through the unit, and the timestep.

Fan Coil Sensible Cooling Rate[W]

This field reports the dry air sensible heat extraction rate of the fan coil unit from the zone it is serving in Watts. This is determined by the outlet and zone conditions and the mass flow rate through the unit.

Fan Coil Sensible Cooling Energy[J]

This field is the dry air sensible heat extraction of the fan coil unit from the zone it is serving in Joules over the timestep being reported. This is determined by the outlet and zone conditions, the mass flow rate through the unit, and the timestep.

Fan Coil Electric Power[W]

This field reports the electricity consumption rate of the fan coil unit in Watts.

Fan Coil Electric Consumption[J]

This field is the electricity consumption of the fan coil unit in Joules over the timestep being reported.

ZoneHVAC:UnitVentilator

Unit ventilators are zone equipment units which are assembled from other components. They contain a built-in outdoor air mixer, a fan, a heating coil, and a cooling coil. These components are described elsewhere in this document, except the built-in outdoor air mixer which is contained within the unit ventilator statement. The unit ventilator input simply requires the names of these other three components, which have to be described elsewhere in the input. The input also requires the name of an availability schedule, maximum airflow rate, outdoor air control information (control type and schedules), an outdoor airflow rate, and maximum and minimum hot and cold water mass flow rates. The unit is connected to the zone inlet and exhaust nodes and the outdoor air by specifying unit inlet, outlet, outdoor air and exhaust (relief) air node names. Note that the unit air inlet node should be the same as a zone exhaust node and the unit outlet node should be the same as a zone inlet node. In general, the unit ventilator input is very similar to the fan coil unit input, and the unit is connected to a hot water loop (demand side) through its hot water coil and to a chilled water loop (demand side) through its cooling coil.

The main difference between the fan coil and unit ventilator input is that the unit ventilator has a built-in outdoor air mixer with its own specialized controls. The outdoor air control type can be selected from one of the following options: “variable percent”, “fixed temperature” or “fixed amount”. In fixed temperature control, the amount of outdoor air is varied between the minimum outdoor air fraction (specified by a schedule) and 100% outdoor air to obtain a mixed air temperature as close as possible to the temperature schedule defined in the input. Variable percent control will also vary the amount of outdoor air between the minimum and

maximum fractions (both specified in input by the user) to meet the load without the use of a coil if possible. In fixed amount control, the outdoor air flow rate is fixed to the specified value by the user. In this control strategy, the maximum outdoor air flow rate and schedule are automatically set to be equal to the minimum outdoor air flow rate and schedule. These control types are based on the 2004 ASHRAE Systems and Equipment Handbook (pp. 31.1-31.3) description of unit ventilator systems.

The unit is controlled to meet the zone (remaining) heating or cooling demand. If there is a heating demand, the cooling coil is off and the hot water flow through the heating coil is throttled to meet the demand. The hot water control node must be specified (same as the hot water coil inlet node) as well as maximum and minimum possible hot water volumetric flow rates. If there is a cooling demand from the zone, the hot water coil is off and the chilled water flow through the cooling coil is throttled to meet the load. The cooling coil control node must be specified (same as the cooling coil inlet node) and the maximum and minimum chilled water volumetric flow rates must be given. Finally both heating and cooling require a convergence tolerance, which is the tolerance denoting how closely the fan coil unit will meet the heating or cooling load. The tolerance is always relative to the zone load.

Overall, control of the unit must consider the outdoor air. Here is a more detailed description of the overall unit control:

Off: Unit is schedule off or there is no load on it. All flow rates are set to zero and the temperatures are set to zone conditions (except for the outdoor air inlet). Outdoor air requirements will not override this condition.

Heating/No Coil/VariablePercent: The unit is on, there is a heating load, no heating coil is present or it has been scheduled off, and variable percent outdoor air control type has been specified. In this case, the variable percent outdoor air controls what happens with the outdoor air. If the outside temperature is greater than the return temperature, then the outdoor air is set to the maximum as defined by the user input. If the outdoor air temperature is less than the return temperature from the zone, then the outdoor air is set to the minimum outdoor air flow rate as defined by the user. Since a coil is not present to further condition the supply air, the zone simply receives whatever temperature air results from the outdoor air controls.

Heating/No Coil/FixedTemperature: The unit is on, there is a heating load, no heating coil is present or it has been scheduled off, and fixed temperature has been specified. The unit ventilator tries to use outdoor air as best as possible to meet the temperature goal. If it cannot meet this goal because the temperature goal is not between the zone return temperature and the outdoor air temperature, then the unit ventilator will either use the maximum or minimum outdoor air flow rate.

Heating/No Coil/FixedAmount: The unit is on, there is a heating load, no heating coil is present or it has been scheduled off, and fixed amount control has been specified. The unit ventilator fixes the outdoor air flow rate as defined by the user and sets the maximum and minimum outdoor air flow rate to be equal in order to avoid the variation of outdoor air flow rate between the maximum and minimum values. Since a coil is not present to further condition the supply air, the zone simply receives whatever temperature air results from the outdoor air controls.

Heating /With Coil/VariablePercent: The unit is on, there is a heating load, and variable percent control is specified. The outdoor air fraction is set to the minimum outdoor air fraction (schedule based), and the heating coil is activated. The heating coil attempts to meet the remaining load on the zone being served by the unit ventilator.

Heating /With Coil/FixedAmount: The unit is on, there is a heating load, a heating coil is present and is scheduled on, and fixed amount control has been specified. The unit ventilator fixes the outdoor air flow rate as defined by the user and sets the maximum and minimum outdoor air flow rate to be equal in order to avoid the variation of outdoor air flow rate between the maximum and minimum values. The heating coil then attempts to meet any remaining zone heating load.

Cooling/No Coil/VariablePercent: The unit is on, there is a cooling load, no coil is present or it has been scheduled off, and variable percent outdoor air control type has been specified. In this case, the variable percent outdoor air controls what happens with the outdoor air. If the outside temperature is greater than the return temperature, then the outdoor air is set to the minimum as defined by the user input. If the outdoor air temperature is less than the return temperature from the zone, then the outdoor air is set to the maximum outdoor air flow rate as defined by the user. This may be somewhat simplistic in that it could result in overcooling of the space. However, since a temperature goal was not established, this is the best that can be done by the simulation. Since a coil is not present to further condition the supply air, the zone simply receives whatever temperature air results from the outdoor air controls.

Cooling/No Coil/FixedTemperature: The unit is on, there is a cooling load, no cooling coil is present or it has been scheduled off, and fixed temperature has been specified. The unit ventilator tries to use outdoor air as best as possible to meet the temperature goal. If it cannot meet this goal because the temperature goal is not between the zone return temperature and the outdoor air temperature, then the unit ventilator will either use the maximum or minimum outdoor air flow rate in the same fashion as the variable percent outdoor air control.

Cooling/No Coil/FixedAmount: The unit is on, there is a cooling load, no cooling coil is present or it has been scheduled off, and fixed amount control has been specified. The unit ventilator fixes the outdoor air flow rate as defined by the user and sets the maximum and minimum outdoor air flow rate to be equal in order to avoid the variation of outdoor air flow rate between the maximum and minimum values. Since a coil is not present to further condition the supply air, the zone simply receives whatever temperature air results from the outside air controls.

Cooling/With Coil/VariablePercent: The unit is on, there is a cooling load, a coil is present and is scheduled on, and variable percent outdoor air control type has been specified. In this case, the percentage of outdoor air is set to the minimum flow outdoor air flow rate. The coil then attempts to meet any remaining zone load.

Cooling/With Coil/FixedTemperature: The unit is on, there is a cooling load, a cooling coil is present and is scheduled on, and fixed temperature has been specified. The unit ventilator tries to use outdoor air as best as possible to meet the temperature goal. If it cannot meet this goal because the temperature goal is not between the zone return temperature and the outdoor air temperature, then the unit ventilator will either use the maximum or minimum outdoor air flow rate in the same fashion as the fixed temperature outdoor air control for the “no coil” conditions. The cooling coil then attempts to meet any remaining zone load.

Cooling/With Coil/FixedAmount: The unit is on, there is a cooling load, a cooling coil is present and is scheduled on, and fixed amount control has been specified. The unit ventilator fixes the outdoor air flow rate as defined by the user and sets the maximum and minimum outdoor air flow rate to be equal in order to avoid the variation of outdoor air flow rate between the maximum and minimum values. The cooling coil then attempts to meet any remaining zone cooling load.

Note: the unit ventilator controls are strictly temperature based and do not factor humidity into the equation (not an enthalpy economy cycle but rather a simple return air economy cycle). In addition, temperature predictions are not strict energy balances here in the control routine though in the mixing routine an energy balance is preserved.

Field: Name

This field is simply the identifying name that distinguishes one particular unit ventilator from another in the input data file. Like all other names in EnergyPlus, it is assumed that this is a unique character string and that no other unit ventilators use this same name.

Field: Availability Schedule Name

This field is a schedule name (ref: Schedule) that determines whether the unit ventilator is available to operate. The schedule is interpreted as a digital switch. If the schedule value of the unit ventilator availability schedule for a particular time frame is less than or equal to zero,

then the unit ventilator is unavailable and will not operate. For any schedule value greater than zero, the unit ventilator is considered available and may operate, if necessary.

Field: Maximum Supply Air Flow Rate

This field allows the user to enter the maximum volumetric flow rate of air through the unit ventilator system in m^3/sec . This parameter should be some real number greater than zero.

Field: Outdoor Air Control Type

This field allows the user to control how outdoor air is used in the unit ventilator system. The unit ventilator system described by this syntax has its own outdoor air handler. The three options for outdoor air control are “**VariablePercent**”, “**FixedTemperature**” and “**FixedAmount**”. Those keys are the only allowed choices for this parameter. In general, the variable percent control will attempt to vary the amount of outdoor air between some minimum and maximum schedules of fractions (see next two fields) to best meet the current heating or cooling load. The fixed temperature control will vary the amount of outdoor air between the minimum schedule (fraction of maximum, see next field) and 100% available outdoor air to come as close as possible to a desired mixed air temperature (see 2 fields down) that can be scheduled. The fixed amount control will fix the outdoor air flow rate as minimum outdoor air flow rate and schedule specified by the user and automatically set the maximum and minimum outside flow rate to be equal by ignoring the maximum outdoor air flow rate. More information on the controls and operation of the unit ventilator are given in the introductory section above.

Field: Minimum Outdoor Air Flow Rate

This field allows the user to enter the minimum volumetric flow rate of outdoor air (in m^3/sec) that will be brought in to the unit ventilator. The actual minimum outdoor air flow rate will be this number multiplied by the schedule value from the minimum outdoor air schedule. If “**FixedAmount**” type is selected as the outdoor air control strategy, the outdoor air flow rate will be fixed as this field and the unit ventilator will automatically set the maximum and minimum outside flow rate to be equal by ignoring the maximum outdoor air flow rate.

Field: Minimum Outdoor Air Schedule Name

This field contains a schedule name (ref: Schedule) that should contain values for the minimum outdoor air used by the unit ventilator system for IAQ or other reasons. Note that if the unit ventilator is scheduled off or if there is no load sensed in the zone that the system will not operate even to achieve the minimum air fraction. However, if the system is operating, it will always bring in this fraction of the minimum air flow rate (see minimum air flow rate field above). If “**FixedAmount**” type is selected as the outdoor air control strategy, the actual outdoor air flow rate will be this number multiplied by the minimum outdoor air flow rate in the field above. The unit ventilator will automatically set the maximum and minimum outdoor air schedule to be equal by ignoring the maximum outdoor air schedule.

Field: Maximum Outdoor Air Flow Rate

This field allows the user to enter the maximum volumetric flow rate of outdoor air that can be brought into the unit ventilator system in m^3/sec . This parameter should be some real number greater than zero. Note that the value for this parameter may be less than the maximum air flow rate of the unit ventilator and this may affect the maximum fraction of outdoor air within the control strategy defined above. This parameter is an absolute maximum and will supercede any scheduled fraction of the unit ventilator maximum airflow rate. If “**FixedAmount**” type is selected as the outdoor air control strategy, this field will be ignored and be automatically set to be equal to the minimum outdoor air flow rate specified in the field above.

Field: Maximum Outdoor Air Fraction or Temperature Schedule Name

This field can have one of two meanings depending the type of control selected in the outdoor air control type parameter above. If “VariablePercent” or “FixedAmount” was selected, then this field is a schedule name (ref: Schedule) corresponding to a maximum air fraction schedule. Furthermore, if “FixedAmount” type is selected as the outdoor air control strategy, this field will be ignored and be automatically set to be equal to the minimum outdoor air fraction specified in the field below. Note that this is a fraction of the maximum airflow rate field (see parameter above) for the unit ventilator. If “FixedTemperature” control was selected, then this field is still a schedule name (ref: Schedule), but it corresponds to a schedule of mixed air temperatures that the outdoor air control will try to attain.

Field: Air Inlet Node Name

This field is a node name used to identify the node that serves as the inlet (air side) to the unit ventilator. In EnergyPlus, nodes represent points between components or at various points in the loops. In a unit ventilator, the air inlet node to the system will typically be the same node as a zone outlet node. While a node name may be referenced more than once in an input data file, each node must have a unique name.

Field: Air Outlet Node Name

This field is a node name used to identify the node that serves as the outlet (air side) to the unit ventilator. In EnergyPlus, nodes represent points between components or at various points in the loops. In a unit ventilator, the air outlet node from the system will typically be the same node as a zone inlet node. While a node name may be referenced more than once in an input data file, each node must have a unique name.

Field: Fan Outlet Node Name

This field is a node name used to identify the node that serves as the air outlet to fan of the the unit ventilator. In EnergyPlus, nodes represent points between components or at various points in the loops. In a unit ventilator, the air outlet node from the fan is also considered the inlet node to the coils. While a node name may be referenced more than once in an input data file, each node must have a unique name.

Field: Outdoor Air Node Name

This field is a node name used to identify the node associated with fresh air brought into the unit ventilator from the outdoor environment. You should also have defined an OutdoorAir:Node object with the same name and assign it an optional height (above ground).

Field: Exhaust Air Node Name

This field is a node name used to identify the node associated with air exhausted out of the unit ventilator to the outdoor environment. While from a simulation standpoint this name is arbitrary and not a “necessity”, assigning a name to this node allows the user to receive output on conditions at this node to verify the correct operation of the unit ventilator.

Field: Mixed Air Node Name

This field is a node name used to identify the node associated with the “mixed” air of the unit ventilator. These conditions are post-“mixing box” since they are the conditions of the fraction of return air combined with the outdoor air. Since this is a simple system, this can also be viewed as the conditions of the air being sent to the coils. While from a simulation standpoint this name is arbitrary and not a “necessity”, assigning a name to this node allows the user to receive output on conditions at this node to verify the correct operation of the unit ventilator.

Field: Fan Name

This field is the name of a fan (ref: Fan:ConstantVolume, Fan: VariableVolume) that is part of the unit ventilator system. This name links the unit ventilator to particular fan data entered

elsewhere in the input data file. A fan name is required since it is the prime mover of air in the unit ventilator system.

Field: Coil Option

This field allows the user to specify the coil operating options as one of the following options: **None**, **Heating**, **Cooling** or **HeatingAndCooling**. If **None** is selected, the unit ventilator does not have any coils, and any other input will be ignored. If either **Heating** or **Cooling** is selected, only a heating or cooling coil, respectively, is present. Thus, only four more inputs will be expected. If **HeatingAndCooling** is selected, both heating and cooling coil input must be entered, and the unit ventilator will have both a heating and a cooling coil.

Field: Heating Coil Object Type

This field is the type of coil that is used for heating in the unit ventilator system. It is used in conjunction with the heating coil name (see next field) to specify the heating coil present within the system. Allowable heating coil types are:

```
Coil:Heating:Water
Coil:Heating:Electric
Coil:Heating:Gas
Coil:Heating:Steam
```

Field: Heating Coil Name

This field is the name of the heating coil that is part of the unit ventilator system. It is assumed that there is always some sort of heating coil associated with a unit ventilator system. This name links the unit ventilator to particular heating coil data entered elsewhere in the input data file.

Field: Hot Water or Steam Inlet Node Name

This field corresponds to the water inlet node to the heating coil for a water coil. The water inlet node controls how a water heating coil operates. This field is ignored/not needed for gas and electric heating coils.

Field: Heating Convergence Tolerance

The control tolerance for the unit heating output. This field allows the user some control over how closely the heating coil will control the air side conditions. The relative size of this parameter relates directly to the closeness of the control. A very small value in this field will result in tight control and will probably result in larger numbers of iterations. A large value in this field will result in looser controls and could result in unsatisfactory fluctuations in supply conditions (that could in turn result in excessive iterations). Initial experience with this parameter lends to the recommendation of using 0.001 as a starting point. This field is ignored for gas and electric heating coils.

The unit is controlled by matching the unit output to the zone demand. For units with water coils, the model must be numerically inverted to obtain a specified output. The heating convergence tolerance is the error tolerance used to terminate the numerical inversion procedure. Basically this is the fraction:

$$\frac{|Q_{UnitVentilator,Out} - Q_{ZoneLoad}|}{Q_{ZoneLoad}} \leq HeatingConvergenceTolerance$$

Field: Cooling Coil Object Type

This field is the type of coil that is used for cooling in the unit ventilator system. It is used in conjunction with the cooling coil name (see next field) to specify the cooling coil present within the system.

Only the following coil types can be used:

Coil:Cooling:Water
 Coil:Cooling:Water:DetailedGeometry
 CoilSystem:Cooling:Water:HeatExchangerAssisted

Field: Cooling Coil Name

This field is the name of the cooling coil that is part of the unit ventilator system. This name links the unit ventilator to particular cooling coil data entered elsewhere in the input data file. Note that a cooling coil is not a required part of a unit ventilator system. If no cooling coil is present, the previous field may be followed by a semi-colon and the remaining parameters in this statement may be ignored.

Field: Cold Water Inlet Node Name

This field corresponds to the water inlet node to the cooling coil. The water inlet node controls how a water cooling coil operates and is required for the unit ventilator that has a cooling coil associated with it to function properly.

Field: Cooling Convergence Tolerance

The convergence tolerance for the unit cooling output. This field allows the user some control over how closely the cooling coil will control the air side conditions. The relative size of this parameter relates directly to the closeness of the control. A very small value in this field will result in tight control and will probably result in larger numbers of iterations. A large value in this field will result in looser controls and could result in unsatisfactory fluctuations in supply conditions (that could in turn result in excessive iterations). Initial experience with this parameter lends to the recommendation of using 0.001 as a starting point.

The unit is controlled by matching the unit output to the zone demand. For units with water coils, the model must be numerically inverted to obtain a specified output. The cooling convergence tolerance is the error tolerance used to terminate the numerical inversion procedure. Basically this is the fraction:

$$\frac{|Q_{UnitVentilator,Out} - Q_{ZoneLoad}|}{Q_{ZoneLoad}} \leq CoolingConvergenceTolerance$$

The input data dictionary definition of the unit ventilator is as follows:

```
ZoneHVAC:UnitVentilator,
  \min-fields 16
A1 , \field Name
  \required-field
A2 , \field Availability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
N1 , \field Maximum Supply Air Flow Rate
  \required-field
  \units m3/s
  \minimum> 0
  \autosizable
A3 , \field Outdoor Air Control Type
  \required-field
  \type choice
  \key FixedAmount
  \key VariablePercent
  \key FixedTemperature
N2 , \field Minimum Outdoor Air Flow Rate
  \required-field
  \units m3/s
  \autosizable
  \minimum 0.0
```

```

A4 , \field Minimum Outdoor Air Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
    \note schedule values multiply the minimum outdoor air flow rate
N3 , \field Maximum Outdoor Air Flow Rate
    \required-field
    \units m3/s
    \minimum 0
    \autosizable
A5 , \field Maximum Outdoor Air Fraction or Temperature Schedule Name
    \note that this depends on the control type as to whether it is a fraction or temperature
    \required-field
    \type object-list
    \object-list ScheduleNames
A6 , \field Air Inlet Node Name
    \required-field
A7 , \field Air Outlet Node Name
    \required-field
A8 , \field Fan Outlet Node Name
    \required-field
    \note inlet to heating coil
A9, \field Outdoor Air Node Name
    \required-field
A10, \field Exhaust Air Node Name
    \required-field
A11, \field Mixed Air Node Name
    \required-field
    \note inlet to coils
A12 , \field Fan Name
    \required-field
    \note Allowable fan types are Fan:ConstantVolume and
    \note Fan:VariableVolume
    \type object-list
    \object-list FansCVandVAV
A13, \field Coil Option
    \required-field
    \type choice
    \key None
    \key Heating
    \key Cooling
    \key HeatingAndCooling
A14, \field Heating Coil Object Type
    \type choice
    \key Coil:Heating:Water
    \key Coil:Heating:Electric
    \key Coil:Heating:Gas
    \key Coil:Heating:Steam
A15, \field Heating Coil Name
    \type object-list
    \object-list HeatingCoilName
A16, \field Hot Water or Steam Inlet Node Name
    \note Not used when heating coil is gas or electric
N4 , \field Heating Convergence Tolerance
    \type real
    \minimum> 0.0
    \default 0.001
A17, \field Cooling Coil Object Type
    \type choice
    \key Coil:Cooling:Water
    \key Coil:Cooling:Water:DetailedGeometry
    \key CoilSystem:Cooling:Water:HeatExchangerAssisted
A18, \field Cooling Coil Name
    \type object-list
    \object-list CoolingCoilsWater
A19, \field Cold Water Inlet Node Name
N5 ; \field Cooling Convergence Tolerance
    \type real
    \minimum> 0.0
    \default 0.001

```

An example input for a unit ventilator, including its constituent components, is shown below.

```

ZoneHVAC:UnitVentilator,
  ZoneUnitVent,          !- Name
  UnitVentAvailability,  !- Availability Schedule Name
  0.84,                  !- Maximum Supply Air Flow Rate {m3/s}
  VariablePercent,      !- Outdoor Air Control Type
  0.168,                 !- Minimum Outdoor Air Flow Rate {m3/s}
  UnitVentMinOA,        !- Minimum Outdoor Air Schedule Name
  0.84,                  !- Maximum Outdoor Air Flow Rate {m3/s}
  UnitVentMaxOA,        !- Maximum Outdoor Air Fraction or Temperature Schedule Name
  ZoneUnitVentAirInletNode, !- Air Inlet Node Name
  ZoneUnitVentAirOutletNode, !- Air Outlet Node Name
  ZoneUnitVentFanOutletNode, !- Fan Outlet Node Name
  ZoneUnitVentOAINode,  !- Outdoor Air Node Name
  ZoneUnitVentExhNode,  !- Exhaust Air Node Name
  ZoneUnitVentOAMixerOutletNode, !- Mixed Air Node Name
  ZoneUnitVentFan,      !- Fan Name
  HeatingAndCooling,    !- Coil Option
  Coil:Heating:Water,   !- Heating Coil Object Type
  ZoneUnitVentHeatingCoil, !- Heating Coil Name
  ZoneUnitVentHWInletNode, !- Hot Water Sensor Node Name
  0.001,                 !- Heating Convergence Tolerance
  Coil:Cooling:Water,   !- Cooling Coil Object Type
  ZoneUnitVentCoolingCoil, !- Cooling Coil Name
  ZoneUnitVentChWInletNode, !- Cold Water Sensor Node Name
  0.001;                 !- Cooling Convergence Tolerance

```

```

OutdoorAir:Node,
  ZoneUnitVentOAINode,  !- Name
  -1.0;                 !- Height Above Ground {m}

```

```

Fan:ConstantVolume,
  ZoneUnitVentFan,      !- Name
  UnitVentAvailability, !- Availability Schedule Name
  0.5,                  !- Fan Efficiency
  75.0,                 !- Pressure Rise {Pa}
  0.84,                 !- Maximum Flow Rate {m3/s}
  0.9,                  !- Motor Efficiency
  1.0,                  !- Motor In Airstream Fraction
  ZoneUnitVentOAMixerOutletNode, !- Fan Inlet Node Name
  ZoneUnitVentFanOutletNode; !- Fan Outlet Node Name

```

```

Coil:Cooling:Water,
  ZoneUnitVentCoolingCoil, !- Name
  FanAndCoilAvailSched,    !- Availability Schedule Name
  0.0010,                  !- Design Water Flow Rate {m3/s}
  0.84,                    !- Design Air Flow Rate {m3/s}
  6.67,                     !- Design Inlet Water Temperature {C}
  30,                       !- Design Inlet Air Temperature {C}
  12,                       !- Design Outlet Air Temperature {C}
  0.013,                    !- Design Inlet Air Humidity Ratio {kg-H2O/kg-air}
  0.008,                     !- Design Outlet Air Humidity Ratio {kg-H2O/kg-air}
  ZoneUnitVentChWInletNode, !- Water Inlet Node Name
  ZoneUnitVentChWOutletNode, !- Water Outlet Node Name
  ZoneUnitVentFanOutletNode, !- Air Inlet Node Name
  ZoneUnitVentCCOutletNode, !- Air Outlet Node Name
  SimpleAnalysis,           !- Type of Analysis
  CrossFlow;                !- Heat Exchanger Configuration

```



```

Coil:Heating:Water,
  ZoneUnitVentHeatingCoil, !- Name
  FanAndCoilAvailSched,    !- Availability Schedule Name
  400.,                    !- U-Factor Times Area Value {W/K}
  0.0005,                 !- Maximum Water Flow Rate {m3/s}
  ZoneUnitVentHWInletNode, !- Water Inlet Node Name
  ZoneUnitVentHWOutletNode, !- Water Outlet Node Name
  ZoneUnitVentCCOutletNode, !- Air Inlet Node Name
  ZoneUnitVentAirOutletNode, !- Air Outlet Node Name
  UFactorTimesAreaAndDesignWaterFlowRate, !- Performance Input Method
  autosize,              !- Nominal Capacity {W}
  82.2,                  !- Design Inlet Water Temperature {C}
  16.6,                 !- Design Inlet Air Temperature {C}
  71.1,                 !- Design Outlet Water Temperature {C}
  32.2;                 !- Design Outlet Air Temperature {C}

```

Unit Ventilator Outputs

```

HVAC,Average,Unit Ventilator Heating Rate[W]
HVAC,Sum,Unit Ventilator Heating Energy[J]
HVAC,Average,Unit Ventilator Total Cooling Rate[W]
HVAC,Sum,Unit Ventilator Total Cooling Energy[J]
HVAC,Average,Unit Ventilator Sensible Cooling Rate[W]
HVAC,Sum,Unit Ventilator Sensible Cooling Energy[J]
HVAC,Average,Unit Ventilator Fan Electric Power[W]
HVAC,Sum,Unit Ventilator Fan Electric Consumption[J]

```

Unit Ventilator Heating Rate[W]

This field reports the heating output rate of the unit ventilator system to the zone it is serving in Watts. This is determined by outlet and zone air conditions and the mass flow rate through the unit ventilator.

Unit Ventilator Heating Energy[J]

This field is the heating output of the unit ventilator system to the zone it is serving in Joules over the timestep being reported. This is determined by outlet and zone air conditions, the mass flow rate through the unit ventilator, and the timestep.

Unit Ventilator Total Cooling Rate[W]

This field reports the total cooling (sensible plus latent) output rate of the unit ventilator system to the zone it is serving in Watts. This is determined by outlet and zone air conditions and the mass flow rate through the unit ventilator.

Unit Ventilator Total Cooling Energy[J]

This field is the total cooling (sensible plus latent) output of the unit ventilator system to the zone it is serving in Joules over the timestep being reported. This is determined by outlet and zone air conditions, the mass flow rate through the unit ventilator, and the timestep.

Unit Ventilator Sensible Cooling Rate[W]

This field reports the sensible cooling output rate of the unit ventilator system to the zone it is serving in Watts. This is determined by outlet and zone air conditions and the mass flow rate through the unit ventilator.

Unit Ventilator Sensible Cooling Energy[J]

This field is the sensible cooling output of the unit ventilator system to the zone it is serving in Joules over the timestep being reported. This is determined by outlet and zone air conditions, the mass flow rate through the unit ventilator, and the timestep.

Unit Ventilator Fan Electric Power[W]

This field reports the electric power consumption rate of the fan of the unit ventilator in Watts.

Unit Ventilator Fan Electric Consumption[J]

This field reports the electric power consumed by the fan of the unit ventilator over the timestep in Joules.

ZoneHVAC:UnitHeater

Unit heaters are zone equipment units which are assembled from other components and are a simplification of unit ventilators. They contain only a fan and a heating coil. These components are described elsewhere in this document. The unit heater input simply requires the names of these components, which have to be described elsewhere in the input. The input also requires the name of an availability schedule, maximum airflow rate, and maximum and minimum hot water volumetric flow rates. The unit is connected to the zone inlet and exhaust nodes by specifying unit inlet and outlet node names. Note that the unit air inlet node should be the same as a zone exhaust node and the unit outlet node should be the same as a zone inlet node.

While the control of the heating coil is similar to the fan coil units and the unit ventilator, the overall control of the unit heater is much different. There are four different modes in which a unit heat can operate based on the user input:

Off: Unit is schedule off. All flow rates are set to zero and the temperatures are set to zone conditions.

NoLoad OR Cooling/OnOff Fan Control: Unit is available, but there is no heating load. All flow rates are set to zero and the temperatures are set to zone conditions.

NoLoad OR Cooling/Continuous Fan Control: Unit is available and the fan is running (if it is scheduled to be available also). No heating is provided, only circulation via the fan running.

Heating: The unit is on/available and there is a heating load. The heating coil is modulated (constant fan speed) to meet the heating load.

Control of the heating coil and its flow rate is identical to the fan coil unit and unit ventilator.

Field: Name

This field is simply the identifying name that distinguishes one particular unit heater from another in the input data file. Like all other names in EnergyPlus, it is assumed that this is a unique character string and that no other unit heaters use this same name.

Field: Availability Schedule Name

This field is a schedule name (ref: Schedule) that determines whether the unit heater is available to operate. The schedule is interpreted as a digital switch. If the schedule value of the unit heater availability schedule for a particular time frame is less than or equal to zero, then the unit heater is unavailable and will not operate. For any schedule value greater than zero, the unit heater is considered available and may operate.

Field: Air Inlet Node Name

This field is a node name used to identify the node that serves as the inlet (air side) to the unit heater. In EnergyPlus, nodes represent points between components or at various points in the loops. In a unit heater, the air inlet node to the system will typically be the same node as a zone outlet node. While a node name may be referenced more than once in an input data file, each node must have a unique name.

Field: Air Outlet Node Name

This field is a node name used to identify the node that serves as the outlet (air side) to the unit heater. In EnergyPlus, nodes represent points between components or at various points in the loops. In a unit heater, the air outlet node from the system will typically be the same

node as a zone inlet node. While a node name may be referenced more than once in an input data file, each node must have a unique name.

Field: Fan Name

This field is the name of a fan (ref: Fan:ConstantVolume, Fan:VariableVolume) that is part of the unit heater system. This name links the unit heater to particular fan data entered elsewhere in the input data file. A fan name is required since it is the prime mover of air in the unit heater system.

Field: Maximum Supply Air Flow Rate

This field allows the user to enter the maximum volumetric flow rate of air through the unit heater system in m³/s. This parameter should be some real number greater than zero.

Field: Fan Control Type

This field allows the user to define how the unit heater will operate under “no load” or cooling conditions. The user may select from two options. If the “**OnOff**” control is selected, then the fan will not run unless there is a heating load. If the fan does not run, this effectively shuts the unit heater system off (there is no option to simply run the heating coil and allow natural convection to transfer heat from the unit to the zone). If the “**Continuous**” control is selected, then the fan will always run if the unit heater is available. This will produce air movement in the zone but also add some amount of heat to the energy balance since the fan will generate some heat. For more information on controlling the operation of the unit heater, see the general description given above.

Field: Fan Outlet Node Name

This field is a node name used to identify the node that serves as the air outlet to fan of the the unit heater. In EnergyPlus, nodes represent points between components or at various points in the loops. In a unit heater, the air outlet node from the fan is also considered the inlet node to the coils. While a node name may be referenced more than once in an input data file, each node must have a unique name.

Field: Heating Coil Object Type

This field is the type of coil that is used for heating in the unit heater system. It is used in conjunction with the heating coil name (see next field) to specify the heating coil present within the system. Allowable heating coil types are:

```
Coil:Heating:Water  
Coil:Heating:Electric  
Coil:Heating:Gas  
Coil:Heating:Steam
```

Field: Heating Coil Name

This field is the name of the heating coil that is part of the unit heater system. It is assumed that there is always some sort of heating coil associated with a unit heater system. This name links the unit ventilator to particular heating coil data entered elsewhere in the input data file.

Field: Maximum Hot Water or Steam Flow Rate

This field allows the user to enter a maximum volumetric flow rate of water through a water heating coil in m³/sec. This number should be some number greater than zero and greater than the minimum hot water volumetric flow rate (see next field). Note that this parameter has no meaning for either an electric or a gas heating coil.

Field: Minimum Hot Water or Steam Flow Rate

This field allows the user to enter a minimum volumetric flow rate of water through a water heating coil in m³/sec. This number should be some number greater than zero and less than

the maximum hot water volumetric flow rate (see previous field). Note that this parameter has no meaning for either an electric or a gas heating coil.

Field: Hot Water or Steam Inlet Node Name

This field corresponds to the water inlet node to the heating coil for a water coil. The water inlet node controls how a water heating coil operates and is required for the unit ventilator to function properly. This field is ignored for gas and electric heating coils.

Field: Heating Convergence Tolerance

The convergence tolerance for the unit heating output. This field allows the user some control over how closely the heating coil will control the air side conditions. The relative size of this parameter relates directly to the closeness of the control. A very small value in this field will result in tight control and will probably result in larger numbers of iterations. A large value in this field will result in looser controls and could result in unsatisfactory fluctuations in supply conditions (that could in turn result in excessive iterations). Initial experience with this parameter lends to the recommendation of using 0.001 as a starting point. This field is ignored for gas and electric heating coils.

The unit is controlled by matching the unit output to the zone demand. For units with water coils, the model must be numerically inverted to obtain a specified output. The heating convergence tolerance is the error tolerance used to terminate the numerical inversion procedure. Basically this is the fraction:

$$\frac{|Q_{unit\ heater, out} - Q_{zone\ load}|}{Q_{zone\ load}} \leq HeatingConvergenceTolerance$$

The IDD definition for the Unit Heater follows:

```
ZoneHVAC:UnitHeater,
  A1 , \field Name
      \required-field
  A2 , \field Availability Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
  A3 , \field Air Inlet Node Name
  A4 , \field Air Outlet Node Name
  A5 , \field Fan Name
      \note Allowable fan types are Fan:ConstantVolume and
      \note Fan:VariableVolume
      \type object-list
      \object-list FansCVandVAV
  N1 , \field Maximum Supply Air Flow Rate
      \required-field
      \units m3/s
      \minimum> 0
      \autosizable
  A6 , \field Fan Control Type
      \required-field
      \type choice
      \key OnOff
      \key Continuous
  A7 , \field Fan Outlet Node Name
```

```

A8 , \field Heating Coil Object Type
    \required-field
    \type choice
    \key Coil:Heating:Water
    \key Coil:Heating:Electric
    \key Coil:Heating:Gas
    \key Coil:Heating:Steam
A9 , \field Heating Coil Name
    \required-field
    \type object-list
    \object-list HeatingCoilName
N2 , \field Maximum Hot Water or Steam Flow Rate
    \note Not used when heating coil is gas or electric
    \units m3/s
    \minimum> 0
    \autosizable
    \ip-units gal/min
N3 , \field Minimum Hot Water or Steam Flow Rate
    \note Not used when heating coil is gas or electric
    \units m3/s
    \minimum 0
    \default 0
    \ip-units gal/min
A10 , \field Hot Water or Steam Inlet Node Name
    \note Not used when heating coil is gas or electric
N4 ; \field Heating Convergence Tolerance
    \type real
    \minimum> 0.0
    \default 0.001

```

An example input for a unit heater, including its constituent components, is shown below.

```

ZoneHVAC:UnitHeater,
  ZonelUnitHeat,          !- Name
  UnitHeatAvailability,  !- Availability Schedule Name
  ZonelUnitHeatAirInletNode, !- Air Inlet Node Name
  ZonelUnitHeatAirOutletNode, !- Air Outlet Node Name
  ZonelUnitHeatFan,      !- Fan Name
  0.84,                  !- Maximum Supply Air Flow Rate {m3/s}
  Continuous,           !- Fan Control Type
  ZonelUnitHeatFanOutletNode, !- Fan Outlet Node Name
  Coil:Heating:Water,    !- Heating Coil Object Type
  ZonelUnitHeatHeatingCoil, !- Heating Coil Name
  0.0005,                !- Maximum Hot Water Flow {m3/s}
  0.0,                   !- Minimum Hot Water Flow {m3/s}
  ZonelUnitHeatHWInletNode, !- Hot Water Sensor Node Name
  0.001;                 !- Heating Convergence Tolerance

```

```

Fan:ConstantVolume,
  ZonelUnitHeatFan,      !- Name
  UnitHeatAvailability,  !- Availability Schedule Name
  0.5,                   !- Fan Efficiency
  75.0,                  !- Pressure Rise {Pa}
  0.84,                  !- Maximum Flow Rate {m3/s}
  0.9,                   !- Motor Efficiency
  1.0,                   !- Motor In Airstream Fraction
  ZonelUnitHeatAirInletNode, !- Fan Inlet Node Name
  ZonelUnitHeatFanOutletNode; !- Fan Outlet Node Name

```

```

Coil:Heating:Water,
  ZoneUnitHeatHeatingCoil, !- Name
  FanAndCoilAvailSched,    !- Availability Schedule Name
  400.,                    !- U-Factor Times Area Value {W/K}
  0.0005,                 !- Maximum Water Flow Rate {m3/s}
  ZoneUnitHeatHWInletNode, !- Water Inlet Node Name
  ZoneUnitHeatHWOutletNode, !- Water Outlet Node Name
  ZoneUnitHeatFanOutletNode, !- Air Inlet Node Name
  ZoneUnitHeatAirOutletNode, !- Air Outlet Node Name
  UFactorTimesAreaAndDesignWaterFlowRate, !- Performance Input Method
  autosize,               !- Nominal Capacity {W}
  82.2,                   !- Design Inlet Water Temperature {C}
  16.6,                   !- Design Inlet Air Temperature {C}
  71.1,                   !- Design Outlet Water Temperature {C}
  32.2;                   !- Design Outlet Air Temperature {C}

```

Unit Heater Outputs

```

HVAC,Average,Unit Heater Heating Rate[W]
HVAC,Sum,Unit Heater Heating Energy[J]
HVAC,Average,Unit Heater Fan Electric Power[W]
HVAC,Sum,Unit Heater Fan Electric Consumption[J]

```

Unit Heater Heating Rate[W]

This field reports the heating output rate of the unit heater system to the zone it is serving in Watts. This is determined by outlet and zone air conditions and the mass flow rate through the unit heater.

Unit Heater Heating Energy[J]

This field is the heating output of the unit heater system to the zone it is serving in Joules over the timestep being reported. This is determined by outlet and zone air conditions, the mass flow rate through the unit heater, and the timestep.

Unit Heater Fan Electric Power[W]

This field reports the electric power consumption rate of the fan of the unit heater in Watts.

Unit Heater Fan Electric Consumption[J]

This field reports the electric power consumed by the fan of the unit heater over the timestep in Joules.

ZoneHVAC:WindowAirConditioner

The Window Air Conditioner is a unit of zone equipment made up of other components. Each window air conditioner consists of an outdoor air mixer, a fan, and a direct expansion (DX) cooling coil. These components are described elsewhere in this document. The input for a window air conditioner requires the names of these three pieces of equipment, which are then specified individually elsewhere in the input. The input for a window air conditioner also requires the name of an availability schedule, the maximum unit airflow rate, and the maximum outdoor airflow rate for the unit. The unit is connected to a zone by specifying an air inlet node, which must be the same as a zone exhaust node; and an air outlet node, which must be the same as a zone inlet node (ref. ZoneHVAC:EquipmentConnections). The unit is connected to the outdoor air by giving the names of the outdoor air node and the exhaust (relief) node of the unit's outdoor air mixer.

A supply air fan operating mode schedule must also be specified. The supply air fan operating mode schedule value determines if the supply air fan can run continuously with the DX coil cycling on/off to match the zone cooling demand or the fan and DX coil can cycle on/off together to meet the cooling demand. The placement of the supply air fan, in relation to the DX coil, must also be specified (blow through or draw through). The cooling convergence tolerance is required, which is the tolerance denoting how closely the window air conditioner

will meet the cooling load. The tolerance is always relative to the zone load (i.e., the unit will operate to meet the zone load to within the tolerance value times the zone load for each simulation timestep). Finally, the DX cooling coil type must be specified.

Field: Name

A unique user assigned name for an instance of a window air conditioner unit. Any reference to this window air conditioner by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the window air conditioner unit can run during a given hour. A schedule value of 1 indicates that the unit can be on during the hour. A value of 0 denotes that the unit must be off for the hour.

Field: Maximum Supply Air Flow Rate

The maximum volumetric airflow rate through the window air conditioner in cubic meters per second. Since the unit operates by cycling on/off, this is also the design, rated airflow rate of the unit.

Field: Maximum Outdoor Air Flow Rate

If the window air conditioner uses outdoor air, this field specifies the outdoor air volumetric flow rate in cubic meters per second. This flow rate should be less than or equal to the maximum airflow rate. A value of zero specifies no outdoor air. Note that the outdoor airflow rate is fixed: it cannot change during the simulation

Field: Air Inlet Node Name

The name of the HVAC system node (see Node) from which the window air conditioner draws its indoor air. This should be one of the zone exhaust nodes for the zone which the window air conditioner is cooling.

Field: Air Outlet Node Name

The name of the HVAC system node (see Node) to which the window air conditioner sends its outlet air. This should be one of the inlet air nodes for the zone which is being cooled.

Field: Outdoor Air Node Name

The name of the HVAC system node (see Node) from which the window air conditioner draws its outdoor air. This should be the same node as the outdoor air node of the unit's outdoor air mixer (object: OutdoorAir:Mixer).

Field: Air Relief Node Name

The name of the HVAC system node (see Node) to which the window air conditioner exhausts its relief air. This should be the same node as the relief air node of the unit's outdoor air mixer.

Field: Outdoor Air Mixer Name

The name of an outdoor air mixer component which composes part of the window air conditioner unit. Note that some of the input for the outdoor air mixer will duplicate input fields of the window air conditioner. The outdoor air node of the outdoor air mixer should be the same as the outdoor air node of the window air conditioner. The relief air node of the outdoor air mixer should be the same as the relief air node of the window air conditioner. The return air node of the outdoor air mixer should be the same node as the air inlet node of the window air conditioner. In addition, the outdoor air mixer's mixed air node should be the same as the window air conditioner's fan inlet air node (for blow through) or the air conditioner's DX coil inlet node (for draw through)

Field: Fan Name

The name of a constant volume fan component that composes part of the window air conditioner. Note that the fan's maximum flow rate should be the same as the maximum airflow rate of the window air conditioner. A fan of type Fan:OnOff may be used with either cycling or continuous fan, and a fan of type Fan:ConstantVolume is used only with continuous fan (see Supply Air Fan Operating Mode Schedule field below). The fan's inlet node should be the same as the outdoor air mixer's mixed air node (for blow through) or the DX coil's outlet node (for draw through). The fan's outlet node should be the same as the DX coil's air inlet node (for blow through) or the window air conditioner's air outlet node (for draw through).

Field: DX Cooling Coil Name

The name of a DX cooling coil component that composes part of the window air conditioner unit. The DX coil air inlet node should be the same as the fan outlet node (for blow through) or the outdoor air mixer's mixed air node (for draw through). The DX coil air outlet node should be the same as the window air conditioner's air outlet node (for blow through) or the fan's inlet node (for draw through).

Field: Supply Air Fan Operating Mode Schedule Name

This alpha field specifies the name of the supply air fan operating mode schedule. The supply air fan operating mode may vary during the simulation based on time-of-day or with a change of season. Schedule values of 0 denote that the supply air fan and the heating or cooling coil cycle on and off together to meet the heating or cooling load (a.k.a. AUTO fan). Schedule values other than 0 denote that the supply air fan runs continuously while the heating or cooling coil cycles to meet the load. If this field is left blank, the model assumes the supply air fan cycles with the heating or cooling coil throughout the simulation. The operating mode specified here overrides the operating mode specified in the cooling coil object.

Field: Fan Placement

This input field has two choices: **BlowThrough** or **DrawThrough**. The first choice stands for "blow through fan". This means that the unit consists of an outdoor air mixer followed by a fan followed by a DX coil. The fan "blows through" the DX coil. The second choice stands for "draw through fan". This means that the unit consists of an outdoor air mixer followed by a DX coil followed by a fan. The fan "draws air through" the coil.

Field: Cooling Convergence Tolerance

This input field defines the convergence tolerance for the unit's cooling output. This field allows the user some control over how closely the air conditioner will control the air-side conditions. The relative size of this parameter relates directly to the closeness of the control. A very small value in this field will result in tight control and will probably result in larger numbers of iterations. A large value in this field will result in looser controls and could result in unsatisfactory fluctuations in zone air temperature. Initial experience with this parameter lends to the recommendation of using 0.001 as the starting point.

The window air conditioner is controlled by matching its sensible (temperature) cooling output to the zone sensible load (demand). Because the performance of the DX coil is frequently non-linear, the air conditioner model must call the DX coil model several times (iterate) to determine the proper run time fraction to meet the zone load. The cooling convergence tolerance is the error tolerance used to terminate the iteration procedure when the following equation is satisfied:

$$\frac{|Q_{ZoneLoad} - Q_{WindowAirConditioner,out}|}{Q_{ZoneLoad}} \leq CoolingConvergenceTolerance$$

The maximum number of iterations is limited, with a warning message generated if the above equation is not satisfied within the maximum number of iterations.

Field: Cooling Coil Object Type

This field specifies the type of cooling coil to be modeled for this window air conditioner. The input requirements for these cooling coil objects are described elsewhere in this document. If the user wants to control the enhanced dehumidification performance of the Heat Exchanger Assisted coil type based on zone air humidity level, then the input file must include a humidistat object (ref. ZoneControl:Humidistat) for the zone being served by this air conditioner and a high humidity set point manager (ref. SetpointManager:SingleZone:Humidity:Maximum) with the high humidity set point placed on the outlet node of the heat exchanger assisted cooling coil. Only allowable coil types are:

```
Coil:Cooling:DX:SingleSpeed
CoilSystem:Cooling:DX:HeatExchangerAssisted
```

Below is the IDD specification of the cycling window air conditioner.

```
ZoneHVAC:WindowAirConditioner,
  \min-fields 15
A1, \field Name
  \required-field
  \type alpha
A2, \field Availability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
N1, \field Maximum Supply Air Flow Rate
  \required-field
  \type real
  \units m3/s
  \autosizable
N2, \field Maximum Outdoor Air Flow Rate
  \required-field
  \type real
  \units m3/s
  \autosizable
A3, \field Air Inlet Node Name
  \required-field
  \type alpha
A4, \field Air Outlet Node Name
  \required-field
  \type alpha
A5, \field Outdoor Air Node Name
  \required-field
  \type alpha
A6, \field Air Relief Node Name
  \required-field
  \type alpha
A7, \field Outdoor Air Mixer Name
  \required-field
  \type alpha
A8, \field Fan Name
  \required-field
  \note Fan type Fan:ConstantVolume is used with continuous fan
  \note and fan type Fan:OnOff is used with cycling Fan.
  \type object-list
  \object-list FansCVandOnOff
A9, \field DX Cooling Coil Name
  \required-field
  \type object-list
  \object-list CoolingCoilsDXSingleSpeed
```

```

A10, \field Supply Air Fan Operating Mode Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Enter the name of a schedule that controls fan operation. Schedule Name values of 0 denote
      \note cycling fan operation (fan cycles with cooling coil). Schedule values greater
      \note than 0 denote constant fan operation (fan runs continually regardless of coil operation).
      \note The fan operating mode defaults to cycling fan operation if this field is left blank.
A11, \field Fan Placement
      \required-field
      \type choice
      \key BlowThrough
      \key DrawThrough
N3 , \field Cooling Convergence Tolerance
      \type real
      \minimum> 0.0
      \default 0.001
A12; \field Cooling Coil Object Type
      \required-field
      \type choice
      \key Coil:Cooling:DX:SingleSpeed
      \key CoilSystem:Cooling:DX:HeatExchangerAssisted
    
```

Following is an example input for the cycling window air conditioner, along with its constituent components.

```

ZoneHVAC:WindowAirConditioner,
  Zone3WindAC,           ! name of window AC unit
  FanAndCoilAvailSched, ! availability schedule
  0.6,                  ! maximum air flow rate in m3/s
  0.05,                ! maximum outdoor air flow rate in m3/s
  Zone3WindACAirInletNode, ! air inlet node to AC; also a zone exhaust node
  Zone3WindACAirOutletNode, ! air outlet node of AC; also a zone inlet node
  Zone3WindACOAInNode,   ! outdoor air inlet node
  Zone3WindACExhNode,   ! relief air node
  Zone3WindACOAMixer,   ! outdoor air mixer name
  Zone3WindACFan,       ! fan name
  Zone3WindACDXCoil,    ! DX cooling coil name
  CyclingFanSch,        ! Supply air fan operation mode schedule name
  DrawThrough,         ! fan placement
  0.001,               ! Cooling Convergence Tolerance
  Coil:Cooling:DX:SingleSpeed; ! Cooling coil type
    
```

```

Schedule:Compact,
  CyclingFanSch,        !- Name
  Fraction,            !- ScheduleType
  Through: 12/31,      !- Complex Field #1
  For: AllDays,        !- Complex Field #2
  Until: 24:00,        !- Complex Field #7
  0.0;                !- Complex Field #8
    
```

```

OutdoorAir:Mixer,
  Zone3WindACOAMixer,   ! name
  Zone3WindACOAMixerOutletNode, ! mixer outlet node
  Zone3WindACOAMixerInletNode, ! mixer OA node
  Zone3WindACExhNode,   ! mixer relief node
  Zone3WindACAirInletNode; ! mixer inlet node
    
```

```

Fan:ConstantVolume,
  Zone3WindACFan,           ! name
  FanAndCoilAvailSched,    ! fan on/off schedule
  0.5,                      ! total efficiency
  75.0,                    ! pressure rise in Pascals (typical fan coil value)
  0.6,                    ! flow rate in m3/s
  0.9,                    ! motor efficiency
  1.0,                    ! motor in air stream fraction
  Zone3WindACDXOutletNode, ! fancoil fan inlet node
  Zone3WindACAirOutletNode; ! fancoil fan outlet node

```

```

Coil:Cooling:DX:SingleSpeed,
  Zone3WindACDXCoil,      !- Name
  CoolingCoilAvailSched, !- Availability Schedule Name
  autosize,              !- Rated Total Cooling Capacity {W}
  autosize,              !- Rated Sensible Heat Ratio
  3.0,                   !- Rated COP
  autosize,              !- Rated Air Flow Rate {m3/s}
  Zone3WindACOAMixerOutletNode, !- Air Inlet Node Name
  Zone3WindACDXOutletNode, !- Air Outlet Node Name
  WindACCoolCapFT,       !- Total Cooling Capacity Function of Temperature Curve Name
  WindACCoolCapFFF,      !- Total Cooling Capacity Function of Flow Fraction Curve Name
  WindACEIRFT,          !- Energy Input Ratio Function of Temperature Curve Name
  WindACEIRFFF,         !- Energy Input Ratio Function of Flow Fraction Curve Name
  WindACPLFFPLR,        !- Part Load Fraction Correlation Curve Name
  ContinuousFanWithCyclingCompressor; !- Supply Air Fan Operating Mode

```

ZoneHVAC:WindowAirConditioner Outputs

```

HVAC,Average,Window AC Total Zone Cooling Rate[W]
HVAC,Sum,Window AC Total Zone Cooling Energy[J]
HVAC,Average,Window AC Sensible Zone Cooling Rate[W]
HVAC,Sum,Window AC Sensible Zone Cooling Energy[J]
HVAC,Average,Window AC Latent Zone Cooling Rate[W]
HVAC,Sum,Window AC Latent Zone Cooling Energy[J]
HVAC,Average,Window AC Electric Power[W]
HVAC,Sum,Window AC Electric Consumption[J]
HVAC,Average,Window AC Fan RunTime Fraction
HVAC,Average,Window AC Compressor RunTime Fraction

```

Window AC Total Zone Cooling Rate[W]

This field is the total (sensible and latent) heat extraction rate of the window air conditioner unit from the zone it is serving in Watts. This is determined by the outlet and zone conditions and the mass flow rate through the unit.

Window AC Total Zone Cooling Energy[J]

This is the total (sensible and latent) heat extraction of the window air conditioner unit from the zone it is serving in Joules over the timestep being reported. This is determined by outlet and zone air conditions, the mass flow rate through the unit, and the timestep.

Window AC Sensible Zone Cooling Rate[W]

This field reports the moist air sensible heat extraction rate of the window air conditioner unit from the zone it is serving in Watts. This is determined by the outlet and zone conditions and the mass flow rate through the unit.

Window AC Sensible Zone Cooling Energy[J]

This field reports the moist air sensible heat extraction of the window air conditioner unit from the zone it is serving in Joules over the timestep being reported. This is determined by the outlet and zone conditions and the mass flow rate through the unit.

Window AC Latent Zone Cooling Rate[W]

This output is the latent heat extraction rate of the window air conditioner unit from the zone it is serving in Watts. This is determined by the outlet and zone conditions and the mass flow rate through the unit.

Window AC Latent Zone Cooling Energy[J]

This is the latent heat extraction of the window air conditioner unit from the zone it is serving in Joules over the timestep being reported. This is determined by the outlet and zone conditions and the mass flow rate through the unit.

Window AC Electric Power[W]

This output is the electricity consumption rate of the window air conditioner unit in Watts. The consumption includes electricity used by the compressor and the fans (indoor supply air fan and the condenser fan).

Window AC Electric Consumption[J]

This output is the electricity consumption of the window air conditioner unit in Joules for the time period being reported. The consumption includes electricity used by the compressor and the fans (indoor supply air fan and the condenser fan).

Window AC Fan RunTime Fraction

This is the fraction of the report timestep during which the fan had operated.

Window AC Compressor RunTime Fraction

This is the fraction of the report timestep during which the DX unit compressor had operated.

ZoneHVAC:PackagedTerminalAirConditioner

The packaged terminal air conditioner (PTAC) is a compound object made up of other components. Each PTAC consists of an outdoor air mixer, direct expansion (DX) cooling coil, heating coil (gas, electric, hot water, or steam) and a supply air fan. While the figure below shows the PTAC with draw through fan placement, blow through fan placement can also be modeled by positioning the supply air fan between the outdoor air mixer and the DX cooling coil. The packaged terminal air conditioner coordinates the operation of these components and is modeled as a type of zone equipment (Ref. ZoneHVAC:EquipmentList and ZoneHVAC:EquipmentConnections).

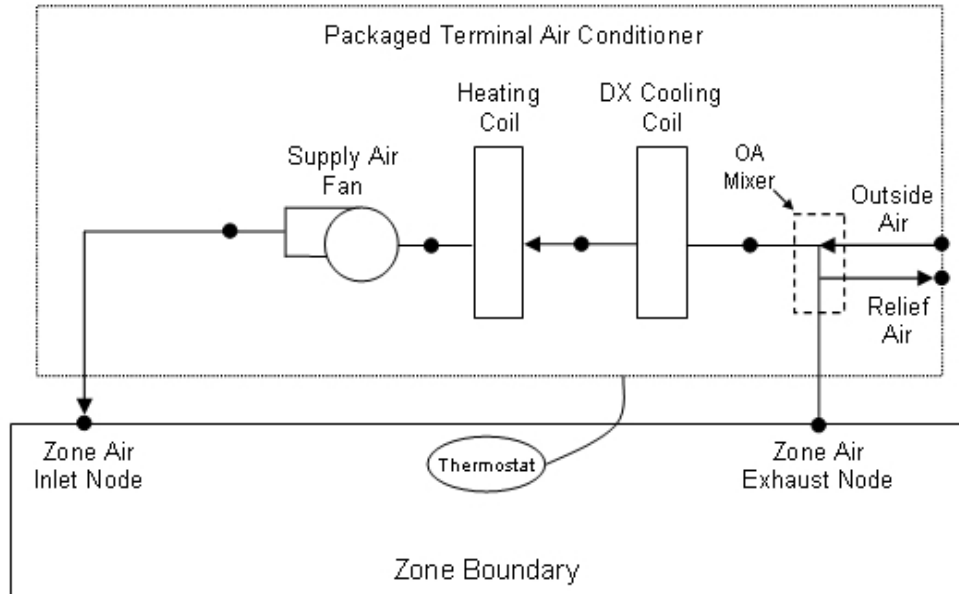


Figure 87. Schematic of a packaged terminal air conditioner with draw through fan placement

Links to the PTAC's supply air fan, DX cooling coil, heating coil, and outdoor air mixer specifications are provided in the air conditioner's input syntax. Additional inputs include supply and outdoor air flow rates during cooling operation, heating operation, and when neither cooling or heating is required. A description of each input field for the packaged terminal air conditioner compound object is provided below.

Field: Name

This alpha field defines a unique user-assigned name for an instance of a packaged terminal air conditioner. Any reference to this air conditioner by another object will use this name.

Field: Availability Schedule Name

This alpha field defines the name of the schedule (ref: Schedule) that denotes whether the air conditioner operates during a given time period. A schedule value equal to 0 denotes that the air conditioner must be off for that time period. A value greater than 0 denotes that the air conditioner is available to operate during that time period. This schedule may be used to completely disable the air conditioner (all of its coils and the supply air fan) as required.

Field: Air Inlet Node Name

This alpha field defines the name of the HVAC system node from which the air conditioner draws its inlet air. This node name must be the name of a zone air exhaust node (Ref. ZoneHVAC:EquipmentConnections).

Field: Air Outlet Node Name

This alpha field defines the name of the HVAC system node to which the air conditioner sends its outlet air. This node name must be the name of a zone air inlet node (Ref. ZoneHVAC:EquipmentConnections).

Field: Outdoor Air Mixer Name

This alpha field defines the name of an outdoor air mixer component which composes part of the PTAC. The return air node of the outdoor air mixer should also be the same node as the air inlet node of the PTAC. Furthermore, the outdoor air mixer's mixed air node should be the same as the PTAC's fan inlet air node (for blow through fan placement) or the PTAC's DX cooling coil inlet node (for draw through fan placement).

Field: Supply Air Flow Rate During Cooling Operation

This numeric field defines the supply air flow rate leaving the air conditioner in cubic meters per second when the DX cooling coil is operating. Values must be greater than 0 or this field is autosizable.

Field: Supply Air Flow Rate During Heating Operation

This numeric field defines the supply air flow rate leaving the air conditioner in cubic meters per second when the heating coil is operating. Values must be greater than 0 or this field is autosizable.

Field: Supply Air Flow Rate When No Cooling or Heating is Needed

This numeric field defines the supply air flow rate leaving the air conditioner in cubic meters per second when neither cooling nor heating is required (i.e., DX coil and heater are off but the supply air fan operates). This field is only used when the air conditioner's supply air fan operating mode schedule specifies continuous fan operation. Values must be greater than or equal to zero, or this field is autosizable. If the air conditioner's supply air fan operating mode schedule specifies continuous fan operation and this value is set to zero or this field is left blank, then the model assumes that the supply air flow rate when no cooling/heating is needed is equal to the supply air flow rate when the cooling or heating coil was last operating (for cooling operation or heating operation).

Field: Outdoor Air Flow Rate During Cooling Operation

This numeric field defines the outdoor air flow rate through the air conditioner in cubic meters per second when the DX cooling coil is operating. Values must be greater than or equal to 0, or this field is autosizable. Note that the outdoor air flow rate during cooling operation is fixed; it cannot change during the simulation. In addition, the outdoor air flow rate during cooling operation cannot be greater than the air conditioner's supply air volumetric flow rate during cooling operation.

Field: Outdoor Air Flow Rate During Heating Operation

This numeric field defines the outdoor air flow rate through the air conditioner in cubic meters per second when the heating coil is operating. Values must be greater than or equal to 0, or this field is autosizable. Note that the outdoor air flow rate during heating operation is fixed; it cannot change during the simulation. In addition, the outdoor air flow rate during heating operation cannot be greater than the air conditioner's supply air volumetric flow rate during heating operation.

Field: Outdoor Air Flow Rate When No Cooling or Heating is Needed

This numeric field defines the outdoor air flow rate through the air conditioner in cubic meters per second when neither cooling nor heating is required (i.e., cooling and heating coils are off but the supply air fan operates). Values must be greater than or equal to 0, or this field is autosizable. Note that the outdoor air flow rate when no cooling/heating is needed is fixed; it cannot change during the simulation. In addition, the outdoor air flow rate when no cooling/heating is needed cannot be greater than the air conditioner's supply air volumetric flow rate when no cooling/heating is needed. This field is only used when the air conditioner's supply air fan operating mode schedule specifies continuous fan operation. If the air conditioner's supply air fan operating mode schedule specifies continuous fan operation and the field 'Supply air volumetric flow rate when no cooling or heating is needed' is set to zero or is left blank, then the model assumes that the outdoor air flow rate when no cooling/heating is needed is equal to the outdoor air flow rate when the cooling or heating coil was last operating (for cooling operation [i.e., Outdoor air Flow rate during cooling operation] or heating operation [i.e., Outdoor air flow rate during heating operation]) and this field is not used.

Field: Supply Air Fan Object Type

This alpha field defines the type of fan used by this PTAC. The only valid choices are **Fan:OnOff** and **Fan:ConstantVolume**. A fan of type Fan:OnOff is used with cycling fan operating mode, and a fan of type Fan:ConstantVolume is used with continuous fan operating mode (see Supply Air Fan Operating Mode Schedule field below). The input requirements for these fan objects are described elsewhere in this document.

Field: Supply Air Fan Name

The name of a constant volume fan component that composes part of the PTAC. Note that the fan's maximum flow rate should be greater than or equal to the maximum supply air flow rate for the PTAC. The fan's inlet node should be the same as the outdoor air mixer's mixed air node (for blow through fan placement) or the heating coil's outlet node (for draw through fan placement). The fan's outlet node should be the same as the DX cooling coil's air inlet node (for blow through fan placement) or the PTAC's air outlet node (for draw through fan placement).

Field: Heating Coil Object Type

This alpha field defines the type of heating coil to be used by this PTAC. The input requirements for this heating coil object are described elsewhere in this document. Allowable heating coil types are:

```
Coil:Heating:Water
Coil:Heating:Electric
Coil:Heating:Gas
Coil:Heating:Steam
```

Field: Heating Coil Name

This alpha field defines the name of the heating coil used by this PTAC, and this name should match the name specified in the corresponding heating coil object.

Field: Cooling Coil Object Type

This alpha field defines the type of DX cooling coil used by this PTAC. The input requirements for these DX cooling coil objects are described elsewhere in this document. Only allowable coil types are:

```
Coil:Cooling:DX:SingleSpeed
CoilSystem:Cooling:DX:HeatExchangerAssisted
```

Field: Cooling Coil Name

This alpha field defines the name of the cooling coil used by this PTAC, and this name should match the name specified in the corresponding DX cooling coil object.

Field: Fan Placement

This alpha field has two choices: **BlowThrough** or **DrawThrough**. The first choice stands for "blow through fan". This means that the unit consists of an outdoor air mixer followed by a fan followed by the DX cooling coil and heating coil. The fan "blows through" the DX cooling coil and the heating coil. The second choice stands for "draw through fan". This means that the unit consists of an outdoor air mixer followed by the DX cooling coil and heating coil with the fan located at the outlet of the PTAC. The fan "draws air through" the DX cooling coil and the heating coil. If this field is left blank, the default is draw through.

Note: the packaged terminal air conditioner's supply air fan, cooling coil and heating coil must be connected according to the configuration shown above (Figure 87) for the draw through fan configuration. The only other valid configuration is with a blow through fan placement, where the fan is located between the outdoor air mixer and the DX cooling coil.

Field: Supply Air Fan Operating Mode Schedule Name

This alpha field specifies the name of the supply air fan operating mode schedule. The supply air fan operating mode may vary during the simulation based on time-of-day or with a change of season. Schedule values of 0 denote that the supply air fan and the heating or cooling coil cycle on and off together to meet the heating or cooling load (a.k.a. AUTO fan). Schedule values other than 0 denote that the supply fan runs continuously while the heating or cooling coil cycles to meet the load.

Below is the IDD specification for the packaged terminal air conditioner compound object.

```

ZoneHVAC:PackagedTerminalAirConditioner,
  \min-fields 17
A1, \field Name
  \required-field
  \type alpha
  \note Unique name for this packaged terminal air conditioner object.
A2, \field Availability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
  \note Schedule values of 0 denote the unit is off.
A3, \field Air Inlet Node Name
  \required-field
  \type alpha
  \note Air inlet node for the PTAC must be a zone air exhaust Node.
A4, \field Air Outlet Node Name
  \required-field
  \type alpha
  \note Air outlet node for the PTAC must be a zone air inlet node.
A5, \field Outdoor Air Mixer Name
  \required-field
  \type alpha
  \note Needs to match the name of the PTAC outdoor air mixer object.
N1, \field Supply Air Flow Rate During Cooling Operation
  \required-field
  \type real
  \units m3/s
  \minimum> 0.0
  \autosizable
  \note Must be less than or equal to fan size.
N2, \field Supply Air Flow Rate During Heating Operation
  \required-field
  \type real
  \units m3/s
  \minimum> 0.0
  \autosizable
  \note Must be less than or equal to fan size.
N3, \field Supply Air Flow Rate When No Cooling or Heating is Needed
  \type real
  \units m3/s
  \minimum 0
  \autosizable
  \note Must be less than or equal to fan size.
  \note Only used when supply air fan operating mode schedule values specify continuous fan
  \note (schedule values greater than 0 specify continuous fan operation).
  \note This air flow rate is used when no heating or cooling is required and the cooling or
  \note heating coil is off. If this field is left blank or zero, the supply air flow rate
  \note from the previous on cycle (either cooling or heating) is used.
N4, \field Outdoor Air Flow Rate During Cooling Operation
  \required-field
  \type real
  \units m3/s
  \minimum 0
  \autosizable
  \note Must be less than or equal to supply air flow rate during cooling operation.

```



```

N5 , \field Outdoor Air Flow Rate During Heating Operation
    \required-field
    \type real
    \units m3/s
    \minimum 0
    \autosizable
    \note Must be less than or equal to supply air flow rate during heating operation.
N6 , \field Outdoor Air Flow Rate When No Cooling or Heating is Needed
    \type real
    \units m3/s
    \minimum 0
    \autosizable
    \note Only used when supply air fan operating mode schedule values specify continuous fan
    \note (schedule values greater than 0 specify continuous fan operation).
    \note This air flow rate is used when no heating or cooling is required and the cooling or
    \note heating coil is off. If this field is left blank or zero, the outdoor air flow rate
    \note from the previous on cycle (either cooling or heating) is used.
A6 , \field Supply Air Fan Object Type
    \required-field
    \type choice
    \key Fan:OnOff
    \key Fan:ConstantVolume
    \note Fan:ConstantVolume only works when continuous fan operation is used the entire
    \note simulation (all supply air fan operating mode schedule values are greater than 0).
    \note If any fan operating mode schedule values are 0 a Fan:OnOff object must be used.
A7 , \field Supply Air Fan Name
    \required-field
    \type object-list
    \object-list FansCVandOnOff
    \note Needs to match in the fan object.
A8 , \field Heating Coil Object Type
    \required-field
    \type choice
    \key Coil:Heating:Gas
    \key Coil:Heating:Electric
    \key Coil:Heating:Water
    \key Coil:Heating:Steam
    \note Select the type of heating coil.
A9 , \field Heating Coil Name
    \required-field
    \type object-list
    \object-list HeatingCoilName
    \note Needs to match in the heating coil object.
A10, \field Cooling Coil Object Type
    \required-field
    \type choice
    \key Coil:Cooling:DX:SingleSpeed
    \key CoilSystem:Cooling:DX:HeatExchangerAssisted
    \note Select the type of Cooling Coil.
    \note Only works with Coil:Cooling:DX:SingleSpeed or
    \note CoilSystem:Cooling:DX:HeatExchangerAssisted.
A11, \field Cooling Coil Name
    \required-field
    \type object-list
    \object-list CoolingCoilsDXSingleSpeed
    \note Needs to match a DX cooling coil object.
A12, \field Fan Placement
    \type choice
    \key BlowThrough
    \key DrawThrough
    \default DrawThrough
    \note Select fan placement as either blow through or draw through.
A13; \field Supply Air Fan Operating Mode Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note Enter the name of a schedule that controls fan operation. Schedule Name values of 0 denote
    \note cycling fan operation (fan cycles with cooling or heating coil). Schedule Name values
greater
    \note than 0 denote constant fan operation (fan runs continually regardless of coil operation).

```

As shown in the example below, correct specification of the packaged terminal air conditioner requires the following objects in addition to the compound object itself:

- 1) Fan (Fan:OnOff or Fan:ConstantVolume)
- 2) DX cooling coil (Coil:Cooling:DX:SingleSpeed or CoilSystem:Cooling:DX:HeatExchangerAssisted)
- 3) Heating coil (Coil:Heating:Gas, Coil:Heating:Electric, Coil:Heating:Water, or Coil:Heating:Steam)
- 4) OutdoorAir:Mixer

```

ZoneHVAC:PackagedTerminalAirConditioner,
Zone2PTAC,           !- Air conditioner name
FanAndCoilAvailSched, !- Availability schedule name
Zone2PTACAirInletNode, !- Air inlet node name
Zone2PTACAirOutletNode, !- Air outlet node name
Zone2PTACOAMixer,    !- Outdoor air mixer name
autosize,           !- Supply air volumetric flow rate during cooling operation {m3/s}
autosize,           !- Supply air volumetric flow rate during heating operation {m3/s}
autosize,           !- Supply air volumetric flow rate when no cooling or heating is needed {m3/s}
autosize,           !- Outdoor air volumetric flow rate during cooling operation {m3/s}
autosize,           !- Outdoor air volumetric flow rate during heating operation {m3/s}
autosize,           !- Outdoor air volumetric flow rate when no cooling or heating is needed {m3/s}
Fan:OnOff,          !- Supply air fan type
Zone2PTACFan,       !- Supply air fan name
Coil:Heating:Electric, !- Heating coil type
Zone2PTACHeatCoil, !- Heating coil name
Coil:DX:Cooling:SingleSpeed, !- Cooling coil type
Zone2PTACDXCoolCoil, !- Cooling coil name
BlowThrough,       !- Fan placement
SupplyFanSch;      !- Supply air fan operating mode schedule name
    
```

```

Schedule:Compact,
SupplyFanSch,      !- Name
Fraction,         !- ScheduleType
Through: 12/31,   !- Complex Field #1
For: AllDays,     !- Complex Field #2
Until: 7:00,      !- Complex Field #3
0.0,             !- Complex Field #4
Until: 18:00,    !- Complex Field #5
1.0,            !- Complex Field #6
Until: 24:00,    !- Complex Field #7
0.0;            !- Complex Field #8
    
```

```

OutdoorAir:Mixer,
Zone2PTACOAMixer, !- Name
Zone2PTACOAMixerOutletNode, !- Mixed_Air_Node
Zone2PTACOAInNode, !- Outside_Air_Stream_Node
Zone2PTACExhNode, !- Relief_Air_Stream_Node
Zone2PTACAirInletNode; !- Return_Air_Stream_Node
    
```

```

Fan:OnOff,
Zone2PTACFan,     !- Fan Name
FanAndCoilAvailSched, !- Available Schedule
0.5,             !- Fan Total Efficiency
75.0,           !- Delta Pressure {Pa}
autosize,       !- Max Flow Rate {m3/s}
0.9,           !- Motor Efficiency
1.0,          !- Motor In Airstream Fraction
Zone2PTACOAMixerOutletNode, !- Fan_Inlet_Node
Zone2PTACFanOutletNode; !- Fan_Outlet_Node
    
```

```

Coil:Cooling:DX:SingleSpeed,
  Zone2PTACDXCoolCoil,           !- Coil Name
  CoolingCoilAvailSched,         !- Availability Schedule
  autosize,                      !- Rated Total Cooling Capacity (gross) {W}
  autosize,                      !- Rated SHR
  3.0,                          !- Rated COP
  autosize,                      !- Rated Air Volume Flow Rate {m3/s}
  Zone2PTACFanOutletNode,       !- Coil Air Inlet Node
  Zone2PTACCoolCoilOutletNode,  !- Coil Air Outlet Node
  HPACCoolCapFT,                !- Total Cooling Capacity Modifier Curve (function of temperature)
  HPACCoolCapFFF,               !- Total Cooling Capacity Modifier Curve (function of flow fraction)
  HPACEIRFT,                    !- Energy Input Ratio Modifier Curve (function of temperature)
  HPACEIRFFF,                   !- Energy Input Ratio Modifier Curve (function of flow fraction)
  HPACPLFFPLR,                  !- Part Load Fraction Correlation (function of part load ratio)
  ContinuousFanWithCyclingCompressor; !- Supply Air Fan Operating Mode

```

```

Coil:Heating:Electric,
  Zone2PTACHeatCoil,           !- Coil Name
  HeatingCoilAvailSched,       !- Available Schedule
  1.0,                         !- Efficiency of the Coil
  autosize,                    !- Nominal Capacity of the Coil {W}
  Zone2PTACCoolCoilOutletNode, !- Coil_Air_Inlet_Node
  Zone2PTACAirOutletNode;     !- Coil_Air_Outlet_Node

```

ZoneHVAC:PackagedTerminalAirConditioner Outputs

```

HVAC,Average,Packaged Terminal Air Conditioner Total Zone Heating Rate[W]
HVAC,Sum,Packaged Terminal Air Conditioner Total Zone Heating Energy[J]
HVAC,Average,Packaged Terminal Air Conditioner Total Zone Cooling Rate[W]
HVAC,Sum,Packaged Terminal Air Conditioner Total Zone Cooling Energy[J]
HVAC,Average,Packaged Terminal Air Conditioner Sensible Zone Heating Rate[W]
HVAC,Sum,Packaged Terminal Air Conditioner Sensible Zone Heating Energy[J]
HVAC,Average,Packaged Terminal Air Conditioner Sensible Zone Cooling Rate[W]
HVAC,Sum,Packaged Terminal Air Conditioner Sensible Zone Cooling Energy[J]
HVAC,Average,Packaged Terminal Air Conditioner Latent Zone Heating Rate[W]
HVAC,Sum,Packaged Terminal Air Conditioner Latent Zone Heating Energy[J]
HVAC,Average,Packaged Terminal Air Conditioner Latent Zone Cooling Rate[W]
HVAC,Sum,Packaged Terminal Air Conditioner Latent Zone Cooling Energy[J]
HVAC,Average,Packaged Terminal Air Conditioner Electric Power[W]
HVAC,Sum,Packaged Terminal Air Conditioner Electric Consumption[J]
HVAC,Average,Packaged Terminal Air Conditioner Fan Part-Load Ratio
HVAC,Average,Packaged Terminal Air Conditioner Part-Load Ratio

```

Packaged Terminal Air Conditioner Total Zone Heating Rate[W]

This output field is the total (enthalpy) heat addition rate of the packaged terminal air conditioner to the zone it is serving in Watts. This value is calculated using the enthalpy difference of the air conditioner outlet air and inlet air streams, and the air mass flow rate through the air conditioner. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy addition only) are averaged for the timestep being reported.

Packaged Terminal Air Conditioner Total Zone Heating Energy[J]

This output field is the total (enthalpy) heat addition of the packaged terminal air conditioner to the zone it is serving in Joules over the timestep being reported. This value is calculated using the enthalpy difference of the air conditioner outlet air and inlet air streams, the air mass flow rate through the air conditioner, and the HVAC simulation timestep. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy addition only) are summed for the timestep being reported.

Packaged Terminal Air Conditioner Total Zone Cooling Rate[W]

This output field is the total (enthalpy) heat extraction rate of the packaged terminal air conditioner from the zone it is serving in Watts. This value is calculated using the enthalpy difference of the air conditioner outlet air and inlet air streams, and the air mass flow rate through the air conditioner. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy extraction only) are averaged for the timestep being reported.

Packaged Terminal Air Conditioner Total Zone Cooling Energy[J]

This output field is the total (enthalpy) heat extraction of the packaged terminal air conditioner from the zone it is serving in Joules over the timestep being reported. This value is calculated using the enthalpy difference of the air conditioner outlet air and inlet air streams, the air mass flow rate through the air conditioner, and the HVAC simulation timestep. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy extraction only) are summed for the timestep being reported.

Packaged Terminal Air Conditioner Sensible Zone Heating Rate[W]

This output field is the sensible heat addition rate of the packaged terminal air conditioner to the zone it is serving in Watts. This value is calculated using the enthalpy difference of the air conditioner outlet air and inlet air streams at a constant humidity ratio, and the air mass flow rate through the air conditioner. This value is calculated for each HVAC system timestep being simulated, and the results (heating only) are averaged for the timestep being reported.

Packaged Terminal Air Conditioner Sensible Zone Heating Energy[J]

This output field is the sensible heat addition of the packaged terminal air conditioner to the zone it is serving in Joules over the timestep being reported. This value is calculated using the enthalpy difference of the air conditioner outlet air and inlet air streams at a constant humidity ratio, the air mass flow rate through the air conditioner, and the HVAC simulation timestep. This value is calculated for each HVAC system timestep being simulated, and the results (heating only) are summed for the timestep being reported.

Packaged Terminal Air Conditioner Sensible Zone Cooling Rate[W]

This output field reports the moist air sensible heat extraction rate of the packaged terminal air conditioner from the zone it is serving in Watts. This value is calculated using the enthalpy difference of the air conditioner outlet air and inlet air streams at a constant humidity ratio, and the air mass flow rate through the air conditioner. This value is calculated for each HVAC system timestep being simulated, and the results (cooling only) are averaged for the timestep being reported.

Packaged Terminal Air Conditioner Sensible Zone Cooling Energy[J]

This output field reports the moist air sensible heat extraction of the packaged terminal air conditioner from the zone it is serving in Joules over the timestep being reported. This value is calculated using the enthalpy difference of the air conditioner outlet air and inlet air streams at a constant humidity ratio, the air mass flow rate through the air conditioner, and the HVAC simulation timestep. This value is calculated for each HVAC system timestep being simulated, and the results (cooling only) are summed for the timestep being reported.

Packaged Terminal Air Conditioner Latent Zone Heating Rate[W]

This output field is the latent heat addition (humidification) rate of the packaged terminal air conditioner to the zone it is serving in Watts. This value is calculated as the difference between the total energy rate and the sensible energy rate provided by the packaged terminal air conditioner. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat addition only) are averaged for the timestep being reported.

Packaged Terminal Air Conditioner Latent Zone Heating Energy[J]

This output field is the latent heat addition (humidification) of the packaged terminal air conditioner to the zone it is serving in Joules over the timestep being reported. This value is calculated as the difference between the total energy delivered to the zone and the sensible energy delivered to the zone by the packaged terminal air conditioner. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat addition only) are summed for the timestep being reported.

Packaged Terminal Air Conditioner Latent Zone Cooling Rate[W]

This output field is the latent heat extraction (dehumidification) rate of the packaged terminal air conditioner from the zone it is serving in Watts. This value is calculated as the difference between the total energy rate and the sensible energy rate provided by the packaged terminal air conditioner. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat extraction only) are averaged for the timestep being reported.

Packaged Terminal Air Conditioner Latent Zone Cooling Energy[J]

This output field is the latent heat extraction (dehumidification) of the packaged terminal air conditioner from the zone it is serving in Joules over the timestep being reported. This value is calculated as the difference between the total energy delivered to the zone and the sensible energy delivered to the zone by the packaged terminal air conditioner. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat extraction only) are summed for the timestep being reported.

Packaged Terminal Air Conditioner Electric Power[W]

This output field is the electricity consumption rate of the packaged terminal air conditioner in Watts. The consumption includes electricity used by the compressor (including crankcase heater), fans (indoor supply air fan and the condenser fan), and the heating coil (includes electricity consumption rate for electric heating coil or parasitic electricity consumption rate for non-electric coils). This value is calculated for each HVAC system timestep being simulated, and the results are averaged for the timestep being reported.

Packaged Terminal Air Conditioner Electric Consumption[J]

This output field is the electricity consumption of the packaged terminal air conditioner in Joules for the time period being reported. The consumption includes electricity used by the compressor (including crankcase heater), fans (indoor supply air fan and the condenser fan), and the heating coil (includes electricity consumption for electric heating coil or parasitic electricity consumption for non-electric coils). This value is calculated for each HVAC system timestep being simulated, and the results are summed for the timestep being reported.

Packaged Terminal Air Conditioner Fan Part-Load Ratio

This output field is the part-load ratio of the fan. The fan part-load ratio is defined as the average supply air mass flow rate divided by the maximum supply air mass flow rate. The maximum supply air mass flow rate depends on whether heating, cooling, or no heating or cooling is required during the timestep. This value is calculated for each HVAC system timestep being simulated, and the results are averaged for the timestep being reported.

Packaged Terminal Air Conditioner Part-Load Ratio

This output field is the part-load ratio used by the coils (cooling and heating). Part-load ratio is defined as the total coil load divided by the coil steady-state capacity. This value is calculated for each HVAC system timestep being simulated, and the results are averaged for the timestep being reported.

ZoneHVAC:PackagedTerminalHeatPump

The packaged terminal heat pump (PTHP) is a compound object made up of other components. Each PTHP consists of an outdoor air mixer, direct expansion (DX) cooling coil, DX heating coil, supply air fan, and a supplemental heating coil as shown in the figure below. These individual components are described elsewhere in this document. The packaged terminal heat pump coordinates the operation of these components and is modeled as a type of zone equipment (Ref. ZoneHVAC:EquipmentList and ZoneHVAC:EquipmentConnections).

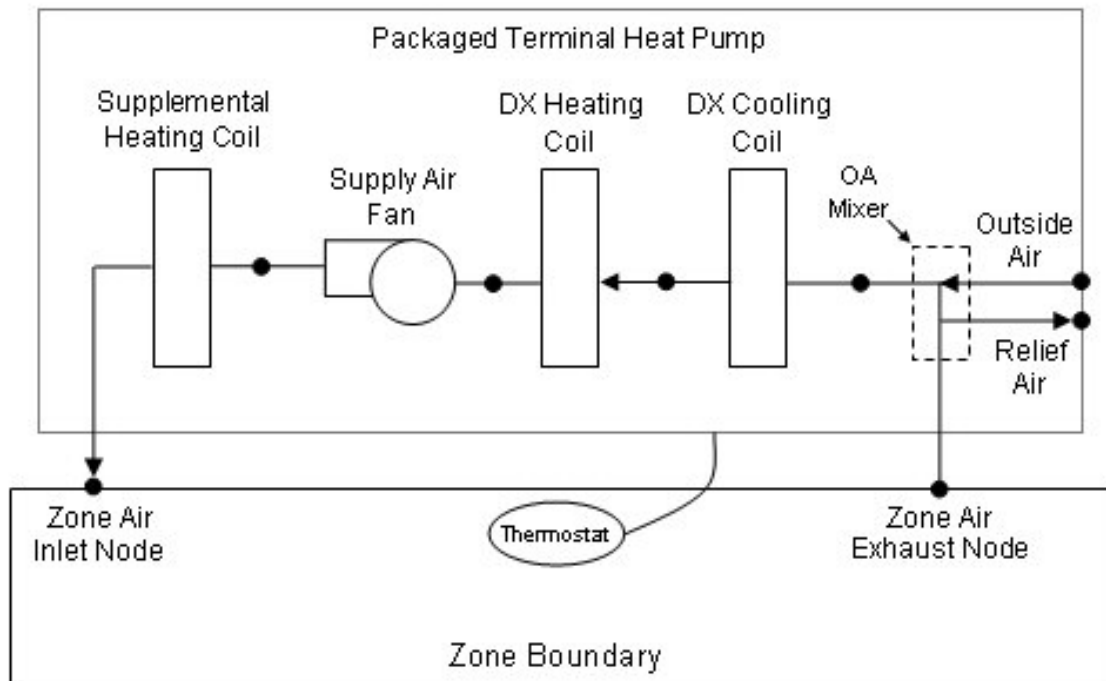


Figure 88. Schematic of a packaged terminal heat pump (draw through fan placement)

Links to the PTHP's supply air fan, DX coils, supplemental heating coil, and outdoor air mixer specifications are provided in the heat pump's input syntax. Additional inputs include supply and outdoor air flow rates during cooling operation, heating operation, and when neither cooling or heating is required. A description of each input field for the packaged terminal heat pump compound object is provided below.

Field: Name

This alpha field defines a unique user-assigned name for an instance of a packaged terminal heat pump. Any reference to this heat pump by another object will use this name.

Field: Availability Schedule Name

This alpha field defines the name of the schedule (ref: Schedule) that denotes whether the heat pump operates during a given time period. A schedule value equal to 0 denotes that the heat pump must be off for that time period. A value greater than 0 denotes that the heat pump is available to operate during that time period. This schedule may be used to completely disable the heat pump (all of its coils and the supply air fan) as required.

Field: Air Inlet Node Name

This alpha field defines the name of the HVAC system node from which the heat pump draws its inlet air. This node name must be the name of a zone air exhaust node (Ref. ZoneHVAC:EquipmentConnections).

Field: Air Outlet Node Name

This alpha field defines the name of the HVAC system node to which the heat pump sends its outlet air. This node name must be the name of a zone air inlet node (Ref. ZoneHVAC:EquipmentConnections).

Field: Outdoor Air Mixer Name

This alpha field defines the name of an outdoor air mixer component which composes part of the PTHP. Note that the return air node of the outdoor air mixer should also be the same node as the air inlet node of the PTHP. Furthermore, the outdoor air mixer's mixed air node should be the same as the PTHP's fan inlet air node (for blow through fan placement) or the PTHP's DX cooling coil inlet node (for draw through fan placement).

Field: Supply Air Flow Rate During Cooling Operation

This numeric field defines the supply air flow rate leaving the heat pump in cubic meters per second when the DX cooling coil is operating. Values must be greater than 0 or this field is autosizable.

Field: Supply Air Flow Rate During Heating Operation

This numeric field defines the supply air flow rate leaving the heat pump in cubic meters per second when the DX heating coil and/or supplemental heater are operating. Values must be greater than 0 or this field is autosizable.

Field: Supply Air Flow Rate When No Cooling or Heating is Needed

This numeric field defines the supply air flow rate leaving the heat pump in cubic meters per second when neither cooling or heating is required (i.e., DX coils and supplemental heater are off but the supply air fan operates). This field is only used when the heat pump's supply air fan operating mode schedule specifies continuous fan operation. Values must be greater than or equal to zero, or this field is autosizable. If the heat pump's supply air fan operating mode schedule specifies continuous fan operation and this value is set to zero or this field is left blank, then the model assumes that the supply air flow rate when no cooling/heating is needed is equal to the supply air flow rate when the cooling or heating coil was last operating (for cooling operation or heating operation).

Field: Outdoor Air Flow Rate During Cooling Operation

This numeric field defines the outdoor air flow rate through the heat pump in cubic meters per second when the DX cooling coil is operating. Values must be greater than or equal to 0, or this field is autosizable. Note that the outdoor air flow rate during cooling operation is fixed; it cannot change during the simulation. In addition, the outdoor air flow rate during cooling operation cannot be greater than the heat pump's supply air volumetric flow rate during cooling operation.

Field: Outdoor Air Flow Rate During Heating Operation

This numeric field defines the outdoor air flow rate through the heat pump in cubic meters per second when the DX heating coil and/or supplemental heater are operating. Values must be greater than or equal to 0, or this field is autosizable. Note that the outdoor air flow rate during heating operation is fixed; it cannot change during the simulation. In addition, the outdoor air flow rate during heating operation cannot be greater than the heat pump's supply air volumetric flow rate during heating operation.

Field: Outdoor Air Flow Rate When No Cooling or Heating is Needed

This numeric field defines the outdoor air flow rate through the heat pump in cubic meters per second when neither cooling or heating is required (i.e., DX coils and supplemental heater are off but the supply air fan operates). Values must be greater than or equal to 0, or this field is autosizable. Note that the outdoor air flow rate when no cooling/heating is needed is fixed; it cannot change during the simulation. In addition, the outdoor air flow rate when no cooling/heating is needed cannot be greater than the heat pump's supply air volumetric flow rate when no cooling/heating is needed. This field is only used when the heat pump's supply air fan operating mode schedule specifies continuous fan operation. If the heat pump's supply air fan operating mode schedule specifies continuous fan operation and the field 'Supply air volumetric flow rate when no cooling or heating is needed' is set to zero or is left blank, then the model assumes that the outdoor air flow rate when no cooling/heating is needed is equal to the outdoor air flow rate when the cooling or heating coil was last operating (for cooling operation [i.e., Outdoor air flow rate during cooling operation] or heating operation [i.e., Outdoor air flow rate during heating operation]) and this field is not used.

Field: Supply Air Fan Object Type

This alpha field defines the type of fan used by this PTHP. The only valid choices are Fan:OnOff and Fan:ConstantVolume. A fan of type Fan:OnOff may be used with either cycling or continuous fan operating mode, and a fan of type Fan:ConstantVolume is used only with continuous fan operating mode (see Supply Air Fan Operating Mode Schedule field below). The input requirements for these fan objects are described elsewhere in this document.

Field: Supply Air Fan Name

The name of a constant volume fan component that composes part of the PTHP. Note that the fan's maximum flow rate should be greater than or equal to the maximum supply air flow rate for the PTHP. The fan's inlet node should be the same as the outdoor air mixer's mixed air node (for blow through fan placement) or the DX heating coil's outlet node (for draw through fan placement). The fan's outlet node should be the same as the DX cooling coil's air inlet node (for blow through fan placement) or the supplemental heater's air inlet node (for draw through fan placement).

Field: Heating Coil Object Type

This alpha field defines the type of DX heating coil to be used by this PTHP. The only valid choice is **Coil:Heating:DX:SingleSpeed**. The input requirements for this DX heating coil object are described elsewhere in this document.

Field: Heating Coil Name

This alpha field defines the name of the DX heating coil used by this PTHP, and this name should match the name specified in the corresponding DX heating coil object.

Field: Heating Convergence Tolerance

This numeric field defines the convergence tolerance for the unit's heating output. This field allows the user some control over how closely the heat pump will control the air-side conditions. The relative size of this parameter relates directly to the closeness of the control. A very small value in this field will result in tight control and will probably result in larger numbers of iterations. A large value in this field will result in looser controls and could result in unsatisfactory fluctuations in zone air temperature. Initial experience with this parameter lends to the recommendation of using 0.001 as the starting point.

The heat pump is controlled by matching its sensible (temperature) heating output to the zone sensible load (demand). Because the performance of the DX heating coil is frequently non-linear, the heat pump model must call the DX heating coil model several times (iterate) to determine the proper run time fraction to meet the zone load. The heating convergence

tolerance is the error tolerance used to terminate the iteration procedure when the following equation is satisfied:

$$\frac{|(Q_{ZoneLoad} - Q_{HeatPump,out})|}{Q_{ZoneLoad}} \leq HeatingConvergenceTolerance$$

The maximum number of iterations is limited, with a warning message generated if the above equation is not satisfied within the maximum number of iterations.

Field: Minimum Outdoor Dry-Bulb Temperature for Compressor Operation

This numeric field defines the minimum outdoor dry-bulb temperature in degrees Celsius for PTHP compressor operation. The compressor will not operate (for DX heating or DX cooling) when outdoor dry-bulb temperatures fall below this value. The minimum value must be greater than or equal to -20 °C. If this field is left blank, the default value is -8°C. This temperature should match the minimum compressor operating temperature specified for the heat pump's DX heating coil (if they don't match, the highest of the two temperatures will be the cut-off temperature for compressor operation).

Field: Cooling Coil Object Type

This alpha field defines the type of DX cooling coil used by this PTHP. The input requirements for these DX cooling coil objects are described elsewhere in this document. Only allowable coil types are:

```
Coil:Cooling:DX:SingleSpeed
CoilSystem:Cooling:DX:HeatExchangerAssisted
```

Field: Cooling Coil Name

This alpha field defines the name of the cooling coil used by this PTHP, and this name should match the name specified in the corresponding DX cooling coil object.

Field: Cooling Convergence Tolerance

This numeric field defines the convergence tolerance for the unit's cooling output. This field allows the user some control over how closely the heat pump will control the air-side conditions. The relative size of this parameter relates directly to the closeness of the control. A very small value in this field will result in tight control and will probably result in larger numbers of iterations. A large value in this field will result in looser controls and could result in unsatisfactory fluctuations in zone air temperature. Initial experience with this parameter lends to the recommendation of using 0.001 as the starting point.

The heat pump is controlled by matching its sensible (temperature) cooling output to the zone sensible load (demand). Because the performance of the DX cooling coil is frequently non-linear, the heat pump model must call the DX cooling coil model several times (iterate) to determine the proper run time fraction to meet the zone load. The cooling convergence tolerance is the error tolerance used to terminate the iteration procedure when the following equation is satisfied:

$$\frac{|(Q_{ZoneLoad} - Q_{HeatPump,out})|}{Q_{ZoneLoad}} \leq CoolingConvergenceTolerance$$

The maximum number of iterations is limited, with a warning message generated if the above equation is not satisfied within the maximum number of iterations.

Field: Supplemental Heating Coil Object Type

This alpha field defines the type of supplemental heating coil to be used by this PTHP. The input requirements for these heating coil objects are described elsewhere in this document. Only allowable coil types are:

Coil:Heating:Electric Coil:Heating:Gas

Field: Supplemental Heating Coil Name

This alpha field defines the name of the supplemental heating coil used by this PTHP, and this name should match the name specified in the corresponding heating coil object.

Field: Maximum Supply Air Temperature from Supplemental Heater

This numeric field defines the maximum supply air temperature in degrees Celsius exiting the heat pump supplemental heater coil. The supplemental heater will be controlled so that its supply air temperature does not exceed this value. This field is autosizable.

Field: Maximum Outdoor Dry-Bulb Temperature for Supplemental Heater Operation

This numeric field defines the maximum outdoor dry-bulb temperature in degrees Celsius for PTHP supplemental heater operation. The supplemental heater will not operate when the outdoor dry-bulb temperature is above this value. The maximum value must be less than or equal to 21°C. If this field is left blank, the default value is 21°C.

Field: Fan Placement

This alpha field has two choices: **BlowThrough** or **DrawThrough**. The first choice stands for “blow through fan”. This means that the unit consists of an outdoor air mixer followed by a fan followed by the DX coils and supplemental heating coil. The fan “blows through” the cooling and heating coils. The second choice stands for “draw through fan”. This means that the unit consists of an outdoor air mixer followed by the DX coil(s) followed by a fan, with the supplemental heater located at the outlet of the fan. The fan “draws air through” the DX coil(s). If this field is left blank, the default is draw through.

Note: the packaged terminal heat pump’s supply air fan, cooling coil, heating coil and supplementary heating coil must be connected according to the configuration shown above (Figure 88) for the draw through fan configuration. The only other valid configuration is with a blow through fan placement, where the fan is located between the outdoor air mixer and the DX cooling coil.

Field: Supply Air Fan Operating Mode Schedule Name

This alpha field specifies the name of the supply air fan operating mode schedule. The supply air fan operating mode may vary during the simulation based on time-of-day or with a change of season. Schedule values of 0 denote that the supply air fan and the heating or cooling coil cycle on and off together to meet the heating or cooling load (a.k.a. AUTO fan). Schedule values other than 0 denote that the supply air fan runs continuously while the heating or cooling coil cycles to meet the load. If this field is left blank, the model assumes the supply air fan cycles with the heating or cooling coil throughout the simulation. The operating mode specified here overrides the operating mode specified in the cooling and heating coil objects.

Below is the IDD specification for the packaged terminal heat pump compound object.

```

ZoneHVAC:PackagedTerminalHeatPump,
  \min-fields 26
A1, \field Name
   \required-field
   \type alpha
   \note Unique name for this packaged terminal heat pump object.
A2, \field Availability Schedule Name
   \required-field
   \type object-list
   \object-list ScheduleNames
   \note Schedule values of 0 denote the unit is off.
A3, \field Air Inlet Node Name
   \required-field
   \type alpha
   \note Air inlet node for the PTHP must be a zone air exhaust node.
A4, \field Air Outlet Node Name
   \required-field
   \type alpha
   \note Air outlet node for the PTHP must be a zone air inlet node.
A5, \field Outdoor Air Mixer Name
   \required-field
   \type alpha
   \note Needs to match name of outdoor air mixer object.
N1, \field Supply Air Flow Rate During Cooling Operation
   \required-field
   \type real
   \units m3/s
   \minimum> 0.0
   \autosizable
   \note Must be less than or equal to fan size.
N2, \field Supply Air Flow Rate During Heating Operation
   \required-field
   \type real
   \units m3/s
   \minimum> 0.0
   \autosizable
   \note Must be less than or equal to fan size.
N3, \field Supply Air Flow Rate When No Cooling or Heating is Needed
   \type real
   \units m3/s
   \minimum 0
   \autosizable
   \note Must be less than or equal to fan size.
   \note Only used when heat pump fan operating mode is ContinuousFanWithCyclingCompressor. This air
flow rate
   \note is used when no heating or cooling is required and the DX coil compressor is off.
   \note If this field is left blank or zero, the supply air flow rate from the previous on cycle
   \note (either cooling or heating) is used.
N4, \field Outdoor Air Flow Rate During Cooling Operation
   \required-field
   \type real
   \units m3/s
   \minimum 0
   \autosizable
   \note Must be less than or equal to supply air flow rate during cooling operation.
N5, \field Outdoor Air Flow Rate During Heating Operation
   \required-field
   \type real
   \units m3/s
   \minimum 0
   \autosizable
   \note Must be less than or equal to supply air flow rate during heating operation.

```

```

N6 , \field Outdoor Air Flow Rate When No Cooling or Heating is Needed
    \type real
    \units m3/s
    \minimum 0
    \autosizable
    \note Only used when heat pump Fan operating mode is ContinuousFanWithCyclingCompressor. This air
flow rate
    \note is used when no heating or cooling is required and the DX coil compressor is off.
    \note If this field is left blank or zero, the outdoor air flow rate from the previous on cycle
    \note (either cooling or heating) is used.
A6 , \field Supply Air Fan Object Type
    \required-field
    \type choice
    \key Fan:OnOff
    \key Fan:ConstantVolume
    \note Fan:ConstantVolume only works with operating mode = ContinuousFanWithCyclingCompressor.
A7 , \field Supply Air Fan Name
    \required-field
    \type object-list
    \object-list FansCVandOnOff
    \note Needs to match a fan object.
A8 , \field Heating Coil Object Type
    \required-field
    \type choice
    \key Coil:Heating:DX:SingleSpeed
    \note Only works with Coil:Heating:DX:SingleSpeed.
A9 , \field Heating Coil Name
    \required-field
    \type object-list
    \object-list HeatingCoilsDXSingleSpeed
    \note Needs to match in the DX Heating Coil object.
N7 , \field Heating Convergence Tolerance
    \type real
    \minimum> 0.0
    \default 0.001
    \units dimensionless
    \note Defines Heating convergence tolerance as a fraction of Heating load to be met.
N8 , \field Minimum Outdoor Dry-Bulb Temperature for Compressor Operation
    \type real
    \minimum -20.0
    \default -8.0
    \units C
    \note Needs to match the corresponding minimum outdoor temperature defined
    \note in the DX Heating Coil object.
A10, \field Cooling Coil Object Type
    \required-field
    \type choice
    \key Coil:Cooling:DX:SingleSpeed
    \key CoilSystem:Cooling:DX:HeatExchangerAssisted
    \note Only works with Coil:Cooling:DX:SingleSpeed or
    \note CoilSystem:Cooling:DX:HeatExchangerAssisted.
A11, \field Cooling Coil Name
    \required-field
    \type object-list
    \object-list CoolingCoilsDXSingleSpeed
    \note Needs to match in the DX Cooling Coil object.
N9 , \field Cooling Convergence Tolerance
    \type real
    \minimum> 0.0
    \default 0.001
    \units dimensionless
    \note Defines Cooling convergence tolerance as a fraction of the Cooling load to be met.
A12, \field Supplemental Heating Coil Object Type
    \required-field
    \type choice
    \key Coil:Heating:Gas
    \key Coil:Heating:Electric
    \note Only works with Coil:Heating:Gas or Coil:Heating:Electric.

```

```

A13, \field Supplemental Heating Coil Name
    \required-field
    \type object-list
    \object-list HeatingCoilsGasElec
    \note Needs to match in the supplemental heating coil object.
N10, \field Maximum Supply Air Temperature from Supplemental Heater
    \required-field
    \type real
    \units C
    \autosizable
    \note Supply air temperature from the supplemental heater will not exceed this value.
N11, \field Maximum Outdoor Dry-Bulb Temperature for Supplemental Heater Operation
    \type real
    \maximum 21.0
    \default 21.0
    \units C
    \note Supplemental heater will not operate when outdoor temperature exceeds this value.
A14, \field Fan Placement
    \type choice
    \key BlowThrough
    \key DrawThrough
    \default DrawThrough
    \note Select fan placement as either blow through or draw through.
A15; \field Supply Air Fan Operating Mode Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note Enter the name of a schedule that controls fan operation. Schedule values of 0 denote
    \note cycling fan operation (fan cycles with cooling or heating coil). Schedule Name values
greater
    \note than 0 denote constant fan operation (fan runs continually regardless of coil operation).
    \note The fan operating mode defaults to cycling fan operation if this field is left blank.

```

As shown in the example below, correct specification of the packaged terminal heat pump requires the following objects in addition to the compound object itself:

- 1) Fan (Fan:OnOff or Fan:ConstantVolume)
- 2) DX cooling coil (Coil:Cooling:DX:SingleSpeed or CoilSystem:Cooling:DX:HeatExchangerAssisted)
- 3) DX heating coil (Coil:Heating:DX:SingleSpeed)
- 4) Supplemental heating coil (Coil:Heating:Gas or Coil:Heating:Electric)
- 5) OutdoorAir:Mixer

```

ZoneHVAC:PackagedTerminalHeatPump,
  Zone2PTHP,                !- Name
  FanAndCoilAvailSched,    !- Availability Schedule Name
  Zone2PTHPAirInletNode,   !- Air Inlet Node Name
  Zone2PTHPAirOutletNode,  !- Air Outlet Node Name
  Zone2PTHPOAMixer,        !- Outdoor Air Mixer Name
  autosize,                 !- Supply Air Flow Rate During Cooling Operation {m3/s}
  autosize,                 !- Supply Air Flow Rate During Heating Operation {m3/s}
  autosize,                 !- Supply Air Flow Rate When No Cooling or Heating is Needed {m3/s}
  autosize,                 !- Outdoor Air Flow Rate During Cooling Operation {m3/s}
  autosize,                 !- Outdoor Air Flow Rate During Heating Operation {m3/s}
  autosize,                 !- Outdoor Air Flow Rate When No Cooling or Heating is Needed {m3/s}
  Fan:OnOff,                !- Supply Air Fan Object Type
  Zone2PTHPFan,            !- Supply Air Fan Name
  Coil:Heating:DX:SingleSpeed, !- Heating Coil Object Type
  Zone2PTHPDHeatCoil,      !- Heating Coil Name
  0.001,                    !- Heating Convergence Tolerance {dimensionless}
  2.0,                      !- Minimum Outdoor Dry-Bulb Temperature for Compressor Operation {C}
  Coil:Cooling:DX:SingleSpeed, !- Cooling Coil Object Type
  Zone2PTHPDCoolCoil,     !- Cooling Coil Name
  0.001,                    !- Cooling Convergence Tolerance {dimensionless}
  Coil:Heating:Electric,   !- Supplemental Heating Coil Object Type
  Zone2PTHPSupHeater,     !- Supplemental Heating Coil Name
  autosize,                !- Maximum Supply Air Temperature from Supplemental Heater {C}
  10.0,                    !- Maximum Outdoor Dry-Bulb Temperature for Supplemental Heater Operation {C}
  BlowThrough,             !- Fan Placement
  CyclingFanSch;           !- Supply Air Fan Operating Mode Schedule Name
    
```

```

Schedule:Compact,
  CyclingFanSch,           !- Name
  Fraction,                !- ScheduleType
  Through: 12/31,          !- Complex Field #1
  For: AllDays,            !- Complex Field #2
  Until: 24:00,            !- Complex Field #7
  0.0;                     !- Complex Field #8
    
```

```

OutdoorAir:Mixer,
  Zone2PTHPOAMixer,        !- Name
  Zone2PTHPOAMixerOutletNode, !- Mixed_Air_Node
  Zone2PTHPOAInNode,       !- Outside_Air_Stream_Node
  Zone2PTHPExhNode,        !- Relief_Air_Stream_Node
  Zone2PTHPAirInletNode;   !- Return_Air_Stream_Node
    
```

```

Fan:OnOff,
  Zone2PTHPFan,            !- Fan Name
  FanAndCoilAvailSched,   !- Available Schedule
  0.5,                     !- Fan Total Efficiency
  75.0,                    !- Delta Pressure {Pa}
  autosize,                !- Max Flow Rate {m3/s}
  0.9,                     !- Motor Efficiency
  1.0,                     !- Motor In Airstream Fraction
  Zone2PTHPOAMixerOutletNode, !- Fan_Inlet_Node
  Zone2PTHPFanOutletNode; !- Fan_Outlet_Node
    
```

```

Coil:DX:Cooling:SingleSpeed,
  Zone2PTHDPXCoolCoil,           !- Coil Name
  CoolingCoilAvailSched,         !- Availability Schedule
  autosize,                      !- Rated Total Cooling Capacity (gross) {W}
  autosize,                      !- Rated SHR
  3.0,                          !- Rated COP
  autosize,                      !- Rated Air Volume Flow Rate {m3/s}
  Zone2PTHDPFanOutletNode,       !- Coil Air Inlet Node
  Zone2PTHPCoolCoilOutletNode,   !- Coil Air Outlet Node
  HPACCoolCapFT,                 !- Total Cooling Capacity Modifier Curve (function of temperature)
  HPACCoolCapFFF,               !- Total Cooling Capacity Modifier Curve (function of flow fraction)
  HPACEIRFT,                    !- Energy Input Ratio Modifier Curve (function of temperature)
  HPACEIRFFF,                   !- Energy Input Ratio Modifier Curve (function of flow fraction)
  HPACPLFFPLR,                  !- Part Load Fraction Correlation (function of part load ratio)
  CyclingFanAndCompressor;      !- Supply Air Fan Operation Mode
    
```

```

COIL:DX:Heating:SingleSpeed,
  Zone2PTHDPXHeatCoil,          !- Coil Name
  HeatingCoilAvailSched,        !- Availability Schedule
  autosize,                    !- Rated Total Heating Capacity {W}
  2.75,                        !- Rated COP
  autosize,                    !- Rated Air Volume Flow Rate {m3/s}
  Zone2PTHPCoolCoilOutletNode, !- Coil Air Inlet Node
  Zone2PTHDPXHeatCoilOutletNode, !- Coil Air Outlet Node
  HPACHeatCapFT,               !- Total heating capacity modifier curve (function of temperature)
  HPACHeatCapFFF,             !- Total heating capacity modifier curve (function of flow fraction)
  HPACHeatEIRFT,              !- Energy input ratio modifier curve (function of temperature)
  HPACHeatEIRFFF,             !- Energy input ratio modifier curve (function of flow fraction)
  HPACCOOLPLFFPLR,            !- Part load fraction correlation (function of part load ratio)
  ,                             !- Defrost energy input ratio modifier curve (function of temperature)
  CyclingFanAndCompressor,     !- Supply Air Fan Operation Mode
  2.0,                         !- Minimum Outdoor Dry-bulb Temperature for Compressor Operation {C}
  5.0,                         !- Maximum Outdoor Dry-bulb Temperature for Defrost Operation {C}
  200.0,                       !- Crankcase Heater Capacity {W}
  10.0,                        !- Maximum Outdoor Dry-bulb Temperature for Crankcase Heater Operation {C}
  Resistive,                   !- Defrost Strategy
  TIMED,                       !- Defrost Control
  0.166667,                   !- Defrost Time Period Fraction
  20000;                       !- Resistive Defrost Heater Capacity {W}
    
```

```

Coil:Heating:Electric,
  Zone2PTHPSupHeater,          !- Coil Name
  HeatingCoilAvailSched,       !- Available Schedule
  1.0,                         !- Efficiency of the Coil
  autosize,                   !- Nominal Capacity of the Coil {W}
  Zone2PTHDPXHeatCoilOutletNode, !- Coil_Air_Inlet_Node
  Zone2PTHPAirOutletNode;      !- Coil_Air_Outlet_Node
    
```

ZoneHVAC:PackagedTerminalHeatPump Outputs

```

HVAC,Average,Packaged Terminal Heat Pump Total Zone Heating Rate[W]
HVAC,Sum,Packaged Terminal Heat Pump Total Zone Heating Energy[J]
HVAC,Average,Packaged Terminal Heat Pump Total Zone Cooling Rate[W]
HVAC,Sum,Packaged Terminal Heat Pump Total Zone Cooling Energy[J]
HVAC,Average,Packaged Terminal Heat Pump Sensible Zone Heating Rate[W]
HVAC,Sum,Packaged Terminal Heat Pump Sensible Zone Heating Energy[J]
HVAC,Average,Packaged Terminal Heat Pump Sensible Zone Cooling Rate[W]
HVAC,Sum,Packaged Terminal Heat Pump Sensible Zone Cooling Energy[J]
HVAC,Average,Packaged Terminal Heat Pump Latent Zone Heating Rate[W]
HVAC,Sum,Packaged Terminal Heat Pump Latent Zone Heating Energy[J]
HVAC,Average,Packaged Terminal Heat Pump Latent Zone Cooling Rate[W]
HVAC,Sum,Packaged Terminal Heat Pump Latent Zone Cooling Energy[J]
HVAC,Average,Packaged Terminal Heat Pump Electric Power[W]
HVAC,Sum,Packaged Terminal Heat Pump Electric Consumption[J]
HVAC,Average,Packaged Terminal Heat Pump Fan Part-Load Ratio
HVAC,Average,Packaged Terminal Heat Pump Compressor Part-Load Ratio
    
```

Packaged Terminal Heat Pump Total Zone Heating Rate[W]

This output field is the total (enthalpy) heat addition rate of the packaged terminal heat pump to the zone it is serving in Watts. This value is calculated using the enthalpy difference of the heat pump outlet air and inlet air streams, and the air mass flow rate through the heat pump. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy addition only) are averaged for the timestep being reported.

Packaged Terminal Heat Pump Total Zone Heating Energy[J]

This output field is the total (enthalpy) heat addition of the packaged terminal heat pump to the zone it is serving in Joules over the timestep being reported. This value is calculated using the enthalpy difference of the heat pump outlet air and inlet air streams, the air mass flow rate through the heat pump, and the HVAC simulation timestep. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy addition only) are summed for the timestep being reported.

Packaged Terminal Heat Pump Total Zone Cooling Rate[W]

This output field is the total (enthalpy) heat extraction rate of the packaged terminal heat pump from the zone it is serving in Watts. This value is calculated using the enthalpy difference of the heat pump outlet air and inlet air streams, and the air mass flow rate through the heat pump. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy extraction only) are averaged for the timestep being reported.

Packaged Terminal Heat Pump Total Zone Cooling Energy[J]

This output field is the total (enthalpy) heat extraction of the packaged terminal heat pump from the zone it is serving in Joules over the timestep being reported. This value is calculated using the enthalpy difference of the heat pump outlet air and inlet air streams, the air mass flow rate through the heat pump, and the HVAC simulation timestep. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy extraction only) are summed for the timestep being reported.

Packaged Terminal Heat Pump Sensible Zone Heating Rate[W]

This output field is the sensible heat addition rate of the packaged terminal heat pump to the zone it is serving in Watts. This value is calculated using the enthalpy difference of the heat pump outlet air and inlet air streams at a constant humidity ratio, and the air mass flow rate through the heat pump. This value is calculated for each HVAC system timestep being simulated, and the results (heating only) are averaged for the timestep being reported.

Packaged Terminal Heat Pump Sensible Zone Heating Energy[J]

This output field is the sensible heat addition of the packaged terminal heat pump to the zone it is serving in Joules over the timestep being reported. This value is calculated using the enthalpy difference of the heat pump outlet air and inlet air streams at a constant humidity ratio, the air mass flow rate through the heat pump, and the HVAC simulation timestep. This value is calculated for each HVAC system timestep being simulated, and the results (heating only) are summed for the timestep being reported.

Packaged Terminal Heat Pump Sensible Zone Cooling Rate[W]

This output field reports the moist air sensible heat extraction rate of the packaged terminal heat pump from the zone it is serving in Watts. This value is calculated using the enthalpy difference of the heat pump outlet air and inlet air streams at a constant humidity ratio, and the air mass flow rate through the heat pump. This value is calculated for each HVAC system timestep being simulated, and the results (cooling only) are averaged for the timestep being reported.

Packaged Terminal Heat Pump Sensible Zone Cooling Energy[J]

This output field reports the moist air sensible heat extraction of the packaged terminal heat pump from the zone it is serving in Joules over the timestep being reported. This value is calculated using the enthalpy difference of the heat pump outlet air and inlet air streams at a constant humidity ratio, the air mass flow rate through the heat pump, and the HVAC simulation timestep. This value is calculated for each HVAC system timestep being simulated, and the results (cooling only) are summed for the timestep being reported.

Packaged Terminal Heat Pump Latent Zone Heating Rate[W]

This output field is the latent heat addition (humidification) rate of the packaged terminal heat pump to the zone it is serving in Watts. This value is calculated as the difference between the total energy rate and the sensible energy rate provided by the packaged terminal heat pump. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat addition only) are averaged for the timestep being reported.

Packaged Terminal Heat Pump Latent Zone Heating Energy[J]

This output field is the latent heat addition (humidification) of the packaged terminal heat pump to the zone it is serving in Joules over the timestep being reported. This value is calculated as the difference between the total energy delivered to the zone and the sensible energy delivered to the zone by the packaged terminal heat pump. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat addition only) are summed for the timestep being reported.

Packaged Terminal Heat Pump Latent Zone Cooling Rate[W]

This output field is the latent heat extraction (dehumidification) rate of the packaged terminal heat pump from the zone it is serving in Watts. This value is calculated as the difference between the total energy rate and the sensible energy rate provided by the packaged terminal heat pump. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat extraction only) are averaged for the timestep being reported.

Packaged Terminal Heat Pump Latent Zone Cooling Energy[J]

This output field is the latent heat extraction (dehumidification) of the packaged terminal heat pump from the zone it is serving in Joules over the timestep being reported. This value is calculated as the difference between the total energy delivered to the zone and the sensible energy delivered to the zone by the packaged terminal heat pump. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat extraction only) are summed for the timestep being reported.

Packaged Terminal Heat Pump Electric Power[W]

This output field is the electricity consumption rate of the packaged terminal heat pump in Watts. The consumption includes electricity used by the compressor (including crankcase heater), fans (indoor supply air fan and the condenser fan), and the supplemental heating coil (if electric). This value is calculated for each HVAC system timestep being simulated, and the results are averaged for the timestep being reported.

Packaged Terminal Heat Pump Electric Consumption[J]

This output field is the electricity consumption of the packaged terminal heat pump in Joules for the time period being reported. The consumption includes electricity used by the compressor (including crankcase heater), fans (indoor supply air fan and the condenser fan), and the supplemental heating coil (if electric). This value is calculated for each HVAC system timestep being simulated, and the results are summed for the timestep being reported.

Packaged Terminal Heat Pump Fan Part-Load Ratio

This output field is the part-load ratio of the fan. The fan part-load ratio is defined as the average supply air mass flow rate divided by the maximum supply air mass flow rate. The maximum supply air mass flow rate depends on whether heating, cooling, or no heating or cooling is required during the timestep. This value is calculated for each HVAC system timestep being simulated, and the results are averaged for the timestep being reported.

Packaged Terminal Heat Pump Compressor Part-Load Ratio

This output field is the part-load ratio of the compressor used by the DX coils (cooling and heating). Compressor part-load ratio is defined as the total coil load divided by the coil steady-state capacity. This value is calculated for each HVAC system timestep being simulated, and the results are averaged for the timestep being reported.

ZoneHVAC:EnergyRecoveryVentilator

The ZoneHVAC:EnergyRecoveryVentilator - stand alone energy recovery ventilator (ERV) is a single-zone HVAC component used for exhaust air heat recovery (Figure 89). This compound object consists of 3 required components: a generic air-to-air heat exchanger (see object Heat Exchanger:Air to Air:Generic), a supply air fan, and an exhaust air fan (see object Fan:OnOff).

An optional controller (see object ZoneHVAC:EnergyRecoveryVentilator:Controller) may be used to simulate economizer (free cooling) operation, modify air flow rates based on high indoor humidity, or simulate a “push-button” type economizer controller.

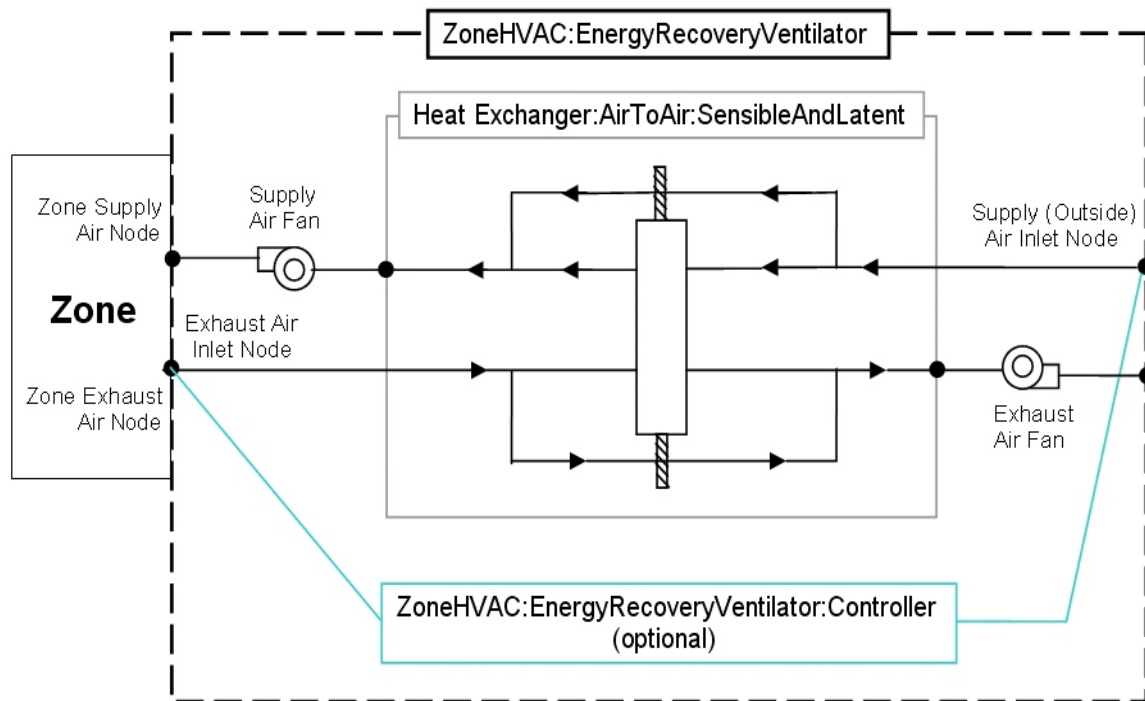


Figure 89. Schematic of the ZoneHVAC:EnergyRecoveryVentilator compound object

This compound object models the basic operation of supply and exhaust air fans and an air-to-air heat exchanger. The stand alone ERV operates whenever the unit is scheduled to be available (Availability schedule). The stand alone ERV object can be used in conjunction with an economizer feature whereby heat exchange is suspended whenever free cooling is available (i.e., air flow is fully bypassed around a fixed-plate heat exchanger or the rotation of a rotary heat exchanger is stopped). The economizer feature may also be activated based on a time-of-day schedule. Heat exchange is also suspended when air flow rates through the

heat exchanger are modified in response to a zone humidistat. When an economizer is used in conjunction with high humidity control, high humidity control has the priority.

To model a stand alone ERV connected to a single zone, the input data file should include the following objects:

- ZoneHVAC:EnergyRecoveryVentilator
- HeatExchanger:AirToAir:SensibleAndLatent
- Fan:OnOff (supply air)
- Fan:OnOff (exhaust air)
- ZoneHVAC:EnergyRecoveryVentilator:Controller (if economizer [free cooling] mode or high humidity control operation is desired)
- ZoneControl:Humidistat (required for high humidity control option)
- SetpointManager:Scheduled (if supply air outlet temperature control is used, Ref. Heat Exchanger:Air to Air:Generic for additional guidance)
- ZoneHVAC:EquipmentConnections
- ZoneHVAC:EquipmentList
- OutdoorAir:NodeList

A description of each input field for this compound object is provided below.

Field: Name

A unique user-assigned name for the stand alone ERV unit. Any reference to this unit by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the unit can operate during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit can operate during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit will not operate.

Field: Heat Exchanger Name

The user-assigned name corresponding to the air-to-air heat exchanger used in this compound object. The only allowable type is:

HeatExchanger:AirToAir:SensibleAndLatent

Field: Supply Air Flow Rate

The supply air flow rate through the ERV unit in cubic meters per second at standard temperature and pressure (dry air at 20° C drybulb). The program uses local barometric pressure to account for altitude using the equation for "standard atmospheric" pressure on p 6.1 of the ASHRAE 1997 HOF (SI edition) to initialize the air systems being simulated.

$$p=101325*(1-2.25577E-05*Z)**5.2559$$

where p=pressure in Pa and Z=altitude in m

Note that this flow rate must be within the valid air flow range for the heat exchanger (ref: HeatExchanger:AirToAir:SensibleAndLatent in the Engineering Document). In addition, this flow rate must be less than or equal to the supply fan air flow rate (Fan:OnOff). If the supply air flow rate is less than the exhaust air flow rate, the zone infiltration (ref: ZoneInfiltration) should be specified accordingly (the infiltration induced by imbalanced air flows is not accounted for automatically). The ERV supply air flow rate may also be autosized using the ventilation rate per floor area and/or ventilation rate per occupant fields below. When autosizing, the heat exchanger and fan air flow rates should also be autosized.

Note: The supply air inlet node specified in the generic heat exchanger object must be an outdoor air node (ref: OutdoorAir:Node and OutdoorAir:NodeList). The supply air outlet node specified in the generic heat exchanger object must be a zone air inlet node (ref: ZoneHVAC:EquipmentConnections).

Field: Exhaust Air Flow Rate

The exhaust air flow rate through the ERV unit in cubic meters per second at standard temperature and pressure (dry air at 20° C drybulb). The program uses local barometric pressure to account for altitude using the equation for "standard atmospheric" pressure on p 6.1 of the ASHRAE 1997 HOF (SI edition) to initialize the air systems being simulated.

$$p=101325*(1-2.25577E-05*Z)**5.2559$$

where p=pressure in Pa and Z=altitude in m

Note that this flow rate must be within the valid air flow range for the heat exchanger (ref: HeatExchanger:AirToAir:SensibleAndLatent in the Engineering Document). In addition, this flow rate must be less than or equal to the exhaust fan air flow rate (Fan:OnOff). If the exhaust air flow rate is greater than the supply air flow rate, the zone infiltration (ref: ZoneInfiltration) should be specified accordingly (the infiltration induced by imbalanced air flows is not accounted for automatically). The ERV exhaust air flow rate may also be autosized using the ventilation rate per floor area and/or ventilation rate per occupant fields below. When autosizing, the heat exchanger and fan air flow rates should also be autosized.

Note: The exhaust air inlet node specified in the generic heat exchanger object must be a zone air exhaust node (ref: ZoneHVAC:EquipmentConnections).

Field: Supply Air Fan Name

The name of the supply air fan used in this object. Fan type must be Fan:OnOff.

Field: Exhaust Air Fan Name

The name of the exhaust air fan used in this object. Fan type must be Fan:OnOff.

Field: Controller Name

This optional field specifies the name of the controller used by this compound component if economizer (free cooling) mode or high humidity control operation is desired. Controller type must be ZoneHVAC:EnergyRecoveryVentilator:Controller.

Field: Ventilation Rate per Unit Floor Area

This optional numeric field defines the ventilation rate per unit floor area in cubic meters per second per square meter. This field is only used when the supply and exhaust air flow rates are autosized.

Field: Ventilation Rate per Occupant

This optional numeric field defines the ventilation rate per occupant in cubic meters per second per occupant. This field is only used when the supply and exhaust air flow rates are autosized.

The full IDD specification follows:

```

ZoneHVAC:EnergyRecoveryVentilator,
  \memo This compound component models a stand-alone energy recovery ventilator (ERV)
  \memo that conditions outdoor ventilation air and supplies that air directly to a zone.
  \memo The ERV unit is modeled as a collection of components: air-to-air heat exchanger,
  \memo supply air fan, exhaust air fan and an optional controller to avoid overheating
  \memo of the supply air (economizer or free cooling operation).
  \min-fields 7
A1, \field Name
    \required-field
    \type alpha
A2 , \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A3 , \field Heat Exchanger Name
    \required-field
    \note Heat exchanger type must be HeatExchanger:AirToAir:SensibleAndLatent
    \type object-list
    \object-list HXAirToAirSensibleAndLatentNames
N1 , \field Supply Air Flow Rate
    \required-field
    \autosizable
    \type real
    \minimum> 0.0
    \units m3/s
    \note This flow rate must match the supply fan's air flow rate.
N2 , \field Exhaust Air Flow Rate
    \required-field
    \autosizable
    \type real
    \minimum> 0.0
    \units m3/s
    \note This flow rate must match the supply fan air flow rate.
A4 , \field Supply Air Fan Name
    \required-field
    \note Fan type must be Fan:OnOff
    \type object-list
    \object-list FansOnOff
A5 , \field Exhaust Air Fan Name
    \required-field
    \note Fan type must be Fan:OnOff
    \type object-list
    \object-list FansOnOff
A6 , \field Controller Name
    \note Enter the name of a ZoneHVAC:EnergyRecoveryVentilator:Controller object.
    \type object-list
    \object-list ControllerStandAloneEnergyRecoveryVentilator
N3 , \field Ventilation Rate per Unit Floor Area
    \type real
    \units m3/s-m2
    \minimum 0.0
    \note 0.000508 m3/s-m2 corresponds to 0.1 ft3/min-ft2
    \note Used only when supply and exhaust air flow rates are autosized.
N4 ; \field Ventilation Rate per Occupant
    \type real
    \units m3/s-person
    \minimum 0.0
    \note 0.00236 m3/s-person corresponds to 5 ft3/min-person
    \note Used only when supply and exhaust air flow rates are autosized.

```

Following is an example input for this compound object and associated objects that may be defined:

```

ZoneHVAC:EnergyRecoveryVentilator,
  Stand Alone ERV 1,           !- Stand alone ERV name
  FanAndCoilAvailSched,       !- Availability schedule name
  OA Heat Recovery 1,         !- Heat exchanger name
  0.05,                       !- Supply air flow rate {m3/s}
  0.05,                       !- Exhaust air flow rate {m3/s}
  Stand Alone ERV Supply Fan, !- Supply air fan name
  Stand Alone ERV Exhaust Fan, !- Exhaust air fan name
  ERV OA Controller 1;        !- ERV controller name

OutdoorAir:NodeLine,
  OutsideAirInletNodes;       !- 1st Node name or node list name

NodeList,
  OutsideAirInletNodes,       !- Node List Name
  ERV Outdoor air Inlet Node; !- Node_ID_1

```

```

ZoneHVAC:EquipmentConnections,
  RESISTIVE_ZONE,           !- Zone Name
  Zone1Equipment,          !- List Name: Zone Equipment
  Zone1Inlets,             !- List Name: Zone Inlet Nodes
  Zone1Exhausts,          !- List Name: Zone Exhaust Nodes
  Zone 1 Node,             !- Zone Air Node Name
  Zone 1 Outlet Node;      !- Zone Return Air Node Name

ZoneHVAC:EquipmentList,
  Zone1Equipment,          !- Name
ZoneHVAC:EnergyRecoveryVentilator, !- KEY--Zone Equipment Type 1
  Stand Alone ERV 1,       !- Type Name 1
  1,                       !- Cooling Priority
  1;                       !- Heating Priority

NodeList,
  Zone1Inlets,             !- Node List Name
  Stand Alone ERV Supply Fan Outlet Node; !- Node_ID_1

NodeList,
  Zone1Exhausts,          !- Node List Name
  Zone 1 Exhaust Node;    !- Node_ID_1

```

```

ZoneHVAC:EnergyRecoveryVentilator:Controller,
  ERV OA Controller 1,      !- ERV controller name
  0.05,                    !- Outdoor air flow rate {m3/s}
  19.,                     !- Temperature high limit {C}
  14.,                     !- Temperature low limit {C}
  0.0,                     !- Enthalpy high limit {J/kg}
  NoExhaustAirTemperatureLimit, !- Exhaust air temperature limit
  NoExhaustAirEnthalpyLimit; !- Exhaust air enthalpy limit

```

```

HeatExchanger:AirToAir:SensibleAndLatent,
  OA Heat Recovery 1,           !- Heat exchanger name
  FanAndCoilAvailSched,       !- Availability schedule name
  0.05,                        !- Nominal supply air flow rate {m3/s}
  .76,                         !- Sensible effectiveness at 100% airflow heating condition
  .68,                         !- Latent effectiveness at 100% airflow heating condition
  .81,                         !- Sensible effectiveness at 75% airflow heating condition
  .73,                         !- Latent effectiveness at 75% airflow heating condition
  .76,                         !- Sensible effectiveness at 100% airflow cooling condition
  .68,                         !- Latent effectiveness at 100% airflow cooling condition
  .81,                         !- Sensible effectiveness at 75% airflow cooling condition
  .73,                         !- Latent effectiveness at 75% airflow cooling condition
  ERV Outdoor air Inlet Node,  !- Supply air inlet node name
  Heat Recovery Outlet Node,   !- Supply air outlet node name
  Zone 1 Exhaust Node,       !- Exhaust air inlet node name
  Heat Recovery Secondary Outlet Node, !- Exhaust air outlet node name
  50.0,                       !- Nominal electric power {W}
  Yes,                        !- Supply air outlet temperature control
  Rotary,                    !- Heat exchanger type
  MinimumExhaustTemperature,  !- Frost control type
  1.7;                        !- Threshold temperature

```

```

Fan:OnOff,
  Stand Alone ERV Supply Fan,   !- Fan Name
  FanAndCoilAvailSched,       !- Available Schedule
  0.5,                         !- Fan Total Efficiency
  75.0,                       !- Delta Pressure {Pa}
  0.05,                       !- Max Flow Rate {m3/s}
  0.9,                         !- Motor Efficiency
  1.0,                        !- Motor In Airstream Fraction
  Heat Recovery Outlet Node,   !- Fan_Inlet_Node
  Stand Alone ERV Supply Fan Outlet Node; !- Fan_Outlet_Node

Fan:OnOff,
  Stand Alone ERV Exhaust Fan,  !- Fan Name
  FanAndCoilAvailSched,       !- Available Schedule
  0.5,                         !- Fan Total Efficiency
  75.0,                       !- Delta Pressure {Pa}
  0.05,                       !- Max Flow Rate {m3/s}
  0.9,                         !- Motor Efficiency
  1.0,                        !- Motor In Airstream Fraction
  Heat Recovery Secondary Outlet Node, !- Fan_Inlet_Node
  Stand Alone ERV Exhaust Fan Outlet Node; !- Fan_Outlet_Node

SetpointManager:Scheduled,
  Heat Exhchanger Supply Air Temp Manager, !- Name
  Temperature,                !- Control variable
  Heat Exchanger Supply Air Temp Sch,    !- Schedule Name
  Heat Exchanger Supply Air Nodes;      !- Name of the set point Node List

NodeList,
  Heat Exchanger Supply Air Nodes, !- Node List Name
  Heat Recovery Outlet Node;       !- Node_ID_1

```

ZoneHVAC:EnergyRecoveryVentilator Outputs

```

HVAC,Average,Stand Alone ERV Electric Power[W]
HVAC,Sum,Stand Alone ERV Electric Consumption[J]
HVAC,Average,Stand Alone ERV Zone Total Cooling Rate[W]
HVAC,Sum,Stand Alone ERV Zone Total Cooling Energy[J]
HVAC,Average,Stand Alone ERV Zone Total Heating Rate[W]
HVAC,Sum,Stand Alone ERV Zone Total Heating Energy[J]
HVAC,Average,Stand Alone ERV Zone Sensible Cooling Rate[W]
HVAC,Sum,Stand Alone ERV Zone Sensible Cooling Energy[J]
HVAC,Average,Stand Alone ERV Zone Sensible Heating Rate[W]

```

```
HVAC,Sum,Stand Alone ERV Zone Sensible Heating Energy[J]
HVAC,Average,Stand Alone ERV Zone Latent Cooling Rate[W]
HVAC,Sum,Stand Alone ERV Zone Latent Cooling Energy[J]
HVAC,Average,Stand Alone ERV Zone Latent Heating Rate[W]
HVAC,Sum,Stand Alone ERV Zone Latent Heating Energy[J]
```

Stand Alone ERV Electric Power [W]

This output field is the electric consumption rate of the stand alone energy recovery ventilator in Watts. This rate includes the electric consumption by the supply air fan, exhaust air fan and the generic air-to-air heat exchanger.

Stand Alone ERV Electric Consumption [J]

This output field is the electric consumption of the stand alone energy recovery ventilator in Joules for the timestep being reported. This value includes the electric consumption by the supply air fan, exhaust air fan and the generic air-to-air heat exchanger.

Stand Alone ERV Zone Total Cooling Rate [W]

This output field is the total (enthalpy) heat extraction rate of the stand alone energy recovery ventilator from the zone in Watts. This value is calculated using the supply air outlet mass flow rate, and the enthalpy difference of the supply outlet and exhaust inlet air streams. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy extraction only) are averaged for the timestep being reported.

Stand Alone ERV Zone Total Cooling Energy [J]

This output field is the total (enthalpy) heat extraction of the stand alone energy recovery ventilator from the zone in Joules over the timestep being reported. This value is calculated using the supply air outlet mass flow rate, the enthalpy difference of the supply outlet and exhaust inlet air streams, and the HVAC system timestep. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy extraction only) are summed for the timestep being reported.

Stand Alone ERV Zone Total Heating Rate [W]

This output field is the total (enthalpy) heat addition rate of the stand alone energy recovery ventilator to the zone in Watts. This value is calculated using the supply air outlet mass flow rate, and the enthalpy difference of the supply outlet and exhaust inlet air streams. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy addition only) are averaged for the timestep being reported.

Stand Alone ERV Zone Total Heating Energy [J]

This output field is the total (enthalpy) heat addition of the stand alone energy recovery ventilator to the zone in Joules over the timestep being reported. This value is calculated using the supply air outlet mass flow rate, the enthalpy difference of the supply outlet and exhaust inlet air streams, and the HVAC system timestep. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy addition only) are summed for the timestep being reported.

Stand Alone ERV Zone Sensible Cooling Rate [W]

This output is the moist air sensible heat extraction rate of the stand alone energy recovery ventilator from the zone in Watts. This value is calculated using the supply air outlet mass flow rate, and the enthalpy difference of the supply outlet and exhaust inlet air streams at a constant humidity ratio. This value is calculated for each HVAC system timestep being simulated, and the results (cooling only) are averaged for the timestep being reported.

Stand Alone ERV Zone Sensible Cooling Energy [J]

This output is the moist air sensible heat extraction of the stand alone energy recovery ventilator from the zone in Joules over the timestep being reported. This value is calculated using the supply air outlet mass flow rate, the enthalpy difference of the supply outlet and exhaust inlet air streams at a constant humidity ratio, and the HVAC system timestep. This value is calculated for each HVAC system timestep being simulated, and the results (cooling only) are summed for the timestep being reported.

Stand Alone ERV Zone Sensible Heating Rate [W]

This output is the sensible heat addition rate of the stand alone energy recovery ventilator to the zone in Watts. This value is calculated using the supply air outlet mass flow rate, and the enthalpy difference of the supply outlet and exhaust inlet air streams at a constant humidity ratio. This value is calculated for each HVAC system timestep being simulated, and the results (heating only) are averaged for the timestep being reported.

Stand Alone ERV Zone Sensible Heating Energy [J]

This output is the sensible heat addition of the stand alone energy recovery ventilator to the zone in Joules over the timestep being reported. This value is calculated using the supply air outlet mass flow rate, the enthalpy difference of the supply outlet and exhaust inlet air streams at a constant humidity ratio, and the HVAC system timestep. This value is calculated for each HVAC system timestep being simulated, and the results (heating only) are summed for the timestep being reported.

Stand Alone ERV Zone Latent Cooling Rate [W]

This output is the latent heat extraction (dehumidification) rate of the stand alone energy recovery ventilator from the zone in Watts. This value is calculated as the difference between the total energy rate and the sensible energy rate provided by the stand alone ERV. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat extraction only) are averaged for the timestep being reported.

Stand Alone ERV Zone Latent Cooling Energy [J]

This output is the latent heat extraction (dehumidification) of the stand alone energy recovery ventilator from the zone in Joules over the timestep being reported. This value is calculated as the difference between the total energy delivered to the zone and the sensible energy delivered to the zone by the stand alone ERV. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat extraction only) are summed for the timestep being reported.

Stand Alone ERV Zone Latent Heating Rate [W]

This output is the latent heat addition (humidification) rate of the stand alone energy recovery ventilator to the zone in Watts. This value is calculated as the difference between the total energy rate and the sensible energy rate provided by the stand alone ERV. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat addition only) are averaged for the timestep being reported.

Stand Alone ERV Zone Latent Heating Energy [J]

This output is the latent heat addition (humidification) of the stand alone energy recovery ventilator to the zone in Joules over the timestep being reported. This value is calculated as the difference between the total energy delivered to the zone and the sensible energy delivered to the zone by the stand alone ERV. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat addition only) are summed for the timestep being reported.

Group – Unitary Equipment

Furnace and Unitary Systems

The components

```
AirLoopHVAC:Unitary:Furnace:HeatOnly
AirLoopHVAC:Unitary:Furnace:HeatCool
AirLoopHVAC:UnitaryHeatOnly
AirLoopHVAC:UnitaryHeatCool
AirLoopHVAC:UnitaryHeatPump:AirToAir
AirLoopHVAC:UnitaryHeatPump:AirToAir:MultiSpeed
```

are compound components usually placed in the primary air loop as the sole component. On the zone equipment side they are usually connected to one or more zones through Direct Air objects. The maximum or design air flow rate through the furnace or unitary system should usually be set equal to the sum of the maximum air flow rates through the direct air objects. However, the simulation program can account for unequal air flows if the user wishes to model this scenario.

AirLoopHVAC:Unitary:Furnace:HeatCool

The heat/cool furnace is a “virtual” component that consists of a fan component (OnOff or ConstantVolume), a Gas or Electric heating coil component, and a DX cooling coil component. The blow through furnace configuration is shown in Figure 90 below. If the dehumidification control type is specified as CoolReheat, a reheat coil component is also required. The blow through furnace’s configuration when specifying this option is shown in Figure 91. Schematic of Blow Thru Furnace with High Humidity Control below.

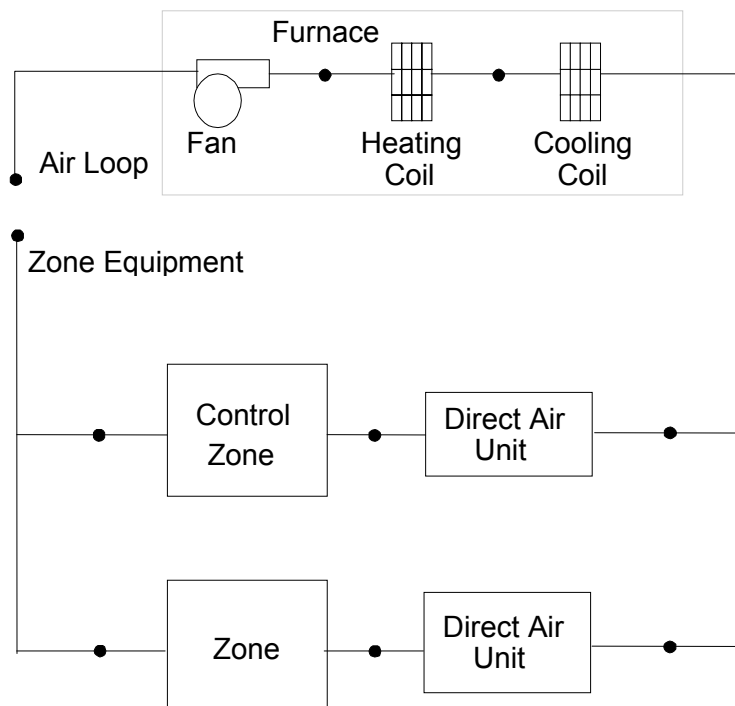


Figure 90. Schematic of EnergyPlus Heat/Cool Furnace

Links to the fan, heating coil, DX cooling coil and optional reheat coil specifications are provided in the furnace input data syntax. In addition the control zone name, the fraction of

the total furnace air flow delivered to the control zone and furnace design operating conditions are specified by the furnace syntax as shown in the Energy+.idd specification below.

```

AirLoopHVAC:Unitary:Furnace:HeatCool,
  \memo identical to the AirLoopHVAC:UnitaryHeatCool object
  \min-fields 18
A1, \field Name
  \required-field
  \type alpha
A2, \field Availability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
  \note A schedule value greater than zero (usually 1 is used) indicates that the unit is
  \note available to operate as needed. A value less than or equal to zero (usually zero
  \note is used) denotes that the unit must be off.
A3, \field Furnace Air Inlet Node Name
  \required-field
  \type alpha
A4, \field Furnace Air Outlet Node Name
  \required-field
  \type alpha
A5, \field Supply Air Fan Operating Mode Schedule Name
  \type object-list
  \object-list ScheduleNames
  \note A fan operating mode schedule value of 0 indicates cycling fan mode (supply air
  \note fan cycles on and off in tandem with the cooling or heating coil).
  \note Any other schedule value indicates continuous fan mode (supply air fan operates
  \note continuously regardless of cooling or heating coil operation). Provide a schedule
  \note with non-zero values when high humidity control is specified.
  \note Leaving this schedule name blank will default to cycling fan mode for the
  \note entire simulation period.
N1, \field Maximum Supply Air Temperature
  \type real
  \units C
  \autosizable
  \default 80.0
N2, \field Supply Air Flow Rate During Cooling Operation
  \required-field
  \type real
  \units m3/s
  \minimum> 0.0
  \autosizable
  \note Must be less than or equal to the fan's maximum flow rate.
N3, \field Supply Air Flow Rate During Heating Operation
  \required-field
  \type real
  \units m3/s
  \minimum> 0.0
  \autosizable
  \note Must be less than or equal to the fan's maximum flow rate.
N4, \field Supply Air Flow Rate When No Cooling or Heating is Needed
  \type real
  \units m3/s
  \minimum 0.0
  \autosizable
  \note Must be less than or equal to the fan's maximum flow rate.
  \note Only used when fan operating mode is continuous (disregarded for cycling fan mode).
  \note This air flow rate is used when no heating or cooling is required (i.e., the DX coil
  \note compressor and heating coil are off). If this field is left blank or zero, the supply
  \note air flow rate from the previous on cycle (either cooling or heating) is used.

```

```

A6, \field Controlling Zone or Thermostat Location
    \required-field
    \type object-list
    \object-list ZoneNames
N5, \field Fraction of Supply Air Flow That Goes Through the Controlling Zone
    \required-field
    \type real
    \minimum> 0.0
    \maximum 1.0
    \autosizable
A7, \field Supply Fan Object Type
    \required-field
    \type choice
    \key Fan:OnOff
    \key Fan:ConstantVolume
    \note Fan:ConstantVolume only works with continuous fan operating mode (i.e. supply
    \note air fan operating mode schedule values not equal to 0).
A8, \field Supply Fan Name
    \required-field
    \type object-list
    \object-list FansCVandOnOff
A9, \field Fan Placement
    \type choice
    \key BlowThrough
    \key DrawThrough
    \default BlowThrough
A10, \field Heating Coil Object Type
    \required-field
    \type choice
    \key Coil:Heating:Gas
    \key Coil:Heating:Electric
    \note Only works with gas and electric coils
A11, \field Heating Coil Name
    \required-field
    \type object-list
    \object-list HeatingCoilsGasElec
A12, \field Cooling Coil Object Type
    \required-field
    \type choice
    \key Coil:Cooling:DX:SingleSpeed
    \key CoilSystem:Cooling:DX:HeatExchangerAssisted
    \note Only works with DX cooling coil types
A13, \field Cooling Coil Name
    \required-field
    \type object-list
    \object-list CoolingCoilsDXSingleSpeed
A14, \field Dehumidification Control Type
    \type choice
    \key None
    \key Multimode
    \key CoolReheat
    \default None
    \note None = meet sensible load only
    \note Multimode = activate enhanced dehumidification mode
    \note as needed and meet sensible load. Valid only with
    \note cooling coil type CoilSystem:Cooling:DX:HeatExchangerAssisted.
    \note This control mode allows the heat exchanger to be turned
    \note on and off based on the zone dehumidification requirements.
    \note A ZoneControl:Humidistat object is also required.
    \note CoolReheat = cool beyond the dry bulb setpoint.
    \note as required to meet the humidity setpoint. Valid with all
    \note cooling coil types. When a heat exchanger assisted cooling
    \note coil is used, the heat exchanger is locked on at all times.
    \note A ZoneControl:Humidistat object is also required.

```

```

A15, \field Reheat Coil Object Type
      \type choice
      \key Coil:Heating:Gas
      \key Coil:Heating:Electric
      \key Coil:Heating:Desuperheater
      \note Only required if dehumidification control type is "CoolReheat"
      \note Only works with gas, electric, and desuperheater heating coils
A16; \field Reheat Coil Name
      \note Only required if dehumidification control type is "CoolReheat"
      \type object-list
      \object-list HeatingCoilsGasElecDesup

```

Field: Name

This alpha field contains the identifying name for the unit.

Field: Availability Schedule Name

This alpha field contains the schedule name which contains information on the availability of the furnace to operate.

Field: Furnace Air Inlet Node Name

This alpha field contains the furnace inlet node name.

Field: Furnace Air Outlet Node Name

This alpha field contains the furnace outlet node name.

Field: Supply Air Fan Operating Mode Schedule Name

This alpha field specifies the name of the supply air fan operating mode schedule. The supply air fan operating mode may vary during the simulation based on time-of-day or with a change of season. Schedule values of 0 denote that the furnace supply air fan and the heating or cooling coil cycle on and off together to meet the heating or cooling load (a.k.a. AUTO fan). Schedule values other than 0 denote that the supply fan runs continuously while the heating or cooling coil cycles to meet the load.

Field: Maximum Supply Air Temperature

This numeric field contains the design operating furnace air outlet temperature in degrees C when the furnace is heating. If this input field is left blank, the default value is 80 C.

Field: Supply Air Flow Rate During Cooling Operation

This numeric field defines the supply air flow rate leaving the furnace in cubic meters per second when the DX cooling coil is operating. Values must be greater than 0 or this field is autosizable.

Field: Supply Air Flow Rate During Heating Operation

This numeric field defines the supply air flow rate leaving the furnace in cubic meters per second when the DX heating coil and/or supplemental heater are operating. Values must be greater than 0 or this field is autosizable.

Field: Supply Air Flow Rate When No Cooling or Heating is Needed

This numeric field defines the supply air flow rate leaving the furnace in cubic meters per second when neither cooling or heating is required (i.e., DX coils and supplemental heater are off but the supply air fan operates). This field is only used when the furnace operating mode is specified as continuous fan operation. Values must be greater than or equal to zero, or this field is autosizable. If the furnace operating mode is specified as continuous fan operation and this value is set to zero or this field is left blank, then the model assumes that the supply air flow rate when no cooling/heating is needed is equal to the supply air flow rate when the compressor was last operating (for cooling operation or heating operation).

Field: Controlling Zone or Thermostat Location

This alpha field contains the identifying zone name where the thermostat controlling the furnace is located.

Field: Fraction of Supply Air Flow That Goes Through the Controlling Zone

This numeric field contains the fraction (>0 to 1) of the total furnace volumetric flow rate that is supplied to the zone with the furnace thermostat.

Field: Supply Fan Object Type

This alpha field contains the identifying type of supply air fan specified for the furnace. Fan type must be **Fan:OnOff** or **Fan:ConstantVolume**. Fan:ConstantVolume is used when the Supply Air Fan Operating Mode Schedule values are never 0 and the fan operates continuously. Fan:OnOff is used when the fan cycles on and off with the cooling or heating coil (i.e. Supply Air Fan Operating Mode Schedule values are at times 0).

Field: Supply Fan Name

This alpha field contains the identifying name given to the furnace fan.

Field: Fan Placement

This alpha field has two choices: **BlowThrough** or **DrawThrough**. The first choice stands for “blow through fan”. This means that the unit consists of a fan followed by the DX coils and supplemental heating coil. The fan “blows through” the cooling and heating coils. The second choice stands for “draw through fan”. This means that the unit consists of the DX coil(s) followed by a fan, with the supplemental heater located at the outlet of the fan. The fan “draws air through” the DX coil(s). If this field is left blank, the default is blow through.

Field: Heating Coil Object Type

This alpha field contains the identifying type of heating coil specified in the furnace. Only allowable coil types are:

Coil:Heating:Electric Coil:Heating:Gas

Field: Heating Coil Name

This alpha field contains the identifying name given to the furnace heating coil.

Field: Cooling Coil Object Type

This alpha field contains the identifying type of cooling coil specified in the furnace. Only allowable coil types are:

Coil:Cooling:DX:SingleSpeed CoilSystem:Cooling:DX:HeatExchangerAssisted
--

Field: Cooling Coil Name

This alpha field contains the identifying name given to the furnace cooling coil.

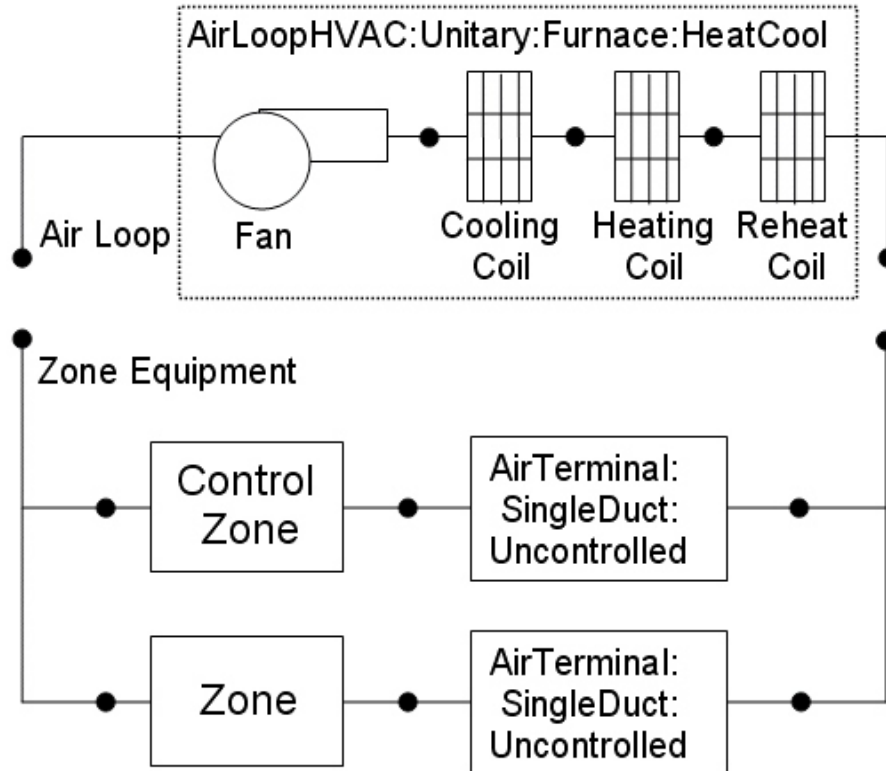


Figure 91. Schematic of Blow Thru Furnace with High Humidity Control

Field: Dehumidification Control Type

This alpha field contains the type of dehumidification control. The following options are valid for this field:

None - meet sensible load only, no active dehumidification control

Multimode - activate enhanced dehumidification mode as needed and meet sensible load. This option is used to model DX equipment with a controllable heat exchanger assisting the DX cooling coil for improved dehumidification. It is valid only with cooling coil type = CoilSystem:Cooling:DX:HeatExchangerAssisted.

CoolReheat - cool beyond the dry-bulb temperature set point as required to meet the high humidity setpoint. If cooling coil type = CoilSystem:Cooling:DX:HeatExchangerAssisted, then the heat exchanger is assumed to always transfer energy between the cooling coil's inlet and outlet airstreams when the cooling coil is operating.

The default is **None**. For the other dehumidification control modes, the maximum humidity setpoint is used. This must be set using a **ZoneControl:Humidistat** object. When extra dehumidification is required, the system may not be able to meet the humidity setpoint if its full capacity is not adequate. If the dehumidification control type is specified as **CoolReheat**, then two additional inputs (reheat coil type and name) are also required as shown below.

Field: Reheat Coil Object Type

This alpha field contains the identifying type of reheat coil specified in the furnace. Reheat coil type must be one of:

```
Coil:Heating:Electric
Coil:Heating:Gas
Coil:Heating:Desuperheater
```

Field: Reheat Coil Name

This alpha field contains the identifying name given to the furnace reheat coil.

As shown in the example below, correct specification of the heat/cool furnace requires specification of the following objects in addition to the furnace object:

- 1) fan (Fan:OnOff or Fan:ConstantVolume)
- 2) heating coil (Coil:Heating:Gas or Coil:Heating:Electric)
- 3) cooling coil (Coil:Cooling:DX:SingleSpeed or CoilSystem:Cooling:DX:HeatExchangerAssisted)
- 4) reheat coil (optional, Coil:Heating:Gas, Coil:Heating:Electric, or Coil:Heating:Desuperheater)
- 5) direct air unit (AirTerminal:SingleDuct:Uncontrolled) for each zone served by the furnace

Note: the furnace's fan, heating coil, cooling coil and optional reheat coil must be connected in the air loop according to the configuration shown above (Figure 90 or Figure 91). In addition, the volumetric air flow rate specified in the direct air unit for the controlling zone should properly reflect the fractional volumetric air flow rate specified in the furnace object.

```
AirLoopHVAC:Unitary:Furnace:HeatCool,
  GasHeat DXAC Furnace 1, !- Name of furnace
  FanAndCoilAvailSched, !- Availability schedule
  Air Loop Inlet Node, !- Furnace inlet node name
  Air Loop Outlet Node, !- Furnace outlet node name
  CycFanSchedule, !- Supply Air Fan Operating Mode Schedule Name
  80, !- Maximum supply air temperature from furnace heater {C}
  1.3, !- Supply air volumetric flow rate during cooling operation {m3/s}
  1.3, !- Supply air volumetric flow rate during heating operation {m3/s}
  0.0, !- Design air volumetric flow rate when no heating or cooling is needed {m3/s}
  East Zone, !- Controlling zone or thermostat location
  0.276923, !- Fraction of the total or design volume flow that goes thru
  Fan:OnOff, !- Supply fan type
  Supply Fan 1, !- Supply fan name
  Coil:Heating:Gas, !- Heating coil type
  Furnace Heating Coil 1, !- Heating coil name
  Coil:Cooling:DX:SingleSpeed, !- Cooling coil type
  Furnace ACDXCoil 1, !- Cooling coil name
  None; !- Dehumidificatioin Control Type
```

```
Coil:Heating:Gas,
  Furnace Heating Coil 1, !- Coil Name
  FanAndCoilAvailSched, !- Available Schedule
  0.8, !- Gas Burner Efficiency of the Coil
  25000, !- Nominal Capacity of the Coil {W}
  Heating Coil Air Inlet Node, !- Coil_Air_Inlet_Node
  DX Cooling Coil Air Inlet Node; !- Coil_Air_Outlet_Node
```



```

Coil:DX:Cooling:SingleSpeed,
  Furnace ACDXCoil 1,      !- Coil Name
  FanAndCoilAvailSched,   !- Availability Schedule
  25000,                   !- Rated Total Cooling Capacity {gross} {W}
  0.75,                    !- Rated SHR
  3.0,                     !- Rated COP
  1.3,                     !- Rated Air Volume Flow Rate {m3/s}
  DX Cooling Coil Air Inlet Node, !- Coil Air Inlet Node
  Air Loop Outlet Node,   !- Coil Air Outlet Node
  WindACCoolCapFT,        !- Total Cooling Capacity Modifier Curve (function of temperature)
  WindACCoolCapFFF,       !- Total Cooling Capacity Modifier Curve (function of flow fraction)
  WindACEIRFT,            !- Energy Input Ratio Modifier Curve (function of temperature)
  WindACEIRFFF,           !- Energy Input Ratio Modifier Curve (function of flow fraction)
  WindACPLFFPLR,         !- Part Load Fraction Correlation (function of part load ratio)
  CyclingFanAndCompressor; !- Supply Air Fan Operation Mode

```

```

Fan:OnOff,
  Supply Fan 1,            !- Fan Name
  FanAndCoilAvailSched,   !- Available Schedule
  0.7,                     !- Fan Total Efficiency
  600.0,                   !- Delta Pressure {Pa}
  1.3,                     !- Max Flow Rate {m3/s}
  0.9,                     !- Motor Efficiency
  1.0,                     !- Motor In Airstream Fraction
  Air Loop Inlet Node,    !- Fan_Inlet_Node
  Heating Coil Air Inlet Node; !- Fan_Outlet_Node

AirTerminal:SingleDuct:Uncontrolled,
  Zone1DirectAir,         !- Direct Air Name
  FanAndCoilAvailSched,   !- Schedule name for on/off schedule
  Zone 1 Inlet Node,      !- Zone Supply Air Node Name
  0.47;                   !- Maximum air flow rate {m3/s}

AirTerminal:SingleDuct:Uncontrolled,
  Zone2DirectAir,         !- Direct Air Name
  FanAndCoilAvailSched,   !- Schedule name for on/off schedule
  Zone 2 Inlet Node,      !- Zone Supply Air Node Name
  0.36;                   !- Maximum air flow rate {m3/s}

AirTerminal:SingleDuct:Uncontrolled,
  Zone3DirectAir,         !- Direct Air Name
  FanAndCoilAvailSched,   !- Schedule name for on/off schedule
  Zone 3 Inlet Node,      !- Zone Supply Air Node Name
  0.47;                   !- Maximum air flow rate {m3/s}

```

Example of Heat/Cool Furnace Specification

AirLoopHVAC:Unitary:Furnace:HeatCool Outputs

```

HVAC,Average,Furnace Fan Part-Load Ratio
HVAC,Average,Furnace Compressor Part-Load Ratio

```

Furnace Fan Part-Load Ratio

This output variable is the ratio of actual air mass flow rate through the furnace to the furnace's design air mass flow rate (i.e., design volumetric flow rate converted to dry air mass flow rate). For continuous fan operation mode, this variable is always 1.0 when the furnace is available (based on the availability schedule). For cycling fan/cycling coil operation mode, the actual air mass flow rate is calculated based on the ratio of the sensible heating (or cooling) load to the steady-state furnace heating (or cooling) capacity. For the cycling fan mode, the runtime fraction for the furnace fan may be different from the fan part-load ratio reported here due the part-load performance of the furnace's heating (or cooling) coil (delay at start-up to reach steady-state output). In general, runtime fractions are reported by individual components where appropriate (e.g., Fan:OnOff).

Furnace Compressor Part-Load Ratio

This output variable is the ratio of the sensible cooling load to the steady-state cooling capacity of the furnace's DX cooling coil. The runtime fraction for the DX cooling coil compressor may be different from the compressor part-load ratio reported here due to the part-load performance of the cooling coil (delay at start-up to reach steady-state output). In general, runtime fractions are reported by individual components where appropriate.

AirLoopHVAC:UnitaryHeatCool

The UnitarySystem: HeatCool is the identical model to the Furnace: HeatCool object. The heat/cool unitary system is a "virtual" component that consists of a fan component (OnOff or ConstantVolume), a Gas or Electric heating coil component and a DX cooling coil component as shown in Figure 92 below. If dehumidification control is selected, a reheat coil component is also required and the system's configuration when specifying this option is shown in Figure 93. Schematic of Blow Through Unitary System (HeatCool) with High Humidity Control below.

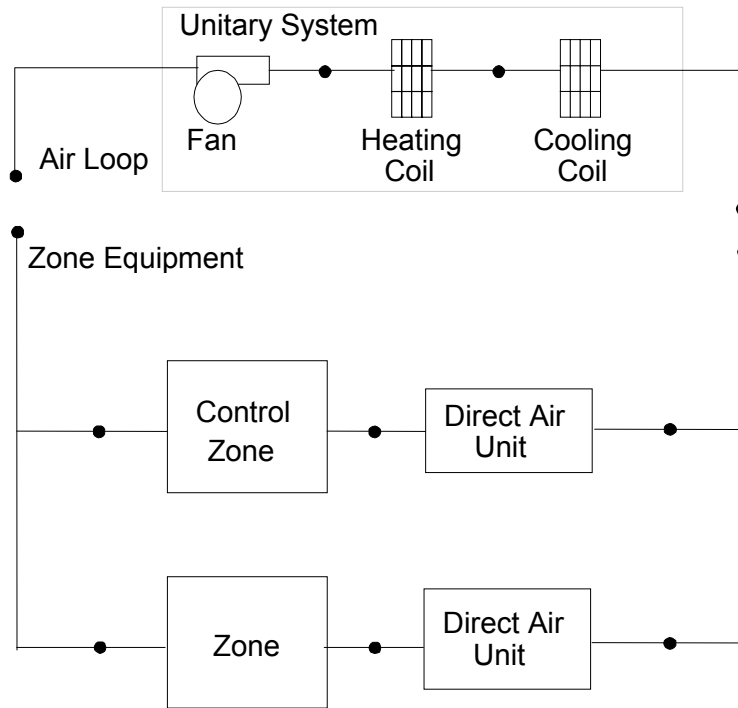


Figure 92. Schematic of Blow Through Heat/Cool Unitary System

Links to the fan, heating coil, DX cooling coil and optional reheat coil specifications are provided in the unitary system input data syntax. In addition the control zone name, the fraction of the total system air flow delivered to the control zone and system design operating conditions are specified by the unitary system syntax as shown in the Energy+.idd specification below.

```

AirLoopHVAC:UnitaryHeatCool,
  \min-fields 18
A1, \field Name
  \required-field
  \type alpha
A2, \field Availability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
A3, \field Unitary System Air Inlet Node Name
  \required-field
  \type alpha
A4, \field Unitary System Air Outlet Node Name
  \required-field
  \type alpha
A5, \field Supply Air Fan Operating Mode Schedule Name
  \type object-list
  \object-list ScheduleNames
  \note A fan operating mode schedule value of 0 indicates cycling fan mode (supply air
  \note fan cycles on and off in tandem with the cooling or heating coil).
  \note Any other schedule value indicates continuous fan mode (supply air fan operates
  \note continuously regardless of cooling or heating coil operation). Provide a schedule
  \note with non-zero values when high humidity control is specified.
  \note Leaving this schedule name blank will default to cycling fan mode for the
  \note entire simulation period.
N1, \field Maximum Supply Air Temperature
  \type real
  \units C
  \autosizable
  \default 80.0
N2, \field Supply Air Flow Rate During Cooling Operation
  \required-field
  \type real
  \units m3/s
  \minimum> 0.0
  \autosizable
  \note Must be less than or equal to the fan's maximum flow rate.
N3, \field Supply Air Flow Rate During Heating Operation
  \required-field
  \type real
  \units m3/s
  \minimum> 0.0
  \autosizable
  \note Must be less than or equal to the fan's maximum flow rate.
N4, \field Supply Air Flow Rate When No Cooling or Heating is Needed
  \type real
  \units m3/s
  \minimum 0
  \autosizable
  \note Must be less than or equal to the fan's maximum flow rate.
  \note Only used when fan operating mode is continuous (disregarded for cycling fan mode).
  \note This air flow rate is used when no heating or cooling is required (i.e., the DX coil
  \note compressor and heating coil are off). If this field is left blank or zero, the supply
  \note air flow rate from the previous on cycle (either cooling or heating) is used.
A6, \field Controlling Zone or Thermostat Location
  \required-field
  \type object-list
  \object-list ZoneNames
N5, \field Fraction of Supply Air Flow That Goes Through the Controlling Zone
  \required-field
  \type real
  \minimum> 0.0
  \maximum 1.0
  \autosizable

```

```

A7, \field Supply Fan Object Type
    \required-field
    \type choice
    \key Fan:OnOff
    \key Fan:ConstantVolume
    \note Fan:ConstantVolume only works with continuous fan operating mode (i.e. supply
    \note air fan operating mode schedule values not equal to 0).
A8, \field Supply Fan Name
    \required-field
    \type object-list
    \object-list FansCVandOnOff
A9 , \field Fan Placement
    \type choice
    \key BlowThrough
    \key DrawThrough
    \default BlowThrough
A10, \field Heating Coil Object Type
    \required-field
    \type choice
    \key Coil:Heating:Gas
    \key Coil:Heating:Electric
    \note Only works with gas and electric Coils
A11, \field Heating Coil Name
    \required-field
    \type object-list
    \object-list HeatingCoilsGasElec
A12, \field Cooling Coil Object Type
    \required-field
    \type choice
    \key Coil:Cooling:DX:SingleSpeed
    \key CoilSystem:Cooling:DX:HeatExchangerAssisted
    \note Only works with DX cooling coil types
A13, \field Cooling Coil Name
    \required-field
    \type object-list
    \object-list CoolingCoilsDXSingleSpeed
A14, \field Dehumidification Control Type
    \type choice
    \key None
    \key Multimode
    \key CoolReheat
    \default None
    \note None = meet sensible load only
    \note Multimode = activate enhanced dehumidification mode
    \note as needed and meet sensible load. Valid only with
    \note cooling coil type CoilSystem:Cooling:DX:HeatExchangerAssisted.
    \note This control mode allows the heat exchanger to be turned
    \note on and off based on the zone dehumidification requirements.
    \note A ZoneControl:Humidistat object is also required.
    \note CoolReheat = cool beyond the dry bulb setpoint.
    \note as required to meet the humidity setpoint. Valid with all
    \note cooling coil types. When a heat exchanger assisted Cooling
    \note coil is used, the heat exchanger is locked on at all times.
    \note A ZoneControl:Humidistat object is also required.
A15, \field Reheat Coil Object Type
    \type choice
    \key Coil:Heating:Gas
    \key Coil:Heating:Electric
    \key Coil:Heating:Desuperheater
    \note Only required if dehumidification control type is "CoolReheat"
    \note Only works with gas, electric, and desuperheater heating coils
A16; \field Reheat Coil Name
    \note Only required if dehumidification control type is "CoolReheat"
    \type object-list
    \object-list HeatingCoilsGasElecDesup

```

Field: Name

This alpha field contains the identifying name for the unitary system.

Field: Availability Schedule Name

This alpha field contains the schedule name which contains information on the availability of the unitary system to operate.

Field: Unitary System Air Inlet Node Name

This alpha field contains the unitary system inlet node name.

Field: Unitary System Air Outlet Node Name

This alpha field contains the unitary system outlet node name.

Field: Supply Air Fan Operating Mode Schedule Name

This alpha field specifies the name of the supply air fan operating mode schedule. The supply air fan operating mode may vary during the simulation based on time-of-day or with a change of season. Schedule values of 0 denote that the unitary system supply air fan and the heating or cooling coil cycle on and off together to meet the heating or cooling load (a.k.a. AUTO fan). Schedule values other than 0 denote that the supply fan runs continuously while the heating or cooling coil cycles to meet the load.

Field: Maximum Supply Air Temperature

This numeric field contains the design operating air outlet temperature in degrees C when the unitary system is heating. If this input field is left blank, the default value is 80 C.

Field: Supply Air Flow Rate During Cooling Operation

This numeric field defines the supply air flow rate leaving the unitary system in cubic meters per second when the DX cooling coil is operating. Values must be greater than 0 or this field is autosizable.

Field: Supply Air Flow Rate During Heating Operation

This numeric field defines the supply air flow rate leaving the unitary system in cubic meters per second when the DX heating coil and/or supplemental heater are operating. Values must be greater than 0 or this field is autosizable.

Field: Supply Air Flow Rate When No Cooling or Heating is Needed

This numeric field defines the supply air flow rate leaving the unitary system in cubic meters per second when neither cooling or heating is required (i.e., DX coils and supplemental heater are off but the supply air fan operates). This field is only used when the unitary system operating mode is specified as continuous fan operation. Values must be greater than or equal to zero, or this field is autosizable. If the unitary system operating mode is specified as continuous fan operation and this value is set to zero or this field is left blank, then the model assumes that the supply air flow rate when no cooling/heating is needed is equal to the supply air flow rate when the compressor was last operating (for cooling operation or heating operation).

Field: Controlling Zone or Thermostat Location

This alpha field contains the identifying zone name where the thermostat controlling the unitary system is located.

Field: Fraction of Supply Air Flow That Goes Through the Controlling Zone

This numeric field contains the fraction (>0 to 1) of the total system volumetric flow rate that is supplied to the zone with the unitary system thermostat.

Field: Supply Fan Object Type

This alpha field contains the identifying type of supply air fan specified for the unitary system. Fan type must be **Fan:OnOff** or **Fan:ConstantVolume**. Fan:ConstantVolume is used when the Supply Air Fan Operating Mode Schedule values are never 0 and the fan operates

continuously. Fan:OnOff is used when the fan cycles on and off with the cooling or heating coil (i.e. Supply Air Fan Operating Mode Schedule values are at times 0).

Field: Supply Fan Name

This alpha field contains the identifying name given to the unitary system fan.

Field: Fan Placement

This alpha field has two choices: **BlowThrough** or **DrawThrough**. The first choice stands for “blow through fan”. This means that the unit consists of a fan followed by the DX coils and supplemental heating coil. The fan “blows through” the cooling and heating coils. The second choice stands for “draw through fan”. This means that the unit consists of the DX coil(s) followed by a fan, with the supplemental heater located at the outlet of the fan. The fan “draws air through” the DX coil(s). If this field is left blank, the default is blow through.

Field: Heating Coil Object Type

This alpha field contains the identifying type of heating coil specified in the unitary system. Only allowable coil types are:

```
Coil:Heating:Electric  
Coil:Heating:Gas
```

Field: Heating Coil Name

This alpha field contains the identifying name given to the unitary system heating coil.

Field: Cooling Coil Object Type

This alpha field contains the identifying type of cooling coil specified in the unitary system. Only allowable coil types are:

```
Coil:Cooling:DX:SingleSpeed  
CoilSystem:Cooling:DX:HeatExchangerAssisted
```

Field: Cooling Coil Name

This alpha field contains the identifying name given to the unitary system cooling coil.

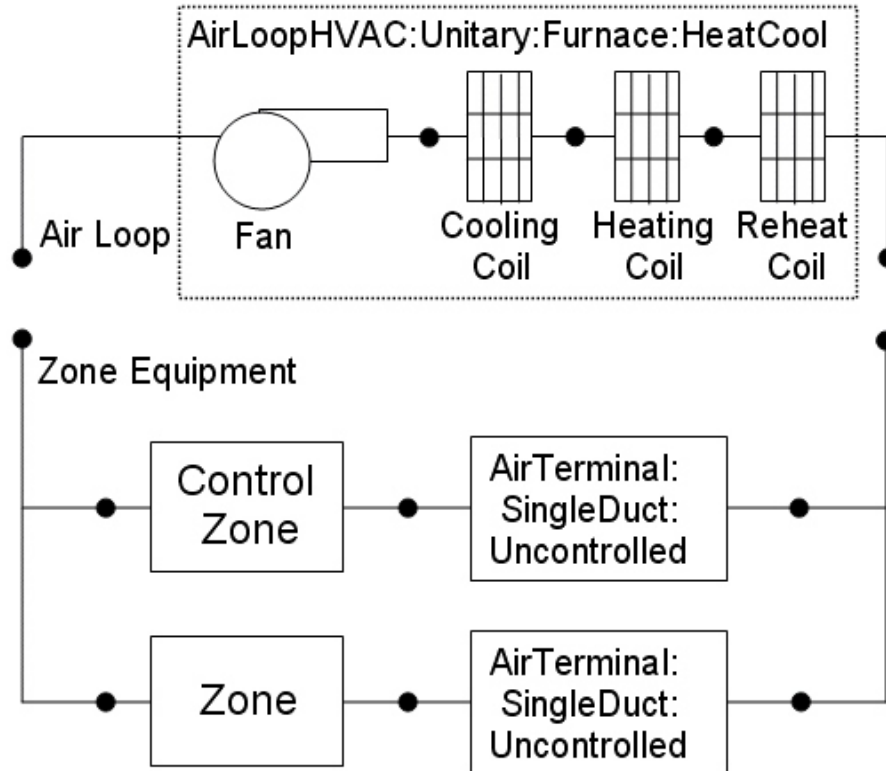


Figure 93. Schematic of Blow Through Unitary System (HeatCool) with High Humidity Control

Field: Dehumidification Control Type

This alpha field contains the type of dehumidification control. The following options are valid for this field:

None - meet sensible load only, no active dehumidification control

Multimode - activate enhanced dehumidification mode as needed and meet sensible load. This option is used to model DX equipment with a controllable heat exchanger assisting the DX cooling coil for improved dehumidification. It is valid only with cooling coil type = CoilSystem:Cooling:DX:HeatExchangerAssisted.

CoolReheat - cool beyond the dry-bulb temperature set point as required to meet the high humidity setpoint. If cooling coil type = CoilSystem:Cooling:DX:HeatExchangerAssisted, then the heat exchanger is assumed to always transfer energy between the cooling coil's inlet and outlet airstreams when the cooling coil is operating.

The default is **None**. For the other dehumidification control modes, the maximum humidity setpoint is used. This must be set using a **ZoneControl:Humidistat** object. When extra dehumidification is required, the system may not be able to meet the humidity setpoint if its full capacity is not adequate. If the dehumidification control type is specified as **CoolReheat**, then two additional inputs (reheat coil type and name) are also required as shown below.

Field: Reheat Coil Object Type

This alpha field contains the identifying type of reheat coil specified in the furnace. Reheat coil type must be one of:

```
Coil:Heating:Electric
Coil:Heating:Gas
Coil:Heating:Desuperheater
```

Field: Reheat Coil Name

This alpha field contains the identifying name given to the unitary system reheat coil.

As shown in the example below, correct specification of the heat/cool unitary system requires specification of the following objects in addition to the unitary system object:

- 1) Fan (Fan:OnOff or Fan:ConstantVolume)
- 2) Heating coil (Coil:Heating:Gas or Coil:Heating:Electric)
- 3) Cooling coil (Coil:DX:Cooling:SingleSpeed or CoilSystem:Cooling:DX:HeatExchangerAssisted)
- 4) Reheat coil (optional, Coil:Heating:Gas, Coil:Heating:Electric, or Coil:Heating:Desuperheater)
- 5) Direct air unit (AirTerminal:SingleDuct:Uncontrolled) for each zone served by the unitary system

Note: the unitary system's fan, heating coil, cooling coil and optional reheat coil must be connected in the air loop according to the configuration shown above (Figure 92 or Figure 93). In addition, the volumetric air flow rate specified in the direct air unit for the controlling zone should properly reflect the fractional volumetric air flow rate specified in the unitary system object.

```
AirLoopHVAC:Unitary:Furnace:HeatCool,
  GasHeat DXAC Unitary System 1,  !- Name of unitary system
  FanAndCoilAvailSched,          !- Availability schedule
  Air Loop Inlet Node,           !- Unitary system inlet node name
  Air Loop Outlet Node,          !- Unitary system outlet node name
  CycFanSchedule,                !- Supply Air Fan Operating Mode Schedule Name
  80,                             !- Maximum supply air temperature from unitary system heater {C}
  1.3,                            !- Supply air volumetric flow rate during cooling operation {m3/s}
  1.3,                            !- Supply air volumetric flow rate during heating operation {m3/s}
  0.0,                            !- Design air volumetric flow rate when no heating or cooling is needed {m3/s}
  East Zone,                      !- Controlling zone or thermostat location
  0.276923,                       !- Fraction of the design volume flow that goes through the controlling zone
  Fan:OnOff,                       !- Supply fan type
  Supply Fan 1,                    !- Supply fan name
  Coil:Heating:Gas,                !- Heating coil type
  Unitary System Heating Coil 1,    !- Heating coil name
  Coil:DX:Cooling:SingleSpeed,     !- Cooling coil type
  Unitary System ACDXCoil 1,        !- Cooling coil name
  None;                             !- High humidity control

Coil:Heating:Gas,
  Unitary System Heating Coil 1,    !- Coil Name
  FanAndCoilAvailSched,            !- Available Schedule
  0.8,                              !- Gas Burner Efficiency of the Coil
  25000,                            !- Nominal Capacity of the Coil {W}
  Heating Coil Air Inlet Node,      !- Coil Air_Inlet_Node
  DX Cooling Coil Air Inlet Node;   !- Coil_Air_Outlet_Node
```



```

Coil:DX:Cooling:SingleSpeed,
  Unitary System ACDXCoil 1,      !- Coil Name
  FanAndCoilAvailSched,         !- Availability Schedule
  25000,                        !- Rated Total Cooling Capacity {W}
  0.75,                          !- Rated SHR
  3.0,                          !- Rated COP
  1.3,                          !- Rated Air Volume Flow Rate {m3/s}
  DX Cooling Coil Air Inlet Node, !- Coil Air Inlet Node
  Air Loop Outlet Node,         !- Coil Air Outlet Node
  WindACCoolCapFT,             !- Total Cooling Capacity Modifier Curve (function of temperature)
  WindACCoolCapFFF,           !- Total Cooling Capacity Modifier Curve (function of flow fraction)
  WindACEIRFT,                !- Energy Input Ratio Modifier Curve (function of temperature)
  WindACEIRFFF,               !- Energy Input Ratio Modifier Curve (function of flow fraction)
  WindACPLFFPLR,              !- Part Load Fraction Correlation (function of part load ratio)
  CyclingFanAndCompressor;     !- Supply Air Fan Operation Mode

```

```

Fan:OnOff,
  Supply Fan 1,                 !- Fan Name
  FanAndCoilAvailSched,       !- Available Schedule
  0.7,                         !- Fan Total Efficiency
  600.0,                       !- Delta Pressure {Pa}
  1.3,                         !- Max Flow Rate {m3/s}
  0.9,                         !- Motor Efficiency
  1.0,                         !- Motor In Airstream Fraction
  Air Loop Inlet Node,         !- Fan_Inlet_Node
  Heating Coil Air Inlet Node; !- Fan_Outlet_Node

AirTerminal:SingleDuct:Uncontrolled,
  Zone1DirectAir,             !- Direct Air Name
  FanAndCoilAvailSched,     !- Schedule name for on/off schedule
  Zone 1 Inlet Node,         !- Zone Supply Air Node Name
  0.47;                       !- Maximum air flow rate {m3/s}

AirTerminal:SingleDuct:Uncontrolled,
  Zone2DirectAir,           !- Direct Air Name
  FanAndCoilAvailSched,     !- Schedule name for on/off schedule
  Zone 2 Inlet Node,         !- Zone Supply Air Node Name
  0.36;                       !- Maximum air flow rate {m3/s}

AirTerminal:SingleDuct:Uncontrolled,
  Zone3DirectAir,           !- Direct Air Name
  FanAndCoilAvailSched,     !- Schedule name for on/off schedule
  Zone 3 Inlet Node,         !- Zone Supply Air Node Name
  0.47;                       !- Maximum air flow rate {m3/s}

```

Example of Heat/Cool Unitary System Specification

AirLoopHVAC:UnitaryHeatCool Outputs

```

HVAC,Average, Unitary System Fan Part-Load Ratio
HVAC,Average, Unitary System Compressor Part-Load Ratio

```

Unitary System Fan Part-Load Ratio

This output variable is the ratio of actual air mass flow rate through the unitary system to the system's design air mass flow rate (i.e., design volumetric flow rate converted to dry air mass flow rate). For continuous fan operation mode, this variable is always 1.0 when the unitary system is available (based on the availability schedule). For cycling fan/cycling coil operation mode, the actual air mass flow rate is calculated based on the ratio of the sensible heating (or cooling) load to the steady-state unitary system heating (or cooling) capacity. For the cycling fan mode, the runtime fraction for the unitary system fan may be different from the fan part-load ratio reported here due the part-load performance of the system's heating (or cooling) coil (delay at start-up to reach steady-state output). In general, runtime fractions are reported by individual components where appropriate (e.g., Fan:OnOff).

Unitary System Compressor Part-Load Ratio

This output variable is the ratio of the sensible cooling load to the steady-state cooling capacity of the unitary system's DX cooling coil. The runtime fraction for the DX cooling coil compressor may be different from the compressor part-load ratio reported here due to the part-load performance of the cooling coil (delay at start-up to reach steady-state output). In general, runtime fractions are reported by individual components where appropriate.

AirLoopHVAC:UnitaryHeatPump:AirToAir

The unitary air-to-air heat pump is a "virtual" component that consists of a fan component (OnOff or ConstantVolume), a DX cooling coil component, a DX heating coil component, and a Gas or Electric supplementary heating coil component as shown in the Figure below.

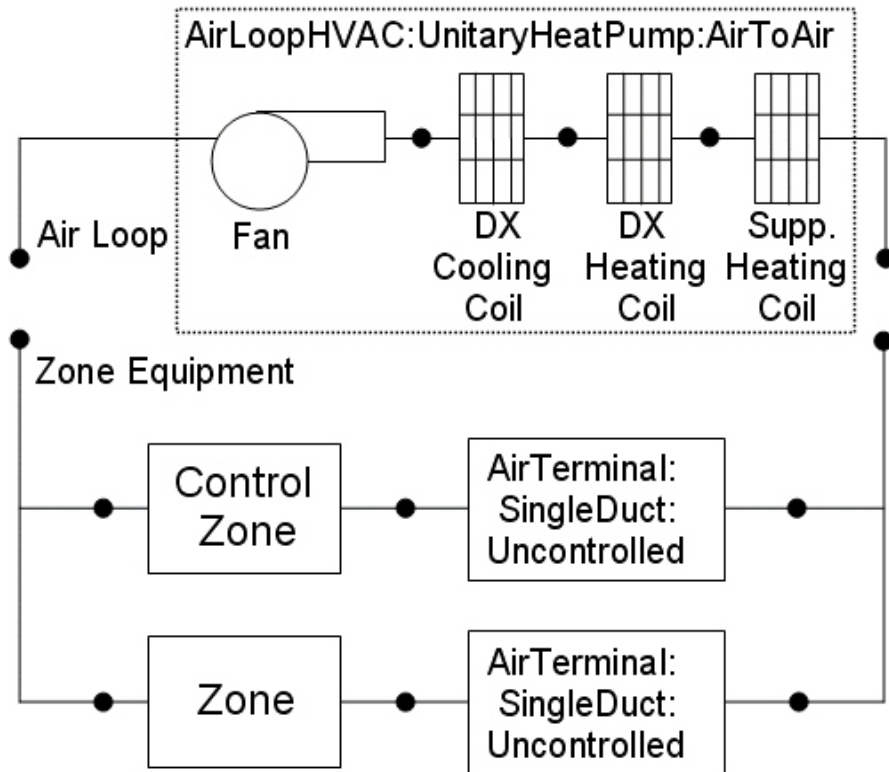


Figure 94. Schematic of EnergyPlus Unitary Air-to-Air Heat Pump (Blow Through Configuration)

Links to the fan, DX cooling coil, DX heating coil, and supplementary heating coil specifications are provided in the heat pump's input data syntax. In addition the control zone name, the fraction of the total system air flow delivered to the control zone and system design operating conditions are specified by the heat pump syntax as shown in the Energy+.idd specification below.

```

AirLoopHVAC:UnitaryHeatPump:AirToAir,
  \min-fields 20
A1, \field Name
  \required-field
  \type alpha
A2, \field Availability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
  \note A schedule value greater than zero (usually 1 is used) indicates that the unit is
  \note available to operate as needed. A value less than or equal to zero (usually zero
  \note is used) denotes that the unit must be off.
A3, \field Air Inlet Node Name
  \required-field
  \type alpha
A4, \field Air Outlet Node Name
  \required-field
  \type alpha
N1, \field Supply Air Flow Rate During Cooling Operation
  \required-field
  \type real
  \units m3/s
  \minimum> 0.0
  \autosizable
  \note Must be less than or equal to the fan's maximum flow rate.
N2, \field Supply Air Flow Rate During Heating Operation
  \required-field
  \type real
  \units m3/s
  \minimum> 0.0
  \autosizable
  \note Must be less than or equal to the fan's maximum flow rate.
N3, \field Supply Air Flow Rate When No Cooling or Heating is Needed
  \type real
  \units m3/s
  \minimum 0.0
  \autosizable
  \note Must be less than or equal to the fan's maximum flow rate.
  \note Only used when fan operating mode is continuous (disregarded for cycling fan mode).
  \note This air flow rate is used when no heating or cooling is required (i.e., the DX coil
  \note compressor and supplemental heating coil are off). If this field is left blank or zero,
  \note the supply air flow rate from the previous on cycle (either cooling or heating) is used.
A5, \field Controlling Zone or Thermostat Location
  \required-field
  \type object-list
  \object-list ZoneNames
N4, \field Fraction of Supply Air Flow That Goes Through the Controlling Zone
  \required-field
  \type real
  \minimum> 0.0
  \maximum 1.0
  \autosizable
A6, \field Supply Air Fan Object Type
  \required-field
  \type choice
  \key Fan:OnOff
  \key Fan:ConstantVolume
  \note Fan:ConstantVolume only works with continuous fan operating mode (i.e. fan
  \note operating mode schedule values are greater than 0 or the fan operating mode
  \note schedule name field is left blank).
A7, \field Supply Air Fan Name
  \required-field
  \type object-list
  \object-list FansCVandOnOff
  \note Needs to match in the fan object

```

```

A8, \field Heating Coil Object Type
    \required-field
    \type choice
    \key Coil:Heating:DX:SingleSpeed
    \note Only works with Coil:Heating:DX:SingleSpeed
A9, \field Heating Coil Name
    \required-field
    \type object-list
    \object-list HeatingCoilsDXSingleSpeed
    \note Needs to match in the DX heating coil object
A10, \field Cooling Coil Object Type
    \required-field
    \type choice
    \key Coil:Cooling:DX:SingleSpeed
    \key CoilSystem:Cooling:DX:HeatExchangerAssisted
    \note Only works with Coil:Cooling:DX:SingleSpeed or
    \note CoilSystem:Cooling:DX:HeatExchangerAssisted
A11, \field Cooling Coil Name
    \required-field
    \note Needs to match in the DX cooling coil object
    \type object-list
    \object-list CoolingCoilsDXSingleSpeed
A12, \field Supplemental Heating Coil Object Type
    \required-field
    \type choice
    \key Coil:Heating:Gas
    \key Coil:Heating:Electric
A13, \field Supplemental Heating Coil Name
    \required-field
    \type object-list
    \object-list HeatingCoilsGasElec
    \note Needs to match in the supplemental heating coil object
N5 , \field Maximum Supply Air Temperature from Supplemental Heater
    \required-field
    \type real
    \units C
    \autosizable
N6 , \field Maximum Outdoor Dry-Bulb Temperature for Supplemental Heater Operation
    \type real
    \maximum 21.0
    \default 21.0
    \units C
A14, \field Fan Placement
    \type choice
    \key BlowThrough
    \key DrawThrough
    \default BlowThrough
A15; \field Supply Air Fan Operating Mode Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note A fan operating mode schedule value of 0 indicates cycling fan mode (supply air
    \note fan cycles on and off in tandem with the cooling or heating coil).
    \note Any other schedule value indicates continuous fan mode (supply air fan operates
    \note continuously regardless of cooling or heating coil operation).
    \note Leaving this schedule name blank will default to cycling fan mode for the
    \note entire simulation period.

```

Field: Name

This alpha field contains the identifying name for the unitary system heat pump.

Field: Availability Schedule Name

This alpha field contains the schedule name (ref. Schedule) that contains information on the availability of the heat pump to operate. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Air Inlet Node Name

This alpha field contains the name of the HVAC system node from which the heat pump draws its inlet air.

Field: Air Outlet Node Name

This alpha field contains the name of the HVAC system node to which the heat pump sends its outlet air.

Field: Supply Air Flow Rate During Cooling Operation

This numeric field defines the supply air flow rate leaving the heat pump in cubic meters per second when the DX cooling coil is operating. Values must be greater than 0 or this field is autosizable.

Field: Supply Air Flow Rate During Heating Operation

This numeric field defines the supply air flow rate leaving the heat pump in cubic meters per second when the DX heating coil and/or supplemental heater are operating. Values must be greater than 0 or this field is autosizable.

Field: Supply Air Flow Rate When No Cooling or Heating is Needed

This numeric field defines the supply air flow rate leaving the heat pump in cubic meters per second when neither cooling or heating is required (i.e., DX coils and supplemental heater are off but the supply air fan operates). This field is only used when the heat pump operating mode is specified as continuous fan operation. Values must be greater than or equal to zero, or this field is autosizable. If the heat pump operating mode is specified as continuous fan operation and this value is set to zero or this field is left blank, then the model assumes that the supply air flow rate when no cooling/heating is needed is equal to the supply air flow rate when the compressor was last operating (for cooling operation or heating operation).

Field: Controlling Zone or Thermostat Location

This alpha field contains the identifying zone name where the thermostat controlling the heat pump is located.

Field: Fraction of Supply Air Flow That Goes Through the Controlling Zone

This numeric field contains the fraction (>0 to 1) of the total system volumetric flow rate that is supplied to the zone where the thermostat controlling the heat pump is located.

Field: Supply Air Fan Object Type

This alpha field contains the identifying type of supply air fan specified for the heat pump. Fan type must be **Fan:OnOff** or **Fan:ConstantVolume**. Fan:ConstantVolume is used when the Supply Air Fan Operating Mode Schedule values are never 0 and the fan operates continuously. Fan:OnOff is used when the fan cycles on and off with the cooling or heating coil (i.e. Supply Air Fan Operating Mode Schedule values are at times 0).

Field: Supply Air Fan Name

This alpha field contains the identifying name given to the heat pump supply air fan, and should match the name specified in the corresponding fan object.

Field: Heating Coil Object Type

This alpha field contains the identifying type of heating coil specified in the heat pump. Heating coil type must be:

Coil:Heating:DX:SingleSpeed

Field: Heating Coil Name

This alpha field contains the identifying name given to the heat pump DX heating coil, and should match the name specified in the corresponding DX heating coil object.

Field: Cooling Coil Object Type

This alpha field contains the identifying type of cooling coil specified in the heat pump. There are two valid choices for this field:

```
Coil:Cooling:DX:SingleSpeed
CoilSystem:Cooling:DX:HeatExchangerAssisted
```

Field: Cooling Coil Name

This alpha field contains the identifying name given to the heat pump cooling coil, and should match the name specified in the corresponding DX cooling coil object.

Field: Supplemental Heating Coil Object Type

This alpha field contains the identifying type of supplemental heating coil specified in the heat pump. Heating coil type must be:

```
Coil:Heating:Electric
Coil:Heating:Gas
```

Field: Supplemental Heating Coil Name

This alpha field contains the identifying name given to the heat pump supplemental heating coil, and should match the name specified in the corresponding heating coil object.

Field: Maximum Supply Air Temperature from Supplemental Heater

This numeric field defines the maximum allowed supply air temperature exiting the heat pump supplemental heating coil.

Field: Maximum Outdoor Dry-Bulb Temperature for Supplemental Heater Operation

This numeric field defines the outdoor air dry-bulb temperature above which the heat pump supplemental heating coil is disabled. The temperature for this input field must be less than or equal to 21 C. If this input field is left blank, the default value is 21 C.

Field: Fan Placement

This alpha field has two choices: **BlowThrough** or **DrawThrough**. The first choice represents a blow through system where the supply air fan is before the DX cooling/heating coil and the supplementary heating coil. The second choice represents a draw through system where the supply air fan is between the DX cooling/heating coil and the supplementary heating coil. If this input field is left blank, the default is blow through.

Field: Supply Air Fan Operating Mode Schedule Name

This alpha field specifies the name of the supply air fan operating mode schedule. The supply air fan operating mode may vary during the simulation based on time-of-day or with a change of season. Schedule values of 0 denote that the unitary system supply air fan and the heating or cooling coil cycle on and off together to meet the heating or cooling load (a.k.a. AUTO fan). Schedule values other than 0 denote that the supply fan runs continuously while the heating or cooling coil cycles to meet the load.

As shown in the example below, correct specification of the air-to-air heat pump requires specification of the following objects in addition to the heat pump object:

- 6)** Fan (Fan:OnOff or Fan:ConstantVolume)
- 7)** Heating coil (Coil:Heating:DX:SingleSpeed)
- 8)** Cooling coil (Coil:DX:Cooling:SingleSpeed or CoilSystem:Cooling:DX:HeatExchangerAssisted)

- 9) Supplemental heating coil (Coil:Heating:Gas or Coil:Heating:Electric)
 10) Direct air unit (AirTerminal:SingleDuct:Uncontrolled) for each zone served by the unitary system

Note: the air-to-air heat pump's fan, cooling coil, heating coil and supplementary heating coil must be connected in the air loop according to the configuration shown above (Figure 94) for the blow-through fan configuration. The only other valid configuration is with a draw-through fan placement, where the fan is located between the DX heating coil and the supplementary heating coil. In addition, the volumetric air flow rate specified in the direct air unit for the controlling zone should properly reflect the fractional volumetric air flow rate specified in the heat pump object.

UnitarySystem:HeatPump:AirToAir Example Specification

```
AirLoopHVAC:UnitaryHeatPump:AirToAir,
  DXAC Heat Pump 1,           ! Heat Pump name
  FanAndCoilAvailSched,      ! Heat Pump availability schedule
  Mixed Air Node,            ! Heat Pump air inlet node
  Air Loop Outlet Node,      ! Heat Pump air outlet node
  1.3,                        !- Supply air volumetric flow rate during cooling operation {m3/s}
  1.3,                        !- Supply air volumetric flow rate during heating operation {m3/s}
  0.0,                        !- Design air volumetric flow rate when no heating or cooling is needed {m3/s}
  East Zone,                 ! Controlling zone or thermostat location
  0.28,                       ! Fraction of the volume flow that goes through the controlling zone
  Fan:OnOff,                 ! Supply air fan type
  Supply Fan 1,              ! Supply air fan name -- same name used in fan object
  Coil:Heating:DX:SingleSpeed, ! Heating coil type
  Heat Pump DX Heating Coil 1, ! Heating coil name -- same name used in DX heating coil object
  Coil:DX:Cooling:SingleSpeed, ! Cooling coil type
  Heat Pump ACDXCoil 1,      ! Cooling coil name -- same name used in DX cooling coil object
  Coil:Heating:Gas,          ! Supplemental heating coil type
  Heat Pump DX Supp Heating Coil 1, ! Supplemental heating coil name-- same as in heating coil object
  50,                         ! Maximum supply air temperature from supplemental heater [C]
  21,                         ! Maximum outdoor dry-bulb temp for supplemental heating coil operation [C]
  BlowThrough,              ! Fan placement
  CycFanSchedule;           ! Supply air fan operating mode schedule name
```

```
Coil:Heating:DX:SingleSpeed,
  Heat Pump DX Heating Coil 1, ! Name of heating coil
  FanAndCoilAvailSched,      ! Heating coil schedule
  35000,                      ! Rated total heating capacity [W] (at 21.11C/8.33C)
  2.75,                       ! Rated heating COP
  1.7,                        ! Rated air flow rate [m3/s]
  Heating Coil Air Inlet Node, ! Coil air inlet node
  SuppHeating Coil Air Inlet Node, ! Coil air outlet node
  HPACHeatCapFT,              ! Heating capacity modifier curve (temperature,C)
  HPACHeatCapFFF,            ! Heating capacity modifier curve (flow fraction)
  HPACHeatEIRFT,             ! Energy input ratio modifier curve (temperature,C)
  HPACHeatEIRFFF,            ! Energy input ratio modifier curve (flow fraction)
  HPACCoolPLFFPLR,           ! Part load fraction modifier curve (function of part-load ratio)
  ,                            ! defrost EIR modifier curve (temp, C) not required for resistive defrost
  CyclingFanAndCompressor,    ! Operation mode (cycling fan, cycling compressor)
  -5.0,                       ! Minimum OAT for heat pump compressor operation [C]
  5.0,                         ! Maximum outdoor dry-bulb temp for defrost operation [C]
  200.0,                       ! Crankcase heater capacity[W]
  10.0,                        ! Maximum OAT for crankcase heater operation [C]
  resistive,                   ! Defrost strategy (resistive or reverse-cycle)
  timed,                       ! Defrost control (timed or on-demand)
  0.166667,                   ! Defrost time period fraction (used for timed defrost control only)
  20000;                       ! Resistive defrost heater capacity [W]
```

```

Coil:DX:Cooling:SingleSpeed,
Heat Pump ACDXCoil 1,      ! Name of cooling coil
FanAndCoilAvailSched,    ! Availability schedule
32000,                    ! Rated total cooling capacity [W]
0.75,                     ! Rated sensible heat ratio
3.0,                      ! Rated COP
1.7,                      ! Rated air flow rate [m3/s]
DX Cooling Coil Air Inlet Node, ! Coil air inlet node
Heating Coil Air Inlet Node, ! Coil air outlet node
HPACCoolCapFT,           ! Cooling capacity modifier curve (temperature,C)
HPACCoolCapFFF,         ! Cooling capacity modifier curve (flow fraction)
HPACCoolEIRFT,          ! Energy input ratio modifier curve (temperature,C)
HPACCoolEIRFFF,         ! Energy input ratio modifier curve (flow fraction)
HPACCoolPLFFPLR,        ! Part load factor modifier curve (function of part-load ratio)
CyclingFanAndCompressor; ! Operation mode (cycling fan, cycling compressor)

Coil:Heating:Gas,
Heat Pump DX Supp Heating Coil 1, ! Name of heating coil
FanAndCoilAvailSched,    ! Availability schedule
0.8 ,                    ! Gas Burner Efficiency of the Coil
32000,                   ! Nominal Capacity of the Coil [W]
SuppHeating Coil Air Inlet Node, ! Supplementary heating coil air side inlet node
Air Loop Outlet Node;    ! Supplementary heating coil air side outlet node

```

```

Fan:OnOff,
Supply Fan 1,             ! Fan Name
FanAndCoilAvailSched,   ! Fan Schedule
0.7,                     ! Fan Efficiency
300.0,                   ! Delta Pressure [N/M^2]
1.7,                     ! Max Vol Flow Rate [m^3/Sec]
0.9,                     ! motor efficiency
1.0,                     ! motor in air stream fraction
Mixed Air Node,          ! fan inlet node
DX Cooling Coil Air Inlet Node; ! fan outlet node

AirTerminal:SingleDuct:Uncontrolled,
Zone1DirectAir,         ! direct air unit name
FanAndCoilAvailSched,   ! schedule name for on/off schedule
Zone 1 Inlet Node,      ! zone supply air node name
0.612;                  ! maximum air flow rate, m3/s

AirTerminal:SingleDuct:Uncontrolled,
Zone2DirectAir,         ! direct air unit name
FanAndCoilAvailSched,   ! schedule name for on/off schedule
Zone 2 Inlet Node,      ! zone supply air node name
0.476;                  ! maximum air flow rate, m3/s

AirTerminal:SingleDuct:Uncontrolled,
Zone3DirectAir,         ! direct air unit name
FanAndCoilAvailSched,   ! schedule name for on/off schedule
Zone 3 Inlet Node,      ! zone supply air node name
0.612;                  ! maximum air flow rate, m3/s

```

AirLoopHVAC:UnitaryHeatPump:AirToAir Outputs

```

HVAC, Average, Unitary Heat Pump Fan Part-Load Ratio
HVAC, Average, Unitary Heat Pump Compressor Part-Load Ratio

```

Unitary Heat Pump Fan Part-Load Ratio

This output variable is the ratio of actual air mass flow rate through the heat pump to the heat pump's design air mass flow rate (i.e., design volumetric flow rate converted to dry air mass flow rate). For continuous fan operation mode, this variable is always 1.0 when the furnace is available (based on the availability schedule). For cycling fan/cycling coil operation mode, the actual air mass flow rate is calculated based on the ratio of the sensible heating (or cooling) load to the steady-state heat pump heating (or cooling) capacity. For the cycling fan mode,

the runtime fraction for the heat pump fan may be different from the fan part-load ratio reported here due the part-load performance of the heat pump’s heating (or cooling) coil (delay at start-up to reach steady-state output). In general, runtime fractions are reported by individual components where appropriate (e.g., Fan:OnOff).

Unitary Heat Pump Compressor Part-Load Ratio

This output variable is the ratio of the sensible load (heating or cooling) to the steady-state capacity of the heat pump’s DX heating or cooling coil. The runtime fraction for the heat pump compressor may be different from the compressor part-load ratio reported here due the part-load performance of the heating/cooling coil (delay at start-up to reach steady-state output). In general, runtime fractions are reported by individual components where appropriate.

AirLoopHVAC:UnitaryHeatPump:AirToAir:MultiSpeed

The multispeed air-to-air heat pump is a “virtual” component that consists of a fan component (On/Off or ConstVolume), a DX multispeed cooling coil component, a DX multispeed heating coil component, and a Gas or Electric supplemental heating coil component. This system also includes the option to use available waste energy to heat water. A schematic diagram of the air-to-air multispeed heat pump is shown below. The component connection sequence for the blow through option (shown below) from inlet to outlet is fan, cooling coil, heating coil, and supplemental heater. The connection sequence for the draw through option is cooling coil, heating coil, fan, and supplemental heater.

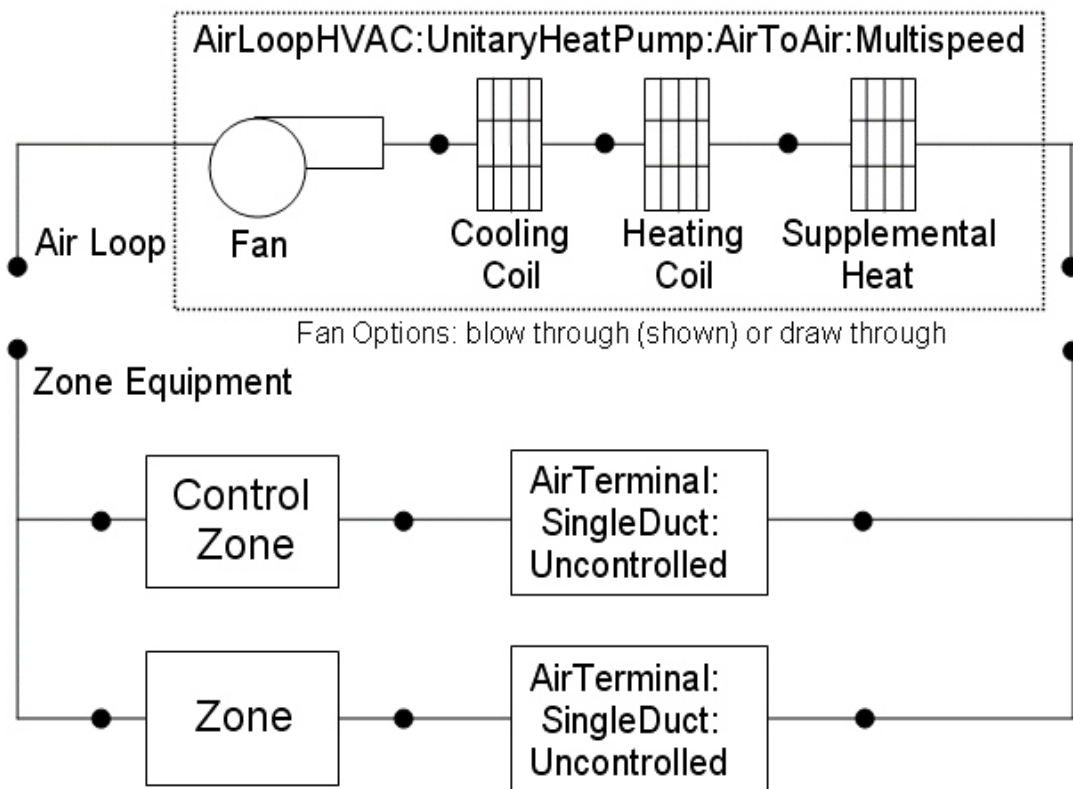


Figure 95. Schematic of EnergyPlus Unitary Air-to-Air Multi Speed Heat Pump

The main difference between this heat pump object and other EnergyPlus heat pump objects is that this object allows from two to four discrete compressor speeds for heating and cooling operation (instead of a single speed for each mode). The lowest speed is called Speed 1, and the highest speed is called Speed n (2, 3 or 4 as specified in the input syntax). This object allows a different number of speeds for cooling and heating, and each speed has an associated airflow rate. The airflow rates for the various heating speeds can be different from

the airflow rates for the cooling speeds. In addition, the airflow rate when no cooling or heating is needed can also be defined. The number of cooling and heating speeds defined by the user in this heat pump object must equal the number of speeds defined in the associated coils (child objects). For example, the number of speeds for cooling defined in this heat pump object must be equal to the number of speeds defined in the associated cooling coil object.

Links to the fan, DX multispeed cooling coil, DX multispeed heating coil, and supplementary heating coil specifications are provided in the heat pump's input data syntax. In addition, the control zone name, airflow rates at the corresponding compressor speeds, and the fraction of total system air flow delivered to the control zone are specified by the heat pump syntax. The object inputs are shown in the Energy+.idd specification below.

```

AirLoopHVAC:UnitaryHeatPump:AirToAir:MultiSpeed,
  \min-fields 32
A1, \field Name
  \required-field
  \type alpha
A2, \field Availability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
A3, \field Air Inlet Node Name
  \required-field
  \type alpha
A4, \field Air Outlet Node Name
  \required-field
  \type alpha
A5, \field Controlling Zone or Thermostat Location
  \required-field
  \type object-list
  \object-list ZoneNames
N1, \field Fraction of Supply Air Flow That Goes Through the Controlling Zone
  \required-field
  \type real
  \minimum> 0
  \maximum 1
  \autosizable
A6, \field Supply Air Fan Object Type
  \required-field
  \type choice
  \key Fan:OnOff
  \key Fan:ConstantVolume
  \note Select the type of supply air fan used in this unitary system.
A7, \field Supply Air Fan Name
  \required-field
  \type object-list
  \object-list FansCVandOnOff
  \note Enter the name of the supply air fan used in this unitary system.
A8, \field Supply Air Fan Placement
  \required-field
  \type choice
  \key BlowThrough
  \key DrawThrough
  \note Select supply air fan placement as either BlowThrough or DrawThrough.
  \note BlowThrough means the supply air fan is located before the cooling
  \note coil. DrawThrough means the supply air fan is located after the heating coil
  \note but before the optional supplemental heating coil.

```

```

A9 , \field Supply Air Fan Operating Mode Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note Enter the name of a schedule to control the supply air fan. Schedule values of zero
    \note mean that the supply air fan will cycle off if there is no cooling or heating load
    \note in the control zone. Non-zero schedule values mean that the supply air fan
    \note will operate continuously even if there is no cooling or heating load
    \note in the control zone. If this field is left blank, the supply air fan will
    \note operate continuously for the entire simulation period.
A10, \field Heating Coil Object Type
    \required-field
    \type choice
    \key Coil:Heating:DX:MultiSpeed
    \note Only works with Coil:Heating:DX:MultiSpeed
A11, \field Heating Coil Name
    \required-field
    \type object-list
    \object-list HeatingCoilsDX
    \note Needs to match in the DX heating coil object
N2 , \field Minimum Outdoor Dry-Bulb Temperature for Compressor Operation
    \type real
    \minimum -20.0
    \default -8.0
    \units C
    \note Needs to match the corresponding minimum outdoor temperature defined
    \note in the DX heating coil object.
A12, \field Cooling Coil Object Type
    \required-field
    \type choice
    \key Coil:Cooling:DX:MultiSpeed
    \note Only works with Coil:Cooling:DX:MultiSpeed
A13, \field Cooling Coil Name
    \required-field
    \note Needs to match in the DX Cooling Coil object
    \type object-list
    \object-list CoolingCoilsDX
A14, \field Supplemental Heating Coil Object Type
    \type choice
    \key Coil:Heating:Gas
    \key Coil:Heating:Electric
A15, \field Supplemental Heating Coil Name
    \type object-list
    \object-list HeatingCoilsGasElec
    \note Needs to match in the supplemental heating coil object
N3 , \field Maximum Supply Air Temperature from Supplemental Heater
    \type real
    \units C
    \autosizable
N4 , \field Maximum Outdoor Dry-Bulb Temperature for Supplemental Heater Operation
    \type real
    \maximum 21.0
    \default 21.0
    \units C
N5 , \field Auxiliary On-Cycle Electric Power
    \type real
    \units W
    \minimum 0
    \default 0
N6 , \field Auxiliary Off-Cycle Electric Power
    \type real
    \units W
    \minimum 0
    \default 0

```

```

N7 , \field Design Heat Recovery Water Flow Rate
      \type real
      \note If non-zero, then the heat recovery inlet and outlet node names must be entered.
      \note Used for heat recovery to an EnergyPlus plant loop.
      \units m3/s
      \minimum 0.0
      \default 0.0
N8,  \field Maximum Temperature for Heat Recovery
      \units C
      \maximum 100.0
      \minimum 0.0
      \default 80.0
A16, \field Heat Recovery Water Inlet Node Name
      \type alpha
A17, \field Heat Recovery Water Outlet Node Name
      \type alpha
N9 , \field Supply Air Flow Rate When No Cooling or Heating is Needed
      \type real
      \units m3/s
      \minimum 0
      \autosizable
      \note Only used when the supply air fan operating mode is continuous (see field
      \note Supply Air Fan Operating Mode Schedule Name). This air flow rate
      \note is used when no heating or cooling is required and the coils are off.
      \note If this field is left blank or zero, the supply air flow rate from the
      \note previous on cycle (either cooling or heating) is used.
N10, \field Number of Speeds for Heating
      \required-field
      \type integer
      \minimum 2
      \maximum 4
      \note Enter the number of the following sets of data for air flow rates.
N11, \field Number of Speeds for Cooling
      \required-field
      \type integer
      \minimum 2
      \maximum 4
      \note Enter the number of the following sets of data for air flow rates.
N12, \field Speed 1 Supply Air Flow Rate During Heating Operation
      \required-field
      \type real
      \units m3/s
      \autosizable
      \minimum> 0
      \note Enter the operating supply air flow rate during heating
      \note operation or specify autosize.
N13, \field Speed 2 Supply Air Flow Rate During Heating Operation
      \required-field
      \type real
      \units m3/s
      \autosizable
      \minimum> 0
      \note Enter the operating supply air flow rate during heating
      \note operation or specify autosize.
N14, \field Speed 3 Supply Air Flow Rate During Heating Operation
      \required-field
      \type real
      \units m3/s
      \autosizable
      \minimum> 0
      \note Enter the operating supply air flow rate during heating
      \note operation or specify autosize.
N15, \field Speed 4 Supply Air Flow Rate During Heating Operation
      \required-field
      \type real
      \units m3/s
      \autosizable
      \minimum> 0
      \note Enter the operating supply air flow rate during heating
      \note operation or specify autosize.

```

```

N16, \field Speed 1 Supply Air Flow Rate During Cooling Operation
      \type real
      \units m3/s
      \autosizable
      \minimum> 0
      \note Enter the operating supply air flow rate during cooling
      \note operation or specify autosize.
N17, \field Speed 2 Supply Air Flow Rate During Cooling Operation
      \type real
      \units m3/s
      \autosizable
      \minimum> 0
      \note Enter the operating supply air flow rate during cooling
      \note operation or specify autosize.
N18, \field Speed 3 Supply Air Flow Rate During Cooling Operation
      \type real
      \units m3/s
      \autosizable
      \minimum> 0
      \note Enter the operating supply air flow rate during cooling
      \note operation or specify autosize.
N19; \field Speed 4 Supply Air Flow Rate During Cooling Operation
      \type real
      \units m3/s
      \autosizable
      \minimum> 0
      \note Enter the operating supply air flow rate during cooling
      \note operation or specify autosize.

```

Field: Name

This alpha field contains the identifying name for the multispeed heat pump.

Field: Availability Schedule Name

This alpha field contains the schedule name (ref. Schedule) that contains information on the availability of the heat pump to operate. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Air Inlet Node Name

This alpha field contains the name of the HVAC system node from which the heat pump draws its inlet air.

Field: Air Outlet Node Name

This alpha field contains the name of the HVAC system node to which the heat pump sends its outlet air.

Field: Controlling Zone or Thermostat Location

This alpha field contains the identifying zone name where the thermostat controlling the multispeed heat pump is located.

Field: Fraction of Supply Air Flow That Goes Through the Controlling Zone

This numeric field contains the fraction (>0 to 1) of the total system volumetric flow rate that is supplied to the zone where the thermostat controlling the multispeed heat pump is located.

Field: Supply Air Fan Object Type

This alpha field contains the identifying type of supply air fan specified for the heat pump. Fan type must be Fan:OnOff or Fan:ConstantVolume. Fan:ConstantVolume can only be used when the supply air fan operating mode is continuous (see field 'Supply air fan operating mode schedule name').

Field: Supply Air Fan Name

This alpha field contains the identifying name given to the heat pump supply air fan, and should match the name specified in the corresponding fan object.

Field: Supply Air Fan Placement

This alpha field has two choices: **BlowThrough** or **DrawThrough**. The first choice stands for “blow through fan”. This means that the unit consists of a fan followed by a DX multispeed cooling coil, DX multispeed heating coil, and a supplemental heating coil. The fan “blows through” the cooling and heating coils. The second choice stands for “draw through fan”. This means that the unit consists of the DX cooling and heating coils followed by a fan, with the supplemental heater located at the outlet of the fan. The fan “draws” air through the DX coils.

Note: the multispeed heat pump's supply air fan, cooling coil, heating coil and supplemental heating coil must be connected according to the configuration shown above (Figure 95) for the ‘blow through’ fan configuration. For the ‘draw through’ fan configuration the fan must be located between the DX heating coil and the supplemental heater, whose outlet node is the system outlet node. In addition, the DX cooling coil and DX heating coil operation mode must be specified consistently with the heat pump's supply air fan operating mode (e.g., with the heat pump's supply air fan set to cycle on and off with the cooling/heating load, the DX cooling and heating coil operation mode must be CyclingFanAndCompressor). If the operation modes in the parent (heat pump) and child (coil) objects are specified differently, the operation mode in the parent object prevails.

Field: Supply Air Fan Operating Mode Schedule Name

This alpha field contains the schedule name (ref. Schedule) that contains information to control the supply air fan. Schedule values of zero mean that the supply air fan will cycle off if there is no cooling or heating load in the control zone. Non-zero schedule values mean that the supply air fan will operate continuously even if there is no cooling or heating load in the control zone. If this field is left blank, the supply air fan will operate continuously for the entire simulation period.

Field: Heating Coil Object Type

This alpha field contains the identifying type of heating coil specified in the heat pump. Heating coil type must be Coil:Heating:DX:MultiSpeed.

Field: Heating Coil Name

This alpha field contains the identifying name given to the DX heating coil, and should match the name specified in the corresponding DX heating coil object.

Field: Minimum Outdoor Dry-Bulb Temperature for Compressor Operation

This numeric field defines the outdoor air dry-bulb temperature below which the DX heating coil turns off. The temperature for this input field must be greater than or equal to –20 C. If this input field is left blank, the default value is -8 C. This temperature should match the minimum compressor operating temperature specified for the multispeed heat pump's DX heating coil.

Field: Cooling Coil Object Type

This alpha field contains the identifying type of cooling coil specified in the heat pump. Cooling coil type must be Coil:Cooling:DX:MultiSpeed.

Field: Cooling Coil Name

This alpha field contains the identifying name given to the heat pump cooling coil, and should match the name specified in the corresponding DX cooling coil object.

Field: Supplemental Heating Coil Object Type

This alpha field contains the identifying type of supplemental heating coil specified in the heat pump. Heating coil type must be Coil:Gas:Heating or Coil:Electric:Heating.

Field: Supplemental Heating Coil Name

This alpha field contains the identifying name given to the heat pump supplemental heating coil, and should match the name specified in the corresponding heating coil object.

Field: Maximum Supply Air Temperature from Supplemental Heater

This numeric field defines the maximum allowed supply air temperature (in degrees C) exiting the heat pump supplemental heating coil. If the calculated supply air temperature exiting the supplemental heater exceeds this value, then it is reset to this maximum temperature. This field is autosizable.

Field: Maximum Outdoor Dry-Bulb Temperature for Supplemental Heater Operation

This numeric field defines the outdoor air dry-bulb temperature above which the heat pump supplemental heating coil is disabled. The temperature for this input field must be less than or equal to 21 C. If this input field is left blank, the default value is 21 C.

Field: Auxiliary On-Cycle Electric Power

This field defines auxiliary electrical power (W) consumed during the on-cycle period (i.e., when the cooling or heating coil is operating). The model assumes that this auxiliary power does not contribute to heating the supply air. The minimum value for this field is 0.0, and the default value is also 0.0 if the field is left blank.

Field: Auxiliary Off-Cycle Electric Power

This field defines auxiliary electrical power (W) consumed during the off-cycle period (i.e., when the cooling and heating coil are not operating). The model assumes that this auxiliary power does not contribute to heating the supply air. The minimum value for this field is 0.0, and the default value is also 0.0 if the field is left blank.

Field: Design Heat Recovery Water Flow Rate

This optional input field defines the design water flow rate used if the heat recovery option is being simulated. If this value is greater than 0.0 then a heat recovery loop must be specified and attached to the multispeed heat pump using the next 2 node fields. To determine how the heat recovery algorithm works, refer to the EnergyPlus Engineering Reference in the AirLoopHVAC:UnitaryHeatPump:AirToAir:MultiSpeed with Heat Recovery section. The units for this input value are cubic meters per second.

Field: Maximum Temperature for Heat Recovery

This field sets the maximum temperature (in degrees C) that this heat pump can produce for heat recovery. The idea behind this field is that the current models do not take temperatures into account for availability and they just pass Q's around the loop without a temperature limit. This temperature limit puts an upper bound on the recovered heat and limits the max temperature leaving the component.

As temperatures in the loop approach the maximum temperature, the temperature difference between the entering water and the surfaces in the piece of equipment becomes smaller. For the given heat recovery flow rate and that temperature difference the amount of heat recovered will be reduced, and eventually there will be no heat recovered when the entering water temperature is equal to the maximum temperature specified by the user in this field. The reduced amount of heat recovered will diminish if the temperature of the loop approach is the maximum temperature, and this will show up in the reporting. This allows the user to set the availability or the quality of the heat recovered for usage in other parts of the system or to heat domestic hot water supply.

Field: Heat Recovery Water Inlet Node Name

This alpha field contains the identifying name for the heat recovery side inlet node.

Field: Heat Recovery Water Outlet Node Name

This alpha field contains the identifying name for the heat recovery side outlet node.

Field: Supply Air Flow Rate When No Cooling or Heating is Needed

This numeric field defines the supply air flow rate leaving the heat pump in cubic meters per second when neither cooling nor heating is required (i.e., DX coils and supplemental heater are off but the supply air fan operates). This field is only used when the heat pump supply air fan is scheduled to operate continuously regardless of DX coil operation (ref. field "Supply air fan operating mode schedule). Values must be greater than or equal to zero, or this field is autosizable. If the heat pump supply air fan is scheduled to operate continuously and the input value for this field is set to zero or this field is left blank, then the model assumes that the supply air flow rate when no cooling/heating is needed is equal to the supply air flow rate when the compressor was last operating (for cooling operation or heating operation).

Field: Number of Speeds for Heating

This field defines the number of heating speeds for the heat pump, and must match the number of heating speeds defined in the associated heating coil. The value for this input field defines the number of airflow rates that must be defined for heating in the field below. The minimum value for this field is two and the maximum value is four.

Field: Number of Speeds for Cooling

This field defines the number of cooling speeds for the heat pump, and must match the number of cooling speeds defined in the associated DX cooling coil. The value for this input field defines the number of airflow rates that must be defined for cooling in the field below. The minimum value for this field is two and the maximum value is four.

Field: Speed 1 Supply Air Flow Rate During Heating Operation

This required numeric field defines the supply air flow rate leaving the heat pump in cubic meters per second when the DX heating coil and/or supplemental heater are operating at Speed 1 (lowest speed). Values must be greater than 0 or this field is autosizable.

Field: Speed 2 Supply Air Flow Rate During Heating Operation

This required numeric field defines the supply air flow rate leaving the heat pump in cubic meters per second when the DX heating coil and/or supplemental heater are operating at Speed 2. Values must be greater than 0 or this field is autosizable. If not autosized, the entered value must be greater or equal to the flow rate specified for heating Speed 1.

Field: Speed 3 Supply Air Flow Rate During Heating Operation

This numeric field defines the supply air flow rate leaving the heat pump in cubic meters per second when the DX heating coil and/or supplemental heater are operating at Speed 3. Values must be greater than 0 or this field is autosizable. If not autosized, the entered value must be greater or equal to the flow rate specified for heating Speed 2. If the 'Number of Speeds for Heating' is less than 3, then this field can be left blank.

Field: Speed 4 Supply Air Flow Rate During Heating Operation

This numeric field defines the supply air flow rate leaving the heat pump in cubic meters per second when the DX heating coil and/or supplemental heater are operating at Speed 4 (high speed). Values must be greater than 0 or this field is autosizable. If not autosized, the entered value must be greater or equal to the flow rate specified for heating Speed 3. If the 'Number of Speeds for Heating' is less than 4, then this field can be left blank.

Note: When autosizable is selected for any of the supply air volumetric flow rate fields, all supply air flow fields at the different speeds must be specified as autosizable. Otherwise, a fatal error will be issued and the simulation will terminate.

Field: Speed 1 Supply Air Flow Rate During Cooling Operation

This required numeric field defines the supply air flow rate leaving the heat pump in cubic meters per second when the DX cooling coil is operating at Speed 1 (lowest speed). Values must be greater than 0 or this field is autosizable.

Field: Speed 2 Supply Air Flow Rate During Cooling Operation

This required numeric field defines the supply air flow rate leaving the heat pump in cubic meters per second when the DX cooling coil is operating at Speed 2. Values must be greater than 0 or this field is autosizable. If not autosized, the entered value must be greater or equal to the flow rate specified for cooling Speed 1.

Field: Speed 3 Supply Air Flow Rate During Cooling Operation

This numeric field defines the supply air flow rate leaving the heat pump in cubic meters per second when the DX cooling coil is operating at Speed 3. Values must be greater than 0 or this field is autosizable. If not autosized, the entered value must be greater or equal to the flow rate specified for cooling Speed 2. If the 'Number of Speeds for Cooling' is less than 3, then this field can be left blank.

Field: Speed 4 Supply Air Flow Rate During Cooling Operation

This numeric field defines the supply air flow rate leaving the heat pump in cubic meters per second when the DX cooling coil is operating at Speed 4 (highest speed). Values must be greater than 0 or this field is autosizable. If not autosized, the entered value must be greater or equal to the flow rate specified for cooling Speed 3. If the 'Number of Speeds for Cooling' is less than 4, then this field can be left blank.

Following is an example input for the object and its associated components.

```

AirLoopHVAC:UnitaryHeatPump:AirToAir:MultiSpeed,
  DXAC Heat Pump 1,          !- Name of multispeed heat pump
  FanAndCoilAvailSched,     !- Availability schedule
  Mixed Air Node,           !- Heat pump air inlet node name
  Air Loop Outlet Node,     !- Heat pump air outlet node name
  East Zone,                !- Controlling zone or thermostat location
  0.28,                    !- Fraction of the total volume flow that goes through the
                          !- controlling zone
  Fan:OnOff,                !- Supply air fan type
  Supply Fan 1,             !- Supply air fan name
  BlowThrough,             !- Supply air fan placement
  FanModeSchedule,         !- Supply air fan operating mode schedule name
  Coil:Heating:DX:MultiSpeed, Heat Pump DX Heating Coil 1, !- Heating coil type & name
  -8.0,                    !- Minimum outdoor dry-bulb temperature for compressor operation
  Coil:Cooling:DX:MultiSpeed, Heat Pump ACDXCoil 1,      !- Cooling coil type & name
  Coil:Heating:Gas,        !- Supplemental heating coil type
  Supp Gas Heating Coil 1, !- Supplemental heating coil name
  50.0,                    !- Maximum supply air temperature from supplemental heater
  21,                      !- Maximum outdoor dry-bulb temperature for supplemental heater operation
  0,                       !- Auxiliary On-Cycle Electric Power {W}
  0,                       !- Auxiliary Off-Cycle Electric Power {W}
  0.00,                    !- Design Heat Recovery Water Flow Rate {m3/s}
  80.0,,,                  !- Maximum Temp for Heat Recovery {C} & Node names (none)
  0.2,                     !- Supply air volumetric flow rate when no cooling or heating is needed
  4,                       !- Number of speeds for heating
  4,                       !- Number of speeds for cooling
  0.4,                     !- Supply air flow rate during heating operation, Speed 1
  0.8,                     !- Supply air flow rate during heating operation, Speed 2
  1.2,                     !- Supply air flow rate during heating operation, Speed 3
  1.7,                     !- Supply air flow rate during heating operation, Speed 4
  0.4,                     !- Supply air flow rate during cooling operation, Speed 1
  0.8,                     !- Supply air flow rate during cooling operation, Speed 2
  1.2,                     !- Supply air flow rate during cooling operation, Speed 3
  1.7;                     !- Supply air flow rate during cooling operation, Speed 4

```

```

Coil:Heating:DX:MultiSpeed,
Heat Pump DX Heating Coil 1,  !- Name of heat pump heating coil
FanAndCoilAvailSched,      !- Availability Schedule
Heating Coil Air Inlet Node, !- Coil Air Inlet Node
SuppHeating Coil Air Inlet Node, !- Coil Air Outlet Node
CyclingFanAndCompressor,    !- Supply Air Fan Operation Mode
-8.0,                       !- Minimum Outdoor Dry-bulb Temperature for Compressor Operation {C}
200.0,                      !- Crankcase Heater Capacity {W}
10.0,                       !- Maximum Outdoor Dry-bulb Temperature for Crankcase Heater
                             !- Operation {C}
HPACDefrostCAPFT,          !- Defrost energy input ratio modifier curve (temperature)
7.22,                      !- Maximum Outdoor Dry-bulb Temperature for Defrost Operation
reverse-cycle,             !- Defrost Strategy
timed,                    !- Defrost Control
0.058333,                 !- Defrost Time Period Fraction
2000.0,                   !- Resistive Defrost Heater Capacity {W}
No,                       !- Apply Part Load Fraction to Speeds greater than 1
NaturalGas,               !- Fuel type
4,                         !- Number of speeds
7500,                    !- Rated Total Heating Capacity, Speed 1 {W}
2.75,                    !- Rated COP, Speed 1
0.45,                    !- Rated Air Volume Flow Rate, Speed 1 {m3/s}
HPACHeatCapFT Speed 1,    !- Total Heating Capacity Modifier Curve, Speed 1 (temperature)
HPACHeatCapFF Speed 1,    !- Total Heating capacity modifier curve, Speed 1 (flow fraction)
HPACHeatEIRFT Speed 1,    !- Energy input ratio modifier curve, Speed 1 (temperature)
HPACHeatEIRFF Speed 1,    !- Energy input ratio modifier curve, Speed 1 (flow fraction)
HPACHeatPLFFPLR Speed 1,  !- Part load fraction correlation, Speed 1 (part load ratio)
0.2,                      !- Rated waste heat fraction of power input, Speed 1
HAPCHeatWHFT Speed 1,     !- Waste heat modifier curve, Speed 1 (temperature)
17500,                   !- Rated Total Heating Capacity, Speed 2 {W}
2.75,                    !- Rated COP, Speed 2
0.85,                    !- Rated Air Volume Flow Rate, Speed 2 {m3/s}
HPACHeatCapFT Speed 2,    !- Total Heating Capacity Modifier Curve, Speed 2 (temperature)
HPACHeatCapFF Speed 2,    !- Total Heating capacity modifier curve, Speed 2 (flow fraction)
HPACHeatEIRFT Speed 2,    !- Energy input ratio modifier curve, Speed 2 (temperature)
HPACHeatEIRFF Speed 2,    !- Energy input ratio modifier curve, Speed 2 (flow fraction)
HPACHeatPLFFPLR Speed 2,  !- Part load fraction correlation, Speed 2 (part load ratio)
0.2,                      !- Rated waste heat fraction of power input, Speed 2
HAPCHeatWHFT Speed 2,     !- Waste heat modifier curve, Speed 2 (temperature)
25500,                   !- Rated Total Heating Capacity, Speed 3 {W}
2.75,                    !- Rated COP, Speed 3
1.25,                    !- Rated Air Volume Flow Rate, Speed 3 {m3/s}
HPACHeatCapFT Speed 3,    !- Total Heating Capacity Modifier Curve, Speed 3 (temperature)
HPACHeatCapFF Speed 3,    !- Total Heating capacity modifier curve, Speed 3 (flow fraction)
HPACHeatEIRFT Speed 3,    !- Energy input ratio modifier curve, Speed 3 (temperature)
HPACHeatEIRFF Speed 3,    !- Energy input ratio modifier curve, Speed 3 (flow fraction)
HPACHeatPLFFPLR Speed 3,  !- Part load fraction correlation, Speed 3 (part load ratio)
0.2,                      !- Rated waste heat fraction of power input, Speed 3
HAPCHeatWHFT Speed 3,     !- Waste heat modifier curve, Speed 3 (temperature)
35500,                   !- Rated Total Heating Capacity, Speed 4 {W}
2.75,                    !- Rated COP, Speed 4
1.75,                    !- Rated Air Volume Flow Rate, Speed 4 {m3/s}
HPACHeatCapFT Speed 4,    !- Total Heating Capacity Modifier Curve, Speed 4 (temperature)
HPACHeatCapFF Speed 4,    !- Total Heating capacity modifier curve, Speed 4 (flow fraction)
HPACHeatEIRFT Speed 4,    !- Energy input ratio modifier curve, Speed 4 (temperature)
HPACHeatEIRFF Speed 4,    !- Energy input ratio modifier curve, Speed 4 (flow fraction)
HPACHeatPLFFPLR Speed 4,  !- Part load fraction correlation, Speed 4 (part load ratio)
0.2,                      !- Rated waste heat fraction of power input, Speed 4
HAPCHeatWHFT Speed 4;     !- Waste heat modifier curve, Speed 4 (temperature)

```

```

COIL:DX:Cooling:MultiSpeed,
Heat Pump ACDXCoil 1,      !- Coil Name
FanAndCoilAvailsched,    !- Availability Schedule
DX Cooling Coil Air Inlet Node, !- Coil Air Inlet Node
Heating Coil Air Inlet Node, !- Coil Air Outlet Node
CyclingFanAndCompressor,  !- Supply Air Fan Operation Mode
Outdoor Condenser Air Node, !- Condenser Air Inlet Node Name
AirCooled,                !- Condenser Type
,                          !- Name of Water Storage Tank for Supply
,                          !- Name of Water Storage Tank for Condensate Collection
No,                        !- Apply Part Load Fraction to Speeds greater than 1
No,                        !- Apply Latent Degradation to Speeds greater than 1
200.0,                    !- Crankcase Heater Capacity {W}
10.0,                      !- Maximum Outdoor Dry-bulb Temperature for Crankcase Heater
                            !- Operation {C}
NaturalGas,               !- Fuel type
4,                         !- Number of speeds
7500,                     !- Rated Total Cooling Capacity, Speed 1 (gross) {W}
0.75,                     !- Rated SHR, Speed 1
3.0,                       !- Rated COP, Speed 1
0.40,                     !- Rated Air Volume Flow Rate, Speed 1 {m3/s}
HPACCoolCapFT Speed 1,    !- Total Cooling Capacity Modifier Curve, Speed 1 (temperature)
HPACCoolCapFF Speed 1,    !- Total Cooling Capacity Modifier Curve, Speed 1 (flow fraction)
HPACCOOLEIRFT Speed 1,    !- Energy Input Ratio Modifier Curve, Speed 1 (temperature)
HPACCOOLEIRFF Speed 1,    !- Energy Input Ratio Modifier Curve, Speed 1 (flow fraction)
HPACCOOLPLFFPLR Speed 1, !- Part Load Fraction Correlation, Speed 1 (part load ratio)
1000.0,                   !- Nominal Time for Condensate Removal to Begin, Speed 1 {s}
1.5,                       !- Ratio of Initial Moisture Evaporation Rate and Steady-state Latent
                            !- Capacity, Speed 1 {dimensionless}
3.0,                       !- Maximum ON/OFF Cycling Rate, Speed 1 {cycles/hr}
45.0,                     !- Latent Capacity Time Constant, Speed 1 {s}
0.2,                       !- Rated waste heat fraction of power input, Speed 1 {dimensionless}
HAPCCoolWHFT Speed 1,     !- Waste heat modifier curve, Speed 1 (temperature)
0.9,                       !- Evaporative Condenser Effectiveness, Speed 1 {dimensionless}
0.05,                     !- Evaporative Condenser Air Volume Flow Rate, Speed 1 {m3/s}
50,                        !- Evaporative Condenser Pump Rated Power Consumption, Speed 1 {W}
17500,                    !- Rated Total Cooling Capacity, Speed 2 (gross) {W}
0.75,                     !- Rated SHR, Speed 2
3.0,                       !- Rated COP, Speed 2
0.85,                     !- Rated Air Volume Flow Rate, Speed 2 {m3/s}
HPACCoolCapFT Speed 2,    !- Total Cooling Capacity Modifier Curve, Speed 2 (temperature)
HPACCoolCapFF Speed 2,    !- Total Cooling Capacity Modifier Curve, Speed 2 (flow fraction)
HPACCOOLEIRFT Speed 2,    !- Energy Input Ratio Modifier Curve, Speed 2 (temperature)
HPACCOOLEIRFF Speed 2,    !- Energy Input Ratio Modifier Curve, Speed 2 (flow fraction)
HPACCOOLPLFFPLR Speed 1, !- Part Load Fraction Correlation, Speed 2 (part load ratio)
1000.0,                   !- Nominal Time for Condensate Removal to Begin, Speed 2 {s}
1.5,                       !- Ratio of Initial Moisture Evaporation Rate and Steady-state Latent
                            !- Capacity, Speed 2 {dimensionless}
3.0,                       !- Maximum ON/OFF Cycling Rate, Speed 2 {cycles/hr}
45.0,                     !- Latent Capacity Time Constant, Speed 2 {s}
0.2,                       !- Rated waste heat fraction of power input, Speed 2 {dimensionless}
HAPCCoolWHFT Speed 2,     !- Waste heat modifier curve, Speed 2 (temperature)
0.9,                       !- Evaporative Condenser Effectiveness, Speed 2 {dimensionless}
0.1,                       !- Evaporative Condenser Air Volume Flow Rate, Speed 2 {m3/s}
60,                        !- Evaporative Condenser Pump Rated Power Consumption, Speed 2 {W}
25500,                    !- Rated Total Cooling Capacity, Speed 3 (gross) {W}
0.75,                     !- Rated SHR, Speed 3
3.0,                       !- Rated COP, Speed 3
1.25,                     !- Rated Air Volume Flow Rate, Speed 3 {m3/s}
HPACCoolCapFT Speed 3,    !- Total Cooling Capacity Modifier Curve, Speed 3 (temperature)
HPACCoolCapFF Speed 3,    !- Total Cooling Capacity Modifier Curve, Speed 3 (flow fraction)
HPACCOOLEIRFT Speed 3,    !- Energy Input Ratio Modifier Curve, Speed 3 (temperature)
HPACCOOLEIRFF Speed 3,    !- Energy Input Ratio Modifier Curve, Speed 3 (flow fraction)
HPACCOOLPLFFPLR Speed 1, !- Part Load Fraction Correlation, Speed 3 (part load ratio)
1000.0,                   !- Nominal Time for Condensate Removal to Begin, Speed 3 {s}
1.5,                       !- Ratio of Initial Moisture Evaporation Rate and Steady-state Latent
                            !- Capacity, Speed 3 {dimensionless}
3.0,                       !- Maximum ON/OFF Cycling Rate, Speed 3 {cycles/hr}
45.0,                     !- Latent Capacity Time Constant, Speed 3 {s}
0.2,                       !- Rated waste heat fraction of power input, Speed 3 {dimensionless}
HAPCCoolWHFT Speed 3,     !- Waste heat modifier curve, Speed 3 (temperature)

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0.9,           !- Evaporative Condenser Effectiveness, Speed 3 {dimensionless}
0.2,           !- Evaporative Condenser Air Volume Flow Rate, Speed 3 {m3/s}
80,            !- Evaporative Condenser Pump Rated Power Consumption, Speed 3 {W}
35500,         !- Rated Total Cooling Capacity, Speed 4 (gross) {W}
0.75,          !- Rated SHR, Speed 4
3.0,           !- Rated COP, Speed 4
1.75,          !- Rated Air Volume Flow Rate, Speed 4 {m3/s}
HPACCoolCapFT Speed 4, !- Total Cooling Capacity Modifier Curve, Speed 4 (temperature)
HPACCoolCapFF Speed 4, !- Total Cooling Capacity Modifier Curve, Speed 4 (flow fraction)
HPACCOOLEIRFT Speed 4, !- Energy Input Ratio Modifier Curve, Speed 4 (temperature)
HPACCOOLEIRFF Speed 4, !- Energy Input Ratio Modifier Curve, Speed 4 (flow fraction)
HPACCOOLPLFFPLR Speed 1, !- Part Load Fraction Correlation, Speed 4 (part load ratio)
1000.0,        !- Nominal Time for Condensate Removal to Begin, Speed 4 {s}
1.5,           !- Ratio of Initial Moisture Evaporation Rate and Steady-state Latent
                !- Capacity, Speed 4 {dimensionless}
3.0,           !- Maximum ON/OFF Cycling Rate, Speed 4 {cycles/hr}
45.0,          !- Latent Capacity Time Constant, Speed 4 {s}
0.2,           !- Rated waste heat fraction of power input, Speed 4 {dimensionless}
HAPCCoolWHFT Speed 4, !- Waste heat modifier curve, Speed 4 (temperature)
0.9,           !- Evaporative Condenser Effectiveness, Speed 4 {dimensionless}
0.3,           !- Evaporative Condenser Air Volume Flow Rate, Speed 4 {m3/s}
100;           !- Evaporative Condenser Pump Rated Power Consumption, Speed 4 {W}

```

```

Coil:Heating:Gas,
  Supp Gas Heating Coil 1, !- Coil Name
  FanAndCoilAvailSched,   !- Available Schedule
  0.8,                     !- Gas Burner Efficiency of the Coil
  45000,                   !- Nominal Capacity of the Coil {W}
  SuppHeating Coil Air Inlet Node, !- Coil_Air_Inlet_Node
  Air Loop Outlet Node;    !- Coil_Air_Outlet_Node

Fan:OnOff,
  Supply Fan 1,           !- Fan Name
  FanAndCoilAvailSched, !- Available Schedule
  0.7,                    !- Fan Total Efficiency
  300.0,                  !- Delta Pressure {Pa}
  1.7,                    !- Max Flow Rate {m3/s}
  0.9,                    !- Motor Efficiency
  1.0,                    !- Motor In Airstream Fraction
  Mixed Air Node,        !- Fan_Inlet_Node
  DX Cooling Coil Air Inlet Node; !- Fan_Outlet_Node

AirTerminal:SingleDuct:Uncontrolled,
  Zone1DirectAir,        ! direct air unit name
  FanAndCoilAvailSched, ! schedule name for on/off schedule
  Zone 1 Inlet Node,     ! zone supply air node name
  0.612;                 ! maximum air flow rate, m3/s

AirTerminal:SingleDuct:Uncontrolled,
  Zone2DirectAir,        ! direct air unit name
  FanAndCoilAvailSched, ! schedule name for on/off schedule
  Zone 2 Inlet Node,     ! zone supply air node name
  0.476;                 ! maximum air flow rate, m3/s

AirTerminal:SingleDuct:Uncontrolled,
  Zone3DirectAir,        ! direct air unit name
  FanAndCoilAvailSched, ! schedule name for on/off schedule
  Zone 3 Inlet Node,     ! zone supply air node name
  0.612;                 ! maximum air flow rate, m3/s

```

AirLoopHVAC:UnitaryHeatPump:AirToAir:MultiSpeed Outputs

```

HVAC,Average,Unitary MSHP Fan Part-Load Ratio
HVAC,Average,Unitary MSHP Compressor Part-Load Ratio
HVAC,Average,Unitary MSHP DX Coil Cycling Ratio
HVAC,Average,Unitary MSHP DX Coil Speed Ratio
HVAC,Average,Unitary MSHP DX Coil Speed Number
HVAC,Average,Unitary MSHP Electric Power[W]

```

```

HVAC,Sum,Unitary MSHP Electricity Energy Consumption[J]
HVAC,Average,Unitary MSHP Total Cooling Energy Rate [W]
HVAC,Average,Unitary MSHP Total Heating Energy Rate [W]
HVAC,Average,Unitary MSHP Sensible Cooling Energy Rate [W]
HVAC,Average,Unitary MSHP Sensible Heating Energy Rate [W]
HVAC,Average,Unitary MSHP Latent Cooling Energy Rate [W]
HVAC,Average,Unitary MSHP Latent Heating Energy Rate [W]
HVAC,Average,Unitary MSHP Auxiliary Electric Power[W]
HVAC,Sum,Unitary MSHP Auxiliary Electric Cooling Consumption[J]
HVAC,Sum,Unitary MSHP Auxiliary Electric Heating Consumption[J]
If heat recovery is specified:
HVAC,Average, Unitary MSHP Waste Heat Recovery Rate[W]
HVAC,Average, Unitary MSHP Waste Heat Recovery Inlet Temp[C]
HVAC,Average, Unitary MSHP Waste Heat Recovery Outlet Temp[C]
HVAC,Average, Unitary MSHP Waste Heat Recovery Mass Flow Rate[kg/s]
HVAC,Sum, Unitary MSHP Waste Heat Recovery Energy[J]

```

Unitary MSHP Fan Part-Load Ratio

This output variable is the ratio of actual air mass flow rate through the multispeed heat pump to the heat pump's design air mass flow rate (i.e., design volumetric flow rate converted to dry air mass flow rate) at Speed 1. For continuous fan operation mode, this variable is always 1.0 when the heat pump is available (based on the availability schedule). For cycling fan/cycling coil operation mode, the actual air mass flow rate is calculated based on the ratio of the sensible heating (or cooling) load to the steady-state heat pump heating (or cooling) capacity. For the cycling fan mode, the runtime fraction for the heat pump fan may be different from the fan part-load ratio reported here due the part-load performance of the heat pump's heating (or cooling) coil (delay at start-up to reach steady-state output). In general, runtime fractions are reported by individual components where appropriate (e.g., Fan:OnOff). When the speed number is greater than 1, the value is 1.0.

Unitary MSHP Compressor Part-Load Ratio

This output variable is the ratio of the sensible load (heating or cooling) to the steady-state capacity of the multispeed heat pump's DX heating or cooling coil at Speed 1. The runtime fraction for the heat pump compressor may be different from the compressor part-load ratio reported here due the part-load performance of the heating/cooling coil (delay at start-up to reach steady-state output). In general, runtime fractions are reported by individual components where appropriate. When the speed number is greater than 1, the value is 1.0.

Unitary MSHP DX Coil Cycling Ratio

This output variable is the ratio of the sensible load (heating or cooling) to the steady-state capacity of the multispeed heat pump's DX heating or cooling coil (Speed 1) for the entire system timestep. The value is between 0.0 and 1.0 when the heat pump is cycling on and off its lowest speed (Speed 1) and 1.0 when the multispeed heat pump operates at speeds above 1.

Unitary MSHP DX Coil Speed Ratio

This output variable is the ratio of time in a system timestep that the compressor is at rated speed between two consecutive speed numbers ([Compressor Speed - Compressor speed at Speed i-1] / [Compressor speed at Speed i - Compressor speed at Speed i-1]). The compressor speed ratio reports (1.0 is max, 0.0 is min) and any value in between as it is averaged over the timestep. The value is 0.0 during Speed 1 operation.

The physical meaning of the speed ratio is dependent on the compressor configuration defined in the field of child coil object: Apply Part Load Fraction to Speeds greater than 1. The allowed choice is either Yes or No. When No is entered, one compressor is assumed for all speeds. The speed ratio represents how long the higher speed runs as a fraction of the system timestep, and the lower speed runs in the rest of the system timestep. When Yes is entered, multiple compressors are assumed, and each compressor has associated speed.

The speed ratio represents how long the higher speed runs as a fraction of the system timestep, and the low speed runs in a whole system timestep.

Unitary MSHP DX Coil Speed Number

This output variable reports the maximum speed needed when the heat pump operates to meet the sensible load (heating or cooling) in a system timestep. When the value is 1, the heat pump operates at Speed 1 (lowest speed). For this case the cycling ratio is between 0.0 and 1.0, while the speed ratio is 0.0. When the speed number output variable is above one, such as *i*, the heat pump operation is determined by the speed ratio through linear interpolation. For example, when the speed ratio is 0.4 and the speed number is 3, the heat pump operates at Speed 3 for 40% of a system timestep and at Speed 2 for 60% of a system timestep for a single compressor. For multiple compressors, the heat pump operates at Speed 3 in the 40% of a system timestep and at Speed 2 in the whole system timestep.

Unitary MSHP Total Heating Energy Rate [W]

This output field is the total (enthalpy) heat addition rate of the multispeed heat pump to the zones it is serving in Watts. This value is calculated using the enthalpy difference of the heat pump outlet air and inlet air streams, and the air mass flow rate through the heat pump. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy addition only) are averaged for the timestep being reported.

Unitary MSHP Total Cooling Energy Rate [W]

This output field is the total (enthalpy) heat extraction rate of the multispeed heat pump from the zones it is serving in Watts. This value is calculated using the enthalpy difference of the heat pump outlet air and inlet air streams, and the air mass flow rate through the heat pump. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy extraction only) are averaged for the timestep being reported.

Unitary MSHP Sensible Heating Energy Rate [W]

This output field reports the sensible heat addition rate of the multispeed heat pump to the zones it is serving in Watts. This value is calculated using the enthalpy difference of the heat pump outlet air and inlet air streams at a constant humidity ratio, and the air mass flow rate through the heat pump. This value is calculated for each HVAC system timestep being simulated, and the results (heating only) are averaged for the timestep being reported.

Unitary MSHP Sensible Cooling Energy Rate [W]

This output field reports the moist air sensible heat extraction rate of the multispeed heat pump from the zones it is serving in Watts. This value is calculated using the enthalpy difference of the heat pump outlet air and inlet air streams at a constant humidity ratio, and the air mass flow rate through the heat pump. This value is calculated for each HVAC system timestep being simulated, and the results (cooling only) are averaged for the timestep being reported.

Unitary MSHP Latent Heating Energy Rate [W]

This output field is the latent heat addition (humidification) rate of the multispeed heat pump in Watts. This value is calculated as the difference between the total energy rate and the sensible energy rate provided by the multispeed heat pump. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat addition only) are averaged for the timestep being reported.

Unitary MSHP Latent Cooling Energy Rate [W]

This output field is the latent heat extraction (dehumidification) rate of the multispeed heat pump in Watts. This value is calculated as the difference between the total energy rate and the sensible energy rate provided by the multispeed heat pump. This value is calculated for

each HVAC system timestep being simulated, and the results (latent heat extraction only) are averaged for the timestep being reported.

Unitary MSHP Electric Power [W]

This output field is the electricity consumption rate of the multispeed heat pump in Watts. The consumption includes electricity used by the DX coils (including crankcase heater if the fuel type is electricity), fans (indoor supply air fan and the condenser fans associated with the DX coil[s]), auxiliary power during on and off period, and the supplemental heating coil (if electric). This value is calculated for each HVAC system timestep being simulated, and the results are averaged for the timestep being reported. Any non-electric energy use is not reported by the heat pump object but is reported in the associated coil objects as appropriate.

Unitary MSHP Electric Consumption [J]

This output field is the electricity consumption of the multispeed heat pump in Joules for the timestep being reported. The consumption includes electricity used by the DX compressor (including crankcase heater if the fuel type is electricity), fans (indoor supply air fan and the condenser fans associated with the DX coil[s]), auxiliary power during on and off period, and the supplemental heating coil (if electric). This value is calculated for each HVAC system timestep being simulated, and the results are summed for the timestep being reported. Any non-electric energy use is not reported by the heat pump object but is reported in the associated coil objects as appropriate.

Unitary MSHP Auxiliary Electric Power [W]

This output field is the average auxiliary electricity consumption rate (including both on-cycle and off-cycle) in Watts for the timestep being reported.

Unitary MSHP Auxiliary Electric Cooling Consumption [J]

This is the auxiliary electricity consumption in Joules for the timestep being reported. This is the auxiliary electricity consumption during periods when the heat pump is providing cooling (DX cooling coil is operating). This output is also added to a report meter with Resource Type = Electricity, End Use Key = Cooling, Group Key = System (ref. Report Meter).

Unitary MSHP Auxiliary Electric Heating Consumption [J]

This is the auxiliary electricity consumption in Joules for the timestep being reported. This is the auxiliary electricity consumption during periods when the heat pump is providing heating (DX heating coil is operating). This output is also added to a report meter with Resource Type = Electricity, End Use Key = Heating, Group Key = System (ref. Report Meter).

Unitary MSHP Waste Heat Recovery Inlet Temp [C]

Unitary MSHP Waste Heat Recovery Outlet Temp [C]

Unitary MSHP Waste Heat Recovery Mass Flow Rate [kg/s]

These outputs are the heat recovery inlet and outlet temperatures and water mass flow rate for multispeed heat pumps with heat recovery.

Unitary MSHP Waste Heat Recovery Rate [W]

Unitary MSHP Waste Heat Recovery Energy [J]

For multispeed heat pumps with heat recovery, these outputs are the recoverable energy rate (in Watts) and energy (in Joules).

AirLoopHVAC:Unitary:Furnace:HeatOnly

The EnergyPlus furnace is a “virtual” component that consists of a fan component (OnOff or ConstantVolume) and a Gas or Electric heating coil component. The blow through furnace configuration is shown in the Figure below.

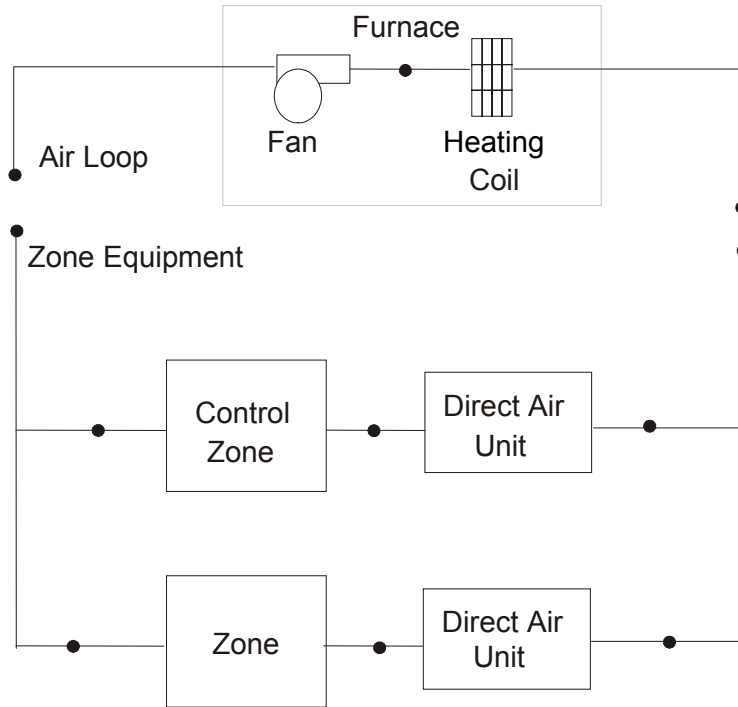


Figure 96. Schematic of Blow Through Furnace Model

Links to the fan and heating coil specifications are provided in the furnace input data syntax. In addition the control zone name, the fraction of the total furnace air flow delivered to the control zone and furnace design operating conditions are specified by the furnace syntax as shown in the Energy+.idd specification below.

```

AirLoopHVAC:Unitary:Furnace:HeatOnly,
    \memo identical to the AirLoopHVAC:UnitaryHeatOnly object
    \min-fields 14
A1, \field Name
    \required-field
    \type alpha
A2, \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A3, \field Furnace Air Inlet Node Name
    \required-field
    \type alpha
A4, \field Furnace Air Outlet Node Name
    \required-field
    \type alpha
A5, \field Supply Air Fan Operating Mode Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note A fan operating mode schedule value of 0 indicates cycling fan mode (supply air
    \note fan cycles on and off in tandem with the heating coil).
    \note Any other schedule value indicates continuous fan mode (supply air fan operates
    \note continuously regardless of heating coil operation).
    \note Leaving this schedule name blank will default to cycling fan mode for the
    \note entire simulation period.
    
```

```

N1, \field Maximum Supply Air Temperature
    \type real
    \units C
    \autosizable
    \default 80.0
N2, \field Supply Air Flow Rate
    \required-field
    \type real
    \note This value should be > 0 and <= than the fan air flow rate.
    \units m3/s
    \minimum> 0.0
    \autosizable
A6, \field Controlling Zone or Thermostat Location
    \required-field
    \type object-list
    \object-list ZoneNames
N3, \field Fraction of Supply Air Flow That Goes Through the Controlling Zone
    \required-field
    \type real
    \minimum> 0.0
    \maximum 1.0
    \autosizable
A7, \field Supply Fan Object Type
    \required-field
    \type choice
    \key Fan:OnOff
    \key Fan:ConstantVolume
    \note Fan:ConstantVolume only works with continuous fan operating mode (i.e. fan
    \note operating mode schedule values are greater than 0).
A8, \field Supply Fan Name
    \required-field
    \type object-list
    \object-list FansCVandOnOff
A9 , \field Fan Placement
    \type choice
    \key BlowThrough
    \key DrawThrough
    \default BlowThrough
A10, \field Heating Coil Object Type
    \required-field
    \type choice
    \key Coil:Heating:Gas
    \key Coil:Heating:Electric
    \note Only works with gas and electric coils
A11; \field Heating Coil Name
    \required-field
    \type object-list
    \object-list HeatingCoilsGasElec

```

Field: Name

This alpha field contains the identifying name for the furnace.

Field: Availability Schedule Name

This alpha field contains the schedule name which contains information on the availability of the furnace to operate.

Field: Furnace Inlet Node Name

This alpha field contains the furnace inlet node name.

Field: Furnace Outlet Node Name

This alpha field contains the furnace outlet node name.

Field: Supply Air Fan Operating Mode Schedule Name

This alpha field specifies the name of the supply air fan operating mode schedule. The supply air fan operating mode may vary during the simulation based on time-of-day or with a change of season. Schedule values of 0 denote that the furnace supply air fan and the heating coil

cycle on and off together to meet the heating load (a.k.a. AUTO fan). Schedule values other than 0 denote that the supply fan runs continuously while the heating coil cycles to meet the load.

Field: Maximum Supply Air Temperature

This numeric field contains the design operating furnace air outlet temperature in degrees C when the furnace is heating. If this input field is left blank, the default value is 80 C.

Field: Supply Air Flow Rate

This numeric field contains the design volumetric flow rate of the furnace in cubic meters per second. This volumetric flow rate should match the flow rate specified for the furnace fan.

Field: Controlling Zone or Thermostat Location

This alpha field contains the identifying zone name where the thermostat controlling the furnace is located.

Field: Fraction of Supply Air Flow That Goes Through the Controlling Zone

This numeric field contains the fraction (>0 to 1) of the total furnace volumetric flow rate that is supplied to the zone with the furnace thermostat.

Field: Supply Fan Object Type

This alpha field contains the identifying type of supply air fan specified for the furnace. Fan type must be **Fan:OnOff** or **Fan:ConstantVolume**. Fan:ConstantVolume is used when the Supply Air Fan Operating Mode Schedule values are never 0 and the fan operates continuously. Fan:OnOff is used when the fan cycles on and off with the cooling or heating coil (i.e. Supply Air Fan Operating Mode Schedule values are at times 0).

Field: Supply Fan Name

This alpha field contains the identifying name given to the furnace fan.

Field: Fan Placement

This alpha field has two choices: **BlowThrough** or **DrawThrough**. The first choice stands for “blow through fan”. This means that the unit consists of a fan followed by the heating coil. The fan “blows through” the heating coil. The second choice stands for “draw through fan”. This means that the unit consists of the heating coil followed by a fan. The fan “draws air through” the heating coil. If this field is left blank, the default is blow through.

Field: Heating Coil Object Type

This alpha field contains the identifying type of heating coil specified in the furnace. Heating coil type must be:

Coil:Heating:Electric
Coil:Heating:Gas

Field: Heating Coil Name

This alpha field contains the identifying name given to the furnace heating coil.

As shown in the example below, correct specification of the furnace requires specification of the following objects in addition to the furnace object:

- 1) fan (Fan:OnOff or Fan:ConstantVolume)
- 2) heating coil (Coil:Heating:Gas or Coil:Heating:Electric)
- 3) direct air unit (AirTerminal:SingleDuct:Uncontrolled) for each zone served by the furnace

Note: the furnace's fan and heating coil must be connected in the air loop according to the configuration shown above (Figure 96) when a blow through fan configuration is specified. If a draw through fan is used, the fan is located down stream of the heating coil. In addition, the volumetric air flow rate specified in the direct air unit for the controlling zone should properly reflect the fractional volumetric air flow rate specified in the furnace object.

```
AirLoopHVAC:Unitary:Furnace:HeatOnly,
  Gas Furnace 1,          !- Name of furnace
  FanAndCoilAvailSched,  !- Availability schedule
  Air Loop Inlet Node,    !- Furnace inlet node name
  Air Loop Outlet Node,   !- Furnace outlet node name
  CycFanSchedule,        !- Supply Air Fan Operating Mode Schedule Name
  80,                    !- Maximum supply air temperature from furnace heater {C}
  1.3,                   !- Design air flow rate through the furnace {m3/s}
  East Zone,             !- Controlling zone or thermostat location
  0.276923,              !- Fraction of the design volume flow that goes through controlling zone
  Fan:OnOff,            !- Supply fan type
  Supply Fan 1,          !- Supply fan name
  BlowThrough,           !- Fan Placement
  Coil:Heating:Gas,      !- Heating coil type
  Furnace Coil;          !- Heating coil name
```

```
Coil:Heating:Gas,
  Furnace Coil,          !- Coil Name
  FanAndCoilAvailSched, !- Available Schedule
  0.8,                   !- Gas Burner Efficiency of the Coil
  20000,                 !- Nominal Capacity of the Coil {W}
  Heating Coil Air Inlet Node, !- Coil_Air_Inlet_Node
  Air Loop Outlet Node,   !- Coil_Air_Outlet_Node
  ,                      !- Coil_Temp_Setpoint_Node
  100,                   !- Parasitic Electric Load {W}
  PLFCurveforGasFurnace, !- Part load fraction correlation (function of part load ratio)
  10;                    !- Parasitic Gas Load {W}
```

```
Curve:Cubic,
  PLFCurveforGasFurnace, !- Name
  0.8, !- Coefficient1 Constant
  0.2, !- Coefficient2 x
  0.0, !- Coefficient3 x**2
  0.0, !- Coefficient4 x**3
  0, !- Minimum Value of x
  1; !- Maximum Value of x
```

```
Fan:OnOff,
  Supply Fan 1,          !- Fan Name
  FanAndCoilAvailSched, !- Available Schedule
  0.7, !- Fan Total Efficiency
  600.0, !- Delta Pressure {Pa}
  1.3, !- Max Flow Rate {m3/s}
  0.9, !- Motor Efficiency
  1.0, !- Motor In Airstream Fraction
  Air Loop Inlet Node,   !- Fan_Inlet_Node
  Heating Coil Air Inlet Node; !- Fan_Outlet_Node
```

```

AirTerminal:SingleDuct:Uncontrolled,
Zone1DirectAir,      !- Direct Air Name
FanAndCoilAvailSched, !- Schedule name for on/off schedule
Zone 1 Inlet Node,   !- Zone Supply Air Node Name
0.47;    !- Maximum air flow rate {m3/s}

AirTerminal:SingleDuct:Uncontrolled,
Zone2DirectAir,      !- Direct Air Name
FanAndCoilAvailSched, !- Schedule name for on/off schedule
Zone 2 Inlet Node,   !- Zone Supply Air Node Name
0.36;    !- Maximum air flow rate {m3/s}

AirTerminal:SingleDuct:Uncontrolled,
Zone3DirectAir,      !- Direct Air Name
FanAndCoilAvailSched, !- Schedule name for on/off schedule
Zone 3 Inlet Node,   !- Zone Supply Air Node Name
0.47;    !- Maximum air flow rate {m3/s}

```

Example of Heat-Only Furnace Specification

AirLoopHVAC:Unitary:Furnace:HeatOnly Outputs

HVAC,Average,Furnace Fan Part-Load Ratio

Furnace Fan Part-Load Ratio

This output variable is the ratio of actual air mass flow rate through the furnace to the furnace's design air mass flow rate (i.e., design volumetric flow rate converted to dry air mass flow rate). For continuous fan operation mode, this variable is always 1.0 when the furnace is available (based on the availability schedule). For cycling fan/cycling coil operation mode, the actual air mass flow rate is calculated based on the ratio of the sensible heating load to the furnace heating capacity. For the cycling fan mode, the runtime fraction for the furnace fan may be different from the fan part-load ratio reported here due the part-load performance of the furnace's heating coil (delay at start-up to reach steady-state heating output). In general, runtime fractions are reported by individual components where appropriate (e.g., Fan:OnOff).

AirLoopHVAC:UnitaryHeatOnly

The `AirLoopHVAC:UnitaryHeatOnly` is identical to the `AirLoopHVAC:Unitary:Furnace:HeatOnly` model. The heat-only unitary system is a "virtual" component that consists of a fan component (OnOff or ConstantVolume) and a Gas or Electric heating coil component. The blow through unitary system configuraion is shown in the Figure below.

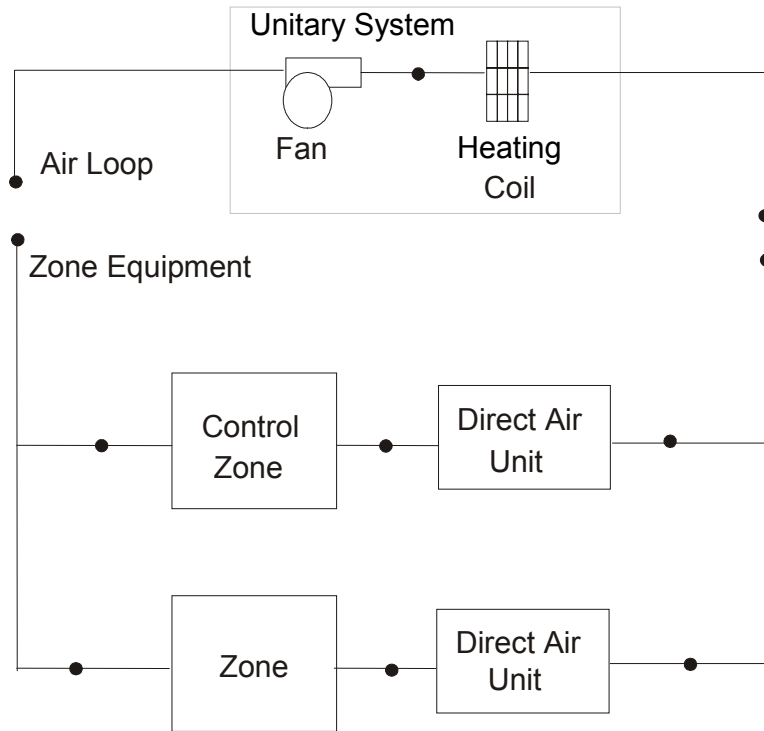


Figure 97. Schematic of Blow Through Heat-Only Unitary System

Links to the fan and heating coil specifications are provided in the unitary system input data syntax. In addition the control zone name, the fraction of the total unitary system air flow delivered to the control zone and unitary system design operating conditions are specified by the unitary system syntax as shown in the Energy+.idd specification below.

```

AirLoopHVAC:UnitaryHeatOnly,
    \min-fields 14
A1, \field Name
    \required-field
    \type alpha
A2, \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A3, \field Unitary System Air Inlet Node Name
    \required-field
    \type alpha
A4, \field Unitary System Air Outlet Node Name
    \required-field
    \type alpha
A5, \field Supply Air Fan Operating Mode Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note A fan operating mode schedule value of 0 indicates cycling fan mode (supply air
    \note fan cycles on and off in tandem with the heating coil).
    \note Any other schedule value indicates continuous fan mode (supply air fan operates
    \note continuously regardless of heating coil operation).
    \note Leaving this schedule name blank will default to cycling fan mode for the
    \note entire simulation period.
    
```

```

N1, \field Maximum Supply Air Temperature
    \type real
    \units C
    \autosizable
    \default 80.0
N2, \field Supply Air Flow Rate
    \required-field
    \type real
    \note This value should be > 0 and <= than the fan air flow rate.
    \units m3/s
    \minimum> 0.0
    \autosizable
A6, \field Controlling Zone or Thermostat Location
    \required-field
    \type object-list
    \object-list ZoneNames
N3, \field Fraction of Supply Air Flow That Goes Through the Controlling Zone
    \required-field
    \type real
    \minimum> 0.0
    \maximum 1.0
    \autosizable
A7, \field Supply Fan Object Type
    \required-field
    \type choice
    \key Fan:OnOff
    \key Fan:ConstantVolume
    \note Fan:ConstantVolume only works with continuous fan operating mode (i.e. fan
    \note operating mode schedule values are greater than 0).
A8, \field Supply Fan Name
    \required-field
    \type object-list
    \object-list FansCVandOnOff
A9, \field Fan Placement
    \type choice
    \key BlowThrough
    \key DrawThrough
    \default BlowThrough
A10, \field Heating Coil Object Type
    \required-field
    \type choice
    \key Coil:Heating:Gas
    \key Coil:Heating:Electric
    \note Only works with gas and electric coils
A11; \field Heating Coil Name
    \required-field
    \type object-list
    \object-list HeatingCoilsGasElec

```

Field: Name

This alpha field contains the identifying name for the unitary system.

Field: Availability Schedule Name

This alpha field contains the schedule name which contains information on the availability of the unitary system to operate.

Field: Unitary System Air Inlet Node Name

This alpha field contains the unitary system inlet node name.

Field: Unitary System Air Outlet Node Name

This alpha field contains the unitary system outlet node name.

Field: Supply Air Fan Operating Mode Schedule Name

This alpha field specifies the name of the supply air fan operating mode schedule. The supply air fan operating mode may vary during the simulation based on time-of-day or with a change of season. Schedule values of 0 denote that the furnace supply air fan and the heating coil

cycle on and off together to meet the heating load (a.k.a. AUTO fan). Schedule values other than 0 denote that the supply fan runs continuously while the heating coil cycles to meet the load.

Field: Maximum Supply Air Temperature

This numeric field contains the design air outlet temperature in degrees C when the unitary system is heating. If this input field is left blank, the default value is 80 C.

Field: Supply Air Flow Rate

This numeric field contains the design volumetric flow rate of the unitary system in cubic meters per second. This volumetric flow rate should match the flow rate specified for the unitary system fan.

Field: Controlling Zone or Thermostat Location

This alpha field contains the identifying zone name where the thermostat controlling the unitary system is located.

Field: Fraction of Supply Air Flow That Goes Through the Controlling Zone

This numeric field contains the fraction (>0 to 1) of the total system volumetric flow rate that is supplied to the zone with the unitary system thermostat.

Field: Supply Fan Object Type

This alpha field contains the identifying type of supply air fan specified for the unitary system. Fan type must be **Fan:OnOff** or **Fan:ConstantVolume**. Fan:ConstantVolume is used when the Supply Air Fan Operating Mode Schedule values are never 0 and the fan operates continuously. Fan:OnOff is used when the fan cycles on and off with the cooling or heating coil (i.e. Supply Air Fan Operating Mode Schedule values are at times 0).

Field: Supply Fan Name

This alpha field contains the identifying name given to the unitary system fan.

Field: Fan Placement

This alpha field has two choices: **BlowThrough** or **DrawThrough**. The first choice stands for “blow through fan”. This means that the unit consists of a fan followed by the heating coil. The fan “blows through” the heating coil. The second choice stands for “draw through fan”. This means that the unit consists of the heating coil followed by a fan. The fan “draws air through” the heating coil. If this field is left blank, the default is blow through.

Field: Heating Coil Object Type

This alpha field contains the identifying type of heating coil specified in the unitary system. Heating coil type must be

Coil:Heating:Electric
Coil:Heating:Gas

Field: Heating Coil Name

This alpha field contains the identifying name given to the unitary system heating coil.

As shown in the example below, correct specification of the heat-only unitary system requires specification of the following objects in addition to the unitary system object:

- 4) fan (Fan:OnOff or Fan:ConstantVolume)
- 5) heating coil (Coil:Heating:Gas or Coil:Heating:Electric)
- 6) direct air unit (AirTerminal:SingleDuct:Uncontrolled) for each zone served by the furnace

Note: the unitary system's fan and heating coil must be connected in the air loop according to the configuration shown above (Figure 97) when a blow through fan configuration is specified. If a draw through fan is used, the fan is located down stream of the heating coil. In addition, the volumetric air flow rate specified in the direct air unit for the controlling zone should properly reflect the fractional volumetric air flow rate specified in the unitary system object.

```
AirLoopHVAC:UnitaryHeatOnly,
  Gas Unitary System 1, !- Name of unitary system
  FanAndCoilAvailSched, !- Availability schedule
  Air Loop Inlet Node, !- Unitary system inlet node name
  Air Loop Outlet Node, !- Unitary system outlet node name
  CycFanSchedule, !- Supply Air Fan Operating Mode Schedule Name
  80, !- Maximum supply air temperature from unitary system heater {C}
  1.3, !- Design air flow rate through the unitary system {m3/s}
  East Zone, !- Controlling zone or thermostat location
  0.276923, !- Fraction of the design volume flow that goes through controlling zone
  Fan:OnOff, !- Supply fan type
  Supply Fan 1, !- Supply fan name
  BlowThrough, ! Fan Placement
  Coil:Heating:Gas, !- Heating coil type
  Unitary System Heating Coil; !- Heating coil name
```

```
Coil:Heating:Gas,
  Unitary System Heating Coil, !- Coil Name
  FanAndCoilAvailSched, !- Available Schedule
  0.8, !- Gas Burner Efficiency of the Coil
  20000, !- Nominal Capacity of the Coil {W}
  Heating Coil Air Inlet Node, !- Coil_Air_Inlet_Node
  Air Loop Outlet Node, !- Coil_Air_Outlet_Node
  , !- Coil_Temp_Setpoint_Node
  100, !- Parasitic Electric Load {W}
  PLFCurveforUnitarySystem, !- Part load fraction correlation (function of part load ratio)
  10; !- Parasitic Gas Load {W}
```

```
Curve:Cubic,
  PLFCurveforUnitarySystem, !- Name
  0.8, !- Coefficient1 Constant
  0.2, !- Coefficient2 x
  0.0, !- Coefficient3 x**2
  0.0, !- Coefficient4 x**3
  0, !- Minimum Value of x
  1; !- Maximum Value of x
```

```
Fan:OnOff,
  Supply Fan 1, !- Fan Name
  FanAndCoilAvailSched, !- Available Schedule
  0.7, !- Fan Total Efficiency
  600.0, !- Delta Pressure {Pa}
  1.3, !- Max Flow Rate {m3/s}
  0.9, !- Motor Efficiency
  1.0, !- Motor In Airstream Fraction
  Air Loop Inlet Node, !- Fan_Inlet_Node
  Heating Coil Air Inlet Node; !- Fan_Outlet_Node
```

```

AirTerminal:SingleDuct:Uncontrolled,
Zone1DirectAir,      !- Direct Air Name
FanAndCoilAvailSched, !- Schedule name for on/off schedule
Zone 1 Inlet Node,   !- Zone Supply Air Node Name
0.47;               !- Maximum air flow rate {m3/s}

AirTerminal:SingleDuct:Uncontrolled,
Zone2DirectAir,      !- Direct Air Name
FanAndCoilAvailSched, !- Schedule name for on/off schedule
Zone 2 Inlet Node,   !- Zone Supply Air Node Name
0.36;               !- Maximum air flow rate {m3/s}

AirTerminal:SingleDuct:Uncontrolled,
Zone3DirectAir,      !- Direct Air Name
FanAndCoilAvailSched, !- Schedule name for on/off schedule
Zone 3 Inlet Node,   !- Zone Supply Air Node Name
0.47;               !- Maximum air flow rate {m3/s}

```

Example of Heat-Only Unitary System Specification

AirLoopHVAC:UnitaryHeatOnly Outputs

```
HVAC,Average,Unitary System Fan Part-Load Ratio
```

Unitary System Fan Part-Load Ratio

This output variable is the ratio of actual air mass flow rate through the unitary system to the unitary system's design air mass flow rate (i.e., design volumetric flow rate converted to dry air mass flow rate). For continuous fan operation mode, this variable is always 1.0 when the unitary system is available (based on the availability schedule). For cycling fan/cycling coil operation mode, the actual air mass flow rate is calculated based on the ratio of the sensible heating load to the unitary system heating capacity. For the cycling fan mode, the runtime fraction for the unitary system fan may be different from the fan part-load ratio reported here due the part-load performance of the unitary system's heating coil (delay at start-up to reach steady-state heating output). In general, runtime fractions are reported by individual components where appropriate (e.g., Fan:OnOff).

AirLoopHVAC:UnitaryHeatPump:WaterToAir

The unitary water-to-air heat pump is relatively similar to the unitary air-to-air except water is used on the source side. Links to the fan, WaterToAirHP cooling coil, WaterToAirHP heating coil, and supplementary heating coil specifications are provided in the heat pump's input data syntax. The heat pump would switch back and forth between cooling and heating depending on the zone's demand. The load side(air) of the unitary water-to-air heat pump consists of an On/Off fan component, a WaterToAirHP cooling coil component, a WaterToAirHP heating coil component, and a Gas or Electric supplementary heating coil component. However, the source side (water) of the heat pump is usually connected to a ground heat exchanger through the condenser loop. The diagram below shows the setup and connection of the heat pump for the source side and load side.

There are two type of WaterToAirHP coil models available in EnergyPlus:

```

Coil:Cooling:WaterToAirHeatPump:ParameterEstimation
Coil:Heating:WaterToAirHeatPump:ParameterEstimation
Coil:Cooling:WaterToAirHeatPump:EquationFit
Coil:Heating:WaterToAirHeatPump:EquationFit

```

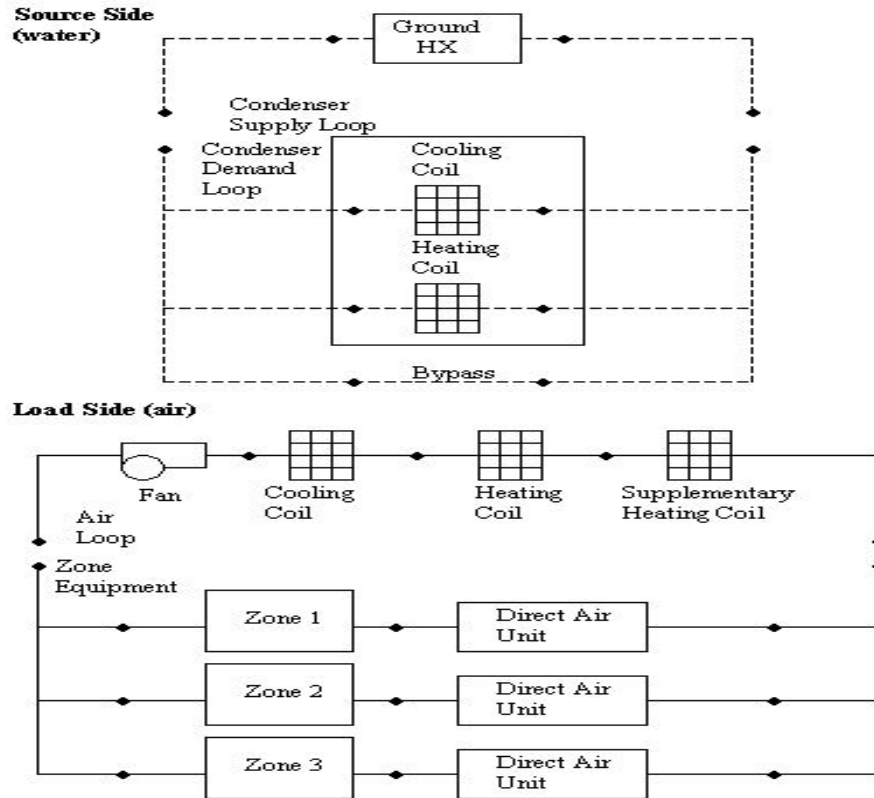


Figure 98. Layout of Water to Air Heat pump

In addition, the control zone name, the fraction of the total system air flow delivered to the control zone and system design operating conditions are specified by the heat pump syntax in the Energy+.idd specification below:

```

AirLoopHVAC:UnitaryHeatPump:WaterToAir,
  \min-fields 26
  A1, \field Name
      \required-field
      \type alpha
  A2, \field Availability Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
  A3, \field Air Inlet Node Name
      \required-field
      \type alpha
  A4, \field Air Outlet Node Name
      \required-field
      \type alpha
  N1, \field Supply Air Flow Rate
      \required-field
      \type real
      \note This value should be > 0 and <= than the fan air flow rate.
      \units m3/s
      \minimum> 0.0
      \autosizable
  A5, \field Controlling Zone or Thermostat Location
      \required-field
      \type object-list
      \object-list ZoneNames

```

```

N2, \field Fraction of Supply Air Flow That Goes Through the Controlling Zone
    \required-field
    \type real
    \minimum> 0.0
    \maximum 1.0
    \autosizable
A6, \field Supply Air Fan Object Type
    \required-field
    \type choice
    \key Fan:OnOff
    \note Only works with On/Off Fan
A7, \field Supply Air Fan Name
    \required-field
    \type object-list
    \object-list FansOnOff
    \note Needs to match Fan:OnOff object
A8, \field Heating Coil Object Type
    \required-field
    \type choice
    \key Coil:Heating:WaterToAirHeatPump:ParameterEstimation
    \key Coil:Heating:WaterToAirHeatPump:EquationFit
A9, \field Heating Coil Name
    \required-field
    \type object-list
    \object-list HeatingCoilsWaterToAirHP
    \note Needs to match in the water-to-air heatpump heating coil object
N3, \field Heating Convergence
    \required-field
    \type real
    \minimum> 0.0
    \default 0.001
A10, \field Cooling Coil Object Type
    \required-field
    \type choice
    \key Coil:Cooling:WaterToAirHeatPump:ParameterEstimation
    \key Coil:Cooling:WaterToAirHeatPump:EquationFit
A11, \field Cooling Coil Name
    \required-field
    \type object-list
    \object-list CoolingCoilsWaterToAirHP
    \note Needs to match in the water-to-air heatpump cooling coil object
N4, \field Cooling Convergence
    \required-field
    \type real
    \minimum> 0.0
    \default 0.001
N5, \field Maximum Cycling Rate
    \type real
    \units cycles/hr
    \minimum 0.0
    \maximum 5.0
    \default 2.5
    \note The maximum on-off cycling rate for the compressor
    \note Suggested value is 2.5 for a typical heat pump
N6, \field Heat Pump Time Constant
    \type real
    \units s
    \minimum 0.0
    \maximum 500.0
    \default 60.0
    \note Time constant for the cooling coil's capacity to reach steady state after startup
    \note Suggested value is 60 for a typical heat pump
N7, \field Fraction of On-Cycle Power Use
    \minimum 0.0
    \maximum 0.05
    \default 0.01
    \note The fraction of on-cycle power use to adjust the part load fraction based on
    \note the off-cycle power consumption due to crankcase heaters, controls, fans, and etc.
    \note Suggested value is 0.01 for a typical heat pump

```

```

N8, \field Heat Pump Fan Delay Time
    \units s
    \minimum 0.0
    \default 60
    \note Programmed time delay for heat pump fan to shut off after compressor cycle off.
    \note Only required for heat pump operating mode=CyclingFanAndCompressor
    \note Enter 0 for heat pump operating mode=ContinuousFanWithCyclingCompressor
A12, \field Supplemental Heating Coil Object Type
    \required-field
    \type choice
    \key Coil:Heating:Gas
    \key Coil:Heating:Electric
A13, \field Supplemental Heating Coil Name
    \required-field
    \type object-list
    \object-list HeatingCoilsGasElec
    \note Needs to match in the supplemental heating coil object
N9, \field Maximum Supply Air Temperature from Supplemental Heater
    \required-field
    \type real
    \units C
    \autosizable
N10, \field Maximum Outdoor Dry-Bulb Temperature for Supplemental Heater Operation
    \type real
    \maximum 21.0
    \default 21.0
    \units C
A14, \field Outdoor Dry-Bulb Temperature Sensor Node Name
    \type alpha
A15, \field Fan Placement
    \type choice
    \key BlowThrough
    \key DrawThrough
    \default BlowThrough
A16; \field Supply Air Fan Operating Mode Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note Enter the name of a schedule that controls fan operation. Schedule values of 0 denote
    \note cycling fan operation (fan cycles with cooling or heating coil). Schedule values greater
    \note than 0 denote constant fan operation (fan runs continually regardless of coil operation).
    \note The fan operating mode defaults to cycling fan operation if this field is left blank.

```

Field: Name

This alpha field contains the identifying name for the unitary system heat pump.

Field: Availability Schedule Name

This alpha field contains the schedule name (ref. Schedule) that contains information on the availability of the heat pump to operate. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Air Inlet Node Name

This alpha field contains the name of the HVAC system node from which the heat pump draws its inlet air

Field: Air Outlet Node Name

This alpha field contains the name of the HVAC system node to which the heat pump sends its outlet air

Field: Supply Air Flow Rate

This numeric field contains the design volumetric flow rate through the heat pump in cubic meters per second. This volumetric flow rate should match the flow rate specified for the heat pump's supply air fan, WaterToAirHP cooling coil, WaterToAirHP heating coil and supplemental heating coil.

Field: Controlling Zone or Thermostat Location

This alpha field contains the identifying zone name where the thermostat controlling the heat pump is located

Field: Fraction of Supply Air Flow That Goes Through the Controlling Zone

This numeric field contains the fraction (>0 to 1) of the total system volumetric flow rate that is supplied to the zone where the thermostat controlling the heat pump is located

Field: Supply Air Fan Object Type

This alpha field contains the identifying type of supply air fan specified in the heat pump. Fan type must be Fan:OnOff.

Field: Supply Air Fan Name

This alpha field contains the identifying name given to the heat pump supply air fan, and should match the name specified in the corresponding fan object.

Field: Heating Coil Object Type

This alpha field contains the identifying type of heating coil specified in the heat pump. Heating coil types are:

```
Coil:Heating:WaterToAirHeatPump:ParameterEstimation
Coil:Heating:WaterToAirHeatPump:EquationFit
```

Field: Heating Coil Name

This alpha field contains the identifying name given to the WaterToAirHP heating coil, and should match the name specified in the corresponding WaterToAirHP heating coil object.

Field: Heating Convergence

This numeric value allows the user to determine how close the air side has to be controlled. Lower the value of convergence better the control of air side conditions and less the zone temperature fluctuations. However in a poorly designed system, a lower convergence might result in warning errors which are caused due to the iteration limit for run time fraction calculation is limited to 20.

Field: Cooling Coil Object Type

This alpha field contains the identifying type of cooling coil specified in the heat pump. Cooling coil types are:

```
Coil:Cooling:WaterToAirHeatPump:ParameterEstimation
Coil:Cooling:WaterToAirHeatPump:EquationFit
```

Field: Cooling Coil Name

This alpha field contains the identifying name given to the WaterToAirHP cooling coil, and should match the name specified in the corresponding WaterToAirHP cooling coil object.

Field: Cooling Convergence

This numeric value allows the user to determine how close the air side has to be controlled. Lower the value of convergence better the control of air side conditions and less the zone temperature fluctuations. However in a poorly designed system, a lower convergence might result in warning errors which are caused due to the iteration limit for run time fraction calculation is limited to 20.

Field: Maximum Cycling Rate

This numeric field contains the maximum on-off cycling rate for the compressor, which occurs at 50% run time fraction. Suggested values are shown below (Henderson et. al 1999):

Heat Pump Condition	Recommended Values
Typical	2.5
Good	2.5
Poor	3.0

Field: Heat Pump Time Constant

This numeric field contains the time constant for the cooling coil's capacity to reach steady state after startup. Suggested values are shown below (Henderson et. al 1999):

Heat Pump Condition	Recommended Values
Typical	60
Good	60
Poor	60

Field: Fraction of On-Cycle Power Use

This numeric field contains the fraction of on-cycle power use to adjust the part load fraction based on the off-cycle power consumption due to crankcase heaters, controls, fans, and etc. Suggested value values are below (Henderson et. al 1999):

Heat Pump Condition	Recommended Values
Typical	0.01
Good	0.01
Poor	0.03

Field: Heat Pump Fan Delay Time

This numeric field contains the time delay for heat pump fan to shut off after compressor cycle off. This field can be obtained from the manufacturer or the heat pump catalog. Enter a value of zero for heat pump operating mode "ContinuousFanWithCyclingCompressor" because field is not required. Suggested value is 60s.

Field: Supplemental Heating Coil Object Type

This is the object type of the supplemental heating coil. The only valid choices are:

Coil:Heating:Electric
Coil:Heating:Gas

Field: Supplemental Heating Coil Name

This alpha field contains the identifying name given to the supplemental heating coil, and should match the name specified in the corresponding supplemental heating coil object.

Field: Maximum Supply Air Temperature from Supplemental Heater

This numeric field defines the maximum allowed supply air temperature exiting the heat pump supplemental heating coil.

Field: Maximum Outdoor Dry-Bulb Temperature for Supplemental Heater Operation

This numeric field defines the outdoor air dry-bulb temperature above which the heat pump supplemental heating coil is disabled. The temperature for this input field must be less than or equal to 21 C. If this input field is left blank, the default value is 21 C.

Field: Outdoor Dry-Bulb Temperature Sensor Node Name

This alpha field specifies the name of the outdoor node which controls the operation of the supplemental heating coil. If this field is left blank, the outdoor temperature is based solely on the weather data. If this field is not blank, the node name specified must also be listed in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor temperature from the weather data. Alternately, the node name must be

specified in an OutdoorAir:NodeList object where the outdoor temperature is taken directly from the weather data.

Field: Fan Placement

This alpha field has two choices: **BlowThrough** or **DrawThrough**. The first choice represents a blow through system where the supply air fan is before the WatertoAirHP cooling/heating coil and the supplementary heating coil. The second choice represents a draw through system where the supply fan is between the WatertoAirHP cooling/heating coil and the supplementary heating coil. If this input field is left blank, the default is blow through.

Field: Supply Air Fan Operating Mode Schedule Name

This alpha field specifies the name of the supply air fan operating mode schedule. The supply air fan operating mode may vary during the simulation based on time-of-day or with a change of season. Schedule values of 0 denote that the supply air fan and the heating or cooling coil cycle on and off together to meet the heating or cooling load (a.k.a. AUTO fan). Schedule values other than 0 denote that the supply air fan runs continuously while the heating or cooling coil cycles to meet the load. If this field is left blank, the model assumes the supply air fan cycles with the heating or cooling coil throughout the simulation.

As shown in the example below, correct specifications of the water-air heat pump requires specification of the following objects in addition to the heat pump object:

- On/Off fan
- WatertoAirHP cooling coil
- WatertoAirHP heating coil
- Supplementary heating coil
- Direct air unit for each zone served by the heat pump
- Condenser demand branches

It should be noted that the volumetric air flow rate specified in the direct air unit for the controlling zone should properly reflect the fractional volumetric air flow rate specified in the heat pump object.

```
AirLoopHVAC:UnitaryHeatPump:WaterToAir,
DXAC Heat Pump 1,          !- Heat pump Name
FanAndCoilAvailSched,     !- Availability schedule
Mixed Air Node,           !- Heat pump air inlet node name
Air Loop Outlet Node,     !- Heat pump air outlet node name
2,                         !- Design air flow rate through the heat pump {m3/s}
East Zone,                !- Controlling zone or thermostat location
0.5,                      !- Fraction of the total volume flow that goes through the con
Fan:OnOff,                !- Supply air fan type
Supply Fan 1,             !- Supply air fan name
COIL:WATERTOAIRHP:ParameterEstimation:Heating, !- Heating coil type
Heat Pump Heating Mode,  !- Heating coil name
38000,                   !- Nominal HP Heating Coil Capacity {W}
0.001,                   !- Heating coil convergence
COIL:WATERTOAIRHP:ParameterEstimation:Cooling, !- Cooling coil type
Heat Pump Cooling Mode,  !- Cooling coil name
38000,                   !- Nominal HP Cooling Coil Capacity {W}
0.001,                   !- Cooling coil convergence
2.5, !Maximum ON/OFF Cycling Rate {cycles/hr}
60, !Heat Pump Time Constant {s}
0.01, !fraction of on-cycle power use
60, !Heat pump fan delay time {s}
Coil:Heating:Gas,        !- Supplemental heating coil type
Heat Pump DX Supp Heating Coil 1, !- Supplemental heating coil name
32000,                   !- Supplemental heating coil capacity {W}
50,                      !- Maximum supply air temperature from heat pump supplemental {C}
21,                      !- Maximum outdoor dry-bulb temperature for supplemental heat {C}
BlowThrough,             !- Fan placement
CyclingFanSch,          !- Supply air fan operating mode schedule name
```



```
Schedule:Compact,
CyclingFanSch,      !- Name
Fraction,           !- ScheduleType
Through: 12/31,    !- Complex Field #1
For: AllDays,      !- Complex Field #2
Until: 24:00,      !- Complex Field #7
0.0;                !- Complex Field #8
```

```
Coil:Cooling:WaterToAirHeatPump:ParameterEstimation,
Heat Pump Cooling Mode, !- Heat Pump Cooling Coil Name
Scroll,                 !- Compressor Type
Water,                  !- Source Side Fluid Name
R22,                    !- Refrigerant Type
0.0015,                 !- Design water flow rate of HP {m3/sec}
38000, !- Nominal HP cooling coil capacity {W}
0, !- Nominal Time for Condensate Removal to Begin
0, !- Ratio of Initial Moisture Evaporation Rate and Steady-state Latent Capacity
3000000, !- High Pressure CutOff {Pa}
0, !- Low Pressure CutOff {Pa}
Water to Air Heat Pump Source Side1 Inlet Node, !- Heat Pump Cooling Coil Water Inlet Node Name
Water to Air Heat Pump Source Side1 Outlet Node, !- Heat Pump Cooling Coil Water Outlet Node Name
Cooling Coil Air Inlet Node, !- Cooling Coil Air Inlet Node Name
Heating Coil Air Inlet Node, !- Cooling Coil Air Outlet Node Name
3.78019E+03, !- Parameter 1 (Load Side Outside Surface Heat Transfer Coeffi {W/K}
2.80303E+03, !- Parameter 2 (Load Side Total Heat Transfer Coefficient) {W/K}
7.93591E-01, !- Parameter 3 (Superheat Temperature) {C}
1.91029E+03, !- Parameter 4 (Compressor Power Losses) {W}
2.66127E+00, !- Parameter 5 (Compressor Efficiency)
1.06009E-02, !- Parameter 6
1.65103E+00, !- Parameter 7
9.73887E-03, !- Parameter 8
1.04563E+03; !- Parameter 9
```

```
Coil:Heating:WaterToAirHeatPump:ParameterEstimation,
Heat Pump HEATING Mode, !- Heat Pump Heating Coil Name
Scroll,                 !- Compressor Type
Water,                  !- Source Side Fluid Name
R22,                    !- Refrigerant Type
0.0015,                 !- Design water flow rate of HP {m3/sec}
38000, !- Nominal HP Heating Coil Capacity {W}
3000000, !- High Pressure CutOff
0, !- Low Pressure CutOff {Pa}
Water to Air Heat Pump Source Side2 Inlet Node, !- Heat Pump Heating Coil Water Inlet Node Name
Water to Air Heat Pump Source Side2 Outlet Node, !- Heat Pump Heating Coil Water Outlet Node Name
Heating Coil Air Inlet Node, !- Heating Coil Air Inlet Node Name
SuppHeating Coil Air Inlet Node, !- Heating Coil Air Outlet Node Name
3.91379E+03, !- Parameter 1 (Load Side Total Heat Transfer Coefficient) {W/K}
5.94753E-01, !- Parameter 2 (Superheat Temperature) {C}
2.49945E+03, !- Parameter 3 (Compressor Power Losses) {W}
8.68734E-01, !- Parameter 4 (Compressor Efficiency)
7.23595E-03, !- Parameter 5
3.69126E+00, !- Parameter 6
1.75701E-05, !- Parameter 7
3.65348E+03; !- Parameter 8
```

```
Coil:Heating:Gas,
Heat Pump DX Supp Heating Coil 1, !- Coil Name
FanAndCoilAvailSched, !- Available Schedule
0.8, !- Gas Burner Efficiency of the Coil
32000, !- Nominal Capacity of the Coil {W}
SuppHeating Coil Air Inlet Node, !- Coil_Air_Inlet_Node
Air Loop Outlet Node; !- Coil_Air_Outlet_Node
```

```

BRANCH,
  Gshp Cooling Condenser Branch, !Branch Name
  0, !Maximum Branch Flow Rate {m3/s}
  Coil:Cooling:WaterToAirHeatPump:ParameterEstimation, !Compl Type
  Heat Pump Cooling Mode, !Compl Name
  Water to Air Heat Pump Source Side1 Inlet Node, !Compl Inlet Node Name
  Water to Air Heat Pump Source Side1 Outlet Node, !Compl Outlet Node Name
  ACTIVE; !Compl Branch Control Type

BRANCH,
  Gshp Heating Condenser Branch, !Branch Name
  0, !Maximum Branch Flow Rate {m3/s}
  Coil:Heating:WaterToAirHeatPump:ParameterEstimation, !Compl Type
  Heat Pump Heating Mode, !Compl Name
  Water to Air Heat Pump Source Side2 Inlet Node, !Compl Inlet Node Name
  Water to Air Heat Pump Source Side2 Outlet Node, !Compl Outlet Node Name
  ACTIVE; !Compl Branch Control Type

BRANCH,
  Condenser Demand Bypass Branch, !Branch Name
  0, !Maximum Branch Flow Rate {m3/s}
  PIPE, !Compl Type
  Condenser Demand Side Bypass, !Compl Name
  Cond Demand Bypass Inlet Node, !Compl Inlet Node Name
  Cond Demand Bypass Outlet Node, !Compl Outlet Node Name
  BYPASS; !Compl Branch Control Type

```

```

Fan:OnOff,
  Supply Fan 1, !Fan Name
  FanAndCoilAvailSched, !Available Schedule
  0.7, !Fan Total Efficiency
  300.0, !Delta Pressure {Pa}
  2.0, !Max Flow Rate {m3/s}
  0.9, !Motor Efficiency
  1.0, !Motor In Airstream Fraction
  Mixed Air Node, !Fan_Inlet_Node
  Cooling Coil Air Inlet Node; !Fan_Outlet_Node

AirTerminal:SingleDuct:Uncontrolled,
  Zone1DirectAir, !- Direct Air Name
  FanAndCoilAvailSched, !- Schedule name for on/off schedule
  Zone 1 Inlet Node, !- Zone Supply Air Node Name
  0.7; !- Maximum air flow rate {m3/s}

AirTerminal:SingleDuct:Uncontrolled,
  Zone2DirectAir, !- Direct Air Name
  FanAndCoilAvailSched, !- Schedule name for on/off schedule
  Zone 2 Inlet Node, !- Zone Supply Air Node Name
  0.6; !- Maximum air flow rate {m3/s}

AirTerminal:SingleDuct:Uncontrolled,
  Zone3DirectAir, !- Direct Air Name
  FanAndCoilAvailSched, !- Schedule name for on/off schedule
  Zone 3 Inlet Node, !- Zone Supply Air Node Name
  0.7; !- Maximum air flow rate {m3/s}

```

AirLoopHVAC:UnitaryHeatPump:WaterToAir Outputs

Energy use reporting for the water-to-air heat pump is documented under the heat pump coil object types:

```

Coil:Cooling:WaterToAirHeatPump:ParameterEstimation
Coil:Heating:WaterToAirHeatPump:ParameterEstimation
Coil:Cooling:WaterToAirHeatPump:EquationFit
Coil:Heating:WaterToAirHeatPump:EquationFit

```

The heat pump *demand* as well as the compressor and fan part-load ratios may be obtained with the report variables shown below.

```

HVAC,Average, Unitary Heat Pump Sensible Cooling Demand[W]
HVAC,Average, Unitary Heat Pump Latent Cooling Demand[W]
HVAC,Average, Unitary Heat Pump Heating Demand[W]
HVAC,Average, Unitary Heat Pump Compressor Part-Load Ratio

```

HVAC, Average, Unitary Heat Pump Fan Part-Load Ratio
--

Unitary Heat Pump Sensible Cooling Demand

This output variable is the sensible cooling requested from the zone thermostat in watts. This value is calculated using the unitary heat pump outlet air and zone conditions, the specific heat of the zone air, and the supply air mass flow rate entering/leaving the system. This value is calculated for each HVAC system timestep being simulated, and the results are averaged for the timestep being reported.

Unitary Heat Pump Latent Cooling Demand

This output variable is the latent cooling requested from the zone humidistat in watts. This value is calculated using the unitary heat pump outlet air and zone conditions, the heat of vaporization of water at the current zone conditions, and the supply air mass flow rate entering/leaving the system. This value is calculated for each HVAC system timestep being simulated, and the results are averaged for the timestep being reported.

Unitary Heat Pump Heating Demand

This output variable is the sensible heating requested from the zone thermostat in watts. This value is calculated using the unitary heat pump outlet air and zone conditions, the specific heat of the zone air, and the supply air mass flow rate entering/leaving the system. This value is calculated for each HVAC system timestep being simulated, and the results are averaged for the timestep being reported.

Unitary Heat Pump Compressor Part-Load Ratio

This output variable is the ratio of actual load on the unitary system to the unitary system's steady state output. This ratio is based on the nominal capacity of the unit.

Unitary Heat Pump Fan Part-Load Ratio

This output variable is the ratio of actual air mass flow rate through the unitary system to the unitary system's design air mass flow rate (i.e., design volumetric flow rate converted to dry air mass flow rate). For continuous fan operation mode, this variable is always 1.0 when the unitary system is available (based on the availability schedule).

AirLoopHVAC:UnitaryHeatCool:VAVChangeoverBypass

The changeover-bypass variable air volume (CBVAV) unitary system is a compound object made up of other components. Each CBVAV system consists of an outdoor air mixer, direct expansion (DX) cooling coil, heating coil, and a supply air fan as shown in the figures below. Zone thermostats and terminal units are required in each zone served by this system. The terminal units are specific to this system type and are either `AirTerminal:SingleDuct:VAV:HeatAndCool:Reheat` or `AirTerminal:SingleDuct:VAV:HeatAndCool:NoReheat`. A zone humidistat and single zone max humidity set point manager may also be specified to help control high humidity levels. These individual components are described elsewhere in this document. The CBVAV unitary system object coordinates the operation of these components and is modeled as a type of air loop equipment (Ref. `AirLoopHVAC`).

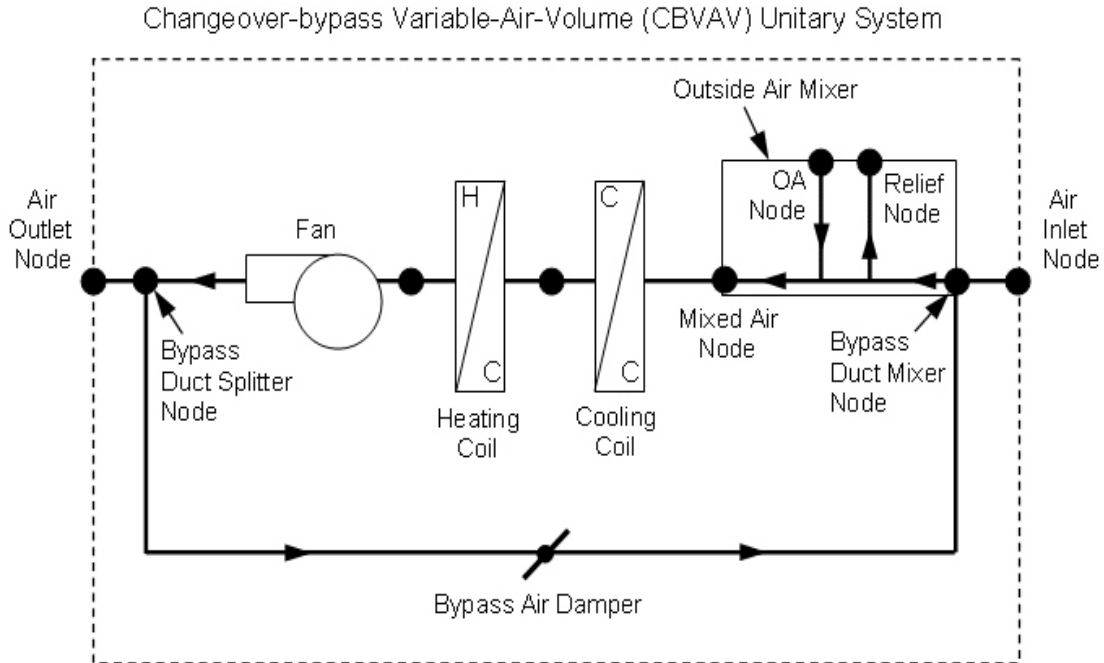


Figure 99. Schematic of a CBVAV unitary system (draw through fan placement)

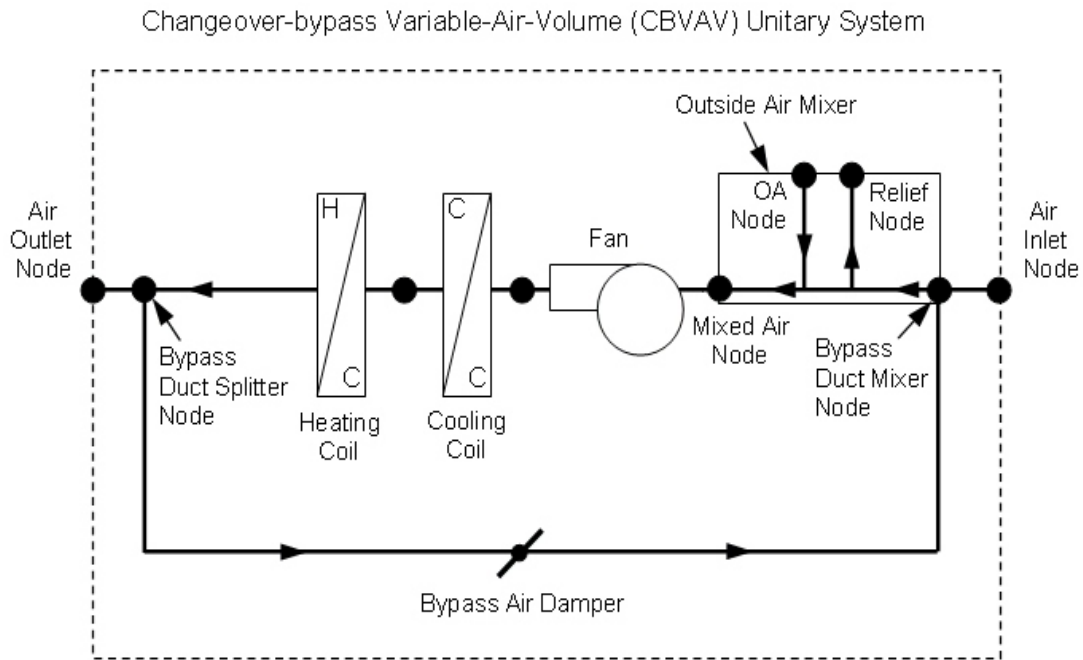


Figure 100. Schematic of a CBVAV unitary system (blow through fan placement)

Links to the CBVAV system’s supply air fan, coils, and outdoor air mixer specifications are provided in the object’s input syntax. Additional inputs include system and outdoor air flow rates during heating and cooling operation, the priority control mode, and dehumidification

control type. A description of each input field for the CBVAV unitary system compound object is provided below.

Field: Name

This alpha field defines a unique user-assigned name for an instance of a changeover-bypass VAV system. Any reference to this system by another object will use this name.

Field: Availability Schedule Name

This alpha field defines the name of the schedule (ref: Schedule) that denotes whether the system operates during a given time period. A schedule value equal to 0 denotes that the system must be off for that time period, and a schedule value greater than 0 denotes that the system is available to operate during that time period. This schedule may be used to completely disable the system (all of its coils and the supply air fan) as required.

Field: System Air Flow Rate During Cooling Operation

This numeric field defines the air flow rate through the system (i.e., through the fan and heating/cooling coils) in cubic meters per second when the DX cooling coil is operating. Values must be greater than 0, or this field is autosizable.

Field: System Air Flow Rate During Heating Operation

This numeric field defines the air flow rate through the system (i.e., through the fan and heating/cooling coils) in cubic meters per second when the heating coil is operating. Values must be greater than 0, or this field is autosizable.

Field: System Air Flow Rate When No Cooling or Heating is Needed

This numeric field defines the air flow rate through the system (i.e., through the fan and heating/cooling coils) in cubic meters per second when neither cooling nor heating is required (i.e., the DX cooling coil and heating coil are off but the supply air fan operates). Values must be greater than or equal to zero, or this field is autosizable. This field is only used when the unitary system's supply air fan operating mode is specified as continuous fan operation (Ref. Field: Supply air fan operating mode schedule name). If the system's supply air fan operating mode is specified as continuous fan operation and this value is set to zero or the field is left blank, then the model assumes that the system air flow rate when no heating/cooling is needed is equal to the system air flow rate when the coils were last operating (for cooling operation or heating operation).

Field: Outdoor Air Flow Rate During Cooling Operation

This numeric field defines the outdoor air flow rate through the system (i.e., through the Outdoor air Mixer's Outside_Air_Stream_Node) in cubic meters per second when the DX cooling coil is operating. Values must be greater than or equal to 0, or this field is autosizable. Note that the outdoor air flow rate during cooling operating can be changed during the simulation using a multiplier schedule (Ref. Field: Outdoor air volumetric flow rate multiplier schedule name). For any simulation timestep, the outdoor air flow rate during cooling operation cannot exceed the system air volumetric flow rate during cooling operation.

Field: Outdoor Air Flow Rate During Heating Operation

This numeric field defines the outdoor air flow rate through the system (i.e., through the Outdoor air Mixer's Outside_Air_Stream_Node) in cubic meters per second when the heating coil is operating. Values must be greater than or equal to 0, or this field is autosizable. Note that the outdoor air flow rate during heating operating can be changed during the simulation using a multiplier schedule (Ref. Field: Outdoor air volumetric flow rate multiplier schedule name). For any simulation timestep, the outdoor air flow rate during heating operation cannot exceed the system air volumetric flow rate during heating operation.

Field: Outdoor Air Flow Rate When No Cooling or Heating is Needed

This numeric field defines the outdoor air flow rate through the system (i.e., through the Outdoor air Mixer's Outside_Air_Stream_Node) in cubic meters per second when neither cooling nor heating is required (i.e., the DX cooling coil and heating coil are off but the supply air fan operates). Values must be greater than or equal to 0, or this field is autosizable. Note that the outdoor air flow rate when no cooling/heating is needed can be changed during the simulation using a multiplier schedule (Ref. Field: Outdoor air volumetric flow rate multiplier schedule name). For any simulation timestep, the outdoor air flow rate when no cooling/heating is needed cannot exceed the system air volumetric flow rate when no cooling/heating is needed. This field is only used when the unitary system's supply air fan operating mode is specified as continuous fan operation (Ref. Field: Supply air fan operating mode schedule name). If the system's supply air fan operating mode is specified as continuous fan operation and this value is set to zero or the field is left blank, then the model assumes that the outdoor air flow rate when no cooling/heating is needed is equal to the outdoor air flow rate when the coils were last operating (for cooling operation [i.e. Outdoor air volumetric flow rate during cooling operation] or heating operation [i.e. Outdoor air volumetric flow rate during heating operation]) and this field is not used.

Field: Outdoor Air Flow Rate Multiplier Schedule Name

This alpha field defines the name of a schedule (ref: Schedule) that contains multipliers for the outdoor air volume flow rates (heating, cooling, no heating/cooling). Schedule values must be from zero to 1. If this field is left blank, then the model assumes that the outdoor air multiplier is 1 for the entire simulation period.

Field: Air Inlet Node Name

This alpha field defines the name of the HVAC system node from which the system draws its inlet air.

Field: Bypass Duct Mixer Node Name

This alpha field defines the name of the HVAC system node where the bypass air mixes with the unitary system's inlet air. This name should match the name of the Return Air Stream Node Name for the OutdoorAir:Mixer associated with this system. This node name must be different from the system's air inlet node name.

Field: Bypass Duct Splitter Node Name

This alpha field defines the name of the HVAC system node where the conditioned air is split into bypass air and supply air leaving the system (e.g., delivered to the terminal units). This splitter air node name should match the outlet node name for the last component (furthest downstream) in this unitary system. For blow through fan placement, the splitter air node is the outlet node of the heating coil. For draw through fan placement, the splitter node is the outlet node of the supply air fan.

Field: Air Outlet Node Name

This alpha field defines the name of the HVAC system node to which the system sends its outlet air.

Field: Outdoor Air Mixer Name

This alpha field defines the name of an outdoor air mixer component that composes part of the CBVAV system. The name of the outdoor air mixer's Return_Air_Stream_Node should match the bypass duct mixer node name, and be different from the CBVAV system's air inlet node name. The Mixed Air Node Name of the outdoor air mixer should be the same as the CBVAV system's supply fan inlet air node (for blow through fan placement) or the system's DX cooling coil inlet node (for draw through fan placement).

Field: Supply Air Fan Object Type

This alpha field defines the type of fan used by this unitary system. The only valid choices are **Fan:OnOff** and **Fan:ConstantVolume**. The input requirements for these fan objects are described elsewhere in this document.

Field: Supply Air Fan Name

This alpha field defines the name of the fan component that composes part of this unitary system. Note that the fan component's maximum flow rate should be greater than or equal to the largest system air volumetric flow rate specified for this unitary system (heating, cooling, and no heating/cooling). In addition, the fan's inlet air node should be the same as the outdoor air mixer's Mixed Air Node (for blow through fan placement) or the heating coil's outlet node (for draw through fan placement). The fan outlet air node should be the same as the DX cooling coil's air inlet node (for blow through fan placement) or the system's bypass duct splitter node (for draw through fan placement).

Field: Supply Air Fan Placement

This alpha field defines the placement of the supply air fan within this unitary system. The only valid choices are **BlowThrough** and **DrawThrough**. With blow through placement, the supply air fan is located immediately upstream of the system's cooling coil. With draw through placement, the supply air fan is located immediately downstream of the heating coil.

Field: Supply Air Fan Operating Mode Schedule Name

This alpha field defines the name of a schedule that specifies the supply air fan operating mode during the simulation. A schedule value of 0 denotes the fan cycles off when no cooling or heating is required, and any other value denotes that the fan runs continuously regardless of the need for heating or cooling. If this field is left blank, the model assumes continuous supply air fan operation for the entire simulation period.

Field: Cooling Coil Object Type

This alpha field defines the type of cooling coil used by this unitary system. There are three valid choices for this field:

```
Coil:Cooling:DX:SingleSpeed
CoilSystem:Cooling:DX:HeatExchangerAssisted
Coil:Cooling:DX:TwoStageWithHumidityControlMode
```

The input requirements for these cooling coil objects are described elsewhere in this document.

Field: Cooling Coil Name

This alpha field defines the name of the cooling coil used by this unitary system, and this name should match the name specified in the corresponding cooling coil object.

Field: Heating Coil Object Type

This alpha field defines the type of heating coil used by this unitary system. The only valid choices are:

```
Coil:Heating:Electric
Coil:Heating:Gas
Coil:Heating:DX:SingleSpeed
```

The input requirements for these heating coil objects are described elsewhere in this document.

Field: Heating Coil Name

This alpha field defines the name of the heating coil used by this unitary system, and this name should match the name specified in the corresponding heating coil object.

Field: Priority Control Mode

This choice field defines the cooling or heating priority control mode for the unitary system. Valid choices are:

CoolingPriority HeatingPriority ZonePriority
--

If CoolingPriority is selected, the system operates to meet the cooling load if any zone served by this system (air loop) requires cooling. If no zones require cooling, then the system operates in heating mode if needed. If HeatingPriority is selected, the system operates to meet the heating load if any zone requires heating. If no zones require heating, then the system operates in cooling mode if needed. If ZonePriority is selected, the system operates based on the maximum number of zones requiring either heating or cooling. If the number of zones requiring cooling is greater than the number of zones requiring heating, then the system operates in cooling mode. If the number of zones requiring heating is greater than the number of zones requiring cooling, then the system operates in heating mode. If the number of zones requiring cooling equals the number of zones requiring heating, then the largest combined load (i.e., the sum of the cooling loads for zones requiring cooling compared to the sum of the heating loads for zones that require heating) sets the cooling or heating operating mode for the system during that simulation timestep.

Field: Minimum Outlet Air Temperature During Cooling Operation

This numeric field defines the minimum outlet air temperature leaving the system when the unit is operating to provide cooling. Values are specified in degrees Celsius and must be greater than 0. The default value is 8°C. This value must be less than or equal to the maximum outlet air temperature during heating operation.

Field: Maximum Outlet Air Temperature During Heating Operation

This numeric field defines the maximum outlet air temperature leaving the system when the unit is operating to provide heating. Values are specified in degrees Celsius and must be greater than 0. The default value is 50°C. This value must be greater than or equal to the minimum outlet air temperature during cooling operation.

Field: Dehumidification Control Type

This alpha field contains the type of dehumidification control. The following options are valid for this field:

None - meet sensible load only, no active dehumidification control

Multimode - activate enhanced dehumidification mode as needed and meet sensible load. This option is used to model DX equipment with a controllable heat exchanger assisting the DX cooling coil for improved dehumidification. It is valid only with cooling coil type = Coil:Cooling:DX:TwoStageWithHumidityControlMode.

CoolReheat - cool beyond the dry-bulb temperature set point as required to meet the high humidity setpoint. It is valid only with cooling coil type = Coil:Cooling:DX:TwoStageWithHumidityControlMode.

The default is **None**. For the other dehumidification control modes, the maximum humidity setpoint on the CBVAV system's air outlet node is used. This must be set using a **ZoneControl:Humidistat** and **SetpointManager:SingleZone:Humidity:Maximum** objects. When extra dehumidification is required, the system may not be able to meet the humidity setpoint if its full capacity is not adequate.

The CBVAV unitary system IDD object is shown below:


```

AirLoopHVAC:UnitaryHeatCool:VAVChangeoverBypass,
  \min-fields 22
A1, \field Name
   \required-field
   \type alpha
   \note Enter a unique name for this unitary system.
A2, \field Availability Schedule Name
   \required-field
   \type object-list
   \object-list ScheduleNames
   \note Enter the availability schedule name. Schedule values of zero denote system
   \note is Off. Non-zero schedule values denote system is available to operate.
N1, \field System Air Flow Rate During Cooling Operation
   \required-field
   \type real
   \units m3/s
   \autosizable
   \minimum> 0.0
   \note Enter the system air flow rate during cooling
   \note operation or specify autosize.
N2, \field System Air Flow Rate During Heating Operation
   \required-field
   \type real
   \units m3/s
   \autosizable
   \minimum> 0.0
   \note Enter the system air flow rate during heating
   \note operation or specify autosize.
N3, \field System Air Flow Rate When No Cooling or Heating is Needed
   \type real
   \units m3/s
   \minimum 0.0
   \autosizable
   \note Only used when the supply air fan operating mode is continuous (see field
   \note Supply air fan operating mode schedule name). This system air flow rate
   \note is used when no heating or cooling is required and the coils are off.
   \note If this field is left blank or zero, the system air flow rate from the
   \note previous on cycle (either cooling or heating) is used.
N4, \field Outdoor Air Flow Rate During Cooling Operation
   \required-field
   \type real
   \units m3/s
   \autosizable
   \minimum 0.0
   \note Enter the outdoor air flow rate during
   \note cooling operation or specify autosize.
N5, \field Outdoor Air Flow Rate During Heating Operation
   \required-field
   \type real
   \units m3/s
   \autosizable
   \minimum 0.0
   \note Enter the outdoor air flow rate during
   \note heating operation or specify autosize.
N6, \field Outdoor Air Flow Rate When No Cooling or Heating is Needed
   \type real
   \units m3/s
   \minimum 0.0
   \autosizable
   \note Only used when the supply air fan operating mode is continuous (see field
   \note Supply air fan operating mode schedule name). This outdoor air flow rate
   \note is used when no heating or cooling is required and the coils are off.
   \note If this field is left blank or zero, the outdoor air flow rate from the previous on cycle
   \note (either cooling or heating) is used.

```

- A3 , \field Outdoor Air Flow Rate Multiplier Schedule Name
 \type alpha
 \note Enter the name of a schedule that contains multipliers for the outdoor air flow rates. Schedule values must be from 0 to 1.
 \note If field is left blank, model assumes multiplier is 1 for the entire simulation period.
- A4 , \field Air Inlet Node Name
 \required-field
 \type alpha
 \note Enter the name of the unitary system's air inlet node.
- A5 , \field Bypass Duct Mixer Node Name
 \required-field
 \type alpha
 \note Enter the name of the bypass duct mixer node. This name should be the name of the return air node for the outdoor air mixer associated with this system.
 \note This node name must be different from the air inlet node name.
- A6 , \field Bypass Duct Splitter Node Name
 \required-field
 \type alpha
 \note Enter the name of the bypass duct splitter node.
 \note This splitter air node is the outlet node of the last component in this unitary system. For blow through fan placement, the splitter air node is the outlet node of the heating coil. For draw through fan placement, the splitter node is the outlet node of the supply air fan.
- A7 , \field Air Outlet Node Name
 \required-field
 \type alpha
 \note Enter the name of the unitary system's air outlet node.
- A8 , \field Outdoor Air Mixer Name
 \required-field
 \type object-list
 \object-list OutdoorAirMixers
 \note Enter the name of the outdoor air mixer used with this unitary system.
- A9 , \field Supply Air Fan Object Type
 \required-field
 \type choice
 \key Fan:OnOff
 \key Fan:ConstantVolume
 \note Specify the type of supply air fan used in this unitary system.
- A10, \field Supply Air Fan Name
 \required-field
 \type object-list
 \object-list FansCVandOnOff
 \note Enter the name of the supply air fan used in this unitary system.
- A11, \field Supply Air Fan Placement
 \required-field
 \type choice
 \key BlowThrough
 \key DrawThrough
 \note Specify supply air fan placement as either blow through or draw through.
 \note BlowThrough means the supply air fan is located before the cooling coil. DrawThrough means the supply air fan is located after the heating coil.
- A12, \field Supply Air Fan Operating Mode Schedule Name
 \type object-list
 \object-list ScheduleNames
 \note Enter the name of a schedule to control the supply air fan. Schedule Name values of zero mean that the supply air fan will cycle off if there is no cooling or heating load in any of the zones being served by this system. Non-zero schedule values mean that the supply air fan will operate continuously even if there is no cooling or heating load in any of the zones being served. If this field is left blank, the supply air fan will operate continuously for the entire simulation period.
- A13, \field Cooling Coil Object Type
 \required-field
 \type choice
 \key Coil:Cooling:DX:SingleSpeed
 \key CoilSystem:Cooling:DX:HeatExchangerAssisted
 \key Coil:Cooling:DX:TwoStageWithHumidityControlMode
 \note Specify the type of cooling coil used in this unitary system.

```

A14, \field Cooling Coil Name
      \required-field
      \type object-list
      \object-list CoolingCoilsDXMultiModeandSingleSpeed
      \note Enter the name of the cooling coil used in this unitary system.
A15, \field Heating Coil Object Type
      \required-field
      \type choice
      \key Coil:Heating:DX:SingleSpeed
      \key Coil:Heating:Gas
      \key Coil:Heating:Electric
      \note Specify the type of heating coil used in this unitary system.
A16, \field Heating Coil Name
      \required-field
      \type object-list
      \object-list HeatingCoilsGasElecDX
      \note Enter the name of the heating coil used in this unitary system.
A17, \field Priority Control Mode
      \type choice
      \key CoolingPriority
      \key HeatingPriority
      \key ZonePriority
      \default ZonePriority
      \note CoolingPriority = system provides cooling if any zone requires cooling.
      \note HeatingPriority = system provides heating if any zone requires heating.
      \note ZonePriority = system controlled based on the total number of zones
      \note requiring cooling or heating (highest number of zones
      \note in cooling or heating determines the system's operating mode).
N7 , \field Minimum Outlet Air Temperature During Cooling Operation
      \type real
      \units C
      \minimum> 0.0
      \default 8.0
      \note Specify the minimum outlet air temperature allowed for this unitary system
      \note during cooling operation. This value should be less than the maximum outlet
      \note air temperature during heating operation.
N8 , \field Maximum Outlet Air Temperature During Heating Operation
      \type real
      \units C
      \minimum> 0.0
      \default 50.0
      \note Specify the maximum outlet air temperature allowed for this unitary system
      \note during heating operation. This value should be greater than the minimum outlet
      \note air temperature during cooling operation.
A18; \field Dehumidification Control Type
      \type choice
      \key None
      \key Multimode
      \key CoolReheat
      \default None
      \note None = meet sensible load only.
      \note Multimode = activate enhanced dehumidification mode
      \note as needed and meet sensible load. Valid only with
      \note Coil:Cooling:DX:TwoStageWithHumidityControlMode.
      \note CoolReheat = cool beyond the Dry-Bulb temperature setpoint
      \note as required to meet the humidity setpoint. Valid only with
      \note Coil:Cooling:DX:TwoStageWithHumidityControlMode.
      \note For all dehumidification controls, the max humidity setpoint
      \note on this unitary system's air outlet node is used.
      \note This must be set using ZoneControl:Humidistat and
      \note SetpointManager:SingleZone:Humidity:Maximum objects.

```

As shown in the example below, correct specification of the CBVAV unitary system requires specification of the following objects in addition to the UnitarySystem:VAV: ChangeoverBypass object:

- 1) outdoor air mixer (OutdoorAir:Mixer)
- 2) fan (Fan:OnOff or Fan:ConstantVolume)

- 3) cooling coil (Coil:DX:Cooling:SingleSpeed, CoilSystem:Cooling:DX:HeatExchangerAssisted, or Coil:Cooling:DX:TwoStageWithHumidityControlMode)
- 4) heating coil (Coil:Heating:Gas, Coil:Heating:Electric, or Coil:Heating:DX:SingleSpeed)
- 5) terminal unit for each zone being served by this system (AirTerminal:SingleDuct:VAV:HeatAndCool:Reheat or AirTerminal:SingleDuct:VAV:HeatAndCool:NoReheat)

Note: The fan, heating coil, cooling coil, and outdoor air mixer must be connected in the air loop according to the configurations shown above (Figure 99 and Figure 100).

```
AirLoopHVAC:UnitaryHeatCool:VAVChangeoverBypass,
  GasHeat CBVAV System,      !- Name of unitary system
  FanAndCoilAvailSched,     !- Availability schedule name
  1.8,                       !- System air volumetric flow rate during cooling operation {m3/s}
  1.7,                       !- System air volumetric flow rate during heating operation {m3/s}
  1.6,                       !- System air volumetric flow rate when no cooling or heating is needed {m3/s}
  0.32,                     !- Outdoor air volumetric flow rate during cooling operation {m3/s}
  0.3,                       !- Outdoor air volumetric flow rate during heating operation {m3/s}
  0.27,                     !- Outdoor air volumetric flow rate when no cooling or heating is needed {m3/s}
  Outdoor Air Multiplier Schedule, !- Outdoor air volumetric flow rate multiplier schedule name
  Air Loop Inlet Node,       !- Air inlet node name
  Mixer Inlet Node,         !- Bypass duct mixer node name
  Heating Coil Air Outlet Node, !- Bypass duct splitter node name
  Air Loop Outlet Node,     !- Air outlet node name
  Outdoor air Mixer,        !- Outdoor air mixer name
  Fan:OnOff,                !- Supply air fan type
  Supply Fan 1,             !- Supply air fan name
  BlowThrough,              !- Supply air fan placement
  Fan OpMode Schedule,      !- Supply air fan operating mode schedule name
  Coil:Cooling:DX:TwoStageWithHumidityControlMode, !- Cooling coil type
  ACDXCoil 2,               !- Cooling coil name
  Coil:Heating:Gas,         !- Heating coil type
  Furnace Heating Coil 1,   !- Heating coil name
  CoolingPriority,          !- Priority control mode
  10.0,                     !- Minimum outlet air temperature during cooling operation {C}
  50.0,                     !- Maximum outlet air temperature during heating operation {C}
  None;                     !- Dehumidification control type

OutdoorAir:Mixer,
  Outdoor air Mixer,        !- Name
  Mixed Air Node,          !- Mixed_Air_Node
  Outdoor air Inlet Node,  !- Outside_Air_Stream_Node
  Relief Air Outlet Node,  !- Relief_Air_Stream_Node
  Mixer Inlet Node;        !- Return_Air_Stream_Node
```

```
Fan:OnOff,
  Supply Fan 1,             !- Fan Name
  FanAndCoilAvailSched,    !- Available Schedule
  0.7,                      !- Fan Total Efficiency
  600.0,                    !- Delta Pressure {Pa}
  1.8,                      !- Max Flow Rate {m3/s}
  0.9,                      !- Motor Efficiency
  1.0,                      !- Motor In Airstream Fraction
  Mixed Air Node,          !- Fan_Inlet_Node
  DX Cooling Coil Air Inlet Node; !- Fan_Outlet_Node
```

```

Coil:Cooling:DX:TwoStageWithHumidityControlMode,
  ACDXCoil 2,           !- Coil Name
  FanAndCoilAvailSched, !- Availability Schedule
  DX Cooling Coil Air Inlet Node, !- Coil Air Inlet Node
  Heating Coil Air Inlet Node, !- Coil Air Outlet Node
  ,                    !- Crankcase Heater Capacity {W}
  ,                    !- Maximum Outdoor Dry-bulb Temperature for Crankcase Heater Operation {C}
  2,                   !- Number of Capacity Stages
  0,                   !- Number of Enhanced Dehumidification Modes
  CoilPerformance:DX:Cooling, !- Normal Mode Stage 1 Coil Performance Object Type
  ACDXCoil 2 Standard Mode-Stage 1, !- Normal Mode Stage 1 Coil Performance Object Name
  CoilPerformance:DX:Cooling, !- Normal Mode Stage 1+2 Coil Performance Object Type
  ACDXCoil 2 Standard Mode-Stage 1&2; !- Normal Mode Stage 1+2 Coil Performance Object Name

Coil:Heating:Gas,
  Furnace Heating Coil 1, !- Coil Name
  FanAndCoilAvailSched, !- Available Schedule
  0.8,                   !- Gas Burner Efficiency of the Coil
  35000,                 !- Nominal Capacity of the Coil {W}
  Heating Coil Air Inlet Node, !- Coil_Air_Inlet_Node
  Heating Coil Air Outlet Node; !- Coil_Air_Outlet_Node

AirTerminal:SingleDuct:VAV:HeatAndCool:Reheat,
  Zone 1 VAV System,    !- Name of System
  FanAndCoilAvailSched, !- System Availability schedule
  Zone 1 Reheat Air Inlet Node, !- DAMPER Air Outlet Node
  Zone 1 VAV Inlet Node, !- UNIT Air Inlet Node
  0.583,                !- Maximum air flow rate {m3/s}
  0.25,                 !- Zone Minimum Air Flow Fraction
  ,                    !- Control node
  Coil:Heating:Electric, !- Reheat Component Object
  Reheat Coil Zone 1,   !- Name of Reheat Component
  0.0,                  !- Max Reheat Water Flow {m3/s}
  0.0,                  !- Min Reheat Water Flow {m3/s}
  Zone 1 Reheat Air Outlet Node, !- UNIT Air Outlet Node
  0.001;                !- Convergence Tolerance

AirTerminal:SingleDuct:VAV:HeatAndCool:Reheat,
  Zone 2 VAV System,    !- Name of System
  FanAndCoilAvailSched, !- System Availability schedule
  Zone 2 Reheat Air Inlet Node, !- DAMPER Air Outlet Node
  Zone 2 VAV Inlet Node, !- UNIT Air Inlet Node
  0.583,                !- Maximum air flow rate {m3/s}
  0.25,                 !- Zone Minimum Air Flow Fraction
  ,                    !- Control node
  Coil:Heating:Electric, !- Reheat Component Object
  Reheat Coil Zone 2,   !- Name of Reheat Component
  0.0,                  !- Max Reheat Water Flow {m3/s}
  0.0,                  !- Min Reheat Water Flow {m3/s}
  Zone 2 Reheat Air Outlet Node, !- UNIT Air Outlet Node
  0.001;                !- Convergence Tolerance

AirTerminal:SingleDuct:VAV:HeatAndCool:NoReheat,
  Zone 3 VAV System,    !- Name of System
  FanAndCoilAvailSched, !- System Availability schedule
  Zone 3 Reheat Air Outlet Node, !- UNIT Air Outlet Node
  Zone 3 VAV Inlet Node, !- UNIT Air Inlet Node
  0.584,                !- Maximum air flow rate {m3/s}
  0.25;                 !- Zone Minimum Air Flow Fraction

```

AirLoopHVAC:UnitaryHeatCool:VAVChangeoverBypass Outputs

```

HVAC,Average,Changeover-bypass VAV Total Heating Rate[W]
HVAC,Sum,Changeover-bypass VAV Total Heating Energy[J]
HVAC,Average,Changeover-bypass VAV Total Cooling Rate[W]
HVAC,Sum,Changeover-bypass VAV Total Cooling Energy[J]
HVAC,Average,Changeover-bypass VAV Sensible Heating Rate[W]
HVAC,Sum,Changeover-bypass VAV Sensible Heating Energy[J]
HVAC,Average,Changeover-bypass VAV Sensible Cooling Rate[W]
HVAC,Sum,Changeover-bypass VAV Sensible Cooling Energy[J]

```

HVAC, Average, Changeover-bypass	VAV Latent Heating Rate[W]
HVAC, Sum, Changeover-bypass	VAV Latent Heating Energy[J]
HVAC, Average, Changeover-bypass	VAV Latent Cooling Rate[W]
HVAC, Sum, Changeover-bypass	VAV Latent Cooling Energy[J]
HVAC, Average, Changeover-bypass	VAV Electric Power[W]
HVAC, Sum, Changeover-bypass	VAV Electric Consumption[J]
HVAC, Average, Changeover-bypass	VAV Fan Part-Load Ratio
HVAC, Average, Changeover-bypass	VAV Compressor Part-Load Ratio
HVAC, Average, Changeover-bypass	VAV Bypass Mass Flow Rate[kg/s]
HVAC, Average, Changeover-bypass	VAV Outlet Air Set Point Temp[C]

Changeover-bypass VAV Total Heating Rate[W]

This output field is the total (enthalpy) heat addition rate of the CBVAV system in Watts. This value is calculated using the enthalpy difference of the outlet air and inlet air streams, and the supply air mass flow rate entering/leaving the system. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy addition only) are averaged for the timestep being reported.

Changeover-bypass VAV Total Heating Energy[J]

This output field is the total (enthalpy) heat addition of the CBVAV system in Joules over the timestep being reported. This value is calculated using the enthalpy difference of the outlet air and inlet air streams, the supply air mass flow rate entering/leaving the system, and the HVAC simulation timestep. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy addition only) are summed for the timestep being reported.

Changeover-bypass VAV Total Cooling Rate[W]

This output field is the total (enthalpy) heat extraction rate of the CBVAV system in Watts. This value is calculated using the enthalpy difference of the outlet air and inlet air streams, and the supply air mass flow rate entering/leaving the system. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy extraction only) are averaged for the timestep being reported.

Changeover-bypass VAV Total Cooling Energy[J]

This output field is the total (enthalpy) heat extraction of the CBVAV system in Joules over the timestep being reported. This value is calculated using the enthalpy difference of the outlet air and inlet air streams, the supply air mass flow rate entering/leaving the system, and the HVAC simulation timestep. This value is calculated for each HVAC system timestep being simulated, and the results (enthalpy extraction only) are summed for the timestep being reported.

Changeover-bypass VAV Sensible Heating Rate[W]

This output field is the sensible heat addition rate of the CBVAV system in Watts. This value is calculated using the enthalpy difference of the outlet air and inlet air streams at a constant humidity ratio, and the supply air mass flow rate entering/leaving the system. This value is calculated for each HVAC system timestep being simulated, and the results (heating only) are averaged for the timestep being reported.

Changeover-bypass VAV Sensible Heating Energy[J]

This output field is the sensible heat addition of the CBVAV system in Joules over the timestep being reported. This value is calculated using the enthalpy difference of the outlet air and inlet air streams at a constant humidity ratio, the supply air mass flow rate entering/leaving the system, and the HVAC simulation timestep. This value is calculated for each HVAC system timestep being simulated, and the results (heating only) are summed for the timestep being reported.

Changeover-bypass VAV Sensible Cooling Rate[W]

This output field reports the moist air sensible heat extraction rate of the CBVAV system in Watts. This value is calculated using the enthalpy difference of the outlet air and inlet air streams at a constant humidity ratio, and the supply air mass flow rate entering/leaving the system. This value is calculated for each HVAC system timestep being simulated, and the results (cooling only) are averaged for the timestep being reported.

Changeover-bypass VAV Sensible Cooling Energy[J]

This output field reports the moist air sensible heat extraction of the CBVAV system in Joules over the timestep being reported. This value is calculated using the enthalpy difference of the outlet air and inlet air streams at a constant humidity ratio, the supply air mass flow rate entering/leaving the system, and the HVAC simulation timestep. This value is calculated for each HVAC system timestep being simulated, and the results (cooling only) are summed for the timestep being reported.

Changeover-bypass VAV Latent Heating Rate[W]

This output field is the latent heat addition (humidification) rate of the CBVAV system in Watts. This value is calculated as the difference between the total energy rate and the sensible energy rate provided by the system. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat addition only) are averaged for the timestep being reported.

Changeover-bypass VAV Latent Heating Energy[J]

This output field is the latent heat addition (humidification) of the CBVAV system in Joules over the timestep being reported. This value is calculated as the difference between the total energy and the sensible energy delivered by the system. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat addition only) are summed for the timestep being reported.

Changeover-bypass VAV Latent Cooling Rate[W]

This output field is the latent heat extraction (dehumidification) rate of the CBVAV system in Watts. This value is calculated as the difference between the total energy rate and the sensible energy rate provided by the system. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat extraction only) are averaged for the timestep being reported.

Changeover-bypass VAV Latent Cooling Energy[J]

This output field is the latent heat extraction (dehumidification) of the CBVAV system in Joules over the timestep being reported. This value is calculated as the difference between the total energy and the sensible energy delivered by the system. This value is calculated for each HVAC system timestep being simulated, and the results (latent heat extraction only) are summed for the timestep being reported.

Changeover-bypass VAV Electric Power[W]

This output field is the electricity consumption rate of the CBVAV system in Watts. The consumption includes electricity used by the DX compressor (including crankcase heater), fans (indoor supply air fan and the condenser fans associated with the DX coil[s]), and the heating coil (if electric). This value is calculated for each HVAC system timestep being simulated, and the results are averaged for the timestep being reported.

Changeover-bypass VAV Electric Consumption[J]

This output field is the electricity consumption of the CBVAV system in Joules for the time period being reported. The consumption includes electricity used by the DX compressor (including crankcase heater), fans (indoor supply air fan and the condenser fans associated with the DX coil[s]), and the heating coil (if electric). This value is calculated for each HVAC

system timestep being simulated, and the results are summed for the timestep being reported.

Changeover-bypass VAV Fan Part-Load Ratio

This output field is the part-load ratio of the supply air fan, which will be either zero or 1 for each simulation timestep. For this system, the fan will operate continuously for the simulation timestep if the system is available (ref. Field: Availability schedule name) and there is a cooling or heating load to be met (i.e., fan part-load ratio will equal 1). When the system is available but there is no cooling or heating load to be met, the fan will either be off for the entire timestep or on for the entire timestep depending on the supply air fan operating mode schedule (ref. Field: Supply air fan operating mode schedule name). This value is set for each HVAC system timestep being simulated, and the results are averaged for the timestep being reported.

Changeover-bypass VAV Compressor Part-Load Ratio

This output field is the part-load ratio of the compressor used by the DX coils (cooling and heating). The compressor part-load ratio is defined as the total coil load divided by the coil steady-state capacity (steady-state capacity of first stage for multi-mode coils). This value is calculated for each HVAC system timestep being simulated, and the results are averaged for the timestep being reported.

Changeover-bypass VAV Bypass Mass Flow Rate[kg/s]

This output field is the mass flow rate of air, in kg/s, being bypassed from the supply air path and blended with the air entering the CBVAV system. This value is calculated for each HVAC system timestep being simulated, and the results are averaged for the timestep being reported.

Changeover-bypass VAV Outlet Air Set Point Temp[C]

This output field is the dry-bulb set point temperature in degrees Celsius. This set point temperature is calculated by the model based on the zone cooling/heating loads calculated by EnergyPlus, and the priority control mode and the dehumidification control type specified for this unitary system. The CBVAV system attempts to achieve the outlet air set point temperature to the extent possible.

AirLoopHVAC:UnitaryCoolOnly

The AirLoopHVAC:UnitaryCoolOnly DX System is a “virtual” component that consists of a DX cooling coil component as shown in the Figure below. The DX cooling coil specifications are provided in the input data syntax. This coil can be specified anywhere in the air loop simulation but will control the best with a blow through fan since the fan heat will be handled the most accurate.

This system does not need any plant specification and will provide the electric consumption necessary to operate the compressor and the condenser fan. The supply fan is simulated separately. This coil can be used with any system that a coil roughly meets a deck temperature and can be designed for use with all the terminal reheat, variable volume either single or multi duct systems. Any system where the deck temperature is met in the air loop and the trim control for the zone is met downstream.

For single-zone systems, using appropriate set point managers, this system can also be used to model packaged equipment as blow-thru or draw-thru, with or without humidity controls.

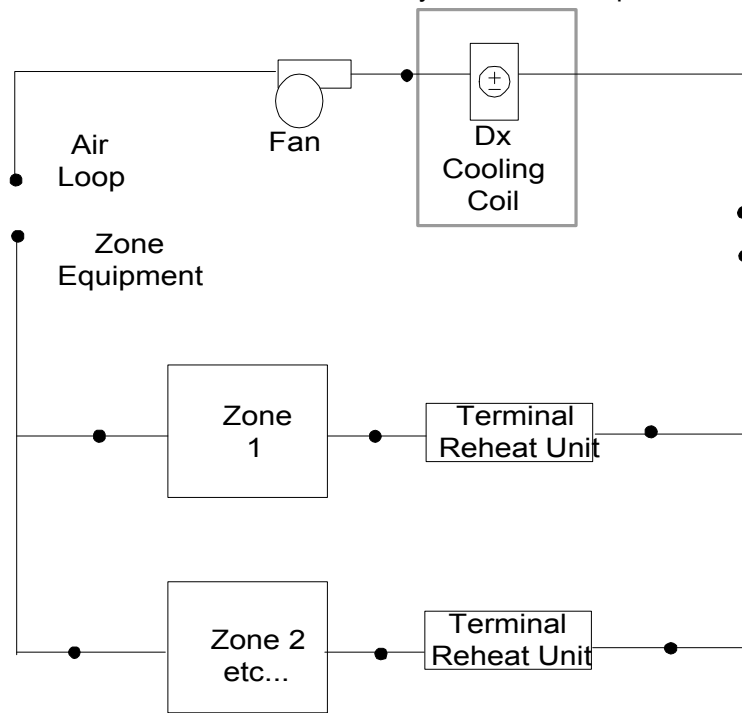


Figure 101. Schematic of EnergyPlus DX System in Air Loop for a Blow-Thru Application

The IDD is shown below:

```

AirLoopHVAC:UnitaryCoolOnly,
  \min-fields 7
  A1 , \field Name
      \required-field
      \type alpha
  A2 , \field Availability Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
  A3 , \field DX Cooling Coil System Inlet Node Name
      \required-field
      \type alpha
  A4 , \field DX Cooling Coil System Outlet Node Name
      \required-field
      \type alpha
  A5 , \field DX Cooling Coil System Sensor Node Name
      \required-field
      \type alpha
  A6, \field Cooling Coil Object Type
      \required-field
      \type choice
      \key Coil:Cooling:DX:SingleSpeed
      \key CoilSystem:Cooling:DX:HeatExchangerAssisted
      \key Coil:Cooling:DX:TwoSpeed
      \key Coil:Cooling:DX:TwoStageWithHumidityControlMode
  A7, \field Cooling Coil Name
      \required-field
      \type object-list
      \object-list CoolingCoilsDX
    
```

```

A8, \field Dehumidification Control Type
    \type choice
    \key None
    \key Multimode
    \key CoolReheat
    \default None
    \note None = meet sensible load only
    \note Multimode = activate enhanced dehumidification mode
    \note as needed and meet sensible load. Valid only with
    \note Coil:Cooling:DX:TwoStageWithHumidityControlMode or
    \note CoilSystem:Cooling:DX:HeatExchangerAssisted.
    \note CoolReheat = cool beyond the dry bulb setpoint.
    \note as required to meet the humidity setpoint.
    \note Valid for all coil types.
    \note For all dehumidification controls, the max
    \note humidity setpoint on the Sensor Node is used.
    \note This must be set using ZoneControl:Humidistat and
    \note SetpointManager:SingleZone:Humidity:Maximum and
    \note SetpointManager:OutdoorAirPretreat(optional) objects
A9, \field Run on Sensible Load
    \type choice
    \key Yes
    \key No
    \default Yes
    \note If Yes, unit will run if there is a sensible load.
    \note If No, unit will not run if there is only a sensible load.
    \note Dehumidification controls will be active if specified.
A10; \field Run on Latent Load
    \type choice
    \key Yes
    \key No
    \default No
    \note If Yes, unit will run if there is a latent load.
    \note even if there is no sensible load.
    \note If No, unit will not run only if there is a latent load.
    \note Dehumidification controls will be active if specified.

```

Field: Name

This alpha field contains the identifying name for the DX System.

Field: Availability Schedule Name

This alpha field contains the schedule name that contains information on the availability of the DX System to operate.

Field: DX Cooling Coil System Inlet Node Name

This alpha field contains the identifying name given to the DX cooling coil inlet node, as specified in the DX cooling coil object.

Field: DX Cooling Coil System Outlet Node Name

This alpha field contains the identifying name given to the DX cooling coil outlet node, as specified in the cooling coil object.

Field: DX Cooling Coil System Sensor Node Name

This alpha field contains the identifying name given to the DX cooling coil control node, this is the node at which the temperature set point is specified by the set point manager.

Field: Cooling Coil Object Type

This alpha field contains the identifying type of cooling coil specified in the DX system. The valid choices for this field are:

```

Coil:Cooling:DX:SingleSpeed
CoilSystem:Cooling:DX:HeatExchangerAssisted

```

```
Coil:Cooling:DX:TwoSpeed
Coil:Cooling:DX:TwoStageWithHumidityControlMode
```

Field: Cooling Coil Name

This alpha field contains the identifying name given to the DX cooling coil.

As shown in the example below, correct specification of this system requires specification of the DX Cooling Coil object in addition to the AirLoopHVAC:UnitaryCoolOnly object.

In addition, the DX cooling coil operation mode must be specified consistently with the DX system operating mode (e.g., the DX cooling coil operation mode must be ContinuousFanWithCyclingCompressor).

Field: Dehumidification Control Type

This alpha field contains the type of dehumidification control. The following options are valid for this field:

None - meet sensible load only, no active dehumidification control

MultiMode - activate enhanced dehumidification mode as needed and meet sensible load. This option is used to model DX equipment with a switchable option such as subcool reheat. It is valid only with Cooling coil type= Coil:Cooling:DX:TwoStageWithHumidityControlMode or CoilSystem:Cooling:DX:HeatExchangerAssisted.

CoolReheat - cool beyond the dry-bulb setpoint as required to meet the humidity setpoint. It is valid only with Cooling coil type=Coil:Cooling:DX:TwoStageWithHumidityControlMode.

The default is **None**. For all dehumidification controls, the max humidity setpoint on the control node is used. This must be set using a **ZoneControl:Humidistat** along with **SetpointManager:SingleZone:Humidity:Maximum** and **SetpointManager:OutdoorAirPretreat** (optional) objects. When extra dehumidification is required, the equipment may not be able to meet the humidity setpoint if its full capacity is not adequate.

Field: Run on Sensible Load

This alpha field specifies if the unit will operate to meet a sensible load as determined by the inlet node dry-bulb temperature and the dry-bulb temperature setpoint on the control node. There are two valid choices, **Yes** or **No**. If **Yes**, unit will run if there is a sensible load. If **No**, unit will not run if there is only a sensible load. The default is **Yes**.

Field: Run on Latent Load

This alpha field specifies if the unit will operate to meet a latent load as determined by the inlet node humidity ratio and the max humidity setpoint on the control node. There are two valid choices, **Yes** or **Yes**. If **Yes**, unit will run if there is a latent load. If **No**, unit will not run if there is only a latent load. The default is **No**.

An example IDF specification:

```

AirLoopHVAC:UnitaryCoolOnly,
  DX Cooling Coil System 1, !- Name of DX Cooling Coil System
  CoolingCoilAvailSched,    !- Availability schedule
  Cooling Coil Air Inlet Node, !- DX Cooling Coil System inlet node name
  Air Loop Outlet Node,     !- DX Cooling Coil System outlet node name
  Air Loop Outlet Node,     !- DX Cooling Coil System Control Node
  Coil:DX:Cooling:SingleSpeed, !- Cooling coil type
  ACDXCoil 1,              !- Cooling coil name
  None,                    !- Dehumidification Control Type
  Yes,                     !- Run on Sensible Load
  No;                      !- Run on Latent Load

Coil:DX:Cooling:SingleSpeed,
  ACDXCoil 1,              !- Coil Name
  CoolingCoilAvailSched,  !- Availability Schedule
  25000,                   !- Rated Total Cooling Capacity (gross) {W}
  0.75,                   !- Rated SHR
  3.0,                    !- Rated COP
  1.3,                    !- Rated Air Volume Flow Rate {m3/s}
  Cooling Coil Air Inlet Node, !- Coil Air Inlet Node
  Air Loop Outlet Node,    !- Coil Air Outlet Node
  WindACCoolCapFT,        !- Total Cooling Capacity Modifier Curve (function of temperature)
  WindACCoolCapFFF,      !- Total Cooling Capacity Modifier Curve (function of flow fraction)
  WindACEIRFT,           !- Energy Input Ratio Modifier Curve (function of temperature)
  WindACEIRFFF,          !- Energy Input Ratio Modifier Curve (function of flow fraction)
  WindACPLFFPLR,         !- Part Load Fraction Correlation (function of part load ratio)
  ContinuousFanWithCyclingCompressor; !- Supply Air Fan Operation Mode

```

Example of DX System Specification

AirLoopHVAC:UnitaryCoolOnly Outputs

```

Coil Type= Coil:Cooling:DX:TwoStageWithHumidityControlMode
HVAC,Average,DXSystem Cycling Part-Load Ratio
HVAC,Average,DXSystem Compressor Speed Ratio
Coil types=Coil:DX:Cooling:SingleSpeed &
CoilSystem:Cooling:DX:HeatExchangerAssisted
HVAC,Average,DXSystem Part-Load Ratio

```

DXSystem Cycling Part-Load Ratio

The system may operate for the entire system timestep, but to meet the load the compressor can cycle on and off. This reports the fraction of the system timestep that the compressor is operating. (1.0 is continuous, 0.0 is off).

DXSystem Compressor Speed Ratio

This is the ratio of time in a system timestep that the compressor is at rated speed. The compressor speed ratio reports (1.0 is max, 0.0 is min) and any value in between as it is averaged over the timestep.

DXSystem Part-Load Ratio

The DX system can operate with a cycling compressor or a varying speed compressor, This variable reports the fraction of the Full Load that is met during the system timestep. This can differ from the cycling part load ratio or the compressor speed ratio. (1.0 is Full Load and 0.0 is no load)

Group – Radiative / Convective Units

This section describes the radiative/convective zone equipment units. The following units are included in this section:

- ZoneHVAC:Baseboard:Convective:Electric
- ZoneHVAC:Baseboard:RadiantConvective:Water

- ZoneHVAC:Baseboard:Convective:Water
- ZoneHVAC:HighTemperatureRadiant
- ZoneHVAC:LowTemperatureRadiant:ConstantFlow
- ZoneHVAC:LowTemperatureRadiant:Electric
- ZoneHVAC:LowTemperatureRadiant:VariableFlow

ZoneHVAC:Baseboard:RadiantConvective:Water

The objective of this model is to calculate the convective and radiant heat transfer from baseboard heaters to the people and the surfaces within a zone so that surface heat balances can take into account the radiant heat transfer to the surfaces and thus enhance the accuracy of thermal comfort predictions within the space. The radiant heat gains are distributed to the surfaces by fractions defined by user input. The input data dictionary definition of the unit is as follows.

Field: Name

A unique user assigned name for an instance of a hot water baseboard heater unit. Any reference to this unit by another object will use this name.

Field: Available Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the hot water baseboard heater unit can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Inlet Node Name

This field is the name of the hot water inlet node for the baseboard heater.

Field: Outlet Node Name

This field is the name of the hot water outlet node for the baseboard heater.

Field: Average Water Temperature

This field is the average water temperature for the baseboard heater from manufacturer's information in degree Celsius.

Field: Standard Water Mass Flow Rate

This field is the rated standard water flow rate in kg/s which is published as part of the manufacturer's data. This flow rate is used by the manufacturer when determining the rated capacity (see next field).

Field: Rated Capacity

This field is the rated baseboard capacity in W at the rated water flow rate (see previous field).

Field: Maximum Water Flow Rate

This field is the maximum hot water volumetric flow rate in m³/sec. This field can be autosized by EnergyPlus.

Field: Convergence Tolerance

This field is the control tolerance for the unit heating output. The unit is controlled by matching the unit output to the zone demand. For hot water baseboards, the model must be numerically inverted to obtain a specified output. The convergence tolerance is the error tolerance used to terminate the numerical inversion procedure. Basically this is the fraction:

$$\frac{|(Q_{bb,out} - Q_{ZoneLoad})|}{Q_{ZoneLoad}} \leq \text{ConvergenceTolerance}$$

The default is 0.001.

Field: Fraction Radiant

This field specifies what fraction of the power input to the baseboard heater is actually transferred to the space as radiant heat. The fraction should be between 0 and 1. This is the portion of the total power that is modeled as radiant, the remaining energy is added to the zone as convective heat transfer. The portion that is radiant heat transfer from the baseboard heater is distributed to people and specific surfaces using the remaining fields. Note that the sum of the fractions in the remaining fields (people and surfaces) must equal 1.0 so that all the radiant power is distributed properly.

Field: Fraction of Radiant Energy Incident on People

This field specifies the fraction of radiant portion of heat transfer to the zone from the baseboard heater that is incident directly on people within the space. This has an impact on the predicted thermal comfort of the zone occupants. Note that although this energy is “radiant” it is actually modeled in the zone heat balance as convective energy (like an internal gain). The basic assumption here is that most radiant energy falling on people will most likely be rereleased to the zone air by convection. This is a simplification of reality, but it maintains the overall energy balance.

Field Set: Surface Name, Fraction of Radiant Energy to Surface

The following two items are repeated up to a maximum of 20 surface/fraction pairs. At least one surface/fraction pair must appear in an input file. In other words, at least one surface must be identified as a recipient of radiant energy from the baseboard heater.

Field: Surface <x> Name

This field is the name of the first surface to which radiant heat transfer from the baseboard heater is distributed. Used in conjunction with the next field, it helps to define the distribution of the radiant energy on the surfaces within the zone. Note that up to 20 pairs of surface names and corresponding fractions may be entered for a single radiant heater system.

Field: Fraction of Radiant Energy to Surface <x>

This field is paired with the preceding surface name (previous field) to define the fraction of radiant heat transfer leaving the baseboard heater that is incident on a particular surface. Users should take into account the directionality of baseboard heaters and their location when defining the value for this input field.

Note on Fraction of Radiant Energy Incident on People and to Surfaces

The radiant energy from the baseboard heater is defined by the total energy input to the baseboard heater from the water loop times the fraction radiant field shown above. This radiant energy is distributed to surfaces and people using the surface and fraction pairs and the fraction to people input by the user. These fractions to people and surfaces must add up to 1.0. In other words, in an input file, the following relation should be maintained by the user input:

$$\text{FractionIncidentOnPeople} + \sum \text{FractionToSurfaces} = 1$$

The IDD Definition of the object:

ZoneHVAC:Baseboard:RadiantConvective:Water,

```

A1, \field Name
    \required-field
A2, \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A3, \field Inlet Node Name
    \required-field
A4, \field Outlet Node Name
    \required-field
N1, \field Average Water Temperature
    \note Select an average water temperature for the same or similar baseboard in I=B=R document
    \required-field
    \units C
    \default 76.67

N2, \field Standard Water Mass Flow Rate
    \note Standard is I=B=R Rating document where all baseboards are rated at either 0.063 kg/s (1
gpm)
    \note or 0.252 kg/s (4 gpm). It is recommended that users find data for the baseboard heater
that
    \note corresponds to performance at 0.063 kg/s unless the flow rate is expected to be above
0.252 kg/s.
    \note If the flow rate is expected to be above 0.252 kg/s, the user should use baseboard data
    \note for 0.252 kg/s with this model.
    \minimum> 0.0
    \units Kg/s
    \default 0.063
N3, \field Rated Capacity
    \note User should multiply the actual finned length provided by the manufacturers to the rated
capacity
    \note in I=B=R document
    \required-field
    \units W
    \default 3000
N4, \field Maximum Water Flow Rate
    \required-field
    \autosizable
    \units m3/s
N5, \field Convergence Tolerance
    \type real
    \minimum> 0.0
    \default 0.001
N6, \field Fraction Radiant
    \required-field
    \minimum 0
    \maximum 1
N7, \field Fraction of Radiant Energy Incident on People
    \minimum 0
    \maximum 1
A5, \field Surface 1 Name
    \note Radiant energy may be distributed to specific surfaces
    \type object-list
    \object-list AllHeatTranSurfNames
N8, \field Fraction of Radiant Energy to Surface 1
    \minimum 0
    \maximum 1
A6, \field Surface 2 Name
    \type object-list
    \object-list AllHeatTranSurfNames

```

<reduced for brevity>

An example IDF for the hot water baseboard is shown below.

```

ZoneHVAC:Baseboard:RadiantConvective:Water,
SPACE2-1 Baseboard,      !- Baseboard Name
ReheatCoilAvailSched,   !- Available Schedule
SPACE2-1 Zone Coil Water In Node,  !- Inlet_Node
SPACE2-1 Zone Coil Water Out Node,  !- Outlet_Node
76.67,                  !- Average Water Temperature {C}
0.063,                  !- Standard Water Mass Flow Rate {Kg/s}
3000.0,                 !- Rated Capacity {W}
0.0013,                 !- Max Water Volumetric Flow Rate {m3/s}
0.001,                  !- Convergence Tolerance
0.3,                    !- Fraction radiant
0.3,                    !- Fraction of radiant energy incident on people
C2-1,                   !- Surface 1 Name
0.1,                    !- Fraction of radiant energy from heater distributed to surface 1
F2-1,                   !- Surface 2 Name
0.2,                    !- Fraction of radiant energy from heater distributed to surface 2
SB21,                   !- surface 3 Name
0.1,                    !- fraction of radiant energy from heater distributed to surface 3
SB23,                   !- surface 4 Name
0.1,                    !- fraction of radiant energy from heater distributed to surface 4
SB25,                   !- surface 5 Name
0.1,                    !- fraction of radiant energy from heater distributed to surface 5
WR-1,                   !- surface 6 Name
0.1;                    !- fraction of radiant energy from heater distributed to surface 6
    
```

ZoneHVAC:Baseboard:RadiantConvective:Water Outputs

```

HVAC,Average,Baseboard Convective System Impact Rate[W]
HVAC,Average,Baseboard Heating Rate[W]
HVAC,Average,Baseboard Convective Heating Rate[W]
HVAC,Average,Baseboard Radiant Heating Rate[W]
HVAC,Sum,Baseboard Convective System Impact Energy[J]
HVAC,Sum,Baseboard Heating Energy[J]
HVAC,Sum,Baseboard Convective Heating Energy[J]
HVAC,Sum,Baseboard Radiant Heating Energy[J]
HVAC,Meter,Baseboard:EnergyTransfer [J]
    
```

Baseboard Convective System Impact Rate [W]

This is the actual convective heat addition rate of the baseboard to the zone in Watts. This value includes the heat convected to the zone air from the baseboard unit, the heat radiated to people in the zone from the baseboard unit, and the additional convection from surfaces within the zone that have been heated by radiation from the baseboard unit. This value will be different from (and almost always less than) the next field.

Baseboard Heating Rate [W]

This is the total heat addition rate of the baseboard to the zone it is serving in Watts.

Baseboard Convective Heating Rate [W]

This field reports the rate at which convective heat addition is transferred from the baseboard to the zone in Watts.

Baseboard Radiant Heating Rate [W]

This field reports the rate at which radiant heat addition is transferred from the baseboard to the people and the surfaces within the zone in Watts.

Baseboard Convective System Impact Energy [W]

This is the actual, total convective energy transferred directly and indirectly from the baseboard to the zone it is serving in Joules. Direct convective heat transfer includes the convective portion of the baseboard unit. Indirect convective heat transfer includes heat radiated to people that is then convected to the zone air and heat that is radiated to the surfaces and then convected to the zone air.

Baseboard Heating Energy [J]

This is the total energy of the baseboard to the zone it is serving in Joules over the timestep being reported.

Baseboard Convective Heating Energy [J]

This field reports the amount of convective energy transferred from the baseboard directly to the zone air in Joules.

Baseboard Radiant Heating Energy [J]

This field reports the amount of radiant energy transferred from the baseboard to the zone in Joules.

Baseboard:EnergyTransfer [J]

This meter report variable is the sum of the baseboard heat output from all the baseboards in the HVAC systems in the simulation.

ZoneHVAC:Baseboard:Convective:Water

The hot water baseboard heater is a component of zone equipment. The component is controlled to meet any remaining zone load not met by other equipment in the zone that have higher heating priority. The control is accomplished by throttling the hot water flow. Input resembles that for the simple heating coil: there is an availability schedule, an overall UA, and a maximum hot water mass flow rate. The unit is connected to a hot water loop (demand side) with an inlet and outlet node. Finally, there is the convergence tolerance, which is the tolerance on how closely the baseboard outlet will meet the zone load. Of course, this tolerance is relative to the zone load. The input data dictionary definition of the unit is as follows.

Field: Name

A unique user assigned name for an instance of a hot water baseboard heater unit. Any reference to this unit by another object will use this name.

Field: Available Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the hot water baseboard heater unit can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Inlet Node Name

The name of the hot water inlet node for the baseboard heater.

Field: Outlet Node Name

The name of the hot water outlet node for the baseboard heater.

Field: U-Factor Times Area Value

The overall heat transfer coefficient for the baseboard heater in watts per degree Celsius at design conditions. The U-Factor Times Area Value (UA) is used in an NTU - effectiveness calculation. An estimate of the UA can be obtained from:

$$q = UA \times (T_{water,avg} - T_{air,avg})$$

where q is the heat transferred from water to the air in watts; $T_{water,avg}$ is the average water temperature in degrees C; and $T_{air,avg}$ is the average air temperature in degrees C. Or the LMTD temperature difference can be used.

Field: Maximum Water Flow Rate

The maximum hot water volumetric flow rate in m³/sec.

Field Convergence Tolerance

The control tolerance for the unit heating output. The unit is controlled by matching the unit output to the zone demand. For hot water baseboards, the model must be numerically inverted to obtain a specified output. The convergence tolerance is the error tolerance used to terminate the numerical inversion procedure. Basically this is the fraction:

$$\frac{|(Q_{bb,out} - Q_{ZoneLoad})|}{Q_{ZoneLoad}} \leq ConvergenceTolerance$$

The default is 0.001.

```
ZoneHVAC:Baseboard:Convective:Water,
A1 , \field Name
      \required-field
A2 , \field Availability Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
A3 , \field Inlet Node Name
      \required-field
A4 , \field Outlet Node Name
      \required-field
N1 , \field U-Factor Times Area Value
      \required-field
      \autosizable
      \units W/K
N2 , \field Maximum Water Flow Rate
      \required-field
      \units m3/s
      \autosizable
      \ip-units gal/min
N3 ; \field Convergence Tolerance
      \type real
      \minimum> 0.0
      \default 0.001
```

An example IDF for the hot water convective baseboard is shown below.

```
ZoneHVAC:Baseboard:Convective:Water,
Zone3Baseboard, ! name
FanAndCoilAvailSched, ! on/off schedule
Zone 3 Reheat Water Inlet Node, ! water inlet node
Zone 3 Reheat Water Outlet Node, ! water outlet node
500., ! UA
0.0013, ! maximum water flow rate m3/s
0.001; ! tolerance
```

ZoneHVAC:Baseboard:Convective:Water Outputs

```
HVAC,Average,Baseboard Heating Rate[W]
HVAC,Sum,Baseboard Heating Energy[J]
HVAC,Meter,Baseboard:EnergyTransfer [J]
```

Baseboard Heating Rate[W]

This is the heat addition rate of the convective baseboard to the zone it is serving in Watts.

Baseboard Heating Energy[J]

This is the heat addition of the convective baseboard to the zone it is serving in Joules over the timestep being reported.

Baseboard:EnergyTransfer [J]

This meter report variable is the sum of the baseboard heat output from all the baseboards in the HVAC systems in the simulation.

ZoneHVAC:Baseboard:Convective:Electric

The electric baseboard heater is a component in the zone equipment simulation. The component is controlled to meet any remaining zone load not met by other equipment in the zone that have higher heating priority. The control is accomplished by taking the remaining zone load and dividing by the efficiency of the baseboard. The input data dictionary definition of the unit is as follows.

Field: Name

A unique user assigned name for an instance of a electric baseboard heater unit. Any reference to this unit by another object will use this name.

Field: Available Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the electric baseboard heater unit can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Nominal Capacity

This is the nominal, or maximum capacity, of this electric baseboard unit.

Field: Efficiency

This is the overall electrical efficiency of the electric baseboard. The zone load met by this unit is divided by the electrical efficiency to obtain the total electric energy used.

```
ZoneHVAC:Baseboard:Convective:Electric,
A1 , \field Name
      \required-field
A2 , \field Availability Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
N1 , \field Nominal Capacity
      \required-field
      \units W
      \autosizable
      \ip-units W
N2 ; \field Efficiency
      \required-field
      \maximum 1.0
      \minimum> 0.0
      \default 1.0
```

An example IDF for the electric convective baseboard is shown below.

```
ZoneHVAC:Baseboard:Convective:Electric,
Zone1Baseboard, !- Baseboard Name
FanAndCoilAvailSched, !- Available Schedule
5000, !- Nominal Capacity of the BaseBoard {W}
0.97; !- Efficiency of the BaseBoard
```

ZoneHVAC:Baseboard:Convective:Electric Outputs

```
HVAC,Average,Baseboard Heating Rate[W]
HVAC,Sum,Baseboard Heating Energy[J]
HVAC,Meter,Baseboard:EnergyTransfer [J]
HVAC,Sum,Baseboard Electric Consumption[J]
HVAC,Average,Baseboard Electric Power[W]
```

HVAC, Meter, Heating:Electricity[J]

Baseboard Heating Rate[W]

This is the heat addition rate of the electric convective baseboard to the zone it is serving in Watts.

Baseboard Heating Energy[J]

This is the heat addition of the convective baseboard to the zone it is serving in Joules over the timestep being reported.

Baseboard:EnergyTransfer [J]

This meter report variable is the sum of the baseboard heat output from all the baseboards in the HVAC systems in the simulation regardless of Energy input.

Baseboard Electric Consumption [J]

This is the total electric consumption of the baseboard for the zone it is serving in Joules over the timestep being reported.

Baseboard Electric Power [W]

This is the electric power required by the baseboard to the zone it is serving in Watts.

Heating:Electricity [J]

This meter report variable is the sum of the electric output from all the electric baseboards in the HVAC systems in the simulation.

ZoneHVAC:LowTemperatureRadiant:VariableFlow

This low temperature radiant system (hydronic) is a component of zone equipment that is intended to model any “radiant system” where water is used to supply/remove energy to/from a building surface (wall, ceiling, or floor). The component is controlled to meet any remaining zone load not met by other equipment in the zone that have higher priority. The control is accomplished by throttling the hot or chilled water flow to the unit. This model covers a wide range of low temperature radiant systems: heating and/or cooling, panel or embedded pipes, etc. It is not intended to simulate high temperature electric or gas radiant heaters. Those devices will be handled by a separate model and different input syntax. Low temperature radiant systems that use electric resistance heating should also be defined using separate input syntax (ref: ZoneHVAC:LowTemperatureRadiant:Electric).

Field: Name

This field is an unique user assigned name for an instance of a hydronic low temperature radiant system. Any reference to this unit by another object will use this name.

Field: Availability Schedule Name

This field is the name of the schedule (ref: Schedule) that denotes whether the hydronic low temperature radiant system can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit is available and can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit is not available and must be off for the hour.

Field: Zone Name

This field is the name of the zone (Ref: Zone) in which the hydronic low temperature radiant system is principally located and intended to affect. A system that is between two zones will still act upon each zone; however, the zone name referenced here should be the zone that controls the radiant system response.

Field: Surface Name or Radiant Surface Group Name

This field is the name of the surface (Ref: BuildingSurface) or surface list (Ref: ZoneHVAC:LowTemperatureRadiant:SurfaceGroup) in which the hydronic tubing is embedded/contained. This specification attaches the source or sink from the radiant system to a particular surface and the contribution of the system to the heat balances of that surface. If this field is a surface list, then the source or sink is attached to all of the surfaces in the list with the radiant system surface group defining the breakdown of how flow rate is split between the various surfaces. Only base surfaces (e.g., BuildingSurface:Detailed) are valid. Window/Door surfaces and Internal Mass are not valid surface types for embedded radiant systems.

Field: Hydronic Tubing Inside Diameter

This field is the inside diameter of the tubes through which water is circulated for the system being defined by this statement. The inside diameter should be recorded in meters and is used to determine the convective heat transfer from the water to the inside surface of the hydronic tubing.

Field: Hydronic Tubing Length

This field is the total length of pipe embedded in the surface named above in the surface name field. The length of the tube should be entered in meters and is used to determine the effectiveness of heat transfer from the fluid being circulated through the tubes and the tube/surface. Longer tubing lengths result in more heat will be transferred to/from the radiant surface to the circulating fluid.

Field: Temperature Control Type

This field specifies along with the throttling range and setpoint schedules how the user wishes to control the hydronic radiant system. The temperature denoted in the setpoint schedule can refer to one of five different temperatures: the zone mean air temperature, the zone mean radiant temperature, the zone operative temperature, the outdoor dry-bulb temperature, or the outdoor wet-bulb temperature. The choice of temperature is controlled by the current field—temperature control type. The user must select from the following options:

MeanAirTemperature MeanRadiantTemperature OperativeTemperature OutdoorDryBulbTemperature OutdoorWetBulbTemperature
--

Operative temperature for radiant system controls is the average of Mean Air Temperature and Mean Radiant Temperature. If the user does not select a control type, **MeanAirTemperature** control is assumed by EnergyPlus. See the throttling range and control temperature schedule fields below for more information.

Field: Maximum Hot Water Flow

This field is the maximum flow rate of hot water through the radiant system in m³/sec. The controls for the radiant system will vary the flow rate of hot water through the surface using zero flow and the maximum flow rate specified in this field as the lower and upper bounds, respectively.

Field: Heating Water Inlet Node Name

This field contains the name of the hot water inlet node to the radiant system. Note that this node name must also show up in the branch description when defining the plant demand side network in a manner identical to defining a heating coil.

Field: Heating Water Outlet Node Name

This field contains the name of the hot water outlet node to the radiant system. Note that this node name must also show up in the branch description when defining the plant demand side network in a manner identical to defining a heating coil.

Field: Heating Control Throttling Range

This field specifies the range of temperature in degrees Celsius over which the radiant system throttles from zero flow rate up to the maximum defined by the maximum hot water flow rate field described above. The throttling range parameter is used in conjunction with the control temperature to define the response of the system to various zone conditions. The heating control temperature schedule specifies the “setpoint” temperature where the flow rate to the system is at half of the maximum flow rate. For example, if the heating control temperature setpoint is currently 15°C and the heating throttling range is 2°C, the water flow rate to the radiant system will be zero when the controlling temperature (MAT, MRT, Operative Temperature, ODB, or OWB; see control type field above) is at or above 16°C and the maximum flow rate when the controlling temperature is at or below 14°C. This represents a throttling range of 2°C around the setpoint of 15°C. In between 14°C and 16°C, the flow rate to the radiant system is varied linearly.

Field: Heating Control Temperature Schedule Name

This field specifies the heating setpoint or control temperature for the radiant system in degrees Celsius. Used in conjunction with the previous field (heating control throttling range), it will define whether or not the system is running and the current flow rate. Water flow rate to the system is varied linearly around the setpoint temperature based on the throttling range and the maximum heating flow rate parameters (see above). It should be noted that this control schedule will allow different setpoint temperatures throughout the year for heating. In addition, this schedule may be different than the thermostatic control schedule defined for overall operation of components serving the zone in which the radiant system is located. The thermostatic control determines whether or not there is a heating or cooling load in the space and thus whether the systems should be operating. This field simply controls the flow rate to the radiant system.

Field: Maximum Cold Water Flow

This field is the maximum flow rate of cold water through the radiant system in m³/sec. The controls for the radiant system will vary the flow rate of cold water through the surface using zero flow and the maximum flow rate specified in this field as the lower and upper bounds, respectively. Note that this field is optional and not required for a heating only system.

Field: Cooling Water Inlet Node Name

This field contains the name of the cold water inlet node to the radiant system. Note that this node name must also show up in the branch description when defining the plant demand side network in a manner identical to defining a cooling coil. As with the maximum cold water flow rate, this field is optional and not required for a heating only system.

Field: Cooling Water Outlet Node Name

This field contains the name of the cold water outlet node to the radiant system. Note that this node name must also show up in the branch description when defining the plant demand side network in a manner identical to defining a cooling coil. As with the maximum cold water flow rate, this field is optional and not required for a heating only system.

Field: Cooling Control Throttling Range

This field specifies the range of temperature in degrees Celsius over which the radiant system throttles from zero flow rate up to the maximum defined by the maximum cold water flow rate field described above. The throttling range parameter is used in conjunction with the control temperature to define the response of the system to various zone conditions. The

cooling control temperature schedule specifies the “setpoint” temperature where the flow rate to the system is at half of the maximum flow rate. For example, if the cooling control temperature setpoint is currently 25°C and the cooling throttling range is 2°C, the water flow rate to the radiant system will be zero when the controlling temperature (MAT, MRT, Operative Temperature, ODB, or OWB; see control type field above) is at or below 24°C and the maximum flow rate when the controlling temperature is at or above 26°C. This represents a throttling range of 2°C around the setpoint of 25°C. In between 24°C and 26°C, the flow rate to the radiant system is varied linearly.

Field: Cooling Control Temperature Schedule Name

This field specifies the cooling setpoint or control temperature for the radiant system in degrees Celsius. Used in conjunction with the previous field (cooling control throttling range), it will define whether or not the system is running and the current flow rate. Water flow rate to the system is varied linearly around the setpoint temperature based on the throttling range and the maximum cooling flow rate parameters (see above). It should be noted that this control schedule will allow different setpoint temperatures throughout the year for cooling. In addition, this schedule may be different that the thermostatic control schedule defined for overall operation of components serving the zone in which the radiant system is located. The thermostatic control determines whether or not there is a heating or cooling load in the space and thus whether the systems should be operating. This field simply controls the flow rate to the radiant system.

Field: Condensation Control Type

When radiant systems do cooling, there is the possibility that condensation will occur on the surface that is being cooled. This is due to the fact that the surface temperature may drop below the dew-point temperature of the space. When this occurs, condensation on the surface will occur. In EnergyPlus, users have several options for handling this situation including: Off, SimpleOff, VariableOff. When the user chooses the Off option, EnergyPlus will not do anything other than produce a warning message when condensation is predicted to occur. The program will simply continue on; no moisture will be removed from the zone air and there will be no adjustment of the surface temperature as a result of the condensation. When the user chooses the SimpleOff option, the program will predict cases where condensation will occur and shut-off the radiant system to avoid this situation. With this option, the users also have the opportunity to adjust when the system will shut down. This is specified with the next parameter (field: condensation differential parameter). Finally, when the user selects the VariableOff option, the variable flow radiant system will decrease the flow to the radiant system as much as possible to try to avoid condensation. If necessary, the radiant system will shut off flow completely. This parameter is optional and EnergyPlus will use the SimpleOff strategy when this parameter is not specified.

Field: Condensation Control Dewpoint Offset

This optional parameter is only valid with the SimpleOff condensation handling algorithm (see previous input parameter). It establishes the difference between the calculated dew-point temperature of the space and the allowed surface temperature to which the surface can drop before the radiant system shuts down in degrees Celsius. This parameter can be any positive, negative, or zero value. When this parameter is zero, the radiant system will shut down when the surface temperature drops to the dew-point temperature or below. When this parameter is positive, the radiant system will shut down when the surface is the number of degrees Celsius above the dew-point temperature. This allows some extra safety to avoid condensation. When this parameter is negative, the radiant system will shut down when the surface temperature is the number of degrees Celsius below the dew-point temperature. While not recommended, this strategy allows the user to simulate a situation where small amounts of condensation are tolerable.

The input data dictionary for the object follows:

```

ZoneHVAC:LowTemperatureRadiant:VariableFlow,
A1 , \field Name
    \required-field
A2 , \field Availability Schedule Name
    \type object-list
    \object-list ScheduleNames
A3 , \field Zone Name
    \note Name of zone system is serving
    \type object-list
    \object-list ZoneNames
A4 , \field Surface Name or Radiant Surface Group Name
    \note Identifies surfaces that radiant system is embedded in.
    \note For a system with multiple surfaces, enter the name of
    \note a ZoneHVAC:LowTemperatureRadiant:SurfaceGroup object.
    \type object-list
    \object-list RadGroupAndSurfNames
N1 , \field Hydronic Tubing Inside Diameter
    \units m
    \minimum> 0
    \default 0.013
    \ip-units in
N2 , \field Hydronic Tubing Length
    \note (total length of pipe embedded in surface)
    \units m
    \minimum> 0
    \autosizable
A5 , \field Temperature Control Type
    \note (Temperature on which unit is controlled)
    \type choice
    \key MeanAirTemperature
    \key MeanRadiantTemperature
    \key OperativeTemperature
    \key OutdoorDryBulbTemperature
    \key OutdoorWetBulbTemperature
    \default MeanAirTemperature
N3 , \field Maximum Hot Water Flow
    \units m3/s
    \minimum 0
    \autosizable
    \ip-units gal/min
A6 , \field Heating Water Inlet Node Name
A7 , \field Heating Water Outlet Node Name
N4 , \field Heating Control Throttling Range
    \units deltaC
    \minimum 0
    \default 0
A8 , \field Heating Control Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
N5 , \field Maximum Cold Water Flow
    \units m3/s
    \minimum 0
    \autosizable
    \ip-units gal/min
A9 , \field Cooling Water Inlet Node Name
A10, \field Cooling Water Outlet Node Name
N6 , \field Cooling Control Throttling Range
    \units deltaC
    \minimum 0
    \default 0
A11, \field Cooling Control Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
A12, \field Condensation Control Type
    \type choice
    \key OFF
    \key SimpleOff
    \key VariableOff
    \default SimpleOff
N7 ; \field Condensation Control Dewpoint Offset
    \units C

```



```
\default 1.0
```

An example IDF with a hydronic low temperature radiant system is shown below.

```
ZoneHVAC:LowTemperatureRadiant:VariableFlow,
  Resistive Zone Radiant Floor, ! name of hydronic low temperature radiant system
  RadiantSysAvailSched,       ! availability schedule
  Resistive Zone,             ! Zone name (name of zone system is serving)
  Zn001:Flr001,              ! Surface name (name of surface system is embedded in)
  0.012,                      ! Hydronic tubing inside diameter in meters
  400.0,                      ! Hydronic tubing length (total length of pipe embedded in surf) in meters
  MeanAirTemperature,        ! control type (control on mean air temperature)
  0.00008,                    ! maximum hot water flow in m3/s
  Resistive Zone Radiant Water Inlet Node, ! heating water inlet node
  Resistive Zone Radiant Water Outlet Node, ! heating water outlet node
  2.0,                        ! heating throttling range in degrees Celsius
  Radiant Heating Setpoints,  ! heating setpoint temperature schedule
  0.0012,                     ! maximum cold water flow in m3/s
  Zone 1 Cooling Water Inlet Node, ! cooling water inlet node
  Zone 1 Cooling Water Outlet Node, ! cooling water outlet node
  2.0,                        ! cooling throttling range in degrees Celsius
  Radiant Cooling Setpoints,  ! cooling setpoint temperature schedule
  SimpleOff,                  ! condensation control type
  0.5;                        ! condensation control dewpoint offset
```

ZoneHVAC:LowTemperatureRadiant:VariableFlow Outputs

```
HVAC,Average,Hydronic Low Temp Radiant Heating Rate[W]
HVAC,Sum,Hydronic Low Temp Radiant Heating Energy[J]
HVAC,Average,Hydronic Low Temp Radiant Cooling Rate[W]
HVAC,Sum,Hydronic Low Temp Radiant Cooling Energy[J]
HVAC,Average,Hydronic Low Temp Radiant Water Mass Flow[kg/s]
HVAC,Average,Hydronic Low Temp Radiant Water Inlet Temp[C]
HVAC,Average,Hydronic Low Temp Radiant Water Outlet Temp[C]
HVAC,Sum,Hydronic Low Temp Radiant Time Condensation Occurring[s]
```

Hydronic Low Temp Radiant Heating Rate[W]

This field reports the heating input rate to the low temperature radiant system in Watts. This is the heat source to the surface that is defined as the radiant system. The heating rate is determined by the zone conditions and the control scheme defined in the user input.

Hydronic Low Temp Radiant Heating Energy[J]

This field reports the heating input to the low temperature radiant system in Joules. This is the heat source to the surface that is defined as the radiant system. The heating rate is determined by the zone conditions, the control scheme defined in the user input, and the timestep.

Hydronic Low Temp Radiant Cooling Rate[W]

This field reports the cooling input rate to the low temperature radiant system in Watts. This is the heat sink to the surface that is defined as the radiant system. The cooling rate is determined by the zone conditions and the control scheme defined in the user input.

Hydronic Low Temp Radiant Cooling Energy[J]

This field reports the cooling input to the low temperature radiant system in Joules. This is the heat sink to the surface that is defined as the radiant system. The cooling rate is determined by the zone conditions, the control scheme defined in the user input, and the timestep.

Hydronic Low Temp Radiant Water Mass Flow Rate[kg/s]

This field reports the mass flow rate of water through the low temperature radiant system in kilograms per second.

Hydronic Low Temp Radiant Water Inlet Temp[C]

This field reports the temperature of water entering the low temperature radiant system in Celsius.

Hydronic Low Temp Radiant Water Outlet Temp[C]

This field reports the temperature of water leaving the low temperature radiant system in Celsius.

Hydronic Low Temp Radiant Time Condensation Occurring[s]

This field reports the amount of time when condensation is occurring. When using the Off condensation control, this simply reports the amount of time when condensation occurs. When using the SimpleOff condensation control, this indicates the amount of time when the system has been shut off because of the potential danger of condensation.

ZoneHVAC:LowTemperatureRadiant:ConstantFlow

This low temperature radiant system (hydronic) is a component of zone equipment that is intended to model any “radiant system” where water is used to supply/remove energy to/from a building surface (wall, ceiling, or floor). The component is controlled to meet any remaining zone load not met by other equipment in the zone that have higher priority. The constant flow system differs from the hydronic system describe above in what it controls. The hydronic system varies the flow rate through the radiant system based on some control temperature. The constant flow system keeps flow rate constant via a local circulation pump and varies the water temperature that is sent to the radiant system. This is accomplished with a mixing valve that is controlled by a sensor. This model covers a wide range of low temperature radiant systems: heating and/or cooling, panel or embedded pipes, etc. It is not intended to simulate high temperature electric or gas radiant heaters. Those devices will be handled by a separate model and different input syntax. Low temperature radiant systems that use electric resistance heating should also be defined using separate input syntax (ref: ZoneHVAC:LowTemperatureRadiant:Electric). Low temperature radiant systems that vary the flow rate through the radiant system should also be defined using separate input syntax (ref: ZoneHVAC:LowTemperatureRadiant:VariableFlow)

One of the other differences between this model and the variable flow hydronic radiant system is that the constant flow radiant system has a built-in local secondary loop. It will recirculate flow coming out of the system and mix this with flow from the loop to arrive at the desired inlet temperature to the radiant system (note that this model has the temperature sensor AFTER the pump to insure proper inlet temperature to the radiant system). The local loop also contains a pump which is assumed to be upstream of the radiant system and after the mixing valve. So, the local loop can have some recirculation. The flow from the main loop may also bypass the radiant system if more than enough flow is available and the main loop is also a constant flow system.

Field: Name

This field is an unique user assigned name for an instance of a constant flow low temperature radiant system. Any reference to this unit by another object will use this name.

Field: Availability Schedule Name

This field is the name of the schedule (ref: Schedule) that denotes whether the constant flow low temperature radiant system can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit is available and can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit is not available and must be off for the hour.

Field: Zone Name

This field is the name of the zone (Ref: Zone) in which the constant flow low temperature radiant system is principally located and intended to affect. A system that is between two zones will still act upon each zone; however, the zone name referenced here should be the zone that controls the radiant system response.

Field: Surface Name or Radiant Surface Group Name

This field is the name of the surface (Ref: BuildingSurface:Detailed) or surface list (Ref: ZoneHVAC:LowTemperatureRadiant:SurfaceGroup) in which the hydronic tubing is embedded/contained. This specification attaches the source or sink from the radiant system to a particular surface and the contribution of the system to the heat balances of that surface. If this field is a surface list, then the source or sink is attached to all of the surfaces in the list with the radiant system surface group defining the breakdown of how flow rate is split between the various surfaces. Only base surfaces (BuildingSurface:Detailed) are valid. Window/Door surfaces and Internal Mass are not valid surface types for embedded radiant systems.

Field: Hydronic Tubing Inside Diameter

This field is the inside diameter of the tubes through which water is circulated for the system being defined by this statement. The inside diameter should be recorded in meters and is used to determine the convective heat transfer from the water to the inside surface of the hydronic tubing.

Field: Hydronic Tubing Length

This field is the total length of pipe embedded in the surface named above in the surface name field. The length of the tube should be entered in meters and is used to determine the effectiveness of heat transfer from the fluid being circulated through the tubes and the tube/surface. Longer tubing lengths result in more heat being transferred to/from the radiant surface to the circulating fluid.

Field: Temperature Control Type

This field specifies along with setpoint (control) and water schedules how the user wishes to control the constant flow radiant system. The temperature denoted in the setpoint schedule can refer to one of five different temperatures: the zone mean air temperature, the zone mean radiant temperature, the zone operative temperature, the outdoor dry-bulb temperature, or the outdoor wet-bulb temperature. The choice of temperature is controlled by the current field—temperature control type. The user must select from the following options:

MeanAirTemperature MeanRadiantTemperature OperativeTemperature OutdoorDryBulbTemperature OutdoorWetBulbTemperature
--

Operative temperature for radiant system controls is the average of Mean Air Temperature and Mean Radiant Temperature. If the user does not select a control type, **MeanAirTemperature** control is assumed by EnergyPlus. See the throttling range and control temperature schedule fields below for more information.

Field: Rated Flow Rate

This field is the maximum flow rate of water through the radiant system in m³/sec. This flow rate is held constant by the local component pump, but the user has the option of varying this flow rate via a schedule (see next input field). The constant flow system will accept this flow rate and control the inlet temperature based on the control and water temperature schedules defined below.

Field: Pump Flow Rate Schedule Name

This field modifies the maximum flow rate of water through the radiant system in m³/sec. This input is “optional”. If the user does not enter a schedule, the flow rate through the radiant system is assumed to be constant during all hours that it is operating based on the value entered in the previous input field. Note that the values for this schedule must be between zero and one.

Field: Rated Pump Head

This numeric field contains the pump’s rated head in Pascals.

Field: Rated Power Consumption

This numeric field contains the pump’s rated power consumption in Watts.

Field: Motor Efficiency

This numeric field contains the pump’s efficiency in decimal form (0 = 0%, 1 = 100%).

Field: Fraction of Motor Inefficiencies to Fluid Stream

This numeric field contains the pump’s fraction of power loss to the fluid.

Field: Heating Water Inlet Node Name

This field contains the name of the hot water inlet node to the radiant system. Note that this node name must also show up in the branch description when defining the plant demand side network in a manner identical to defining a heating coil.

Field: Heating Water Outlet Node Name

This field contains the name of the hot water outlet node to the radiant system. Note that this node name must also show up in the branch description when defining the plant demand side network in a manner identical to defining a heating coil.

Field: Heating High Water Temperature Schedule Name

This field specifies the high water temperature in degrees Celsius for the temperature control of a constant flow radiant heating system. Water and control temperatures for heating work together to provide a linear function that determines the water temperature sent to the radiant system. The current control temperature (see Temperature Control Type above) is compared to the high and low control temperatures at the current time. If the control temperature is above the high temperature, then the inlet water temperature is set to the low water temperature. If the control temperature is below the low temperature, then the inlet water temperature is set to the high water temperature. If the control temperature is between the high and low value, then the inlet water temperature is linearly interpolated between the low and high water temperature values.

Field: Heating Low Water Temperature Schedule Name

This field specifies the low water temperature in degrees Celsius for the temperature control of a constant flow heating radiant system. For more information on its interpretation, see Heating High Water Temperature Schedule above.

Field: Heating High Control Temperature Schedule Name

This field specifies the high control temperature in degrees Celsius for the temperature control of a constant flow heating radiant system. For more information on its interpretation, see Heating High Water Temperature Schedule above.

Field: Heating Low Control Temperature Schedule Name

This field specifies the low control temperature in degrees Celsius for the temperature control of a constant flow heating radiant system. For more information on its interpretation, see Heating High Water Temperature Schedule above.

Field: Cooling Water Inlet Node Name

This field contains the name of the cold water inlet node to the radiant system. Note that this node name must also show up in the branch description when defining the plant demand side network in a manner identical to defining a cooling coil. As with the maximum cold water flow rate, this field is optional and not required for a heating only system.

Field: Cooling Water Outlet Node Name

This field contains the name of the cold water outlet node to the radiant system. Note that this node name must also show up in the branch description when defining the plant demand side network in a manner identical to defining a cooling coil. As with the maximum cold water flow rate, this field is optional and not required for a heating only system.

Field: Cooling High Water Temperature Schedule Name

This field specifies the high water temperature in degrees Celsius for the temperature control of a constant flow radiant cooling system. Water and control temperatures for heating work together to provide a linear function that determines the water temperature sent to the radiant system. The current control temperature (see Temperature Control Type above) is compared to the high and low control temperatures at the current time. If the control temperature is above the high temperature, then the inlet water temperature is set to the low water temperature. If the control temperature is below the low temperature, then the inlet water temperature is set to the high water temperature. If the control temperature is between the high and low value, then the inlet water temperature is linearly interpolated between the low and high water temperature values.

Field: Cooling Low Water Temperature Schedule Name

This field specifies the low water temperature in degrees Celsius for the temperature control of a constant flow cooling radiant system. For more information on its interpretation, see Cooling High Water Temperature Schedule above.

Field: Cooling High Control Temperature Schedule Name

This field specifies the high control temperature in degrees Celsius for the temperature control of a constant flow cooling radiant system. For more information on its interpretation, see Cooling High Water Temperature Schedule above.

Field: Cooling Low Control Temperature Schedule Name

This field specifies the low control temperature in degrees Celsius for the temperature control of a constant flow cooling radiant system. For more information on its interpretation, see Cooling High Water Temperature Schedule above.

Field: Condensation Control Type

When radiant systems do cooling, there is the possibility that condensation will occur on the surface that is being cooled. This is due to the fact that the surface temperature may drop below the dew-point temperature of the space. When this occurs, condensation on the surface will occur. In EnergyPlus, users have several options for handling this situation including: Off, SimpleOff, VariableOff. When the user chooses the Off option, EnergyPlus will not do anything other than produce a warning message when condensation is predicted to occur. The program will simply continue on; no moisture will be removed from the zone air and there will be no adjustment of the surface temperature as a result of the condensation. When the user chooses the SimpleOff option, the program will predict cases where condensation will occur and shut-off the radiant system to avoid this situation. With this

option, the users also have the opportunity to adjust when the system will shut down. This is specified with the next parameter (field: condensation differential parameter). Finally, when the user selects the VariableOff option, the variable flow radiant system will decrease the flow to the radiant system as much as possible to try to avoid condensation. If necessary, the radiant system will shut off flow completely. This parameter is optional and EnergyPlus will use the SimpleOff strategy when this parameter is not specified.

Field: Condensation Control Dewpoint Offset

This optional parameter is only valid with the SimpleOff condensation handling algorithm (see previous input parameter). It establishes the difference between the calculated dew-point temperature of the space and the allowed surface temperature to which the surface can drop before the radiant system shuts down in degrees Celsius. This parameter can be any positive, negative, or zero value. When this parameter is zero, the radiant system will shut down when the surface temperature drops to the dew-point temperature or below. When this parameter is positive, the radiant system will shut down when the surface is the number of degrees Celsius above the dew-point temperature. This allows some extra safety to avoid condensation. When this parameter is negative, the radiant system will shut down when the surface temperature is the number of degrees Celsius below the dew-point temperature. While not recommended, this strategy allows the user to simulate a situation where small amounts of condensation are tolerable.

The input data dictionary definition the object follows.

```

ZoneHVAC:LowTemperatureRadiant:ConstantFlow,
  A1 , \field Name
        \required-field
  A2 , \field Availability Schedule Name
        \type object-list
        \object-list ScheduleNames
  A3 , \field Zone Name
        \note Name of zone system is serving
        \type object-list
        \object-list ZoneNames
  A4 , \field Surface Name or Radiant Surface Group Name
        \note Identifies surfaces that radiant system is embedded in.
        \note For a system with multiple surfaces, enter the name of
        \note a ZoneHVAC:LowTemperatureRadiant:SurfaceGroup object.
        \type object-list
        \object-list RadGroupAndSurfNames
  N1 , \field Hydronic Tubing Inside Diameter
        \units m
        \minimum> 0
        \default 0.013
  N2 , \field Hydronic Tubing Length
        \note Total length of pipe embedded in surface
        \units m
        \minimum> 0
  A5 , \field Temperature Control Type
        \note Temperature used to control system
        \type choice
        \key MeanAirTemperature
        \key MeanRadiantTemperature
        \key OperativeTemperature
        \key OutdoorDryBulbTemperature
        \key OutdoorWetBulbTemperature
        \default MeanAirTemperature
  N3 , \field Rated Flow Rate
        \units m3/s

```

```

A6 , \field Pump Flow Rate Schedule Name
    \note Modifies the Rated Flow Rate of the pump on a time basis
    \note the default is that the pump is ON and runs according to its other
    \note operational requirements specified above. The schedule is for special
    \note pump operations.
    \type object-list
    \object-list ScheduleNames
N4 , \field Rated Pump Head
    \units Pa
    \default 179352
    \note default head is 60 feet
N5 , \field Rated Power Consumption
    \units W
N6 , \field Motor Efficiency
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0.9
N7 , \field Fraction of Motor Inefficiencies to Fluid Stream
    \minimum 0.0
    \maximum 1.0
    \default 0.0
A7 , \field Heating Water Inlet Node Name
A8 , \field Heating Water Outlet Node Name
A9 , \field Heating High Water Temperature Schedule Name
    \note Water and control temperatures for heating work together to provide
    \note a linear function that determines the water temperature sent to the
    \note radiant system. The current control temperature (see Temperature Control Type above) is
    \note compared to the high and low control temperatures at the current time.
    \note If the control temperature is above the high temperature, then the
    \note inlet water temperature is set to the low water temperature. If the
    \note control temperature is below the low temperature, then the inlet
    \note water temperature is set to the high water temperature. If the control
    \note temperature is between the high and low value, then the inlet water
    \note temperature is linearly interpolated between the low and high water
    \note temperature values.
    \type object-list
    \object-list ScheduleNames
A10, \field Heating Low Water Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
A11, \field Heating High Control Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
A12, \field Heating Low Control Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
A13, \field Cooling Water Inlet Node Name
A14, \field Cooling Water Outlet Node Name
A15, \field Cooling High Water Temperature Schedule Name
    \note See note for Heating High Water Temperature Schedule above for
    \note interpretation information (or see the Input/Output Reference).
    \type object-list
    \object-list ScheduleNames
A16, \field Cooling Low Water Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
A17, \field Cooling High Control Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
A18, \field Cooling Low Control Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
A19, \field Condensation Control Type
    \type choice
    \key Off
    \key SimpleOff
    \key VariableOff
    \default SimpleOff

```

```
N8 ; \field Condensation Control Dewpoint Offset
      \units C
      \default 1.0
```

An example IDF with a constant flow low temperature radiant system is shown below.

```
ZoneHVAC:LowTemperatureRadiant:ConstantFlow,
  Resistive Zone Radiant Floor, !- name of CONSTANT FLOW low temperature radiant system
  RadiantSysAvailSched, !- availability schedule
  Resistive Zone, !- Zone name
  Zn001:Flr001, !- Surface name or group
  0.012, !- Hydronic tubing inside diameter {m}
  400.0, !- Hydronic tubing length {m}
  MeanAirTemperature, !- temperature control type
  0.0004, !- maximum water volumetric flow rate {m3/s}
  , !-schedule for flow rate (optional, non-existent means constant)
  30000, !-Rated Pump Head in Pa
  50, !-Rated Power Consumption in W
  0.87, !-Motor Efficiency
  0.1, !-Fraction of Motor Inefficiencies to Fluid Stream
  Resistive Zone Radiant Water Inlet Node, !- heating water inlet node
  Resistive Zone Radiant Water Outlet Node, !- heating water outlet node
  RadHeatHighWaterTemp, !-high water temperature schedule
  RadHeatLowWaterTemp, !-low water temperature schedule
  RadHeatHighControlTemp, !-high control temperature schedule
  RadHeatLowControlTemp, !-low control temperature schedule
  Zone 1 Cooling Water Inlet Node, !- cooling water inlet node
  Zone 1 Cooling Water Outlet Node, !- cooling water outlet node
  RadCoolHighWaterTemp, !-cooling high water temperature schedule
  RadCoolLowWaterTemp, !-cooling low water temperature schedule
  RadCoolHighControlTemp, !- cooling high control temperature schedule
  RadCoolLowControlTemp, !- cooling low control temperature schedule
  SimpleOff, !- condensation control type
  0.5; !- condensation control dewpoint offset
```

ZoneHVAC:LowTemperatureRadiant:ConstantFlow Outputs

```
HVAC,Average,Constant Flow Low Temp Radiant Heating Rate[W]
HVAC,Sum,Constant Flow Low Temp Radiant Heating Energy[J]
HVAC,Average,Constant Flow Low Temp Radiant Cooling Rate[W]
HVAC,Sum,Constant Flow Low Temp Radiant Cooling Energy[J]
HVAC,Average,Constant Flow Low Temp Radiant Mass Flow[kg/s]
HVAC,Average,Constant Flow Low Temp Radiant Injection Mass Flow[kg/s]
HVAC,Average,Constant Flow Low Temp Radiant Recirculation Mass Flow[kg/s]
HVAC,Average,Constant Flow Low Temp Radiant Water Inlet Temp[C]
HVAC,Average,Constant Flow Low Temp Radiant Water Outlet Temp[C]
HVAC,Average,Constant Flow Low Temp Radiant Pump Water Inlet Temp[C]
HVAC,Average,Constant Flow Low Temp Radiant Pump Electric Power[W]
HVAC,Sum,Constant Flow Low Temp Radiant Pump Electric Consumption[J]
HVAC,Average,Constant Flow Low Temp Radiant Pump Water Mass Flow[kg/s]
HVAC,Average,Constant Flow Low Temp Radiant Pump Heat To Fluid[W]
HVAC,Sum,Constant Flow Low Temp Radiant Pump Heat To Fluid Energy[J]
HVAC,Sum,Constant Flow Low Temp Radiant Time Condensation Occurring[s]
```

Constant Flow Low Temp Radiant Heating Rate[W]

This field reports the heating input rate to the low temperature radiant system in Watts. This is the heat source to the surface that is defined as the radiant system. The heating rate is determined by the zone conditions and the control scheme defined in the user input.

Constant Flow Low Temp Radiant Heating Energy[J]

This field reports the heating input to the low temperature radiant system in Joules. This is the heat source to the surface that is defined as the radiant system. The heating rate is determined by the zone conditions, the control scheme defined in the user input, and the timestep.

Constant Flow Low Temp Radiant Cooling Rate[W]

This field reports the cooling input rate to the low temperature radiant system in Watts. This is the heat sink to the surface that is defined as the radiant system. The cooling rate is determined by the zone conditions and the control scheme defined in the user input.

Constant Flow Low Temp Radiant Cooling Energy[J]

This field reports the cooling input to the low temperature radiant system in Joules. This is the heat sink to the surface that is defined as the radiant system. The cooling rate is determined by the zone conditions, the control scheme defined in the user input, and the timestep.

Constant Flow Low Temp Radiant Water Mass Flow Rate[kg/s]

This field reports the mass flow rate of water through the low temperature radiant system in kilograms per second. This should be identical to the pump flow rate for the system.

Constant Flow Low Temp Radiant Injection Mass Flow Rate[kg/s]

This field reports the mass flow rate of water that is injected into the radiant system from the main loop. A valve will control the injection and recirculation mass flow rates (see next field) to match the temperature controls specified by the user and dictated by the current simulation conditions.

Constant Flow Low Temp Radiant Recirculation Mass Flow Rate[kg/s]

This field reports the mass flow rate of water that is recirculated from the radiant system outlet and mixed with the injection flow from the main loop. A valve will control the injection and recirculation mass flow rates (see next field) to match the temperature controls specified by the user and dictated by the current simulation conditions.

Constant Flow Low Temp Radiant Water Inlet Temp[C]

This field reports the temperature of water entering the low temperature radiant system in Celsius. This may differ from the inlet node temperature for the component since this component has its own local secondary loop.

Constant Flow Low Temp Radiant Water Outlet Temp[C]

This field reports the temperature of water leaving the low temperature radiant system in Celsius. This may differ from the outlet node temperature for the component since this component has its own local secondary loop.

Constant Flow Low Temp Pump Water Inlet Temp[C]

This field reports the temperature of water entering the low temperature radiant system pump in Celsius. This may differ from the inlet node temperature for the component since this component has its own local secondary loop. It is assumed that the pump is upstream of the radiant system.

Constant Flow Low Temp Pump Electric Power[W]

This field reports the rate of electric power consumption for the pump which supplies flow to the constant flow radiant system in Watts.

Constant Flow Low Temp Pump Electric Consumption[J]

This field reports the electric power consumption for the pump which supplies flow to the constant flow radiant system in Joules.

Constant Flow Low Temp Radiant Pump Water Mass Flow[kg/s]

This field reports the mass flow rate of water through the low temperature radiant system pump in kilograms per second. This should be identical to the flow rate for the system.

Constant Flow Low Temp Pump Heat to Fluid[W]

This field reports the rate at which heat is added to the fluid stream as it passes through the pump in Watts. This heat is reflected in the radiant system inlet temperature which will be different from the pump inlet temperature if this field has a non-zero value.

Constant Flow Low Temp Pump Heat to Fluid Energy[J]

This field reports the amount of heat energy added to the fluid stream as it passes through the pump in Joules. This heat is reflected in the radiant system inlet temperature which will be different from the pump inlet temperature if this field has a non-zero value.

Constant Flow Low Temp Radiant Time Condensation Occurring[s]

This field reports the amount of time when condensation is occurring. When using the Off condensation control, this simply reports the amount of time when condensation occurs. When using the SimpleOff condensation control, this indicates the amount of time when the system has been shut off because of the potential danger of condensation.

ZoneHVAC:LowTemperatureRadiant:Electric

This low temperature radiant system (electric) is a component of zone equipment that is intended to model any “radiant system” where electric resistance heating is used to supply energy (heat) to a building surface (wall, ceiling, or floor). The component is controlled to meet any remaining zone heating load not met by other equipment in the zone that have higher heating priority. The control is accomplished by varying the electrical power supplied to the unit. This model covers either a radiant panel system or wires embedded in entire walls, floors, or ceilings. It is not intended to simulate high temperature electric or gas radiant heaters. Those devices will be handled by a separate model and different input syntax. Low temperature radiant systems that use water flowing through tubes to provide heat to the system should also be defined using separate input syntax (ref: Low Temp Radiant System:Hydronic).

Field: Name

This field is a unique user assigned name for an instance of an electric low temperature radiant system. Any reference to this unit by another object will use this name.

Field: Availability Schedule Name

This field is the name of the schedule (ref: Schedule) that denotes whether the electric low temperature radiant system can operate during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit is available and can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit is not available and must be off for the hour.

Field: Zone Name

This field is the name of the zone (Ref: Zone) in which the electric low temperature radiant system is principally located and intended to affect. A system that is between two zones will still act upon each zone; however, the zone name referenced here should be the zone that controls the radiant system response.

Field: Surface Name or Radiant Surface Group Name

This field is the name of the surface (Ref: BuildingSurface) or surface list (Ref: ZoneHVAC:LowTemperatureRadiant:SurfaceGroup) in which the hydronic tubing is embedded/contained. This specification attaches the source or sink from the radiant system to a particular surface and the contribution of the system to the heat balances of that surface. If this field is a surface list, then the source or sink is attached to all of the surfaces in the list with the radiant system surface group defining the breakdown of how flow rate is split between the various surfaces. Only base surfaces (e.g. BuildingSurface:Detailed) are valid.

Window/Door surfaces and Internal Mass are not valid surface types for embedded radiant systems.

Field: Maximum Electrical Power to Panel

This field is the maximum amount of electrical energy that can be converted to heat in this particular radiant system in Watts. The controls for the radiant system will vary the amount of power supplied to the surface between zero input and the maximum power specified in this field as the lower and upper bounds, respectively.

Field: Temperature Control Type

This field specifies along with the throttling range and setpoint schedules how the user wishes to control the low temperature electric radiant system. The temperature denoted in the setpoint schedule can refer to one of three different temperatures: the zone mean air temperature, the zone mean radiant temperature, the zone operative temperature, the outdoor dry-bulb temperature, or the outdoor wet-bulb temperature. The choice of temperature is controlled by the current field—temperature control type. The user must select from the following options:

MeanAirTemperature MeanRadiantTemperature OperativeTemperature OutdoorDryBulbTemperature OutdoorWetBulbTemperature
--

Operative temperature for radiant system controls is the average of Mean Air Temperature and Mean Radiant Temperature. If the user does not select a control type, **MeanAirTemperature** control is assumed by EnergyPlus. See the throttling range and control temperature schedule fields below for more information.

Field: Heating Throttling Range

This field specifies the range of temperature in degrees Celsius over which the radiant system throttles from zero heat input via the electric resistance wires up to the maximum defined by the maximum electrical power field described above. The throttling range parameter is used in conjunction with the control temperature (see below) to define the response of the system to various zone conditions. The heating control temperature schedule specifies the “setpoint” temperature where the power input to the system is at half of the maximum power input. For example, if the heating control temperature setpoint is currently 15°C and the heating throttling range is 2°C, the electrical power supplied to the radiant system will be zero when the controlling temperature (MAT, MRT, Operative Temperature, ODB, or OWB; see control type field above) is at or above 16°C and the maximum power input when the controlling temperature is at or below 14°C. This represents a throttling range of 2°C around the setpoint of 15°C. In between 14°C and 16°C, the power input to the radiant system is varied linearly.

Field: Heating Setpoint Temperature Schedule Name

This field specifies the heating setpoint or control temperature for the radiant system in degrees Celsius. Used in conjunction with the previous field (heating throttling range), it will define whether or not the system is running and the current power input to the radiant surface. Power input to the system is varied linearly around the setpoint temperature based on the throttling range and the maximum electrical power parameters (see above). It should be noted that this control schedule will allow different setpoint temperatures throughout the year for heating. In addition, this schedule may be different that the thermostatic control schedule defined for overall operation of components serving the zone in which the radiant system is located. The thermostatic control determines whether or not there is a heating or cooling load in the space and thus whether the systems should be operating. This field simply controls the flow rate to the radiant system.

The input data dictionary definition the object follows.

```

ZoneHVAC:LowTemperatureRadiant:Electric,
  \memo Electric resistance low temperature radiant system
A1 , \field Name
  \required-field
A2 , \field Availability Schedule Name
  \type object-list
  \object-list ScheduleNames
A3 , \field Zone Name
  \note Name of zone system is serving
  \type object-list
  \object-list ZoneNames
A4 , \field Surface Name or Radiant Surface Group Name
  \note Identifies surfaces that radiant system is embedded in.
  \note For a system with multiple surfaces, enter the name of
  \note a ZoneHVAC:LowTemperatureRadiant:SurfaceGroup object.
  \type object-list
  \object-list RadGroupAndSurfNames
N1 , \field Maximum Electrical Power to Panel
  \units W
  \minimum 0
  \autosizable
  \ip-units W
A5 , \field Temperature Control Type
  \note Temperature used to control unit
  \type choice
  \key MeanAirTemperature
  \key MeanRadiantTemperature
  \key OperativeTemperature
  \key OutdoorDryBulbTemperature
  \key OutdoorWetBulbTemperature
  \default MeanAirTemperature
N2 , \field Heating Throttling Range
  \units deltaC
  \minimum 0
  \default 0
A6 ; \field Heating Setpoint Temperature Schedule Name
  \type object-list
  \object-list ScheduleNames

```

An example IDF with an electric low temperature radiant system is shown below.

```

ZoneHVAC:LowTemperatureRadiant:Electric, Zone 2 Radiant Floor,
RadiantPanelAvailsched , ! Availability schedule
EAST ZONE , ! Zone name (name of zone system is serving)
Zn002:Flr001 , ! Surface name (name of surface system is embedded in)
10000 , ! maximum electrical power to panel (in Watts)
MeanAirTemperature, ! control type (control on mean air temperature)
2.0 , ! heating throttling range (in C)
Radiant Heating Setpoints ; ! heating setpoint temperatures

```

ZoneHVAC:LowTemperatureRadiant:Electric Outputs

```

HVAC,Average, Electric Low Temp Radiant Electric Power[W]
HVAC,Sum, Electric Low Temp Radiant Electric Consumption[J]

```

Electric Low Temp Radiant Electric Power [W]

This field reports the rate at which electric energy is “burned” in the low temperature radiant system in Watts. This is the heat source to the surface that is defined as the radiant system. The heating rate is determined by the zone conditions and the control scheme defined in the user input.

Electric Low Temp Radiant Electric Consumption [J]

This field reports the amount of electric energy “burned” in the low temperature radiant system in Joules. This is the heat source to the surface that is defined as the radiant system. The heating rate is determined by the zone conditions, the control scheme defined in the user input, and the timestep.

ZoneHVAC:LowTemperatureRadiant:SurfaceGroup

A low temperature radiant system (hydronic or electric) may consist of multiple active surfaces that are serving to condition the space. Surfaces that act serially can be specified as multiple radiant systems using the standard radiant system input described above. However, if the multiple surfaces act in parallel, the Radiant System Surface Group input line is used to specify which surfaces are acting in a coordinated fashion and how flow rate is split between the surfaces. This list of surfaces (the name it is assigned) replaces the name of a single surface in the radiant system input described above. Note that all of the surfaces within a single list must be a part of the same zone and that the zone of these surfaces must also match the zone the radiant system is attempting to condition.

Field: Name

This field is an unique user assigned name for the list of surfaces that are acting in coordination with one another. Any reference to this list by a radiant system will use this name.

Field Set: Surface Name, Flow Fraction to Surface

The pairs of Surface Name, Flow Fraction to Surface are used in several objects. There can be up to 10 specified. The object is extensible so more can be added.

Field: Surface <x> Name

This field is the name of a surface in the zone being conditioned by the radiant system. Only base surfaces (walls, roofs, floors) are valid. Window/Door surfaces and Internal Mass are not valid surface types for embedded radiant systems.

Field: Flow Fraction for Surface <x>

This field is the fraction of the total radiant system flow rate that is being sent to this particular surface. Note that the Surface Name/Surface Flow Fraction pair can be repeated up to 10 times. Flow rate fractions must sum to unity, otherwise the program will not accept the input as valid.

```
ZoneHVAC:LowTemperatureRadiant:SurfaceGroup,
  \memo This is used to allow the coordinate control of several radiant system surfaces.
  \memo Note that the following flow fractions must sum up to 1.0
  \extensible:2 - repeat last two fields, remembering to remove ; from "inner" fields.
  \memo The number of surfaces can be expanded beyond 10, if necessary, by adding more
  \memo groups to the end of the list
A1 , \field Name
    \required-field
    \type alpha
    \reference RadGroupAndSurfNames
A2 , \field Surface 1 Name
    \required-field
    \type object-list
    \object-list SurfaceNames
N1 , \field Flow Fraction for Surface 1
    \required-field
    \minimum 0.0
<reduced>
```

An example IDF with an electric low temperature radiant system is shown below.

```

ZoneHVAC:LowTemperatureRadiant:SurfaceGroup,
Zone 1 Radiant Surfaces, !- name of surface list
Zn001:Flr001,           !- Surface name 1
0.75,                  !- Flow fraction for surface 1
Zn001:Roof001,         !- Surface name 2
0.25;                  !- Flow fraction for surface 2

```

ZoneHVAC:HighTemperatureRadiant

The high temperature radiant system (gas-fired or electric) is a component of zone equipment that is intended to model any “high temperature” or “high intensity” radiant system where electric resistance or gas-fired combustion heating is used to supply energy (heat) to a building occupants directly as well as the building surfaces (wall, ceiling, or floor). The component is controlled to meet any remaining zone heating load not met by other equipment in the zone that have higher heating priority. The control is accomplished by varying the electrical power supplied to or gas consumed by the unit. It is not intended to simulate low temperature electric or hydronic radiant systems. Those devices will be handled by a separate model and different input syntax (ref: the low temperature systems described elsewhere).

Field: Name

This field is an unique user assigned name for an instance of the high temperature radiant system. Any reference to this unit by another object will use this name.

Field: Availability Schedule Name

This field is the name of the schedule (ref: Schedule) that denotes whether the high temperature radiant system can operate during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit is available and can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit is not available and must be off for the hour.

Field: Zone Name

This field is the name of the zone (Ref: Zone) in which the high temperature radiant system is principally located and intended to affect.

Field: Maximum Power Input

This field is the maximum amount of energy (rate) that can be converted to heat in this particular radiant system in Watts. The controls for the radiant system will vary the amount of power supplied to the surface between zero input and the maximum power specified in this field as the lower and upper bounds, respectively.

Field: Fuel Type

This field denotes the type of high temperature radiant heater: gas or electric. The user must specify this by inputting either the keyword “Gas” or “Electric” for this field.

Field: Combustion Efficiency

This field is the combustion efficiency for a gas high temperature radiant heater. This value should be greater than 0 and less than or equal to 1. It is intended to take into account any potential inefficiencies in the combustion process inside the radiant heater. The heater gas consumption is the ratio of heater output over the combustion efficiency. This parameter has no meaning for an electric high temperature radiant heater and is ignored when the previous field is equal to “Electric”.

Field: Fraction of Input Converted to Radiant Energy

This field specifies what fraction of the power input to the high temperature radiant heater is actually radiant heat transfer. The fraction should be between 0 and 1. In conjunction with the next two parameters, it defines the breakdown of how the power input to the heater is

distributed to the rest of the zone. The sum of these fractions must be less than or equal to 1. If the fractions are less than one, the remaining energy is added to the zone as convective heat transfer. The radiant heat transfer from the heat is distributed to people and surfaces using the distribution fractions listed below.

Field: Fraction of Input Converted to Latent Energy

This field specifies the fraction of the power input to the high temperature radiant heater that is converted to a latent heat gain within the space. This may be appropriate when a combustion process produces moisture that is transferred into the space. The latent heat addition from a high temperature radiant heater is handled as any other latent heat gain within the space, affecting the moisture balance on the zone air.

Field: Fraction of Input that Is Lost

This field specifies the fraction of power input to the high temperature radiant heater that is “lost”. This energy is a loss term, and this fraction of the input power has no effect on the zone heat balances.

Field: Temperature control type

This field specifies along with the throttling range and setpoint schedules how the user wishes to control the high temperature radiant system. The temperature denoted in the setpoint schedule can refer to one of three different temperatures: a mean air temperature, a mean radiant temperature, or an operative temperature. The choice of temperature is controlled by the current field—temperature control type. The user must select from the following options:

```
MeanAirTemperature
MeanRadiantTemperature
OperativeTemperature
MeanAirTemperatureSetpoint
MeanRadiantTemperatureSetpoint
OperativeTemperatureSetpoint
```

If the user does not select a control type, OperativeTemperature control is assumed by EnergyPlus. For the setpoint control strategies (those ending in Setpoint above), EnergyPlus will attempt to find the correct heater output to meet the heating setpoint temperature (see below) through iteration and interpolation. This will more closely match the operation of an actual thermostat, but it will require significantly longer execution times. For more information on the standard piecewise linear control algorithm used by the Mean Air Temperature, Mean Radiant Temperature, and Operative Temperature control types (the “non-Setpoint” controls), see the throttling range and control temperature schedule fields below for more information.

Field: Heating Throttling Range

This field specifies the range of temperature in degrees Celsius over which the radiant system throttles from zero heat input via the electric resistance wires up to the maximum defined by the maximum electrical power field described above. The throttling range parameter is used in conjunction with the control temperature (see below) to define the response of the system to various zone conditions. The heating control temperature schedule specifies the “setpoint” temperature where the power input to the system is at half of the maximum power input. For example, if the heating control temperature setpoint is currently 15°C and the heating throttling range is 2°C, the electrical power supplied to the radiant system will be zero when the controlling temperature (Mean Air Temperature, Mean Radiant Temperature, and Operative Temperature; see control type field above) is at or above 16°C and the maximum power input when the controlling temperature is at or below 14°C. This represents a throttling range of 2°C around the setpoint of 15°C. In between 14°C and 16°C, the power input to the radiant system is varied linearly.

Field: Heating Setpoint Temperature Schedule Name

This field specifies the heating setpoint or control temperature for the radiant system in degrees Celsius. Used in conjunction with the previous field (heating throttling range), it will define whether or not the system is running and the current power input to the radiant surface. Power input to the system is varied linearly around the setpoint temperature based on the throttling range and the maximum electrical power parameters (see above). It should be noted that this control schedule will allow different setpoint temperatures throughout the year for heating. In addition, this schedule may be different than the thermostatic control schedule defined for overall operation of components serving the zone in which the radiant system is located. The thermostatic control determines whether or not there is a heating or cooling load in the space and thus whether the systems should be operating. This field simply controls the flow rate to the radiant system.

Field: Fraction of Radiant Energy Incident on People

This field specifies the fraction of radiant heat transfer to the zone from the radiant heater that is incident directly on people within the space. This has an impact on the predicted thermal comfort of the zone occupants. Note that since the thermal comfort models only use the results of the zone heat balances this energy is accounted for within the heat balance as convective energy, directly affecting the zone air heat balance. The basic assumption here is that most radiant energy falling on people will most likely be convected to the surroundings. This is a simplification of reality, but it maintains the overall energy balance.

Field Set: Surface Name, Fraction of radiant energy to Surface

The pairs of Surface Name, Fraction of Radiant Energy to Surface are used in several objects. There can be up to 20 specified.

Field: Surface <x> Name

This field is the name of the first surface to which radiant heat transfer from the high temperature radiant heater is distributed. Used in conjunction with the next field, it helps to define the distribution of the radiant energy on the surfaces within the zone. Note that up to 20 pairs of surface names and corresponding fractions may be entered for a single radiant heater system.

Field: Fraction of Radiant Energy to Surface <x>

This field is paired with the preceding surface name (previous field) to define the fraction of radiant heat transfer leaving the high temperature radiant system that is incident on a particular surface. Users should take into account the directionality of high temperature radiant heaters and their location when defining the value for this input field. Note that the sum of all fractions plus the fraction of radiant energy incident on people must add up to less than or equal to 1.

The Input Data Dictionary definition follows:

```
ZoneHVAC:HighTemperatureRadiant,
A1, \field Name
    \required-field
A2 , \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A3 , \field Zone Name
    \note Name of zone system is serving
    \required-field
    \type object-list
    \object-list ZoneNames
```



```

N1 , \field Maximum Power Input
    \required-field
    \units W
    \minimum 0
    \autosizable
A4 , \field Fuel Type
    \note gas or electric
    \required-field
    \type choice
    \key Gas
    \key Electric
N2 , \field Combustion Efficiency
    \note Not used for non-gas radiant heaters
    \required-field
    \minimum 0
    \maximum 1
    \default 0.9
N3 , \field Fraction of Input Converted to Radiant Energy
    \required-field
    \note Radiant+latent+lost fractions must sum to 1 or less, remainder is considered convective heat
    \minimum 0
    \maximum 1
    \default 0.7
N4 , \field Fraction of Input Converted to Latent Energy
    \required-field
    \minimum 0
    \maximum 1
    \default 0.0
N5 , \field Fraction of Input that Is Lost
    \note Fraction of input vented to outdoor environment
    \required-field
    \minimum 0
    \maximum 1
    \default 0.0
A5 , \field Temperature Control Type
    \note Temperature type used to control unit
    \type choice
    \key MeanAirTemperature
    \key MeanRadiantTemperature
    \key OperativeTemperature
    \key MeanAirTemperatureSetpoint
    \key MeanRadiantTemperatureSetpoint
    \key OperativeTemperatureSetpoint
    \default OperativeTemperature
N6 , \field Heating Throttling Range
    \required-field
    \units deltaC
    \minimum 0
    \default 2.0
A6 , \field Heating Setpoint Temperature Schedule Name
    \note This setpoint is an "operative temperature" setpoint
    \type object-list
    \object-list ScheduleNames
N7 , \field Fraction of Radiant Energy Incident on People
    \note This will affect thermal comfort but from an energy balance standpoint this value
    \note gets added to the convective gains from the radiant heater
    \minimum 0
    \maximum 1
A7 , \field Surface 1 Name
    \note Radiant energy may be distributed to specific surfaces
    \type object-list
    \object-list AllHeatTranSurfNames
N8 , \field Fraction of Radiant Energy to Surface 1
    \minimum 0
    \maximum 1
--reduced for brevity --

```

An example IDF with a high temperature radiant system is shown below.

```

ZoneHVAC:HighTemperatureRadiant, Zone 2 Radiant Heater,
  RadiantPanelAvailSched , ! Availability schedule
  EAST ZONE , ! Zone name (name of zone system is serving)
  10000 , ! maximum power input (in Watts)
  Gas, ! type of heater (either gas or electric)
  0.8, ! combustion efficiency (ignored for electric radiant heaters)
  0.80, ! fraction radiant
  0.00, ! fraction latent
  0.00, ! fraction lost
  OperativeTemperature, ! temperature control type (controls on operative temperature)
  2.0 , ! heating throttling range (in C)
  Radiant Heating Setpoints, ! heating setpoint temperatures
  0.04, ! fraction of radiant energy that is incident directly on people
  Zn002:Flr001, 0.80, ! fraction of radiant energy that is incident on the surface indicated
  Zn002:Wall001, 0.04, ! fraction of radiant energy that is incident on the surface indicated
  Zn002:Wall002, 0.04, ! fraction of radiant energy that is incident on the surface indicated
  Zn002:Wall003, 0.04, ! fraction of radiant energy that is incident on the surface indicated
  Zn002:Wall004, 0.04; ! fraction of radiant energy that is incident on the surface indicated

```

ZoneHVAC:HighTemperatureRadiant Outputs

```

HVAC,Average, High Temperature Radiant Heating Rate[W]
HVAC,Sum, High Temperature Radiant Heating Energy[J]
HVAC,Average, High Temperature Radiant Gas Consumption Rate[W]
HVAC,Sum, High Temperature Radiant Gas Consumption[J]
HVAC,Average, High Temperature Radiant Electric Power[W]
HVAC,Sum, High Temperature Radiant Electric Consumption [J]

```

High Temperature Radiant Heating Rate[W]

This field reports the rate at which energy is transferred from the high temperature radiant system to the zone in Watts. This rate is determined by the zone conditions and the control scheme defined in the user input. Note that this amount takes into account any combustion inefficiency and thus could be different that the gas consumption rate in a high temperature gas radiant system.

High Temperature Radiant Heating Energy[J]

This field reports the amount of energy transferred from the high temperature gas radiant system to the zone in Joules. This amount is determined by the zone conditions, the control scheme defined in the user input, and the timestep. Note that this amount takes into account any combustion inefficiency and thus could be different that the gas consumption in a high temperature gas radiant system.

High Temperature Radiant Gas Consumption Rate[W]

This field reports the rate at which gas is “burned” in a high temperature gas radiant system in Watts. This rate is determined by the zone conditions and the control scheme defined in the user input.

High Temperature Radiant Gas Consumption[J]

This field reports the amount of gas “burned” in a high temperature gas radiant system in Joules. This amount is determined by the zone conditions, the control scheme defined in the user input, and the timestep.

High Temperature Radiant Electric Power[W]

This field reports the rate at which electric energy is “burned” in a high temperature electric radiant system in Watts. This rate is determined by the zone conditions and the control scheme defined in the user input.

High Temperature Radiant Electric Consumption[J]

This field reports the amount of electric energy “burned” in a high temperature electric radiant system in Joules. This amount is determined by the zone conditions, the control scheme defined in the user input, and the timestep.

ZoneHVAC:VentilatedSlab

Ventilated slab systems in general use outdoor air to “precool” slabs with colder nighttime air. This method of precooling the thermal mass of a space can be very effective when nighttime temperatures are low and the mass of the system is high enough to provide a significant amount of cooling potential during the day to counteract internal heat gains within a zone. Nearly all ventilated slabs are simple systems such as that shown in the right side of Figure 102. The fan is shown in a blow through position, but the model will allow either a blow or draw through configuration.

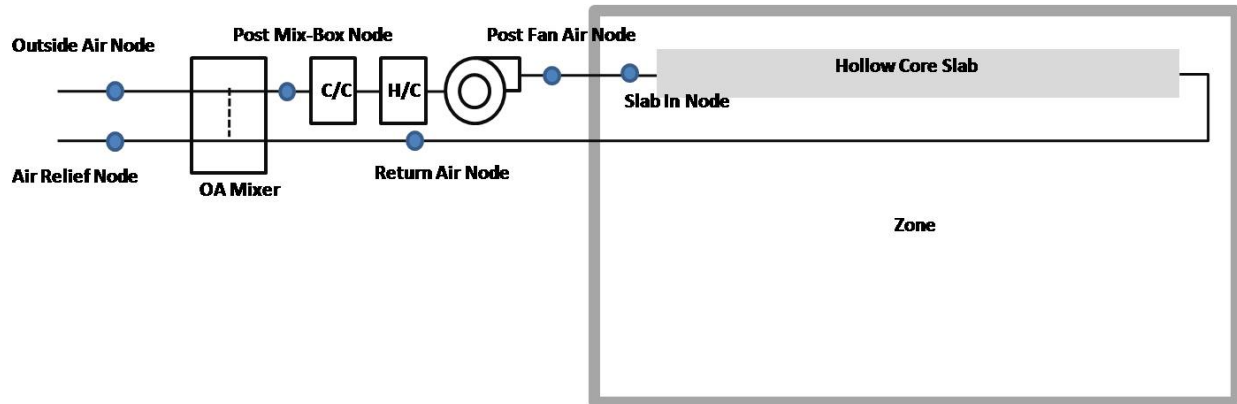


Figure 102. Ventilated Slab model - basic system

It should be noted that in this figure the use of “unit ventilator” and “low temperature radiant system” do not imply that the user must also specify these elements in the input file. In fact, the ventilated slab model combines aspects of these two existing EnergyPlus features into a single model that the user specifies through the input shown below and does not require any additional radiant system or unit ventilator input.

Field: Name

This field is a unique user assigned name for an instance of a ventilated slab system. Any reference to this unit by another object will use this name. Other objects that use this ventilated slab system will reference it by this name.

Field: Availability Schedule Name

This field is the name of the schedule (ref: Schedule) that denotes whether the ventilated slab system can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit is available and can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit is not available and must be off for the hour.

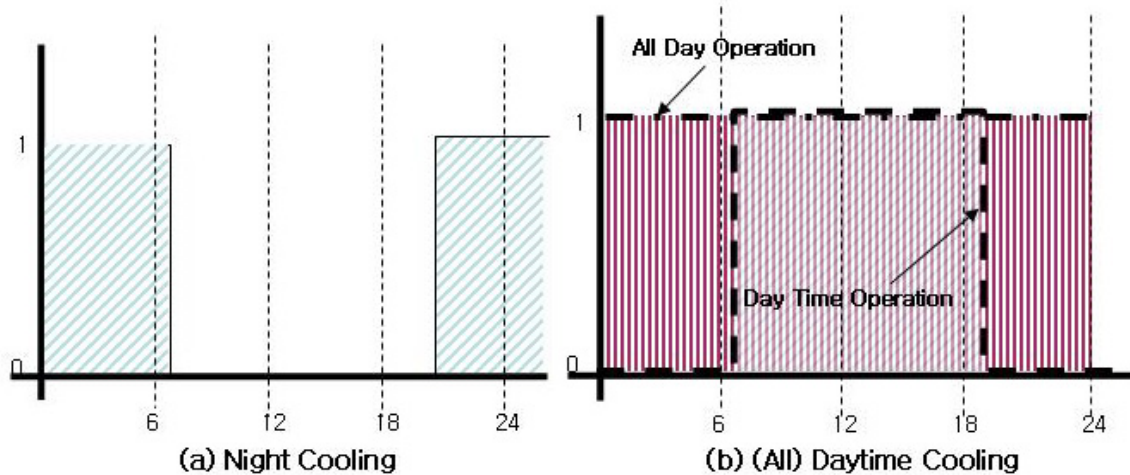


Figure 103. Example operating schedule for Ventilated Slab

Field: Zone Name

This field is the name of the zone (Ref: Zone) in which the ventilated slab system is principally located and intended to affect. A system that is between two zones will still act upon each zone; however, the zone name referenced here should be the zone that controls the system response.

Field: Surface Name or Radiant Surface Group Name

This field is the name of the surface (Ref: Surface) or surface list (Ref: ZoneHVAC:VentilatedSlab:SlabGroup) in which the hollow cores are embedded/contained. This specification attaches the source or sinks from the radiant system to a particular surface and the contribution of the system to the heat balances of that surface. If this field is a surface list, then the source or sink is attached to all of the surfaces in the list with the radiant system surface group defining the breakdown of how flow rate is split between the various surfaces. Only base surfaces (Walls, Roofs, Floors) are valid. Window/Door surfaces and Internal Mass are not valid surface types for embedded radiant systems.

Field: Maximum Air Flow Rate

This field allows the user to enter the maximum volumetric flow rate of air through the ventilated slab system in m^3/sec . This parameter should be some real number greater than zero.

Field: Outdoor Air Control Type

This field allows the user to control how outdoor air is used in the ventilated slab system. The ventilated slab system described by this syntax has its own outdoor air handler. The three options for outdoor air control are “**VariablePercent**”, “**FixedTemperature**” and “**FixedAmount**”. Those keywords are the only allowed choices for this parameter. In general, the variable percent control will attempt to vary the amount of outdoor air between some minimum and maximum schedules of fractions (see next two fields) to best meet the current heating or cooling load. The fixed temperature control will vary the amount of outdoor air between the minimum schedule (fraction of maximum, see next field) and 100% available outdoor air to come as close as possible to a desired mixed air temperature (see two fields down) that can be scheduled. The fixed amount control will fix the outdoor air flow rate as minimum outdoor air flow rate and schedule specified by the user and automatically set the maximum and minimum outside flow rate to be equal by ignoring the maximum outdoor air flow rate. More information on the controls and operation of the ventilated slab are given in the section above (preceding the IDD/IDF description).

Field: Minimum Outdoor Air Flow Rate

This field allows the user to enter the minimum volumetric flow rate of outdoor air (in m³/sec) that will be brought in to the ventilated slab. The actual minimum outdoor air flow rate will be this number multiplied by the schedule value from the minimum outdoor air schedule. If “FixedAmount” type is selected as the outdoor air control strategy, the outdoor air flow rate will be fixed at the value of this field and the ventilated slab will automatically set the maximum and minimum outside flow rate to be equal by ignoring the maximum outdoor air flow rate.

Field: Minimum Outdoor Air Schedule Name

This field contains a schedule name (ref: Schedule) that should contain values for the minimum outdoor air used by the ventilated slab system for IAQ or other reasons. Note that if the ventilated slab is scheduled off or if there is no load sensed in the zone that the system will not operate even to achieve the minimum air fraction. However, if the system is operating, it will always bring in at least this fraction of the minimum air flow rate (see minimum air flow rate field above). If “FixedAmount” type is selected as the outdoor air control strategy, the actual outdoor air flow rate will be this number multiplied by the minimum outdoor air flow rate in the field above. The ventilated slab will automatically set the maximum and minimum outdoor air schedule to be equal by ignoring the maximum outdoor air schedule.

Field: Maximum Outdoor Air Flow Rate

This field allows the user to enter the maximum volumetric flow rate of outdoor air that can be brought into the ventilated slab in m³/sec. This parameter should be some real number greater than zero. Note that the value for this parameter may be less than the maximum air flow rate of the ventilated slab and this may affect the maximum fraction of outdoor air within the control strategy defined above. This parameter is an absolute maximum and will supercede any scheduled fraction of the ventilated slab maximum airflow rate. If “FixedAmount” type is selected as the outdoor air control strategy, this field will be ignored and be automatically set to be equal to the minimum outdoor air flow rate specified in the field above.

Field: Maximum Outdoor Air Fraction or Temperature Schedule Name

This field can have one of two meanings depending the type of control selected in the outdoor air control type parameter above. If “VariablePercent” or “FixedAmount” was selected, then this field is a schedule name (ref: Schedule) corresponding to a maximum air fraction schedule. Furthermore, if “FixedAmount” type is selected as the outdoor air control strategy, this field will be ignored and be automatically set to be equal to the minimum outdoor air fraction specified in the field below. Note that this is a fraction of the maximum airflow rate field (see parameter above) for the ventilated slab. If “FixedTemperature” control was selected, then this field is still a schedule name (ref: Schedule), but it corresponds to a schedule of mixed air temperatures that the outdoor air control will try to attain.

Field: System Configuration Type

This field allows the user to control how the air is circulated using the ventilated slab system. The options for system configuration are

SlabOnly SlabAndZone SeriesSlabs
--

In the **SlabOnly**, the ventilation air is sent to the slab only and does not enter the zone. In the **SlabAndZone**, the air first enters the slab and then is delivered to the zone before returning to the system. With the **SeriesSlabs** option, the user specifies a list of slabs (ZoneHVAC:VentilatedSlab:SlabGroup). This list determines the order of slabs through which the air passes. In this option, air is not delivered to any zone.

Field: Hollow Core Inside Diameter

This field is the inside diameter of the cores through which air is circulated for the system being defined by this statement. The inside diameter should be recorded in meters and is used to determine the convective heat transfer from the circulated air to the inside surface of the ventilated slab.

Field: Hollow Core Length

This field is the length of core embedded in the surface named above in the surface name field. In other words, this should be the distance that air travels as it through the slab. The length of the hollow core in the slab should be entered in meters and is used to determine the effectiveness of heat transfer from the air being circulated through the cores and the core inside surface. Longer core lengths result in more heat transferred to/from the radiant surface to the circulating fluid.

Field: Number of Cores

This field allows the user to specify how many cores there are in the ventilated slab. Air flow will be divided equally among the different cores.

Field: Temperature Control Type

This field specifies along with the throttling range and setpoint schedules how the user wishes to control the ventilated slab system. The temperature denoted in the set temperature schedule can refer to one of seven different temperatures: the zone mean air temperature, the zone mean radiant temperature, the zone operative temperature, the surface temperature of the ventilated slab, the outdoor dry-bulb temperature, the outdoor wet-bulb temperature, or the dewpoint temperature of zone mean air temperature. The choice of temperature is controlled by the current field—temperature control type. The user must select from the following options:

```
MeanAirTemperature
MeanRadiantTemperature
OperativeTemperature
OutdoorDryBulbTemperature
OutdoorWetBulbTemperature
SurfaceTemperature
ZoneAirDewPointTemperature
```

If the user does not select a control type, **MeanAirTemperature** control is assumed by EnergyPlus. See the control temperature schedule fields below for more information.

Field: Heating High Air Temperature Schedule Name

This field specifies the high air temperature in degrees Celsius for the temperature control of a ventilated slab system. Air and control temperatures for heating work together to provide a linear function that determines the air temperature sent to the ventilated slab. The current control temperature (see Temperature Control Type above) is compared to the high and low control temperatures at the current time. If the control temperature is above the high temperature, then the inlet air temperature is set to the low air temperature. If the control temperature is below the low temperature, then the inlet air temperature is set to the high air temperature. If the control temperature is between the high and low value, then the inlet air temperature is linearly interpolated between the low and high air temperature values.

Field: Heating Low Air Temperature Schedule Name

This field specifies the low air temperature in degrees Celsius for the temperature control of a ventilated slab. For more information on its interpretation, see Heating High Air Temperature Schedule above.

Field: Heating High Control Temperature Schedule Name

This field specifies the high control temperature in degrees Celsius for the temperature control of a ventilated slab. For more information on its interpretation, see Heating High Air Temperature Schedule above.

Field: Heating Low Control Temperature Schedule Name

This field specifies the low control temperature in degrees Celsius for the temperature control of a ventilated slab. For more information on its interpretation, see Heating High Air Temperature Schedule above.

Field: Cooling High Air Temperature Schedule Name

This field specifies the high air temperature in degrees Celsius for the temperature control of a ventilated slab system. Air and control temperatures for cooling work together to provide a linear function that determines the air temperature sent to the ventilated slab system. The current control temperature (see Temperature Control Type above) is compared to the high and low control temperatures at the current time. If the control temperature is above the high temperature, then the inlet air temperature is set to the low air temperature. If the control temperature is below the low temperature, then the inlet air temperature is set to the high air temperature. If the control temperature is between the high and low value, then the inlet air temperature is linearly interpolated between the low and high air temperature values.

Field: Cooling Low Air Temperature Schedule Name

This field specifies the low air temperature in degrees Celsius for the temperature control of a constant flow cooling radiant system. For more information on its interpretation, see Cooling High Air Temperature Schedule above.

Field: Cooling High Control Temperature Schedule Name

This field specifies the high control temperature in degrees Celsius for the temperature control of a constant flow cooling radiant system. For more information on its interpretation, see Cooling High Air Temperature Schedule above.

Field: Cooling Low Control Temperature Schedule Name

This field specifies the low control temperature in degrees Celsius for the temperature control of a ventilated slab system. For more information on its interpretation, see Cooling High Air Temperature Schedule above.

Field: Return Air Node Name

This field is a node name used to identify the node that serves as the inlet (air side) to the ventilated slab. In EnergyPlus, nodes represent points between components or at various points in the loops. In a ventilated slab, the air inlet node to the system will typically be the same node as a zone outlet node. While a node name may be referenced more than once in an input data file, each node must have a unique name.

Field: Slab In Node Name

This field is a node name used to identify the node that serves as the outlet (air side) of the ventilated slab. In EnergyPlus, nodes represent points between components or at various points in the loops. In a ventilated slab, the air outlet node from the system will typically be the same node as a zone inlet node. While a node name may be referenced more than once in an input data file, each node must have a unique name.

Field: Zone Supply Air Node Name

This field is a node name used to identify the node that serves as the outlet from the system to zone. In EnergyPlus, nodes represent points between components or at various points in the loops. In a ventilated slab, the air outlet node from the system will typically be the same node as a zone inlet node. In the case of “SlabOnly” configuration, it should be left BLANK.

Although it has data in this field, it will be ignored for “SlabOnly” configuration. While a node name may be referenced more than once in an input data file, each node must have a unique name.

Field: Outdoor Air Node Name

This field is a node name used to identify the node associated with fresh air brought into the ventilated slab from the outdoor environment. While from a simulation standpoint this name is arbitrary and not a “necessity”, assigning a name to this node allows the user to receive output on conditions at this node to verify the correct operation of the ventilated slab.

Field: Relief Air Node Name

This field is a node name used to identify the node associated with air exhausted out of the ventilated slab to the outdoor environment. While from a simulation standpoint this name is arbitrary and not a “necessity”, assigning a name to this node allows the user to receive output on conditions at this node to verify the correct operation of the ventilated slab.

Field: Outdoor Air Mixer Outlet Node Name

This field is a node name used to identify the node associated with the “mixed” air of the ventilated slab. These conditions are post-“mixing box” since they are the conditions of the fraction of return air combined with the outdoor air. Since this is a simple system, this can also be viewed as the conditions of the air being sent to the coils. While from a simulation standpoint this name is arbitrary and not a “necessity”, assigning a name to this node allows the user to receive output on conditions at this node to verify the correct operation of the ventilated slab.

Field: Fan Outlet Node Name

This field is a node name used to identify the node that serves as the air outlet to fan before the ventilated slab. In EnergyPlus, nodes represent points between components or at various points in the loops. In a ventilated slab, the air outlet node from the fan is also considered the inlet node to the coils. While a node name may be referenced more than once in an input data file, each node must have a unique name.

Field: Fan Name

This field is the name of a fan (ref: Fan:ConstantVolume) that is part of the ventilated slab system. This name links the ventilated slab to particular fan data entered elsewhere in the input data file. A fan name is required since it is the prime mover of air in the ventilated slab system.

Field: Coil Option Type

This field allows the user to specify the coil operating options as one of the following options:

None Heating Cooling HeatingAndCooling

If **None** is selected, the ventilated slab does not have any coils, and any other input will be ignored. If either **Heating** or **Cooling** is selected, only a heating or cooling coil, respectively, is present. Thus, only four more inputs will be expected. If **HeatingAndCooling** is selected, both heating and cooling coil input must be entered, and the ventilated slab will have both a heating and a cooling coil.

Field: Heating Coil Object Type

This field is the type of coil (ref: Coil:Heating:Water, Coil:Heating:Electric, Coil:Heating:Gas, Coil:Heating:Steam) that is used for heating in the ventilated slab system. This field must be one of the following keywords: Coil:Heating:Water, Coil:Heating:Electric, Coil:Heating:Gas,

Coil:Heating:Steam. It is used in conjunction with the heating coil name (see next field) to specify the heating coil present within the system.

Field: Heating Coil Name

This field is the name of the heating coil that is part of the ventilated slab system. It is assumed that there is always some sort of heating coil associated with a ventilated slab system. This name links the ventilated slab to particular heating coil data entered elsewhere in the input data file.

Field: Hot Water or Steam Inlet Node Name

This field corresponds to the water inlet node to the heating coil for a water coil. The water inlet node controls how a water heating coil operates. This field is ignored/not needed for gas and electric heating coils.

Field: Cooling Coil Object Type

This field is the name of the cooling coil (ref: Coil:Cooling:Water, Coil:Cooling:Water:DetailedGeometry, CoilSystem:Cooling:Water:HeatExchangerAssisted) that is part of the ventilated slab system. This name links the ventilated slab system to particular cooling coil data entered elsewhere in the input data file. If no cooling coil is present, the previous field may be followed by a semi-colon and the remaining parameters in this statement may be ignored.

Field: Cooling Coil Name

This field is the name of the cooling coil that is part of the ventilated slab system. It is assumed that there is always some sort of cooling coil associated with a ventilated slab system. This name links the ventilated slab to particular cooling coil data entered elsewhere in the input data file.

Field: Cold Water Inlet Node Name

This field corresponds to the water inlet node to the cooling coil. The water inlet node controls how a water cooling coil operates and is required for the ventilated slab system that has a cooling coil associated with it to function properly.

The IDD definition for the ventilated slab system module is shown below.

```
ZoneHVAC:VentilatedSlab,
  A1, \field Name
      \required-field
  A2, \field Availability Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
  A3, \field Zone Name
      \required-field
      \note (name of zone system is serving)
      \type object-list
      \object-list ZoneNames
  A4, \field Surface Name or Radiant Surface Group Name
      \note (name of surface system is embedded in) or list of surfaces
      \type object-list
      \object-list RadGroupAndSurfNames
```

```
N1, \field Maximum Air Flow Rate
    \required-field
    \units m3/s
    \minimum > 0
    \autosizable
A5, \field Outdoor Air Control Type
    \required-field
    \type choice
    \key VariablePercent
    \key FixedTemperature
    \key FixedAmount
N2, \field Minimum Outdoor Air Flow Rate
    \required-field
    \units m3/s
    \autosizable
    \minimum 0.0
A6, \field Minimum Outdoor Air Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
N3, \field Maximum Outdoor Air Flow Rate
    \required-field
    \units m3/s
    \autosizable
    \minimum 0.0
    \note schedule values multiply the minimum outdoor air flow rate
A7, \field Maximum Outdoor Air Fraction or Temperature Schedule Name
    \note Note that this depends on the control type as to whether schedule values are a fraction or
        temperature
    \required-field
    \type object-list
    \object-list ScheduleNames
A8, \field System Configuration Type
    \required-field
    \type choice
    \key SlabOnly
    \key SlabAndZone
    \key SeriesSlabs
    \default SlabOnly
N4, \field Hollow Core Inside Diameter
    \units m
N5, \field Hollow Core Length
    \note (length of core cavity embedded in surface)
    \units m
N6, \field Number of Cores
    \note flow will be divided evenly among the cores
A9, \field Temperature Control Type
    \required-field
    \note (temperature on which unit is controlled)
    \type choice
    \key MeanAirTemperature
    \key MeanRadiantTemperature
    \key OperativeTemperature
    \key OutdoorDryBulbTemperature
    \key OutdoorWetBulbTemperature
    \key SurfaceTemperature
    \key ZoneAirDewPointTemperature
    \default OutdoorDryBulbTemperature
```

```

A10, \field Heating High Air Temperature Schedule Name
    \required-field
    \note Air and control temperatures for heating work together to provide
    \note a linear function that determines the air temperature sent to the
    \note radiant system. The current control temperature (see A14) is
    \note compared to the high and low control temperatures at the current time.
    \note If the control temperature is above the high temperature, then the
    \note inlet air temperature is set to the low air temperature. If the
    \note control temperature is below the low temperature, then the inlet
    \note air temperature is set to the high air temperature. If the control
    \note temperature is between the high and low value, then the inlet air
    \note temperature is linearly interpolated between the low and high air
    \note temperature values.
    \type object-list
    \object-list ScheduleNames
A11, \field Heating Low Air Temperature Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A12, \field Heating High Control Temperature Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A13, \field Heating Low Control Temperature Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A14, \field Cooling High Air Temperature Schedule Name
    \required-field
    \note See note for heating high air temperature schedule above for
    \note interpretation information (or see the Input/Output Reference).
    \type object-list
    \object-list ScheduleNames
    \note
A15, \field Cooling Low Air Temperature Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A16, \field Cooling High Control Temperature Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A17, \field Cooling Low Control Temperature Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A18, \field Return Air Node Name
    \required-field
A19, \field Slab In Node Name
    \required-field
A20, \field Zone Supply Air Node Name
    \note Leave blank when the system configuration is Slab Only
    \type object-list
    \object-list NodeNames
A21, \field Outdoor Air Node Name
    \required-field
A22, \field Relief Air Node Name
    \required-field
A23, \field Outdoor Air Mixer Outlet Node Name
    \required-field
    \note node is inlet to coils
A24, \field Fan Outlet Node Name
    \required-field
A25, \field Fan Name
    \required-field
    \note Allowable fan type is Fan:ConstantVolume
    \type object-list
    \object-list FansCV

```

A26,	\field Coil Option Type
	\required-field
	\type choice
	\key None
	\key Heating
	\key Cooling
	\key HeatingAndCooling
A27,	\field Heating Coil Object Type
	\type choice
	\key Coil:Heating:Water
	\key Coil:Heating:Electric
	\key Coil:Heating:Gas
	\key Coil:Heating:Steam
A28,	\field Heating Coil Name
	\type object-list
	\object-list HeatingCoilName
A29,	\field Hot Water or Steam Inlet Node Name
A30,	\field Cooling Coil Object Type
	\type choice
	\key Coil:Cooling:Water
	\key Coil:Cooling:Water:DetailedGeometry
	\key CoilSystem:Cooling:Water:HeatExchangerAssisted
A31,	\field Cooling Coil Name
	\type object-list
	\object-list CoolingCoilsWater
A32;	\field Cold Water Inlet Node Name

An example IDF with a ventilated slab is shown below.

ZoneHVAC:VentilatedSlab,	
Zone4VentSlab,	!- name of ventilated slab system
VentSlabAvailability,	!- availability schedule
SPACE 4-1,	!- Zone name
0.84,	! maximum air flow rate in m3/s
VariablePercent,	! outdoor air control type which varies between some max and some min schedule
0.168,	! min outdoor air flow rate in m3/s
VentSlabMinOA,	! minimum outdoor air schedule name
0.84,	! outdoor air flow rate in m3/s
VentSlabMaxOA,	! maximum outdoor air fraction or temperature schedule
SlabAndZone,	! ventilated slab configuration
0.05,	! Hollow Core inside diameter {m}
30.0,	! Hollow Core length {m}
50,	! number of cores
MeanRadiantTemperature,	! temperature control type
VentSlabHeatHighAirTemp,	! heating high air temperature schedule
VentSlabHeatLowAirTemp,	! heating low air temperature schedule
VentSlabHeatHighControlTemp,	! heating high control temperature schedule
VentSlabHeatLowControlTemp,	! heating low control temperature schedule
VentSlabCoolHighAirTemp,	! cooling high air temperature schedule
VentSlabCoolLowAirTemp,	! cooling low air temperature schedule
VentSlabCoolHighControlTemp,	! cooling high control temperature schedule
VentSlabCoolLowControlTemp;	! cooling low control temperature schedule
Zone4VentSlabRANode,	! a zone or slab exhaust node
Zone4VentSlabSlabInNode	! slab inlet node
Zone4VentSlabZoneInNode	! air inlet node to zone
Zone4VentSlabOAINode,	! outdoor air inlet node
Zone4VentSlabExhNode,	! Ventilated Slab System relief air node outdoor air inlet node
Zone4VentSlabOAMIXNode,	! Ventilated Slab System OA mixer outlet node
Zone4VentSlabFanOutletNode,	! fan outlet node
Zone4VentSlabFan,	! name of fan in Ventilated Slab
HeatingAndCooling,	! coil option (both a heating and cooling coil are present)
Coil:Heating:Electric,	! heating coil type
Zone4VentSlabHeatingCoil,	! name of heating coil in Ventilated Slab
,	! Ventilated Slab hot water control node
COIL:Water:SimpleCooling;	! Cooling coil type
Zone4VentSlabCoolingCoil,	! name of cooling coil in Ventilated Slab
Zone4VentSlabChWInletNode,	! Ventilated Slab chilled water control node

ZoneHVAC:VentilatedSlab Outputs

```

HVAC,Average,Ventilated Slab Radiant Heating Rate [W]
HVAC,Sum,Ventilated Slab Radiant Heating Energy [J]
HVAC,Average,Ventilated Slab Radiant Cooling Rate [W]
HVAC,Sum,Ventilated Slab Radiant Cooling Energy [J]
HVAC,Average,Ventilated Slab Coil Heating Rate [W]
HVAC,Sum,Ventilated Slab Coil Heating Energy [J]
HVAC,Average,Ventilated Slab Total Coil Cooling Rate [W]
HVAC,Sum,Ventilated Slab Total Coil Cooling Energy [J]
HVAC,Average,Ventilated Slab Sensible Coil Cooling Rate [W]
HVAC,Sum,Ventilated Slab Sensible Coil Cooling Energy [J]
HVAC,Average,Ventilated Slab Latent Coil Cooling Rate [W]
HVAC,Sum,Ventilated Slab Latent Coil Cooling Energy [J]
HVAC,Average,Ventilated Slab Air Mass Flow [kg/s]
HVAC,Average, Ventilated Slab Fan Electric Power [W]
HVAC,Sum,Ventilated Slab Fan Electric Consumption [J]
HVAC,Average,Ventilated Slab Slab Inlet Air Temperature [C]
HVAC,Average,Ventilated Slab Slab Outlet Air Temperature [C]
HVAC,Average,Ventilated Slab Zone Inlet Air Temperature [C]
HVAC,Average,Ventilated Slab Slab Return Air Temperature [C]
HVAC,Average,Ventilated Slab Slab Fan Outlet Air Temperature [C]

```

Ventilated Slab Radiant Heating Rate [W]

This field reports the radiant heating input rate of the ventilated slab system to the zone it is serving in Watts. This is determined by outlet and zone air conditions and the mass flow rate through the ventilated slab system.

Ventilated Slab Radiant Heating Energy [J]

This field is the heating radiant input of the ventilated slab system to the zone it is serving in Joules over the timestep being reported. This is determined by outlet and zone air conditions, the mass flow rate through the ventilated slab system, and the timestep.

Ventilated Slab Radiant Cooling Rate [W]

This field reports the radiant cooling input rate to the ventilated slab system in Watts. This is the heat sink to the surface that is defined as the ventilated slab system. The cooling rate is determined by the zone conditions and the control scheme defined in the user input.

Ventilated Slab Radiant Cooling Energy [J]

This field reports the radiant cooling input to the ventilated slab system in Joules. This is the heat sink to the surface that is defined as the radiant system. The cooling rate is determined by the zone conditions, the control scheme defined in the user input, and the timestep.

Ventilated Slab Coil Heating Rate [W]

This field reports the heating input rate of the heating coil of ventilated slab system the zone it is serving in Watts. This is determined by return air and zone air conditions and the mass flow rate through the ventilation slab system.

Ventilated Slab Coil Heating Energy [J]

This field is the heating output of the heating coil of the ventilated slab system the zone it is serving in Joules over the timestep being reported. This is determined by return air and zone air conditions, the mass flow rate through the ventilation slab system, and the timestep.

Ventilated Slab Total Coil Cooling Rate [W]

This field reports the total cooling (sensible plus latent) output rate of the cooling coil of the ventilated slab system to the zone it is serving in Watts. This is determined by outlet and zone air conditions and the mass flow rate through the ventilation slab system.

Ventilated Slab Total Coil Cooling Energy [J]

This field is the total cooling (sensible plus latent) output of the cooling coil of the ventilated slab system to the zone it is serving in Joules over the timestep being reported. This is determined by outlet and zone air conditions, the mass flow rate through the ventilation slab system, and the timestep.

Ventilated Slab Sensible Coil Cooling Rate [W]

This field reports the sensible cooling output rate of the cooling coil of the ventilated slab system to the zone it is serving in Watts. This is determined by outlet and zone air conditions and the mass flow rate through the ventilation slab system.

Ventilated Slab Sensible Coil Cooling Energy [J]

This field is the sensible cooling output of the cooling coil of the ventilated slab system to the zone it is serving in Joules over the timestep being reported. This is determined by outlet and zone air conditions, the mass flow rate through the ventilation slab system, and the timestep.

Ventilated Slab Latent Coil Cooling Rate [W]

This field reports the latent cooling output rate of the cooling coil of the ventilated slab system to the zone it is serving in Watts. This is determined by outlet and zone air conditions and the mass flow rate through the ventilation slab system.

Ventilated Slab Latent Coil Cooling Energy [J]

This field is the latent cooling output of the cooling coil of the ventilated slab system to the zone it is serving in Joules over the timestep being reported. This is determined by outlet and zone air conditions, the mass flow rate through the ventilation slab system, and the timestep.

Ventilated Slab Air Mass Flow Rate [kg/s]

This field reports the mass flow rate of air through the ventilated slab system in kilograms per second.

Ventilated Slab Fan Electric Power [W]

This field reports the electric power consumption rate of the fan of the ventilated slab system in Watts.

Ventilated Slab Fan Electric Consumption [J]

This field reports the electric power consumed by the fan of the ventilated slab system over the timestep in Joules.

Ventilated Slab Slab Inlet Air Temperature [C]

This field reports the temperature of air entering the ventilated slab system in Celsius.

Ventilated Slab Slab Outlet Air Temperature [C]

This field reports the temperature of air leaving the ventilated slab system in Celsius.

Ventilated Slab Zone Inlet Air Temperature [C]

This field reports the temperature of air entering the zone in Celsius.

Ventilated Slab Return Air Temperature [C]

This field reports the temperature of air leaving the zone in Celsius. When system does not circulate air to zone ("SlabOnly" Configuration), the slab outlet temperature and return air temperature will be the same.

Ventilated Slab Fan Outlet Air Temperature [C]

This field reports the fan outlet air temperature for the ventilated slab system in Celsius.

ZoneHVAC:VentilatedSlab:SlabGroup

A ventilated slab system may consist of multiple active slabs that are serving to condition the zone. Slabs that act serially can be specified as multiple radiant systems using the standard ventilated slab input described above. This list of surfaces (the name it is assigned) replaces the name of a single surface in the ventilated slab system input described above.

Field : Name of Ventilated Slab Surface Group

This field is a unique user assigned name for the list of surfaces that are acting in coordination with one another. Any reference to this list by a ventilated slab system will use this name.

Field: Zone Name

This field is the name of the zone in which the surface is principally located and intended to affect.

Field: Surface Name

This field is the name of a surface in the zone being conditioned by the ventilated slab system. Only base surfaces like walls, floors and roofs are valid. Door/Window Surface and Internal Mass are not valid surface types for the ventilated slab system.

Field: Core Diameter

This field is the inside diameter of the cores through which air is circulated for the surface being defined by this statement. The inside diameter should be recorded in meters and is used to determine the convective heat transfer from the circulated air to the inside surface of the ventilated slab.

Field: Core length

This field is the length of core embedded in the surface named above in the surface name field. In other words, this should be the distance that air travels as it through the slab. The length of the hollow core in the surface should be entered in meters and is used to determine the effectiveness of heat transfer from the air being circulated through the cores and the core inside surface. Longer core lengths result in more heat transferred to/from the radiant surface to the circulating fluid.

Field: Number of Cores

This field allows the user to specify how many cores there are in the ventilated slab. Air flow will be divided equally among the different cores.

Field: Slab Inlet Node Name

This field is a node name (character string) used to identify the node that serves as the inlet (air side) to the surface. In EnergyPlus, nodes represent points between components or at various points in the loops. While a node name may be referenced more than once in an input data file, each node must have a unique name.

Field: Slab Outlet Node Name

This field is a node name (character string) used to identify the node that serves as the outlet (air side) of the surface. In EnergyPlus, nodes represent points between components or at various points in the loops. While a node name may be referenced more than once in an input data file, each node must have a unique name.

```

ZoneHVAC:VentilatedSlab:SlabGroup,
    \memo This is used to allow the coordinate control of several radiant system surfaces.
    \extensible:2 - repeat last two fields, remembering to remove ; from "inner" fields.
    \memo The number of surfaces can be expanded beyond 10, if necessary, by adding more
    \memo groups to the end of the list
A1 , \field Name
    \required-field
    \type alpha
    \reference RadGroupAndSurfNames
A2 , \field Zone 1 Name
    \required-field
    \type object-list
    \object-list ZoneNames
A3 , \field Surface 1 Name
    \required-field
    \type object-list
    \object-list SurfaceNames
N1 , \field Core Diameter for Surface 1
    \required-field
    \minimum 0.0
N2 , \field Core Length for Surface 1
    \required-field
    \minimum 0.0
N3 , \field Core Numbers for Surface 1
    \required-field
    \minimum 0.0
A4 , \field Slab In Node Name for Surface 1
    \required-field
    \type alpha
A5 , \field Slab Outlet Node Name for Surface 1
    \required-field
    \type alpha
<reduced for brevity>

```

An Example IDF with a ventilated slab system is shown below

```

ZoneHVAC:VentilatedSlab:SlabGroup,
Z125,                !- Name
SPACE1-1,           !- Zone 1 Name
C1-1,               !- Surface 1 Name
0.05,              !- Core Diameter for Surface 1
30,                 !- Core Length for Surface 1
20,                 !- Core Numbers for Surface 1
Z1VentslabIn,       !- Slab In Node Name for Surface 1
Z1VentSlabOut,      !- Slab Outlet Node Name for Surface 1
SPACE2-1,           !- Zone 2 Name
C2-1,               !- Surface 2 Name
0.05,              !- Core Diameter for Surface 2
15,                 !- Core Length for Surface 2
20,                 !- Core Numbers for Surface 2
Z2VentSlabIn,       !- Slab In Node Name for Surface 2
Z2VentSlabOut,      !- Slab Outlet Node Name for Surface 2
SPACE5-1,           !- Zone 3 Name
C5-1,               !- Surface 3 Name
0.05,              !- Core Diameter for Surface 3
30,                 !- Core Length for Surface 3
20,                 !- Core Numbers for Surface 3
Z5VentSlabIn,       !- Slab In Node Name for Surface 3
Z5VentSlabOut;      !- Slab Outlet Node Name for Surface 3

```

Group – Refrigeration

There are two ways to model a supermarket refrigeration system. The first uses one or more Refrigeration Case objects with a refrigeration compressor rack object (Ref. Refrigeration:Case and Refrigeration:CompressorRack). The second uses one or more Refrigeration Case objects with a refrigeration system (Ref. Refrigeration:Case and Refrigeration:System). The refrigeration system requires the use of a case list object, a compressor list object, one or more compressor objects, and one condenser object, which

may be either air-cooled, evaporative-cooled, or water-cooled (Ref. Refrigeration:CaseList, Refrigeration:CompressorList, Refrigeration:Compressor, Refrigeration:Condenser:AirCooled, Refrigeration:Condenser:EvaporativeCooled, or Refrigeration:Condenser:WaterCooled). The system may optionally use subcoolers (Ref. Refrigeration:Subcooler).

Refrigeration:CompressorRack

The refrigeration compressor rack object works in conjunction with the refrigeration case object (Ref. Refrigeration:Case) to simulate the performance of a refrigerated case system. This object models the electric consumption of the rack compressors and the condenser fans. Heat removed from the refrigerated cases and compressor/condenser fan heat can be rejected either outdoors or to a zone. Compressor rack waste heat can also be reclaimed for use by an optional air- or water-heating coil (Ref. Coil:Heating:Desuperheater and Coil:WaterHeating:Desuperheater).

If heat is rejected outdoors, condenser cooling can either be accomplished by direct air flow, evaporative water cooling, or a by water-cooled condenser with appropriate plant loop piping. With evaporative cooling, water is sprayed through the air stream to effectively lower the air temperature experienced by the condenser coil as a result of water evaporation. The use of a water-cooled condenser requires the definition of a plant loop to supply cooling to the condenser. Waste heat can be reclaimed and stored using a water storage device.

The inputs for the compressor rack object include a name, the heat rejection location, the compressor rack coefficient of performance (COP) at design conditions, the design condenser fan power, and the type of condenser cooling. The model requires two curve objects to describe performance at off-design conditions. If the condenser is water-cooled, the inlet and outlet node names as well as the water outlet temperature schedule name are required. If the condenser has evaporative cooling, additional inputs for evaporative condenser effectiveness, condenser air flow rate, basin heater parameters, water pump power, water source, and an evaporative cooling availability schedule are available. The names of refrigerated cases connected to the compressor rack are the final inputs to the model. Currently, up to six refrigerated cases can be connected to a single rack; however these fields are extensible.

Field: Name

A unique user-assigned name for an instance of a refrigeration compressor rack. Any reference to this compressor rack by another object will use this name.

Field: Heat Rejection Location

The location of the compressor rack's condenser. The compressor rack condenser heat can be directed "Outdoors" to model an outdoor air or water-cooled condenser or "Zone" to model a condenser located in a zone (e.g., a stand-alone packaged refrigerated case with integral condenser located in a conditioned zone). If the heat rejection location is "Zone", then all refrigerated cases connected to this compressor rack must be located in the same zone. The default for this field is "Outdoors".

NOTE: When modeling a heat reclaim coil, the heat rejection location must be "Outdoors". If the heat rejection location is "Zone", the total amount of waste heat available for reclaim (e.g., by a desuperheater heating coil) is set to zero by this compressor rack object and the simulation proceeds.

Field: Design Compressor Rack COP

The coefficient of performance (COP) for the compressor rack at design conditions (compressors only, excluding condenser fan power). This value must be greater than zero, with a default value of 2.0 if this field is left blank. This value should represent the compressor

rack COP corresponding to the lowest evaporating temperature of any case served by the rack.

Field: Compressor Rack COP Function of Temperature Curve Name

The name of the curve object defining the change in compressor rack COP as a function of the temperature of air entering the condenser. The curve object will be evaluated using the zone air dry-bulb temperature when rack heat rejection location equals “Zone” and the outdoor air dry-bulb temperature when rack heat rejection location equals “Outdoors” and the condenser type is air-cooled. As explained below, if the condenser is cooled by evaporative or water loop cooling, the curve object is evaluated using an effective temperature. The output from this curve is multiplied by the design compressor rack COP to yield the actual COP at the specific air temperature entering the condenser. This curve must be cubic or quadratic (Curve:Cubic or Curve:Quadratic), and should be normalized to 1.0 at the condenser entering air temperature at which the design compressor rack COP occurs. This curve should represent the compressor rack COP corresponding to the lowest evaporating temperature of any case served by the rack.

Field: Design Condenser Fan Power

This field defines the design power for the condenser fan(s) in Watts. This field is applicable for air or evaporative cooling only. If the condenser is water-cooled, the fan power is captured in the cooling object (e.g., cooling tower). If applicable, this value must be greater than 0.0, with a default value of 250 Watts if this field is left blank.

Field: Condenser Fan Power Function of Temperature Curve Name

This field is the name of the curve object defining the change in condenser fan power as a function of the temperature of air entering the condenser. This curve is used to simulate the modulation of air flow by the condenser fans (e.g., staging, multi-speed, or variable speed) as a function of temperature. The curve object will be evaluated using the zone air dry-bulb temperature when rack heat rejection location equals “Zone” and the outdoor air dry-bulb temperature when rack heat rejection location equals “Outdoors” and the condenser type is air-cooled. As explained below, if the condenser is cooled by evaporative cooling, the curve object is evaluated using an effective temperature. The output from this curve is multiplied by the design condenser fan power to yield the actual fan power at the specific air temperature entering the condenser. This curve must be cubic or quadratic (Curve:Cubic or Curve:Quadratic), and should be normalized to 1.0 at the condenser entering air temperature at which the design condenser fan power occurs. The actual condenser fan power is not allowed to exceed the design condenser fan power defined in the previous input field or go below zero (i.e., the output of the curve object is limited to values from 0.0 to 1.0). If this field is left blank, then the model assumes the condenser fan power is at the design power level when any of the refrigerated cases connected to this rack are operating.

Field: Condenser Type

When the heat rejection location is “Outdoors”, the condenser may be either cooled by dry air by specifying “AirCooled”, by wet evaporative cooling by specifying “EvaporativelyCooled”, or by a water loop by specifying “WaterCooled”. If the condenser type is “WaterCooled”, then a plant cooling loop will need to be defined using other EnergyPlus objects, e.g., plant loop, pump, cooling tower, etc. The default value is “AirCooled”.

Field: Water-cooled Condenser Inlet Node Name

When the condenser type is “WaterCooled”, a node name for the water-side condenser inlet must be provided.

Field: Water-cooled Condenser Outlet Node Name

When the condenser type is “WaterCooled”, a node name for the water-side condenser outlet must be provided.

Field: Water-cooled Loop Flow Type

When the condenser type is “WaterCooled”, the type of flow loop should be specified. The two choices are **VariableFlow**, in which a Pump:VariableSpeed needs to be included in the plant loop, or **ConstantFlow**, in which the loop circuit has a constant flow rate, typically associated with a Pump:ConstantSpeed object. If the flow type is VariableFlow, the flow needed to remove the condenser heat energy will be calculated and requested of the pump. If the flow type is Constant Flow, the outlet water temperature will be determined based on the fixed loop flow rate and heat energy to be removed. The default type is **VariableFlow**. Refer to additional discussion in the Engineering Reference.

Field: Water-cooled Condenser Outlet Temperature Schedule Name

When the water-cooled loop flow type is “Variable Flow”, the name of a schedule (Ref: Schedule) that defines the desired condenser water outlet temperature must be provided. The schedule may define an outlet temperature that varies through time.

Field: Water-cooled Condenser Design Volumetric Flow Rate

When the water-cooled loop flow type is “Constant Flow”, this is the design water flow rate in m^3/s that will be requested initially. This requested flow will be passed to the loop simulation, and resulting actual flow will be dependent upon supply system capabilities (e.g., pump capability). The design flow rate must always be less than the maximum flow rate, defined below.

Field: Water-cooled Condenser Maximum Volumetric Flow Rate

When the condenser type is “Water Cooled”, this is the maximum water flow rate in m^3/s that will be allowed through the condenser. When the loop flow type is Variable Flow, if the calculated flow rate is higher than the maximum flow rate, an error message will be generated, and the flow rate will be reset to the maximum flow rate.

Field: Water-cooled Condenser Maximum Water Outlet Temperature

This field specifies the maximum allowed water temperature in degrees C leaving the compressor rack condenser. The default value is 55 degrees C.

Field: Water-cooled Condenser Minimum Water Inlet Temperature

This field specifies the minimum allowed water temperature in degrees C entering the compressor rack condenser. The default value is 10 degrees C. Refer to additional discussion in the Engineering Reference.

Field: Evaporative Condenser Availability Schedule Name

For evaporative cooled condensers, the name of the optional schedule (Ref: Schedule) that specifies the time periods that evaporative cooling is available/unavailable. In some colder climates, evaporative cooling is periodically discontinued and the basin sumps drained to avoid freezing. In these times, the condenser runs as a typical dry air cooled condenser, and related evaporative cooling systems (e.g., water pump, basin heaters) do not operate. Use of this optional schedule permits modeling of planned, seasonal interruptions of evaporative cooling. All schedule values must be greater than or equal to zero. Typically, an ON/OFF schedule type is used with values being either 0 or 1. A schedule value of 1 indicates that evaporative cooling is available during the defined time period, and a value of 0 denotes that evaporative cooling is not available during the defined time period. If the schedule name is omitted (blank) and Condenser Type = “Evap Cooled”, then the model assumes that evaporative cooling of the condenser is available for the entire simulation period.

Field: Evaporative Condenser Effectiveness

This field specifies the effectiveness of the evaporative system in modifying the temperature of the air entering the condenser coil. The resulting effective temperature is determined as

$$T_{effective} = T_{owb} + (1 - \varepsilon) * [T_{odb} - T_{owb}]$$

where:

- $T_{effective}$ = effective dry-bulb temperature of air entering the condenser cooling coil (°C)
- T_{owb} = outdoor air wet-bulb temperature (°C)
- T_{odb} = outdoor air dry-bulb temperature (°C)
- ε = evaporative condenser effectiveness.

The resulting condenser inlet air temperature is used by the Compressor Rack COP as a Function of Temperature Curve and the Condenser Fan Power as a Function of Temperature Curve. The default value for this field is 0.9, although valid entries can range from 0.0 to 1.0. This field is not used when Condenser Type = AirCooled. If the user wants to model an air-cooled condenser, they should simply specify "AirCooled" in the field Condenser Type.

If the two function-of-temperature curves (i.e., Compressor Rack COP as a Function of Temperature Curve and Condenser Fan Power as a Function of Temperature Curve) are based on wet-bulb temperature rather than dry-bulb temperature, the evaporative condenser effectiveness should be set to 1.0 for consistency.

Field: Evaporative Condenser Air Flow Rate

The air volume flow rate, in m³ per second, entering the evaporative condenser. This value is used to calculate the amount of water evaporated when evaporatively cooling the condenser inlet air. The value for this field must be greater than zero. This input field is also autocalculatable, equivalent to 0.000144 m³/s per watt of total cooling capacity [850 cfm/ton] where the total cooling capacity is the sum of the rated total cooling capacities for the refrigerated cases connected to this compressor rack (Ref. Refrigeration:Case). This field is not used when Condenser Type = AirCooled.

Field: Basin Heater Capacity

This field defines the power level of the basin heater, if applicable, used to avoid water freezing in an outdoor evaporative cooler basin. This numeric field contains the capacity of the electric basin heater in watts per degree Kelvin. This field is used in conjunction with the Basin Heater Set Point Temperature described in the following field. The basin heater electric power is equal to this field multiplied by the difference between the basin heater set point temperature and the dry-bulb temperature of the condenser coil inlet air. The basin heater only operates when the condenser fan is off (i.e., no compressor heat rejection). The basin heater capacity must be greater than or equal to zero, with a default value of 200 W/K if this field is left blank.

Field: Basin Heater Setpoint Temperature

This numeric field contains the set point temperature (°C) for the basin heater described in the previous field. The basin heater is active when the outdoor air dry-bulb temperature falls below this set point temperature, as long as the condenser fan is off. The default value is 2°C if this field is left blank.

Field: Design Evaporative Condenser Water Pump Power

The rated power of the evaporative condenser water pump in Watts. This value is used to calculate the power required to pump the water used to evaporatively cool the condenser inlet air. The value for this field must be greater than or equal to 0, with a default value of 1000 Watts if this field is left blank. This input field is also autocalculatable, equivalent to 0.004266 W per watt [15 W/ton] of total cooling capacity where the total cooling capacity is the sum of the rated total cooling capacities for the refrigerated cases connected to this

compressor rack (Ref. Refrigeration:Case). This field is not used when Condenser Type = AirCooled.

Field: *Evaporative Water Supply Tank Name*

This field is used to define where the compressor rack obtains water used for evaporative cooling of its condenser. If this field is left blank, the unit will obtain water directly from the mains (Ref. Water Mains Temperatures). If the name of a Water Storage Tank object is used here, then the unit will obtain its water from that tank. This field is not used when Condenser Type = Air Cooled.

Field: *Condenser Air Inlet Node Name*

This optional alpha field contains the name of the node from which the outdoor compressor rack condenser draws its outdoor air. This field is applicable only when the heat rejection location is "Outdoors" (if the heat rejection location is "Zone", this field is disregarded). If this field is left blank, the outdoor air temperature entering the condenser (dry-bulb or wet-bulb) is taken directly from the weather data. If this field is not blank, this node name must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air temperature from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air temperature is taken directly from the weather data.

Field: *End-Use Subcategory*

This field allows the specification of a user-defined end-use subcategory (e.g., "Low Temperature Rack"). A new meter for reporting is created for each unique subcategory (Ref: Report Meter). Subcategories are also reported in the ABUPS table. If this field is left blank, the equipment will be assigned to the "General" end-use subcategory.

Field: *Refrigeration:Case Name or CaseList Name*

This alpha field is the name of a single refrigerated case or the name of a caselist for multiple refrigerated cases connected to this compressor rack. This field is required.

Below is the input data dictionary definition for the Refrigeration Compressor Rack object.

```

Refrigeration:CompressorRack,
  \min-fields 25
  \extensible:1 - repeat last field, remembering to remove ; from "inner" fields.
  \memo extensible: add additional fields for field Refrigeration:Case #XX Name as necessary
A1 , \field Name
  \required-field
  \type alpha
  \reference RefrigeratedCaseCompressorRack
  \reference DesuperHeatingCoilSources
A2 , \field Heat Rejection Location
  \type choice
  \key Outdoors
  \key Zone
  \default Outdoors
N1 , \field Design Compressor Rack COP
  \type real
  \units W/W
  \minimum> 0.0
  \default 2.0
A3 , \field Compressor Rack COP Function of Temperature Curve Name
  \required-field
  \type object-list
  \object-list QuadraticCubicCurves
N2 , \field Design Condenser Fan Power
  \note Design power for condenser fan(s).
  \type real
  \units W
  \minimum 0.0
  \default 250.0
A4 , \field Condenser Fan Power Function of Temperature Curve Name
  \type object-list
  \object-list QuadraticCubicCurves
A5 , \field Condenser Type
  \type choice
  \key AirCooled
  \key EvaporativelyCooled
  \key WaterCooled
  \default AirCooled
  \note Applicable only when Heat Rejection Location is Outdoors.
A6 , \field Water-Cooled Condenser Inlet Node Name
  \type alpha
A7 , \field Water-Cooled Condenser Outlet Node Name
  \type alpha
A8 , \field Water-Cooled Loop Flow Type
  \type choice
  \key VariableFlow
  \key ConstantFlow
  \default VariableFlow
  \note Applicable only when Condenser Type is WaterCooled.
A9 , \field Water-Cooled Condenser Outlet Temperature Schedule Name
  \type object-list
  \object-list ScheduleNames
  \note Applicable only when loop Flow type is VariableFlow.
N3, \field Water-Cooled Condenser Design Flow Rate
  \type real
  \units m3/s
  \minimum> 0.0
  \note Applicable only when loop flow type is ConstantFlow.
N4, \field Water-Cooled Condenser Maximum Flow Rate
  \type real
  \units m3/s
  \minimum> 0.0
N5, \field Water-Cooled Condenser Maximum Water Outlet Temperature
  \type real
  \units C
  \minimum 10.0
  \maximum 60.0
  \default 55.0

```

```

N6, \field Water-Cooled Condenser Minimum Water Inlet Temperature
    \type real
    \units C
    \minimum 10.0
    \maximum 30.0
    \default 10.0
A10, \field Evaporative Condenser Availability Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note This field is only used for Condenser Type = EvaporativelyCooled.
    \note Schedule values greater than 0 indicate that evaporative cooling of the
    \note condenser is available. This schedule allows the user to define seasonal
    \note shutdown/draining of the water cooling system in cold climate applications.
    \note For periods with schedule values of 0, the condenser operates as AirCooled.
N7, \field Evaporative Condenser Effectiveness
    \type real
    \units dimensionless
    \minimum 0.0
    \maximum 1.0
    \default 0.9
    \note Applicable only for Condenser Type = EvaporativelyCooled.
N8, \field Evaporative Condenser Air Flow Rate
    \type real
    \units m3/s
    \minimum > 0.0
    \autocalculatable
    \default Autocalculate
    \note Applicable only for Condenser Type = EvaporativelyCooled.
    \note Used to calculate evaporative condenser water use.
N9, \field Basin Heater Capacity
    \type real
    \units W/K
    \minimum 0.0
    \default 200.0
    \note This field is only used for Condenser Type = EvaporativelyCooled and for periods
    \note when the evaporatively cooled condenser is available (field Evaporative Condenser
Availability
    \note Schedule Name). For this situation, the heater heats the basin water when the
    \note outdoor air dry-bulb temperature falls below the setpoint temperature, but
    \note only when the condenser fans are off (i.e., no refrigerated case load).
N10, \field Basin Heater Setpoint Temperature
    \type real
    \units C
    \minimum 2.0
    \default 2.0
    \note Enter the outdoor dry-bulb temperature at which the basin heater turns on.
N11, \field Design Evaporative Condenser Water Pump Power
    \type real
    \units W
    \minimum 0.0
    \default 1000.0
    \autocalculatable
    \note Design recirc water pump power for Condenser Type = EvaporativelyCooled.
    \note Applicable only for Condenser Type = EvaporativelyCooled.
A11, \field Evaporative Water Supply Tank Name
    \type object-list
    \object-list WaterStorageTankNames
    \note If blank, water supply is from Mains.
    \note Applicable only for Condenser Type = EvaporativelyCooled.
A12, \field Condenser Air Inlet Node Name
    \type alpha
    \note Applicable only when Heat Rejection Location is Outdoors and Condenser Type is
    \note not WaterCooled; otherwise, leave field blank. If field is left blank with
    \note Heat Rejection Location = Outdoors, then the model assumes that the Inlet Air
    \note conditions are the outdoor air conditions for the current timestep
    \note (e.g., no adjustment for height above ground).
A13, \field End-Use Subcategory
    \type alpha
    \retaincase
    \default General

```

```

A14 ; \field Refrigeration Case Name or Refrigeration CaseList Name
      \note Enter the name of a Refrigeration:Case or Refrigeration CaseList object.
      \type object-list
      \object-list RefrigeratedCaseNames
      \object-list RefrigeratedCaseListNames

```

The following is an example input for a Refrigeration Compressor Rack with water cooled condenser.

```

Refrigeration:CompressorRack,
MediumTempRack,          !- Refrigeration Compressor Rack Name
Outdoors,               !- Heat Rejection Location
1.7,                   !- Design Compressor Rack COP {W/W}
RackCOPfTCurve,        !- Compressor Rack COP as a Function of Temperature Curve
1025.0,                !- Design Condenser Fan Power {W}
RackCondFanCurve,      !- Condenser Fan Power as a Function of Temperature Curve
WaterCooled,          !- Condenser Type
Condenser Inlet Node,  !- Water-cooled Condenser Inlet Node Name
Condenser Outlet Node, !- Water-cooled Condenser Outlet Node Name
VariableFlow,          !- Water-cooled Loop Flow Type
Cond Outlet Temp Sch,  !- Water-cooled Condenser Outlet Temperature Schedule Name
,                      !- Water-cooled Condenser Design Volumetric Flow Rate {m3/s}
0.003,                !- Water-cooled Condenser Maximum Volumetric Flow Rate {m3/s}
55,                   !- Water-cooled Condenser Maximum Water Outlet Temperature {C}
,                      !- Water-cooled Condenser Minimum Water Inlet Temperature {C}
,                      !- Evaporative Condenser Availability Schedule Name
,                      !- Evaporative Condenser Effectiveness {dimensionless}
,                      !- Evaporative Condenser Air Volume Flow Rate {m3/s}
,                      !- Basin Heater Capacity {W/K}
,                      !- Basin Heater Set Point Temperature {C}
,                      !- Design Evaporative Condenser Water Pump Power {W}
,                      !- Evaporative Water Supply Tank Name
,                      !- Condenser Air Inlet Node Name
,                      !- End-Use Subcategory
MediumTempCaseList;    !- Refrigeration:Case or CaseList Name

```

Refrigeration Compressor Rack Outputs

```

Zone,Average, Refrigeration Compressor Rack Electric Power [W]
Zone,Sum, Refrigeration Compressor Rack Electric Consumption [J]
Zone,Average, Refrigeration Compressor Rack Condenser Fan Electric Power [W]
Zone,Sum, Refrigeration Compressor Rack Condenser Fan Electric Consumption [J]
Zone,Average, Refrigeration Compressor Rack Total Heat Transfer Rate [W]
Zone,Sum, Refrigeration Compressor Rack Total Heat Transfer Energy [J]
Zone,Average, Refrigeration Compressor Rack COP [W/W]
If Condenser Type = Evap Cooled and Heat Rejection Location = Outdoors:
Zone,Average, Refrigeration Compressor Rack Evap Condenser Pump Electric Power [W]
Zone,Sum, Refrigeration Compressor Rack Evap Condenser Pump Elec Consumption [J]
Zone,Average, Refrigeration Compressor Rack Evap Cond Basin Heater Elec Power [W]
Zone,Sum, Refrigeration Compressor Rack Evap Cond Basin Heater Elec Consumption [J]
Zone,Average, Refrigeration Compressor Rack Evap Condenser Water Consumption Rate [m3/s]
Zone,Sum, Refrigeration Compressor Rack Evap Condenser Water Consumption [m3]
If Condenser Type = Water Cooled and Heat Rejection Location = Outdoors:
System,Average, Compressor Rack Condenser Mass Flow Rate [kg/s]
System,Average, Compressor Rack Condenser Heat Transfer Rate [W]
System,Sum, Compressor Rack Condenser Heat Transfer Energy [J]
If Heat Rejection Location = Zone:
Zone,Average, Rack Sensible Heating Rate To Zone [W]
Zone,Sum, Rack Sensible Heating Energy To Zone [J]

```


Zone, Average, Rack Sensible Heating Rate To HVAC Return Air [W]
 Zone, Sum, Rack Sensible Heating Energy To HVAC Return Air [J]

Refrigeration Compressor Rack Electric Power [W]

This output is the electric power input to the rack compressor(s) in Watts.

Refrigeration Compressor Rack Electric Consumption [J]

This is the electricity consumption of the rack compressor(s) in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Refrigeration, Group Key = Plant (Ref. Report Meter).

Refrigeration Compressor Rack Condenser Fan Electric Power [W]

This output is the electric input to the rack condenser fan(s) in Watts.

Refrigeration Compressor Rack Condenser Fan Electric Consumption [J]

This is the electricity consumption of the rack condenser fan(s) in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Refrigeration, Group Key = Plant (Ref. Report Meter).

Refrigeration Compressor Rack Total Heat Transfer Rate [W]

This output is the total heat transfer rate of the refrigeration compressor rack in Watts. It is the sum of all of the heat transfer rates for the refrigerated cases that are connected to this rack. This value does not include compressor or condenser fan heat.

Refrigeration Compressor Rack Total Heat Transfer [J]

This is the total heat transfer of the refrigeration compressor rack in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = EnergyTransfer, End Use Key = Refrigeration, Group Key = Plant (Ref. Report Meter).

Refrigeration Compressor Rack COP [W/W]

This field is the refrigeration compressor rack coefficient of performance. It is the actual compressor rack COP for the timestep being reported, accounting for the COP variation as a function of temperature. It is calculated as the Design Compressor Rack COP times the Compressor Rack COP as a Function of Temperature Curve evaluated at the effective condenser entering air temperature for the timestep being reported.

Refrigeration Compressor Rack Evap Condenser Pump Electric Power [W]

This is the electrical power requirement in Watts for the timestep being reported for the water pump used with evaporative cooling of the compressor rack condenser.

Refrigeration Compressor Rack Evap Condenser Pump Elec Consumption [J]

This is the electricity consumption in Joules of the water pump used with evaporative cooling of the compressor rack condenser for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Refrigeration, Group Key = Plant. Use of an optional subkey category is also available, with default to the General end-use subcategory (Ref. Report Meter).

Refrigeration Compressor Rack Evap Cond Basin Heater Elec Power [W]

This is the electrical power requirement in Watts for the timestep being reported for the water heater in the basin of the evaporative system used to cool the compressor rack condenser.

Refrigeration Compressor Rack Evap Cond Basin Heater Elec Consumption [J]

This is the electricity consumption in Joules of the water heater used to prevent freezing of the evaporative cooling system for the compressor rack condenser for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End

Use Key = Refrigeration, Group Key = Plant. Use of an optional subkey category is also available, with default to the General end-use subcategory (Ref. Output:Meter).

Refrigeration Compressor Rack Evap Condenser Water Consumption Rate [m³/s]

The volumetric flow rate in m³/s of water consumed while providing evaporative cooling of the compressor rack condenser.

Refrigeration Compressor Rack Evap Condenser Water Consumption [m³]

This is the water consumed by evaporation in m³ while providing evaporative cooling of the compressor rack condenser for the timestep being reported. This output is also added to a report meter with Resource Type = Water, End Use Key = Refrigeration, Group Key = Plant. Use of an optional subkey category is also available, with default to the General end-use subcategory (Ref. Report Meter).

Compressor Rack Condenser Mass Flow Rate [kg/s]

When condenser type is Water Cooled, this is the mass flow rate of water flowing through the water cooled condenser.

Compressor Rack Condenser Heat Transfer Rate [W]

When condenser type is Water Cooled, this is the total heat transfer across the condenser (i.e., compressor energy and case cooling).

Compressor Rack Condenser Heat Transfer Energy [J]

When condenser type is Water Cooled, this is the total heat energy flowing across the condenser for the timestep being reported.

Rack Sensible Heating Rate To Zone [W]

This field is the rate of sensible heating in Watts provided to the zone by condenser waste heat rejection, which impacts the zone air heat balance.

Rack Sensible Heating Energy To Zone [J]

This field is the sensible heating energy in Joules provided to the zone by condenser waste heat rejection for the timestep being reported.

Rack Sensible Heating Rate To HVAC Return Air [W]

This field is the rate of sensible heating in Watts provided by condenser waste heat rejection to the HVAC return air (zone return air path outlet node), which impacts the HVAC return air temperature. If the HVAC system is off for a simulation timestep (no return air mass flow), then this sensible heating is actually provided to the zone air instead (even though a non-zero value is reported here).

Rack Sensible Heating Energy To HVAC Return Air [J]

This field is the sensible heating energy in Joules provided by condenser waste heat rejection to the HVAC return air (zone return air path outlet node) for the timestep being reported. If the HVAC system is off for a simulation timestep (no return air mass flow), then this sensible heating is actually provided to the zone air instead (even though a non-zero value is reported here).

Refrigeration:Case

The Refrigeration Case object works in conjunction with a compressor rack or a refrigeration system object (Refrigeration:CompressorRack or Refrigeration:System) to simulate the performance of a refrigerated case system. The refrigerated case model uses performance information at rated conditions along with performance curves for latent case credits and defrost heat load to determine performance at off-rated conditions. Energy use for lights, fans and anti-sweat heaters is modeled based on inputs for nominal power, schedules, and control

type. The refrigerated case model accounts for the sensible and latent heat exchange with the surrounding environment (termed "case credits") which impacts the temperature and humidity in the zone where the case is located.

The Refrigeration Case object inputs include a case name, an availability schedule name, the zone name for the location of the case, and the temperature and relative humidity of the ambient (zone) air surrounding the refrigerated case at the rating conditions for case performance. Additional inputs include the total cooling capacity, latent heat ratio, and run time fraction of the refrigerated case at rated conditions. The case length and operating temperature (average temperature of air/products within the case) must also be specified.

The refrigerated case model requires two curves to describe performance at off-rated conditions (i.e., at different zone humidity levels): the latent case credit curve and the defrost energy correction curve. The user must enter cubic performance curves with the independent variable being user selectable (case temperature, zone relative humidity, or zone dewpoint temperature).

The user can select from six case defrost types, with additional inputs being required depending on the type selected. The user must enter a defrost schedule (unless Case Defrost Type = None), and an optional defrost drip-down schedule can be specified to allow additional time for melted frost to drain from the cooling coil following the regular defrost period.

Inputs are required for case fans, lights, and anti-sweat heaters. Case lighting can be controlled by the user through entering a schedule. The case fans operate whenever the cooling coil is operating and during defrost periods for certain case defrost types. Anti-sweat heater power can be controlled by several methods which are user selectable. The model assumes that the fans are contained within the thermal envelope of the case and provide a direct heat load on the case cooling coil. For lighting and anti-sweat heaters, the user can specify the fraction of their respective heat loads that directly impact the case cooling coil (with the remainder of their heat load impacting the surrounding zone air).

The user has the option of specifying a case restocking schedule and a schedule for modifying the case credits if needed. Finally, the user can specify the under case HVAC return air fraction which determines the portion of the case credits that directly impact the HVAC return air conditions (with the remainder of the case credits impacting the zone sensible and latent loads).

Field: Name

A unique user-assigned name for an instance of a refrigerated case. Any reference to this case by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the refrigerated case can operate during a given time period. A schedule value greater than 0 (maximum schedule value of 1.0 is typically used) indicates that the case will operate during a given time period. A value equal to 0 denotes that the case does not operate (everything is OFF: refrigeration, fans, lights, anti-sweat, etc.). Typically the refrigerated case will operate throughout the day (i.e., the schedule will contain 1 for all time periods); however, cases require maintenance and/or cleaning and this can be modeled accordingly using this schedule if desired.

Field: Zone Name

The name of the zone where the refrigerated case is located. The refrigerated case will impact the air heat balance in this zone. When modeling multiple refrigerated cases connected to a single compressor rack where the condenser heat is rejected to the zone (ref: Refrigeration:CompressorRack), **all** of the refrigerated cases connected to that compressor rack must be located in the same zone.

Field: Rated Ambient Temperature

Dry-bulb temperature of the ambient (zone) air surrounding the refrigerated case at the rating conditions for refrigerated case performance. The default value for this field is 23.9°C (75°F). This temperature must be greater than 0°C and greater than the case operating temperature.

Field: Rated Ambient Relative Humidity

Relative humidity of the ambient (zone) air surrounding the refrigerated case at the rating conditions for refrigerated case performance. The default value for this field is 55% RH.

Field: Rated Total Cooling Capacity per Unit Length

The total, full load cooling capacity (sensible plus latent) in watts per unit length of refrigerated case (W/m) at rated conditions (i.e., at the Rated Ambient Temperature, Rated Ambient Relative Humidity, and Case Operating Temperature). The value entered for this field must be greater than zero, with a default value of 1900 W/m if the field is blank.

Field: Rated Latent Heat Ratio

The latent heat ratio (LHR=latent capacity divided by total cooling capacity) of the refrigerated case at rated conditions (i.e., at the Rated Ambient Temperature, Rated Ambient Relative Humidity, and Case Operating Temperature). The value for this field can range from zero to 1.0, with a default value of 0.3 if the field is blank.

Field: Rated Runtime Fraction

The runtime fraction of the refrigerated case at rated conditions (i.e., at the Rated Ambient Temperature, Rated Ambient Relative Humidity, and Case Operating Temperature). Even at rated conditions, refrigerated cases typically include additional cooling capacity to account for product stocking and recovery from defrost. The rated runtime fraction for refrigerated cases typically ranges from 0.8 to 0.9. The entered value for this field must be greater than 0.0 and less than or equal to 1.0, and the default value is 0.85 if the field is blank.

Field: Case Length

The length of the refrigerated case in meters. The entered value for this field must be greater than 0.0, and the default value is 3 meters if the field is blank.

Field: Case Operating Temperature

The average temperature of the air and products within the refrigerated case in °C. The refrigerated case manufacturer typically provides this information in the product literature. Typical operating temperatures for medium temperature cases are 1.6°C to 7.2°C (35°F to 45°F). Typical operating temperatures for low temperature cases are -28.9°C to -17.8°C (-20°F to 0°F). The entered value for this field must be less than 20°C and lower than the Rated Ambient Temperature. The default value is 1.1°C if the field is blank.

Field: Latent Case Credit Curve Type

This alpha field defines the form of the curve used to modify the latent case credits (latent heat removed from the zone where the refrigerated case is located) at off-rated conditions. The valid choices for this field are:

- CaseTemperatureMethod

This method defines the variation in latent case credits as a cubic function of Case Operating Temperature. The result from the cubic curve is multiplied by the difference between the rated ambient relative humidity and the actual zone relative humidity, and one minus this value is multiplied by the Rated LHR to give the operating LHR at the actual zone humidity condition.

- RelativeHumidityMethod

This method defines the variation in latent case credits as a cubic function of ambient (zone) air relative humidity.

- DewpointMethod

This method defines the variation in latent case credits as a cubic function of ambient (zone) air dewpoint temperature.

The default curve type is the Case Temperature Method. Refer to the Engineering Reference for further information on how latent case credits are modeled.

Field: Latent Case Credit Curve Name

The name of a **cubic** performance curve (ref: Performance Curves) that parameterizes the variation of the latent case credits at off-rated conditions. The curve should be normalized to have a value of 1.0 at the rated ambient air conditions defined above.

Field: Standard Case Fan Power per Unit Length

The total standard fan power in watts per unit length of refrigerated case (W/m). This value is representative of refrigerated cases with standard fans and is used to determine the sensible case credits. The entered value for this field must be greater than or equal to zero, and the default value is 75.0 W/m if the field is blank.

Field: Operating Case Fan Power per Unit Length

The total operating fan power in watts per unit length of refrigerated case (W/m). Enter the actual power for the installed fans. High efficiency fans may be modeled by inserting the high efficiency fan power in this field with the standard efficiency fan power inserted in the previous field (i.e., Standard Case Fan Power per Unit Length). The entered value for this field must be greater than or equal to zero, and the default value is 75.0 W/m if the field is blank.

Field: Standard Case Lighting Power per Unit Length

The total lighting power in watts per unit length of refrigerated case (W/m). This value should represent the standard lighting provided by the case manufacturer. If energy-efficient lights are being modeled, then use the next field (i.e. Case Lighting Schedule Name) to specify the name of a schedule that contains the fraction of the Standard Case Lighting Power per Unit Length to be modeled for each timestep of the simulation period. The entered value for this field must be greater than or equal to zero, and the default value is 90.0 W/m if the field is blank.

Field: Case Lighting Schedule Name

The name of the schedule (ref: Schedule) that denotes the fraction of refrigerated case lights that operate during a given time period. A schedule value greater than 0 indicates that the lights will operate during that time period (maximum schedule value of 1.0 means lights are fully on at the Standard Case Lighting Power per Unit Length level). A schedule value of zero denotes that the lights are off. The refrigerated case lights will typically operate only when the store is open for business and can be scheduled off as desired via this schedule. The user should enter the nominal lighting power for “standard” lights for the refrigerated case in the field Standard Case Lighting Power per Unit Length. If energy-efficient lights are used, the maximum case lighting schedule values may be 0.7 – 0.8 to account for the improved lighting efficiency.

Field: Fraction of Lighting Energy To Case

The fraction of the lighting energy that directly contributes to the case heat load. The remainder of the lighting energy (1 – fraction) is a heating load to the zone where the case is located. This field can be used to model lighting ballasts and bulbs located outside the air curtain of the refrigerated case. The value for this field can range from zero to 1.0, with a default value of 1.0 if the field is blank.

Field: Case Anti-Sweat Heater Power per Unit Length

The electric anti-sweat heater power in watts per unit length of refrigerated case (W/m). The entered value for this field must be greater than or equal to zero, and the default value is 0 W/m if the field is blank.

Field: Minimum Anti-Sweat Heater Power per Unit Length

The minimum electric anti-sweat heater power in watts per unit length of refrigerated case (W/m). Anti-sweat heater power will remain at or above this value for anti-sweat heater control types linear, dewpoint method, or heat balance method. Other anti-sweat heater control types disregard this field. The entered value for this field must be greater than or equal to zero, and the default value is 0 W/m if the field is blank.

Field: Anti-Sweat Heater Control Type

The type of anti-sweat heater control used for this refrigerated case. Valid choices are None, Constant, Linear, DewpointMethod, or HeatBalanceMethod. The default is None if the field is blank. Refer to the Engineering Reference for further information on how the different anti-sweat heater controls are modeled.

Field: Humidity at Zero Anti-Sweat Heater Energy

The value of this numeric field is only used when the Linear anti-sweat heater control type is selected. Enter the zone relative humidity where anti-sweat heater energy use is zero. Negative values for relative humidity may be entered. Other anti-sweat heater control types disregard this field. The value entered for this field must be less than the Rated Ambient Relative Humidity specified above. The default for this field is -10.0.

Field: Case Height

The value of this numeric field is used when Heat Balance Method anti-sweat heater control is selected. Enter the case height in meters. Other anti-sweat heater control types disregard this field. The entered value for this field must be greater than zero when Heat Balance Method anti-sweat heater control is selected, and the default value is 1.5 meters if the field is blank.

Field: Fraction of Anti-Sweat Heater Energy To Case

This value denotes the fraction of anti-sweat heater energy that results in a direct heat load to the refrigerated case. The remainder of the anti-sweat heater energy (1-fraction) is a heating load to the zone where the refrigerated case is located. The value for this field can range from zero to 1.0, with a default value of 1.0 if the field is blank.

Field: Case Defrost Power per Unit Length

The defrost power in watts per unit length of refrigerated case (W/m). This input is required for hot-gas or electric defrost types. Refrigerated case manufacturers do not typically provide information on the heat input for hot-gas defrost. Information provided for electric defrost power can be substituted here for refrigerated cases using hot-gas defrost if other information is not available. Only electric Case Defrost Types consume electricity during the defrost period. The entered value for this field must be greater than or equal to zero, and the default value is 0 W/m if the field is blank.

Field: Case Defrost Type

The type of defrost used for this refrigerated case. Valid choices are None, Off-Cycle, Hot-Gas, Hot-Gas with Temperature Termination, Electric, and Electric with Temperature Termination. The default defrost type is Off-Cycle if the field is blank. Refer to the Engineering Reference for further information on how the different case defrost types are modeled.

Field: Case Defrost Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the refrigerated case requires defrosting. A schedule value greater than 0 (maximum schedule value of 1.0 is usually used) indicates that defrost can be on during a given time period. A value equal to 0 denotes that the defrost is off. Defrost schedules normally repeat the duration and number of defrost cycles for each day of the year. The refrigerated case manufacturer typically provides this information with the product literature. The use of Compact Schedules (ref. Schedules) are ideal for this purpose.

Field: Case Defrost Drip-Down Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the refrigerated case requires additional time for draining condensate after the defrost period. A schedule value greater than 0 (maximum schedule value of 1.0 is usually used) indicates that the defrost drip-down period is on during a given time period. A value equal to 0 denotes that the defrost drip-down period is over. The refrigerated case manufacturer typically provides this information with the product literature.

Each defrost drip-down period specified in this schedule should start at the same time as the corresponding defrost period specified in the schedule for Case Defrost Schedule, and the drip-down schedule defrost period should always be longer than or equal to the length of the defrost schedule time period. For example, if the case defrost schedule contains a defrost period from 7:00 to 7:15, you would specify a case defrost drip-down period from 7:00 to 7:20 if you wanted to model a 5 minute condensate drip-down period after the regular defrost period. If no drip-down schedule is entered, then the case defrost schedule (specified for the previous input field) will be used. The use of Compact Schedules (ref. Schedules) are ideal for this purpose.

Field: Defrost Energy Correction Curve Type

This alpha field defines the form of the correction curve used to modify the defrost energy use (and the associated load on the case cooling coil) at off-rated conditions. The valid choices for this field are:

- None
This choice specifies that a defrost energy correction curve will not be used.
- CaseTemperatureMethod
This method defines the variation in defrost energy as a cubic function of Case Operating Temperature. The result from the cubic curve is multiplied by the difference between the rated ambient relative humidity and the actual zone relative humidity, and one minus this value is multiplied by the Case Defrost Power to give the (average) operating defrost power at the actual zone humidity condition.
- RelativeHumidityMethod
This method defines the variation in defrost energy as a cubic function of ambient (zone) air relative humidity.
- DewpointMethod
This method defines the variation in defrost energy as a cubic function of ambient (zone) air dewpoint temperature.

The default curve type is None. The methods described here (e.g. Case Temperature, Relative Humidity, and Dewpoint) are applicable only to Electric with Temperature Termination and Hot-Gas with Temperature Termination case defrost types. Refer to the Engineering Reference for further information on how the defrost energy correction types are modeled.

Field: Defrost Energy Correction Curve Name

The name of a **cubic** performance curve (ref: Performance Curves) that parameterizes the variation of the defrost energy (and the associated load on the case cooling coil) at off-rated conditions. The curve should be normalized to have the value of 1.0 at the rated ambient air conditions defined above. The defrost energy correction curve name is used only for the Electric with Temperature Termination and Hot-Gas with Temperature Termination case defrost types.

Field: Under Case HVAC Return Air Fraction

This field denotes the fraction of HVAC system (air loop) return air that passes beneath the refrigerated case, if any. At times it is necessary to design HVAC systems with under case returns to avoid overcooling the area around the refrigerated case, thus providing a more comfortable environment for the zone occupants. This return air fraction affects the portion of the case credits (sensible and latent) that are applied to the air returning to the HVAC system, while the remainder of the case credits directly impacts the zone air heat balance. Refer to the Engineering Reference for further information on how this is modeled. The sum of the Under Case HVAC Return Air Fractions for all refrigerated cases located in a single zone must be less than or equal to 1.0. The value for this field can range from zero to 1.0, with a default value of 0 if the field is blank.

Field: Refrigerated Case Restocking Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the refrigerated case is being restocked with product. The schedule should contain values in units of Watts per unit length of refrigerated case (W/m). This field can be used to denote the additional load imposed on the refrigerated case from stocking the case with product that is warmer than the refrigerated case temperature. This information is difficult to find and may require additional research for proper modeling; however, this schedule is available for this purpose if desired. If restocking of the refrigerated case will not be simulated, enter a schedule with values of zero for all time periods or leave this field blank.

Field: Case Credit Fraction Schedule Name

The name of the schedule (ref: Schedule) that denotes a fraction of both the sensible and latent case credits to be applied to the zone and/or the HVAC system return air. Schedule values must be from 0 to 1. This allows correction of the case credits for various refrigerated case types. For instance, if glass door refrigerated display cases are installed in a store that is operated 12 hours per day, then the doors will remain closed during the unoccupied times and would therefore reduce the sensible and latent case credits during the unoccupied time. Leaving this field blank will result in no case credit fraction being applied during the simulation.

Field: Design Evaporator Temperature

The value of this numeric field is used only with the refrigeration system and is not read for the compressor-rack system. For the refrigeration system, it is used to evaluate compressor performance and is also used when the evaporator pressure and temperature are allowed to float at load less than the design load. The minimum value is -70C and the maximum value is 40C. The default value is 5C less than the case temperature.

Field: Average Refrigerant Charge Inventory

The value of this optional field is the refrigerant inventory present in the refrigerated case during ordinary operation. The value is used to produce an estimate of the total refrigerant present in the refrigeration system. The value is entered in kg/m.

Below is the input data dictionary description for the Refrigeration:Case object.


```
Refrigeration:Case,  
  \min-fields 27  
A1, \field Name  
  \required-field  
  \type alpha  
  \reference RefrigeratedCaseNames  
A2, \field Availability Schedule Name  
  \required-field  
  \type object-list  
  \object-list ScheduleNames  
A3, \field Zone Name  
  \note This must be a controlled zone and appear in a ZoneHVAC:EquipmentConnections object.  
  \required-field  
  \type object-list  
  \object-list ZoneNames  
N1, \field Rated Ambient Temperature  
  \type real  
  \units C  
  \default 23.9  
  \minimum> 0.0  
N2, \field Rated Ambient Relative Humidity  
  \type real  
  \units percent  
  \default 55.0  
  \minimum> 0.0  
  \maximum< 100.0  
N3, \field Rated Total Cooling Capacity per Unit Length  
  \type real  
  \units W/m  
  \default 1900  
  \minimum> 0.0  
N4, \field Rated Latent Heat Ratio  
  \type real  
  \default 0.3  
  \minimum 0.0  
  \maximum 1.0  
N5, \field Rated Runtime Fraction  
  \type real  
  \default 0.85  
  \minimum> 0.0  
  \maximum 1.0  
N6, \field Case Length  
  \type real  
  \units m  
  \default 3.0  
  \minimum> 0.0  
N7, \field Case Operating Temperature  
  \type real  
  \units C  
  \default 1.1  
  \maximum< 20.0
```

```

A4 , \field Latent Case Credit Curve Type
     \type choice
     \key CaseTemperatureMethod
     \key RelativeHumidityMethod
     \key DewpointMethod
     \default CaseTemperatureMethod
A5 , \field Latent Case Credit Curve Name
     \required-field
     \type object-list
     \object-list CubicCurves
N8 , \field Standard Case Fan Power per Unit Length
     \type real
     \units W/m
     \default 75.0
     \minimum 0.0
N9 , \field Operating Case Fan Power per Unit Length
     \type real
     \units W/m
     \default 75.0
     \minimum 0.0
N10, \field Standard Case Lighting Power per Unit Length
     \type real
     \units W/m
     \default 90.0
A6 , \field Case Lighting Schedule Name
     \required-field
     \type object-list
     \object-list ScheduleNames
N11, \field Fraction of Lighting Energy to Case
     \type real
     \default 1.0
     \minimum 0.0
     \maximum 1.0
N12, \field Case Anti-Sweat Heater Power per Unit Length
     \type real
     \units W/m
     \minimum 0
     \default 0
N13, \field Minimum Anti-Sweat Heater Power per Unit Length
     \type real
     \units W/m
     \minimum 0
     \default 0
     \note This field is only applicable to the Linear, Dewpoint Method, and
     \note Heat Balance Method anti-sweat heater control types
A7 , \field Anti-Sweat Heater Control Type
     \type choice
     \key None
     \key Constant
     \key Linear
     \key DewpointMethod
     \key HeatBalanceMethod
     \default None
N14, \field Humidity at Zero Anti-Sweat Heater Energy
     \type real
     \units percent
     \default -10.0
     \note This field is only applicable to Linear AS heater control type
     \note Zone relative humidity (%) where anti-sweat heater energy is zero
N15, \field Case Height
     \type real
     \units m
     \minimum 0
     \default 1.5
     \note This field only applicable to Heat Balance Method AS heater control type
     \note Height must be greater than zero if Heat Balance Method AS heater control is selected
N16, \field Fraction of Anti-Sweat Heater Energy to Case
     \type real
     \default 1.0
     \minimum 0.0
     \maximum 1.0

```

```

N17, \field Case Defrost Power per Unit Length
      \type real
      \units W/m
      \note Used with electric and hot-gas defrost types only
      \default 0.0
      \minimum 0.0
A8,  \field Case Defrost Type
      \type choice
      \key None
      \key OffCycle
      \key HotGas
      \key Electric
      \key HotGasWithTemperatureTermination
      \key ElectricWithTemperatureTermination
      \default OffCycle
A9,  \field Case Defrost Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note A case defrost schedule name is required unless case defrost type = None
A10, \field Case Defrost Drip-Down Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note The start time for each defrost period in this drip-down schedule should coincide with
      \note the start time for each defrost period in the case defrost schedule (previous input
      \note field).The length of each defrost drip-down period must be greater than or equal to the
      \note corresponding defrost period specified in the case defrost schedule. This extra time
      \note allows the melted frost to drip from the coil before refrigeration is restarted.
A11, \field Defrost Energy Correction Curve Type
      \type choice
      \key None
      \key CaseTemperatureMethod
      \key RelativeHumidityMethod
      \key DewpointMethod
      \default None
      \note Case Temperature, Relative Humidity, and Dewpoint Method are applicable to case defrost
      \note types electric with temperature termination and hot-gas with temperature termination only.
A12, \field Defrost Energy Correction Curve Name
      \type object-list
      \object-list CubicCurves
      \note Defrost Energy Correction Curve Name is applicable to case defrost types electric
      \note with temperature termination and hot-gas with temperature termination only.
N18, \field Under Case HVAC Return Air Fraction
      \type real
      \minimum 0.0
      \maximum 1.0
      \default 0.0
A13, \field Refrigerated Case Restocking Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Schedule values should be in units of Watts per unit case length (W/m)
      \note Leave this field blank if no restocking is to be modeled
A14, \field Case Credit Fraction Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Schedule values should be from 0 to 1
      \note Leave this field blank if no case credit fraction is to be applied
N19, \field Design Evaporator Temperature
      \note saturated temperature for pressure leaving case
      \note required for detailed refrigeration system, not for compressor rack
      \type real
      \units C
      \minimum -70.0
      \maximum 40.0
N20; \field Average Refrigerant Charge Inventory
      \note Units are kg/m
      \type real
      \default 0.0

```

Refrigeration:Case Outputs

Zone,Average,Refrigerated Case Evaporator Total Heat Transfer Rate [W]
--

```

Zone,Sum,Refrigerated Case Evaporator Total Heat Transfer [J]
Zone,Average,Refrigerated Case Evaporator Sensible Heat Transfer Rate [W]
Zone,Sum,Refrigerated Case Evaporator Sensible Heat Transfer [J]
Zone,Average,Evaporator Latent Heat Transfer Rate [W]
Zone,Sum,Refrigerated Case Evaporator Latent Heat Transfer [J]
Zone,Average,Refrigerated Case Sensible Cooling Zone Credit Rate [W]
Zone,Sum,Refrigerated Case Sensible Cooling Zone Credit Energy [J]
Zone,Average,Refrigerated Case Sensible Heating Zone Credit Rate [W]
Zone,Sum,Refrigerated Case Sensible Heating Zone Credit Energy [J]
Zone,Average,Refrigerated Case Latent Zone Credit Rate [W]
Zone,Sum,Refrigerated Case Latent Zone Credit Energy [J]
Zone,Average,Refrigerated Case Sensible Cooling HVAC RA Credit Rate [W]
Zone,Sum,Refrigerated Case Sensible Cooling HVAC RA Credit Energy [J]
Zone,Average,Refrigerated Case Sensible Heating HVAC RA Credit Rate [W]
Zone,Sum,Refrigerated Case Sensible Heating HVAC RA Credit Energy [J]
Zone,Average,Refrigerated Case Latent HVAC RA Credit Rate [W]
Zone,Sum,Refrigerated Case Latent HVAC RA Credit Energy [J]
Zone,Average,Refrigerated Case Evaporator Fan Electric Power [W]
Zone,Sum,Refrigerated Case Evaporator Fan Electric Consumption [J]
Zone,Average,Refrigerated Case Lighting Electric Power [W]
Zone,Sum,Refrigerated Case Lighting Electric Consumption [J]
Zone,Average,Refrigerated Case Latent Case Credit Curve Value
If case defrost type is Electric or Hot-Gas, with Temperature Termination
Zone,Average,Refrigerated Case Defrost Energy Correction Curve Value
If anti-sweat heater control type is not equal to None:
Zone,Average,Refrigerated Case Anti-Sweat Electric Power [W]
Zone,Sum,Refrigerated Case Anti-Sweat Electric Consumption [J]
If case defrost type is Electric or Electric with Temperature Termination:
Zone,Average,Refrigerated Case Defrost Electric Power [W]
Zone,Sum,Refrigerated Case Defrost Electric Consumption [J]

```

Refrigerated Case Evaporator Total Heat Transfer Rate [W]

This field is the total (sensible plus latent) cooling rate of the refrigerated case evaporator coil in Watts.

Refrigerated Case Evaporator Total Heat Transfer [J]

This field is the total (sensible plus latent) cooling of the refrigerated case evaporator coil in Joules over the timestep being reported. This output is also added to a report meter with Resource Type = EnergyTransfer, End Use Key = Refrigeration, Group Key = Building (Ref. Report Meter).

Refrigerated Case Evaporator Sensible Heat Transfer Rate [W]

This field is the sensible cooling rate of the refrigerated case evaporator coil in Watts.

Refrigerated Case Evaporator Sensible Heat Transfer [J]

This field is the sensible cooling of the refrigerated case evaporator coil in Joules over the timestep being reported.

Refrigerated Case Evaporator Latent Heat Transfer Rate [W]

This field is the latent cooling (dehumidification) rate of the refrigerated case evaporator coil in Watts.

Refrigerated Case Evaporator Latent Heat Transfer [J]

This field is the latent cooling (dehumidification) of the refrigerated case evaporator coil in Joules over the timestep being reported.

Refrigerated Case Sensible Cooling Zone Credit Rate [W]

This field is the rate of sensible cooling case credits delivered to the zone in Watts. If an under case return duct is simulated, only a portion of the sensible case credits are applied to the zone. A positive value is reported when the zone is cooled by sensible case credits, otherwise a zero is reported.

Refrigerated Case Sensible Cooling Zone Credit Energy [J]

This field is the amount of sensible cooling case credit energy delivered to the zone in Joules. If an under case return duct is simulated, only a portion of the sensible case credits are applied to the zone. A positive value is reported when the zone is cooled by sensible case credits, otherwise a zero is reported.

Refrigerated Case Sensible Heating Zone Credit Rate [W]

This field is the rate of sensible heating case credits delivered to the zone in Watts. If an under case return duct is simulated, only a portion of the sensible case credits are applied to the zone. A positive value is reported when the zone is heated by sensible case credits, otherwise a zero is reported.

Refrigerated Case Sensible Heating Zone Credit Energy [J]

This field is the amount of sensible heating case credit energy delivered to the zone in Joules. If an under case return duct is simulated, only a portion of the sensible case credits are applied to the zone. A positive value is reported when the zone is heated by sensible case credits, otherwise a zero is reported.

Refrigerated Case Latent Zone Credit Rate [W]

This field is the rate of latent cooling (dehumidification) case credits delivered to the zone in Watts. If an under case return duct is simulated, only a portion of the latent case credits are applied to the zone. A negative value (or zero) will be reported since the refrigerated case provides dehumidification (thereby reducing the zone latent load).

Refrigerated Case Latent Zone Credit Energy [J]

This field is the amount of latent cooling (dehumidification) case credit energy delivered to the zone in Joules. If an under case return duct is simulated, only a portion of the latent case credits are applied to the zone. A negative value (or zero) will be reported since the refrigerated case provides dehumidification (thereby reducing the zone latent load).

Refrigerated Case Sensible Cooling HVAC RA Credit Rate [W]

This field is the rate of sensible cooling case credits delivered to the return air duct (zone return air node) in Watts. If an under case return duct is simulated, a portion of the sensible case credits are applied to the HVAC (zone) return air. A positive value is reported when the return air is cooled by sensible case credits, otherwise a zero is reported. If the HVAC system is off for a simulation timestep (no return air mass flow), then this sensible cooling is actually provided to the zone air instead (even though a non-zero value is reported here).

Refrigerated Case Sensible Cooling HVAC RA Credit Energy [J]

This field is the amount of sensible cooling case credit energy delivered to the return air duct (zone return air node) in Joules. If an under case return duct is simulated, a portion of the sensible case credits are applied to the HVAC (zone) return air. A positive value is reported when the return air is cooled by sensible case credits, otherwise a zero is reported. If the HVAC system is off for a simulation timestep (no return air mass flow), then this sensible cooling is actually provided to the zone air instead (even though a non-zero value is reported here).

Refrigerated Case Sensible Heating HVAC RA Credit Rate [W]

This field is the rate of sensible heating case credits delivered to the return air duct (zone return air node) in Watts. If an under case return duct is simulated, a portion of the sensible case credits are applied to the HVAC (zone) return air. A positive value is reported when the return air is heated by sensible case credits, otherwise a zero is reported. If the HVAC system is off for a simulation timestep (no return air mass flow), then this sensible heating is actually provided to the zone air instead (even though a non-zero value is reported here).

Refrigerated Case Sensible Heating HVAC RA Credit Energy [J]

This field is the amount of sensible heating case credit energy delivered to the return air duct (zone return air node) in Joules. If an under case return duct is simulated, a portion of the sensible case credits are applied to the HVAC (zone) return air. A positive value is reported when the return air is heated by sensible case credits, otherwise a zero is reported. If the HVAC system is off for a simulation timestep (no return air mass flow), then this sensible heating is actually provided to the zone air instead (even though a non-zero value is reported here).

Refrigerated Case Latent HVAC RA Credit Rate [W]

This field is the rate of latent cooling (dehumidification) case credits delivered to the return air duct (zone return air node) in Watts. If an under case return duct is simulated, a portion of the latent case credits are applied to the HVAC (zone) return air. A negative value (or zero) will be reported in all cases since the refrigerated case provides dehumidification (thereby reducing the zone latent load). If the HVAC system is off for a simulation timestep (no return air mass flow), then this latent energy is actually provided to the zone air instead (even though a non-zero value is reported here).

Refrigerated Case Latent HVAC RA Credit Energy [J]

This field is the amount of latent cooling (dehumidification) case credit energy delivered to the return air duct (zone return air node) in Joules. If an under case return duct is simulated, only a portion of the latent case credits are applied to the HVAC (zone) return air. A negative value (or zero) will be reported since the refrigerated case provides dehumidification (thereby reducing the zone latent load). If the HVAC system is off for a simulation timestep (no return air mass flow), then this latent energy is actually provided to the zone air instead (even though a non-zero value is reported here).

Refrigerated Case Evaporator Fan Electric Power [W]

This field is the electric power input to the refrigerated case fan(s) in Watts.

Refrigerated Case Evaporator Fan Electric Consumption [J]

This field is the electricity consumption of the refrigerated case fan(s) in Joules over the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Refrigeration, Group Key = Building (Ref. Report Meter).

Refrigerated Case Lighting Electric Power [W]

This field is the electric power input to the refrigerated case lights in Watts.

Refrigerated Case Lighting Electric Consumption [J]

This field is the electricity consumption of the refrigerated case lights in Joules over the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Refrigeration, Group Key = Building (Ref. Report Meter).

Refrigerated Case Defrost Energy Correction Curve Value

This field is the output of the Defrost Energy Correction Curve which denotes the variation in defrost energy at off-rated conditions. The output of the defrost energy correction curve directly impacts the energy used during the defrost time period. It does not, however, impact

the duration of the defrost period. This output is available only for Electric with Temperature Termination or Hot-Gas with Temperature Termination case defrost types.

Refrigerated Case Latent Case Credit Curve Value

This field is the output of the Latent Case Credit Curve which denotes the variation in latent case credits at off-rated conditions. The output of the latent case credit curve directly impacts the amount of frost formation on the refrigerated case evaporator coil and the requirement for defrost.

Refrigerated Case Anti-Sweat Heater Electric Power [W]

This field is the electric power input to the refrigerated case anti-sweat heater in Watts. This output is available unless anti-sweat heater control type is specified as NONE.

Refrigerated Case Anti-Sweat Heater Electric Consumption [J]

This field is the total electricity consumption of the refrigerated case anti-sweat heater in Joules over the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Refrigeration, Group Key = Building (Ref. Report Meter). This output is available unless anti-sweat heater control type is specified as NONE.

Refrigerated Case Defrost Electric Power [W]

This field is the electric power input to the refrigerated case electric defrost heater(s) in Watts. This output is available if case defrost type is Electric or Electric with Temperature Termination.

Refrigerated Case Defrost Electric Consumption [J]

This field is the total electricity consumption of the refrigerated case electric defrost heater(s) in Joules over the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Refrigeration, Group Key = Building (Ref. Report Meter). This output is available if case defrost type is Electric or Electric with Temperature Termination.

Refrigeration:System

The refrigeration system works in conjunction with the case list object, the Refrigeration Case object, the compressor list object, the compressor object, and an optional subcooler object (Ref. Refrigeration:System, Refrigeration:CaseList, Refrigeration:Case, Refrigeration:CompressorList, Refrigeration:Compressor, and Refrigeration:Subcooler) to simulate the performance of a supermarket refrigeration system. Heat is rejected outdoors in a condenser by direct air flow, evaporative water cooling, or by a water-cooled condenser with appropriate plant loop piping. With evaporative cooling, water is sprayed through the air stream to effectively lower the air temperature experienced by the condenser coil as a result of water evaporation. The use of a water-cooled condenser requires the definition of a plant loop to supply cooling to the condenser (ref: Refrigeration:Condenser:AirCooled, Refrigeration:Condenser:EvaporativeCooled, Refrigeration:Condenser:WaterCooled). The system object coordinates the energy flows between the other refrigeration objects and is used to set system parameters. Compressor waste heat can also be reclaimed for use by an optional air- or water-heating coil (Ref. Coil:Heating:Desuperheater and Coil:WaterHeating:Desuperheater).

The inputs for the refrigeration system object include a name, the name of a single refrigerated case or a list of refrigerated cases, the name of the condenser, the name of a single compressor or a list of compressors, the minimum condensing temperature, the refrigeration system working fluid, the names of any subcoolers, and the type of suction temperature control.

Field: Name

A unique user-assigned name for an instance of a refrigeration system. Any reference to this refrigeration system by another object will use this name.

Field: Refrigeration Case or Case List Name

Identifies a single case, or a particular list of refrigerated cases, that are cooled by this refrigeration system. The name will be validated against the case or caselist names (ref: List:Refrigeration:Cases) in the input file.

Field: Refrigeration Condenser Name

The name of the condenser that is used to reject heat from this refrigeration system. The name will be validated against the condenser names (ref: Refrigeration:Condenser:AirCooled, Refrigeration:Condenser:WaterCooled, and Refrigeration:Condenser:EvapCooled) in the input file.

Field: Compressor or Compressor List Name

Identifies a single compressor, or a particular list of compressors, that provide cooling energy to this refrigeration system. The name will be validated against the compressor list names (ref: List:Refrigeration:Compressors) in the input file.

Field: Minimum Condensing Temperature

This numeric field specifies the minimum condensing temperature (C), which is usually determined by the temperature required to maintain acceptable thermal expansion valve performance.

Field: Refrigeration System Working Fluid Type

The type of refrigerant used by the system. Valid choices are R11, R123, R134A, R12, R22, R404A, R507A, or R410A. This name will be validated against Fluid Names (ref: Fluid Properties section) in the input file. Note that the corresponding property data, available in FluidPropertiesRefData.idf, must be supplied in the input file.

Field: Suction Temperature Control Type

The type of suction temperature control used by the system. Valid choices are **FloatSuctionTemperature** and **ConstantSuctionTemperature**. If the field is blank, the default will be **ConstantSuctionTemperature**. See the Engineering Reference section, Variable Evaporator Temperature, for a discussion of this option.

Field: Mechanical Subcooler Name

This optional field identifies a particular mechanical subcooler that provides cooling to this refrigeration system. The name will be validated against the subcooler names (ref: Refrigeration:Subcooler) in the input file.

Field: Liquid Suction Heat Exchanger Subcooler Name

This optional field identifies a particular liquid suction heat exchanger (LSHX) subcooler present in this refrigeration system. The name will be validated against the subcooler names (ref: Refrigeration:Subcooler) in the input file.

Field: End-Use Subcategory

This field allows the specification of a user-defined end-use subcategory (e.g., "Low Temperature Rack"). A new meter for reporting is created for each unique subcategory (Ref: Report Meter). Subcategories are also reported in the ABUPS table. If this field is left blank, the equipment will be assigned to the "General" end-use subcategory.

Below is the input data dictionary description for the Refrigeration:System object.


```

Refrigeration:System,
  \min-fields 6
A1 , \field Name
     \required-field
     \type alpha
     \reference RefrigerationDetailedSystemNames
     \reference DesuperHeatingCoilSources
     \reference DesuperheaterWaterHeater
A2 , \field Refrigerated Case Name or Case List Name
     \required-field
     \type object-list
     \object-list RefrigeratedCaseListNames
     \object-list RefrigeratedCaseNames
A3 , \field Refrigeration Condenser Name
     \required-field
     \type object-list
     \object-list RefrigerationDetailedCondenserNames
A4 , \field Compressor Name or Compressor List Name
     \required-field
     \type object-list
     \object-list RefrigerationCompressorListNames
     \object-list RefrigerationCompressorName
N1 , \field Minimum Condensing Temperature
     \type real
     \units C
     \required-field
     \note related to the proper operation of the thermal expansion
     \note valves and compressors
A5 , \field Refrigeration System Working Fluid Type
     \note Fluid property data for the refrigerant must be entered.
     \note The fluid property data, including the objects:
     \note FluidProperties:Names, FluidProperties:Temperatures,
     \note FluidProperties:Saturated and FluidProperties:Superheated
     \note can be copied from the FluidPropertiesRefData.idf dataset
     \required-field
     \type object-list
     \object-list FluidNames
A6 , \field Suction Temperature Control Type
     \type choice
     \key FloatSuctionTemperature
     \key ConstantSuctionTemperature
     \default ConstantSuctionTemperature
A7 , \field Mechanical Subcooler Name
     \type object-list
     \object-list RefrigerationSubcoolerNames
     \note Optional Field
     \note Recipient of refrigeration capacity
     \note receives cool liquid to help meet aggregate case loads
A8 , \field Liquid Suction Heat Exchanger Subcooler Name
     \type object-list
     \object-list RefrigerationSubcoolerNames
     \note Optional Field
     \note Liquid Suction Heat Exchanger Name, or leave blank
A9 ; \field End-Use Subcategory
     \type alpha
     \retaincase
     \default General

```

The following is an example input for a refrigeration system.

```

Refrigeration:System,
MediumTempSystem,      !- Refrigeration System Name
MediumTempCaselist,    !- Refrigeration Case List Name
AirCooledCondenserA,   !- Refrigeration Condenser Name
MediumTempCompressorlist, !- Refrigeration Compressor List Name
25.0,                  !- Minimum Condensing Temperture {C}
R134a,                 !- Refrigeration System Working Fluid
ConstantSuctionTemperature, !- Suction Temperature Control
,                      !- Optional mechanical subcooler name
,                      !- Optional LSHX subcooler name
MedTempRefrig;        !- End-Use Subcategory
    
```

Refrigeration:System Outputs

```

Zone,Average, Refrigeration System Total Compressor Electric Power [W]
Zone,Sum, Refrigeration System Total Compressor Electric Consumption [J]
Zone,Average, Refrigeration System Average Compressor COP [W/W]
Zone,Average, Refrigeration System Total Compressor Heat Transfer Rate [W]
Zone,Sum, Refrigeration System Total Compressor Heat Transfer Energy [J]
Zone,Average, Refrigeration System Total Cases Heat Transfer Rate [W]
Zone,Average, Refrigeration System Estimated Refrigerant Inventory [kg]
Zone,Average, Refrigeration System Estimated Refrigerant Mass Flow [kg/s]
Zone,Average, Refrigeration System Condensing Temperature [C]'
Zone,Average, Refrigeration System Evaporating Temperature [C]
Zone,Average, Refrigeration System Suction Temperature [C]
Zone,Average, Refrigeration System Liquid Temperature to TXV [C]
    
```

Refrigeration System Total Compressor Electric Power [W]

This output is the total electric power input to the systems compressor(s) in Watts.

Refrigeration System Total Compressor Electric Consumption [J]

This is the electricity consumption of the system’s compressor(s) in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Refrigeration, Group Key = Plant (Ref. Report Meter).

Refrigeration System Average Compressor COP [W/W]

This output is the system average compressor COP, the total refrigeration effect divided by the total power to the compressors

Refrigeration System Total Compressor Heat Transfer Rate [W]

This output is the total heat transfer rate of the Refrigeration Compressor rack in Watts. It is the sum of all of the heat transfer rates for the refrigerated cases and subcoolers that are connected to this system. This value does not include compressor or condenser fan heat.

Refrigeration System Total Compressor Heat Transfer Energy [J]

This is the total heat transfer of the Refrigeration Compressor rack in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = EnergyTransfer, End Use Key = Refrigeration, Group Key = Plant (Ref. Report Meter).

Refrigeration System Total Cases Heat Transfer Rate [W]

This output is the total heat transfer rate of the from the refrigerated cases served by this system in Watts. It is the sum of all of the heat transfer rates for the refrigerated cases that are connected to this rack. This value does not include compressor or condenser fan heat.

Refrigeration System Estimated Refrigerant Inventory [kg]

This output is the sum of the input inventory values for the condenser, receiver, cases, and liquid pipes that are a part of this system.

Refrigeration System Estimated Refrigerant Mass Flow [kg/s]

This output is the calculated refrigerant mass flow through the compressors for this system.

Refrigeration System Condensing Temperature [C]

This is the saturated condensing temperature.

Refrigeration System Evaporating Temperature [C]

This is the saturated evaporating temperature.

Refrigeration System Suction Temperature [C]

This is the temperature at the compressor inlet including superheat after the cases and superheat from any liquid suction heat exchangers.

Refrigeration System Liquid Temperature to TXV [C]

This is the temperature entering the thermal expansion valve before the cases, equal to the condensing temperature minus any subcooling included in the condenser or provided by mechanical or liquid suction heat exchanger subcoolers.

Refrigeration:CompressorList

This object provides a list of all the compressors included within a single refrigeration system (Ref: Refrigeration:System). Each list must contain at least one compressor. The order in which the individual compressors are listed here will be the order in which the compressors are dispatched to meet the system load. That is, at very low loads, only compressor #1 will be operating. As the load increases, the first two compressors will be operating, and so on. This list is extensible.

Field: Name

A unique user-assigned name for an instance of a compressor list. Any reference to this compressor list by another object will use this name.

Field: Refrigeration Compressor <x> Name

Identifies a particular compressor that works in conjunction with the other compressors on this list to provides cooling to a single refrigeration system. The name will be validated against the compressor names (ref: Refrigeration:Compressor) in the input file. Up to 20 are available in the IDD; this object is extensible.

Below is the input data dictionary description for the List:Refrigeration:Compressors object.

```
Refrigeration:CompressorList,
  \min-fields 2
  \extensible:1 repeat last field, remembering to remove ; from "inner" fields.
  \note IMPORTANT: List compressor names in the order in which the compressors will be loaded
  A1 , \field Name
      \required-field
      \type alpha
      \reference RefrigerationCompressorListNames
  A2 , \field Refrigeration Compressor 1 Name
      \note Enter the name of a Refrigeration:Compressor object.
      \required-field
      \type object-list
      \object-list RefrigerationCompressorNames
<repeated to as many compressors as desired. 4 supplied in IDD. Extensible>
```

The following is an example input for a compressor list.

```
Refrigeration:CompressorList,
  MediumTempCompressorList, !- Refrigeration Compressor List Name
  CompressorA,              !- Refrigeration Compressor Name #1
  CompressorB,              !- Refrigeration Compressor Name #2
  CompressorC;              !- Refrigeration Compressor Name #3
```

Refrigeration:CaseList

This object provides a list of all the refrigerated cases cooled by a single refrigeration system (ref: Refrigeration:System). This list is extensible.

Field: Name

A unique user-assigned name for an instance of a case list. Any reference to this case list by another object will use this name.

Field: Case <x> Name

Identifies a particular refrigerated case. The name will be validated against the Refrigeration Case names (ref: Refrigeration:Case) in the input file. Up to 20 are provided in the IDD; this object is extensible.

Below is the input data dictionary description for the List:Refrigeration:Cases object.

```
Refrigeration:CaseList,
  \extensible:1 repeat last field, remembering to remove ; from "inner" fields.
  A1 , \field Refrigerated Case List Name
      \required-field
      \type alpha
      \reference RefrigerationCaseListNames
  A2 , \field Case 1 Name
      \note Enter the name of a Refrigeration:Case object.
      \type object-list
<repeated to as many cases as desired. 20 supplied in IDD. Extensible>
```

The following is an example input for a CaseList.

```
Refrigeration:CaseList,
  MediumTempCaselist,      !- Refrigeration Case List Name
  UprightDairyCase,        !- Refrigeration Case Name #1
  LunchmeatCase,          !- Refrigeration Case Name #2
  FlowerDisplayCase,       !- Refrigeration Case Name #3
  DeliCaseOne;            !- Refrigeration Case Name #4
```

Refrigeration:Compressor

The compressors are described here using manufacturer's data for curves that provide the efficiency, cooling capacity, and power consumption. The corresponding rated values for cycle superheat and subcooling are also required. A dataset has been provided containing the compressor rating data, including the performance curve inputs, for a large number of compressors. See RefrigerationCompressorCurves.idf.

Field: Refrigeration Compressor Name

A unique user-assigned name for an instance of a compressor. Any reference to this compressor by another object will use this name.

Field: Refrigeration Compressor Power Curve Name

This required field provides the name of the curve object that describes the compressor power as a function of the evaporating and condensing temperatures, as specified in ARI 540. The curve is of the bicubic form(ref: Curve:Bicubic). However, the input order for the Energy Plus bicubic curve does not match the ARI 540 standard order. When this curve is entered, the user should use the following assignments:

N1 is ARI C1 and N2 is ARI C2.
N3 is ARI C4 and N4 is ARI C3.
N5 is ARI C6 and N6 is ARI C5,
N7 is ARI C7.
N8 is ARI C10, N9 is ARI C8, and N10 is ARI C9.
N11 is the Minimum evaporating temperature and N12 is the Maximum evaporating temperature.
N13 is the the Minimum condensing temperature and N14 is the Maximum condensing temperature

Field: Refrigeration Compressor Capacity Curve Name

This required field provides the name of the curve object that describes the compressor cooling capacity as a function of the evaporating and condensing temperatures, as specified in ARI 540. The curve is of the bicubic form(ref: Curve:Bicubic). However, the input order for the Energy Plus bicubic curve does not match the ARI 540 standard order. When this curve is entered, the user should use the following assignments:

N1 is ARI C1 and N2 is ARI C2.
N3 is ARI C4 and N4 is ARI C3.
N5 is ARI C6 and N6 is ARI C5,
N7 is ARI C7.
N8 is ARI C10, N9 is ARI C8, and N10 is ARI C9.
N11 is the Minimum evaporating temperature and N12 is Maximum evaporating temperature.
N13 is the Minimum condensing temperature and N14 is the Maximum condensing temperature

Field: Superheat Rating Type

The type of rating information provided by the compressor manufacture consistent with the curves input for capacity, mass flow, and power consumption. Valid choices are RatedSuperheat and RatedReturnGasTemperature. Some manufacturers specify a constant return gas temperature. This corresponds to the type, RatedReturnGasTemperature. Some manufacturers specify a constant superheat (the difference between the saturated evaporating temperature and the actual return gas temperature). This corresponds to the RatedSuperheat choice.

Field: Compressor Rated Suction Temperature

This numeric field is the either the rated return gas temperature, or the rated superheat (C) as stated by the compressor manufacturer corresponding to the rating curves and as identified by the Superheat Rating Type.

Field: Subcooling Rating Type

The type of rating information provided by the compressor manufacture consistent with the curves input for capacity, mass flow, and power consumption. Valid choices are RatedSubcooling and RatedLiquidTemperature. Some manufacturers specify a constant liquid temperature. This corresponds to the type, RatedLiquidTemperature. Some manufacturers specify a constant subcooling (the difference between the saturated condensing temperature and the actual liquid temperature). This corresponds to the RatedSubcooling choice.

Field: Compressor Rated Subcooling

This numeric field is either the rated liquid temperature or the rated subcooling (C) as stated by the compressor manufacturer corresponding to the rating curves and consistent with the Subcooling Rating Type.

Field: End-Use Subcategory

This field allows the specification of a user-defined end-use subcategory (e.g., "Low Temperature System"). A new meter for reporting is created for each unique subcategory (Ref: Report Meter). Subcategories are also reported in the ABUPS table. If this field is left blank, the equipment will be assigned to the "General" end-use subcategory.

Below is the input data dictionary description for the Refrigeration:Compressor object.

```

Refrigeration:Compressor,
  \min-fields 4
A1 , \field Name
  \required-field
  \type alpha
  \reference RefrigerationCompressorNames
A2 , \field Refrigeration Compressor Power Curve Name
  \required-field
  \type object-list
  \object-list BiCubicCurves
  \note the input order for the Curve:Bicubic does not
  \note match the ARI 540-2004 Eq. 1 coefficient order
  \note N1 is ARI_C1, N2 is ARI_C2, N3 is ARI_C4, N4 is ARI_C3,
  \note N5 is ARI_C6, N6 is ARI_C5, N7 is ARI_C7, N8 is ARI_C10,
  \note N9 is ARI_C8, N10 is ARI_C9,
  \note N11 is Minimum Suction dewpoint temperature,
  \note N12 is Maximum Suction dewpoint temperature,
  \note N13 is Minimum Discharge dewpoint temperature,
  \note N14 is Maximum Discharge dewpoint temperature
A3 , \field Refrigeration Compressor Capacity Curve Name
  \required-field
  \type object-list
  \object-list BiCubicCurves
  \note the input order for the Curve:Bicubic does not
  \note match the ARI 540-2004 Eq. 1 coefficient order
  \note N1 is ARI_C1, N2 is ARI_C2, N3 is ARI_C4, N4 is ARI_C3,
  \note N5 is ARI_C6, N6 is ARI_C5, N7 is ARI_C7, N8 is ARI_C10,
  \note N9 is ARI_C8, N10 is ARI_C9,
  \note N11 is Minimum Suction dewpoint temperature,
  \note N12 is Maximum Suction dewpoint temperature,
  \note N13 is Minimum Discharge dewpoint temperature,
  \note N14 is Maximum Discharge dewpoint temperature
A4 , \field Superheat Rating Type
  \type choice
  \required-field
  \key RatedSuperheat
  \key RatedReturnGasTemperature
N1 , \field Compressor Rated Suction Temperature
  \type real
  \required-field
  \units C
  \note must correspond to Superheat Rating Type
A5 , \field Subcooling Rating Type
  \type choice
  \required-field
  \key RatedSubcooling
  \key RatedLiquidTemperature
N2, \field Compressor Rated Subcooling
  \required-field
  \units C
  \note must correspond to Subcooling Rating Type
A6 ; \field End-Use Subcategory
  \type alpha
  \retaincase
  \default General

```

The following is an example input for a refrigeration compressor.

Refrigeration:Compressor,	
CompressorA,	!- Refrigeration Compressor Name
PowerCurveCompA,	!- Refrigeration Compressor Power Curve Name
CapCurveCompA,	!- Refrigeration Compressor Capacity Curve Name
RatedSuperheat,	! - Rating based on constant difference between evap and suction temps
10.0,	!- Compressor Rated Suction Superheat {C}
RatedSubcooling,	! - Rating based on constant diff between condensing and liquid temps
15.0,	!- Compressor Rated Subcooling
MedTempRefrig;	!- End-Use Subcategory

Refrigeration:Compressor Outputs

Zone,Average,Refrigeration Compressor Electric Power [W]
Zone,Sum,Refrigeration Compressor Electric Energy [J]
Zone,Average,Refrigeration Compressor Heat Transfer Rate [W]
Zone,Sum,Refrigeration Compressor Heat Transfer Energy [J]

Refrigeration Compressor Electric Power [W]

This output is the electric power input to the compressor in Watts.

Refrigeration Compressor Electric Energy [J]

This is the electric energy consumed by the compressor in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Refrigeration, Group Key = Plant (Ref. Report Meter).

Refrigeration Compressor Heat Transfer Rate [W]

This output is the heat removed from the refrigerated cases by the compressor in Watts.

Refrigeration Compressor Heat Transfer Energy [J]

This is the heat removed from the refrigerated cases by the compressor in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Refrigeration, Group Key = Plant (Ref. Report Meter).

Refrigeration:Subcooler

Two types of subcoolers are modeled by the detailed refrigeration system. As described in the Engineering Reference, the liquid suction heat exchanger uses cool suction gas to subcool the hot condensate after it leaves the condenser and before it reaches the thermal expansion valve. For the liquid suction heat exchanger, both the source and sink of energy are located within the same refrigeration system. In contrast, a mechanical subcooler is used to transfer cooling capacity from one refrigeration system to another. The mechanical subcooler is listed as a part of the system for which the condensate is cooled. However, the input data for the mechanical subcooler includes a field that identifies the system that provides the cooling capacity.

Field: Name

A unique user-assigned name for an instance of a subcooler. Any reference to this subcooler by another object will use this name.

Field: Subcooler Type

The type of subcooler. Valid choices are Mechanical and LiquidSuction. If the field is blank, the default will be LiquidSuction.

Field: Liquid Suction Design Subcooling Temperature

This numeric field is the design subcooling (C) for a liquid suction heat exchanger and should be blank for a mechanical subcooler.

Field: Design Liquid Inlet Temperature

This numeric field is the design inlet temperature for the hot liquid entering a liquid suction heat exchanger and should be blank for a mechanical subcooler.

Field: Design Vapor Inlet Temperature

This numeric field is the design inlet temperature for the cool vapor entering a liquid suction heat exchanger and should be blank for a mechanical subcooler.

Field: Capacity-Providing System

This field is the name of the refrigeration system object that provides the cooling capacity for the mechanical subcooler (ref: Refrigeration:System Name). This field should be blank for a liquid suction heat exchanger.

Field: Outlet Control Temperature

This numeric field is the controlled outlet temperature (C) for subcooled liquid exiting a mechanical subcooler. This field should be blank for a liquid suction heat exchanger.

Below is the input data dictionary description for the Refrigeration:Subcooler object.

```

Refrigeration:Subcooler,
  \min-fields 5
A1 , \field Name
  \type alpha
  \required-field
  \reference RefrigerationSubcoolerNames
A2 , \field Subcooler Type
  \type choice
  \key Mechanical
  \key LiquidSuction
  \default LiquidSuction
  \note plan to add ambient subcoolers at future time
N1 , \field Liquid Suction Design Subcooling Temperature
  \type real
  \units C
  \note Applicable only and required for liquid suction heat exchangers
  \note design liquid suction subcooling
N2 , \field Design Liquid Inlet Temperature
  \type real
  \units C
  \note design inlet temperature on liquid side
  \note Applicable only and required for liquid suction heat exchangers (LSHX)
N3 , \field Design Vapor Inlet Temperature
  \type real
  \units C
  \note design inlet temperature on vapor side
  \note Applicable only and required for liquid suction heat exchangers (LSHX)
  \note Design vapor inlet temperature must be less than or equal to
  \note (cont.) the Liquid inlet design temp
A3 , \field Capacity-Providing System
  \type object-list
  \object-list RefrigerationSystemNames
  \note Name of the Refrigeration System Detailed providing cooling capacity
  \note Applicable only and required for mechanical subcoolers
N4 ; \field Outlet Control Temperature
  \type real
  \units C
  \note Control Temperature Out for subcooled liquid
  \note Applicable only and required for mechanical subcoolers

```

The following is example input for both liquid suction and mechanical subcoolers.


```

REFRIGERATION:SUBCOOLER,
  SampleLSHx,      !Subcooler Name
  LiquidSuction,  !subcooler type
  6,               !design liquid suction subcooling {deg C}
  16,             !design inlet temperature on liquid side {deg C}
  0,              !design inlet temperature on vapor side {deg C}
  ,               !Refrigeration System Detailed Name providing cooling capacity
  ;               !Control Temperature Out for subcooled liquid {deg C}

! Mechanical Subcooler (uses Med Temp System to cool low temp liquid to 10C)
REFRIGERATION:SUBCOOLER,
  SampleMSC,      !Subcooler Name
  Mechanical,     !subcooler type
  ,               !design liquid suction subcooling {deg C}
  ,               !design inlet temperature on liquid side {deg C}
  ,               !design inlet temperature on vapor side {deg C}
  MediumTempSystem, !Refrigeration System Detailed Name providing cooling capacity
  10;             !Control Temperature Out for subcooled liquid {deg C}

```

Refrigeration:Subcooler Outputs

```

Zone,Average, Refrigeration Liquid Suction Subcooler Load Transfer Rate [W]
Zone,Average, Refrigeration Mechanical Subcooler Load Transfer Rate [W]

```

Refrigeration Liquid Suction Subcooler Load Transfer Rate [W]

This output is the energy transferred from the refrigerant before it enters the thermal expansion valve to the refrigerant leaving the refrigerated cases in Watts.

Refrigeration Mechanical Subcooler Load Transfer Rate [W]

This output is the cooling energy transferred from one system's compressor group to the refrigerant leaving the condenser for another refrigeration system in Watts.

Refrigeration:Condenser:AirCooled

The refrigeration system requires a single condenser. The air cooled condenser object is one of three options for this condenser. In an air-cooled condenser, the total heat of rejection is characterized by a linear relationship between the difference between the outside drybulb and condensing temperatures. This curve is commonly found in the condenser manufacturers' literature. This rating curve, which corresponds to ARI 460 standards, also has an associated rated value for subcooling that should be entered. The rated condenser fan power and fan speed control type must be specified. If the condenser is not at ground level, the user may specify an air inlet node name (ref: OutdoorAir:Node name). Optional input is provided to help the user compare refrigerant inventories for different systems. These inputs represent the design values for the refrigerant inventory within the condenser, within a receiver beneath the condenser, and in the liquid pipes between the condenser and the refrigerated cases.

Field: Name

Identifies a particular condenser that rejects heat for a single refrigeration system. The name must be unique and will be validated against all the condenser names (ref: Refrigeration:Condenser) in the input file, including names used for evaporative- and water-cooled condensers.

Field: Rated Effective Total Heat Rejection Rate Curve Name

This field is the name of a curve object defining the condenser heat rejection as a function of the difference between the condensing and entering air temperatures. The curve should be linear (Curve:Linear). See the Engineering Reference for more discussion on the curve coefficients.

Field: Rated Subcooling Temperature

This numeric field specifies the rated subcooling (C) specified by the manufacturer, consistent with the heat rejection curve rating data.

Field: Condenser Fan Speed Control Type

The type of fan speed control used by the condenser fan. Valid choices are **Fixed**, **VariableSpeed**, and **TwoSpeed**. If the field is blank, **Fixed** will be used. See the Engineering Reference for a discussion of this option's effect on fan energy consumption.

Field: Rated Fan Power

This numeric field specifies the rated fan power (W) specified by the manufacturer, under standard rating conditions.

Field: Air Inlet Node Name

This optional alpha field contains the name of the node from which the condenser draws its outdoor air. If this field is left blank, the outdoor air drybulb temperature entering the condenser is taken directly from the weather data. If this field is not blank, this node name must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air temperature from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air temperature is taken directly from the weather data.

Field: End-Use Subcategory

This field allows the specification of a user-defined end-use subcategory (e.g., "Low Temperature Rack"). A new meter for reporting is created for each unique subcategory (Ref: Report Meter). Subcategories are also reported in the ABUPS table. If this field is left blank, the equipment will be assigned to the "General" end-use subcategory.

Field: Condenser Refrigerant Operating Charge Inventory

This numeric field specifies the amount of refrigerant present within the condenser (kg) specified by the manufacturer, under standard rating conditions.

Field: Condensate Receiver Refrigerant Inventory

This numeric field specifies the amount of refrigerant present within the condensate receiver (kg) specified by the manufacturer or system designer, under standard rating conditions.

Field: Condensate Piping Refrigerant Inventory

This numeric field specifies the amount of refrigerant present within the condensate piping (kg) specified by the system designer, under standard rating conditions.

Below is the input data dictionary description for the Refrigeration:Condenser:AirCooled object.

```
Refrigeration:Condenser:AirCooled,
  \min-fields 5
  A1 , \field Name
      \required-field
      \type alpha
      \reference RefrigerationDetailedCondenserNames
  A2 , \field Rated Effective Total Heat Rejection Rate Curve Name
      \note Rating as per ARI 460
      \note Be sure the rating corresponds to the correct refrigerant
      \type object-list
      \object-list LinearCurves
      \note HeatRejection(W)=C1 +C2(Condensing Temp - Entering Air Temp, deg C)
      \note Will be adjusted for elevation automatically
      \reference CurveLinearNames
```

```

N1 , \field Rated Subcooling Temperature
    \type real
    \units C
    \default 0.0
    \minimum 0.0
    \note must correspond to rating given for total heat rejection effect
A3 , \field Condenser Fan Speed Control Type
    \type choice
    \key Fixed
    \key VariableSpeed
    \key TwoSpeed
    \default Fixed
N2 , \field Rated Fan Power
    \note Power for condenser fan(s) corresponding to rated total heat rejection effect.
    \type real
    \units W
    \minimum 0.0
    \default 250.0
    \required-field
A4 , \field Air Inlet Node Name
    \type alpha
    \note If field is left blank,
    \note then the model assumes that the inlet air
    \note conditions are the outdoor air conditions for the current timestep
    \note (e.g., no adjustment for height above ground).
A5 , \field End-Use Subcategory
    \type alpha
    \retaincase
    \default General
N3 , \field Condenser Refrigerant Operating Charge Inventory
    \type real
    \units kg
    \default 0.0
    \note optional input
N4 , \field Condensate Receiver Refrigerant Inventory
    \type real
    \units kg
    \default 0.0
    \note optional input
N5 ; \field Condensate Piping Refrigerant Inventory
    \type real
    \units kg
    \default 0.0
    \note optional input

```

The following is an example input for an air-cooled condenser.

```

Refrigeration:Condenser:AirCooled,
MediumTempCondenser,      !- Name of condenser
MediumTempCondenserHRCurve, !-name of condenser heat of rejection curve, linear
0.,                        ! Rated subcooling
VariableSpeed,            ! Fan speed control type
4000.,                    ! Design condenser fan power
Refrigeration MediumTempSystem CondenserNode, !- Condenser Air Inlet Node Name
MediumTempRefrig;        !- End-Use Subcategory

```

Refrigeration:Condenser:AirCooled Outputs

```

Zone,Average, Refrigeration System Condenser Fan Electric Power [W]
Zone, Sum, Refrigeration System Condenser Fan Electric Energy [J]
Zone,Average, Refrigeration System Condenser Heat Transfer Rate [W]
Zone, Sum, Refrigeration System Condenser Heat Transfer Energy [J]

```

Refrigeration System Condenser Fan Electric Power [W]

This output is the electric input to the system's condenser fan(s) in Watts.

Refrigeration System Condenser Fan Electric Energy [J]

This is the electricity consumption of the system's condenser fan(s) in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Refrigeration, Group Key = Plant (Ref. Report Meter).

Refrigeration System Condenser Heat Transfer Rate [W]

This is the total heat transfer across the condenser (i.e., compressor energy and case cooling).

Refrigeration System Condenser Heat Transfer Energy [J]

This is the total heat energy flowing across the condenser for the timestep being reported.

Refrigeration:Condenser:EvaporativeCooled

Each refrigeration system requires a single condenser. The evaporative cooled condenser object is one of three options for this condenser. In an evaporative-cooled condenser, the total heat of rejection is characterized by a four-factor relationship between the difference between the outside wetbulb and condensing temperatures. This curve must be developed by regression from the condenser manufacturers' literature. This rating curve, which is based upon rated data taken according to ARI 460 standards, also has an associated rated value for subcooling that should be entered. The rated condenser fan power and fan speed control type must be specified. If the condenser is not at ground level, the user may specify an air inlet node name (ref: OutdoorAir:Node name). Optional input is provided to help the user compare refrigerant inventories for different systems. These input represent the design values for the refrigerant inventory within the condenser, within a receiver beneath the condenser, and in the liquid pipes between the condenser and the refrigerated cases.

Additional inputs are needed for basin heater parameters, water pump power, water source, and an evaporative cooling availability schedule are available.

Field: Name

Identifies a particular condenser that rejects heat for a single refrigeration system. The name must be unique and will be validated against all the condenser names (ref: Refrigeration:Condenser) in the input file, including names used for air- and water-cooled condensers.

Field: Rated Effective Total Heat Rejection Rate

This numeric field should be the rated heat rejection effect (W) at standard rating conditions per ARI 490. Be sure the rating corresponds to the correct refrigerant.

Field: Rated Subcooling Temperature

This numeric field specifies the rated subcooling (C) specified by the manufacturer, consistent with the rated value for total heat rejection.

Field: Fan Speed Control Type

The type of fan speed control used by the condenser fan. Valid choices are **Fixed**, **VariableSpeed**, and **TwoSpeed**. If the field is blank, **Fixed** will be used. See the Engineering Reference for a discussion of this option's effect on fan energy consumption.

Field: Rated Fan Power

This numeric field specifies the rated fan power (W) specified by the manufacturer, under standard rating conditions.

Field: Approach Temperature Constant Term

As described in the Engineering Reference (ref Refrigeration:Condenser:Evaporative), the heat rejection capacity factor is specified according to the form (where Twetbulb and Tcondense are in C):

$$(T_{\text{condense}} - T_{\text{wetbulb}}) = A1 + A2(\text{hrCF}) + A3/(\text{hrCF}) + A4(T_{\text{wb}})$$

This numeric field is the value for A1 and has a default value of 6.63, a minimum of 0. and a maximum of 20. (C)

Field: Approach Temperature Coefficient 2

As described in the Engineering Reference (ref Refrigeration:Condenser:Evaporative), the heat rejection capacity factor is specified according to the form (where Twetbulb and Tcondense are in C):

$$(T_{\text{condense}} - T_{\text{wetbulb}}) = A1 + A2(\text{hrCF}) + A3/(\text{hrCF}) + A4(T_{\text{wb}})$$

This numeric field is the value for A2 and has a default value of 0.468, a minimum of 0, and a maximum of 20 (C).

Field: Approach Temperature Coefficient 3

As described in the Engineering Reference (ref Refrigeration:Condenser:Evaporative), the heat rejection capacity factor is specified according to the form (where Twetbulb and Tcondense are in C):

$$(T_{\text{condense}} - T_{\text{wetbulb}}) = A1 + A2(\text{hrCF}) + A3/(\text{hrCF}) + A4(T_{\text{wb}})$$

This numeric field is the value for A3 and has a default value of 17.93, a minimum of 0, and a maximum of 30 (C).

Field: Approach Temperature Coefficient 4

As described in the Engineering Reference (ref Refrigeration:Condenser:Evaporative), the heat rejection capacity factor is specified according to the form (where Twetbulb and Tcondense are in C):

$$(T_{\text{condense}} - T_{\text{wetbulb}}) = A1 + A2(\text{hrCF}) + A3/(\text{hrCF}) + A4(T_{\text{wb}})$$

This numeric field is the value for A4 and has a default value of -0.322, a minimum of -20., and a maximum of 20 (dimensionless).

Field: Minimum Capacity Factor

This numeric field is the minimum heat rejection capacity factor in the manufacturer's data used to develop the equation described in the preceding four fields. The default value is 0.5.

Field: Maximum Capacity Factor

This numeric field is the maximum heat rejection capacity factor in the manufacturer's data used to develop the equation described in the preceding four fields. The default value is 5.0.

Field: Air Inlet Node Name

This optional alpha field contains the name of the node from which the condenser draws its outdoor air.. If this field is left blank, the outdoor air drybulb temperature entering the condenser is taken directly from the weather data. If this field is not blank, this node name must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air temperature from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air temperature is taken directly from the weather data.

Field: Rated Air Flow Rate

The air volume flow rate, in m³ per second, entering the evaporative condenser. This value is used to calculate the amount of water evaporated when evaporatively cooling the condenser inlet air. The value for this field must be greater than zero. This input field is also

autocalculatable, equivalent to 0.000144 m³/s per watt of total cooling capacity [850 cfm/ton] where the total cooling capacity is the total heat of rejection.

Field: Basin Heater Capacity

This field defines the power level of the basin heater, if applicable, used to avoid water freezing in an outdoor evaporative cooler basin. This numeric field contains the capacity of the electric basin heater in Watts per degree C. This field is used in conjunction with the Basin Heater Set Point Temperature described in the following field. The basin heater electric power is equal to this field multiplied by the difference between the basin heater set point temperature and the dry-bulb temperature of the condenser coil inlet air. The basin heater only operates when the condenser fan is off (i.e., no compressor heat rejection). The basin heater capacity must be greater than or equal to zero, with a default value of 200 W/C if this field is left blank.

Field: Basin Heater Setpoint Temperature

This numeric field contains the set point temperature (°C) for the basin heater described in the previous field. The basin heater is active when the outdoor air dry-bulb temperature falls below this set point temperature, as long as the condenser fan is off. The default value is 2°C if this field is left blank.

Field: Rated Water Pump Power

The rated power of the evaporative condenser water pump in Watts. This value is used to calculate the power required to pump the water used to evaporatively cool the condenser inlet air. The value for this field must be greater than or equal to 0, with a default value of 1000 Watts if this field is left blank. This input field is also autocalculatable, equivalent to 0.004266 W per Watt [15 W/ton] of total cooling capacity.

Field: Evaporative Water Supply Tank Name

This field is used to define where the condenser obtains water used for evaporative cooling. If this field is left blank, the unit will obtain water directly from the mains (Ref. Water Mains Temperatures). If the name of a Water Storage Tank object is used here, then the unit will obtain its water from that tank.

Field: Evaporative Condenser Availability Schedule Name

For evaporative cooled condensers, the name of the optional schedule (Ref: Schedule) that specifies the time periods that evaporative cooling is available/unavailable. In some colder climates, evaporative cooling is periodically discontinued and the basin sumps drained to avoid freezing and to avoid ice formation on the condenser. In these times, the condenser runs as a typical dry air cooled condenser, and related evaporative cooling systems (e.g., water pump, basin heaters) do not operate. Use of this optional schedule permits modeling of planned, seasonal interruptions of evaporative cooling. All schedule values must be greater than or equal to zero. Typically, an ON/OFF schedule type is used with values being either 0 or 1. A schedule value of 1 indicates that evaporative cooling is available during the defined time period, and a value of 0 denotes that evaporative cooling is not available during the defined time period. If the schedule name is omitted (blank), then the model assumes that evaporative cooling of the condenser is available for the entire simulation period. Note: the use of this schedule is the correct way to model an evaporative condenser in a climate subject to freezing weather. However, because some users will take a single model description and run it for a multiple climates, the code also includes an automatic switch from wet to dry operation, as described in the Engineering Reference.

Field: End-Use Subcategory

This field allows the specification of a user-defined end-use subcategory (e.g., "Low Temperature Rack"). A new meter for reporting is created for each unique subcategory (Ref:

Report Meter). Subcategories are also reported in the ABUPS table. If this field is left blank, the equipment will be assigned to the "General" end-use subcategory.

Field: Condenser Refrigerant Operating Charge Inventory

This numeric field specifies the amount of refrigerant present within the condenser (kg) specified by the manufacturer, under standard rating conditions.

Field: Condensate Receiver Refrigerant Inventory

This numeric field specifies the amount of refrigerant present within the condensate receiver (kg) specified by the manufacturer or system designer, under standard rating conditions.

Field: Condensate Piping Refrigerant Inventory

This numeric field specifies the amount of refrigerant present within the condensate piping (kg) specified by the system designer, under standard rating conditions.

Below is the input data dictionary description for the object.

```
Refrigeration:Condenser:EvaporativeCooled,
  \min-fields 11
A1 , \field Name
     \required-field
     \type alpha
     \reference RefrigerationDetailedCondenserNames
N1 , \field Rated Effective Total Heat Rejection Rate
     \note Rating as per ARI 490
     \required-field
     \minimum 0.0
     \note Be sure the rating corresponds to the correct refrigerant
     \type real
     \units W
N2 , \field Rated Subcooling Temperature
     \type real
     \units C
     \default 0.0
     \minimum 0.0
     \note must correspond to rating given for total heat rejection effect
A2 , \field Fan Speed Control Type
     \type choice
     \key Fixed
     \key VariableSpeed
     \key TwoSpeed
     \default Fixed
     \note required for air-cooled condenser
N3 , \field Rated Fan Power
     \note Power for condenser fan(s) corresponding to rated total heat rejection effect.
     \type real
     \units W
     \minimum 0.0
     \required-field
N4 , \field Approach Temperature Constant Term
     \type real
     \units C
     \minimum 0.0
     \maximum 20.0
     \default 6.63
     \note A1 in delta T = A1 + A2(hrcf) + A3/(hrcf) + A4(Twb)
N5 , \field Approach Temperature Coefficient 2
     \type real
     \units C
     \minimum 0.0
     \maximum 20.0
     \default 0.468
     \note A2 in delta T = A1 + A2(hrcf) +A3/(hrcf) +A4(Twb)
```

```

N6 , \field Approach Temperature Coefficient 3
     \type real
     \units C
     \minimum 0.0
     \maximum 30.0
     \default 17.93
     \note A3 in  $\Delta T = A1 + A2(\text{hrcf}) + A3/(\text{hrcf}) + A4(T_{wb})$ 
N7 , \field Approach Temperature Coefficient 4
     \type real
     \units dimensionless
     \minimum -20.0
     \maximum 20.0
     \default -0.322
     \note A4 in  $\Delta T = A1 + A2(\text{hrcf}) + A3/(\text{hrcf}) + A4(T_{wb})$ 
N8 , \field Minimum Capacity Factor
     \type real
     \default 0.50
     \note taken from manufacturer's Heat Rejection Capacity Factor Table
N9 , \field Maximum Capacity Factor
     \type real
     \default 5.0
     \note taken from manufacturer's Heat Rejection Capacity Factor Table
A3 , \field Air Inlet Node Name
     \type alpha
     \note If field is left blank,
     \note then the model assumes that the inlet air
     \note conditions are the outdoor air conditions for the current timestep
     \note (e.g., no adjustment for height above ground).
N10 , \field Rated Air Flow Rate
      \type real
      \units m3/s
      \autocalculatable
      \default autocalculate
      \note Used to calculate evaporative condenser water use and fan energy use.
N11 , \field Basin Heater Capacity
      \type real
      \units W/K
      \minimum 0.0
      \default 200.0
      \note This field is only used for periods
      \note when the evap condenser is available (field Evaporative Condenser Availability
      \note Schedule). For this situation, the heater heats the basin water when the
      \note outdoor air dry-bulb temperature falls below the set point temperature, but
      \note only when the condenser fans are off (i.e., no refrigerated case load).
N12 , \field Basin Heater Setpoint Temperature
      \type real
      \units C
      \minimum 2.0
      \default 2.0
      \note Enter the outdoor dry-bulb temperature at which the basin heater turns on.
N13 , \field Rated Water Pump Power
      \type real
      \units W
      \default 1000.0
      \autocalculatable
      \note Design recirculating water pump power.
A4 , \field Evaporative Water Supply Tank Name
     \type object-list
     \object-list WaterStorageTankNames
     \note If blank, water supply is from Mains.
A5 , \field Evaporative Condenser Availability Schedule Name
     \type object-list
     \object-list ScheduleNames
     \note
     \note Schedule values greater than 0 indicate that evaporative cooling of the
     \note condenser is available. This schedule allows the user to define seasonal
     \note shutdown/drainage of the water cooling system in cold climate applications.
     \note For periods with schedule values of 0, the condenser operates as Air Cooled.

```



```
A6, \field End-Use Subcategory
    \type alpha
    \retaincase
    \default General
N14 , \field Condenser Refrigerant Operating Charge Inventory
    \type real
    \units kg
    \default 0.0
    \note optional input
N15 , \field Condensate Receiver Refrigerant Inventory
    \type real
    \units kg
    \default 0.0
    \note optional input
N16 ; \field Condensate Piping Refrigerant Inventory
    \type real
    \units kg
    \default 0.0
    \note optional input
```

The following is an example input for an evaporative condenser

```
Refrigeration:Condenser:EvaporativeCooled,
MedTempEvapCooledCondenser , !- Refrigeration Condenser Name
64800. , !- Rated Total Heat Rejection Effect, {W}
0. , !- Rated Subcooling
VariableSpeed , !- Condenser Fan Speed Control
746. , !- Design Condenser Fan Power
6.63 , !- Evaporative Condenser Approach Temp Const, {C}
0.468 , !- Evaporative Condenser Approach Temp HRCF Coefficient
17.93 , !- Evaporative Condenser Approach Temp 1/hrcf coefficient
-0.322, !- Evaporative Condenser Approach Temp Twb coefficient {1/C}
0.6 , !- Minimum Condenser Capacity Factor
4.8 , !- Maximum Condenser Capacity Factor
Outside Air Inlet Node, !- Condenser Air Inlet Node Name
1.79 , !- Evaporative Condenser Air Volume Flow Rate {m3/s}
66.7 , !- Basin Heater Capacity {W/C}
1.0 , !- Basin Heater Set Point Temperature {C}
250. , !- Design Evaporative Condenser Water Pump Power {W}
EvapWaterStorageTank, !- Evaporative Water Supply Tank Name
EvapCondAvail, !- Evaporative Condenser Availability Schedule Name
, !- End-UseSubcategory
21.9 , !- Condenser Refrigerant Operating Charge {kg}
10. , !- Condensate Receiver Refrigerant Inventory
25. ; !- Condensate Piping Refrigerant Inventory
```

Refrigeration:Condenser:EvaporativeCooled Outputs

```
Zone,Average, Refrigeration System Condenser Fan Electric Power [W]
Zone, Sum, Refrigeration System Condenser Fan Electric Energy [J]
Zone,Average, Refrigeration System Condenser Heat Transfer Rate [W]
Zone, Sum, Refrigeration System Condenser Heat Transfer Energy [J]
Zone,Average, Refrigeration System Condenser Pump Electric Power [W]
Zone, Sum, Refrigeration System Condenser Pump Electric Energy [J]
Zone,Average, Refrigeration System Condenser Basin Heater Electric Power [W]
Zone, Sum, Refrigeration System Condenser Basin Heater Electric Energy [J]
Zone,Average, Refrigeration System Condenser Water Consumption Rate [m3/s]
Zone, Sum, Refrigeration System Condenser Water Consumption [m3]
```

Refrigeration System Condenser Fan Electric Power [W]

This output is the electric input to the system’s condenser fan(s) in Watts.

Refrigeration System Condenser Fan Electric Energy [J]

This is the electricity consumption of the system's condenser fan(s) in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Refrigeration, Group Key = Plant (Ref. Report Meter).

Refrigeration System Condenser Heat Transfer Rate [W]

This is the total heat transfer across the condenser (i.e., compressor energy and case cooling) in Watts.

Refrigeration System Condenser Heat Transfer Energy [J]

This is the total heat energy flowing across the condenser for the timestep being reported.

Refrigeration System Condenser Pump Electric Power [W]

This is the electrical power requirement in Watts for the timestep being reported for the water pump used with evaporative cooling of the condenser.

Refrigeration System Condenser Pump Electric Energy [J]

This is the electricity consumption in Joules of the water pump used with evaporative cooling of the condenser for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Refrigeration, Group Key = Plant. Use of an optional subkey category is also available, with default to the General end-use subcategory (Ref. Report Meter).

Refrigeration System Condenser Basin Heater Electric Power [W]

This is the electrical power requirement in Watts for the timestep being reported for the water heater in the basin of the evaporative system used to cool the condenser.

Refrigeration System Condenser Basin Heater Electric Energy [J]

This is the electricity consumption in Joules of the water heater used to prevent freezing of the evaporative cooling system for the condenser for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Refrigeration, Group Key = Plant. Use of an optional subkey category is also available, with default to the General end-use subcategory (Ref. Report Meter).

Refrigeration System Condenser Water Consumption Rate [m³/s]

The volumetric flow rate in m³/s of water consumed while providing evaporative cooling of the condenser.

Refrigeration System Condenser Water Consumption [m³]

This is the water consumed by evaporation in m³ while providing evaporative cooling of the condenser for the timestep being reported. This output is also added to a report meter with Resource Type = Water, End Use Key = Refrigeration, Group Key = Plant. Use of an optional subkey category is also available, with default to the General end-use subcategory (Ref. Report Meter).

Refrigeration:Condenser:WaterCooled

The refrigeration system requires a single condenser. The water cooled condenser object is one of three options for this condenser. Manufacturer's data is required for the rated total heat rejection, the rated condensing temperature, and the rated leaving liquid refrigerant temperature, all per ARI 450. These values are used to calculate the subcooling included in the rated capacity. The inlet and outlet node names as well as the water outlet temperature schedule name are required. Optional input is provided to help the user compare refrigerant inventories for different systems. These input represent the design values for the refrigerant

inventory within the condenser, within a receiver beneath the condenser, and in the liquid pipes between the condenser and the refrigerated cases.

Field: Name

Identifies a particular condenser that rejects heat for a single refrigeration system. The name must be unique and will be validated against all the condenser names (ref: Refrigeration:Condenser) in the input file, including names used for air- and evaporative-cooled condensers.

Field: Rated Effective Total Heat Rejection Rate

This numeric field should be the rated heat rejection effect (W) at standard rating conditions per ARI 450. Be sure the rating corresponds to the correct refrigerant.

Field: Rated Condensing Temperature

This numeric field provides the rated condensing temperature (C) corresponding to the rated heat rejection capacity.

Field: Rated Subcooling Temperature

This numeric field provides the rated liquid refrigerant subcooling (C) corresponding to the rated heat rejection capacity. Note this is equal to the difference between the saturated condensing temperature and the leaving liquid refrigerant temperature.

Field: Rated Water Inlet Temperature

This numeric field provides the rated water inlet temperature (C) corresponding to the rated heat rejection capacity at the rated condensing temperature.

Field: Water Inlet Node Name

A node name for the water-side condenser inlet must be provided.

Field: Water Outlet Node Name

A node name for the water-side condenser outlet must be provided.

Field: Water-Cooled Loop Flow Type

The type of flow loop should be specified. The two choices are **VariableFlow**, in which a Pump:VariableSpeed must be included in the plant loop, or **ConstantFlow**, in which the loop circuit has a constant flow rate, typically associated with a Pump:ConstantSpeed object. If the flow type is VariableFlow, the flow needed to remove the condenser heat energy will be calculated and requested of the pump. If the flow type is ConstantFlow, the outlet water temperature will be determined based on the fixed loop flow rate and heat energy to be removed. The default type is VariableFlow. Refer to additional discussion in the Engineering Reference.

Field: Water Outlet Temperature Schedule Name

When the water-cooled loop flow type is "VariableFlow", the name of a schedule (Ref: Schedule) that defines the desired condenser water outlet temperature must be provided. The schedule may define an outlet temperature that varies through time.

Field: Water Design Flow Rate

When the water-cooled loop flow type is "ConstantFlow", this is the design water flow rate in m³/s that will be requested initially. This requested flow will be passed to the loop simulation, and resulting actual flow will be dependent upon supply system capabilities (e.g., pump capability). The design flow rate must always be less than the maximum flow rate, defined below.

Field: Water Maximum Flow Rate

This numeric field is the maximum water flow rate in m³/s that will be allowed through the condenser. When the loop flow type is Variable Flow, if the calculated flow rate is higher than the maximum flow rate, an error message will be generated, and the flow rate will be reset to the maximum flow rate.

Field: Water Maximum Water Outlet Temperature

This numeric field specifies the maximum allowed water temperature in degrees C leaving the condenser. The default value is 55 degrees C.

Field: Water Minimum Water Inlet Temperature

This numeric field specifies the minimum allowed water temperature in degrees C entering the compressor rack condenser. The default value is 10 degrees C. Refer to additional discussion in the Engineering Reference.

Field: End-Use Subcategory

This field allows the specification of a user-defined end-use subcategory (e.g., "Low Temperature System"). A new meter for reporting is created for each unique subcategory (Ref: Report Meter). Subcategories are also reported in the ABUPS table. If this field is left blank, the equipment will be assigned to the "General" end-use subcategory.

Field: Condenser Refrigerant Operating Charge Inventory

This numeric field specifies the amount of refrigerant present within the condenser (kg) specified by the manufacturer, under standard rating conditions.

Field: Condensate Receiver Refrigerant Inventory

This numeric field specifies the amount of refrigerant present within the condensate receiver (kg) specified by the manufacturer or system designer, under standard rating conditions.

Field: Condensate Piping Refrigerant Inventory

This numeric field specifies the amount of refrigerant present within the condensate piping (kg) specified by the system designer, under standard rating conditions.

Below is the input data dictionary description for the object.

```
Refrigeration:Condenser:WaterCooled,
A1 , \field Name
    \required-field
    \type alpha
    \reference RefrigerationDetailedCondenserNames
N1 , \field Rated Effective Total Heat Rejection Rate
    \note Rating as per ARI 450
    \note Be sure the rating corresponds to the correct refrigerant
    \type real
    \units W
    \minimum >0.0
    \note not used in calculations, only for identification and output
N2 , \field Rated Condensing Temperature
    \required-field
    \type real
    \minimum >0.0
    \units C
    \note must correspond to rating given for total heat rejection effect
```

```

N3 , \field Rated Subcooling Temperature
    \default 0.0
    \minimum 0.0
    \type real
    \units C
    \note must correspond to rating given for total heat rejection effect
N4 , \field Rated Water Inlet Temperature
    \required-field
    \minimum >0.0
    \type real
    \units C
    \note must correspond to rating given for total heat rejection effect
A2 , \field Water Inlet Node Name
    \type alpha
A3 , \field Water Outlet Node Name
    \type alpha
A4 , \field Water-Cooled Loop Flow Type
    \type choice
    \key VariableFlow
    \key ConstantFlow
    \default Variable Flow
    \note Applicable only when Condenser Type is Water Cooled.
A5 , \field Water Outlet Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note Applicable only when loop flow type is Variable Flow.
N5 , \field Water Design Flow Rate
    \type real
    \units m3/s
    \note note required units must be converted from L/s as specified in ARI 450-2007
    \minimum > 0.0
    \note Applicable only when loop flow type is Constant Flow.
N6 , \field Water Maximum Flow Rate
    \type real
    \units m3/s
    \minimum > 0.0
N7 , \field Water Maximum Water Outlet Temperature
    \type real
    \units C
    \minimum 10.0
    \maximum 60.0
    \default 55.0
N8 , \field Water Minimum Water Inlet Temperature
    \type real
    \units C
    \minimum 10.0
    \maximum 30.0
    \default 10.0
    \note related to the minimum allowed refrigeration system condensing temperature
A6 , \field End-Use Subcategory
    \type alpha
    \retaincase
    \default General
N9 , \field Condenser Refrigerant Operating Charge Inventory
    \type real
    \units kg
    \note optional input
N10 , \field Condensate Receiver Refrigerant Inventory
    \type real
    \units kg
    \note optional input
N11 ; \field Condensate Piping Refrigerant Inventory
    \type real
    \units kg
    \note optional input

```

The following is an example input for a water cooled condenser.

```

Refrigeration:Condenser:WaterCooled,
MediumTempCondenser ,      !- Refrigeration Condenser Name
58000. ,                    !- Rated Total Heat Rejection Effect {W}
29.4 ,                      !- Rated Condensing Temperature
0.0 ,                       !- Rated Subcooling
10.0 ,                      !- Rated Water Inlet Temperature
Condenser Inlet Node,      !- Water-cooled Condenser Inlet Node Name
Condenser Outlet Node,    !- Water-cooled Condenser Outlet Node Name
Variable Flow,            !- Water-cooled Loop Flow Type
Cond Outlet Temp Sch,     !- Water-cooled Condenser Outlet Temperature Schedule Name
,                          !- Water-cooled Condenser Design Volumetric Flow Rate {m3/s}
0.003,                    !- Water-cooled Condenser Maximum Volumetric Flow Rate {m3/s}
55.,                      !- Water-cooled Condenser Maximum Water Outlet Temperature {C}
,                          !- Water-cooled Condenser Minimum Water Inlet Temperature {C}
,                          !- End-Use Subcategory
30. ,                     !- Condenser Refrigerant Operating Charge {kg}
65. ,                     !- Condensate Receiver Refrigerant Inventory {kg}
20. ;                     !- Condensate Piping Refrigerant Inventory {kg}

```

Refrigeration:Condenser:WaterCooled Outputs

```

Zone,Average, Refrigeration System Condenser Heat Transfer Rate [W]
Zone, Sum, Refrigeration System Condenser Heat Transfer Energy [J]
Zone,Average, Refrigeration System Condenser Water Mass Flow Rate [kg/s]

```

Refrigeration System Condenser Heat Transfer Rate [W]

This is the total heat transfer across the condenser (i.e., compressor energy and case cooling) in Watts.

Refrigeration System Condenser Heat Transfer Energy [J]

This is the total heat energy flowing across the condenser for the timestep being reported.

Refrigeration System Condenser Water Mass Flow Rate [kg/s]

This is the mass flow rate of the water used to cool the condenser in kg/s.

Group – Zone Controls – Thermostats and Humidistats

Zone Control objects are used to control zone conditions to a specific setpoint. The four types of zone control are described in this section. They are, by name, ZoneControl:<name>.. These types are:

Thermostat – The object provides the traditional approach to space control using air temperatures. Each controlled zone contains a thermostat object.

Humidistat – The object is used to control a zone to a specified relative humidity.

Thermostat:ThermalComfort – The object provides a method to control a zone to a dry-bulb temperature setpoint based on a thermal comfort model (e.g. Fanger) and a user-specified thermal comfort setpoint schedule.

Thermostat:OperativeTemperature – The operative temperature control is formulated to reuse all of the traditional thermostat objects. One input object will be used for each thermal zone to indicate if that zone's thermostat control mode should be overridden to effect operative temperature control rather than traditional air temperature control. The user will still have to input all the traditional ZoneControl:Thermostat and setpoint objects.

ZoneControl:Thermostat

The thermostatic zone control object is used to control a zone to a specified temperature. ZoneControl:Thermostat references a control type schedule and one or more control type objects which in turn reference one or more setpoint schedules. The example at the end of

this section illustrates a complete zone thermostat specification including the control type and setpoint schedules.

The control type schedule and the list of control type/name pairs are directly related. The schedule defines the type of control that is to be used throughout the simulation. Valid Control Types are:

- 0 - Uncontrolled (No specification or default)
- 1 - Single Heating Setpoint
- 2 - Single Cooling SetPoint
- 3 - Single Heating/Cooling Setpoint
- 4 - Dual Setpoint (Heating and Cooling) with deadband

Thus, if the schedule referenced in the ZoneControl:Thermostat statement has a control type of 4 for a particular time period, this indicates that during that time period "Dual Setpoint with deadband" control is to be used. The specific "Dual Setpoint (Heating and Cooling) with deadband" control object to be used is specified in the list of control type/name pairs. Then the specific control type objects reference the thermostat setpoint temperature schedule to be used. Because only one control can be specified for each control type in a ZoneControl:Thermostat statement, there are only four pairs possible in a particular ZoneControl:Thermostat type/name list. This is because individual controls can be defined throughout the simulation, thus giving the user a full range of flexibility. Since putting in the name of the control type directly in the schedule would be very cumbersome, the control types are assigned a number which is used in the schedule profile.

Field: Name

Unique identifying name for the thermostat.

Field: Zone Name

Name of the zone that is being controlled.

Field: Control Type Schedule Name

Schedule which defines what type of control is active during the simulation. Valid Control Types are:

- 0 - Uncontrolled (No specification or default)
- 1 - Single Heating Setpoint
- 2 - Single Cooling SetPoint
- 3 - Single Heating Cooling Setpoint
- 4 - Dual Setpoint with Deadband (Heating and Cooling)

Each non-zero control type which is used in this schedule must appear in the following fields which list the specific thermostat control objects to be used for this zone.

Field Set (Control Object Type, Control Name)

Up to four pairs of Control Object Type and Control Name may be listed to specify which control objects are used for this zone. This list is not order-dependent, and the position in this list has no impact on the control type schedule. In the control type schedule, a value of 1 always means "Single Heating Setpoint", even if that control type is not first in this list.

Field: Control Object <x>Type

This field specifies the control type to be used for this zone. Available control types are:

```
ThermostatSetpoint:SingleHeating
ThermostatSetpoint:SingleCooling
ThermostatSetpoint:SingleHeatingOrCooling
ThermostatSetpoint:DualSetpoint
```

Field: Control <x> Name

The corresponding control type name. The name is used in an object with the name of the control type and specifies the schedule.

The input data dictionary description for the thermostat object is shown below:

```

ZoneControl:Thermostat,
  A1 , \field Name
        \required-field
        \reference ZoneControlThermostaticNames
  A2 , \field Zone Name
        \required-field
        \type object-list
        \object-list ZoneNames
  A3 , \field Control Type Schedule Name
        \note This schedule contains appropriate control types for thermostat.
        \note Control types are integers:
        \note 0 - Uncontrolled (floating, no thermostat),
        \note 1 = ThermostatSetpoint:SingleHeating,
        \note 2 = ThermostatSetpoint:SingleCooling,
        \note 3 = ThermostatSetpoint:SingleHeatingOrCooling,
        \note 4 = ThermostatSetpoint:DualSetpoint          \required-field
        \type object-list
        \object-list ScheduleNames
  A4 , \field Control 1 Object Type
        \required-field
        \type choice
        \key ThermostatSetpoint:SingleHeating
        \key ThermostatSetpoint:SingleCooling
        \key ThermostatSetpoint:SingleHeatingOrCooling
        \key ThermostatSetpoint:DualSetpoint
  A5 , \field Control 1 Name
        \note Control names are names of individual control objects (e.g. ThermostatSetpoint:SingleHeating)
        \note Schedule values in these objects list actual setpoint temperatures for the control types
        \required-field
        \type object-list
        \object-list ControlTypeNames

```

An example of this statement in an IDF is:

```

ZoneControl:Thermostat, Zone 3 Thermostat, NORTH ZONE,
  Zone Control Type Sched,
  DUAL SETPOINT WITH DEADBAND, VAV Setpoints;

```

A complete zone thermostat example showing this statement and all of the objects it must reference is:

```

! Zone control object which links thermostats to a particular zone
ZoneControl:Thermostat, Zone 2 Thermostat, EAST ZONE,
  Zone Control Type Sched,
  ThermostatSetpoint:SingleCooling, Cooling Setpoint with SB,
  ThermostatSetpoint:SingleHeating,, Heating Setpoint with SB;

```

```

! Control type objects - these may be used in more than one zone
ThermostatSetpoint:SingleCooling,,
  Cooling Setpoint with SB,
  Cooling Setpoints;

ThermostatSetpoint:SingleHeating,,
  Heating Setpoint with SB,
  Heating Setpoints;

```



```
! Schedule type definitions
  ScheduleTypeLimits, Temperature, -60:200, CONTINUOUS;
  ScheduleTypeLimits, Control Type, 0:4, DISCRETE;

! Control type schedule definition
  Schedule:Compact, Zone Control Type Sched, Control Type,
    Through: 3/31,
    For: AllDays,
    Until: 24:00, 1,  !- Single Heating
    Through: 9/30,
    For: AllDays,
    Until: 24:00, 2,  !- Single Cooling
    Through: 12/31,
    For: AllDays,
    Until: 24:00, 1;  !- Single Heating
```

```
! Heating setpoint schedule definition
  Schedule:Compact, Heating Setpoints, Temperature,
    Through: 12/31,
    For: AllDays,
    Until: 7:00, 15.,
    Until: 17:00, 20.,
    Until: 24:00, 15.;
```

```
! Cooling setpoint schedule definition
  Schedule:Compact, Cooling Setpoints, Temperature,
    Through: 12/31,
    For: AllDays,
    Until: 7:00, 30.,
    Until: 20:00, 23.,
    Until: 24:00, 30.;
```

ZoneControl:Thermostat Outputs

Outputs available from the ZoneControl:Thermostat:

```
HVAC, Average, Zone/Sys Sensible Load Predicted[W]
HVAC, Average, Zone/Sys Sensible Load to Heating Setpoint Predicted[W]
HVAC, Average, Zone/Sys Sensible Load to Cooling Setpoint Predicted[W]
Zone, Average, Zone/Sys Thermostat Control Type
Zone, Average, Zone/Sys Thermostat Heating Setpoint [C]
Zone, Average, Zone/Sys Thermostat Cooling Setpoint [C]
```

Zone/Sys Sensible Load Predicted[W]

This is the predicted sensible load in W required to meet the current zone thermostat setpoint. A positive value indicates a heating load, a negative value indicates a cooling load. This is calculated and reported from the Predict step in the Zone Predictor-Corrector module. For nearly all equipment types, the Predictor-Corrector evaluates the active heating and/or cooling setpoints, determines if the zone requires heating or cooling or is in the deadband, and then passes this single load to the equipment. This value is not multiplied by zone or group multipliers.

Zone/Sys Sensible Load to Heating Setpoint Predicted[W]

This is the predicted sensible load in W required to meet the current zone thermostat heating setpoint. A positive value indicates a heating load, a negative value indicates a cooling load. This is calculated and reported from the Predict step in the Zone Predictor-Corrector module. This value is not multiplied by zone or group multipliers.

Zone/Sys Sensible Load to Cooling Setpoint Predicted[W]

This is the predicted sensible load in W required to meet the current zone thermostat cooling setpoint. A positive value indicates a heating load, a negative value indicates a cooling load.

This is calculated and reported from the Predict step in the Zone Predictor-Corrector module. This value is not multiplied by zone or group multipliers.

Zone/Sys Thermostat Control Type

This is the current zone thermostat control type (0 through 4). This value is set at each zone timestep. Using the averaged value for longer reporting frequencies (hourly, for example) may not be meaningful in some applications.

Zone/Sys Thermostat Heating Setpoint [C]

This is the current zone thermostat heating setpoint in degrees C. If there is no heating thermostat active, then the value will be 0. This value is set at each zone timestep. Using the averaged value for longer reporting frequencies (hourly, for example) may not be meaningful in some applications.

Zone/Sys Thermostat Cooling Setpoint [C]

This is the current zone thermostat cooling setpoint in degrees C. If there is no cooling thermostat active, then the value will be 0. This value is set at each zone timestep. Using the averaged value for longer reporting frequencies (hourly, for example) may not be meaningful in some applications.

Time Heating Setpoint Not Met[hr]

Hours when the zone temperature is lower than 0.2 degrees C below the heating setpoint.

Time Heating Setpoint Not Met While Occupied[hr]

Hours when the zone temperature is lower than 0.2 degrees C below the heating setpoint and when people are present in the zone.

Time Cooling Setpoint Not Met[hr]

Hours when the zone temperature is greater than 0.2 degrees C above the cooling setpoint.

Time Cooling Setpoint Not Met While Occupied[hr]

Hours when the zone temperature is greater than 0.2 degrees C above the cooling setpoint and when people are present in the zone.

Time Zone Temperature Oscillating[hr]

Hours when the temperature in the zone is oscillating back and forth. Oscillation is defined as times when the three differences between zone temperatures during successive timesteps are greater in magnitude than 0.15 degrees C and the sign of the differences changes from positive to negative to positive or from negative to positive to negative.

This may indicate a simulation with reduced reliability during the oscillation. Some oscillating hours should be expected in all simulations but excessive oscillations call into question the overall validity of the results. If excessive oscillations are occurring, try reducing the minimum system timestep (see ConvergenceLimits object) and the zone timestep (see the TimeStep object). Reducing these timestep lengths does increase the total computer time needed to complete the simulation. Having the zone timestep and the minimum system timestep the same length of time can also cause more oscillations. What amount of oscillations is considered “excessive” is difficult to quantify. One approach is comparing the number of oscillations to the case with 15 minute zone timesteps (4 per hour) and 1 minute minimum system timesteps. Often this variable is used as an indicator of the validity of the results when trying to decrease the time needed to perform the simulation.

Time Any Zone Temperature Oscillating[hr]

Hours when any zone in the building has oscillations. See Time Zone Temperature Oscillating definition above.

Zone Thermostat Setpoints

The syntax for the current set of four zone thermostat setpoint objects is given below. In each case, the keyword is accompanied by an identifying name and either one or two schedule names (depending on whether the control is a single or dual setpoint control). The schedule defines a temperature setpoint for the control type. The schedule would be defined through the standard schedule syntax described earlier in this document. For an uncontrolled zone no thermostat is specified or necessary.

ThermostatSetpoint:SingleHeating

This would be for a heating only thermostat. The setpoint can be scheduled and varied throughout the simulation but only heating is allowed with this control type.

Field: Name

Unique name for this control type.

Field: Setpoint Temperature Schedule Name

The name of the associated schedule. Values in the schedule are temperatures {C}.

ThermostatSetpoint:SingleCooling

This would be for a cooling only thermostat. The setpoint can be scheduled and varied throughout the simulation but only cooling is allowed.

Field: Name

Unique name for this control type.

Field: Setpoint Temperature Schedule Name

The name of the associated schedule. Values in the schedule are temperatures {C}.

ThermostatSetpoint:SingleHeatingOrCooling

This would be for heating and cooling thermostat but only heating or cooling can be scheduled at any given time period. The setpoint can be scheduled and varied throughout the simulation for both heating and cooling.

Field: Name

Unique name for this control type.

Field: Setpoint Temperature Schedule Name

The name of the associated schedule. Values in the schedule are temperatures {C}.

ThermostatSetpoint:DualSetpoint

This would be for heating and cooling thermostat where both a heating and cooling setpoint can be scheduled for any given time period. The setpoint can be scheduled and varied throughout the simulation for both heating and cooling.

Field: Name

Unique name for this control type.

Field: Heating Setpoint Temperature Schedule Name

The heating temperature schedule. Values in the schedule are temperatures {C}.

Field: Cooling Setpoint Temperature Schedule Name

The cooling temperature schedule. Values in the schedule are temperatures {C}.

The input data dictionary description for the thermostat control objects is shown below:

```

ThermostatSetpoint:SingleHeating,
  A1 , \field Name
      \required-field
      \type alpha
      \reference ControlTypeNames
  A2 ; \field Setpoint Temperature Schedule Name
      \type object-list
      \object-list ScheduleNames

ThermostatSetpoint:SingleCooling,
  A1 , \field Name
      \required-field
      \type alpha
      \reference ControlTypeNames
  A2 ; \field Setpoint Temperature Schedule Name
      \type object-list
      \object-list ScheduleNames

ThermostatSetpoint:SingleHeatingOrCooling,
  A1 , \field Name
      \required-field
      \type alpha
      \reference ControlTypeNames
  A2 ; \field Setpoint Temperature Schedule Name
      \type object-list
      \object-list ScheduleNames

ThermostatSetpoint:DualSetpoint,
  A1 , \field Name
      \required-field
      \type alpha
      \reference ControlTypeNames
  A2 , \field Heating Setpoint Temperature Schedule Name
      \type object-list
      \object-list ScheduleNames
  A3 ; \field Cooling Setpoint Temperature Schedule Name
      \type object-list
      \object-list ScheduleNames

```

Examples of these statements in an IDF are:

```

ThermostatSetpoint:SingleHeating, Heating Setpoint with SB, Heating Setpoints;
ThermostatSetpoint:SingleCooling, Cooling Setpoint with SB, Cooling Setpoints;
ThermostatSetpoint:SingleHeatingOrCooling, Heating Cooling Setpoint Sched, Heating Cooling Setpoints;
ThermostatSetpoint:DualSetpoint, VAV Setpoints, Heating Setpoints, Cooling Setpoints;

```

ZoneControl:Thermostat:OperativeTemperature

This object is used to modify the program's behavior for ZoneControl:Thermostat objects. One input object is used for each thermal zone to indicate if that zone's thermostat control mode should be overridden to effect operative temperature control rather than traditional air temperature control. Zone Control:Thermostatic and related set point objects also need to be included in the input file. When this object is used, the zone can be controlled by a weighted mixture of radiant and air temperatures (rather than just air temperatures).

This thermostatic operative temperature, T_{OP} , is defined as:

$$T_{OP} = \gamma T_{MRT} + (1 - \gamma) T_{drybulb}$$

where,

γ is the radiative fraction,

T_{MRT} is the mean radiant temperature for the thermal zone, and

$T_{drybulb}$ is the mean zone air temperature.

The radiative fraction γ is selected by the user and can be scheduled to vary during the simulation. A typical value is 0.5. The maximum value needs to be less than 0.9 and the minimum is 0.0. A value of 0.0 is the same as controlling on only zone air temperature. If air velocities are higher than 0.2 m/s, then lower values for radiative fraction might apply. Niu and Burnett (1998) cite International Standard ISO 77300 in recommending the values for this fraction listed in the following table.

Table 25. Radiative Fraction vs Air Velocity (Operative Temperature Control)

Air Velocity (m/s)	< 0.2	0.2 to 0.6	0.6 to 1.0
γ	0.5	0.4	0.3

Reference: J. Niu and J. Burnett. 1998. Integrating Radiant/Operative Temperature Controls into Building Energy Simulations. ASHRAE Transactions Vol. 104. Part 2. page 210. ASHRAE. Atlanta, GA.

Field: Thermostat Name

Name of ZoneControl:Thermostat object defined elsewhere in the input file whose operation is to be modified to effect control based on operative temperature.

Field: Radiative Fraction Input Mode

This field controls whether the input for radiative fraction is a constant value or if it is entered using a schedule. Enter “**Constant**” here to use a fixed radiative fraction defined in the following field. Enter “**Scheduled**” to vary the radiative fraction according to the schedule named in the second field below.

Field: Fixed Radiative Fraction

This is the fraction, γ , of the operative temperature that is due to the mean radiant temperature in the zone. This field is used by the program if the previous field is set to **Constant**.

Field: Radiative Fraction Schedule Name

This field contains the name of a schedule, defined elsewhere, that determines the value for radiative fraction γ during the simulation period. This schedule should have fractional values from 0.0 to 0.9. When the value of this schedule is 0.0, the controlling will be equivalent to control based only on zone air temperature. This field is used by the program if the Input Mode field is set to **Scheduled**.

Note that by setting the values in this schedule separately for design days, the user can control how operative temperature control is applied during autosizing. (Operative temperature control tends to increase the equipment capacities calculated during sizing.)

The input data dictionary for this object follows.

```

ZoneControl:Thermostat:OperativeTemperature,
A1, \field Thermostat Name
    \note Enter the name of a ZoneControl:Thermostat object.
    \note This object modifies a ZoneControl:Thermostat object to add a
    \note radiative fraction.
    \required-field
    \type object-list
    \object-list ZoneControlThermostaticNames
A2, \field Radiative Fraction Input Mode
    \required-field
    \type choice
    \key Constant
    \key Scheduled
N1, \field Fixed Radiative Fraction
    \minimum 0.0
    \maximum< 0.9
A3; \field Radiative Fraction Schedule Name
    \note Schedule values of 0.0 indicate no operative temperature control
    \type object-list
    \object-list ScheduleNames

```

An example of this object follows.

```

ZoneControl:Thermostat:OperativeTemperature,
Zone 1 Thermostat,  !- ZoneControl:Thermostat Name
Constant,          !- Radiative Fraction Input Mode
0.5,              !- Fixed Radiative Fraction
; !- Radiative Fraction Schedule

```

Zone Control Thermostatic Operative Temperature Outputs

Zone, Average, Zone Thermostat Operative Temperature [C]

Zone Thermostat Operative Temperature [C]

Operative temperature (OT) is a weighted mixture of Zone Mean Air Temperature (MAT) and Zone Mean Radiant Temperature (MRT), using the current value of Radiative Fraction (RF): $OT = (1-RF)*MAT + RF*MAT$. This report variable does not include the direct effect of high temperature radiant systems. See also Zone Operative Temperature.

ZoneControl:Humidistat

The humidistat zone control object is used to control a zone to a single relative humidity setpoint schedule, or to dual humidity setpoint schedules (humidifying/ dehumidifying setpoints with deadband). The single setpoint humidistat requires single setpoint input only, and the dual-setpoint humidistat requires inputs of both humidifying and dehumidifying setpoints. The schedules consist of relative humidities, expressed as a percentage (0-100), to be used during the simulation for that zone's moisture prediction calculation. Only one humidistat control statement can be specified for each zone. For a single setpoint humidistat, if the zone relative humidity is below the control relative humidity setpoint and the equipment specified can humidify then that equipment will try and meet the zone's humidification load. The opposite is true if the zone relative humidity is above the control relative humidity setpoint and the equipment can dehumidify. For a dual setpoint humidistat, if the zone relative humidity is below the **humidifying** relative humidity setpoint and the equipment specified can humidify then that equipment will try and meet the zone's humidification load. The opposite is true if the zone relative humidity is above the **dehumidifying** relative humidity setpoint and the equipment can dehumidify.

If the ZoneControl:Humidistat is used by a furnace or unitary system (Ref. Furnace and Unitary Systems) no other objects are required. The signal from the humidistat is used directly by that component. If the Zone Control:Humidistat object is used to control a Humidifier or used in conjunction with a Controller:WaterCoil object with control variable **TemperatureAndHumidityRatio**, then either the "SetpointManager:SingleZone:Humidity:Minimum" or "SetpointManager:SingleZone:Humidity:Minimum" objects are required to determine a

setpoint for those components for a single setpoint humidistat. For a dual setpoint humidistat, both the “SetpointManager:SingleZone:Humidity:Maximum” and “SetpointManager:SingleZone:Humidity:Minimum” objects are required to determine the setpoints for the corresponding humidification and dehumidification components.

Field: Name

Unique identifying name for the humidistat.

Field: Zone Name

Name of the zone that is being controlled.

Field: Humidifying Relative Humidity Setpoint Schedule Name

Name of a schedule that defines the humidifying relative humidity setpoint, expressed as a percentage (0-100), for each timestep of the simulation.

Note: If only a single setpoint humidistat is desired, then input the single schedule name in the Humidifying Setpoint Schedule Name field (and leave the Dehumidifying Setpoint Schedule Name blank).

Field: Dehumidifying Relative Humidity Setpoint Schedule Name

Name of a schedule that defines the dehumidifying relative humidity setpoint, expressed as a percentage (0-100), for each timestep of the simulation. This field is optional, only used if a dual setpoint humidistat is to be modeled.

The input data dictionary description for the humidistat object is shown below:

```
ZoneControl:Humidistat,
  \min-fields 3
  A1 , \field Name
      \required-field
  A2 , \field Zone Name
      \required-field
      \type object-list
      \object-list ZoneNames
  A3 , \field Humidifying Relative Humidity Setpoint Schedule Name
      \required-field
      \note hourly schedule values should be in Relative Humidity (percent)
      \type object-list
      \object-list ScheduleNames
  A4 ; \field Dehumidifying Relative Humidity Setpoint Schedule Name
      \note hourly schedule values should be in Relative Humidity (percent)
      \type object-list
      \object-list ScheduleNames
```

An example of this statement in an IDF is:

```
ZoneControl:Humidistat,
  Zone 2 Humidistat,      !- Humidistat Name
  EAST ZONE,              !- Zone Name
  Min Rel Hum Set Sch,    !- Humidifying Relative Humidity Setpoint SCHEDULE Name
  Max Rel Hum Set Sch;    !- Dehumidifying Relative Humidity Setpoint SCHEDULE Name
```

An example schedule for the Zone Control:Humidistat

```

ScheduleTypeLimits, Humidity, 0:100, CONTINUOUS;

Schedule:Compact,
  Min Rel Hum Set Sch,      !- Name
  Humidity,                 !- ScheduleType
  Through: 12/31,          !- Complex Field #1
  For: AllDays,            !- Complex Field #2
  Until: 24:00,            !- Complex Field #3
  30.0;                    !- Complex Field #4
Schedule:Compact,,
  Max Rel Hum Set Sch,     !- Name
  Humidity,                !- ScheduleType
  Through: 12/31,          !- Complex Field #1
  For: AllDays,            !- Complex Field #2
  Until: 24:00,            !- Complex Field #3
  55.0;                    !- Complex Field #4

```

ZoneControl:Humidistat Outputs

Outputs available from the ZoneControl:Humidistat:

```

HVAC, Average, Zone/Sys Moisture Load Rate Predicted[kgWater/sec]
HVAC, Average, Zone/Sys Moisture Load Rate Predicted to Humidifying Setpoint[kgWater/sec]
HVAC, Average, Zone/Sys Moisture Load Rate Predicted to Dehumidifying Setpoint[kgWater/sec]

```

Zone/Sys Moisture Load Rate Predicted[kgWater/sec]

This is the predicted latent (moisture) load in $\text{kg}_{\text{water}}/\text{s}$ required to meet the current zone humidistat setpoint. A positive value indicates a humidification load, a negative value indicates a dehumidification load. For a dual setpoint humidistat, the value is zero when the controlled zone's relative humidity is between the defined humidifying and dehumidifying setpoints. This moisture load rate is calculated and reported from the Predict step in the Zone Predictor-Corrector module. For nearly all equipment types, the Predictor-Corrector evaluates the active humidistat setpoints, determines if the zone requires humidification or dehumidification, and then passes this single load to the equipment for the single setpoint humidistat case. This value is not multiplied by zone or group multipliers.

Zone/Sys Moisture Load Rate Predicted to Humidifying Setpoint [kgWater/sec]

This is the predicted latent (moisture) load in $\text{kg}_{\text{water}}/\text{s}$ required to meet the current zone humidistat **humidifying** setpoint. This is calculated and reported from the Predict step in the Zone Predictor-Corrector module. For nearly all equipment types, the Predictor-Corrector evaluates the active humidistat humidifying setpoints, determines if the zone requires humidification or not, and then passes this load to the equipment for the case of a dual setpoint humidistat (see Zone/Sys Moisture Load Rate Predicted, above, for single setpoint humidistat case). This value is multiplied by zone or group multipliers.

Zone/Sys Moisture Load Rate Predicted to Dehumidifying Setpoint [kgWater/sec]

This is the predicted latent (moisture) load in $\text{kg}_{\text{water}}/\text{s}$ required to meet the current zone humidistat **dehumidifying** setpoint. This is calculated and reported from the Predict step in the Zone Predictor-Corrector module. For nearly all equipment types, the Predictor-Corrector evaluates the active humidistat humidifying setpoints, determines if the zone requires dehumidification or not, and then passes this load to the equipment for a dual setpoint humidistat (see Zone/Sys Moisture Load Rate Predicted, above, for single setpoint humidistat case). This value is multiplied by zone or group multipliers.

ZoneControl:Thermostat:ThermalComfort

The thermal comfort zone control provides a method to control a zone to a dry-bulb temperature setpoint based on a thermal comfort model (e.g. Fanger) and a user-specified thermal comfort setpoint schedule.

This object references a control type schedule and one or more thermal comfort control type objects which in turn reference one or more setpoint schedules. The example at the end of this section illustrates a complete zone thermal comfort control specification including the control type and setpoint schedules. The control type schedule and the list of control type/name pairs are directly related. The schedule defines the type of control that is to be used during for each hour. Valid Control Types are

- 0 – Uncontrolled (No thermal comfort control)
- 1 - Single Thermal Comfort Heating Setpoint:Fanger
- 2 - Single Thermal Comfort Cooling Setpoint:Fanger
- 3 - Single Thermal Comfort Heating Cooling Setpoint:Fanger
- 4 - Dual Thermal Comfort Setpoint with Deadband:Fanger

Thus, if the schedule referenced in the ZoneControl:Thermostat:ThermalComfort statement has a value of 4 for a particular hour, this indicates that during that hour "Dual Thermal Comfort Setpoint with Deadband:Fanger" is to be used. The specific "Dual Thermal Comfort Setpoint with Deadband:Fanger " control object to be used is specified in the list of control type/name pairs. Then the specific control type objects reference the thermal comfort control setpoint schedule to be used. Because only one control can be specified for each control type in a ZoneControl:Thermostat:ThermalComfort statement, there are only four pairs possible in a particular ZoneControl:Thermostat:ThermalComfort type/name list. This is because individual controls can be defined hourly, thus giving the user a full range of flexibility. Since putting in the name of the control type directly in the schedule would be very cumbersome, the control types are assigned a number which is used in the hourly schedule profile.

The ZoneControl:Thermostat:ThermalComfort object can be used alone, or with a ZoneControl:Thermostat object. When both control objects co-exist for a specific zone and the thermal comfort control type value in the thermal comfort control type schedule is non-zero the thermal comfort object will override the value from the zone thermostat object. If the thermal comfort control is specified as "Uncontrolled" (thermal comfort control type value of 0) for a particular period, then control will revert to thermostat control if specified. If the thermal comfort control is specified as "Uncontrolled" for a particular period and thermostat control is not specified in the input, then conditions will float,

This object currently allows only Fanger comfort control (Ref. Thermal Comfort in Engineering Reference). It requires one or more people objects in a specific zone. It also requires inputs of Fields *Activity Level Schedule Name*, *Work Efficiency Schedule Name*, *Clothing Insulation Schedule Name* and *Air Velocity Schedule Name* in the people object(s). When thermal comfort control is used in a zone, the air velocity entered in the Air Velocity Schedule (Ref. People) should be greater than or equal to 0.1 and less than or equal to 0.5 m/s. A warning message will be issued if thermal comfort control is active and the air velocity is outside this range.

This object reads input PMV values from a given PMV setpoint schedule to calculate a dry-bulb temperature setpoint based on the selected thermal comfort model. The dry-bulb temperature setpoint calculation uses zone air humidity ratio at the previous system timestep and surface temperatures at the previous zone timestep, along with other conditions at the current timestep (e.g., activity level, clothing level and air velocity from the PEOPLE object).

Field: Name

Unique identifying name for this thermal comfort control object.

Field: Zone Name

Name of the zone that is being controlled.

Field: Averaging Method

This choice field specifies the method for calculating the thermal comfort dry-bulb temperature setpoint for a zone with multiple People objects defined. The available choices

are: **SpecificObject**, **ObjectAverage**, and **PeopleAverage**. This field is only used when multiple people objects are defined for this zone. If this field is specified as **PeopleAverage** and the total number of people for all people objects is zero for a particular timestep, the PeopleAverage method can not be applied and the program automatically uses the ObjectAverage method for this timestep. The default input is **PeopleAverage**.

Field: Object Name for Specific Object Averaging Method

This choice field specifies the name of the specific People object to be used for calculating comfort control when multiple People objects are defined. Only used if the Averaging Method is specified as "SpecificObject."

Field: Minimum Dry-Bulb Temperature Setpoint

This field specifies the minimum dry-bulb temperature setpoint allowed for this zone. If the dry-bulb temperature calculated by the thermal comfort setpoint model is below this value, then the temperature setpoint will be set to this value. The default value is 0 °C.

Field: Maximum Dry-Bulb Temperature Setpoint

This field specifies the maximum dry-bulb temperature setpoint allowed for this zone. If the dry-bulb temperature calculated by the thermal comfort setpoint model exceeds this value, then the temperature setpoint will be set to this value. The default value is 50 °C.

Note the minimum and maximum temperature setpoint fields are provided to allow the user to bound the temperature control in a specific zone if necessary. These fields are used to provide boundaries for the dry-bulb temperature setpoint calculated at each system timestep when unrealistic inputs have been specified.

Field: Thermal Comfort Control Type Schedule Name

Schedule which defines what type of thermal comfort control is active during each simulation timestep.

Valid Control Types are

- 0 – No thermal comfort control
- 1 - Single Thermal Comfort Heating Setpoint:Fanger
- 2 - Single Thermal Comfort Cooling Setpoint:Fanger
- 3 - Single Thermal Comfort Heating Cooling Setpoint:Fanger
- 4 - Dual Thermal Comfort Setpoint with Deadband:Fanger

Each non-zero control type used in this schedule must appear in the following fields which list the specific thermal comfort control objects to be used for this zone.

Field Set (Thermal Comfort Control Object Type, Thermal Comfort Control Name)

Up to four pairs of Thermal Comfort Control Type and Thermal Comfort Control Type Name fields may be listed to specify which thermal comfort control type objects are used for this zone. This list is not order-dependent, and the position in this list has no impact on the control type schedule. In the control type schedule, a value of 1 always means "Single Thermal Comfort Heating Setpoint:Fanger", even if that control type is not first in this list.

Field: Thermal Comfort Control <x> Object Type

This field specifies the first control type name to be used for this zone. Available control types are:

```
ThermostatSetpoint:ThermalComfort:Fanger:SingleHeating
ThermostatSetpoint:ThermalComfort:Fanger:SingleCooling
ThermostatSetpoint:ThermalComfort:Fanger:SingleHeatingOrCooling
ThermostatSetpoint:ThermalComfort:Fanger:DualSetpoint
```

Field: Thermal Comfort Control <x> Name

The unique name for the corresponding thermal comfort control type.

The input data dictionary description for the thermal comfort object is shown below:

```

ZoneControl:Thermostat:ThermalComfort,
  \min-fields 9
A1 , \field Name
  \required-field
  \reference ZoneControlThermalComfortNames
A2 , \field Zone Name
  \required-field
  \type object-list
  \object-list ZoneNames
A3 , \field Averaging Method
  \note The method used to calculate thermal comfort dry-bulb temperature setpoint
  \note for multiple people objects in a zone
  \type choice
  \key SpecificObject
  \key ObjectAverage
  \key PeopleAverage
  \default PeopleAverage
A4 , \field Specific People Name
  \note Used only when Averaging Method = SpecificObject in the previous field.
  \type object-list
  \object-list PeopleNames
N1 , \field Minimum Dry-Bulb Temperature Setpoint
  \required-field
  \type real
  \units C
  \minimum 0
  \maximum 50
  \default 0
N2 , \field Maximum Dry-Bulb Temperature Setpoint
  \required-field
  \type real
  \units C
  \minimum 0
  \maximum 50
  \default 50
A5 , \field Thermal Comfort Control Type Schedule Name
  \note The Thermal Comfort Control Type Schedule contains values that are appropriate control types.
  \note Thermal Comfort Control types are integers:
  \note 0 - Uncontrolled (floating),
  \note 1 = ThermostatSetpoint:ThermalComfort:Fanger:SingleHeating
  \note 2 = ThermostatSetpoint:ThermalComfort:Fanger:SingleCooling
  \note 3 = ThermostatSetpoint:ThermalComfort:Fanger:SingleHeatingOrCooling
  \note 4 = ThermostatSetpoint:ThermalComfort:Fanger:DualSetpoint
  \required-field
  \type object-list
  \object-list ScheduleNames
A6 , \field Thermal Comfort Control 1 Object Type
  \required-field
  \type choice
  \key ThermostatSetpoint:ThermalComfort:Fanger:SingleHeating
  \key ThermostatSetpoint:ThermalComfort:Fanger:SingleCooling
  \key ThermostatSetpoint:ThermalComfort:Fanger:SingleHeatingOrCooling
  \key ThermostatSetpoint:ThermalComfort:Fanger:DualSetpoint
A7 , \field Thermal Comfort Control 1 Name
  \note Control type names are names for individual control type objects.
  \note Schedule values in these objects list actual setpoint temperatures for the control types
  \required-field
  \type object-list
  \object-list ThermalComfortControlTypeNames

```

An example of this statement in an IDF is:

```

ZoneControl:Thermostat:ThermalComfort,
Zone 2 Comfort Control,           !- Thermal Comfort Control Name
EAST ZONE,                       !- Zone Name
SpecificObject,                 !- Averaging Method for Zones with Multiple People Objects
EAST ZONE,                       !- Object Name for Specific Object Averaging Method
12.8,                           !- Minimum dry-bulb temperature setpoint
40.0,                           !- Maximum dry-bulb temperature setpoint
Zone Comfort Control Type Sched, !- Thermal Comfort Control Type SCHEDULE Name
Dual Thermal Comfort Setpoint WITH DEADBAND:Fanger, !- Control Type #1
Dual Comfort Setpoint;          !- Thermal Comfort Control Type Name #1

```

ZoneControl:Thermostat:ThermalComfort Outputs

Three outputs are available from the ZoneControl:Thermostat:ThermalComfort object. Two report variables used primarily for the ZoneControl:Thermost object are also described here to explain their meaning when using thermal comfort control.

ZONE CONTROL:THERMAL COMFORT

```

Zone,Average,Zone/Sys Thermal Comfort Control Type
Zone,Average,Zone/Sys Thermal Comfort Control Fanger Low PMV
Zone,Average,Zone/Sys Thermal Comfort Control Fanger High PMV

```

ZoneControl:Thermostat

```

Zone,Average,Zone/Sys Thermostat Heating Setpoint [C]
Zone,Average,Zone/Sys Thermostat Cooling Setpoint [C]

```

Zone/Sys Thermal Comfort Control Type

This is the current zone thermal comfort control type (0 through 4). This value is set at each system timestep and averaged over the reporting interval. Using the averaged value for longer reporting frequencies (hourly, for example) may not be meaningful in some applications.

Zone/Sys Thermal Comfort Control Fanger Low PMV

This is the current zone thermal comfort low PMV value. Values range between -3 and +3. If there is no heating thermal comfort active, then the value reported will be -999. This value is set at each system timestep and averaged over the reporting interval. Using the averaged value for longer reporting frequencies (hourly, for example) may not be meaningful in some applications.

Zone/Sys Thermal Comfort Control Fanger High PMV

This is the current zone thermal comfort high PMV value. Values range between -3 and +3. If there is no cooling thermal comfort active, then the value reported will be 999. This value is set at each system timestep and averaged over the reporting interval. Using the averaged value for longer reporting frequencies (hourly, for example) may not be meaningful in some applications.

Zone/Sys Thermostat Heating Setpoint [C]

The Zone Control:Thermal Comfort object shares the same output variable and overwrites the thermal setpoints defined in object Zone Control:Thermostatic when both objects of Zone Control:Thermostatic and Zone Control:Thermal Comfort co-exist. It outputs the current zone thermal comfort heating setpoint in degrees C when thermal comfort control is active, otherwise this output variable will report the thermostat heating setpoint (Ref. Zone Control:Thermostatic Outputs). If there is no heating thermal comfort active and no thermostat heating setpoint is defined for this zone, this value will be 0. This value is set at each system timestep and averaged over the reporting interval. Using the averaged value for

longer reporting frequencies (hourly, for example) may not be meaningful in some applications.

Zone/Sys Thermostat Cooling Setpoint [C]

This output variable defined in object Zone Control:Thermostatic. The Thermal Comfort object shares the same output variable and overwrites the thermal setpoints defined in object Zone Control:Thermostatic when both objects of Zone Control:Thermostatic and Zone Control:Thermal Comfort co-exist. It outputs the current zone thermal comfort cooling setpoint in degrees C when thermal comfort control is active, otherwise this output variable will report the thermostat cooling setpoint (Ref. Zone Control:Thermostatic Outputs). If there is no cooling thermal comfort active and no thermostat cooling setpoint is defined for this zone, this value will be 0. This value is set at each system timestep and averaged over the reporting interval. Using the averaged value for longer reporting frequencies (hourly, for example) may not be meaningful in some applications.

Thermal Comfort Setpoints

The syntax for the current set (4) of zone thermal comfort control types is given below. In each case, the keyword is accompanied by an identifying name and either one or two schedule names (depending on whether the control type is a single or dual setpoint control). The schedule defines a Predicted Mean Vote (PMV) setpoint for the control type. The schedule would be defined through the standard schedule syntax described earlier in this document. For an uncontrolled thermal comfort zone, no Fanger thermal comfort object is specified or necessary.

ThermostatSetpoint:ThermalComfort:Fanger:SingleHeating

This would be used for heating only thermal comfort control. The PMV setpoint can be scheduled and varied throughout the simulation but only heating is allowed with this control type.

Field: Name

Unique name for this control type.

Field: Fanger Thermal Comfort Schedule Name

The name of the associated schedule containing FANGER PMV values.

ThermostatSetpoint:ThermalComfort:Fanger:SingleCooling

This would be used for cooling only thermal comfort control. The PMV setpoint can be scheduled and varied throughout the simulation but only cooling is allowed with this control type.

Field: Name

Unique name for this control type.

Field: Fanger Thermal Comfort Schedule Name

The name of the associated schedule, containing FANGER PMV values.

ThermostatSetpoint:ThermalComfort:Fanger:SingleHeatingOrCooling

This would be used for heating and cooling thermal comfort control but only heating or cooling can be scheduled at any given time period. The PMV setpoint can be scheduled and varied throughout the simulation for both heating and cooling.

Field: Name

Unique name for this control type.

Field: Fanger Thermal Comfort Schedule Name

The name of the associated schedule containing FANGER PMV values.

ThermostatSetpoint:ThermalComfort:Fanger:DualSetpoint

This would be used for heating and cooling thermal comfort control where both a heating and cooling PMV setpoint can be scheduled for any given time period. The PMV setpoint can be scheduled and varied throughout the simulation for both heating and cooling.

Field: Name

Unique name for this control type.

Field: Fanger Thermal Comfort Heating Schedule Name

The name of the associated schedule containing heating setpoint FANGER PMV values.

Field: Fanger Thermal Comfort Cooling Schedule Name

The name of the associated schedule containing cooling setpoint FANGER PMV values.

The input data dictionary description for the thermal comfort control objects is shown below:

```

ThermostatSetpoint:ThermalComfort:Fanger:SingleHeating,
  \min-fields 2
  A1 , \field Name
        \required-field
        \type alpha
        \reference ThermalComfortControlTypeNames
  A2 ; \field Fanger Thermal Comfort Schedule Name
        \note Schedule values should be Predicted Mean Vote (PMV)
        \required-field
        \type object-list
        \object-list ScheduleNames

ThermostatSetpoint:ThermalComfort:Fanger:SingleCooling,
  \min-fields 2
  A1 , \field Name
        \required-field
        \type alpha
        \reference ThermalComfortControlTypeNames
  A2 ; \field Fanger Thermal Comfort Schedule Name
        \note Schedule values should be Predicted Mean Vote (PMV)
        \required-field
        \type object-list
        \object-list ScheduleNames

ThermostatSetpoint:ThermalComfort:Fanger:SingleHeatingOrCooling,
  \min-fields 2
  A1 , \field Name
        \required-field
        \type alpha
        \reference ThermalComfortControlTypeNames
  A2 ; \field Fanger Thermal Comfort Schedule Name
        \note Schedule values should be Predicted Mean Vote (PMV)
        \required-field
        \type object-list
        \object-list ScheduleNames

```

```

ThermostatSetpoint:ThermalComfort:Fanger:DualSetpoint,
  \min-fields 3
A1 , \field Name
  \required-field
  \type alpha
  \reference ThermalComfortControlTypeNames
A2 , \field Fanger Thermal Comfort Heating Schedule Name
  \note Schedule values should be Predicted Mean Vote (PMV)
  \required-field
  \type object-list
  \object-list ScheduleNames
A3 ; \field Fanger Thermal Comfort Cooling Schedule Name
  \note Schedule values should be Predicted Mean Vote (PMV)
  \required-field
  \type object-list
  \object-list ScheduleNames

```

An example of this statement in an IDF is:

```

ThermostatSetpoint:ThermalComfort:Fanger:SingleHeating,
  Heating Comfort Setpoint,!- Name
  Heating PMV Setpoints;    !- Setpoint Temperature SCHEDULE Name

ThermostatSetpoint:ThermalComfort:Fanger:SingleCooling,
  Cooling Comfort Setpoint,!- Name
  Cooling PMV Setpoints;    !- Setpoint Temperature SCHEDULE Name

ThermostatSetpoint:ThermalComfort:Fanger:SingleHeatingOrCooling,
  Heating Cooling Comfort Setpoint,!- Name
  Heating Cooling PMV Setpoints;    !- Setpoint Temperature SCHEDULE Name

ThermostatSetpoint:ThermalComfort:Fanger:DualSetpoint,
  Dual Comfort Setpoint,    !- Name
  Heating PMV Setpoints,    !- Fanger Thermal Comfort Heating Setpoint PMV SCHEDULE Name
  Cooling PMV Setpoints;    !- Fanger Thermal Comfort Cooling Setpoint PMV SCHEDULE Name

```

Group – Air Path

AirLoopHVAC:SupplyPath, AirLoopHVAC:ReturnPath

The zone supply and return air paths are used to describe the configuration of the flow path that the supply air takes in moving from the main air handler to the zone terminal units and that the return air takes on leaving the zones and returning to the central return air duct. The air paths consist of a group of components – AirLoopHVAC:ZoneSplitters and AirLoopHVAC:SupplyPlenums for the supply path and AirLoopHVAC:ReturnPlenums and AirLoopHVAC:ZoneMixers for the return path. The connectivity of the paths is established by the components' node connections. There are no branches defined in the zone air path constructs.

For a typical single duct air system there will be one AirLoopHVAC:SupplyPath and one AirLoopHVAC:ReturnPath. A typical dual duct system would have 2 AirLoopHVAC:SupplyPaths – one for the hot air and one for the cold air – and 1 AirLoopHVAC:ReturnPath.

The AirLoopHVAC:SupplyPlenum component provides the capability to have supply air be distributed to the conditioned zones through one or more plenum zones such as would occur in an underfloor air distribution system (UFAD). The AirLoopHVAC:ReturnPlenum component allows the program to model return air plenums. Of course plenums are always optional. The simplest AirLoopHVAC:SupplyPath would consist of only a AirLoopHVAC:ZoneSplitter; similarly the simplest return air path consists of a single AirLoopHVAC:ZoneMixer. A UFAD system supply air path might consist of a single AirLoopHVAC:ZoneSplitter connecting to multiple AirLoopHVAC:SupplyPlenums which in turn could each supply one or more conditioned zones. A system with return plenums would have a AirLoopHVAC:ReturnPath in which the conditioned zones connect to the return plenum inlets and the return plenums outlets connect to a single AirLoopHVAC:ZoneMixer.

Both the zone supply and return plenums are solved in the heat balance as thermal zones which couple through heat conduction with adjacent zones. Since they are solved as thermal zones the solution scheme involves the zone predictor-corrector technique which will lag the temperature at the system timestep in every zone. See Summary of Predictor-Corrector Procedure in the EnergyPlus Engineering Document.

Below are the descriptions of the zone supply and return path statements. Note that each statement type has an identifying name, a single inlet/outlet node number, and a list of component type/name pairs. For a single zone being served by an air loop, the inlet to its air distribution unit and the zone outlet can be the zone equipment inlet and outlet nodes directly, thus eliminating the need to specify a `AirLoopHVAC:SupplyPath` and a `AirLoopHVAC:ReturnPath`.

AirLoopHVAC:SupplyPath

The `AirLoopHVAC:SupplyPath` lists the `AirLoopHVAC:ZoneSplitter` and `AirLoopHVAC:SupplyPlenum` components comprising the path. The components are listed in flow order: upstream to downstream. Connectivity is established by means of the individual component inlet and outlet nodes.

Field: Name

Unique name to identify the supply air path, i.e. Main Hot Air Inlet.

Field: Supply Air Path Inlet Node Name

The name of an inlet node for the zone equipment half of the air loop. This should be one of the nodes named in the `AirLoopHVAC` field: Demand Side Inlet Node Names.

Field Set Component Type and Name

The remaining fields are sets of two repeated times: a component type and a name. These pairs of fields define the components on the supply air path.

Field: Component <#> Object Type

Start of the component list for the `AirLoopHVAC:SupplyPath`. This field should contain either `AirLoopHVAC:SupplyPlenum` or `AirLoopHVAC:ZoneSplitter`.

Field: Component <#> Name

Unique name of the `AirLoopHVAC:SupplyPlenum` or `AirLoopHVAC:ZoneSplitter` component.

AirLoopHVAC:ReturnPath

The `AirLoopHVAC:ReturnPath` lists the `AirLoopHVAC:ZoneMixer` and `AirLoopHVAC:ReturnPlenum` components comprising the path. The components are listed in flow order: upstream to downstream. Connectivity is established by means of the individual component inlet and outlet nodes. At this time there can only be 1 `AirLoopHVAC:ZoneMixer` in a `AirLoopHVAC:ReturnPath`.

Field: Name

Unique name to identify the return air path.

Field: Return Air Path Outlet Node Name

The name of the node that is the outlet to the air loop from the `AirLoopHVAC:ReturnPath`. This should be the same node named in the `AirLoopHVAC` field: Demand Side Outlet Node Name.

Field Set Component Type and Name

The remaining fields are sets of two repeated times: a component type and a name. These pairs of fields define the components on the return air path.

Field: Component <#> Object Type

Start of the component list for the AirLoopHVAC:ReturnPath. This field should contain either *AirLoopHVAC:ReturnPlenum* or *AirLoopHVAC:ZoneMixer*.

Field: Component <#> Name

Unique name of the AirLoopHVAC:ReturnPlenum or AirLoopHVAC:ZoneMixer.

The IDD specifications for these objects follow:

```
AirLoopHVAC:SupplyPath,
  \extensible:2 Just duplicate last two fields and \ comments (changing numbering, please)
  \memo A supply path can only contain AirLoopHVAC:ZoneSplitter and AirLoopHVAC:SupplyPlenum objects
  \memo which may be in series or parallel
A1, \field Name
  \required-field
  \reference ZoneSupplyAirPaths
A2, \field Supply Air Path Inlet Node Name
  \required-field
A3, \field Component 1 Object Type
  \note Supply path components must be listed in flow order.
  \required-field
A4, \field Component 1 Name
  \required-field

A51, \field Component 25 Object Type
A52; \field Component 25 Name
```

```
AirLoopHVAC:ReturnPath,
  \extensible:2 Just duplicate last two fields and \ comments (changing numbering, please)
  \memo A return air path can only contain one AirLoopHVAC:ZoneMixer
  \memo and one or more AirLoopHVAC:ReturnPlenum objects.
A1, \field Name
  \required-field
  \reference ZoneReturnAirPaths
A2, \field Return Air Path Outlet Node Name
  \required-field
A3, \field Component 1 Object Type
  \required-field
A4, \field Component 1 Name
  \required-field

A51, \field Component 25 Object Type
A52; \field Component 25 Name
```

Example inputs are shown below

```
AirLoopHVAC:SupplyPath,
  SupplyAirPath 1,           !- Name
  Zone Equip In Node,       !- Supply Air Path Inlet Node Name
  AirLoopHVAC:SupplyPlenum, !- Component 1 Object Type
  Supply-Plenum-1,         !- Component 1 Name
  AirLoopHVAC:ZoneSplitter, !- Component 2 Object Type
  Zone Supply Air Splitter 1; !- Component 2 Name

AirLoopHVAC:ReturnPath,
  ReturnAirPath1,          !- Name
  PLENUM-1 Out Node,      !- Return Air Path Outlet Node Name
  Zone Return Plenum,     !- Component 1 Object Type
  Return-Plenum-1;       !- Component 1 Name
```

AirLoopHVAC:ReturnPlenum

The simple building shown in the figure below, consists of a controlled zone and a return plenum zone that are used for the return air. This simple configuration contains a ground floor controlled zone with a window and a return plenum zone which handles the roof load. The return air plenum is a special type of component since there is both a heat balance connection and building description and a system airflow connection that transfers the airflow directly from the controlled zone to the return plenum zone in the system air simulation. The input described in this section is mainly just for the system airflow connections in the HVAC algorithms. In addition the return plenum zone must be fully input as a zone object for the heat balance calculation. The zone description needs to contain the wall descriptions - the interzone ceiling and floor, and for this simple case the roof. All the other attributes of a zone that can be specified in the building description can be used with a return plenum zone if necessary: scheduled loads, windows, etc.

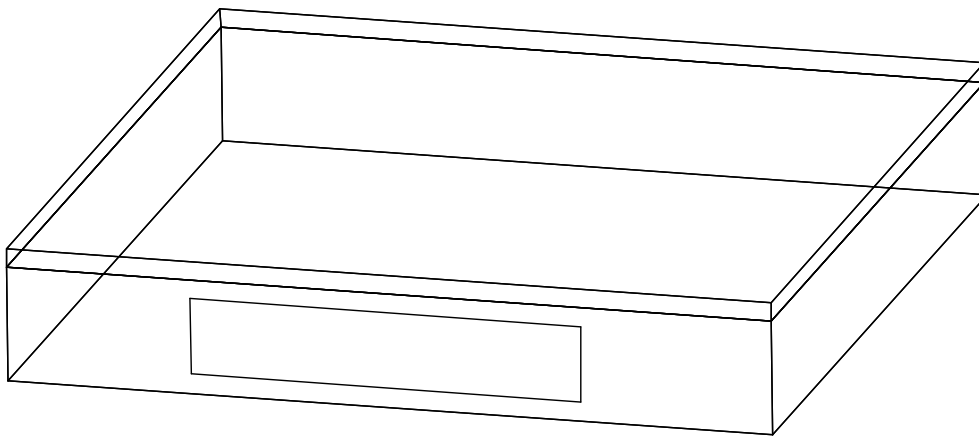


Figure 104. Illustration of Zone Return Plenum

After all the building zone attributes are specified, the AirLoopHVAC:ReturnPlenum object is specified and included as one of the named components in a AirLoopHVAC:ReturnPath.

Field: Name

A unique identifying name identifying the AirLoopHVAC:ReturnPlenum system component.

Field: Zone Name

The zone name specified in the heat balance portion of the input. This piece of input connects the zone return plenum system component to the heat balance data structure.

Field: Zone Node Name

The name of the zone node. The zone node name connects the heat balance data structure to the system airflow data structure through this node. This node name is defined by the user in the field "Zone Air Node Name" in the ZoneHVAC:EquipmentConnections object for the zone named in the previous field.

Field: Outlet Node Name

The name of the zone outlet node. For the zone return plenum there is only one outlet node that can be specified.

Field: Inlet <#> Node Name

The name of one of the plenum inlet nodes. The zone return plenum component can collect air from many different zones, therefore multiple zone inlet nodes can be listed. Currently the limit is 30 per air loop but this can easily be extended by adding more inlet nodes in the Energy+.idd. There can be no duplicate names in the different inlet node name fields.

The IDD entry for this object follows.

```
AirLoopHVAC:ReturnPlenum,
  \extensible:1 Just duplicate last field and \ comments (changing numbering, please)
  \memo Connects N zone inlet air streams, through zone return plenum, to outlet
  \memo Node names cannot be duplicated within a single list.
  A1, \field Name
      \required-field
  A2, \field Zone Name
      \required-field
  A3, \field Zone Node Name
      \required-field
  A4, \field Outlet Node Name
      \required-field
  A5, \field Inlet 1 Node Name
      \required-field

  A34; \field Inlet 30 Node Name
```

And, an IDF example of a zone return plenum component specification:

```
AirLoopHVAC:ReturnPlenum,
  Zone 1a Plenum,           ! Name
  ZONE 1a,                  ! Zone Name
  Zone 1a Node,            ! Zone Node Name
  Zone 1a Plenum Outlet Node, ! Outlet Node Name
  Zone 1 Outlet Node;      ! Inlet 1 Node Name
```

Below is an example of the AirLoopHVAC:ReturnPath for the simple case shown above.

```
AirLoopHVAC:ReturnPath,
  TermReheatReturnPath,    ! Name
  Return Air Mixer Outlet,  ! Return Air Path Outlet Node Name
  Zone Return Plenum,      ! Component 1 Object Type
  Zone 1a Plenum,          ! Component 1 Name
  Zone Mixer,              ! Component 2 Object Type
  Zone Return Air Mixer;   ! Component 2 Name
```

AirLoopHVAC:SupplyPlenum

The building shown in the figure below consists of three controlled zones served by a AirLoopHVAC:SupplyPlenum beneath the floor.

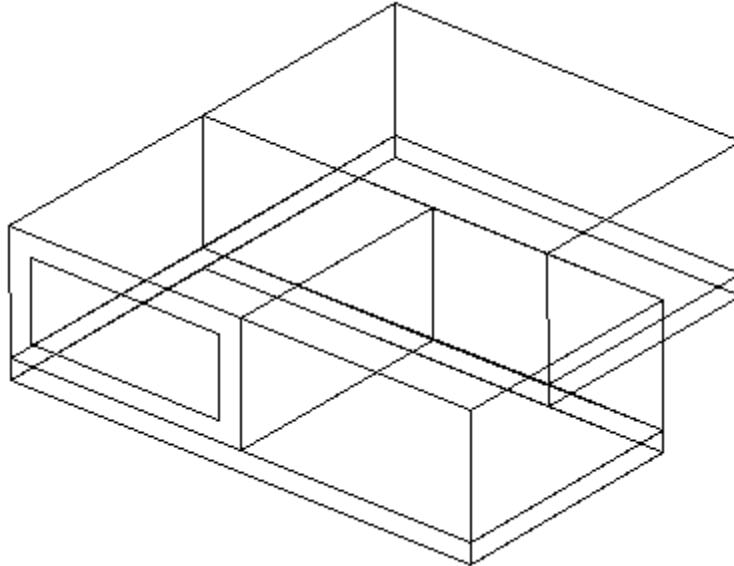


Figure 105. Illustration of AirLoopHVAC:SupplyPlenum

The AirLoopHVAC:SupplyPlenum has a heat balance connection and building description, and a system airflow connection which transfers the airflow from the supply plenum zone to the controlled zones in the system simulation. The input described in this section is mainly just for the system airflow connections in the HVAC algorithms. In addition the supply plenum zone must be fully input in the building zone description. The supply plenum zone description needs to contain the wall descriptions, the interzone ceiling and floor, and the ground connection. All the other attributes of a zone that can be specified in the building description can be utilized with a supply plenum zone if necessary, i.e. scheduled loads, windows, etc.

After all the building zone attributes are specified, the AirLoopHVAC:SupplyPlenum object is specified and included as one of the named components in a AirLoopHVAC:SupplyPath.

Field: Name

A unique identifying name identifying the AirLoopHVAC:SupplyPlenum system component.

Field: Zone Name

The zone name specified in the heat balance portion of the input. This piece of input connects the AirLoopHVAC:SupplyPlenum system component to the heat balance data structure.

Field: Zone Node Name

The name of the zone node. The zone node name connects the heat balance data structure to the system airflow data structure through this node. This node name is defined by the user in the field "Zone Air Node Name" in the ZoneHVAC:EquipmentConnections object for the zone named in the previous field.

Field: Inlet Node Name

The name of the inlet node to the zone supply air path. The AirLoopHVAC:SupplyPlenum component can send air to many outlets but there is only one inlet.

Field: Outlet <#> Node Name

The name of an outlet node. The AirLoopHVAC:SupplyPlenum component can send air to many outlets or zones, therefore multiple outlet nodes can be named and this field can be repeated for as many zones as needed. Currently this value is 30 per air loop but this can

easily be extended by adding more outlet nodes in the Energy+.idd (or rely on automatic extension). There can be no duplicate names in the different outlet node name fields.

The IDD entry for this object follows.

```
AirLoopHVAC:SupplyPlenum,
  \extensible:1 Just duplicate last field and \ comments (changing numbering, please)
  \memo Connects 1 zone inlet air stream, through zone supply plenum, to one or more outlets.
  \memo Node names cannot be duplicated within a single supply plenum list.
  A1, \field Name
      \required-field
      \reference ZonePlenums
  A2, \field Zone Name
      \required-field
      \type object-list
      \object-list ZoneNames
  A3, \field Zone Node Name
      \required-field
  A4, \field Inlet Node Name
      \required-field
  A5, \field Outlet 1 Node Name
      \required-field

  A34; \field Outlet 30 Node Name
```

And, an IDF example of a AirLoopHVAC:SupplyPlenum component specification:

```
AirLoopHVAC:SupplyPlenum,
  Supply Plenum 1,           ! Name
  SUPPLY PLENUM ZONE,       ! Zone Name
  Supply Plenum 1 Zone Node, ! Zone Node Name
  Zone Equipment Inlet Node, ! Inlet Node Name
  Supply Plenum 1 Outlet Node; ! Outlet 1 Node Name
```

Below is an example of the AirLoopHVAC:SupplyPath for the building shown above.

```
AirLoopHVAC:SupplyPath,
  TermReheatSupplyPath,     ! Name
  Zone Equipment Inlet Node, ! Supply Air Path Inlet Node Name
  AirLoopHVAC:SupplyPlenum, ! Component 1 Object Type
  Supply Plenum 1,          ! Component 1 Name
  AirLoopHVAC:ZoneSplitter, ! Component 2 Object Type
  Zone Supply Air Splitter; ! Component 2 Name
```

AirLoopHVAC:ZoneSplitter

The AirLoopHVAC:ZoneSplitter is a component that splits airflow from a single inlet to multiple outlets. It is one of the components included in a AirLoopHVAC:SupplyPath. The input contains only node connection information.

Field: Name

Unique name for this zone splitter.

Field: Inlet Node Name

The name of the single inlet node going into the splitter.

Field: Outlet <#> Node Name

These are all of the outlet node names from the splitter leading to downstream supply air path components. The AirLoopHVAC:ZoneSplitter component can send air to many outlets or zones, therefore multiple outlet nodes can be named and this field can be repeated for as many zones as needed. There can be no duplicate names in the different outlet node name fields.

The IDD entry for this object follows.

```

AirLoopHVAC:ZoneSplitter,
  \extensible:1 Just duplicate last field and \ comments (changing numbering, please)
  \memo Split one air stream into N outlet streams (currently 50 per air loop, but extensible). Node
names
  \memo cannot be duplicated within a single zone splitter list.
  A1, \field Name
      \required-field
      \reference ZoneSplitters
  A2, \field Inlet Node Name
      \required-field
  A3, \field Outlet 1 Node Name
      \required-field

  A52; \field Outlet 50 Node Name

```

An example is shown below.

```

AirLoopHVAC:ZoneSplitter,
  Zone Supply Air Splitter, ! Name
  Zone Equipment Inlet Node, ! Inlet Node Name
  Zone 1 Damper Inlet Node, ! Outlet 1 Node Name
  Zone 2 Damper Inlet Node, ! Outlet 2 Node Name
  Zone 3 Damper Inlet Node; ! Outlet 3 Node Name

```

AirLoopHVAC:ZoneMixer

The AirLoopHVAC:ZoneMixer takes the air from multiple inlets from various zones and mixes the streams together to be sent out of a single outlet node on the return air path. This is a simple process of summing flows and averaging the air properties.

Field: Name

Unique name for this zone mixer.

Field: Outlet Node Name

The name of the single outlet node leaving the mixer.

Field: Inlet <#> Node Name

These are all the inlet node names that are coming from zones or plenums on the return air side and going into the mixer. The AirLoopHVAC:ZoneMixer component can collect air from many outlets or zones, therefore multiple inlet nodes can be named and this field can be repeated for as many zones as needed. There can be no duplicate names in the different inlet node name fields.

The IDD entry for this object follows.

```

AirLoopHVAC:ZoneMixer,
  \extensible:1 Just duplicate last field and \ comments (changing numbering, please)
  \memo Mix N inlet air streams into one (currently 50 per air loop, but extensible). Node names
cannot
  \memo be duplicated within a single zone mixer list.
  A1, \field Name
      \required-field
      \reference ZoneMixers
  A2, \field Outlet Node Name
      \required-field
  A3, \field Inlet 1 Node Name
      \required-field

  A52; \field Inlet 50 Node Name

```

An example is shown below.

```

AirLoopHVAC:ZoneMixer,
  Zone Return Air Mixer,      ! Name
  Return Air Mixer Outlet Node, ! Outlet Node Name
  Zone 1 Outlet Node,        ! Inlet 1 Node Name
  Zone 2 Outlet Node,        ! Inlet 2 Node Name
  Zone 3 Outlet Node;        ! Inlet 3 Node Name

```

Group – Non-Zone Equipment

The non-zone equipment group consists of plant objects that connect to the demand side of the plant loop but are not associated with a specific Zone (and do not have their own group). There is currently one non-zone equipment object called LoadProfile:Plant. This object places a scheduled demand load on the plant.

Non-zone equipment allows the option of performing a plant-only EnergyPlus simulation, i.e. without any zones. This can be useful for comparing the performance of various plant configurations or components without the added complexity of a full building description.

LoadProfile:Plant

The LoadProfile:Plant object is used to simulate a scheduled demand profile. This can be useful when the building loads are already known. Demanded load and flow rate are schedules specified in the object definition. The load profile can specify heating and cooling loads. Cooling loads are entered as negative numbers. The actual load met is dependent on the performance of the supply loop components.

The LoadProfile:Plant object must be connected on the demand side of the plant loop. It should be located on a Branch with its control type set to “Active.” If desired, multiple LoadProfile:Plant objects can be combined in series and/or parallel.

Field: Name

The unique name of the LoadProfile:Plant object.

Field: Inlet Node Name

The name of the inlet node connection to the plant loop.

This node should be on the demand side.

Field: Outlet Node Name

The name of the outlet node connection to the plant loop.

Field: Load Schedule Name

Reference to the schedule object specifying the load profile [W].

Field: Peak Flow Rate

The peak demanded water flow rate [m^3/s]. This value is multiplied by the flow rate fraction schedule values (below) to determine the actual volumetric flow rate.

Field: Flow Rate Fraction Schedule Name

Reference to the schedule object specifying the flow rate fraction relative to the value in the field Peak Flow Rate (above).

The IDD entry for this object follows.

```

LoadProfile:Plant,
  A1 , \field Name
        \required-field
        \type alpha
  A2 , \field Inlet Node Name
        \required-field
        \type alpha
  A3 , \field Outlet Node Name
        \required-field
        \type alpha
  A4 , \field Load Schedule Name
        \required-field
        \type object-list
        \object-list ScheduleNames
  N1 , \field Peak Flow Rate
        \required-field
        \type real
        \units m3/s
  A5 ; \field Flow Rate Fraction Schedule Name
        \required-field
        \type object-list
        \object-list ScheduleNames

```

An example of this object follows.

```

LoadProfile:Plant,
  Load Profile 1,                !- Name
  Demand Load Profile 1 Inlet Node, !- Inlet Node Name
  Demand Load Profile 1 Outlet Node, !- Outlet Node Name
  Load Profile 1 Load Schedule,    !- Load Schedule Name {W}
  0.003,                          !- Peak Flow Rate {m3/s}
  Load Profile 1 Flow Frac Schedule; !- Flow Rate Fraction Schedule Name

```

LoadProfile:Plant Output

The following output variables and meters are reported for the LoadProfile:Plant object:

```

HVAC,Average,Plant Load Profile Mass Flow Rate [kg/s]
HVAC,Average,Plant Load Profile Heat Transfer Rate [W]
HVAC,Sum,Plant Load Profile Heat Transfer Energy [J]
Zone,Meter,EnergyTransfer:Facility [J]
Zone,Meter,EnergyTransfer:Plant [J]
Zone,Meter,Miscellaneous:EnergyTransfer [J]

```

The inlet and outlet node temperatures and mass flow rates can be monitored using the system node output variables:

```

HVAC,Average,System Node Temp [C]
HVAC,Average,System Node MassFlowRate [kg/s]

```

Group – Solar Collectors

Solar collectors are thermal devices that convert solar energy into thermal energy by raising the temperature of a circulating heat transfer fluid. The fluid can then be used to heat water for domestic hot water usage or space heating.

In EnergyPlus solar collectors are components that are connected to the plant loop. A solar heating system can be constructed with a combination of solar collectors, pumps, and hot water tanks.

Solar collectors are defined using two objects: SolarCollector:FlatPlate:Water and SolarCollectorPerformance:FlatPlate. The SolarCollector:FlatPlate:Water object describes the plant component connections. The object also references a SolarCollectorPerformance:FlatPlate object which contains the thermal and optical

performance test data for a specific make and model of collector. Parameters are defined separately so that these values can be organized into a reference data set and need only be entered once if for an array of the same type of collectors.

SolarCollector:FlatPlate:Water

The flat-plate solar collector model simulates glazed, unglazed, and tubular (i.e. evacuated tube) collectors. The SolarCollector:FlatPlate:Water object represents a single collector module connected to the plant loop. The thermal and optical properties of the collector module are taken from the referenced SolarCollectorPerformance:FlatPlate object. A surface or shading object defines the collector tilt, azimuth, and gross area. The collector surface participates normally in all shading calculations if the "FullExterior," "FullInteriorAndExterior," "FullExteriorWithReflections", or "FullInteriorAndExteriorWithReflections" flags are set in the Solar Distribution field of the Building object. Inlet and outlet nodes are specified for plant connections on the demand side of the plant loop.

Field: Name

The unique name of the SolarCollector:FlatPlate:Water object.

Field: Solar Collector Performance Name

Reference name of a SolarCollectorPerformance:FlatPlate object that defines the thermal and optical properties of the collector.

Field: Surface Name

Reference to one of the many different types of surfaces such as the BuildingSurface:Detailed or the Shading:Zone:Detailed objects. The surface named here is used to define the solar collector tilt, azimuth, and gross area.

Field: Inlet Node Name

The name of the inlet node connection to the plant loop.

Field: Outlet Node Name

The name of the outlet node connection to the plant loop.

Field: Maximum Flow Rate

The maximum flow rate [m³/s] allowed through the collector. This field is optional. If not specified, the collector will allow as much flow as the rest of the plant can deliver.

The IDD entry for this object follows.

```
SolarCollector:FlatPlate:Water,
  \memo Solar Radiation Certification Corporation model
  A1 , \field Name
      \required-field
      \type alpha
  A2 , \field Solar Collector Performance Name
      \required-field
      \type object-list
      \object-list FlatPlateSolarCollectorParameters
  A3 , \field Surface Name
      \required-field
      \type object-list
      \object-list AllShadingAndHTSurfNames
  A4 , \field Inlet Node Name
      \required-field
      \type alpha
  A5 , \field Outlet Node Name
      \required-field
      \type alpha
  N1 ; \field Maximum Flow Rate
      \type real
      \minimum> 0
      \units m3/s
```

An example follows.

```
SolarCollector:FlatPlate:Water,
Collector 1,                !- Name
ACR Solar International Fireball 2001, !- Solar Collector Performance Name
Collector Surface,          !- Surface Name
Collector Inlet Node,       !- Inlet Node Name
Collector Outlet Node,     !- Outlet Node Name
0.00005,                   !- Maximum Flow Rate (m3/s)
```

SolarCollector:FlatPlate:Water Output

The following output variables are reported for the SolarCollector:FlatPlate:Water object:

```
HVAC,Average,Solar Collector Incident Angle Modifier []
HVAC,Average,Solar Collector Efficiency []
HVAC,Average,Solar Collector Heat Transfer Rate [W]
HVAC,Average,Solar Collector Heat Gain Rate [W]
HVAC,Average,Solar Collector Heat Loss Rate [W]
HVAC,Sum,Solar Collector Heat Transfer Energy [J]
```

In addition, several surface variables are also relevant for the collector's surface object (BuildingSurface:Detailed or Shading:Zone:Detailed):

```
Zone,Average,Surface Ext Sunlit Area [m2]
Zone,Average,Surface Ext Sunlit Fraction []
Zone,Average,Surface Ext Solar Incident [W/m2]
Zone,Average,Surface Ext Solar Beam Incident [W/m2]
Zone,Average,Surface Ext Solar Sky Diffuse Incident [W/m2]
Zone,Average,Surface Ext Solar Ground Diffuse Incident [W/m2]
Zone,Average,Surface Ext Solar Beam Cosine Of Incidence Angle []
```

The temperatures at the inlet and outlet nodes and the collector mass flow rate can be monitored using the system node output variables:

```
HVAC,Average,System Node Temp[C]
HVAC,Average,System Node MassFlowRate[kg/s]
```

SolarCollectorPerformance:FlatPlate

The SolarCollectorPerformance:FlatPlate object contains the thermal and optical performance parameters for a single collector module. These parameters are based on the testing methodologies described in ASHRAE Standards 93 and 96. The Solar Rating and Certification Corporation (SRCC) applies these standards in their rating procedures of solar collectors. The ratings for commercially available collectors in North America are published in the *Directory of SRCC Certified Solar Collector Ratings*. The SRCC database has also been converted into an EnergyPlus data set of SolarCollectorPerformance:FlatPlate objects that is included with the program (see SolarCollectors.idf in the DataSets folder).

The coefficients for the energy conversion efficiency and incident angle modifier allow first order (linear) or second order (quadratic) correlations. To use a first order correlation, the second order coefficient must be left blank or set to zero.

In order for the model to work correctly, the test conditions for which the performance coefficients were measured must be specified in the fields: *Test Fluid*, *Test Volumetric Flow Rate*, and *Test Correlation Type*. Currently, only water is allowed as the *Test Fluid*.

For more detailed information about the performance coefficients, see the *EnergyPlus Engineering Reference Document*.

Field: Name

The unique name of the SolarCollectorPerformance:FlatPlate object.

Field: Gross Area

The gross area of the collector module [m²]. This value is mainly for reference. The area of the associated collector surface object is used in all calculations.

Field: Test Fluid

The fluid that was used in the testing procedure that resulted in the thermal and optical performance coefficients below. Currently only “Water” is allowed. This is the fluid during the collector testing, not the fluid used during a particular EnergyPlus run.

Field: Test Flow Rate

The volumetric flow rate during testing [m³/s]. If the value is available as flow rate per unit area, it is recommended to multiply by the *Gross Area* of the collector module, not the net aperture area.

Field: Test Correlation Type

This field specifies type of temperature used to develop the correlation equations. The testing procedure is based on an experimental correlation using either “Inlet,” “Average,” or “Outlet” temperature. Enter one of these choices. The ASHRAE Standards 93 and 96 always use Inlet temperature.

Field: Coefficient 1 of Efficiency Equation

First coefficient of efficiency equation for energy conversion [dimensionless]. This is the Y-intercept term.

Field: Coefficient 2 of Efficiency Equation

Second coefficient of efficiency equation for energy conversion [W/m²-deltaC]. This is the first-order term.

Field: Coefficient 3 of Efficiency Equation

Third coefficient of efficiency equation for energy conversion [W/m²-deltaC²]. This field is optional. This is the second-order term. If left blank or set to zero, a first-order linear correlation is used.

Field: Coefficient 2 of Incident Angle Modifier

Second coefficient of the incident angle modifier equation. This the first-order term. (There is no *Coefficient 1 of Incident Angle Modifier* because that number is always 1.0.)

Field: Coefficient 3 of Incident Angle Modifier

Third coefficient of the incident angle modifier equation. This is the second-order term. This field is optional. If left blank or set to zero, a first order linear correlation is used.

The IDD entry for this object follows.

```
SolarCollectorPerformance:FlatPlate,
  A1 , \field Name
      \required-field
      \type alpha
      \reference FlatPlateSolarCollectorParameters
  N1 , \field Gross Area
      \type real
      \minimum> 0
      \units m2
  A2, \field Test Fluid
      \required-field
      \type choice
      \key Water
      \default Water
  N2, \field Test Flow Rate
      \required-field
      \type real
      \minimum> 0
      \units m3/s
  A3 , \field Test Correlation Type
      \required-field
      \type choice
      \key Inlet
      \key Average
      \key Outlet
  N3 , \field Coefficient 1 of Efficiency Equation
      \required-field
      \type real
      \units dimensionless
      \note Y-intercept term
  N4 , \field Coefficient 2 of Efficiency Equation
      \required-field
      \type real
      \units W/m2-K
      \note 1st Order term
  N5 , \field Coefficient 3 of Efficiency Equation
      \type real
      \units W/m2-K2
      \note 2nd order term
  N6 , \field Coefficient 2 of Incident Angle Modifier
      \type real
      \note 1st order term
  N7 ; \field Coefficient 3 of Incident Angle Modifier
      \type real
      \note 2nd order term
```

An example of this object follows.

```

SolarCollectorPerformance:FlatPlate,
ACR Solar International Fireball 2001, !- Name
1.865, !- Gross Area (m2)
Water, !- Test Fluid
0.0000316, !- Test Flow Rate (m3/s)
Inlet, !- Test Correlation Type (Inlet | Average | Outlet)
0.605, !- Coefficient 1 of Efficiency Equation
-3.837, !- Coefficient 2 of Efficiency Equation
0.00165, !- Coefficient 3 of Efficiency Equation
-0.1944, !- Coefficient 2 of Incident Angle Modifier
-0.0186; !- Coefficient 3 of Incident Angle Modifier

```

SolarCollectorPerformance:FlatPlate Output

This object does not generate any output; see SolarCollector:FlatPlate:Water Output

SolarCollector:FlatPlate:PhotovoltaicThermal

This object is used to model hybrid photovoltaic-thermal (PVT) solar collectors that convert incident solar energy into both electricity and useful thermal energy. This object describes the PVT solar collector by referencing other objects that provide more detail or connections to other parts of the EnergyPlus model.

The PVT solar collectors need to be connected to either an HVAC air system or a plant loop for collected thermal energy to be utilized. The input field for the type of thermal working fluid informs the program how the PVT collector is expected to be connected. If the the working fluid is air, then the PVT collectors are modeled as a ventilation air pretreatment component and connected to an outdoor air system. If the working fluid is water, then the PVT collectors are modeled as a hot water solar collector and are connected to a plant loop with a water thermal storage tank.

Field: Name

This field should contain a unique name chosen by the user to identify a specific PVT collector in the building model.

Field: Surface Name

This field is the user-defined name of a surface object (defined elsewhere) to which the PVT module is attached. These can be any type of building surface that is exposed to the exterior environment. The model uses the named surface's geometry for the PVT solar collector.

Field: Photovoltaic-Thermal Model Performance Name

This field is the user-defined name of an object (defined elsewhere) that provides the performance details of the PVT module. This should be the name of a SolarCollectorPerformance:PhotovoltaicThermal:Simple object. Multiple different SolarCollector:FlatPlate:PhotovoltaicThermal objects can reference the same object that provides performance details.

Field: Photovoltaic Generator Name

This field is the user-defined name of a Generator:Photovoltaic object (defined elsewhere) that will be used to model the solar electric portion of the PVT solar collector. The PVT models make any adjustments needed to model PV performance in the context of the PVT collector.

Field: Thermal Working Fluid Type

This field is the user's choice for the type of fluid used to collect thermal energy. PVT solar collectors can capture thermal energy in either air or water streams. The choices available for this field are "Water" or "Air." If the choice is "Air" then the PVT collector needs to be connected to an HVAC air system loop. The PVT collector should be situated as the first

component on an outdoor air inlet stream. If the choice is “Water” then the PVT collector needs to be connected to a Plant water system loop. The connections are made via node names which are defined in the following fields, depending on the working fluid type.

Field: Water Inlet Node Name

This field is the name of Plant loop node that serves as the inlet to the PVT collector. This field is only used if the Thermal Working Fluid Type is set to “Plant/Water.”

Field: Water Outlet Node Name

This field is the name of a plant loop node that serves as the outlet from the PVT collector. This field is only used if the Thermal Working Fluid Type is set to “Plant/Water.”

Field: Air Inlet Node Name

This field is the name of HVAC air loop node that serves as the inlet to the PVT collector. This field is only used if the Thermal Working Fluid Type is set to “HVAC/Air.”

Field: Air Outlet Node Name

This field is the name of HVAC air loop node that serves as the outlet from the PVT collector. This field is only used if the Thermal Working Fluid Type is set to “HVAC/Air.”

Field: Design Flow Rate

This field is used to describe the nominal volume flow rate of the thermal working fluid. The units are m3/s. The volume flow rate is autosizable.

The IDD entry for this object follows.

```
SolarCollector:FlatPlate:PhotovoltaicThermal,
A1 , \field Name
A2 , \field Surface Name
      \required-field
      \type object-list
      \object-list AllShadingAndHTSurfNames
A3 , \field Photovoltaic-Thermal Model Performance Name
      \type object-list
      \object-list FlatPlatePVTParameters
A4 , \field Photovoltaic Name
      \note Enter the name of a Generator:Photovoltaic object.
      \type object-list
      \object-list PVGeneratorNames
A5 , \field Thermal Working Fluid Type
      \type choice
      \key Water
      \key Air
A6 , \field Water Inlet Node Name
A7 , \field Water Outlet Node Name
A8 , \field Air Inlet Node Name
A9 , \field Air Outlet Node Name
N1 ; \Field Design Flow Rate
      \units m3/s
      \autosizable
```

An example of this object follows.

```

SolarCollector:FlatPlate:PhotovoltaicThermal,
  PVT: 1_Ceiling ,                !- Name
  1_Ceiling ,                    !- Surface Name
  30percentPVThalfArea ,        !- Photovoltaic-Thermal Model Performance Name
  PV:ZN_1_FLR_1_SEC_1_Ceiling ,  !- Photovoltaic Name
  Air ,                          !- Thermal Working Fluid Type
  ,                              !- Water Inlet Node Name
  ,                              !- Water Outlet Node Name
  ZN_1_FLR_1_SEC_1:Sys_OAInlet Node , !- Air Inlet Node Name
  PVT:ZN_1_FLR_1_SEC_1_Ceiling Outlet , !- Air Outlet Node Name
  Autosize ;                   !- Design Flow Rate

```

SolarCollector:FlatPlate:PhotovoltaicThermal Outputs

The output variables that are available for flat plate PVT include the following.

```

HVAC,Average,Generator Thermal Power Produced [W]
HVAC,Sum,Generator Thermal Energy Produced [J]
HVAC,Average,PVT Bypass Status [ ]
HVAC,Average,PVT Working Fluid Inlet Temperature [C]
HVAC,Average,PVT Working Fluid Outlet Temperature [C]
HVAC,Average,PVT Working Fluid Mass Flow Rate [kg/s]

```

Generator Thermal Power Produced [W]

Generator Thermal Energy Produced [J]

These outputs are the thermal energy and power produced by the PVT collector. PVT collectors are a type of cogenerator, producing both electrical and thermal power and these variables report the thermal portion in the same manner as other fuel-based cogenerators. The thermal energy is placed on “HeatProduced” meter and is attributed to ‘SolarWater’ or ‘SolarAir’ depending on the type of working fluid. The generator thermal production is also reported at the load center level.

PVT Bypass Status []

This report variable indicates the status a bypass damper. It is only available for air-based PVT. There are no dimensions and the range is between 0.0 and 1.0. If the value is 0.0, then there is no bypassing and all the working fluid goes through the collector. If the value is 1.0, then there is complete bypassing and all the working fluid goes around the collector. If the value is between 0.0 and 1.0, then the model is effectively mixing bypass and collector streams to target a temperature setpoint placed on the outlet node.

PVT Working Fluid Inlet Temperature [C]

This report is the inlet temperature of the working fluid that enters the PVT collector

PVT Working Fluid Outlet Temperature [C]

This report is the outlet temperature of the working fluid that leaves the PVT collector

PVT Working Fluid Mass Flow Rate [kg/s]

This report is the mass flow rate of the working fluid through the PVT collector. This is the overall mass flow rate, portions of the flow may be internally bypassed around the collector itself for control modulation.

SolarCollectorPerformance:PhotovoltaicThermal:Simple

This object is used to provide performance details for the simple PVT model. This is a simple user-defined efficiency model. Thermal conversion efficiency is a constant or scheduled value. There are no output variable for this object, reporting is done by the parent PVT object.

Field: Name

This field is the unique name for this object.

Field: Fraction of Surface Area with Active Thermal Collector

This field is the fraction of the surface area that is active. It should be a decimal fraction between 0.0 and 1.0. The area of the PVT's surface will be multiplied by this fraction to determine the active area of the PVT collector(s).

Field: Thermal Conversion Efficiency Input Mode Type

This field is used to determine how the thermal efficiency is input. There are two choices, "Fixed" or "Scheduled." If this field is set to Fixed, then a constant value for thermal efficiency will be used (set in next field). If this field is set to Scheduled, then the thermal efficiency values are defined in a schedule.

Field: Value for Thermal Conversion Efficiency if Fixed

This field is used to provide a value for the efficiency with which solar energy is collected in the working fluid. This field is only used if the input mode is set to "Fixed" in the previous field. Efficiency is defined as the thermal energy collected divided by the incident solar radiation. The value should be between 0.0 and 1.0. The user should be careful that the thermal efficiency and the electrical efficiency be consistent with each other because the overall efficiency of the PVT collector is the combination of both thermal and electrical.

Field: Name of Schedule for Thermal Conversion Efficiency

This field is used for the name of a schedule that provides values for the efficiency with which solar energy is collected in the working fluid. This field is only used if the input mode is set to "Scheduled" in the field above. Efficiency is defined as the thermal energy collected divided by the incident solar radiation. The values in the named schedule should be between 0.0 and 1.0. The user should be careful that the thermal efficiency and the electrical efficiency be consistent with each other because the overall efficiency of the PVT collector is the combination of both thermal and electrical.

Field: Front Surface Emittance

This field is used to describe an average value for the total hemispherical emittance of the collector's front face exposed to the sky. This is used to model cooling applications where the PVT collectors are operated at night to cool the working fluid.

The IDD entry for this object follows.


```
SolarCollectorPerformance:PhotovoltaicThermal:Simple,
A1 , \field Name
    \reference FlatPlatePVTParameters
N1 , \field Fraction of Surface Area with Active Thermal Collector
    \required-field
    \type real
    \units dimensionless
    \minimum> 0.0
    \maximum 1.0
A2 , \field Thermal Conversion Efficiency Input Mode Type
    \type choice
    \key Fixed
    \key Scheduled
N2 , \field Value for Thermal Conversion Efficiency if Fixed
    \note Efficiency = (thermal power generated [W])/(incident solar[W])
    \type real
    \minimum 0.0
    \maximum 1.0
A3 , \field Thermal Conversion Efficiency Schedule Name
    \type object-list
    \object-list ScheduleNames
N3 ; \field Front Surface Emittance
    \type real
    \default 0.84
    \minimum> 0.00
    \maximum< 1.00
```

An example input object follows.

```
SolarCollectorPerformance:PhotovoltaicThermal:Simple,
20percentEffPVhalfArea ,      !- Name
0.5 ,                          !- Fraction of Surface Area with Active Thermal Collector
Fixed ,                        !- Thermal Conversion Efficiency Input Mode Type
0.2 ,                          !- Value for Thermal Conversion Efficiency if Fixed
,                               !- Name of Schedule for Thermal Conversion Efficiency
0.84 ;                         !- Front Surface Emittance
```

Solar Collector Heating System Plant Connections

This section provides an overview of how to model solar heating systems. A solar heating system can be constructed using a combination of solar collectors, pumps, water tanks and water heaters. The solar collector must be connected on the demand side of the plant loop. Multiple collector modules can be combined in series and parallel using the normal plant connection rules. The supply side of the plant loop should contain a water heater with the solar collector loop connecting to the *Source Side Inlet* and *Source Side Outlet* nodes. As usual, the pump must be the first component on the supply side.

If the solar heating system is for domestic hot water (or service water heating) usage only, the field *Use Flow Rate Fraction Schedule Name* of the WaterHeater:Mixed object can be used to avoid additional plant connections. If the system has more complicated hot water requirements or if the system is for space heating, the *Use Side Inlet* and *Use Side Outlet* nodes must be connected to another plant loop to serve zone and non-zone equipment. (See the WaterHeater:Mixed object documentation for more information.)

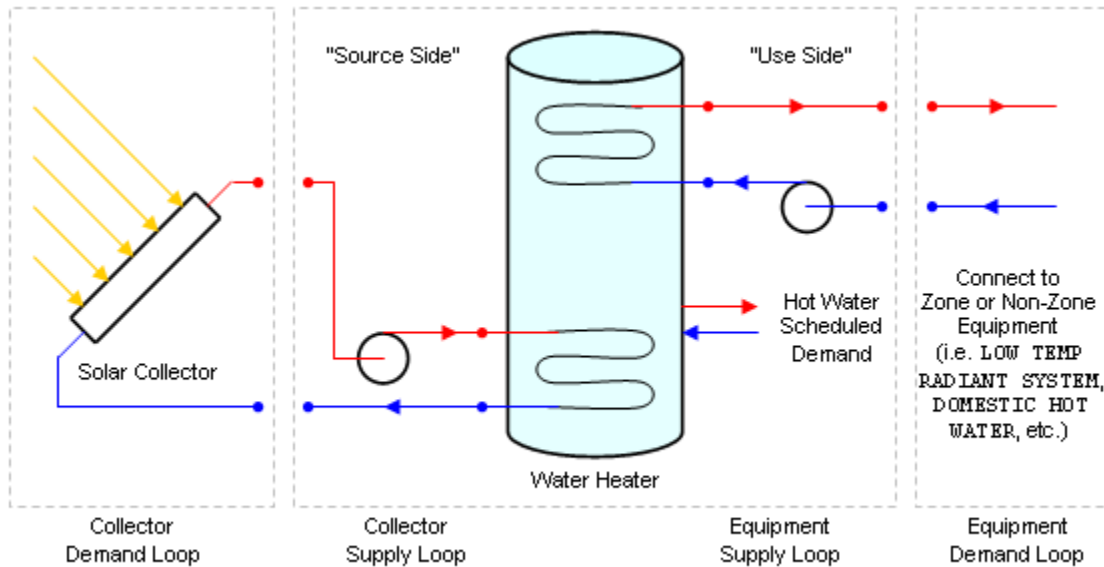


Figure 106. Solar Collector Plant Loop Connection Diagram

NOTE: The EnergyPlus plant simulation requires the pump to be the first component on the supply side. This may be different from the way the solar heating system is actually configured. This should not affect the validity of the simulation results.

In order to realize energy savings with a solar heating system, it is best to use a two-tank system with a storage tank and auxiliary water heater. The storage tank gathers heat directly from the solar collectors and stores it for later use. The storage tank is modeled using a `WaterHeater:Mixed` object with the *Heater Maximum Capacity* set to zero. The auxiliary water heater is positioned downstream of the storage tank on the supply side of the main plant loop. The auxiliary water heater, or booster water heater, provides additional heat if the storage tank water is not hot enough. The auxiliary water heater can be modeled as an instantaneous/tankless water heater or as a standard tanked water heater with heating source (see `WaterHeater:Mixed`).

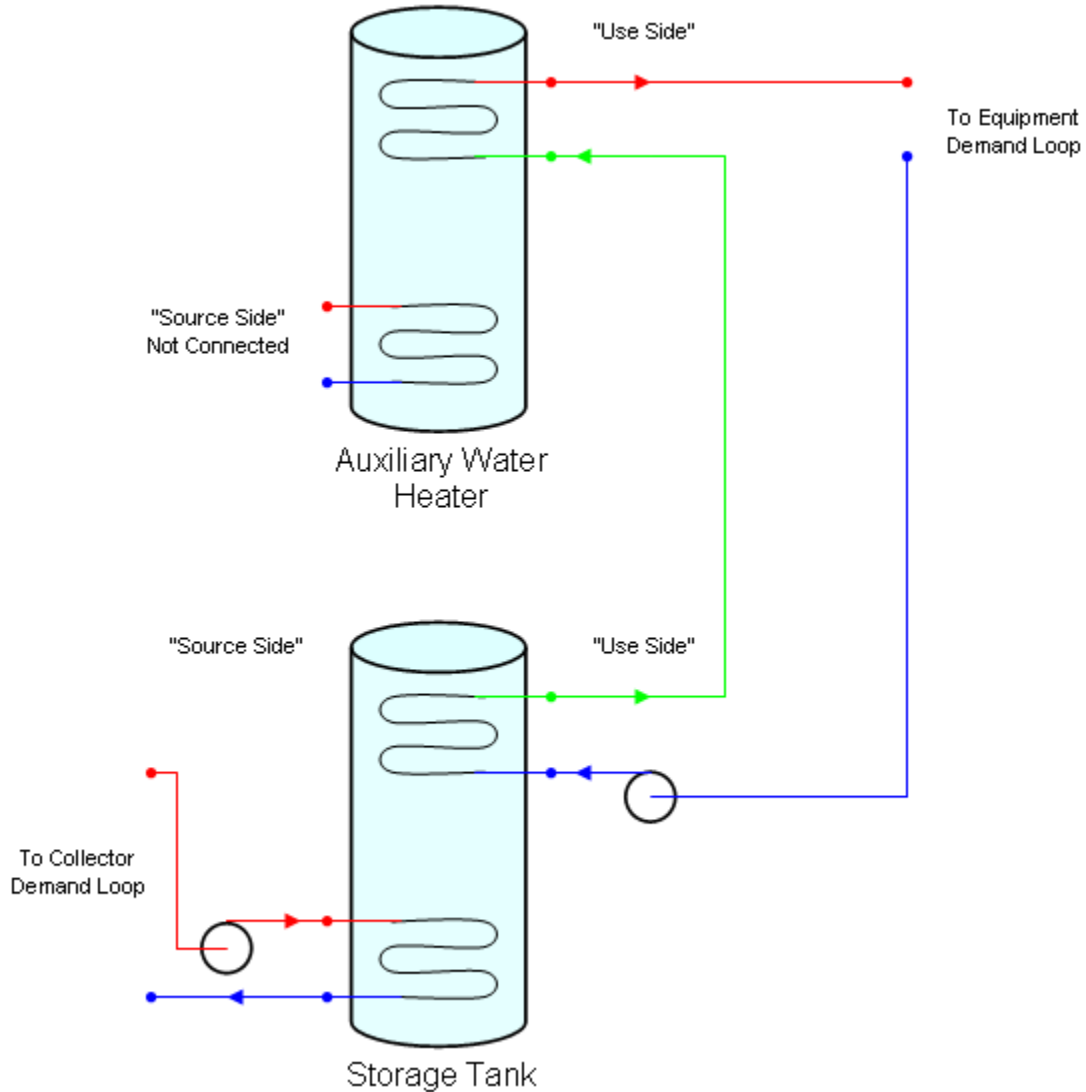


Figure 107. Two-Tank Solar Heating System Connection Diagram

Another strategy to consider for solar heating systems is to allow the storage tank to reach a much higher temperature than necessary for the end use. This allows the tank to store more energy from the solar collectors, when it is available. However, for applications such as domestic hot water, it is undesirable and unsafe to supply excessive hot water temperatures at the point of demand. To take advantage of higher storage temperatures, yet still avoid scalding temperatures at the faucet, the hot water leaving the storage tank can be tempered with cold water using a three-way valve to achieve the target temperature. See the TemperingValve object documentation for more details.

A complete two-tank solar heating system with tempering valve is shown below.

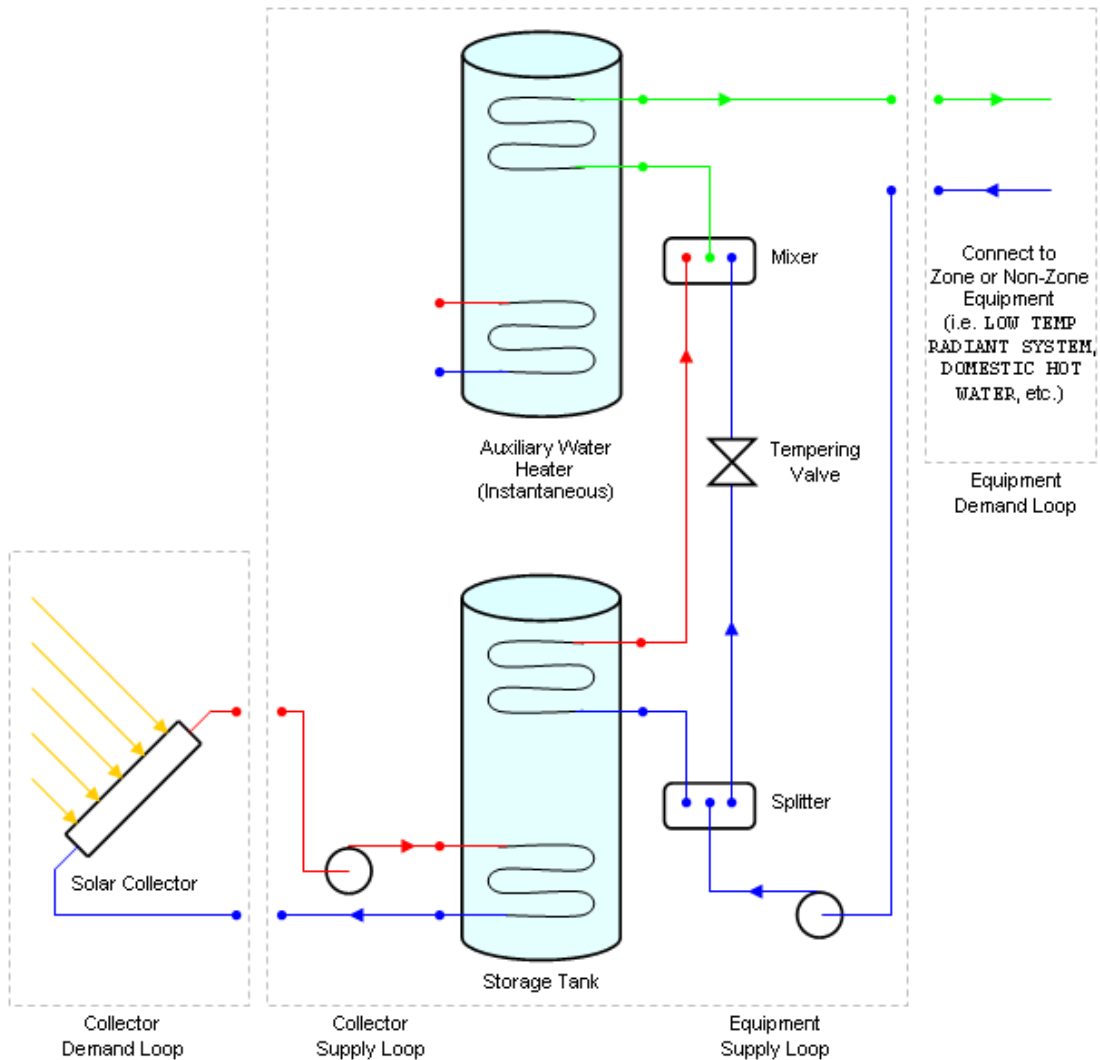


Figure 108. Two-Tank Solar Heating System with Tempering Valve

Solar Heating System Control

There are several options for controlling a solar heating system in EnergyPlus. Since the solar collectors request a constant flow demand based on their *Maximum Flow Rate*, the limiting factor is actually the flow rate determined by the loop pump. Therefore the entire system can be controlled using the *Pump Flow Rate Schedule* of the pump. If the schedule is omitted, the pump and system will run all the time (without any other controls specified). This is usually not the best way to operate a solar heating system.

To better control the collector loop, a differential thermostat can be used to compare the temperature in the water heater to the temperature in the collector so that the pump is only turned on when there is a useful heat gain. The differential thermostat is simulated using the *AvailabilityManager:DifferentialThermostat* object. For a typical system, the *Hot Node Name* field refers to an outlet node of one of the collector modules. The *Cold Node Name* field refers to the *Source Side Outlet* node, i.e. the cold storage water leaving the water heater. The fields *Temperature Difference On Limit* and *Temperature Difference Off Limit* are usually 8 – 12 C and 1 – 3 C respectively. If the two temperature differences are too close, it is possible for the system to turn on and off rapidly without much useful heat gain. This can also

occur if the flow rate through the collector is too high. Without flow the fluid in the collector heats up more quickly; when high flow is turned on, all of the hot fluid is removed and the temperature drops, forcing the system off again.

Another control method is to use a photovoltaic panel to power the pump. The system begins pumping when there is enough solar radiation to operate the pump. This is not yet implemented in EnergyPlus.

Freeze Prevention

In climates with a cold season, the solar heating system must be designed to avoid the risk of fluid freezing in the solar collector or exposed pipes and causing damage. This is not a problem if air is the heat transfer fluid. With water, however, there are several strategies that can minimize the risk.

Seasonal schedule. The simplest strategy is to not use the system during the cold season. This is a hassle because it requires the collector to be manually drained of all fluid. The benefits of the solar heating system are also lost during this time. This can be simulated in EnergyPlus with the appropriate pump schedule for the collector system.

Antifreeze. The freezing point of the liquid is decreased by adding antifreeze to the water or using a different heat transfer liquid with a lower freezing point. This cannot yet be simulated in EnergyPlus because only pure water is currently allowed in plant loops.

Drain-back system. This strategy automatically empties the collector when the pump is not running. This scenario is modeled by default in EnergyPlus, although the extra pump energy required to start the system is not taken into account.

Recirculation system. This strategy automatically recirculates warm liquid from the storage tank back through the collector to maintain the system above the freezing point. There are system losses using this method. This can be simulated in EnergyPlus by using AvailabilityManager:LowTemperatureTurnOn to force the system to turn on when the outdoor air temperature or collector outlet temperature falls below a specified minimum.

Additional Controls

In addition to freeze prevention, it is also necessary to prevent the system from becoming too hot. This is usually a safety issue for the water heater. For this case it is important to have a high temperature cutoff to stop the pump before damaging the water heater. This is accomplished with a AvailabilityManager:HighTemperatureTurnOff.

System Availability Manager List Example

To use the availability managers for the control cases described above, a AvailabilityManagerAssignmentList must be defined and referenced in the PlantLoop object of the collector loop. An example of a differential thermostat, recirculation for freeze prevention, and high temperature cutoff is shown below:

```

AvailabilityManagerAssignmentList,
Collector Loop Availability Manager List,      !- Name
AvailabilityManager:HighTemperatureTurnOff,   !- Availability Manager 1 Object Type
High Temperature Turn Off Availability Manager, !- Availability Manager 1 Name
AvailabilityManager:HighTemperatureTurnOn,    !- Availability Manager 2 Object Type
Low Temperature Turn On Availability Manager,  !- Availability Manager 2 Name
AvailabilityManager:DifferentialThermostat,   !- Availability Manager 3 Object Type
Differential Thermostat Availability Manager;  !- Availability Manager 3 Name

AvailabilityManager:HighTemperatureTurnOff,    ! For water heater safety
High Temperature Turn Off Availability Manager, !- Name
Water Heater Use Outlet Node,                 !- Sensor Node Name
60.0;                                          !- Temperature (C)

AvailabilityManager:HighTemperatureTurnOn,     ! For freeze prevention by recirculation
Low Temperature Turn On Availability Manager,  !- Name
Collector Outlet Node,                        !- Sensor Node Name
0.0;                                          !- Temperature (C)

AvailabilityManager:DifferentialThermostat,    ! For useful heat gain from collector to tank
Differential Thermostat Availability Manager,  !- Name
Collector Outlet Node,                        !- Hot Node Name
Water Heater Source Outlet Node,             !- Cold Node Name
10.0,                                         !- Temperature Difference On Limit (delta C)
2.0;                                          !- Temperature Difference Off Limit (delta C)

```

The AvailabilityManager:DifferentialThermostat object must always be the last manager in the availability manager list. See the AvailabilityManagerAssignmentList object documentation for more information.

SolarCollector:UnglazedTranspired

This object is used to model unglazed transpired solar collectors (UTSC) used to condition outdoor air. These collectors are generally used to heat air drawn through perforated absorbers that are heated by the sun and also recover heat conducted out through the underlying wall. The SolarCollector:UnglazedTranspired object represents a single collector attached to one or more BuildingSurface:Detailed objects and to one or more outdoor air systems. Therefore the transpired collector is part of both the thermal envelope and the HVAC system. An example file is provided called TranspiredCollectors.idf.

The area and orientation of the collector is obtained from BuildingSurface:Detailed objects, which are referenced by name. Although the collector surface itself is slightly detached from the underlying building wall (or roof), no additional surface object is needed to represent the collector itself. When modeling transpired collectors, it is important to consider the size of the collector when developing the building model's BuildingSurface:Detailed objects because the underlying surfaces must match the collector. For example, if the collector covers only part of the wall, then that wall should be split into separate surfaces where one matches the size of the collector. A single collector can be associated with as many BuildingSurface:Detailed objects as desired (although if you need to use more than 10 surfaces, then the IDD will need to be extended). The collector can be arranged at any tilt angle by describing the surfaces appropriately. The surfaces need not be contiguous nor have the same orientation, but the program will issue warnings if surfaces have widely ranging tilts and azimuths.

The collector conditions outdoor air and is connected to the outdoor air system using the usual method of specifying node names. Using the UTSC model requires specifying a relatively complete HVAC air system that includes an outdoor air path. This will typically require using a set of objects that, at a minimum, will include: AirLoopHVAC:ControllerList, AirLoopHVAC:OutdoorAirSystem:EquipmentList, AirLoopHVAC:OutdoorAirSystem, OutdoorAir:NodeList, OutdoorAir:Mixer, SetpointManager:MixedAir, and Controller:OutdoorAir. A single UTSC can serve more than one outdoor air system but requires also using a separate object, called SolarCollector:UnglazedTranspired:MultiSystem to specify node connections.

Controls for the UTSC involve setting the rate of air flow and the status of a bypass damper. If the bypass damper is open, then all the ventilation air goes straight into the outdoor air mixer; if it closed, then all the air first passes through the UTSC. The bypass damper is modeled as completely open or completely closed. The UTSC bypass damper control is determined by an availability manager, the airflow set by the outdoor air mixer controls, and thermostatic type controls that decide if heating is useful. An availability schedule is used to bypass the collector for certain times of the year, eg. summer cooling season. The air flow rates are set by controls associated with the outdoor air mixer (see `SetpointManager:MixedAir`, and `Controller:OutdoorAir`). Thermostatic type control decides if the collector will provide useful heating based on either of two types of setpoints. The first type of temperature setpoint is managed by `SetpointManager:MixedAir`, where the UTSC model looks at a control node, usually the mixed air node. The second type is an extra setpoint especially for free heating that is managed within this object where the UTSC model looks at the zone air node.

Field: Name

This field contains a unique name for the unglazed transpired solar collector.

Field: Boundary Conditions Model Name

This field contains the name of a `SurfaceProperty:OtherSideConditionsModel` object declared elsewhere in the input file. This will connect the collector to the exterior boundary conditions for the underlying heat transfer surface.

Field: Availability Schedule Name

This field contains the name of a schedule that determines whether or not the UTSC is available. When the schedule value is zero, the UTSC is always bypassed. When the schedule value is greater than zero, the UTSC is available and will be used when other conditions are met, such as outdoor air requested by mixer and preheating has been determined to be beneficial based on thermostatic control.

Field: Inlet Node Name

This field contains the name of an air node that provides air into the UTSC. This node name should also be assigned to be an outdoor air node using the `OutdoorAir:NodeList` or `OutdoorAir:Node` objects. This node should also be named as the actuated node in a `Controller:OutdoorAir` object. If the UTSC is connected to more than one air system, then this field can be left blank and the `SolarCollector:UnglazedTranspired:MultiSystem` object should be used to define the nodes.

Field: Outlet Node Name

This field contains the name of an air node that is the outlet of the UTSC. This node name will typically be the inlet to the `OutdoorAir:Mixer` (if there is no other equipment on the outdoor air path). If the UTSC is connected to more than one air system, then this field can be left blank and the `SolarCollector:UnglazedTranspired:MultiSystem` object should be used to define the nodes.

Field: Setpoint Node Name

This field contains the name of an air node that has a setpoint manager controlling its temperature setpoint. This node name will typically be named as the control node in a `Controller:OutdoorAir` object. If the UTSC is connected to more than one air system, then this field can be left blank and the `SolarCollector:UnglazedTranspired:MultiSystem` object should be used to define the nodes.

Field: Zone Node Name

This field contains the name of an air node for a thermal zone that is ultimately connected to the air system. This node is used with the setpoint schedule, defined in the following field, to

provide an added layer of thermostatic control for the UTSC without affecting the control of auxiliary heating. If there is a single air system that is connected to more than one zone, then a single zone should be selected based on where the thermostat might be located. If the UTSC is connected to more than one air system, then this field can be left blank and the SolarCollector:UnglazedTranspired:MultiSystem object should be used to define the nodes.

Field: Free Heating Setpoint Schedule Name

This field contains the name of a temperature schedule defined elsewhere in the input file. This schedule should define temperatures *desired* in the zone, but not necessarily *required*. This secondary setpoint schedule is used to allow the UTSC to operate as if it has its own thermostat that is separate from the primary control mechanism. When the UTSC is used with auxiliary heating, the usual setpoint managers and temperature controllers will determine how the auxiliary heaters are controlled. This allows using a higher zone air temperature setpoint for controlling UTSC bypass than for the auxiliary heating system.

Field: Diameter of Perforations in Collector

This field is used to enter the effective diameter of the perforations in the collector surface. The diameter should be entered in meters. For perforations other than round, use an equivalent diameter for a round hole that would have the same area.

Field: Distance Between Perforations in Collector

This field is used to enter the pitch, or average, shortest distance between perforations.

Field: Thermal Emissivity of Collector Surface

This field is used to enter the thermal emissivity of the collector. This surface property is for longwave infrared radiation. The property is used for both sides of collector. Most painted materials have an emissivity of 0.9.

Field: Solar Absorbtivity of Collector Surface

This field is used to enter the solar absorbtivity of the collector. This surface property is for shortwave, solar radiation. The property is used for the front side of the collector that faces the environment. Darker colors have a higher absorbtivity. While black is the highest performance, other colors might be used to match the color scheme of the rest of the facade. The following table provides sample solar absorbtivities for different colors (source: Conserval Engineering Inc., Toronto, Ontario, Canada).

Color Name of Kynar®⁸ Paint	Solar Absorptivity
Black	0.94
Classic Bronze	0.91
Chocolate Brown	0.90
Hartford Green	0.90
Med. Bronze	0.89
Boysenberry	0.86
Rocky Grey	0.85
Regal Blue	0.85
Forest Green	0.84
Hemlock Green	0.82
Slate Blue	0.80

⁸ Kynar is a registered trademark of Elf Atochem North America, Inc.

Redwood	0.79
Teal	0.79
Slate Grey	0.79
Patina Green	0.77
Mint Green	0.71
Dove Grey	0.69
Mission Red	0.69
Sierra Tan	0.65
Brite Red	0.59
Rawhide	0.57
Sandstone	0.54
Silversmith	0.53
Coppertone	0.51
Concord Cream	0.45
Ascot White	0.40
Bone White	0.30

Field: Effective Overall Height of Collector

This field is used to enter a nominal height for the collector. This value is used in the program to determine a length scale in the vertical direction for the buoyancy-driven portion of natural ventilation that occurs when the collector is inactive. (Note that most of the geometry information is obtained from the underlying surfaces.) The value entered here is adjusted inside the program to account for tilt of the collector. While the value here would generally correspond to the actual distance/height, its value is not critical and it can be used to adjust modeling the air exchange rates in passive mode. If the collector is horizontal, then the length scale is obtained from the following field.

Field: Effective Gap Thickness of Plenum Behind Collector

This field is used to enter a nominal gap thickness for the collector. This distance value is only used when the collector is near horizontal to determine a length scale in the vertical direction for buoyancy calculations. For example, if the collector is mounted on a flat roof, its tilt-adjusted height is zero and the program will use this gap thickness as a length scale rather than the height from the previous field.

Field: Effective Cross Section Area of Plenum Behind Collector

This field is used to enter the nominal cross sectional area of the gap behind the collector. This area is used to determine a velocity scale for surface convection heat transfer correlations when the collector is active. This value is generally the average gap thickness times the average width of the collector.

Field: Hole Layout Pattern for Pitch

This field is used to describe the pattern of perforations in the collector surface. There are currently two choices available: Square and Triangle. Note that the hole layout pattern should be consistent with how the value for pitch was determined.

Field: Heat Exchange Effectiveness Correlation

This field is used to select which correlation is used to model heat transfer from the collector surface to the incoming air when the collector is active. There are two choices available: Kutscher1994, and VanDeckerHollandsBrunger2001. See the Engineering Reference for details and references.

Field: Ratio of Actual Collector Surface Area to Projected Surface Area

This field is used to enter a factor that accounts for the extra surface area resulting from corrugations in the collector surface. Corrugations help stiffen the collector. The projected surface area is obtained by the program from the (flat) underlying surfaces. If the collector is flat then this ratio is 1.0. If the collector is corrugated, then this ratio will be greater than one. A typical value might be 1.165.

Field: Roughness of Collector

This field is used to describe the relative roughness of the collector material. This field is similar to one in the Material object. This parameter only influences the convection coefficients, more specifically the outside convection coefficient. A special keyword is expected in this field with the options being "VeryRough", "Rough", "MediumRough", "MediumSmooth", "Smooth", and "VerySmooth" in order of roughest to smoothest options.

Field: Collector Thickness

This field is used to enter the thickness of the collector material. This value is only needed for the Van Decker Hollands Brunger 2001 correlation. The material thickness should be entered in meters.

Field: Effectiveness for Perforations with Respect to Wind

This field is used to enter a value for the coefficient used to determine natural air exchanges from wind, or Cv. When the collector is inactive, wind will cause exterior air to move in and out of the collector. Cv is an arbitrary coefficient used to model the effectiveness of openings and depends on opening geometry and the orientation with respect to the wind. Cv should probably be in the range 0.25 to 0.65. Increasing Cv will increase the amount of natural ventilation.

Field: Discharge Coefficient for Openings with Respect to Buoyancy Driven Flow

This field is used to enter a value for the coefficient used to determine natural air exchanges from buoyancy, or Cd. When the collector is inactive, stack or buoyancy effects will cause exterior air to move in and out of the collector. Cd is an arbitrary discharge coefficient that depends on the geometry of the opening. Cd should probably be in the range 0.4 to 1.0. Increasing Cd will increase the amount of natural ventilation.

Field: Surface <#> Name

The remaining fields are used to name the BuildingSurface:Detailed objects that are associated with the UTSC. These are the underlying heat transfer surfaces and are defined elsewhere in the input file. These other surfaces should all specify OtherSideConditionsModel as their exterior environment. The input object can currently accommodate up to ten surfaces, but it is extensible.

The IDD entry for this object follows.

```

SolarCollector:UnglazedTranspired,
  \extensible:1 - repeat last field, remembering to remove ; from "inner" fields.
A1 , \field Name
     \required-field
     \type alpha
     \reference UTSCNames
A2, \field Boundary Conditions Model Name
     \type object-list
     \object-list OSCMNames
     \note Enter the name of a SurfaceProperty:OtherSideConditionsModel object
A3 , \field Availability Schedule Name
     \required-field
     \type object-list
     \object-list ScheduleNames
A4 , \field Inlet Node Name
     \type alpha
     \note required field if no SolarCollector:UnglazedTranspired:Multisystem
A5 , \field Outlet Node Name
     \type alpha
     \note required field if no SolarCollector:UnglazedTranspired:Multisystem
A6, \field Setpoint Node Name
     \type alpha
     \note This node is where the mixed air setpoint is determined.
     \note required field if no SolarCollector:UnglazedTranspired:Multisystem
A7, \field Zone Node Name
     \type alpha
     \note This node is used to indentify the affected zone
     \note required field if no SolarCollector:UnglazedTranspired:Multisystem
A8, \field Free Heating Setpoint Schedule Name
     \type real
     \units C
N1, \field Diameter of Perforations in Collector
     \type real
     \minimum> 0
     \units m
N2, \field Distance Between Perforations in Collector
     \type real
     \minimum> 0
     \units m
N3, \field Thermal Emissivity of Collector Surface
     \type real
     \minimum 0
     \maximum 1
     \units dimensionless
N4, \field Solar Absorbitivity of Collector Surface
     \type real
     \minimum 0
     \maximum 1
     \units dimensionless
N5, \field Effective Overall Height of Collector
     \type real
     \minimum> 0.0
N6, \field Effective Gap Thickness of Plenum Behind Collector
     \type real
     \minimum> 0.
     \units m
     \note if corrugated, use average depth
N7, \field Effective Cross Section Area of Plenum Behind Collector
     \type real
     \minimum> 0
     \units m2
     \note if corrugated, use average depth
A9, \field Hole Layout Pattern for Pitch
     \type choice
     \key Triangle
     \key Square
A10, \field Heat Exchange Effectiveness Correlation
     \type choice
     \key Kutscher1994
     \key VanDeckerHollandsBrunger2001
N8, \field Ratio of Actual Collector Surface Area to Projected Surface Area

```

```

        \type real
        \note This parameter is used to help account for corrugations in the collector
        \default 1.0
        \minimum 1.0
        \maximum 2.0
        \units dimensionless
A11, \field Roughness of Collector
        \required-field
        \type choice
        \key VeryRough
        \key Rough
        \key MediumRough
        \key MediumSmooth
        \key Smooth
        \key VerySmooth
N9, \field Collector Thickness
        \type real
        \note Collector thickness is not required for Kutscher correlation
        \note Collector thickness is required for Van Decker et al. correlation
        \minimum 0.0005
        \maximum 0.007
        \units m
N10, \field Effectiveness for Perforations with Respect to Wind
        \note Cv
        \type real
        \units dimensionless
        \default 0.25
        \minimum > 0
        \maximum 1.5
N11, \field Discharge Coefficient for Openings with Respect to Buoyancy Driven Flow
        \note Cd
        \type real
        \units dimensionless
        \default 0.65
        \minimum > 0.0
        \maximum 1.5
A12, \field Surface 1 Name
        \required-field
        \type object-list
        \object-list AllShadingAndHTSurfNames

A21; \field Surface 10 Name
        \type object-list
        \object-list AllShadingAndHTSurfNames

```

An example of this object follows.

```
SolarCollector:UnglazedTranspired,
Shop OA UTSC ZN11,           ! Name
UTSC OSCM ZN11,             ! Boundary Conditions Model Name
HeatingAvailSched ,        ! Availability Schedule Name
Outside Air Inlet Node ZN11 , ! Inlet Node Name
UTSC Outlet Node ZN11 ,    ! Outlet Node Name
Mixed Air Node ZN11 ,      ! Setpoint Node Name
ZN11 Node,                 ! Zone Node Name
ShopFreeHeatingSetpoints,  ! Free Heating Setpoint Schedule Name
0.0016,                    ! Diameter of Perforations in Collector
0.01689,                   ! Distance Between Perforations in Collector
0.9,                       ! Thermal Emissivity of Collector Surface
0.9,                       ! Solar Absorbtivity of Collector Surface
4.0,                       ! Effective Overall Height of Collector
0.1,                       ! Effective Gap Thickness of Plenum Behind Collector
2.0,                       ! Effective Cross Section Area of Plenum Behind Collector
Triangle,                  ! Hole Layout Pattern for Pitch
Kutscher1994,              ! Heat Exchange Effectiveness Correlation
1.165,                     ! Ratio of Actual Collector Surface Area to Projected Surface Area
MediumRough ,              ! Roughness of Collector
0.00086,                   ! Collector Thickness
0.25,                      ! Effectiveness for Perforations with Respect to Wind
0.5,                       ! Discharge Coefficient for Openings with Respect to Buoyancy Driven Flow
ZN11_Shop_1:ExtWall:South; ! Surface 1 Name
```

SolarCollector:UnglazedTranspired Outputs

In addition to related output that can be obtained for air nodes and surfaces, these outputs are available for UTSC systems:

```
HVAC,Average,UTSC Heat Exchanger Effectiveness []
HVAC,Average,UTSC Leaving Air Drybulb from Collector [C]
HVAC,Average,UTSC Average Suction Face Velocity [m/s]
HVAC,Average,UTSC Collector Temperature [C]
HVAC,Average,UTSC Plenum Drybulb Temperature [C]
HVAC,Average,UTSC Sensible Heating Rate [W]
Zone,Meter,SolarAir:Facility [J]
Zone,Meter,SolarAir:HVAC [J]
Zone,Meter,HeatProduced:SolarAir [J]
HVAC,Sum,UTSC Sensible Heating Energy [J]
HVAC,Average,UTSC Air Changes per Hour Passive [ACH]
HVAC,Average,UTSC Total Natural Vent Mass Flow [kg/s]
HVAC,Average,UTSC Total Natural Vent Mass Flow from Wind [kg/s]
HVAC,Average,UTSC Total Natural Vent Mass Flow from Bouyancy [kg/s]
HVAC,Average,UTSC Incident Solar Radiation [W/m2]
HVAC,Average,UTSC Overall Efficiency []
HVAC,Average,UTSC Collector Efficiency []
```

UTSC Heat Exchanger Effectiveness []

The results from UTSC correlations defined by $\epsilon_{HX} = \frac{T_{a,HX} - T_{amb}}{T_{s, coll} - T_{amb}}$.

UTSC Leaving Air Drybulb from Collector [C]

The temperature of air entering the plenum after being heated by the collector.

UTSC Average Suction Face Velocity [m/s]

The bulk velocity of air approaching the collector.

UTSC Collector Temperature [C]

The surface temperature of the collector itself.

UTSC Plenum Drybulb Temperature [C]

The temperature of air inside, and leaving, the plenum behind the collector.

UTSC Sensible Heating Rate [W]

The overall rate at which heat is being added to the outdoor air stream.

SolarAir:Facility [J]

A meter that includes the heating energy provided by the UTSC.

SolarAir:HVAC [J]

A meter that includes the heating energy provided by the UTSC.

HeatProduced:SolarAir [J]

A meter that includes the heating energy provided by the UTSC.

UTSC Sensible Heating Energy [J]

The overall sum of energy added to the outdoor air stream.

UTSC Air Changes per Hour Passive [ACH]

The rate of natural ventilation air exchange between the plenum and ambient when the collector is inactive in Air Changes per Hour.

UTSC Total Natural Vent Mass Flow [kg/s]

The mass flow rate of natural ventilation air exchange between the plenum and ambient when the collector is inactive.

UTSC Total Natural Vent Mass Flow from Wind [kg/s]

The part of mass flow rate of natural ventilation air exchange between the plenum and ambient when the collector is inactive due to wind-driven forces.

UTSC Total Natural Vent Mass Flow from Bouyancy [kg/s]

The part of mass flow rate of natural ventilation air exchange between the plenum and ambient when the collector is inactive due to bouyancy-driven forces.

UTSC Incident Solar Radiation [W/m2]

The intensity of solar radiation incident on the UTSC collector from all sources.

UTSC Overall Efficiency []

The efficiency of the UTSC system including collected solar energy and heat recovered from the underlying surface.

UTSC Collector Efficiency []

The efficiency of the UTSC solar collector.

SolarCollector:UnglazedTranspired:MultiSystem

This object is used to model unglazed transpired solar collectors (UTSC) that are connected to multiple outdoor air systems. This object supplements the SolarCollector:UnglazedTranspired object and is only necessary if more than one air system is connected to a single transpired collector. After the name field, there are sets of four node names used to define the connections of each air system. Each set contains node names for inlet, outlet, control, and zone. If more than five air systems are needed, this object is extensible.

Field: Solar Collector Name

This field is used to identify the name of the SolarCollector:UnglazedTranspired object that needs to be connected to more than one air system. This field must match the name.

Field Set: Inlet Node, Outlet Node, Mixed Air Node, Zone Node

The following four fields form a repeating set of four fields. One set is used for each outdoor air system that is connected to the collector.

Field: Outdoor Air System <#> Collector Inlet Node

This field contains the name of an air node that provides air into the UTSC. This node name should also be assigned to be an outdoor air node using the OutdoorAir:NodeList and OutdoorAir:Node objects. This node is also be named as the actuator node in a Controller:OutdoorAir object.

Field: Outdoor Air System <#> Collector Outlet Node

This field contains the name of an air node that is the outlet of the UTSC. This node name will typically be the Outdoor Air Stream Node Name in the OutdoorAir:Mixer (if there is no other equipment on the outdoor air path).

Field: Outdoor Air System <#> Mixed Air Node

This field contains the name of an air node that has a setpoint manager controlling its temperature setpoint. This node name will typically be named as the mixed air node in a Controller:OutdoorAir object.

Field: Outdoor Air System <#> Zone Node

This field contains the name of an air node for a thermal zone that is ultimately connected to the air system. This node is used with the setpoint schedule, defined in the following field, to provide an added layer of thermostatic control for the UTSC without affecting the control of auxiliary heating. If there is a single air system that is connected to more than one zone, then a single zone should be selected based on where the thermostat might be located.

The IDD entry for this object follows.

```
SolarCollector:UnglazedTranspired:Multisystem,
  \extensible:4 - repeat last four fields, remembering to remove ; from "inner" fields.
  \note quad-tuples of inlet, outlet, control, and zone nodes
  \note for multiple different outdoor air systems attached to same collector
A1 , \field Solar Collector Name
  \required-field
  \note Enter the name of a SolarCollector:UnglazedTranspired object.
  \type object-list
  \object-list UTSCNames
A2 , \field Outdoor Air System 1 Collector Inlet Node
  \type alpha
A3 , \field Outdoor Air System 1 Collector Outlet Node
  \type alpha
A4 , \field Outdoor Air System 1 Mixed Air Node
  \type alpha
A5 , \field Outdoor Air System 1 Zone Node
  \type alpha

A18, \field Outdoor Air System 5 Collector Inlet Node
  \type alpha
A19, \field Outdoor Air System 5 Collector Outlet Node
  \type alpha
A20, \field Outdoor Air System 5 Mixed Air Node
  \type alpha
A21; \field Outdoor Air System 5 Zone Node
  \type alpha
  \type alpha
```

An example of this object follows.

```

SolarCollector:UnglazedTranspired:Multisystem,
OFFICE MultiSystem OA UTSC , ! Solar Collector Name
Outside Air Inlet Node ZN1, ! Outdoor Air System 1 Collector Inlet Node
UTSC Outlet Node ZN1, ! Outdoor Air System 1 Collector Outlet Node
Mixed Air Node ZN1, ! Outdoor Air System 1 Mixed Air Node
ZN1 Node, ! Outdoor Air System 1 Zone Node
Outside Air Inlet Node ZN2, ! Outdoor Air System 2 Collector Inlet Node
UTSC Outlet Node ZN2, ! Outdoor Air System 2 Collector Outlet Node
Mixed Air Node ZN2, ! Outdoor Air System 2 Mixed Air Node
ZN2 Node, ! Outdoor Air System 2 Zone Node
Outside Air Inlet Node ZN3, ! Outdoor Air System 3 Collector Inlet Node
UTSC Outlet Node ZN3, ! Outdoor Air System 3 Collector Outlet Node
Mixed Air Node ZN3, ! Outdoor Air System 3 Mixed Air Node
ZN3 Node, ! Outdoor Air System 3 Zone Node
Outside Air Inlet Node ZN4, ! Outdoor Air System 4 Collector Inlet Node
UTSC Outlet Node ZN4, ! Outdoor Air System 4 Collector Outlet Node
Mixed Air Node ZN4, ! Outdoor Air System 4 Mixed Air Node
ZN4 Node, ! Outdoor Air System 4 Zone Node
Outside Air Inlet Node ZN5, ! Outdoor Air System 5 Collector Inlet Node
UTSC Outlet Node ZN5, ! Outdoor Air System 5 Collector Outlet Node
Mixed Air Node ZN5, ! Outdoor Air System 5 Mixed Air Node
ZN5 Node; ! Outdoor Air System 5 Zone Node

```

Group – Pumps

EnergyPlus plant and condenser loops need pump components to drive liquid flow around the loop. There are various types of pump models available.

Pump:VariableSpeed

Pumps are needed in both plant and condenser loops. The syntax for a variable speed pump is given below.

Field: Name

This alpha field contains the identifying a unique name for the pump.

Field: Inlet Node Name

This alpha field contains the identifying name for the pump inlet node.

Field: Outlet Node Name

This alpha field contains the identifying name for the pump outlet node.

Field: Rated Flow Rate

This numeric field contains the pump's rated volumetric flow rate in cubic meters per second.

Field: Rated Pump Head

This numeric field contains the pump's rated head pressure in Pascals.

Field: Rated Power Consumption

This numeric field contains the pump's rated power consumption in Watts.

Field: Motor Efficiency

This numeric field contains the pump's efficiency in decimal form (0 = 0%, 1 = 100%).

Field: Fraction of Motor Inefficiencies to Fluid Stream

This numeric field contains the pump's fraction of power loss to the fluid.

Field: Coefficient 1 of the Part Load Performance Curve

This numeric field contains the first coefficient in the part load ratio curve. The fraction of full load power is determined by the cubic equation:

$$\text{FractionFullLoadPower} = C_1 + C_2\text{PLR} + C_3\text{PLR}^2 + C_4\text{PLR}^3$$

where $C_1, C_2, C_3,$ and C_4 are Coefficients 1 – 4 (below) and PLR is the Part Load Ratio.

Field: Coefficient 2 of the Part Load Performance Curve

This numeric field contains the second coefficient in the part load ratio curve.

Field: Coefficient 3 of the Part Load Performance Curve

This numeric field contains the third coefficient in the part load ratio curve.

Field: Coefficient 4 of the Part Load Performance Curve

This numeric field contains the fourth coefficient in the part load ratio curve.

Field: Minimum Flow Rate

This field contains the minimum volumetric flow rate while operating in variable flow capacity rate in cubic meters per second.

Field: Pump Control Type

This is a choice field of Continuous or Intermittent. A variable speed pump is defined with maximum and minimum flow rates that are the physical limits of the device. If there is no load on the loop and the pump is operating intermittently, then the pump can shutdown. For any other condition such as the loop having a load and the pump is operating intermittently or the pump is continuously operating (regardless of the loading condition), the pump will operate and select a flow somewhere between the minimum and maximum limits. In these cases where the pump is running, it will try to meet the flow request made by demand side components.

Field: Pump Flow Rate Schedule Name

The schedule values modify the value for Rated Flow Rate of the pump on a time basis. The default is that the pump is ON and runs according to its other operational requirements specified above. This schedule is for special, not typical pump operations.

The IDD entry for this object follows.

```

Pump:VariableSpeed,
    \memo This pump model is described in the ASHRAE secondary HVAC toolkit.
    \min-fields 14
A1 , \field Name
    \required-field
A2 , \field Inlet Node Name
    \required-field
A3 , \field Outlet Node Name
    \required-field
N1 , \field Rated Flow Rate
    \units m3/s
    \autosizable
    \ip-units gal/min
N2 , \field Rated Pump Head
    \units Pa
    \default 179352
    \note default head is 60 feet
    \ip-units ftH2O
N3 , \field Rated Power Consumption
    \units W
    \autosizable
    \ip-units W
N4 , \field Motor Efficiency
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0.9
N5 , \field Fraction of Motor Inefficiencies to Fluid Stream
    \minimum 0.0
    \maximum 1.0
    \default 0.0
N6 , \field Coefficient 1 of the Part Load Performance Curve
    \default 0.0
N7 , \field Coefficient 2 of the Part Load Performance Curve
    \default 1.0
N8 , \field Coefficient 3 of the Part Load Performance Curve
    \default 0.0
N9 , \field Coefficient 4 of the Part Load Performance Curve
    \default 0.0
N10, \field Minimum Flow Rate
    \note This value can be zero and will be defaulted to that if not specified.
    \units m3/s
    \default 0.0
    \ip-units gal/min
A4 , \field Pump Control Type
    \type choice
    \key Continuous
    \key Intermittent
    \default Continuous
A5 ; \field Pump Flow Rate Schedule Name
    \note modifies the Rated Flow Rate of the pump on a time basis
    \note the default is that the pump is ON and runs according to its other
    \note operational requirements specified above. The schedule is for special pump operations
    \type object-list
    \object-list ScheduleNames

```

Examples of this object in the IDF follow.

```

Pump:VariableSpeed,
  HW Circ Pump,           !- Name
  HW Supply Inlet Node,   !- Inlet Node Name
  HW Pump Outlet Node,    !- Outlet Node Name
  autosize,               !- Rated Flow Rate {m3/s}
  179352,                 !- Rated Pump Head {Pa}
  autosize,               !- Rated Power Consumption {W}
  0.9,                   !- Motor Efficiency
  0.0,                   !- Fraction of Motor Inefficiencies to Fluid Stream
  0,                      !- Coefficient 1 of the Part Load Performance Curve
  1,                      !- Coefficient 2 of the Part Load Performance Curve
  0,                      !- Coefficient 3 of the Part Load Performance Curve
  0,                      !- Coefficient 4 of the Part Load Performance Curve
  0,                      !- Minimum Flow Rate {m3/s}
  Intermittent;          !- Pump Control Type

Pump:VariableSpeed,
  Circ Pump,             !- Name
  CW Supply Inlet Node,  !- Inlet Node Name
  CW Pump Outlet Node,   !- Outlet Node Name
  .0011,                 !- Rated Flow Rate {m3/s}
  300000,                !- Rated Pump Head {Pa}
  500,                  !- Rated Power Consumption {W}
  .87,                  !- Motor Efficiency
  0.0,                  !- Fraction of Motor Inefficiencies to Fluid Stream
  0,                      !- Coefficient 1 of the Part Load Performance Curve
  1,                      !- Coefficient 2 of the Part Load Performance Curve
  0,                      !- Coefficient 3 of the Part Load Performance Curve
  0,                      !- Coefficient 4 of the Part Load Performance Curve
  0,                      !- Minimum Flow Rate {m3/s}
  Intermittent;          !- Pump Control Type

```

Pump:VariableSpeed Outputs

```

HVAC,Average,Pump Electric Power [W]
HVAC,Sum,Pump Electric Consumption [J]
HVAC,Average,Pump Shaft Power [W]
HVAC,Average,Pump Heat To Fluid [W]
HVAC,Sum,Pump Heat To Fluid Energy [J]
HVAC,Average,Pump Outlet Temp [C]
HVAC,Average,Pump Mass Flow Rate [kg/s]

```

Pump Electric Power [W]

Pump Electric Consumption [J]

These outputs are the electric power input to the pump motor. Consumption is metered on Pumps:Electricity, Electricity:Plant, and Electricity:Facility.

Pump Shaft Power [W]

This is the shaft power delivered from the motor to the pump.

Pump Heat To Fluid [W]

Pump Heat To Fluid Energy [J]

These outputs are the energy added to the fluid as heat. For the current algorithm, this is equal to Pump Shaft Power, because the loops are closed and all energy added to the fluid will ultimately become heat due to friction.

Pump Outlet Temp [C]

Pump Mass Flow Rate [kg/s]

These outputs are the water outlet temperature and mass flow rate.

Pump:ConstantSpeed

Pumps may be found in both plant and condenser loops. The syntax for a constant speed pump is given below.

Field: Name

This alpha field contains the identifying name for the pump.

Field: Inlet Node Name

This alpha field contains the identifying name for the pump inlet node.

Field: Outlet Node Name

This alpha field contains the identifying name for the pump outlet node.

Field: Rated Flow Rate

This numeric field contains the pump's rated volumetric flow rate in cubic meters per second.

Field: Rated Pump Head

This numeric field contains the pump's rated head pressure in Pascals.

Field: Rated Power Consumption

This numeric field contains the pump's rated power consumption in Watts.

Field: Motor Efficiency

This numeric field contains the pump's efficiency in decimal form (0 = 0%, 1 = 100%).

Field: Fraction of Motor Inefficiencies to Fluid Stream

This numeric field contains the pump's fraction of power loss to the fluid.

Field: Pump Control Type

This is a choice field of Continuous or Intermittent. The operation of a constant speed pump is fairly straightforward. If the user designates a constant speed pump that is operating continuously, the pump will run regardless of whether or not there is a load. This may have the net effect of adding heat to the loop if no equipment is turned on. If the pump is constant speed and operates intermittently, the pump will run at its capacity if a load is sensed and will shut off if there is no load on the loop.

Field: Pump Flow Rate Schedule Name

The schedule values modify the Rated Flow Rate of the pump on a time basis. The default is that the pump is ON and runs according to its other operational requirements specified above. This schedule is for special, not typical pump operations.

The IDD entry for this object follows.

```

Pump:ConstantSpeed,
    \memo This pump model is described in the ASHRAE secondary HVAC toolkit.
    \min-fields 9
A1, \field Name
    \required-field
A2 , \field Inlet Node Name
    \required-field
A3 , \field Outlet Node Name
    \required-field
N1 , \field Rated Flow Rate
    \units m3/s
    \autosizable
    \ip-units gal/min
N2 , \field Rated Pump Head
    \units Pa
    \default 179352
    \note default head is 60 feet
    \ip-units ftH2O
N3 , \field Rated Power Consumption
    \units W
    \autosizable
    \ip-units W
N4 , \field Motor Efficiency
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0.9
N5 , \field Fraction of Motor Inefficiencies to Fluid Stream
    \minimum 0.0
    \maximum 1.0
    \default 0.0
A4 , \field Pump Control Type
    \type choice
    \key Continuous
    \key Intermittent
    \default Continuous
A5 ; \field Pump Flow Rate Schedule Name
    \note modifies the Rated Flow Rate of the pump on a time basis
    \note the default is that the pump is on and runs according to its other
    \note operational requirements specified above. The schedule is for special pump operations
    \type object-list
    \object-list ScheduleNames

```

An example of this object follows.

```

Pump:ConstantSpeed,
    Circ Pump,           !- Name
    CW Supply Inlet Node, !- Inlet Node Name
    PumpChiller Node,   !- Outlet Node Name
    0.0011,              !- Rated Flow Rate
    300000,              !- Rated Pump Head
    700,                 !- Rated Power Consumption
    0.87,                !- Motor Efficiency
    0.0,                 !- Fraction of Motor Inefficiencies to Fluid Stream
    Intermittent;       !- Pump Control Type

```

Pump:ConstantSpeed Outputs

```

HVAC,Average,Pump Electric Power [W]
HVAC,Sum,Pump Electric Consumption [J]
HVAC,Average,Pump Shaft Power [W]
HVAC,Average,Pump Heat To Fluid [W]
HVAC,Sum,Pump Heat To Fluid Energy [J]
HVAC,Average,Pump Outlet Temp [C]
HVAC,Average,Pump Mass Flow Rate [kg/s]

```

Pump Electric Power [W]***Pump Electric Consumption [J]***

These outputs are the electric power input to the pump motor. Consumption is metered on Pumps:Electricity, Electricity:Plant, and Electricity:Facility.

Pump Shaft Power [W]

This is the shaft power delivered from the motor to the pump.

Pump Heat To Fluid [W]***Pump Heat To Fluid Energy [J]***

These outputs are the energy added to the fluid as heat. For the current algorithm, this is equal to Pump Shaft Power, because the loops are closed and all energy added to the fluid will ultimately become heat due to friction.

Pump Outlet Temp [C]***Pump Mass Flow Rate [kg/s]***

These outputs are the water outlet temperature and mass flow rate.

Pump:VariableSpeed:Condensate

The Pump:VariableSpeed:Condensate object can only be used in steam system simulation for the condensate side of the loop. This is a variable speed pump, which pumps the condensate back to the steam boiler. The syntax for condensate pump is given below.

Field: Name

This alpha field contains the identifying unique name for the pump.

Field: Inlet Node Name

This alpha field contains the identifying name for the pump inlet node.

Field: Outlet Node Name

This alpha field contains the identifying name for the pump outlet node.

Field: Rated Flow Rate

This numeric field contains the pump's rated volumetric flow rate in cubic meters per second.

Field: Rated Pump Head

This numeric field contains the pump's rated head in Pascals.

Field: Rated Power Consumption

This numeric field contains the pump's rated power consumption in Watts.

Field: Motor Efficiency

This numeric field contains the pump's efficiency in decimal form (0 = 0%, 1 = 100%).

Field: Fraction of Motor Inefficiencies to Fluid Stream

This numeric field contains the pump's fraction of power loss to the fluid.

Field: Coefficient 1 of the Part Load Performance Curve

This numeric field contains the first coefficient in the part load ratio curve. The fraction of full load power is determined by the cubic equation:

$$FractionFullLoadPower = C_1 + C_2PLR + C_3PLR^2 + C_4PLR^3$$

where $C_1, C_2, C_3,$ and C_4 are Coefficients 1 – 4 (below) and PLR is the Part Load Ratio.

Field: Coefficient 2 of the Part Load Performance Curve

This numeric field contains the second coefficient in the part load ratio curve.

Field: Coefficient 3 of the Part Load Performance Curve

This numeric field contains the third coefficient in the part load ratio curve.

Field: Coefficient 4 of the Part Load Performance Curve

This numeric field contains the fourth coefficient in the part load ratio curve.

Field: Pump Flow Rate Schedule Name

The schedule values modify the Rated Flow Rate of the pump on a time basis the default is that the pump is ON and runs according to its other operational requirements specified above. The schedule is for special, not typical pump operations.

The IDD entry for this object follows.

```
Pump:VariableSpeed:Condensate,
  \memo This pump model is described in the ASHRAE secondary HVAC toolkit.
  \memo Variable Speed Condensate pump for Steam Systems
  \min-fields 13
A1 , \field Name
  \required-field
A2 , \field Inlet Node Name
  \required-field
A3 , \field Outlet Node Name
  \required-field
N1 , \field Rated Flow Rate
  \units m3/s
  \autosizable
  \ip-units gal/min
N2 , \field Rated Pump Head
  \units Pa
  \default 179352
  \note default head is 60 feet
  \ip-units ftH2O
N3 , \field Rated Power Consumption
  \units W
  \autosizable
  \ip-units W
N4 , \field Motor Efficiency
  \type real
  \minimum 0.0
  \maximum 1.0
  \default 0.9
N5 , \field Fraction of Motor Inefficiencies to Fluid Stream
  \minimum 0.0
  \maximum 1.0
  \default 0.0
N6 , \field Coefficient 1 of the Part Load Performance Curve
  \default 0.0
N7 , \field Coefficient 2 of the Part Load Performance Curve
  \default 1.0
N8 , \field Coefficient 3 of the Part Load Performance Curve
  \default 0.0
N9 , \field Coefficient 4 of the Part Load Performance Curve
  \default 0.0
A4 ; \field Pump Flow Rate Schedule Name
  \note modifies the Rated Flow Rate of the pump on a time basis
  \note the default is that the pump is on and runs according to its other
  \note operational requirements specified above. This schedule is for special pump operations.
  \type object-list
  \object-list ScheduleNames
```

Examples of this object in the IDF follow.

```

Pump:VariableSpeed:Condensate,
  Steam Boiler Plant Steam Circ Pump,          !- Name
  Steam Boiler Plant Steam Supply Inlet Node,  !- Inlet Node Name
  Steam Boiler Plant Steam Pump Outlet Node,   !- Outlet Node Name
  0.36,                                       !- Rated Flow Rate {m3/s}
  179352,                                     !- Rated Pump Head {Pa}
  400,                                        !- Rated Power Consumption {W}
  0.9,                                       !- Motor Efficiency
  0.0,                                       !- Fraction of Motor Inefficiencies to Fluid Stream
  0,                                          !- Coefficient 1 of the Part Load Performance Curve
  1,                                          !- Coefficient 2 of the Part Load Performance Curve
  0,                                          !- Coefficient 3 of the Part Load Performance Curve
  0;                                          !- Coefficient 4 of the Part Load Performance Curve

Pump:VariableSpeed:Condensate,
  Steam Boiler Plant Steam Circ Pump,          !- Name
  Steam Boiler Plant Steam Supply Inlet Node,  !- Inlet Node Name
  Steam Boiler Plant Steam Pump Outlet Node,   !- Outlet Node Name
  0.36,                                       !- Rated Flow Rate {m3/s}
  179352,                                     !- Rated Pump Head {Pa}
  autosize,                                  !- Rated Power Consumption {W}
  0.9,                                       !- Motor Efficiency
  0.0,                                       !- Fraction of Motor Inefficiencies to Fluid Stream
  0,                                          !- Coefficient 1 of the Part Load Performance Curve
  1,                                          !- Coefficient 2 of the Part Load Performance Curve
  0,                                          !- Coefficient 3 of the Part Load Performance Curve
  0;                                          !- Coefficient 4 of the Part Load Performance Curve

```

Pump:VariableSpeed:Condensate Outputs

```

HVAC,Average,Pump Electric Power [W]
HVAC,Sum,Pump Electric Consumption [J]

HVAC,Average,Pump Shaft Power [W]
HVAC,Average,Pump Heat To Fluid [W]
HVAC,Sum,Pump Heat To Fluid Energy [J]
HVAC,Average,Pump Outlet Temp [C]
HVAC,Average,Pump Mass Flow Rate [kg/s]

```

Pump Electric Power [W]

Pump Electric Consumption [J]

These outputs are the electric power input to the pump motor. Consumption is metered on Pumps:Electricity, Electricity:Plant, and Electricity:Facility.

Pump Shaft Power [W]

This is the shaft power delivered from the motor to the pump.

Pump Heat To Fluid [W]

Pump Heat To Fluid Energy [J]

These outputs are the energy added to the fluid as heat. For the current algorithm, this is equal to Pump Shaft Power, because the loops are closed and all energy added to the fluid will ultimately become heat due to friction.

Pump Outlet Temp [C]

Pump Mass Flow Rate [kg/s]

These outputs are the water outlet temperature and mass flow rate.

HeaderedPumps:ConstantSpeed

Headered pumps are components with more than one identical pumps connected in parallel. The syntax for HeaderedPumps:ConstantSpeed is as follows.

Field: Name

This alpha field contains the identifying name for the pump bank.

Field: Inlet Node Name

This alpha field contains the identifying name for the pump bank inlet node.

Field: Outlet Node Name

This alpha field contains the identifying name for the pump bank outlet node.

Field: Total Rated Flow Rate

This numeric field contains the pump bank's rated volumetric flow rate in cubic meters per second. This is equal to the product of number of pumps and the flow rate of each individual pump. The field can be autosized.

Field: Number of Pumps in Bank

The numeric field specifies the number of pumps present in the pump bank. All these pumps are connected in parallel internally.

Field: Flow Sequencing Control Scheme

The alpha field specifies the scheme for sequencing flow. Currently the only choice is Sequential, where a pump in the pump bank will be turned ON only after fully loading the previous pump.

Field: Rated Pump Head

This numeric field contains the pump's rated head pressure in Pascals.

Field: Rated Power Consumption

This numeric field contains the pump bank's total power consumption in Watts. This field is equal to the product of number of pumps and the rated power consumption of each individual pump.

Field: Motor Efficiency

This numeric field contains the pump's efficiency in decimal form (0 = 0%, 1 = 100%).

Field: Fraction of Motor Inefficiencies to Fluid Stream

This numeric field contains the pump's fraction of power loss to the fluid.

Field: Pump Control Type

This is a choice field of Continuous or Intermittent. The operation of a constant speed pump bank is fairly straightforward. If the user designates a constant speed pump bank that is operating continuously, the pump bank will run regardless of whether or not there is a load. This may have the net effect of adding heat to the loop if no equipment is turned on. If the pump bank is constant speed and operates intermittently, the pump bank will run at its capacity if a load is sensed and will shut off if there is no load on the loop.

Field: Pump Flow Rate Schedule Name

The schedule values modify the Total Rated Flow Rate of the pump on a time basis. The default is that the pump is ON and runs according to its other operational requirements specified above. This schedule is for special, not typical pump operations.

The IDD entry for this object follows.

```

HeaderedPumps:ConstantSpeed,
  \memo This Headered pump object describes a pump bank with more than 1 pump in parallel
  \min-fields 9
A1 , \field Name
  \required-field
A2 , \field Inlet Node Name
  \required-field
A3 , \field Outlet Node Name
  \required-field
N1 , \field Total Rated Flow Rate
  \Note If the field is not autosized set to the flow rate to the total flow when all pumps are
  \Note running at full load
  \units m3/s
  \autosizable
  \ip-units gal/min
N2 , \field Number of Pumps in Bank
A4 , \field Flow Sequencing Control Scheme
  \type choice
  \key Sequential
  \default Sequential
N3 , \field Rated Pump Head
  \units Pa
  \default 179352
  \note default head is 60 feet
  \ip-units ftH2O
N4 , \field Rated Power Consumption
  \Note If the field is not autosized set to the power consumed by pump bank when all the pumps
  \Note are running at nominal flow
  \units W
  \autosizable
  \ip-units W
N5 , \field Motor Efficiency
  \type real
  \minimum 0.0
  \maximum 1.0
  \default 0.9
N6 , \field Fraction of Motor Inefficiencies to Fluid Stream
  \minimum 0.0
  \maximum 1.0
  \default 0.0
A5 , \field Pump Control Type
  \type choice
  \key Continuous
  \key Intermittent
  \default Continuous
A6 ; \field Pump Flow Rate Schedule Name
  \note modifies the rated flow rate of the pump on a time basis
  \note the default is that the pump is on and runs according to its other
  \note operational requirements specified above. The schedule is for special pump operations
  \type object-list
  \object-list ScheduleNames

```

An example for constant speed pump bank follows.

```

HeaderedPumps:ConstantSpeed,
Chilled Water Headered Pumps,  !- Name
CW Supply Inlet Node,          !- Inlet Node Name
CW Pumps Outlet Node,         !- Outlet Node Name
autosize,                      !- Total Rated Flow Rate
2,                             !- Number of Pumps in Bank
SEQUENTIAL,                   !- Flow Sequencing Control Scheme
179352,                       !- Rated Pump Head
autosize,                      !- Rated Power Consumption
0.9,                          !- Motor Efficiency
0.0,                          !- Fraction of Motor Inefficiencies to Fluid Stream
INTERMITTENT,                 !- Pump Control Type
CoolingPumpAvailSched;        !- Pump Flow Rate Schedule Name

```

HeaderedPumps:ConstantSpeed Outputs

HVAC,Average,Pump Electric Power [W]

HVAC,Sum,Pump Electric Consumption [J]
 HVAC,Average,Pump Shaft Power [W]
 HVAC,Average,Pump Heat To Fluid [W]
 HVAC,Sum,Pump Heat To Fluid Energy [J]
 HVAC,Average,Pump Outlet Temp [C]
 HVAC,Average,Pump Mass Flow Rate [kg/s]
 HVAC,Average,Number of Pumps Operating []

Pump Electric Power [W]**Pump Electric Consumption [J]**

These outputs are the electric power input to the pump motor. Consumption is metered on Pumps:Electricity, Electricity:Plant, and Electricity:Facility.

Pump Shaft Power [W]

This is the shaft power delivered from the motor to the pump.

Pump Heat To Fluid [W]**Pump Heat To Fluid Energy [J]**

These outputs are the energy added to the fluid as heat. For the current algorithm, this is equal to Pump Shaft Power, because the loops are closed and all energy added to the fluid will ultimately become heat due to friction.

Pump Outlet Temp [C]**Pump Mass Flow Rate [kg/s]**

These outputs are the water outlet temperature and mass flow rate.

Number of Pumps Operating []

This output tells the number of pumps in the pump bank operating at any reporting frequency.

HeaderedPumps:VariableSpeed

Headered pumps are components with more than one identical pumps connected in parallel. Currently this object may be found only in plant loops. The syntax for a HeaderedPumps:VariableSpeed pump is given below.

Field: Name

This alpha field contains the identifying unique name for the pump bank.

Field: Inlet Node Name

This alpha field contains the identifying name for the pump bank inlet node.

Field: Outlet Node Name

This alpha field contains the identifying name for the pump bank outlet node.

Field: Total Rated Flow Rate

This numeric field contains the pump bank's rated volumetric flow rate in cubic meters per second. This is equal to the product of number of pumps and the flow rate of each individual pump. The field can be autosized.

Field: Number of Pumps in Bank

The numeric field specifies the number of pumps present in the pump bank. All these pumps are connected in parallel internally.

Field: Flow Sequencing Control Scheme

The alpha field specifies the scheme for sequencing flow. Currently the only choice is Sequential, where a pump in the pump bank will be turned ON only after fully loading the previous pump.

Field: Rated Pump Head

This numeric field contains the pump's rated head in Pascals.

Field: Rated Power Consumption

This numeric field contains the pump bank's total power consumption in Watts. This field is equal to the product of number of pumps and the rated power consumption of each individual pump.

Field: Motor Efficiency

This numeric field contains the efficiency of the individual pump (which will be equivalent to pump bank efficiency) in decimal form (0 = 0%, 1 = 100%).

Field: Fraction of Motor Inefficiencies to Fluid Stream

This numeric field contains the individual pump's fraction of power loss to the fluid.

Field: Coefficient 1 of the Part Load Performance Curve

This numeric field contains the first coefficient (C_1) in the part load ratio curve. The fraction of full load power is determined by the cubic equation:

$$\text{FractionFullLoadPower} = C_1 + C_2\text{PLR} + C_3\text{PLR}^2 + C_4\text{PLR}^3$$

where $C_1, C_2, C_3,$ and C_4 are Coefficients 1 – 4 (below) and PLR is the Part Load Ratio.

Field: Coefficient 2 of the Part Load Performance Curve

This numeric field contains the second coefficient (C_2) in the part load ratio curve.

Field: Coefficient 3 of the Part Load Performance Curve

This numeric field contains the third coefficient (C_3) in the part load ratio curve.

Field: Coefficient 4 of the Part Load Performance Curve

This numeric field contains the fourth coefficient (C_4) in the part load ratio curve.

Field: Minimum Flow Rate

The numeric field specifies the minimum flow allowed for the pump bank as a fraction of the nominal flow. If the requested flow is less than minimum flow pump bank runs at minimum flow.

Field: Pump Control Type

This is a choice field of Continuous or Intermittent. A variable speed pump bank is defined with maximum and minimum flow rates that are the physical limits of the device. If there is no load on the loop and the pump bank is operating intermittently, then the bank can shutdown. For any other condition such as the loop having a load and the pump bank is operating intermittently or the pump bank is continuously operating (regardless of the loading condition), the bank will operate and select a flow somewhere between the minimum and maximum limits. In these cases where the pump bank is running, it will try to meet the flow request made by demand side components.

Field: Pump Flow Rate Schedule Name

Modifies the Rated Volumetric Flow Rate of the pump on a time basis. The default is that the pump is ON and runs according to its other operational requirements specified above. This schedule is for special, not typical pump operations.

The IDD entry for this object follows.

```

HeaderedPumps:VariableSpeed,
  \memo This Headered pump object describes a pump bank with more than 1 pump in parallel
  \min-fields 14
A1 , \field Name
  \required-field
A2 , \field Inlet Node Name
  \required-field
A3 , \field Outlet Node Name
  \required-field
N1 , \field Total Rated Flow Rate
  \note If the field is not autosized set to the flow rate to the total flow when all pumps are
  \note running at full load
  \units m3/s
  \autosizable
  \ip-units gal/min
N2 , \field Number of Pumps in Bank
  \type Integer
A4 , \field Flow Sequencing Control Scheme
  \type choice
  \key Sequential
  \default Sequential
N3 , \field Rated Pump Head
  \units Pa
  \default 179352
  \note default head is 60 feet
  \ip-units ftH2O
N4 , \field Rated Power Consumption
  \note If the field is not autosized set to the Power consumed by pump bank when all the pumps
  \note are running at nominal flow
  \units W
  \autosizable
  \ip-units W
N5 , \field Motor Efficiency
  \type real
  \minimum 0.0
  \maximum 1.0
  \default 0.9
N6 , \field Fraction of Motor Inefficiencies to Fluid Stream
  \minimum 0.0
  \maximum 1.0
  \default 0.0
N7 , \field Coefficient 1 of the Part Load Performance Curve
  \default 0.0
N8 , \field Coefficient 2 of the Part Load Performance Curve
  \default 1.0
N9 , \field Coefficient 3 of the Part Load Performance Curve
  \default 0.0
N10, \field Coefficient 4 of the Part Load Performance Curve
  \default 0.0
N11, \field Minimum Flow Rate
  \note This value can be zero and will be defaulted to that if not specified.
  \default 0.0
  \ip-units gal/min
A5 , \field Pump Control Type
  \type choice
  \key Continuous
  \key Intermittent
  \default Continuous
A6 ; \field Pump Flow Rate Schedule Name
  \note modifies the rated flow rate of the pump on a time basis
  \note the default is that the pump is on and runs according to its other
  \note operational requirements specified above. The schedule is for special pump operations
  \type object-list
  \object-list ScheduleNames

```

An example of this object follows.

```

HeaderedPumps:VariableSpeed,
Chilled Water Headered Pumps, !- Name
CW Supply Inlet Node,      !- Inlet Node Name
CW Pumps Outlet Node,     !- Outlet Node Name
autosize,                 !- Total Rated Flow Rate {m3/s}
2,                        !- Number of Pumps in Bank
SEQUENTIAL,              !- Flow Sequencing Control Scheme
179352,                  !- Rated Pump Head {Pa}
autosize,                 !- Rated Power Consumption {W}
0.9,                     !- Motor Efficiency
0.0,                     !- Fraction of Motor Inefficiencies to Fluid Stream
0,                        !- Coefficient 1 of the Part Load Performance Curve
1,                        !- Coefficient 2 of the Part Load Performance Curve
0,                        !- Coefficient 3 of the Part Load Performance Curve
0,                        !- Coefficient 4 of the Part Load Performance Curve
0.1,                     !- Minimum Flow Rate {m3/s}
INTERMITTENT,           !- Pump Control Type
CoolingPumpAvailSched;   !- Pump Flow Rate Schedule Name

```

HeaderedPumps:VariableSpeed Outputs

```

HVAC,Average,Pump Electric Power [W]
HVAC,Sum,Pump Electric Consumption [J]
HVAC,Average,Pump Shaft Power [W]
HVAC,Average,Pump Heat To Fluid [W]
HVAC,Sum,Pump Heat To Fluid Energy [J]
HVAC,Average,Pump Outlet Temp [C]
HVAC,Average,Pump Mass Flow Rate [kg/s]
HVAC,Average,Number of pumps operating []

```

Pump Electric Power [W]

Pump Electric Consumption [J]

These outputs are the electric power input to the pump motor. Consumption is metered on Pumps:Electricity, Electricity:Plant, and Electricity:Facility.

Pump Shaft Power [W]

This is the shaft power delivered from the motor to the pump.

Pump Heat To Fluid [W]

Pump Heat To Fluid Energy [J]

These outputs are the energy added to the fluid as heat. For the current algorithm, this is equal to Pump Shaft Power, because the loops are closed and all energy added to the fluid will ultimately become heat due to friction.

Pump Outlet Temp [C]

Pump Mass Flow Rate [kg/s]

These outputs are the water outlet temperature and mass flow rate.

Number of Pumps Operating []

This output tells the number of pumps in the pump bank operating at any reporting frequency.

Duct

The Duct object is a component for air systems that is a direct analogue for Pipe:Adiabatic in the fluid loops. It is used when it is necessary (due to the HVAC system configuration) to have a branch that has no functional components. This case most often arises for a bypass branch. Since every branch must have at least one component, the Duct component is used

for this situation. The duct is an adiabatic, pass-through component; all of its inlet conditions are passed through unchanged to its outlet.

Field: Name

This is the unique name for this component. Any reference to this component (in a BranchList, for instance) will refer to it by this name.

Field: Inlet Node Name

The name of the component's air inlet node.

Field: Outlet Node Name

The name of the component's air outlet node.

Below is the IDD definition of the Duct component.

```
Duct,
  \memo Passes inlet node state variables to outlet node state variables
  A1, \field Name
      \required-field
  A2, \field Inlet Node Name
      \required-field
  A3; \field Outlet Node Name
      \required-field
```

Below is an example input for Duct.

```
DUCT,
  VAV Sys 1 Bypass Duct,           !- Name
  VAV Sys 1 Bypass Duct Inlet Node, !- Inlet Node Name
  VAV Sys 1 Bypass Duct Outlet Node;!- Outlet Node Name
```

Duct Outputs

There are no outputs for Duct.

Group – Heating and Cooling Coils

Several different coils may be added to zone equipment and air loops. This includes simple heating (gas, electric, and hot water) and a simple water-cooling coil as well as a more detailed flat fin water-cooling coil model. In general, the heating coil description can be used for a heating coil, a reheat coil, or a preheat coil in the air loop simulation or for zone equipment. Figure 109 is an example of a heating and cooling coil in the air loop simulation in a dual duct system. This does show the basic node structure that will be referenced in the input description. The figure does show water coils since they are the most complex to input in the simulation compared to the Electric and Gas coils which only have air connections.

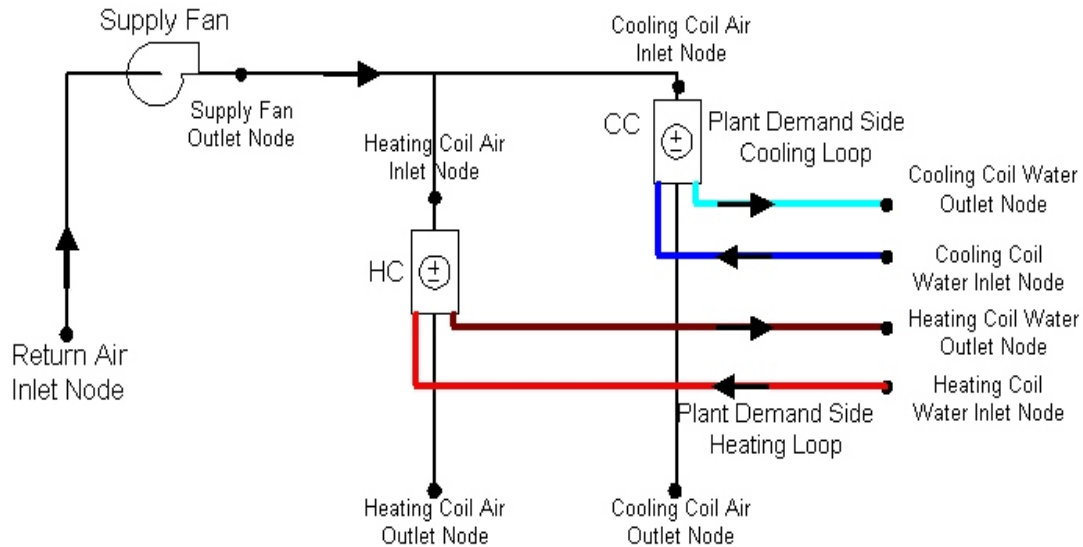


Figure 109. Example Air Loop Heating & Cooling Coil

Coil:Cooling:Water

The water cooling coil (Coil:Cooling:Water) has the ability to give detailed output with simplified inputs, inputting complicated coil geometry is not required by the user for this model instead the coil is sized in terms of auto-sizeable thermodynamic inputs. The coil requires thermodynamic inputs such as temperatures, mass flow rates and humidity ratios.

The coil is sized using auto-sized/user design input conditions and the UA values are calculated from the design conditions. A rough estimate of the coil area is provided along with percentage of surface wet and/or dry. This model uses the NTU-effectiveness approach to model heat transfer and has two types of flow arrangements cross-flow or counter-flow.

The basic underlying idea is - use auto sizeable thermodynamic design inputs, calculate the coil UA's, use these UA values and operating conditions from the nodes connections, calculate the outlet stream conditions, and calculate the heat transfer rates.

See section "Cooling Coil Model" in the EnergyPlus Engineering Document for further details regarding this model.

Field: Name

A unique user-assigned name for an instance of a cooling coil. Any reference to this cooling coil by another object will use this name.

Field: Available Schedule Name

Schedule that defines when the coil is available. The name of the schedule (ref: Schedule) that denotes whether the cooling coil can run during a given time period. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during a given time period. A value less than or equal to 0 (usually 0 is used) denotes that the unit is off.

Field: Design Water Flow Rate

The maximum possible water volume flow rate (m^3/sec) through the coil. This is an auto sizeable design input.

Field: Design Air Flow Rate

The maximum possible air volume flow rate (m^3/sec) through the coil. This is an auto sizeable design input.

Field: Design Inlet Water Temperature

The inlet water temperature for the design flow (deg C). This is an auto sizable design input.

Field: Design Inlet Air Temperature

The inlet air temperature for the design flow (deg C). This is an auto sizable design input.

Field: Design Outlet Air Temperature

The outlet air condition desired for design flow (deg C). This is an auto sizable design input.

Field: Design Inlet Air Humidity Ratio

The highest value of humidity ratio possible for the Design inlet air stream. This is an auto sizable input.

Field: Design Outlet Air Humidity Ratio

The value of humidity ratio for the Design outlet air stream, it is an auto sizable input.

Field: Water Inlet Node Name

The name of the water coil inlet from the chilled water loop, i.e. Cooling Coil Water Inlet Node. It is from this node the operating inputs for water are transferred to the coil.

Field: Water Outlet Node Name

The name of the water coil outlet from the chilled water loop, i.e. Cooling Coil Water Outlet Node. It is from this node the operating output for water are reported to the coil.

Field: Air Inlet Node Name

The name of the air inlet to the water coil, i.e. Cooling Coil Air Inlet Node. It is from this node the operating inputs for air are transferred to the coil.

Field: Air Outlet Node Name

The name of the air outlet from the water coil, i.e. Cooling Coil Air Outlet Node. It is from this node the operating output for airside is reported to the coil.

Field: Type of Analysis

The coil has two modes of operation, termed as **SimpleAnalysis** and **DetailedAnalysis**. The difference between the two modes being, the simple mode reports the value of surface area fraction wet of the coil as dry or wet. The detailed mode give the exact value, however the execution time in detailed mode is noticeably higher.

Field: Heat Exchanger Configuration

The coil is operable in two modes, Cross Flow for general A/C applications and Counter flow mode. Air-conditioning systems generally use cross flow heat exchangers, hence the default is set to cross flow.

Field: Condensate Collection Water Storage Tank Name

This field is optional. It is used to describe where condensate from the coil is collected. If blank or omitted, then any coil condensate is discarded. Enter the name of Water Storage Tank object defined elsewhere and the condensate will then be collected in that tank.

Below is the input data dictionary description for the Cooling coil:

```

Coil:Cooling:Water,
A1 , \field Name
    \required-field
    \reference CoolingCoilName
    \reference CoolingCoilsWater
    \reference CoolingCoilsWaterNoHX
A2 , \field Availability Schedule Name
    \type object-list
    \object-list ScheduleNames
N1 , \field Design Water Flow Rate
    \units m3/s
    \autosizable
    \ip-units gal/min
N2 , \field Design Air Flow Rate
    \units m3/s
    \autosizable
    \ip-units gal/min
N3 , \field Design Inlet Water Temperature
    \units C
    \autosizable
N4 , \field Design Inlet Air Temperature
    \units C
    \autosizable
N5 , \field Design Outlet Air Temperature
    \units C
    \autosizable
N6 , \field Design Inlet Air Humidity Ratio
    \units kg-H2O/kg-air
    \autosizable
N7 , \field Design Outlet Air Humidity Ratio
    \units kg-H2O/kg-air
    \autosizable
A3 , \field Water Inlet Node Name
    \required-field
A4 , \field Water Outlet Node Name
    \required-field
A5 , \field Air Inlet Node Name
    \required-field
A6 , \field Air Outlet Node Name
    \required-field
A7 , \field Type of Analysis
    \type choice
    \key SimpleAnalysis
    \key DetailedAnalysis
    \default SimpleAnalysis
A8 , \field Heat Exchanger Configuration
    \type choice
    \key CrossFlow
    \key CounterFlow
    \default CrossFlow
A9; \field Condensate Collection Water Storage Tank Name
    \type object-list
    \object-list WaterStorageTankNames

```

Examples of the idd statements when auto sized in an IDF are as below:

```

Coil:Cooling:Water,
Main Cooling Coil 1,      !- Coil Name
CoolingCoilAvailSched,  !- Available Schedule
autosize,                !- Design Water Volume Flow Rate of Coil {m3/s}
autosize,                !- Design Air Flow Rate of Coil {m3/s}
autosize,                !- Design Inlet Water Temperature {C}
autosize,                !- Design Inlet Air Temperature {C}
autosize,                !- Design Outlet Air Temperature {C}
autosize,                !- Design Inlet Air Humidity Ratio
autosize,                !- Design Outlet Air Humidity Ratio
Main Cooling Coil 1 Water Inlet Node,  !- Coil_Water_Inlet_Node
Main Cooling Coil 1 Water Outlet Node,  !- Coil_Water_Outlet_Node
Mixed Air Node 1,        !- Coil_Air_Inlet_Node
Main Cooling Coil 1 Outlet Node;        !- Coil_Air_Outlet_Node

```

Examples of the same idd statements when value are input in an IDF are as below:

```

Coil:Cooling:Water,
  Main Cooling Coil 1,      !- Coil Name
  CoolingCoilAvailSched,   !- Available Schedule
  0.0022,                  !- Design Water Volume Flow Rate of Coil {m3/s}
  1.45,                    !- Design Air Flow Rate of Coil {m3/s}
  6.1,                     !- Design Inlet Water Temperature {C}
  25,                      !- Design Inlet Air Temperature {C}
  10,                      !- Design Outlet Air Temperature {C}
  0.012,                   !- Design Inlet Air Humidity Ratio
  0.008,                   !- Design Outlet Air Humidity Ratio
  Main Cooling Coil 1 Water Inlet Node, !- Coil_Water_Inlet_Node
  Main Cooling Coil 1 Water Outlet Node, !- Coil_Water_Outlet_Node
  Mixed Air Node 1,        !- Coil_Air_Inlet_Node
  Main Cooling Coil 1 Outlet Node;      !- Coil_Air_Outlet_Node

```

Coil:Cooling:Water Outputs

Following are the list of possible output report variables from this coil model:

```

HVAC,Sum,Total Water Cooling Coil Energy[J]
HVAC,Sum,Sensible Water Cooling Coil Energy[J]
HVAC,Average,Total Water Cooling Coil Rate[W]
HVAC,Average,Sensible Water Cooling Coil Rate[W]
HVAC,Average,Cooling Coil Area Wet Fraction
HVAC,Average,Cooling Coil Condensate Volumetric Flow Rate [m3/s]
Zone,Meter,OnSiteWater:Facility [m3]
Zone,Meter,OnSiteWater:HVAC [m3]
Zone,Meter,Condensate:OnSiteWater [m3]
HVAC,Sum,Cooling Coil Condensate Volume [m3]

```

Total Water Cooling Coil Energy (J)

Total Water Cooling Coil Energy is the total amount of heat transfer taking place in the coil at the operating conditions.

Sensible Water Cooling Coil Energy (J)

Sensible Water Cooling Coil Energy is the total amount of Sensible heat transfer taking place in the coil at the operating conditions. It only takes into account temperature difference in the inlet and outlet air streams at operating conditions.

Total Water Cooling Coil Rate (W)

Total Water Cooling Coil Rate is the Rate of heat transfer taking place in the coil at the operating conditions. The units are (J/sec) or Watts.

Sensible Water Cooling Coil Rate (W)

Sensible Water Cooling Coil Rate is the Rate of Sensible heat transfer taking place in the coil at the operating conditions.

Cooling Coil Area Wet Fraction

It defines the fraction of total surface area of coil which is wet due to moisture condensation on the surface of the coil. Value varies between 0.0 and 1.0.

In addition, if a Water Storage Tank is used to collect coil condensate, then the following outputs will be available.

Cooling Coil Condensate Volumetric Flow Rate [m3/s]

Cooling Coil Condensate Volume [m3]

These reports provide the rate and amount of condensate from the coil. Condensate is water condensed out of the air as a result of cooling. The condensate volume is also reported on the meter for "OnSiteWater."

Coil:Heating:Water

This simple heating coil model only does sensible heating of the air. The simple heating coil uses the Effectiveness-NTU algorithm and assumes a cross-flow heat exchanger.

Field: Name

A unique identifying name for each coil.

Field: Available Schedule Name

Schedule that defines when the coil is available.

Field: U-Factor Times Area Value

The UA value for the coil needed for the Effectiveness-NTU heat exchanger model. An estimate of the UA can be obtained from:

$$q = UA \times (T_{\text{water, avg}} - T_{\text{air, avg}})$$

where q is the heat transferred from water to the air in watts; $T_{\text{water, avg}}$ is the average water temperature in degrees C; and $T_{\text{air, avg}}$ is the average air temperature in degrees C. Or the LMTD temperature difference can be used. This field is used when *Performance Input Method = UFactorTimesAreaAndDesignWaterFlowRate*. This field is autosizable.

Field: Maximum Water Flow Rate

The maximum possible water flow rate (m^3/sec) through the coil. This field is used when *Coil Performance Input Method = UFactorTimesAreaAndDesignWaterFlowRate*. This field is autosizable.

Field: Water Inlet Node Name

The name of the coil's water inlet node from the hot water loop.

Field: Water Outlet Node Name

The name of the coil's water outlet node from the hot water loop.

Field: Air Inlet Node Name

The name of the air inlet node to the water coil.

Field: Air Outlet Node Name

The name of the air outlet node from the water coil.

Field: Performance Input Method

The user can choose either *UFactorTimesAreaAndDesignWaterFlowRate* or *NominalCapacity*. If *UFactorTimesAreaAndDesignWaterFlowRate* is selected, the user must input values for UA of the Coil and Max Water FlowRate of the Coil (and Rated Capacity is ignored). If *NominalCapacity* is chosen, the user must input a Rated Capacity for the coil; UA of the Coil and Max Water FlowRate of the Coil will be ignored. Rated capacity is defined as the heating capacity in watts of the coil at the rating points (i.e., the rated inlet and outlet water/air temperatures defined in the input fields below). The rated capacity is used to calculate a water mass flow rate and a UA for the coil. The default is *NominalCapacity*.

To autosize the capacity, choose *UfactorTimesAreaAndDesignWaterFlowRate* and put autosize as the inputs for *U-Factor Times Area Value*, *Maximum Water Flow Rate*, and *Rated Capacity*. The program will use the Sizing inputs to size the coil. The rated temperatures (see below) are ignored in autosizing. These are used only when the user is specifying coil performance using the *NominalCapacity* input method.

Field: Rated Capacity

The heating capacity of the coil in watts at the rated inlet and outlet air and water temperatures. This field is used when the *Performance Input Method = Nominal Capacity*. This field is autosizable. The rating points are given in the four subsequent input fields.

Field: Rated Inlet Water Temperature

The inlet water temperature (degrees C) corresponding to the rated heating capacity. The default is 82.2 degrees C (180 degrees F).

Field: Rated Inlet Air Temperature

The inlet air temperature (degrees C) corresponding to the rated heating capacity. The default is 16.6 degrees C (60 degrees F).

Field: Rated Outlet Water Temperature

The outlet water temperature (degrees C) corresponding to the rated heating capacity. The default is 71.1 degrees C (160 degrees F).

Field: Rated Outlet Air Temperature

The outlet air temperature (degrees C) corresponding to the nominal heating capacity. The default is 32.2 degrees C (90 degrees F).

The IDD description of the object is:

```
Coil:Heating:Water,
  \min-fields 14
A1 , \field Name
  \required-field
  \type alpha
  \reference HeatingCoilName
  \reference HeatingCoilsWater
A2 , \field Availability Schedule Name
  \type object-list
  \object-list ScheduleNames
N1 , \field U-Factor Times Area Value
  \units W/K
  \autosizable
  \default Autosize
N2 , \field Maximum Water Flow Rate
  \units m3/s
  \autosizable
  \ip-units gal/min
  \default Autosize
```

```

A3 , \field Water Inlet Node Name
    \required-field
A4 , \field Water Outlet Node Name
    \required-field
A5 , \field Air Inlet Node Name
    \required-field
A6 , \field Air Outlet Node Name
    \required-field
A7 , \field Performance Input Method
    \type Choice
    \key UFactorTimesAreaAndDesignWaterFlowRate
    \key NominalCapacity
    \default UfactorTimesAreaAndDesignWaterFlowRate
N3 , \field Rated Capacity
    \type real
    \units W
    \autosizable
    \minimum 0
    \default Autosize
N4 , \field Rated Inlet Water Temperature
    \units C
    \type real
    \default 82.2
N5, \field Rated Inlet Air Temperature
    \units C
    \type real
    \default 16.6
N6, \field Rated Outlet Water Temperature
    \units C
    \type real
    \default 71.1
N7; \field Rated Outlet Air Temperature
    \units C
    \type real
    \default 32.2
    
```

An example input of the Coil:Water:SimpleHeating input is:

```

Coil:Heating:Water,
SPACE3-1 Zone Coil,      !- Coil Name
ReheatCoilAvailSched,   !- Available Schedule
,                        !- UA of the Coil {W/K}
,                        !- Max Water Flow Rate of Coil {m3/s}
SPACE3-1 Zone Coil Water In Node, !- Coil_Water_Inlet_Node
SPACE3-1 Zone Coil Water Out Node, !- Coil_Water_Outlet_Node
SPACE3-1 Zone Coil Air In Node, !- Coil_Air_Inlet_Node
SPACE3-1 In Node,       !- Coil_Air_Outlet_Node
NominalCapacity,        !- Coil Performance Input Method
10000.;                 !- Rated Capacity
    
```

Coil:Heating:Water Outputs

```

HVAC,Sum, Total Water Heating Coil Energy[J]
HVAC,Average,Total Water Heating Coil Rate[W]
    
```

Total Water Heating Coil Energy (J)

Total Water Heating Coil Energy is the total amount of heat transfer taking place in the coil at the operating conditions.

Total Water Heating Coil Rate (W)

Total Water Heating Coil Rate is the Rate of heat transfer taking place in the coil at the operating conditions. The units are (J/sec) or Watts.

Coil:Heating:Steam

The simple steam to air heating coil model only does sensible heating of the air. The steam to air coils condenses the steam and sub cools steam at loop pressure and discharges the condensate through steam traps at low pressure condensate line.

```
Coil:Heating:Steam,
A1 , \field Name
    \required-field
    \type alpha
    \reference HeatingCoilName
A2 , \field Availability Schedule Name
    \type object-list
    \object-list ScheduleNames
N1 , \field Maximum Steam Flow Rate
    \units m3/s
    \minimum> 0.0
    \autosizable
N2 , \field Degree of SubCooling
    \units C
    \minimum 1.0
    \maximum 5.0
N3 , \field Degree of Loop SubCooling
    \units C
    \minimum 10.0
    \default 20.0
A3 , \field Water Inlet Node Name
    \required-field
A4 , \field Water Outlet Node Name
    \required-field
A5 , \field Air Inlet Node Name
    \required-field
A6 , \field Air Outlet Node Name
    \required-field
A7 , \field Coil Control Type
    \type choice
    \key TemperatureSetpointControl
    \key ZoneLoadControl
A8 ; \field Temperature Setpoint Node Name
    \note only if coil is TemperatureSetpointControl
```

Field: Name

A unique identifying name for each steam coil.

Field: Available Schedule Name

Schedule that defines when the coil is available.

Field: Maximum Steam Flow Rate

The maximum possible steam flow rate (m³/sec) through the coil. This field is autosizable.

Field: Degree of SubCooling

Ideally the steam trap located at the outlet of steam coil should remove all the condensate immediately, however there is a delay in this process in actual systems which causes the condensate to SubCool by certain degree in the coil before leaving the coil, this SubCool occurs in the steam coil and this SubCool-heat is added to the zone. The minimum value is 2 °Celsius and default is 5 °Celsius.

Field: Degree of Loop SubCooling

This essentially represents the heat loss to the atmosphere due to uninsulated condensate return piping to the boiler. Condensate return piping operates at atmospheric pressure and is not insulated. The condensate sub cools to certain degree before it is pumped back to the boiler. The minimum value is 10 °Celsius and default is 20 °Celsius.

Field: Water Inlet Node Name

The name of the steam coil inlet from the steam loop, i.e. Steam Coil steam inlet node.

Field: Water Outlet Node Name

The name of the steam coil outlet to the condensate loop, i.e. Steam Coil condensate outlet node.

Field: Air Inlet Node Name

The name of the air inlet to the steam coil, i.e. Steam Coil Air Inlet Node.

Field: Air Outlet Node Name

The name of the air outlet from the steam coil, i.e. Steam Coil Air Outlet Node.

Field: Coil Control Type

Choice of either **ZoneLoadControl** steam coil or **TemperatureSetpointControl** steam coil. A zone coil is load controlled and an air loop steam coil is temperature controlled.

An example of a Steam Coil input statement (Temperature Controlled) from an IDF is given below:

```
Coil:Heating:Steam,
  VAV SYS 1 Heating Coil,      !- Coil Name
  ReheatCoilAvailSched,      !- Available Schedule
  0.06,                      !- Max Steam volume Flow rate
  5.0,                       !- Deg of Subcooling Desired
  15.0,                      !- Loop Subcooling Desired
  VAV SYS 1 Heating Coil Steam Inlet, !- Coil Steam Inlet Node
  VAV SYS 1 Heating Coil Steam Outlet, !- Coil Water Outlet Node
  VAV SYS 1 Cooling Coil Outlet, !- Coil Air Inlet Node
  VAV SYS 1 Heating Coil Outlet, !- Coil Air Outlet Node
  TemperatureSetPointControl, !- field Coil Control Type
  VAV SYS 1 Heating Coil Outlet; !- field Coil Temp Setpoint Node

Coil:Heating:Steam,
  SPACE1-1 Reheat Coil,      !- Coil Name
  ReheatCoilAvailSched,      !- Available Schedule
  autosize,                  !- Max Steam volume Flow rate
  5.0,                       !- Deg of Subcooling Desired
  15.0,                      !- Loop Subcooling Desired
  SPACE1-1 Reheat Coil Steam Inlet, !- Coil Steam Inlet Node
  SPACE1-1 Reheat Coil Steam Outlet, !- Coil Water Outlet Node
  SPACE1-1 Damper Outlet, !- Coil Air Inlet Node
  SPACE1-1 Supply Inlet, !- Coil Air Outlet Node
  ZoneLoadControl;          !- field Coil Control Type
```

Coil:Heating:Steam Outputs:

```
HVAC,Sum, Total Steam Coil Heating Energy[J]
HVAC,Average,Total Steam Coil Heating Rate[W]
HVAC,Average,Loop Losses[W]
HVAC, Average, Steam Coil Inlet Temp[C]
HVAC, Average, Steam Coil Outlet Temp [C]
HVAC, Average, Steam Coil Mass Flow Rate [kg/s]
```

Total Steam Heating Coil Energy (J)

Total Steam Heating Coil Energy is the total amount of heat transfer taking place in the coil at the operating conditions.

Total Steam Heating Coil Rate (W)

Total Steam Heating Coil Rate is the Rate of heat transfer taking place in the coil at the operating conditions. The units are (J/sec) or Watts.

HVAC,Average,Loop Losses[W]

Loop losses represent the unavoidable loss due to degree of sub cooling in the condensate return piping back to the boiler and the loss occurring due to flashing of steam across the steam trap due to pressure differential between the steam and the condensate side.

Steam Coil Inlet Temp [C]**Steam Coil Outlet Temp [C]****Steam Coil Mass Flow Rate [kg/s]**

These outputs are the Steam inlet and condensate outlet temperatures and steam flow rate for the boiler.

Coil:Heating:Electric

The electric heating coil is a simple capacity model with a user-inputted efficiency. In many cases, this efficiency for the electric coil will be 100%. This coil will be simpler than shown in Figure 109 since it will only have air nodes to connect it in the system. The coil can be used in the air loop simulation or in the zone equipment as a reheat coil. Depending on where it is used determines if this coil is temperature or capacity controlled. If used in the air loop simulation it will be controlled to a specified temperature scheduled from the SetPoint Manager. If it is used in zone equipment, it will be controlled from the zone thermostat by meeting the zone demand.

Field: Name

A unique identifying name for each coil.

Field: Available Schedule Name

Schedule that defines when the coil is available.

Field: Efficiency

This is user-inputted efficiency (decimal units, not percent) and can account for any loss. In most cases for the electric coil, this will be 100%.

Field: Nominal Capacity

This is the maximum capacity of the coil (W). This controlled coil will only provide the needed capacity to meet the control criteria whether it is temperature or capacity controlled. This field is autosizable.

Field: Air Inlet Node Name

The name of the air inlet to the electric coil, i.e. Heating Coil Air Inlet Node.

Field: Air Outlet Node Name

The name of the air outlet from the electric coil, i.e. Heating Coil Air Outlet Node.

```

Coil:Heating:Electric,
A1 , \field Name
      \type alpha
      \reference HeatingCoilName
      \reference HeatingCoilsGasElec
      \reference HeatingCoilsGasElecDesup
A2 , \field Availability Schedule Name
      \type object-list
      \object-list ScheduleNames
N1 , \field Efficiency
      \maximum 1.0
      \minimum 0.0
      \default 1.0
N2 , \field Nominal Capacity
      \units W
      \autosizable
A3 , \field Air Inlet Node Name
      \required-field
A4 , \field Air Outlet Node Name
      \required-field
A5 ; \field Temperature Setpoint Node Name
      \note needed if coil is temperature controlled and not load-base controlled

```

Coil:Heating:Electric Outputs

```

HVAC,Sum,Heating Coil Energy[J]
HVAC,Average,Heating Coil Rate[W]
HVAC,Sum,Heating Coil Electric Consumption [J]
HVAC,Average,Heating Coil Electric Power [W]

```

Heating Coil Energy (J)

Heating Coil Energy is the total amount of heat transfer taking place in the coil at the operating conditions.

Heating Coil Rate[W]

Heating Coil Rate is the Rate of heat transfer taking place in the coil at the operating conditions. The units are (J/sec) or Watts.

Heating Coil Electric Consumption [J]

Heating Coil electric consumption after the efficiency of the coil has been taken into account in Joules for the timestep reported.

Heating Coil Electric Power [W]

This field is the average Heating Coil electric power after the efficiency of the coil has been taken into account in Watts for the timestep reported.

Coil:Heating:Desuperheater

A simplified approach is used to determine the performance of this air heating coil. The model assumes that the heating energy provided by this coil is reclaimed from the superheated refrigerant gas leaving a compressor (i.e., a desuperheating refrigerant-to-air heating coil) and does not impact the performance of the compressor. This coil can be used in air loop simulations but can't be used by certain compound objects (e.g., UnitarySystem: AirToAir:HeatPump, UnitarySystem:WaterToAir:HeatPump, or Desiccant Dehumidifier:Solid) or any air distribution equipment (e.g., Single Duct:Const Volume:Reheat, Single Duct:VAV:Reheat, or Single Duct:Series PIU:Reheat).

The desuperheater heating coil input requires a coil name, an availability schedule, and a heat reclaim recovery efficiency. The reclaim recovery efficiency determines the amount of heat available for use by this heating coil. Approximately 25-30% of the energy rejected by typical refrigeration system condensers is to reduce the superheated refrigerant vapor temperature to the condensing temperature. Recovery efficiencies higher than 30% may

cause the refrigerant gas to condense which in turn impacts the performance of the refrigeration system. For this reason, the maximum heat reclaim recovery efficiency for this coil is 30% for most sources of waste heat, including refrigeration compressor racks. The one exception to this 30% limit is a condenser that is part of a detailed refrigeration system. In a detailed refrigeration system, the portion of the rejected heat that lies within the superheated region is explicitly calculated. Therefore, the desuperheater coils supplied by a condenser attached to a detailed refrigeration system are subject to a maximum reclaim recovery efficiency of 0.9.

The next two input items for the desuperheater heating coil are the node names for the inlet and outlet air streams. The following two input fields define the source of heating energy for the coil. This desuperheater heating coil may only be used with direct expansion (DX) cooling or refrigeration equipment. The first of these two inputs is the heating source object type while the second defines the name of the heating source. For proper modeling, the desuperheater heating coil must be placed downstream of a DX cooling coil when reclaiming heat from that cooling coil. Desuperheating heating coil placement is unrestricted when reclaiming heat from a Refrigeration:CompressorRack or Refrigeration:Condenser.

The next input field is optional and defines the set point node name if the desuperheater heating coil is to be controlled based on temperature. When a load-based control scheme is used, this field is left blank. A final optional input is used to model parasitic electric energy use of auxiliary equipment associated with the desuperheater heating coil (e.g., solenoid valve).

Field: Name

This alpha field defines a unique user-assigned name for an instance of a desuperheater heating coil. Any reference to this desuperheater heating coil by another object will use this name.

Field: Availability Schedule Name

This alpha field defines the name of the schedule (ref: Schedule) that denotes whether the desuperheater heating coil can run during a given time period. Schedule values must range from 0 to 1. A schedule value greater than 0 indicates that the coil can operate during the time period. A value equal to 0 denotes that the coil must be off for that time period.

Field: Heat Reclaim Recovery Efficiency

This numeric field defines the ratio of recovered waste heat from the superheated refrigerant gas to the total rejected waste heat from the heating source (as if no heat reclaim occurred). Values can range from 0.0 up to a maximum of 0.9 if the source is a refrigeration condenser and 0.3 for all other waste heat sources. If this input field is left blank, the default value is 0.8 for a refrigeration condenser source type and 0.25 for all other sources.

Field: Air Inlet Node Name

This alpha field defines the name of the HVAC system node from which the desuperheater heating coil draws its inlet air.

Field: Air Outlet Node Name

This alpha field defines the name of the HVAC system node to which the desuperheater heating coil sends its outlet air.

Field: Heating Source Object Type

This alpha field defines the source of superheated refrigerant gas from which the desuperheater heating coil recovers energy. Valid choices are:

Coil:Cooling:DX:SingleSpeed Coil:Cooling:DX:TwoSpeed Coil:Cooling:DX:TwoStageWithHumidityControlMode Refrigeration:CompressorRack
--

Refrigeration:Condenser

When the heating coil source is a DX Coil, the air loop's supply air fan control mode may be auto fan (cycling fan cycling coil), constant fan, or variable volume. When the heating source is a compressor rack for refrigerated cases or a refrigeration condenser, the supply air fan control mode should be either variable volume or constant fan.

NOTE: Use of the desuperheater heating coil in variable air volume systems should be done with caution since the model assumption of a fixed heat reclaim recovery efficiency may not be valid if the air flow rate over the coil varies significantly.

Field: Heating Source Name

This alpha field defines the name of the desuperheater heating coil source (e.g., the name of a specific valid coil (as mentioned in the previous field) which provides waste heat to this desuperheater heating coil).

NOTE: When the heating source is a Refrigeration Compressor rack, the heat rejection location in the Refrigeration:CompressorRack object must be "Outdoors". If the compressor rack heat rejection location is "Zone", the total amount of heat rejection available for reclaim (e.g., by this desuperheater heating coil) is set to zero by the compressor rack object and the simulation proceeds.

Field: Temperature Setpoint Node Name

This optional alpha field defines the name of the HVAC system node used for temperature-based control (e.g., controlling the heating coil's outlet air dry-bulb temperature to a setpoint). If the desuperheater heating coil is temperature controlled through the use of a Set Point Manager, then the control node specified in the Set Point Manager will be entered here. If the desuperheater heating coil is controlled based on a certain heating load to be met (e.g., using this heating coil as part of UnitarySystem:BlowThru:HeatCool for high humidity control), this field should be left blank.

Field: Parasitic Electric Load

This optional numeric field defines the parasitic electric load (in Watts) due to control valves or other devices specific to the desuperheater heating coil. The load is applied whenever the coil is heating the air. The model assumes that this electric load is small and does not contribute to heating the air.

Below is the IDD Definition for the desuperheater heating coil.

```

Coil:Heating:Desuperheater,
  \min-fields 7
A1 , \field Name
  \required-field
  \type alpha
  \reference HeatingCoilsGasElecDesup
  \reference HeatingCoilsDesuperheater
A2 , \field Availability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
N1 , \field Heat Reclaim Recovery Efficiency
  \type real
  \maximum 0.3
  \minimum 0.0
  \default 0.25
A3 , \field Air Inlet Node Name
  \required-field
  \type alpha
A4 , \field Air Outlet Node Name
  \required-field
  \type alpha
A5 , \field Heating Source Object Type
  \required-field
  \type choice
  \key Coil:Cooling:DX:SingleSpeed
  \key Coil:Cooling:DX:TwoSpeed
  \key Coil:Cooling:DX:TwoStageWithHumidityControlMode
  \key Refrigeration:CompressorRack
  \key Refrigeration:Condenser
A6 , \field Heating Source Name
  \required-field
  \type object-list
  \object-list DesuperHeatingCoilSources
A7 , \field Temperature Setpoint Node Name
  \type alpha
  \note optionally used if coil is controlled based on a setpoint temperature
  \note Temperature-based control requires the use of a Setpoint object
N2 ; \field Parasitic Electric Load
  \type real
  \units W
  \minimum 0
  \note parasitic electric load associated with the desuperheater coil operation
  \note such as solenoid valves, etc.
  \ip-units W
    
```

Following is an example input for a desuperheater heating coil.

```

Coil:Heating:Desuperheater,
DesuperheaterCoil,           !- Coil Name
FanAndCoilAvailsched,      !- Availability Schedule
0.3,                        !- Heat Reclaim Recovery Efficiency
Cooling Coil Air Outlet Node, !- Coil Air Inlet Node Name
Air Loop Outlet Node,      !- Coil Air Outlet Node Name
Coil:DX:Cooling:SingleSpeed, !- Heating Source Type
Furnace ACDXCoil 1,        !- Heating Source Name
,                            !- Coil Temperature Setpoint Node Name
0.1;                        !- Parasitic Electric Load {W}
    
```

Coil:Heating:Desuperheater Outputs

```

HVAC,Average,Heating Coil Rate [W]
HVAC,Sum,Heating Coil Energy [J]
HVAC,Average,Heating Coil Electric Power [W]
HVAC,Sum,Heating Coil Electric Consumption [J]
HVAC,Average,Heating Coil Runtime Fraction
    
```

Heating Coil Rate [W]

This output is the average heating rate of the desuperheater heating coil in Watts over the timestep being reported. This is determined by the coil inlet and outlet air conditions and the air mass flow rate through the coil.

Heating Coil Energy [J]

This output is the total heating output of the desuperheater heating coil in Joules over the timestep being reported. This is determined by the coil inlet and outlet air conditions and the air mass flow rate through the coil. This output is also added to a report meter with Resource Type = EnergyTransfer, End Use Key = HeatingCoils, Group Key = System (ref. Report Meter).

Heating Coil Electric Power [W]

This output is the average electric consumption rate for the parasitic load associated with the desuperheater heating coil in Watts.

Heating Coil Electric Consumption [J]

This output is the electric consumption of the desuperheater heating coil parasitic load in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Heating, Group Key = System (ref. Report Meter).

Heating Coil Runtime Fraction

This is the runtime fraction of the desuperheater heating coil for the timestep being reported. Since the desuperheater heating coil can only provide heat when the heat source object is active, the runtime fraction of the desuperheater heating coil will always be less than or equal to the runtime fraction of the heat source object.

Coil:WaterHeating:Desuperheater

A simplified approach is used to determine the performance of this water heating coil. The model assumes that the heating energy provided by this coil is reclaimed from the superheated refrigerant gas leaving a compressor (i.e., a desuperheating refrigerant-to-water heating coil) and does not impact the performance of the compressor. This coil must be used with a water heater tank (e.g., Water Heater:Mixed) which can supply heated potable water and/or hot water for use in a plant loop (e.g., hydronic air reheat coils).

Except for detailed refrigeration system models, the amount of available superheat is simply a percentage of the total heat being rejected by the DX system's condenser. Approximately 25-30% of the energy rejected by typical refrigeration system condensers is to reduce the superheated refrigerant vapor temperature to the condensing temperature. Recovery efficiencies higher than 30% may cause the refrigerant gas to condense which in turn impacts the performance of the refrigeration system. For this reason, the maximum heat reclaim recovery efficiency for this coil is 30% for most sources of waste heat, including refrigeration compressor racks. The one exception to this 30% limit is a condenser that is part of a detailed refrigeration system. In a detailed refrigeration system, the portion of the rejected heat that lies within the superheated region is explicitly calculated. Therefore, the desuperheater coils supplied by a condenser attached to a detailed refrigeration system are subject to a maximum reclaim recovery efficiency of 90%.

The model includes the ability to modify the heat reclaim recovery efficiency based on variations in inlet water temperature and outdoor air dry-bulb temperature.

This coil model performs the following major functions:

- calculates the amount of heat delivered to the water tank
- calculates the electricity consumption of the integral water pump and on/off-cycle parasitic loads

The input fields for this object are described below in detail:

Field: Name

This alpha field contains a unique user-assigned name for an instance of a desuperheater water heating coil. Any reference to this desuperheater coil by another object will use this name.

Field: Availability Schedule Name

This alpha field contains the name of the schedule (ref: Schedule) that denotes whether the desuperheater coil is available to operate during a given time period. A schedule value equal to 0 denotes that the desuperheater coil is off for that time period. A value other than 0 denotes that the desuperheater coil is available to operate during that time period. During times when the desuperheater coil is scheduled off, the heater (element or burner) in the water tank object operates based on its tank set point temperature schedule and the desuperheater coil's parasitic electric power is also off for that time period.

Field: Setpoint Temperature Schedule Name

This alpha field contains the name of the schedule (ref: Schedule) that specifies the set point (or "cut-out") temperature for the desuperheater coil. Temperature values used in this schedule should be in degrees Celsius. The desuperheater coil turns off when the tank water reaches this set point temperature. Once the desuperheater coil is off, the tank water temperature floats downward until it falls below the set point temperature minus the dead band temperature difference defined below (i.e., the "cut-in" temperature). At this point, the desuperheater coil turns on and remains on until the desuperheater coil set point temperature is reached.

Field: Dead Band Temperature Difference

This numeric field contains the dead band temperature difference in degrees Celsius. The desuperheater coil "cut-in" temperature is defined as the desuperheater coil set point temperature defined above minus this dead band temperature difference. The desuperheater coil turns on when the water temperature in the tank falls below the "cut-in" temperature. The desuperheater coil remains on until the water temperature in the tank rises above the desuperheater coil set point ("cut-out") temperature defined above. The dead band temperature difference must be greater than 0°C and less than or equal to 20°C. If this field is left blank, the default value is 5°C.

Desuperheater water heating coils are typically used to offset energy consumption by the water tank's heater (element or burner). Therefore, the cut-in temperature for the desuperheater coil (set point minus dead band temperature difference) is usually higher than the set point temperature for the heater (element or burner) in the associated water heater tank object. At times when the water heater tank set point temperature is greater than the cut-in temperature of the desuperheater coil, the model disables the desuperheater coil and the tank's heater is used to heat the water.

Field: Rated Heat Reclaim Recovery Efficiency

This numeric field defines the ratio of recovered waste heat from the superheated refrigerant gas to the total rejected waste heat from the heating source (as if no heat reclaim occurred). Input values must be greater than 0 up to a maximum value is 0.3 (with a defaults of 0.25) for most sources of waste heat, including refrigeration compressor racks. The one exception to this 0.3 limit is a source that is a condenser that is part of a detailed refrigeration system. In a detailed refrigeration system, the portion of the rejected heat that lies within the superheated region is explicitly calculated. Therefore, the desuperheater coils supplied by a condenser attached to a detailed refrigeration system are subject to a maximum reclaim recovery efficiency of 0.9. with a default value is 0.8.

Field: Rated Inlet Water Temperature

This numeric field defines the coil inlet water temperature, in degrees Celsius, that corresponds to the rated heat reclaim recovery efficiency. Also see field “Heat Reclaim Efficiency Modifier Curve Name (function of temperature)” below.

Field: Rated Outdoor Air Temperature

This numeric field defines the outdoor air dry-bulb temperature, in degrees Celsius, that corresponds to the rated heat reclaim recovery efficiency. The outdoor air dry-bulb temperature impacts the desuperheater coil refrigerant temperature and the amount of heat available for reclaim. Also see field “Heat Reclaim Efficiency Modifier Curve Name(function of temperature)” below.

Field: Maximum Inlet Water Temperature for Heat Reclaim

This numeric field defines the maximum coil inlet water temperature in degrees Celsius. Any time the inlet water temperature to the desuperheater coil is above this maximum allowed temperature, heat reclaim is restricted so that the tank water does not exceed this temperature.

Field: Heat Reclaim Efficiency Function of Temperature Curve Name

This alpha field specifies the name of a bi-quadratic curve object (ref: Performance Curves) that defines the variation in heat reclaim efficiency as a function of inlet fluid (air and water) temperatures. The bi-quadratic curve uses the coil inlet water temperature and outdoor air dry-bulb temperature (entering the DX coil condenser) as the independent variables. The output of this curve is multiplied by the rated heat reclaim recovery efficiency to give the heat reclaim efficiency at specific operating conditions (i.e., at temperatures different from the rating point temperatures). The curve should be normalized to have the value of 1.0 at the rating point temperatures. If this field is left blank, the heat reclaim efficiency remains constant (curve value assumed to be 1.0 for all conditions). The model restricts the product of the output of this curve and the rated heat reclaim recovery efficiency to a maximum of 0.9 for refrigeration condenser sources and 0.3 for all other sources..

Field: Water Inlet Node Name

This alpha field defines the name of the water node from which the desuperheater heating coil draws its inlet water. This node name must also match the source side outlet node name for the water heater tank used with this coil (ref. Water Heaters).

Field: Water Outlet Node Name

This alpha field defines the name of the water node to which the desuperheater heating coil sends its outlet water. This node name must also match the source side inlet node name for the water heater tank used with this coil (ref. Water Heaters).

Field: Tank Object Type

This alpha (choice) field contains the type of water heater tank used by this desuperheater heating coil. Currently, the only valid choice is Water Heater:Mixed.

Field: Tank Name

This alpha field contains the name of the specific water heater tank (Water Heater:Mixed object) used by this desuperheater heating coil.

Field: Heating Source Object Type

This alpha (choice) field defines the source of superheated refrigerant gas from which the desuperheater water heating coil recovers energy through heat reclaim. Valid choices are:

Coil:Cooling:DX:SingleSpeed
Coil:Cooling:DX:TwoSpeed

Coil:Cooling:DX:TwoStageWithHumidityControlMode Refrigeration:CompressorRack Refrigeration:Condenser
--

Field: Heating Source Name

This alpha field defines the name of the desuperheater coil's heat source (e.g., the name of a specific coil of the type mentioned in the previous field which provides waste heat to this desuperheater water heating coil).

Field: Water Flow Rate

This numeric field defines the desuperheater coil's water flow rate in cubic meters per second. The model assumes that this flow rate is constant (throughout the simulation period) when the desuperheater coil operates, and that it corresponds to the heat reclaim recovery efficiency performance specified by the user. This water flow rate must be greater than zero.

Field: Water Pump Power

This numeric field defines the coil's water circulation pump power in Watts. This is the operating pump power as installed. Values must be greater than or equal to 0. If this field is left blank, the default value is 0. A warning message will be issued if the ratio of water pump power to desuperheater water volumetric flow rate exceeds $7.9264E6$ W/m³/s, but the simulation will continue using the user-defined values. The model assumes that this integral pump (i.e., no need to define a separate pump object) cycles on and off with the desuperheater heating coil.

Field: Fraction of Pump Heat to Water

This numeric field defines the fraction of water circulation pump heat that is transferred to the water. The pump is assumed to be downstream of the desuperheater water heating coil, and this field is used to determine the desuperheater water outlet temperature. Values must be greater than or equal to 0 and less than or equal to 1. If this field is left blank, the default value is 0.2.

Field: On-Cycle Parasitic Electric Load

This optional numeric field contains the on-cycle parasitic electric power in Watts. This is the parasitic electric power consumed by controls or other electrical devices associated with the desuperheater water heating coil. This parasitic electric load is consumed whenever the desuperheater coil is operating, and the model assumes that this parasitic power does not contribute to heating the water nor does it affect the zone air heat balance. The minimum value for this field is 0.0, and the default value is also 0.0 if this field is left blank.

Field: Off-Cycle Parasitic Electric Load

This optional numeric field contains the off-cycle parasitic electric power in Watts. This is the parasitic electric power consumed by controls or other electrical devices associated with the desuperheater water heating coil. This parasitic electric load is consumed whenever the desuperheater coil is available but is not operating, and the model assumes that this parasitic power does not contribute to heating the water nor does it affect the zone air heat balance. The minimum value for this field is 0.0, and the default value is also 0.0 if this field is left blank.

Below is the IDD definition for the object:

```

Coil:WaterHeating:Desuperheater,
  \min-fields 18
A1 , \field Name
  \required-field
  \type alpha
  \reference WaterHeatingCoilsDesuperheater
  \note Unique name for this instance of a desuperheater water heating coil.
A2 , \field Availability Schedule Name
  \type alpha
  \note Schedule values of 0 denote the desuperheater heating coil is off and the parasitic electric
  \note energy is also off.
A3 , \field Setpoint Temperature Schedule Name
  \required-field
  \type alpha
  \note Defines the cut-out temperature where the desuperheater water heating coil turns off.
  \note The desuperheater heating coil setpoint temperature should always be greater
  \note than the water tank's heater (element or burner) setpoint temperature. Temperature
  \note schedule values should be in degrees C.
N1 , \field Dead Band Temperature Difference
  \type real
  \units deltaC
  \minimum> 0
  \maximum 20
  \default 5
  \note Setpoint temperature minus the dead band temperature difference defines
  \note the cut-in temperature where the desuperheater water heating coil turns on.
  \note The water tank's heater (element or burner) setpoint temperature
  \note should always be less than the desuperheater heating coil cut-in temperature.
N2 , \field Rated Heat Reclaim Recovery Efficiency
  \type real
  \minimum> 0.0
  \maximum 0.3
  \default 0.25
  \note Enter the fraction of waste heat reclaimed by the desuperheater water heating coil.
N3 , \field Rated Inlet Water Temperature
  \required-field
  \type real
  \units C
  \note The inlet water temperature corresponding to the rated heat reclaim recovery efficiency.
N4 , \field Rated Outdoor Air Temperature
  \required-field
  \type real
  \units C
  \note The outdoor air dry-bulb temperature corresponding to the
  \note rated heat reclaim recovery efficiency.
N5 , \field Maximum Inlet Water Temperature for Heat Reclaim
  \required-field
  \type real
  \units C
  \note The desuperheater water heating coil is off when the inlet water temperature is above
  \note the maximum inlet water temperature for heat reclaim.
A4 , \field Heat Reclaim Efficiency Function of Temperature Curve Name
  \type object-list
  \object-list CubicCurves
  \note A biquadratic curve defining the performance of the desuperheater heating coil.
  \note Performance can be specified as a function of inlet water temperature, outdoor air
  \note dry-bulb temperature, or both.
  \note Curve = a + b*Tw + c*Tw**2 + d*odb + e*odb**2 + f*Tw*odb.
  \note Tw = desuperheater heating coil entering water temperature (C).
  \note Odb = outdoor dry-bulb temperature at DX system condenser (C).
A5 , \field Water Inlet Node Name
  \required-field
  \type alpha
  \note The node from which the desuperheater heating coil draws its inlet water.
  \note This name should match the source side outlet node name in the associated
  \note water heater tank object.

```

```

A6 , \field Water Outlet Node Name
    \required-field
    \type alpha
    \note The node to which the desuperheater heating coil sends its outlet water.
    \note This name should match the source side inlet node name in the associated
    \note water heater tank object.
A7 , \field Tank Object Type
    \required-field
    \type choice
    \key WaterHeater:Mixed
    \default WaterHeater:Mixed
    \note Specify the type of water heater tank used by this desuperheater water heating coil.
A8 , \field Tank Name
    \required-field
    \type alpha
    \note The name of the water heater tank used by this desuperheater water heating coil.
    \note Needs to match the name used in the corresponding water heater object.
A9 , \field Heating Source Object Type
    \required-field
    \type choice
    \key Coil:Cooling:DX:SingleSpeed
    \key Coil:Cooling:DX:TwoSpeed
    \key Coil:Cooling:DX:TwoStageWithHumidityControlMode
    \key Refrigeration:CompressorRack
    \key Refrigeration:Condenser
    \note The type of DX system that is providing waste heat for reclaim.
A10, \field Heating Source Name
    \required-field
    \type object-list
    \object-list DesuperHeatingCoilSources
    \note The name of the DX system used for heat reclaim.
N6 , \field Water Flow Rate
    \required-field
    \type real
    \units m3/s
    \minimum > 0
    \note The operating water flow rate.
N7 , \field Water Pump Power
    \type real
    \units W
    \minimum 0.0
    \default 0.0
    \note The water circulation pump electric power.
N8 , \field Fraction of Pump Heat to Water
    \type real
    \minimum 0
    \maximum 1
    \default 0.2
    \note The fraction of pump heat transferred to the water. The pump is assumed to be downstream of
    \note the desuperheater water heating coil.
N9 , \field On-Cycle Parasitic Electric Load
    \type real
    \units W
    \minimum 0
    \default 0
    \note Parasitic electric power consumed when the desuperheater water heating coil operates.
    \note Parasitic electric load does not contribute to water heating or the zone air heat balance.
    \ip-units W
N10; \field Off-Cycle Parasitic Electric Load
    \type real
    \units W
    \minimum 0
    \default 0
    \note Parasitic electric load consumed when the desuperheater water heating coil is off.
    \note Parasitic electric load does not contribute to water heating or the zone air heat balance.
    \note Off-cycle parasitic power is 0 when the availability schedule is 0.
    \ip-units W

```

Following is an example input for a desuperheater water heating coil.

```
Coil:WaterHeating:Desuperheater,
  WaterHeatingCoil,      !- Coil Name
  DesuperheaterSched,    !- Availability Schedule Name
  DesuperheaterTempSch,  !- Desuperheater Coil Set Point Temperature Schedule Name
  5.0,                   !- Dead Band Temperature Difference {deltaC}
  0.25,                  !- Rated Heat Reclaim Recovery Efficiency
  50.0,                  !- Rated Inlet Water Temperature {C}
  35.0,                  !- Rated Outdoor Air Temperature {C}
  60.0,                  !- Maximum Inlet Water Temperature for Heat Reclaim {C}
  HEffTemp,             !- Heat Reclaim Efficiency Modifier Curve Name (function of temperature)
  WaterHeatingCoilInletNode, !- Desuperheater Water Inlet Node Name
  WaterHeatingCoilOutletNode, !- Desuperheater Water Outlet Node Name
  Water Heater:Mixed,    !- Water Heater Tank Type
  WaterHeatingCoilTank, !- Water Heater Tank Name
  Coil:DX:Cooling:SingleSpeed, !- Heating Source Type
  Furnace ACDXCoil 1,   !- Heating Source Name
  0.0001,                !- Desuperheater Water Volumetric Flow Rate {m3/s}
  100.0,                 !- Water Pump Power {W}
  0.2,                   !- Fraction of Pump Heat to Water
  10.0,                  !- On-Cycle Parasitic Electric Load {W}
  10.0;                  !- Off-Cycle Parasitic Electric Load {W}
```

Coil:WaterHeating:Desuperheater Outputs

```
HVAC,Average,Desuperheater PLR
HVAC,Average,Desuperheater Water Heating Rate [W]
HVAC,Sum,Desuperheater Water Heating Energy [J]
HVAC,Average,Desuperheater Pump Electric Power [W]
HVAC,Sum,Desuperheater Pump Electric Consumption [J]
HVAC,Average,Desuperheater Heat Reclaim Efficiency Modifier Curve Output
HVAC,Average,Desuperheater On-Cycle Parasitic Electric Power [W]
HVAC,Sum,Desuperheater On-Cycle Parasitic Electric Consumption [J]
HVAC,Average,Desuperheater Off-Cycle Parasitic Electric Power [W]
HVAC,Sum,Desuperheater Off-Cycle Parasitic Electric Consumption [J]
```

Desuperheater Part Load Ratio

This output field contains the part load ratio of the desuperheater heating coil for the timestep being reported. This ratio represents the fraction of the timestep that the desuperheater heating coil is operating.

Desuperheater Water Heating Rate [W]

This output field contains the average heating rate output of the desuperheater heating coil in Watts for the timestep being reported. This value includes the portion of circulation pump heat attributed to heating the water.

Desuperheater Water Heating Energy [J]

This output field contains the total heating output of the desuperheater heating coil in Joules for the timestep being reported. This value includes the portion of circulation pump heat attributed to heating the water.

Desuperheater Pump Electric Power [W]

This output field contains the average electricity consumption rate for the water circulation pump in Watts for the timestep being reported.

Desuperheater Pump Electric Consumption [J]

This output field contains the electricity consumption of the water circulation pump in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key= DHW, Group Key= Plant (ref. Report Meter).

Desuperheater Heat Reclaim Efficiency Modifier Curve Output

This output field contains the average output of the Heat Reclaim Efficiency Modifier Curve (function of temperature) for the timestep being reported.

Desuperheater On-Cycle Parasitic Electric Power [W]***Desuperheater On-Cycle Parasitic Electric Consumption [J]******Desuperheater Off-Cycle Parasitic Electric Power [W]******Desuperheater Off-Cycle Parasitic Electric Consumption [J]***

These outputs are the parasitic electric power and consumption associated with the desuperheater water heating coil. Specific outputs represent parasitic electrical usage during the coil on and off cycles. These outputs represent electronic controls or other electric component. The model assumes that the parasitic power does not contribute to heating the water nor does it impact the zone air heat balance. The parasitic electric consumption outputs are also added to a report meter with Resource Type = Electricity, End Use Key = DHW, Group Key = Plant (ref. Report Meter).

Coil:Heating:Gas

The gas heating coil is a simple capacity model with a user inputted gas burner efficiency. The default for the gas burner efficiency is 80%. This coil will be simpler than shown in Figure 109 since it will only have air nodes to connect it in the system. The coil can be used in the air loop simulation or in the zone equipment as a reheat coil. Depending on where it is used determines if this coil is temperature or capacity controlled. If used in the air loop simulation it will be controlled to a specified temperature scheduled from the Setpoint Manager. If it is used in zone equipment, it will be controlled from the zone thermostat by meeting the zone demand.

Field: Name

A unique identifying name for each coil.

Field: Available Schedule Name

Schedule that defines when the coil is available.

Field: Gas Burner Efficiency

This is user inputted gas burner efficiency (decimal, not percent) and is defaulted to 80%.

Field: Nominal Capacity

This is the maximum capacity of the coil (W). This controlled coil will only provide the needed capacity to meet the control criteria whether it is temperature or capacity controlled. This field is autosizable.

Field: Air Inlet Node Name

The name of the air inlet to the gas coil, i.e. Heating Coil Air Inlet Node.

Field: Air Outlet Node Name

The name of the air outlet from the gas coil, i.e. Heating Coil Air Outlet Node.

Field: Temperature Setpoint Node Name

If the coil is used in the air loop simulation and is temperature controlled by the Set Point Manager then the node that is the control node needs to be specified here.

Field: Parasitic Electric Load

This is the parasitic electric load associated with the gas coil operation, such as an inducer fan, etc.. This will be modified by the PLR (or coil runtime fraction if a part-load fraction correlation is provided in the next input field) to reflect the time of operation in a simulation timestep.

Field: Part Load Fraction Correlation Curve Name

This alpha field defines the name of a quadratic or cubic performance curve (Ref: Performance Curves) that parameterizes the variation of gas consumption rate by the heating coil as a function of the part load ratio (PLR, sensible heating load/nominal capacity of the heating coil). For any simulation timestep, the nominal gas consumption rate (heating load/burner efficiency) is divided by the part-load fraction (PLF) if a part-load curve has been defined. The part-load curve accounts for efficiency losses due to transient coil operation.

The part-load fraction correlation should be normalized to a value of 1.0 when the part load ratio equals 1.0 (i.e., no efficiency losses when the heating coil runs continuously for the simulation timestep). For PLR values between 0 and 1 ($0 \leq \text{PLR} < 1$), the following rules apply:

$$\text{PLF} \geq 0.7 \quad \text{and} \quad \text{PLF} \geq \text{PLR}$$

If $\text{PLF} < 0.7$ a warning message is issued, the program resets the PLF value to 0.7, and the simulation proceeds. The runtime fraction of the heating coil is defined a PLR/PLF . If $\text{PLF} < \text{PLR}$, then a warning message is issues and the runtime fraction of the coil is limited to 1.0.

A typical part load fraction correlation for a conventional gas heating coil (e.g., residential furnace) would be:

$$\text{PLF} = 0.8 + 0.2(\text{PLR})$$

Field: Parasitic Gas Load

This numeric field is the parasitic gas load associated with the gas coil's operation (Watts), such as a standing pilot light. The model assumes that this parasitic load is consumed only for the portion of the simulation timestep where the gas heating coil is not operating.

```
Coil:Heating:Gas,
A1 , \field Name
    \required-field
    \type alpha
    \reference HeatingCoilName
    \reference HeatingCoilsGasElec
    \reference HeatingCoilsGasElecDesup
A2 , \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
N1 , \field Gas Burner Efficiency
    \maximum 1.0
    \minimum 0.0
    \default 0.8
N2 , \field Nominal Capacity
    \units W
    \autosizable
```

```

A3 , \field Air Inlet Node Name
    \required-field
A4 , \field Air Outlet Node Name
    \required-field
A5 , \field Temperature Setpoint Node Name
    \note optional, used if coil is temperature control and not load-base controlled
N3 , \field Parasitic Electric Load
    \units W
    \note parasitic electric load associated with the gas coil operation
    \note such as an inducer fan, etc.. This will be modified by the part load ratio to reflect
    \note the time of operation in a timestep.
    \ip-units W
A6 , \field Part Load Fraction Correlation Curve Name
    \type object-list
    \object-list QuadraticCubicCurves
    \note quadratic curve, PLF = a + b*PLR + c*PLR**2
    \note cubic curve, PLF = a + b*PLR + c*PLR**2 + d*PLR**3
    \note PLF = part load fraction
    \note PLR = part load ratio (sensible heating load/steady-state heating capacity)
    \note Coil runtime fraction = Part Load Ratio / PLF
    \note This part load degradation is for coil performance & will
    \note increase the gas consumption of the coil due to transient coil operation.
N4 ; \field Parasitic Gas Load
    \units W
    \note parasitic gas load associated with the gas coil operation (i.e., standing pilot)

```

Coil:Heating:Gas Outputs

```

HVAC,Sum,Heating Coil Energy[J]
HVAC,Average,Heating Coil Rate[W]
HVAC,Sum,Heating Coil Gas Consumption [J]
HVAC,Average,Heating Coil Gas Consumption Rate [W]
HVAC,Sum,Heating Coil Electric Consumption [J]
HVAC,Average,Heating Coil Electric Power [W]
HVAC,Average,Heating Coil Runtime Fraction
HVAC,Sum,Heating Coil Parasitic Gas Consumption [J]
HVAC,Average,Heating Coil Parasitic Gas Consumption Rate [W]

```

Heating Coil Energy [J]

This field is the total heating output of the coil in Joules over the timestep being reported. This output is also added to a report meter with Resource Type = EnergyTransfer, End Use Key = HeatingCoils, Group Key = System (ref. Report Meter).

Heating Coil Rate [W]

This field is the average heating rate output of the coil in Watts over the timestep being reported.

Heating Coil Gas Consumption [J]

This field is the gas consumption of the heating coil in Joules over the timestep being reported, including the impacts of part-load performance if a part load fraction correlation is specified. This output is also added to a report meter with Resource Type = Gas, End Use Key = Heating, Group Key = System (ref. Report Meter).

Heating Coil Gas Consumption Rate [W]

This field is the average gas consumption rate of the coil in Watts over the timestep being reported, including the impacts of part-load performance if a part load fraction correlation is specified.

Heating Coil Electric Consumption [J]

This field is the electric consumption of the heating coil auxiliaries in Joules over the timestep being reported (e.g., inducer fan). This output is also added to a report meter with Resource Type = Electricity, End Use Key = Heating, Group Key = System (ref. Report Meter).

Heating Coil Electric Power [W]

This field is the average electric consumption rate of the heating coil auxiliaries (e.g., inducer fan) in Watts over the timestep being reported.

Heating Coil Parasitic Gas Consumption [J]

This field is the parasitic gas consumption of the heating coil in Joules over the timestep being reported (e.g., standing pilot light). The model assumes that the parasitic load is accumulated only for the portion of the simulation timestep where the gas heating coil is not operating. This output is also added to a report meter with Resource Type = Gas, End Use Key = Heating, Group Key = System (ref. Report Meter).

Heating Coil Parasitic Gas Consumption Rate [W]

This field is the average parasitic gas consumption rate of the heating coil (e.g., standing pilot light) in Watts over the timestep being reported. The model assumes that the parasitic load is present only for the portion of the simulation timestep where the gas heating coil is not operating.

Coil:Cooling:Water:DetailedGeometry

This detailed flat fin coil model is for continuous plate fins. First, found in Type 12 from MODSIM, but now programmed directly from Elmahdy, A.H. and Mitalas, G.P. Then there was a discontinuity in their original model that was fixed in the EnergyPlus implementation. Now this model can be used in an interval halving solution technique for controlling this coil without the problems of non-convergence.

"A Model for Cooling and Dehumidifying Coils for Use in Energy Requirements for Buildings" ASHRAE Transactions, Vol. 83, Part 2, pp. 103-117 (1977). For fin efficiency see K.A. Gardner, "Efficiency of Extended ," Transactions ASME, Vol. 67, pp. 621-631, 1945.

The following figures illustrate the geometry and circuits in a cooling coil.

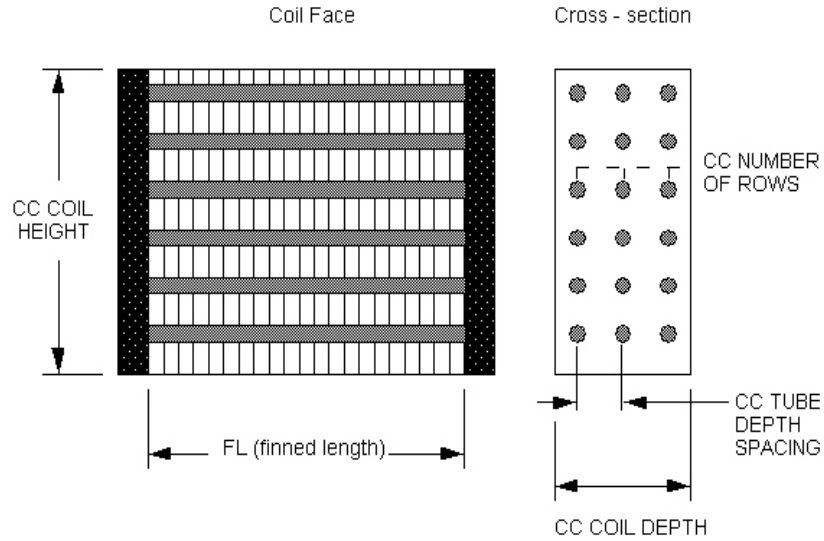
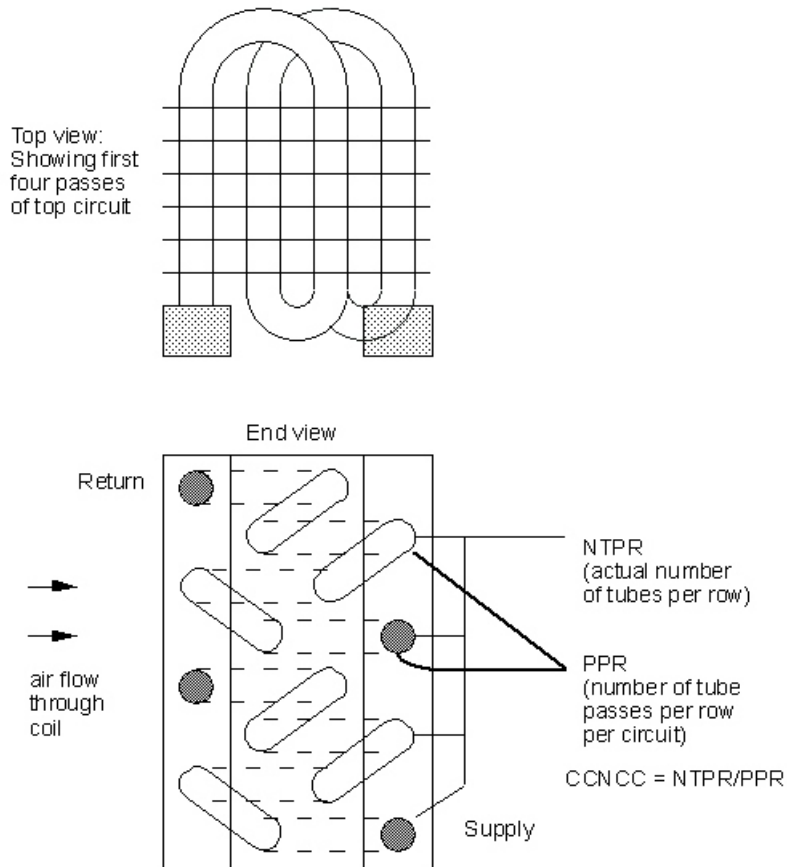


Figure 110. Geometry of a Cooling Coil (CC)



Half Circuiting - 2 passes per vertical row
 (Note: Rows are perpendicular to air flow)

Figure 111. Number of Coolant Circuits (CCNCC)

Field: Name

A unique identifying name for each coil.

Field: Available Schedule Name

Schedule that defines when the coil is available.

Field: Maximum Water Flow Rate

The maximum possible water flow rate (m³/sec) through the coil.

Field: Tube Outside Surface Area

The outside surface area (m²) of the tubes that is exposed to air (i.e. the outside area of the unfinned tubes minus the area of tubes covered by the fins).

Field: Total Tube Inside Area

The total surface area (m²) inside the tubes (water side).

Field: Fin Surface Area

The total surface area (m²) of the fins attached to the coil.

Field: Minimum Air Flow Area

The minimum cross sectional area (m²) available for air passage. Frequently calculated as

$$A_{\min} = (A_{\min}/A_{\text{fr}}) * A_{\text{fr}}$$

where A_{fr} is the frontal area of the heat exchanger, and (A_{\min}/A_{fr}) is the ratio of the minimum airflow area to frontal area.

Field: Coil Depth

The distance (m) from the front of the coil to the back of the coil in the airflow direction. Also called the fin depth. Illustrated in the figure (Figure 110. Geometry of a Cooling Coil (CC)).

Field: Fin Diameter

The outside diameter (m) of the fins. Used instead of COIL HEIGHT

Field: Fin Thickness

Thickness (m) of the air side fins.

Field: Tube Inside Diameter

The inside diameter (m) of the tubes.

Field: Tube Outside Diameter

The outside diameter (m) of the tubes.

Field: Tube Thermal Conductivity

The thermal conductivity (W/m-K) of the tube material.

Field: Fin Thermal Conductivity

The thermal conductivity (W/m-K) of the fin material.

Field: Fin Spacing

The spacing (m) of the fins, centerline to centerline.

Field: Tube Depth Spacing

The spacing (m) of the tube rows, centerline to centerline. Also called tube longitudinal spacing.

Field: Number of Tube Rows

The number of tube rows in the direction of the airflow.

Field: Number of Tubes per Row

The number of tubes per row. (NTPR in the above diagram)

Field: Water Inlet Node Name

The name of the water coil inlet from the chilled water loop, i.e. Cooling Coil Water Inlet Node.

Field: Water Outlet Node Name

The name of the water coil outlet from the chilled water loop, i.e. Cooling Coil Water Outlet Node.

Field: Air Inlet Node Name

The name of the air inlet to the water coil, i.e. Cooling Coil Air Inlet Node.

Field: Air Outlet Node Name

The name of the air outlet from the water coil, i.e. Cooling Coil Air Outlet Node.

Field: Condensate Collection Water Storage Tank Name

This field is optional. It is used to describe where condensate from the coil is collected. If blank or omitted, then any coil condensate is discarded. Enter the name of Water Storage Tank object defined elsewhere and the condensate will then be collected in that tank.

The IDD specification for this object:

```
Coil:Cooling:Water:DetailedGeometry,
A1 , \field Name
    \required-field
    \reference CoolingCoilName
    \reference CoolingCoilsWater
    \reference CoolingCoilsWaterNoHX
A2 , \field Availability Schedule Name
    \type object-list
    \object-list ScheduleNames
N1 , \field Maximum Water Flow Rate
    \units m3/s
    \autosizable
    \ip-units gal/min
N2 , \field Tube Outside Surface Area
    \units m2
    \autosizable
    \note Tube Primary Surface Area
N3 , \field Total Tube Inside Area
    \units m2
    \autosizable
    \note Total tube inside surface area
N4 , \field Fin Surface Area
    \units m2
    \autosizable
N5 , \field Minimum Airflow Area
    \units m2
    \autosizable
N6 , \field Coil Depth
    \autosizable
    \units m
    \ip-units in
```

```
N7 , \field Fin Diameter
      \units m
      \autosizable
      \note Fin diameter or the coil height
      \ip-units in
N8 , \field Fin Thickness
      \units m
      \ip-units in
      \default .0015
N9 , \field Tube Inside Diameter
      \units m
      \note Inner diameter of tubes
      \ip-units in
      \default .01445
N10, \field Tube Outside Diameter
      \units m
      \note Outer diameter of tubes
      \ip-units in
      \default .0159
N11, \field Tube Thermal Conductivity
      \units W/m-K
      \default 0.386
N12, \field Fin Thermal Conductivity
      \units W/m-K
      \default 0.204
N13, \field Fin Spacing
      \units m
      \note Fin spacing or distance
      \ip-units in
      \default .0018
N14, \field Tube Depth Spacing
      \units m
      \ip-units in
      \default .026
N15, \field Number of Tube Rows
      \default 4
N16, \field Number of Tubes per Row
      \autosizable
A3 , \field Water Inlet Node Name
      \required-field
A4 , \field Water Outlet Node Name
      \required-field
A5 , \field Air Inlet Node Name
      \required-field
A6 , \field Air Outlet Node Name
      \required-field
A7 ; \field Condensate Collection Water Storage Tank Name
      \type object-list
      \object-list WaterStorageTankNames
```

Examples of these statements in an IDF are:

```
Coil:Cooling:Water:DetailedGeometry,
  Detailed Cooling Coil, !Name of cooling coil
  CoolingCoilAvailSched, !Cooling Coil Schedule
  0.0011, !Max Water Flow Rate of Coil m3/sec
  6.23816, !Tube Outside Surf Area
  6.20007018, !Tube Inside Surf Area
  101.7158224, !Fin Surf Area
  0.300606367, !Min Air Flow Area
  0.165097968, !Coil Depth
  0.43507152, !Coil Height
  0.001499982, !Fin Thickness
  0.014449958, !Tube Inside Diameter
  0.015879775, !Tube Outside Diameter
  0.385764854, !Tube Thermal Conductivity
  0.203882537, !Fin Thermal Conductivity
  0.001814292, !Fin Spacing
  0.02589977, !Tube Depth
  6, !Number of Tube Rows
  16, !Number of Tubes per Row
  NODE_32,NODE_33, !Coil Water Side Inlet & Outlet Node
  NODE_5, NODE_6; !Coil Air Side Inlet & Outlet Node
```

Coil:Cooling:Water:DetailedGeometry Outputs

```
HVAC,Sum,Total Water Cooling Coil Energy[J]
HVAC,Sum,Sensible Water Cooling Coil Energy[J]
HVAC,Average,Total Water Cooling Coil Rate[W]
HVAC,Average,Sensible Water Cooling Coil Rate[W]
HVAC,Average,Cooling Coil Condensate Volumetric Flow Rate [m3/s]
Zone,Meter,OnSiteWater:Facility [m3]
Zone,Meter,OnSiteWater:HVAC [m3]
Zone,Meter,Condensate:OnSiteWater [m3]
HVAC,Sum,Cooling Coil Condensate Volume [m3]
```

Total Water Cooling Coil Energy (J)

Total Water Cooling Coil Energy is the total amount of heat transfer taking place in the coil at the operating conditions.

Sensible Water Cooling Coil Energy (J)

Sensible Water Cooling Coil Energy is the total amount of Sensible heat transfer taking place in the coil at the operating conditions. It only takes into account temperature difference in the inlet and outlet air streams at operating conditions.

Total Water Cooling Coil Rate (W)

Total Water Cooling Coil Rate is the Rate of heat transfer taking place in the coil at the operating conditions. The units are (J/sec) or Watts.

Sensible Water Cooling Coil Rate (W)

Sensible Water Cooling Coil Rate is the Rate of Sensible heat transfer taking place in the coil at the operating conditions.

In addition, if a Water Storage Tank is used to collect coil condensate, then the following outputs will be available.

Cooling Coil Condensate Volumetric Flow Rate [m3/s]

Cooling Coil Condensate Volume [m3]

These reports provide the rate and amount of condensate from the coil. Condensate is water condensed out of the air as a result of cooling. The condensate volume is also reported on the meter for "OnSiteWater."

Coil:Cooling:DX:SingleSpeed

This DX cooling coil model and input are quite different from that for the heating and cooling water coils. The simple water coils use an NTU-effectiveness heat exchanger model. The single speed DX coil model uses performance information at rated conditions along with curve fits for variations in total capacity, energy input ratio and part-load fraction to determine performance at part-load conditions. Sensible/latent capacity splits are determined by the rated sensible heat ratio (SHR) and the apparatus dewpoint/bypass factor (ADP/BF) approach. This approach is analogous to the NTU-effectiveness calculations used for sensible-only heat exchanger calculations, extended to a cooling and dehumidifying coil.

This DX cooling coil input requires an availability schedule, the rated total cooling capacity, the rated SHR, the rated COP, and the rated air volume flow rate. The latter 4 inputs determine the coil performance at the rating point (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb and air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb). The rated air volume flow rate should be between .00004027 m³/s and .00006041 m³/s per watt of rated total cooling capacity (300 to 450 cfm/ton).

This model requires 5 curves as follows:

1. The total cooling capacity modifier curve (function of temperature) is a biquadratic curve with two independent variables: wet-bulb temperature of the air entering the cooling coil, and dry-bulb temperature of the air entering the air-cooled condenser coil (wet-bulb temperature if modeling an evaporative-cooled condenser). The output of this curve is multiplied by the rated total cooling capacity to give the total cooling capacity at specific temperature operating conditions (i.e., at temperatures different from the rating point temperatures).
2. The total cooling capacity modifier curve (function of flow fraction) is a quadratic or cubic curve with the independent variable being the ratio of the actual air flow rate across the cooling coil to the rated air flow rate (i.e., fraction of full load flow). The output of this curve is multiplied by the rated total cooling capacity and the total cooling capacity modifier curve (function of temperature) to give the total cooling capacity at the specific temperature and air flow conditions at which the coil is operating.
3. The energy input ratio (EIR) modifier curve (function of temperature) is a biquadratic curve with two independent variables: wet-bulb temperature of the air entering the cooling coil, and dry-bulb temperature of the air entering the air-cooled condenser coil (wet-bulb temperature if modeling an evaporative-cooled condenser). The output of this curve is multiplied by the rated EIR (inverse of the rated COP) to give the EIR at specific temperature operating conditions (i.e., at temperatures different from the rating point temperatures).
4. The energy input ratio (EIR) modifier curve (function of flow fraction) is a quadratic or cubic curve with the independent variable being the ratio of the actual air flow rate across the cooling coil to the rated air flow rate (i.e., fraction of full load flow). The output of this curve is multiplied by the rated EIR (inverse of the rated COP) and the EIR modifier curve (function of temperature) to give the EIR at the specific temperature and air flow conditions at which the coil is operating.
5. The part load fraction correlation (function of part load ratio) is a quadratic or cubic curve with the independent variable being part load ratio (sensible cooling load / steady-state sensible cooling capacity). The output of this curve is used in combination with the rated EIR and EIR modifier curves to give the “effective” EIR for a given simulation timestep. The part load fraction (PLF) correlation accounts for efficiency losses due to compressor cycling. The curve should be normalized to a value of 1.0 when the part-load ratio equals 1.0 (i.e., the compressor(s) run continuously for the simulation timestep).

The curves are simply specified by name. Curve inputs are described in the curve manager section of this document (see Performance Curves in this document).

The next input item for this DX cooling coil object is the supply air fan operation mode. Either the supply air fan runs continuously while the DX coil cycles on/off

(ContinuousFanWithCyclingCompressor), or the fan and coil cycle on/off together (CyclingFanAndCompressor). When this DX cooling coil is used in a parent object that has a fan operating mode schedule (e.g. Furnace:HeatCool), this input is not used.

The next four input fields are optional and relate to the degradation of latent cooling capacity when the supply air fan operates continuously while the cooling coil/compressor cycle on and off to meet the cooling load. The field Supply Air Fan Operation Mode must be “ContinuousFanWithCyclingCompressor” (i.e. either in the field above or the fan operating mode schedule specified in the parent object must be greater than 0 to calculate degradation of latent cooling capacity. At times when the parent object’s supply air fan operating mode schedule is 0, latent degradation will be ignored.) and these next four input fields must have positive values in order to model latent capacity degradation.

The next input specifies the outdoor air node used to define the conditions of the air entering the outdoor condenser. If this field is left blank, the outdoor temperature entering the condenser is taken directly from the weather data. If this field is not blank, the node name specified must be listed in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor temperature from the weather data. Alternately, the node name must be specified in an OutdoorAir:NodeList object where the outdoor temperature entering the condenser is taken directly from the weather data.

The next input describes the type of outdoor condenser coil used with the DX cooling coil (Air Cooled or Evap Cooled). The following three inputs are required when modeling an evaporative-cooled condenser: evaporative condenser effectiveness, evaporative condenser air volume flow rate, and the power consumed by the evaporative condenser pump. Crankcase heater capacity and cutout temperature are entered in the next two input fields. The final two fields for this object define the name of the water storage tank for supply and condensate collection. See section “DX Cooling Coil Model” in the EnergyPlus Engineering Document for further details regarding this model.

Field: Name

A unique user-assigned name for an instance of a DX cooling coil. Any reference to this DX coil by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the DX cooling coil can run during a given time period. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during a given time period. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off.

Field: Rated Total Cooling Capacity

The total, full load cooling capacity (sensible plus latent) in watts of the DX coil unit at rated conditions (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb⁹, and a cooling coil air flow rate defined by field “rated air volume flow rate” below). Capacity should be “gross” (i.e., supply air fan heat is NOT included).

Field: Rated Sensible Heat Ratio

The sensible heat ratio (SHR=sensible capacity divided by total cooling capacity) of the DX cooling coil at rated conditions (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb, and a cooling coil air flow rate defined by field “rated air volume flow rate” below). Both the sensible and total cooling capacities used to define the Rated SHR should be “gross” (i.e., supply air fan heat is NOT included).

⁹ The 23.9°C wet-bulb temperature condition is not applicable for air-cooled condensers which do not evaporate condensate.

Field: Rated COP

The coefficient of performance (cooling power output in watts divided by electrical power input in watts) of the DX cooling coil unit at rated conditions (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb, and a cooling coil air flow rate defined by field “rated air volume flow rate” below). The input power includes electric power for the compressor(s) and condenser fan(s) but does not include the power consumption of the supply air fan. The cooling power output is the value entered above in the field “Rated Total Cooling Capacity (gross)”. If this input field is left blank, the default value is 3.0.

Field: Rated Air Flow Rate

The air volume flow rate, in m³ per second, across the DX cooling coil at rated conditions. The rated air volume flow rate should be between 0.00004027 m³/s and 0.00006041 m³/s per watt of rated total cooling capacity (300 to 450 cfm/ton). The rated total cooling capacity, rated SHR and rated COP should be performance information for the unit with air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb, and the rated air volume flow rate defined here.

Field: Air Inlet Node Name

The name of the HVAC system node from which the DX cooling coil draws its inlet air.

Field: Air Outlet Node Name

The name of the HVAC system node to which the DX cooling coil sends its outlet air.

Field: Total Cooling Capacity Function of Temperature Curve Name

The name of a biquadratic performance curve (ref: Performance Curves) that parameterizes the variation of the total cooling capacity as a function of the wet-bulb temperature of the air entering the cooling coil, and the dry-bulb temperature of the air entering the air-cooled condenser coil (wet-bulb temperature if modeling an evaporative-cooled condenser). The output of this curve is multiplied by the rated total cooling capacity to give the total cooling capacity at specific temperature operating conditions (i.e., at temperatures different from the rating point temperatures). The curve is normalized to have the value of 1.0 at the rating point.

Field: Total Cooling Capacity Function of Flow Fraction Curve Name

The name of a quadratic or cubic performance curve (ref: Performance Curves) that parameterizes the variation of total cooling capacity as a function of the ratio of actual air flow rate across the cooling coil to the rated air flow rate (i.e., fraction of full load flow). The output of this curve is multiplied by the rated total cooling capacity and the total cooling capacity modifier curve (function of temperature) to give the total cooling capacity at the specific temperature and air flow conditions at which the coil is operating. The curve is normalized to have the value of 1.0 when the actual air flow rate equals the rated air flow rate.

Field: Energy Input Ratio Function of Temperature Curve Name

The name of a biquadratic performance curve (ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) as a function of the wet-bulb temperature of the air entering the cooling coil, and the dry-bulb temperature of the air entering the air-cooled condenser coil (wet-bulb temperature if modeling an evaporative-cooled condenser). The EIR is the inverse of the COP. The output of this curve is multiplied by the rated EIR (inverse of rated COP) to give the EIR at specific temperature operating conditions (i.e., at temperatures different from the rating point temperatures). The curve is normalized to a value of 1.0 at the rating point.

Field: Energy Input Ratio Function of Flow Fraction Curve Name

The name of a quadratic or cubic performance curve (Ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) as a function of the ratio of actual air flow rate across the cooling coil to the rated air flow rate (i.e., fraction of full load flow). The EIR is the inverse of the COP. The output of this curve is multiplied by the rated EIR and the EIR modifier curve (function of temperature) to give the EIR at the specific temperature and air flow conditions at which the cooling coil is operating. This curve is normalized to a value of 1.0 when the actual air flow rate equals the rated air flow rate.

Field: Part Load Fraction Correlation Curve Name

This alpha field defines the name of a quadratic or cubic performance curve (Ref: Performance Curves) that parameterizes the variation of electrical power input to the DX unit as a function of the part load ratio (PLR, sensible cooling load/steady-state sensible cooling capacity). The product of the rated EIR and EIR modifier curves is divided by the output of this curve to give the “effective” EIR for a given simulation timestep. The part load fraction (PLF) correlation accounts for efficiency losses due to compressor cycling.

The part load fraction correlation should be normalized to a value of 1.0 when the part load ratio equals 1.0 (i.e., no efficiency losses when the compressor(s) run continuously for the simulation timestep). For PLR values between 0 and 1 ($0 \leq \text{PLR} < 1$), the following rules apply:

$$\text{PLF} \geq 0.7 \quad \text{and} \quad \text{PLF} \geq \text{PLR}$$

If $\text{PLF} < 0.7$ a warning message is issued, the program resets the PLF value to 0.7, and the simulation proceeds. The runtime fraction of the coil is defined as PLR/PLF . If $\text{PLF} < \text{PLR}$, then a warning message is issued and the runtime fraction of the coil is limited to 1.0.

A typical part load fraction correlation for a conventional, single-speed DX cooling coil (e.g., residential unit) would be:

$$\text{PLF} = 0.85 + 0.15(\text{PLR})$$

If the user wishes to model no efficiency degradation due to compressor cycling, the part load fraction correlation should be defined as follows:

$$\text{PLF} = 1.0 + 0.0(\text{PLR})$$

Field: Supply Air Fan Operation Mode

This input field has two choices: **CyclingFanAndCompressor** or **ContinuousFanWithCyclingCompressor**. The first choice stands for “cycling fan cycling compressor”. This means that the unit unloads by cycling both the fan and compressor; that is, both the supply air fan and the DX coil unit compressor cycle on and off together to meet the load. The second choice stands for “continuous fan cycling compressor”. The supply air fan runs continuously while the DX coil unit compressor cycles. When this DX cooling coil is used in a parent object that has a fan operating mode schedule (e.g. Furnace:HeatCool), this input is not used.

Field: Nominal Time for Condensate Removal to Begin

The nominal time (in seconds) after startup for condensate to begin leaving the coil's condensate drain line at the coil's rated airflow and temperature conditions, starting with a dry coil. Nominal time is equal to the ratio of the energy of the coil's maximum condensate holding capacity (J) to the coil's steady-state latent capacity (W). Suggested value is 1000; zero value means the latent degradation model is disabled. The default value for this field is zero. The field Supply Air Fan Operation Mode must be “ContinuousFanWithCyclingCompressor”, and this field as well as the next three input fields for this object must have positive values in order to model latent capacity degradation.

Field: Ratio of Initial Moisture Evaporation Rate and Steady State Latent Capacity

Ratio of the initial moisture evaporation rate from the cooling coil (when the compressor first turns off, in Watts) and the coil's steady-state latent capacity (Watts) at rated airflow and temperature conditions. Suggested value is 1.5; zero value means the latent degradation model is disabled. The default value for this field is zero. The field Supply Air Fan Operation Mode must be "ContinuousFanWithCyclingCompressor"; and this field, the previous field and the next two fields must have positive values in order to model latent capacity degradation.

Field: Maximum Cycling Rate

The maximum on-off cycling rate for the compressor (cycles per hour), which occurs at 50% run time fraction. Suggested value is 3; zero value means latent degradation model is disabled. The default value for this field is zero. The field Supply Air Fan Operation Mode must be "ContinuousFanWithCyclingCompressor"; and this field, the previous two fields and the next field must have positive values in order to model latent capacity degradation.

Field: Latent Capacity Time Constant

Time constant (in seconds) for the cooling coil's latent capacity to reach steady state after startup. Suggested value is 45; zero value means latent degradation model is disabled. The default value for this field is zero. The field Supply Air Fan Operation Mode must be "ContinuousFanWithCyclingCompressor", and this field as well as the previous three input fields for this object must have positive values in order to model latent capacity degradation.

Field: Condenser Air Inlet Node Name

This optional alpha field specifies the outdoor air node name used to define the conditions of the air entering the outdoor condenser. If this field is left blank, the outdoor air temperature entering the condenser (dry-bulb or wet-bulb) is taken directly from the weather data. If this field is not blank, the node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air temperature from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air temperature is taken directly from the weather data.

Field: Condenser Type

The type of condenser used by the DX cooling coil. Valid choices for this input field are **AirCooled** or **EvaporativelyCooled**. The default for this field is AirCooled.

Field: Evaporative Condenser Effectiveness

The effectiveness of the evaporative condenser, which is used to determine the temperature of the air entering the outdoor condenser coil as follows:

$$T_{cond\ inlet} = (T_{wb,o}) + (1 - EvapCondEffectiveness)(T_{db,o} - T_{wb,o})$$

where

$T_{cond\ inlet}$ = the temperature of the air entering the condenser coil (C)

$T_{wb,o}$ = the wet-bulb temperature of the outdoor air (C)

$T_{db,o}$ = the dry-bulb temperature of the outdoor air (C)

The resulting condenser inlet air temperature is used by the Total Cooling Capacity Modifier Curve (function of temperature) and the Energy Input Ratio Modifier Curve (function of temperature). The default value for this field is 0.9, although valid entries can range from 0.0 to 1.0. This field is not used when Condenser Type = Air Cooled.

If the user wants to model an air-cooled condenser, they should simply specify AirCooled in the field Condenser Type. In this case, the Total Cooling Capacity Modifier Curve (function of

temperature) and the Energy Input Ratio Modifier Curve (function of temperature) input fields for this object should reference performance curves that are a function of outdoor dry-bulb temperature.

If the user wishes to model an evaporative-cooled condenser AND they have performance curves that are a function of the wet-bulb temperature of air entering the condenser coil, then the user should specify Condenser Type = Evap Cooled and the evaporative condenser effectiveness value should be entered as 1.0. In this case, the Total Cooling Capacity Modifier Curve (function of temperature) and the Energy Input Ratio Modifier Curve (function of temperature) input fields for this object should reference performance curves that are a function of the wet-bulb temperature of air entering the condenser coil.

If the user wishes to model an air-cooled condenser that has evaporative media placed in front of it to cool the air entering the condenser coil, then the user should specify Condenser Type = Evap Cooled. The user must also enter the appropriate evaporative effectiveness for the media. In this case, the Total Cooling Capacity Modifier Curve (function of temperature) and the Energy Input Ratio Modifier Curve (function of temperature) input fields for this object should reference performance curves that are a function of outdoor dry-bulb temperature. Be aware that the evaporative media will significantly reduce the dry-bulb temperature of the air entering the condenser coil, so the Total Cooling Capacity and EIR Modifier Curves must be valid for the expected range of dry-bulb temperatures that will be entering the condenser coil.

Field: *Evaporative Condenser Air Flow Rate*

The air volume flow rate, in m³ per second, entering the evaporative condenser. This value is used to calculate the amount of water used to evaporatively cool the condenser inlet air. The minimum value for this field must be greater than zero, and this input field is autosizable (equivalent to 0.000144 m³/s per watt of rated total cooling capacity [850 cfm/ton]). This field is not used when Condenser Type = Air Cooled.

Field: *Evaporative Condenser Pump Rated Power Consumption*

The rated power of the evaporative condenser water pump in Watts. This value is used to calculate the power required to pump the water used to evaporatively cool the condenser inlet air. The default value for this input field is zero, but it is autosizable (equivalent to 0.004266 W per watt [15 W/ton] of rated total cooling capacity). This field is not used when Condenser Type = Air Cooled.

Field: *Crankcase Heater Capacity*

This numeric field defines the crankcase heater capacity in Watts. When the outdoor air dry-bulb temperature is below the value specified in the input field "Maximum Outdoor Dry-bulb Temperature for Crankcase Heater Operation" (described below), the crankcase heater is enabled during the time that the compressor is not running. If this cooling coil is used as part of an air-to-air heat pump (Ref. UnitarySystem:HeatPump:AirToAir or PackageTerminal:HeatPump:AirToAir), the crankcase heater defined for this DX cooling coil is ignored and the crankcase heater power defined for the DX heating coil (Ref. Coil:DX:HeatingEmpirical) is enabled during the time that the compressor is not running for either heating or cooling. The value for this input field must be greater than or equal to 0, and the default value is 0. To simulate a DX cooling coil without a crankcase heater, enter a value of 0.

Field: *Maximum Outdoor Dry-Bulb Temperature for Crankcase Heater Operation*

This numeric field defines the outdoor air dry-bulb temperature above which the compressor's crankcase heater is disabled. The value for this input field must be greater than or equal to 0.0°C, and the default value is 10°C.

Field: *Supply Water Storage Tank Name*

This field is optional. It is used to describe where the coil obtains water used for evaporative cooling of its condenser. If blank or omitted, then the unit will obtain water directly from the mains. If the name of a Water Storage Tank object is used here, then the unit will obtain its

water from that tank. If a tank is specified, the unit will attempt to obtain all the water it uses from the tank. However if the tank cannot provide all the water the condenser needs, then the unit will still operate and obtain the rest of the water it needs from the mains (referred to as StarvedWater).

Field: Condensate Collection Water Storage Tank Name

This field is optional. It is used to describe where condensate from the coil is collected. If blank or omitted, then any coil condensate is discarded. Enter the name of Water Storage Tank object defined elsewhere and the condensate will then be collected in that tank.

Below is the input data dictionary description for the CoolingBypassFactorEmpirical DX coil.

```
Coil:Cooling:DX:SingleSpeed,
  \min-fields 14
  A1 , \field Name
    \required-field
    \type alpha
    \reference CoolingCoilsDX
    \reference CoolingCoilsDXSingleSpeed
    \reference CoolingCoilsDXBypassFactorEmpirical
    \reference DesuperHeatingCoilSources
  A2 , \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
  N1 , \field Rated Total Cooling Capacity
    \required-field
    \type real
    \units W
    \minimum> 0.0
    \autosizable
    \note gross capacity excluding supply air fan heat
    \note rating point: air entering the cooling coil at 26.7 C dry-bulb/19.4 C wet-bulb, and
    \note air entering the outdoor condenser coil at 35 C dry-bulb/23.9 C wet-bulb
  N2 , \field Rated Sensible Heat Ratio
    \required-field
    \type real
    \minimum 0.5
    \maximum 1.0
    \autosizable
    \note Rated sensible heat ratio (gross sensible capacity/gross total capacity)
    \note sensible and total capacities do not include supply fan heat
  N3 , \field Rated COP
    \type real
    \minimum> 0.0
    \default 3.0
    \note does not include supply fan heat or supply fan electrical energy input
  N4 , \field Rated Air Flow Rate
    \required-field
    \type real
    \units m3/s
    \minimum> 0.0
    \autosizable
    \note Flow rate corresponding to rated total cooling capacity, Rated SHR and Rated COP
    \note should be between 0.00004027 m3/s and .00006041 m3/s per watt of rated total cooling capacity
```

```

A3 , \field Air Inlet Node Name
    \required-field
    \type alpha
A4 , \field Air Outlet Node Name
    \required-field
    \type alpha
A5 , \field Total Cooling Capacity Function of Temperature Curve Name
    \required-field
    \type object-list
    \object-list BiquadraticCurves
    \note curve =  $a + b*wb + c*wb**2 + d*edb + e*edb**2 + f*wb*edb$ 
    \note wb = entering wet-bulb temperature (C)
    \note edb = dry-bulb temperature seen by the condenser (C)
A6 , \field Total Cooling Capacity Function of Flow Fraction Curve Name
    \required-field
    \type object-list
    \object-list QuadraticCubicCurves
    \note quadratic curve =  $a + b*ff + c*ff**2$ 
    \note cubic curve =  $a + b*ff + c*ff**2 + d*ff**3$ 
    \note ff = Fraction of the full load flow
A7 , \field Energy Input Ratio Function of Temperature Curve Name
    \required-field
    \type object-list
    \object-list BiquadraticCurves
    \note curve =  $a + b*wb + c*wb**2 + d*edb + e*edb**2 + f*wb*edb$ 
    \note wb = entering wet-bulb temperature (C)
    \note edb = dry-bulb temperature seen by the condenser (C)
A8 , \field Energy Input Ratio Function of Flow Fraction Curve Name
    \required-field
    \type object-list
    \object-list QuadraticCubicCurves
    \note quadratic curve =  $a + b*ff + c*ff**2$ 
    \note cubic curve =  $a + b*ff + c*ff**2 + d*ff**3$ 
    \note ff = Fraction of the full load flow
A9 , \field Part Load Fraction Correlation Curve Name
    \required-field
    \type object-list
    \object-list QuadraticCubicCurves
    \note quadratic curve =  $a + b*PLR + c*PLR**2$ 
    \note cubic curve =  $a + b*PLR + c*PLR**2 + d*PLR**3$ 
    \note PLR = part load ratio (cooling load/steady-state capacity)
A10, \field Supply Air Fan Operating Mode
    \required-field
    \type choice
    \key CyclingFanAndCompressor
    \key ContinuousFanWithCyclingCompressor
N5, \field Nominal Time for Condensate Removal to Begin
    \type real
    \units s
    \minimum 0.0
    \maximum 3000.0
    \default 0.0
    \note The nominal time for condensate to begin leaving the coil's condensate
    \note drain line at the coil's rated air flow rate and temperature conditions.
    \note Nominal time is equal to the ratio of the energy of the coil's maximum
    \note condensate holding capacity (J) to the coil's steady-state latent capacity (W).
    \note Suggested value is 1000; zero value means latent degradation model is disabled.
N6, \field Ratio of Initial Moisture Evaporation Rate and Steady State Latent Capacity
    \type real
    \units dimensionless
    \minimum 0.0
    \maximum 5.0
    \default 0.0
    \note Ratio of the initial moisture evaporation rate from the cooling coil (when
    \note the compressor first turns off) and the coil's steady-state latent capacity
    \note at rated air flow rate and temperature conditions. Suggested value is 1.5; zero value
    \note means latent degradation model is disabled.

```

```

N7, \field Maximum Cycling Rate
    \type real
    \units cycles/hr
    \minimum 0.0
    \maximum 5.0
    \default 0.0
    \note The maximum on-off cycling Rate for the compressor, which occurs at 50% run time
    \note fraction. Suggested value is 3; zero value means latent degradation model is disabled.
N8, \field Latent Capacity Time Constant
    \type real
    \units s
    \minimum 0.0
    \maximum 500.0
    \default 0.0
    \note Time constant for the cooling coil's latent capacity to reach steady state after
    \note startup. Suggested value is 45; zero value means latent degradation model is disabled.
A11, \field Condenser Air Inlet Node Name
    \type alpha
    \note Enter the name of an outdoor air node. This node name is also specified in
    \note an OutdoorAir:Node or OutdoorAir:NodeList object.
A12, \field Condenser Type
    \type choice
    \key AirCooled
    \key EvaporativelyCooled
    \default AirCooled
N9, \field Evaporative Condenser Effectiveness
    \type real
    \units dimensionless
    \minimum 0.0
    \maximum 1.0
    \default 0.9
N10, \field Evaporative Condenser Air Flow Rate
    \type real
    \units m3/s
    \minimum > 0.0
    \autosizable
    \note Used to calculate evaporative condenser water use
N11, \field Evaporative Condenser Pump Rated Power Consumption
    \type real
    \units W
    \minimum 0.0
    \default 0.0
    \autosizable
    \note Rated power consumed by the evaporative condenser's water pump
N12, \field Crankcase Heater Capacity
    \type real
    \minimum 0.0
    \default 0.0
    \units W
    \ip-units W
N13, \field Maximum Outdoor Dry-Bulb Temperature for Crankcase Heater Operation
    \type real
    \minimum 0.0
    \default 10.0
    \units C
A13, \field Supply Water Storage Tank Name
    \type object-list
    \object-list WaterStorageTankNames
A14, \field Condensate Collection Water Storage Tank Name
    \type object-list
    \object-list WaterStorageTankNames

```

Following is an example input for a CoolingBypassFactorEmpirical DX coil.

```

Coil:DX:Cooling:SingleSpeed,
Zone1WindACDXCoil,          ! Coil Name
FanAndCoilAvailSched,      ! Availability Schedule
10548,                      ! Rated Total Cooling Capacity (gross)
0.75,                      ! Rated SHR
3.0,                       ! Rated COP
0.637,                     ! Rated Air Volume Flow Rate (m3/s)
Zone1WindACFanOutletNode,  ! Coil Air Inlet Node
Zone1WindACAirOutletNode, ! Coil Air Outlet Node
WindACCoolCapFT,           ! Total Cooling Capacity Modifier Curve (function of temperature)
WindACCoolCapFFF,         ! Total Cooling Capacity Modifier Curve (function of flow fraction)
WindACEIRFT,              ! Energy Input Ratio Modifier Curve (function of temperature)
WindACEIRFFF,             ! Energy Input Ratio Modifier Curve (function of flow fraction)
WindACPLFFPLR,            ! Part Load Fraction Correlation (function of part load ratio)
ContinuousFanWithCyclingCompressor, ! Supply Air Fan Operation Mode
1000.,                    ! Nominal Time for Condensate Removal to Begin {s}
1.5,                      ! Ratio of Initial Moisture Evaporation Rate and Steady-state Latent Capacity
3.0,                      ! Maximum ON/OFF Cycling Rate {cycles/hr}
45.0,                    ! Latent Capacity Time Constant {s}
,                          ! Condenser Air Inlet Node Name
AirCooled,                ! Condenser Type
,                          ! Evaporative Condenser Effectiveness
,                          ! Evaporative Condenser Air Volume Flow Rate {m3/s}
,                          ! Evaporative Condenser Pump Rated Power Consumption {W}
30.,                      ! Crankcase Heater Capacity {W}
10.;                      ! Maximum Outdoor Dry-bulb Temperature for Crankcase Heater Operation {C}

```

Coil:Cooling:DX:TwoSpeed

This component models a DX cooling unit with a two speed or variable speed compressor and fan. The method is based on that used for the cycling, single speed DX unit. The single speed unit is described by single full load capacity, SHR, COP, and air flow rate at rated conditions. Off rated full load performance is obtained by the use of 4 modifier curves. At partial load the unit cycles on/off and the cycling losses are described by a part load fraction curve.

The multispeed unit is described by specifying the performance at two states: high speed compressor, high speed fan; and low speed compressor, low speed fan. When the unit load is above the high speed capacity, the unit runs with high speed compressor and fan. When the load on the unit is below the high speed capacity but above the low speed capacity, the unit will run with performance intermediate between high speed and low speed. When the load is less than the low speed capacity, the unit will cycle on/off just like the single speed unit.

The multispeed unit model requires 2 full sets of performance data. There must be a high and low speed capacity, SHR, COP, and evaporator air flow rate; as well as high and low speed performance curves – total cooling capacity modifier curve (function of temperature) and energy input ratio modifier curve (function of temperature).

The multispeed DX component should be used for all cases in which a DX VAV system is being simulated. Obviously this model – in which performance is obtained by interpolating between 2 specified states - is an oversimplification of how real multi-speed and variable speed DX cooling units are controlled. But detailed descriptions of how actual units perform and are controlled are not available. This model should give a good average prediction of multispeed and variable speed DX cooling unit performance.

Field: Name

A unique user-assigned name for an instance of a multispeed DX cooling coil. Any reference to this DX coil by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the DX cooling coil can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit

can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Rated High Speed Total Cooling Capacity

The total, full load cooling capacity (sensible plus latent) in watts of the DX coil unit for high speed compressor and high speed fan at rated conditions (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb, and a cooling coil air flow rate defined by field “rated air volume flow rate” below). Capacity should be “gross” (i.e., supply air fan heat is NOT included).

Field: Rated High Speed Sensible Heat Ratio

The sensible heat ratio (sensible capacity divided by total cooling capacity) of the DX cooling coil for high speed compressor and high speed fan at rated conditions (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb¹⁰, and a cooling coil air flow rate defined by field “rated air volume flow rate” below). Both the sensible and total cooling capacities used to define the Rated SHR should be “gross” (i.e., supply air fan heat is NOT included).

Field: Rated High Speed COP

The coefficient of performance (cooling power output in watts divided by electrical power input in watts) of the DX cooling coil unit for high speed compressor and high speed fan at rated conditions (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb, and a cooling coil air flow rate defined by field “rated air volume flow rate” below). The input power includes electric power for the compressor(s) and condenser fan(s) but does not include the power consumption of the supply air fan. The cooling power output is the value entered above in the field “Rated Total Cooling Capacity (gross)”. If this input field is left blank, the default value is 3.0.

Field: Rated High Speed Air Flow Rate

The high speed air volume flow rate, in m³ per second, across the DX cooling coil at rated conditions. The rated air volume flow rate should be between 0.00004027 m³/s and 0.00006041 m³/s per watt of rated total cooling capacity. The rated total cooling capacity, rated SHR and rated COP should be performance information for the unit with air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb, and the rated air volume flow rate defined here.

Field: Air Inlet Node

The name of the HVAC system node from which the DX cooling coil draws its inlet air.

Field: Air Outlet Node

The name of the HVAC system node to which the DX cooling coil sends its outlet air.

Field: Total Cooling Capacity Function of Temperature Curve Name

The name of a biquadratic performance curve (ref: Performance Curves) that parameterizes the variation of the total cooling capacity as a function of the wet-bulb temperature of the air entering the cooling coil, and the dry-bulb temperature of the air entering the air-cooled condenser (wet-bulb temperature if modeling an evaporative-cooled condenser). The output of this curve is multiplied by the rated total cooling capacity to give the total cooling capacity at specific temperature operating conditions (i.e., at temperatures different from the rating point temperatures). The curve is normalized to have the value of 1.0 at the rating point. This curve is used for performance at the high speed compressor, high speed fan operating point.

¹⁰ The 23.9°C wet-bulb temperature condition is not applicable for air-cooled condensers which do not evaporate condensate.

Field: Total Cooling Capacity Function of Flow Fraction Curve Name

The name of a quadratic performance curve (ref: Performance Curves) that parameterizes the variation of total cooling capacity as a function of the ratio of actual air flow rate across the cooling coil to the rated air flow rate (i.e., fraction of full load flow). The output of this curve is multiplied by the rated total cooling capacity and the total cooling capacity modifier curve (function of temperature) to give the total cooling capacity at the specific temperature and air flow conditions at which the coil is operating. The curve is normalized to have the value of 1.0 when the actual air flow rate equals the rated air flow rate. This curve is applied only at the high speed compressor, high speed fan operating point. There is no corresponding curve for the low speed operating point.

Field: Energy Input Ratio Function of Temperature Curve Name

The name of a biquadratic performance curve (ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) as a function of the wet-bulb temperature of the air entering the cooling coil and the dry-bulb temperature of the air entering the air-cooled condenser (wet-bulb temperature if modeling an evaporative-cooled condenser). The EIR is the inverse of the COP. The output of this curve is multiplied by the rated EIR (inverse of rated COP) to give the EIR at specific temperature operating conditions (i.e., at temperatures different from the rating point temperatures). The curve is normalized to a value of 1.0 at the rating point. This curve is used for performance at the high speed compressor, high speed fan operating point.

Field: Energy Input Ratio Function of Flow Fraction Curve Name

The name of a quadratic performance curve (Ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) as a function of the ratio of actual air flow rate across the cooling coil to the rated air flow rate (i.e., fraction of full load flow). The EIR is the inverse of the COP. The output of this curve is multiplied by the rated EIR and the EIR modifier curve (function of temperature) to give the EIR at the specific temperature and air flow conditions at which the cooling coil is operating. This curve is normalized to a value of 1.0 when the actual air flow rate equals the rated air flow rate. This curve is applied only at the high speed compressor, high speed fan operating point. There is no corresponding curve for the low speed operating point.

Field: Part Load Fraction Correlation Curve Name

This alpha field defines the name of a quadratic or cubic performance curve (Ref: Performance Curves) that parameterizes the variation of electrical power input to the DX unit as a function of the part load ratio (PLR, sensible cooling load/steady-state sensible cooling capacity). The product of the rated EIR and EIR modifier curves is divided by the output of this curve to give the “effective” EIR for a given simulation timestep. The part load fraction (PLF) correlation accounts for efficiency losses due to compressor cycling.

The part load fraction correlation should be normalized to a value of 1.0 when the part load ratio equals 1.0 (i.e., no efficiency losses when the compressor(s) run continuously for the simulation timestep). For PLR values between 0 and 1 ($0 \leq \text{PLR} < 1$), the following rules apply:

$$\text{PLF} \geq 0.7 \quad \text{and} \quad \text{PLF} \geq \text{PLR}$$

If $\text{PLF} < 0.7$ a warning message is issued, the program resets the PLF value to 0.7, and the simulation proceeds. The runtime fraction of the coil is defined as PLR/PLF . If $\text{PLF} < \text{PLR}$, then a warning message is issued and the runtime fraction of the coil is limited to 1.0.

A typical part load fraction correlation for a conventional, single-speed DX cooling coil (e.g., residential unit) would be:

$$\text{PLF} = 0.85 + 0.15(\text{PLR})$$

If the user wishes to model no efficiency degradation due to compressor cycling, the part load fraction correlation should be defined as follows:

$$PLF = 1.0 + 0.0(PLR)$$

Field: Supply Air Fan Operating Mode

This input field is currently not used. The unit operates as a variable speed fan, variable speed compressor when above the low speed limit. Below the low speed limit, the unit cycles on / off.

Field: Rated Low Speed Total Cooling Capacity

The total, full load cooling capacity (sensible plus latent) in watts of the DX coil unit for low speed compressor and low speed fan at rated conditions (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb, and a cooling coil air flow rate defined by field “rated air volume flow rate, low speed” below). Capacity should be “gross” (i.e., supply air fan heat is NOT included).

Field: Rated Low Speed Sensible Heat Ratio

The sensible heat ratio (SHR=sensible capacity divided by total cooling capacity) of the DX cooling coil for low speed compressor and low speed fan at rated conditions (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb, and a cooling coil air flow rate defined by field “rated air volume flow rate, low speed” below). Both the sensible and total cooling capacities used to define the Rated SHR should be “gross” (i.e., supply air fan heat is NOT included).

Field: Rated Low Speed COP

The coefficient of performance (COP=cooling power output in watts divided by electrical power input in watts) of the DX cooling coil unit for low speed compressor and low speed fan at rated conditions (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb, and a cooling coil air flow rate defined by field “rated air volume flow rate, low speed” below). The input power includes power for the compressor(s) and condenser fan(s) but does not include the power consumption of the supply air fan. The cooling power output is the value entered above in the field “Rated Total Cooling Capacity (gross)”. If this input field is left blank, the default value is 3.0.

Field: Rated Low Speed Air Flow Rate

The low speed volume air flow rate, in m³ per second, across the DX cooling coil at rated conditions. The rated air volume flow rate should be between 0.00004027 m³/s and 0.00006041 m³/s per watt of rated total cooling capacity. The rated total cooling capacity, rated SHR and rated COP should be performance information for the unit with air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb, and the rated air volume flow rate defined here.

Field: Low Speed Total Cooling Capacity Function of Temperature Curve Name

The name of a biquadratic performance curve (ref: Performance Curves) that parameterizes the variation of the total cooling capacity as a function of the wet-bulb temperature of the air entering the cooling coil, and the dry-bulb temperature of the air entering the air-cooled condenser (wet-bulb temperature if modeling an evaporative-cooled condenser). The output of this curve is multiplied by the rated total cooling capacity to give the total cooling capacity at specific temperature operating conditions (i.e., at temperatures different from the rating point temperatures). The curve is normalized to have the value of 1.0 at the rating point. This curve is used for performance at the low speed compressor, low speed fan operating point.

Field: Low Speed Energy Input Ratio Function of Temperature Curve Name

The name of a biquadratic performance curve (ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) as a function of the wetbulb temperature of the air

entering the cooling coil and the drybulb temperature of the air entering the air-cooled condenser (wetbulb temperature if modeling an evaporative-cooled condenser). The EIR is the inverse of the COP. The output of this curve is multiplied by the rated EIR (inverse of rated COP) to give the EIR at specific temperature operating conditions (i.e., at temperatures different from the rating point temperatures). The curve is normalized to a value of 1.0 at the rating point. This curve is used for performance at the low speed compressor, low speed fan operating point.

Field: Condenser Air Inlet Node Name

This optional alpha field specifies the outdoor air node name used to define the conditions of the air entering the outdoor condenser. If this field is left blank, the outdoor air temperature entering the condenser (dry-bulb or wet-bulb) is taken directly from the weather data. If this field is not blank, the node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air temperature from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air temperature is taken directly from the weather data.

Field: Condenser Type

The type of condenser used by the multi-speed DX cooling coil. Valid choices for this input field are Air Cooled or Evap Cooled. The default for this field is Air Cooled.

Field: High Speed Evaporative Condenser Effectiveness

The effectiveness of the evaporative condenser at high compressor/fan speed, which is used to determine the temperature of the air entering the outdoor condenser coil as follows:

$$T_{cond\ inlet} = (T_{wb, o}) + (1 - EvapCondEffectiveness_{HighSpeed})(T_{db, o} - T_{wb, o})$$

where

$T_{cond\ inlet}$ = the temperature of the air entering the condenser coil (C)

$T_{wb, o}$ = the wet-bulb temperature of the outdoor air (C)

$T_{db, o}$ = the dry-bulb temperature of the outdoor air (C)

The resulting condenser inlet air temperature is used by the Total Cooling Capacity Modifier Curve (function of temperature) and the Energy Input Ratio Modifier Curve (function of temperature). The default value for this field is 0.9, although valid entries can range from 0.0 to 1.0. This field is not used when Condenser Type = Air Cooled.

If the user wants to model an air-cooled condenser, they should simply specify AirCooled in the field Condenser Type. In this case, the Total Cooling Capacity Modifier Curve (function of temperature) and the Energy Input Ratio Modifier Curve (function of temperature) input fields for this object should reference performance curves that are a function of outdoor dry-bulb temperature.

If the user wishes to model an evaporative-cooled condenser AND they have performance curves that are a function of the wet-bulb temperature of air entering the condenser coil, then the user should specify Condenser Type = Evap Cooled and the evaporative condenser effectiveness value should be entered as 1.0. In this case, the Total Cooling Capacity Modifier Curve (function of temperature) and the Energy Input Ratio Modifier Curve (function of temperature) input fields for this object should reference performance curves that are a function of the wet-bulb temperature of air entering the condenser coil.

If the user wishes to model an air-cooled condenser that has evaporative media placed in front of it to cool the air entering the condenser coil, then the user should specify Condenser Type = Evap Cooled. The user must also enter the appropriate evaporative effectiveness for the media. In this case, the Total Cooling Capacity Modifier Curve (function of temperature)

and the Energy Input Ratio Modifier Curve (function of temperature) input fields for this object should reference performance curves that are a function of outdoor dry-bulb temperature. Be aware that the evaporative media will significantly reduce the dry-bulb temperature of the air entering the condenser coil, so the Total Cooling Capacity and EIR Modifier Curves must be valid for the expected range of dry-bulb temperatures that will be entering the condenser coil.

Field: High Speed Evaporative Condenser Air Flow Rate

The air volume flow rate, in m³ per second, entering the evaporative condenser at high compressor/fan speed. This value is used to calculate the amount of water used to evaporatively cool the condenser inlet air. The minimum value for this field must be greater than zero, and this input field is autosizable (equivalent to 0.000144 m³/s per watt of rated high-speed total cooling capacity [850 cfm/ton]). This field is not used when Condenser Type = Air Cooled.

Field: High Speed Evaporative Condenser Pump Rated Power Consumption

The rated power of the evaporative condenser water pump in Watts at high compressor/fan speed. This value is used to calculate the power required to pump the water used to evaporatively cool the condenser inlet air. The default value for this input field is zero, but it is autosizable (equivalent to 0.004266 W per watt [15 W/ton] of rated high-speed total cooling capacity). This field is not used when Condenser Type = Air Cooled.

Field: Low Speed Evaporative Condenser Effectiveness

The effectiveness of the evaporative condenser at low compressor/fan speed, which is used to determine the temperature of the air entering the outdoor condenser coil as follows:

$$T_{cond\ inlet} = (T_{wb,o}) + (1 - EvapCondEffectiveness_{LowSpeed})(T_{db,o} - T_{wb,o})$$

where

$T_{cond\ inlet}$ = the temperature of the air entering the condenser coil (C)

$T_{wb,o}$ = the wet-bulb temperature of the outdoor air (C)

$T_{db,o}$ = the dry-bulb temperature of the outdoor air (C)

The resulting condenser inlet air temperature is used by the Total Cooling Capacity Modifier Curve, low speed (function of temperature) and the Energy Input Ratio Modifier Curve, low speed (function of temperature). The default value for this field is 0.9, although valid entries can range from 0.0 to 1.0. This field is not used when Condenser Type = Air Cooled. See field “Evaporative Condenser Effectiveness, High Speed” above for further information.

Field: Low Speed Evaporative Condenser Air Flow Rate

The air volume flow rate, in m³ per second, entering the evaporative condenser at low compressor/fan speed. This value is used to calculate the amount of water used to evaporatively cool the condenser inlet air. The minimum value for this field must be greater than zero, and this input field is autosizable (equivalent to 0.000048 m³/s per watt of rated high-speed total cooling capacity [280 cfm/ton]). This field is not used when Condenser Type = Air Cooled.

Field: Low Speed Evaporative Condenser Pump Rated Power Consumption

The rated power of the evaporative condenser water pump in Watts at low compressor/fan speed. This value is used to calculate the power required to pump the water used to evaporatively cool the condenser inlet air. The default value for this input field is zero, but it is autosizable (equivalent to 0.001422 W per watt [5 W/ton] of rated high-speed total capacity). This field is not used when Condenser Type = Air Cooled.

Field: Supply Water Storage Tank Name

This field is optional. It is used to describe where the coil obtains water used for evaporative cooling. If blank or omitted, then the cooler will obtain water directly from the mains. If the name of a Water Storage Tank object is used here, then the cooler will obtain its water from that tank. If a tank is specified, the coil will attempt to obtain all the water it uses from the tank. However if the tank cannot provide all the water the cooler needs, then the cooler will still operate and obtain the rest of the water it needs from the mains (referred to as StarvedWater).

Field: Condensate Collection Water Storage Tank Name

This field is optional. It is used to describe where condensate from the coil is collected. If blank or omitted, then any coil condensate is discarded. Enter the name of Water Storage Tank object defined elsewhere and the condensate will then be collected in that tank.

Below is the input data dictionary description for the object.

```
Coil: Cooling: DX: TwoSpeed,
  \min-fields 20
  A1 , \field Name
        \required-field
        \type alpha
        \reference CoolingCoilsDX
        \reference CoolingCoilsDXMultiSpeed
        \reference DesuperHeatingCoilSources
  A2 , \field Availability Schedule Name
        \required-field
        \type object-list
        \object-list ScheduleNames
  N1 , \field Rated High Speed Total Cooling Capacity
        \required-field
        \type real
        \units W
        \minimum> 0.0
        \autosizable
        \note gross capacity excluding supply air fan heat
        \note rating point: air entering the cooling coil at 26.7 C dry-bulb/19.4 C wet-bulb, and
        \note air entering the outdoor condenser coil at 35 C dry-bulb/23.9 C wet-bulb
  N2 , \field Rated High Speed Sensible Heat Ratio
        \required-field
        \type real
        \minimum 0.5
        \maximum 1.0
        \autosizable
        \note Rated sensible heat ratio (gross sensible capacity/gross total capacity)
        \note sensible and total capacities do not include supply fan heat
  N3 , \field Rated High Speed COP
        \type real
        \minimum> 0.0
        \default 3.0
        \note does not include supply fan heat or supply fan electrical energy input
  N4 , \field Rated High Speed Air Flow Rate
        \required-field
        \type real
        \units m3/s
        \minimum> 0.0
        \autosizable
        \note Flow rate corresponding to rated total cooling capacity, Rated SHR
        \note and Rated COP. Should be between 0.00004027 m3/s and .00006041 m3/s per watt
        \note of rated total cooling capacity.
  A3 , \field Air Inlet Node Name
        \required-field
        \type alpha
  A4 , \field Air Outlet Node Name
        \required-field
        \type alpha
```

```

A5 , \field Total Cooling Capacity Function of Temperature Curve Name
    \required-field
    \type object-list
    \object-list BiquadraticCurves
    \note curve =  $a + b*wb + c*wb**2 + d*edb + e*edb**2 + f*wb*edb$ 
    \note wb = entering wet-bulb temperature (C)
    \note edb = dry-bulb temperature seen by the condenser (C)
A6 , \field Total Cooling Capacity Function of Flow Fraction Curve Name
    \required-field
    \type object-list
    \object-list QuadraticCubicCurves
    \note quadratic curve =  $a + b*ff + c*ff**2$ 
    \note cubic curve =  $a + b*ff + c*ff**2 + d*ff**3$ 
    \note ff = fraction of the full load flow
A7 , \field Energy Input Ratio Function of Temperature Curve Name
    \required-field
    \type object-list
    \object-list BiquadraticCurves
    \note curve =  $a + b*wb + c*wb**2 + d*edb + e*edb**2 + f*wb*edb$ 
    \note wb = entering wet-bulb temperature (C)
    \note edb = dry-bulb temperature seen by the condenser (C)
A8 , \field Energy Input Ratio Function of Flow Fraction Curve Name
    \required-field
    \type object-list
    \object-list QuadraticCubicCurves
    \note quadratic curve =  $a + b*ff + c*ff**2$ 
    \note cubic curve =  $a + b*ff + c*ff**2 + d*ff**3$ 
    \note ff = fraction of the full load flow
A9 , \field Part Load Fraction Correlation Curve Name
    \required-field
    \type object-list
    \object-list QuadraticCubicCurves
    \note quadratic curve =  $a + b*PLR + c*PLR**2$ 
    \note cubic curve =  $a + b*PLR + c*PLR**2 + d*PLR**3$ 
    \note PLR = part load ratio (cooling load/steady-state capacity)
A10, \field Supply Air Fan Operating Mode
    \type choice
    \key CyclingFanAndCompressor
    \key ContinuousFanWithCyclingCompressor
    \key VariableSpeedFanAndCompressor
    \key VariableSpeedFanWithCompressorUnloading
    \default VariableSpeedFanAndCompressor
    \note This field is not used
N5 , \field Rated Low Speed Total Cooling Capacity
    \required-field
    \type real
    \units W
    \minimum> 0.0
    \autosizable
    \note gross capacity excluding supply air fan heat
    \note rating point: air entering the cooling coil at 26.7 C dry-bulb/19.4 C wet-bulb, and
    \note air entering the outdoor condenser coil at 35 C dry-bulb/23.9 C wet-bulb
N6 , \field Rated Low Speed Sensible Heat Ratio
    \required-field
    \type real
    \minimum 0.5
    \maximum 1.0
    \autosizable
    \note Rated sensible heat ratio (gross sensible capacity/gross total capacity)
    \note sensible and total capacities do not include supply fan heat
N7 , \field Rated Low Speed COP
    \type real
    \minimum> 0.0
    \default 3.0
    \note does not include supply fan heat or supply fan electrical energy input

```

```

N8 , \field Rated Low Speed Air Flow Rate
    \required-field
    \type real
    \units m3/s
    \minimum> 0.0
    \autosizable
    \note Flow rate corresponding to rated total cooling capacity, Rated SHR
    \note and Rated COP. Should be between 0.00004027 m3/s and .00006041 m3/s per watt
    \note of rated total cooling capacity.
A11, \field Low Speed Total Cooling Capacity Function of Temperature Curve Name
    \required-field
    \type object-list
    \object-list BiquadraticCurves
    \note curve = a + b*wb + c*wb**2 + d*edb + e*edb**2 + f*wb*edb
    \note wb = entering wet-bulb temperature (C)
    \note edb = dry-bulb temperature seen by the condenser (C)
A12, \field Low Speed Energy Input Ratio Function of Temperature Curve Name
    \required-field
    \type object-list
    \object-list BiquadraticCurves
    \note curve = a + b*wb + c*wb**2 + d*edb + e*edb**2 + f*wb*edb
    \note wb = entering wet-bulb temperature (C)
    \note edb = dry-bulb temperature seen by the condenser (C)
A13, \field Condenser Air Inlet Node Name
    \type alpha
    \note Enter the name of an outdoor air node. This node name is also specified in
    \note an OutdoorAir:Node or OutdoorAir:NodeList object.
A14, \field Condenser Type
    \type choice
    \key AirCooled
    \key EvaporativelyCooled
    \default AirCooled
N9, \field High Speed Evaporative Condenser Effectiveness
    \type real
    \units dimensionless
    \minimum 0.0
    \maximum 1.0
    \default 0.9
N10, \field High Speed Evaporative Condenser Air Flow Rate
    \type real
    \units m3/s
    \minimum> 0.0
    \autosizable
    \note Used to calculate evaporative condenser water use
N11, \field High Speed Evaporative Condenser Pump Rated Power Consumption
    \type real
    \units W
    \minimum 0.0
    \autosizable
    \note Rated power consumed by the evaporative condenser's water pump at high speed
N12, \field Low Speed Evaporative Condenser Effectiveness
    \type real
    \units dimensionless
    \minimum 0.0
    \maximum 1.0
    \default 0.9
N13, \field Low Speed Evaporative Condenser Air Flow Rate
    \type real
    \units m3/s
    \minimum> 0.0
    \autosizable
    \note Used to calculate evaporative condenser water use
N14, \field Low Speed Evaporative Condenser Pump Rated Power Consumption
    \type real
    \units W
    \minimum 0.0
    \autosizable
    \note Rated power consumed by the evaporative condenser's water pump at low speed
A15, \field Supply Water Storage Tank Name
    \type object-list
    \object-list WaterStorageTankNames

```



```
A16; \field Condensate Collection Water Storage Tank Name
      \type object-list
      \object-list WaterStorageTankName
```

Following is an example input for a MultiSpeed:CoolingEmpirical DX coil.

```
Coil:Cooling:DX:TwoSpeed,
  Main Cooling Coil 1,      !- Name
  CoolingCoilAvailSched,   !- Availability Schedule Name
  autosize,                !- Rated High Speed Total Cooling Capacity {W}
  0.68,                   !- Rated High Speed Sensible Heat Ratio
  3.0,                    !- Rated High Speed COP
  autosize,                !- Rated High Speed Air Flow Rate {m3/s}
  Mixed Air Node 1,       !- Air Inlet Node Name
  Main Cooling Coil 1 Outlet Node, !- Air Outlet Node Name
  VarSpeedCoolCapFT,      !- Total Cooling Capacity Function of Temperature Curve Name
  PackagedRatedCoolCapFFlow, !- Total Cooling Capacity Function of Flow Fraction Curve Name
  VarSpeedCoolEIRFT,     !- Energy Input Ratio Function of Temperature Curve Name
  PackagedRatedCoolEIRFFlow, !- Energy Input Ratio Function of Flow Fraction Curve Name
  VarSpeedCyclingPLFFPLR, !- Part Load Fraction Correlation Curve Name
  VariableSpeedFanAndCompressor, !- Supply Air Fan Operating Mode
  autosize,                !- Rated Low Speed Total Cooling Capacity {W}
  0.69,                   !- Rated Low Speed Sensible Heat Ratio
  4.2,                    !- Rated Low Speed COP
  autosize,                !- Rated Low Speed Air Flow Rate {m3/s}
  VarSpeedCoolCapLSFT,    !- Low Speed Total Cooling Capacity Function of Temperature Curve Name
  VarSpeedCoolEIRLSFT,    !- Low Speed Energy Input Ratio Function of Temperature Curve Name
  Main Cooling Coil 1 Condenser Node; !- Condenser Air Inlet Node Name
```

Coil:Cooling:DX:TwoStageWithHumidityControlMode

The multimode DX coil is functionally equivalent to Coil:DX:Cooling:SingleSpeed but with multiple performance modes. It is capable of modeling two-stage DX units and units with an enhanced dehumidification mode such as coil bypass or subcool reheat. This object contains one-time specifications for the DX unit such as node names and crankcase heater specifications. It references one or more CoilPerformance:DX:CoolingBypassFactorEmpirical objects which define the performance for each mode of operation. It can have up to 4 performance modes to accommodate a 2-stage 2-mode unit. The multimode DX coil can be used only as a component of DXSystem:Airloop or UnitarySystem:VAV:ChangeoverBypass (parent object). These parent objects pass a load and dehumidification mode to this coil. If the coil has 2 capacity stages, the multimode coil model determines the stage sequencing.

Field: Name

A unique user-assigned name for an instance of a DX cooling coil. Any reference to this DX coil by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the DX cooling coil can run during a given time period. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during a given time period. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off.

Field: Air Inlet Node Name

The name of the HVAC system node from which the DX cooling coil draws its inlet air.

Field: Air Outlet Node Name

The name of the HVAC system node to which the DX cooling coil sends its outlet air.

Field: Crankcase Heater Capacity

This numeric field defines the crankcase heater capacity in Watts. When the outdoor air dry-bulb temperature is below the value specified in the input field “Maximum Outdoor Dry-bulb Temperature for Crankcase Heater Operation” (described below), the crankcase heater is enabled during the time that the compressor is not running. If this cooling coil is used as part of an air-to-air heat pump (Ref. AirLoopHVAC:UnitaryHeatCool:VAVChangeoverBypass), the crankcase heater defined for this DX cooling coil is ignored and the crankcase heater power defined for the DX heating coil (Ref. Coil:Heating:DX:SingleSpeed) is enabled during the time that the compressor is not running for either heating or cooling. The value for this input field must be greater than or equal to 0, and the default value is 0. To simulate a DX cooling coil without a crankcase heater, enter a value of 0.

Field: Maximum Outdoor Dry-Bulb Temperature for Crankcase Heater Operation

This numeric field defines the outdoor air dry-bulb temperature above which the compressor's crankcase heater is disabled. The value for this input field must be greater than or equal to 0.0°C, and the default value is 10°C.

Field: Number of Capacity Stages

This integer field defines the number of capacity stages. The value for this input field must be greater 1 or 2, and the default value is 1. Larger DX units often have two capacity stages, which are often two completely independent compressor/coil circuits with the evaporator coils arranged in parallel in the supply air stream. 2-stage operation affects cycling losses and latent degradation due to re-evaporation of moisture with continuous fan operation.

Field: Number of Enhanced Dehumidification Modes

This integer field defines the number of enhanced dehumidification modes available. The value for this input field must be 0 or 1, and the default value is 0. If the DX unit can switch operating modes to increase dehumidification based on a humidistat signal, then set this to 1. This field just specified the availability of enhanced dehumidification. Actual control of the operating mode is handled by the coil's parent component.

Field: Normal Mode Stage 1 Coil Performance Object Type**Field: Normal Mode Stage 1 Coil Performance Object Name**

This pair of fields specifies the object type and name for the coil performance object which specifies the DX coil performance for stage 1 operation without enhanced dehumidification (normal mode). The only valid performance object type is CoilPerformance:DX:Cooling.

Field: Normal Mode Stage 1+2 Coil Performance Object Type**Field: Normal Mode Stage 1+2 Coil Performance Object Name**

This pair of fields specifies the object type and name for the coil performance object which specifies the DX coil performance for stage 1+2 operation (both stages active) without enhanced dehumidification (normal mode). The only valid performance object type is CoilPerformance:DX:Cooling.

Field: Dehumidification Mode 1 Stage 1 Coil Performance Object Type**Field: Dehumidification Mode 1 Stage 1 Coil Performance Object Name**

This pair of fields specifies the object type and name for the coil performance object which specifies the DX coil performance for stage 1 operation with enhanced dehumidification active. The only valid performance object type is CoilPerformance:DX:Cooling.

Field: Dehumidification Mode 1 Stage 1+2 Coil Performance Object Type**Field: Dehumidification Mode 1 Stage 1+2 Coil Performance Object Name**

This pair of fields specifies the object type and name for the coil performance object which specifies the DX coil performance for stage 1+2 operation (both stages active) with enhanced dehumidification active. The only valid performance object type is CoilPerformance:DX:Cooling.

Field: Supply Water Storage Tank Name

This field is optional. It is used to describe where the coil obtains water used for evaporative cooling. If blank or omitted, then the cooler will obtain water directly from the mains. If the name of a Water Storage Tank object is used here, then the cooler will obtain its water from that tank. If a tank is specified, the coil will attempt to obtain all the water it uses from the tank. However if the tank cannot provide all the water the cooler needs, then the cooler will still operate and obtain the rest of the water it needs from the mains (referred to as StarvedWater).

Field: Condensate Collection Water Storage Tank Name

This field is optional. It is used to describe where condensate from the coil is collected. If blank or omitted, then any coil condensate is discarded. Enter the name of Water Storage Tank object defined elsewhere and the condensate will then be collected in that tank.

Below is the input data dictionary description for the object.

```
Coil: Cooling: DX: TwoStageWithHumidityControlMode,
  \min-fields 10
  \memo This coil object models a DX coil which has multiple modes of operation.
  \memo For example, a coil with optional sub-cool or hot gas reheat which
  \memo is switched on or off depending on dehumidification requirements.
  \memo The meaning of each mode is defined by the controlling object.
A1 , \field Name
    \required-field
    \type alpha
    \reference CoolingCoilsDX
    \reference CoolingCoilsDXMultiMode
    \reference DesuperHeatingCoilSources
A2 , \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A3 , \field Air Inlet Node Name
    \required-field
    \type alpha
A4 , \field Air Outlet Node Name
    \required-field
    \type alpha
N1 , \field Crankcase Heater Capacity
    \type real
    \minimum 0.0
    \default 0.0
    \units W
    \ip-units W
N2 , \field Maximum Outdoor Dry-Bulb Temperature for Crankcase Heater Operation
    \type real
    \minimum 0.0
    \default 10.0
    \units C
```

```

N3 , \field Number of Capacity Stages
    \type integer
    \minimum 1
    \maximum 2
    \default 1
N4 , \field Number of Enhanced Dehumidification Modes
    \type integer
    \minimum 0
    \maximum 1
    \default 0
A5 , \field Normal Mode Stage 1 Coil Performance Object Type
    \required-field
    \type choice
    \key CoilPerformance:DX:Cooling
A6 , \field Normal Mode Stage 1 Coil Performance Name
    \required-field
    \type object-list
    \object-list CoilPerformanceDX
A7 , \field Normal Mode Stage 1+2 Coil Performance Object Type
    \type choice
    \key CoilPerformance:DX:Cooling
A8 , \field Normal Mode Stage 1+2 Coil Performance Name
    \type object-list
    \object-list CoilPerformanceDX
A9 , \field Dehumidification Mode 1 Stage 1 Coil Performance Object Type
    \type choice
    \key CoilPerformance:DX:Cooling
A10, \field Dehumidification Mode 1 Stage 1 Coil Performance Name
    \type object-list
    \object-list CoilPerformanceDX
A11, \field Dehumidification Mode 1 Stage 1+2 Coil Performance Object Type
    \type choice
    \key CoilPerformance:DX:Cooling
A12, \field Dehumidification Mode 1 Stage 1+2 Coil Performance Name
    \type object-list
    \object-list CoilPerformanceDX
A13, \field Supply Water Storage Tank Name
    \type object-list
    \object-list WaterStorageTankNames
A14, \field Condensate Collection Water Storage Tank Name
    \type object-list
    \object-list WaterStorageTankNames

```

CoilPerformance:DX:Cooling

This coil performance object is used to specify DX coil performance for one mode of operation for a Coil:Cooling:DX:TwoStageWithHumidityControlMode. A single Coil:Cooling:DX:TwoStageWithHumidityControlMode object will reference one to four CoilPerformance:DX:Cooling objects depending on the number of available stages and dehumidification modes as specified in the two stage DX object. For example, a standard 2-stage DX system will use two of these performance objects, one to defined the capacity and performance for stage 1 operation, and a second one for stage 1+2 (both stages active) operation. In nearly all cases, the Rated Air Volume Flow Rate will be the same for all performance objects associated with a given multimode DX coil. If bypass is specified, the Rated Air Volume Flow Rate includes both the bypassed flow and the flow through the active coil.

This DX coil model is identical to Coil:DX:Cooling:SingleSpeed with addition of bypass and multi-stage capabilities. This DX cooling coil model and input are quite different from that for the heating and cooling water coils. The simple water coils use an NTU-effectiveness heat exchanger model. The single speed DX coil model uses performance information at rated conditions along with curve fits for variations in total capacity, energy input ratio and part-load fraction to determine performance at part-load conditions. Sensible/latent capacity splits are determined by the rated sensible heat ratio (SHR) and the apparatus dewpoint/bypass factor (ADP/BF) approach. This approach is analogous to the NTU-effectiveness calculations used for sensible-only heat exchanger calculations, extended to a cooling and dehumidifying coil.

The DX cooling coil input requires the rated total cooling capacity, the rated SHR, the rated COP, the rated air volume flow rate, and the fraction of air flow which is bypassed around the coil. The first 4 inputs determine the coil performance at the rating point (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb and air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb). The rated air volume flow rate (less any bypassed fraction) should be between .00004027 m³/s and .00006041 m³/s per watt of rated total cooling capacity (300 to 450 cfm/ton).

This model requires 5 curves as follows:

1. The total cooling capacity modifier curve (function of temperature) is a biquadratic curve with two independent variables: wet-bulb temperature of the air entering the cooling coil, and dry-bulb temperature of the air entering the air-cooled condenser coil (wet-bulb temperature if modeling an evaporative-cooled condenser). The output of this curve is multiplied by the rated total cooling capacity to give the total cooling capacity at specific temperature operating conditions (i.e., at temperatures different from the rating point temperatures).
2. The total cooling capacity modifier curve (function of flow fraction) is a quadratic or cubic curve with the independent variable being the ratio of the actual air flow rate across the cooling coil to the rated air flow rate (i.e., fraction of full load flow). The output of this curve is multiplied by the rated total cooling capacity and the total cooling capacity modifier curve (function of temperature) to give the total cooling capacity at the specific temperature and air flow conditions at which the coil is operating.
3. The energy input ratio (EIR) modifier curve (function of temperature) is a biquadratic curve with two independent variables: wet-bulb temperature of the air entering the cooling coil, and dry-bulb temperature of the air entering the air-cooled condenser coil (wet-bulb temperature if modeling an evaporative-cooled condenser). The output of this curve is multiplied by the rated EIR (inverse of the rated COP) to give the EIR at specific temperature operating conditions (i.e., at temperatures different from the rating point temperatures).
4. The energy input ratio (EIR) modifier curve (function of flow fraction) is a quadratic or cubic curve with the independent variable being the ratio of the actual air flow rate across the cooling coil to the rated air flow rate (i.e., fraction of full load flow). The output of this curve is multiplied by the rated EIR (inverse of the rated COP) and the EIR modifier curve (function of temperature) to give the EIR at the specific temperature and air flow conditions at which the coil is operating.
5. The part load fraction correlation (function of part load ratio) is a quadratic or cubic curve with the independent variable being part load ratio (sensible cooling load / steady-state sensible cooling capacity). The output of this curve is used in combination with the rated EIR and EIR modifier curves to give the “effective” EIR for a given simulation timestep. The part load fraction (PLF) correlation accounts for efficiency losses due to compressor cycling. The curve should be normalized to a value of 1.0 when the part-load ratio equals 1.0 (i.e., the compressor(s) run continuously for the simulation timestep).

The curves are simply specified by name. Curve inputs are described in the curve manager section of this document (see Performance Curves in this document).

The next input item for this DX cooling coil object is the supply air fan operation mode. Either the supply air fan runs continuously while the DX coil cycles on/off (ContinuousFanWithCyclingCompressor), or the fan and coil cycle on/off together (CyclingFanAndCompressor).

The next four input fields are optional and relate to the degradation of latent cooling capacity when the supply air fan operates continuously while the cooling coil/compressor cycle on and off to meet the cooling load. The field Supply Air Fan Operation Mode must be “ContinuousFanWithCyclingCompressor” and these next four input fields must have positive values in order to model latent capacity degradation.

The next input specifies the outdoor air node used to define the conditions of the air entering the outdoor condenser. If this field is not blank, the node name specified must be listed in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor temperature from the weather data. Alternately, the node name must be specified in an OutdoorAir:NodeList object where the outdoor temperature entering the condenser is taken directly from the weather data. This field may also be left blank, if this is the case then the outdoor temperature entering the condenser is taken directly from the weather data.

The next input describes the type of outdoor condenser coil used with the DX cooling coil (Air Cooled or Evap Cooled). The following three inputs are required when modeling an evaporative-cooled condenser: evaporative condenser effectiveness, evaporative condenser air volume flow rate, and the power consumed by the evaporative condenser pump. See section “DX Cooling Coil Model” in the EnergyPlus Engineering Document for further details regarding this model.

Field: Name

This alpha field is a unique user-assigned name for an instance of DX cooling coil performance. Any reference to this DX coil performance object by another object will use this name.

Field: Rated Total Cooling Capacity

The total, full load cooling capacity (sensible plus latent) in watts of the DX coil unit at rated conditions (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb¹¹, and a cooling coil air flow rate defined by field “rated air volume flow rate” below). Capacity should be “gross” (i.e., supply air fan heat is NOT included).

Field: Rated Sensible Heat Ratio

The sensible heat ratio (SHR=sensible capacity divided by total cooling capacity) of the DX cooling coil at rated conditions (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb, and a cooling coil air flow rate defined by field “rated air volume flow rate” below). Both the sensible and total cooling capacities used to define the Rated SHR should be “gross” (i.e., supply air fan heat is NOT included).

Field: Rated COP

The coefficient of performance (COP=cooling power output in watts divided by electrical power input in watts) of the DX cooling coil unit at rated conditions (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/ 23.9°C wetbulb, and a cooling coil air flow rate defined by field “rated air volume flow rate” below). The input power includes electric power for the compressor(s) and condenser fan(s) but does not include the power consumption of the supply air fan. The cooling power output is the value entered above in the field “Rated Total Cooling Capacity (gross)”. If this input field is left blank, the default value is 3.0.

Field: Rated Air Flow Rate

The air volume flow rate, in m³ per second, across the DX cooling coil at rated conditions. The rated total cooling capacity, rated SHR and rated COP should be performance information for the unit with air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb, and the rated air volume flow rate defined here.

¹¹ The 23.9°C wet-bulb temperature condition is not applicable for air-cooled condensers which do not evaporate condensate.

Field: Fraction of Air Flow Bypassed Around Coil

This numeric field specifies the fraction of the Rated Air Volume Flow Rate which bypasses the active cooling coil for this performance mode. The remaining portion of the flow should be between 0.00004027 m³/s and .00006041 m³/s per watt of rated total cooling capacity (300 to 450 cfm/ton) for this performance mode. This is used to model face-split coils on multi-stage units or bypass dampers. If total flow rate varies during simulation, the same fraction is bypassed. This input may range from 0.0 to <1.0. The default is 0.0. For a multi-stage face-split coil in which stage 1 is 60% of total capacity, this field would be set to 0.4 for the Stage 1 performance and set to 0.0 for the Stage 1+2 performance. For a DX system which activates a bypass damper for improved dehumidification, this field would be set to 0.0 for normal mode performance and set to something greater than zero for enhanced dehumidification mode performance.

Field: Total Cooling Capacity Function of Temperature Curve Name

The name of a **biquadratic** performance curve (ref: Performance Curves) that parameterizes the variation of the total cooling capacity as a function of the wet-bulb temperature of the air entering the cooling coil, and the dry-bulb temperature of the air entering the air-cooled condenser coil (wet-bulb temperature if modeling an evaporative-cooled condenser). The output of this curve is multiplied by the rated total cooling capacity to give the total cooling capacity at specific temperature operating conditions (i.e., at temperatures different from the rating point temperatures). The curve is normalized to have the value of 1.0 at the rating point.

Field: Total Cooling Capacity Function of Flow Fraction Curve Name

The name of a **quadratic** or **cubic** performance curve (ref: Performance Curves) that parameterizes the variation of total cooling capacity as a function of the ratio of actual air flow rate across the cooling coil to the rated air flow rate (i.e., fraction of full load flow). The output of this curve is multiplied by the rated total cooling capacity and the total cooling capacity modifier curve (function of temperature) to give the total cooling capacity at the specific temperature and air flow conditions at which the coil is operating. The curve is normalized to have the value of 1.0 when the actual air flow rate equals the rated air flow rate.

Field: Energy Input Ratio Function of Temperature Curve Name

The name of a **biquadratic** performance curve (ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) as a function of the wet-bulb temperature of the air entering the cooling coil, and the dry-bulb temperature of the air entering the air-cooled condenser coil (wet-bulb temperature if modeling an evaporative-cooled condenser). The EIR is the inverse of the COP. The output of this curve is multiplied by the rated EIR (inverse of rated COP) to give the EIR at specific temperature operating conditions (i.e., at temperatures different from the rating point temperatures). The curve is normalized to a value of 1.0 at the rating point.

Field: Energy Input Ratio Function of Flow Fraction Curve Name

The name of a **quadratic** or **cubic** performance curve (Ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) as a function of the ratio of actual air flow rate across the cooling coil to the rated air flow rate (i.e., fraction of full load flow). The EIR is the inverse of the COP. The output of this curve is multiplied by the rated EIR and the EIR modifier curve (function of temperature) to give the EIR at the specific temperature and air flow conditions at which the cooling coil is operating. This curve is normalized to a value of 1.0 when the actual air flow rate equals the rated air flow rate.

Field: Part Load Fraction Correlation Curve Name

This alpha field defines the name of a **quadratic** or **cubic** performance curve (Ref: Performance Curves) that parameterizes the variation of electrical power input to the DX unit as a function of the part load ratio (PLR, sensible cooling load/steady-state sensible cooling

capacity). The product of the rated EIR and EIR modifier curves is divided by the output of this curve to give the “effective” EIR for a given simulation timestep. The part load fraction (PLF) correlation accounts for efficiency losses due to compressor cycling.

The part load fraction correlation should be normalized to a value of 1.0 when the part load ratio equals 1.0 (i.e., no efficiency losses when the compressor(s) run continuously for the simulation timestep). For PLR values between 0 and 1 ($0 \leq \text{PLR} < 1$), the following rules apply:

$$\text{PLF} \geq 0.7 \quad \text{and} \quad \text{PLF} \geq \text{PLR}$$

If $\text{PLF} < 0.7$ a warning message is issued, the program resets the PLF value to 0.7, and the simulation proceeds. The runtime fraction of the coil is defined as PLR/PLF . If $\text{PLF} < \text{PLR}$, then a warning message is issued and the runtime fraction of the coil is limited to 1.0.

A typical part load fraction correlation for a conventional, single-speed DX cooling coil (e.g., residential unit) would be:

$$\text{PLF} = 0.85 + 0.15(\text{PLR})$$

If the user wishes to model no efficiency degradation due to compressor cycling, the part load fraction correlation should be defined as follows:

$$\text{PLF} = 1.0 + 0.0(\text{PLR})$$

Field: Supply Air Fan Operation Mode

This input field has two choices: `CyclingFanAndCompressor` or `ContinuousFanWithCyclingCompressor`. The first choice stands for “cycling fan cycling compressor”. This means that the unit unloads by cycling both the fan and compressor; that is, both the supply air fan and the DX coil unit compressor cycle on and off together to meet the load. The second choice stands for “continuous fan cycling compressor”. The supply air fan runs continuously while the DX coil unit compressor cycles.

Field: Nominal Time for Condensate Removal to Begin

The nominal time (in seconds) after startup for condensate to begin leaving the coil's condensate drain line at the coil's rated airflow and temperature conditions, starting with a dry coil. Nominal time is equal to the ratio of the energy of the coil's maximum condensate holding capacity (J) to the coil's steady-state latent capacity (W). Suggested value is 1000; zero value means the latent degradation model is disabled. The default value for this field is zero. The field `Supply Air Fan Operation Mode` must be “`ContinuousFanWithCyclingCompressor`”, and this field as well as the next three input fields for this object must have positive values in order to model latent capacity degradation.

Field: Ratio of Initial Moisture Evaporation Rate and Steady State Latent Capacity

Ratio of the initial moisture evaporation rate from the cooling coil (when the compressor first turns off, in Watts) and the coil's steady-state latent capacity (Watts) at rated airflow and temperature conditions. Suggested value is 1.5; zero value means the latent degradation model is disabled. The default value for this field is zero. The field `Supply Air Fan Operation Mode` must be “`ContinuousFanWithCyclingCompressor`”; and this field, the previous field and the next two fields must have positive values in order to model latent capacity degradation.

Field: Maximum Cycling Rate

The maximum on-off cycling rate for the compressor (cycles per hour), which occurs at 50% run time fraction. Suggested value is 3; zero value means latent degradation model is disabled. The default value for this field is zero. The field `Supply Air Fan Operation Mode` must be “`ContinuousFanWithCyclingCompressor`”; and this field, the previous two fields and the next field must have positive values in order to model latent capacity degradation.

Field: Latent Capacity Time Constant

Time constant (in seconds) for the cooling coil's latent capacity to reach steady state after startup. Suggested value is 45; zero value means latent degradation model is disabled. The

default value for this field is zero. The field Supply Air Fan Operation Mode must be “ContinuousFanWithCyclingCompressor”, and this field as well as the previous three input fields for this object must have positive values in order to model latent capacity degradation.

Field: Condenser Air Inlet Node Name

This optional alpha field specifies the outdoor air node name used to define the conditions of the air entering the outdoor condenser. If this field is left blank, the outdoor air temperature entering the condenser (dry-bulb or wet-bulb) is taken directly from the weather data. If this field is not blank, the node name specified must also be specified in an OutdoorAir:Node object where the height of the node is taken into consideration when calculating outdoor air temperature from the weather data. Alternately, the node name may be specified in an OutdoorAir:NodeList object where the outdoor air temperature is taken directly from the weather data.

Field: Condenser Type

The type of condenser used by the DX cooling coil. Valid choices for this input field are **AirCooled** or **EvaporativelyCooled**. The default for this field is **AirCooled**.

Field: Evaporative Condenser Effectiveness

The effectiveness of the evaporative condenser, which is used to determine the temperature of the air entering the outdoor condenser coil as follows:

$$T_{cond\ inlet} = (T_{wb, o}) + (1 - EvapCondEffectiveness)(T_{db, o} - T_{wb, o})$$

where

$T_{cond\ inlet}$ = the temperature of the air entering the condenser coil (C)

$T_{wb, o}$ = the wet-bulb temperature of the outdoor air (C)

$T_{db, o}$ = the dry-bulb temperature of the outdoor air (C)

The resulting condenser inlet air temperature is used by the Total Cooling Capacity Modifier Curve (function of temperature) and the Energy Input Ratio Modifier Curve (function of temperature). The default value for this field is 0.9, although valid entries can range from 0.0 to 1.0. This field is not used when Condenser Type = Air Cooled.

If the user wants to model an air-cooled condenser, they should simply specify AirCooled in the field Condenser Type. In this case, the Total Cooling Capacity Modifier Curve (function of temperature) and the Energy Input Ratio Modifier Curve (function of temperature) input fields for this object should reference performance curves that are a function of outdoor dry-bulb temperature.

If the user wishes to model an evaporative-cooled condenser AND they have performance curves that are a function of the wet-bulb temperature of air entering the condenser coil, then the user should specify Condenser Type = Evap Cooled and the evaporative condenser effectiveness value should be entered as 1.0. In this case, the Total Cooling Capacity Modifier Curve (function of temperature) and the Energy Input Ratio Modifier Curve (function of temperature) input fields for this object should reference performance curves that are a function of the wet-bulb temperature of air entering the condenser coil.

If the user wishes to model an air-cooled condenser that has evaporative media placed in front of it to cool the air entering the condenser coil, then the user should specify Condenser Type = Evap Cooled. The user must also enter the appropriate evaporative effectiveness for the media. In this case, the Total Cooling Capacity Modifier Curve (function of temperature) and the Energy Input Ratio Modifier Curve (function of temperature) input fields for this object should reference performance curves that are a function of outdoor dry-bulb temperature. Be aware that the evaporative media will significantly reduce the dry-bulb temperature of the air

entering the condenser coil, so the Total Cooling Capacity and EIR Modifier Curves must be valid for the expected range of dry-bulb temperatures that will be entering the condenser coil.

Field: Evaporative Condenser Air Flow Rate

The air volume flow rate, in m³ per second, entering the evaporative condenser. This value is used to calculate the amount of water used to evaporatively cool the condenser inlet air. The minimum value for this field must be greater than zero, and this input field is autosizable (equivalent to 0.000144 m³/s per watt of rated total cooling capacity [850 cfm/ton]). This field is not used when Condenser Type = Air Cooled.

Field: Evaporative Condenser Pump Rated Power Consumption

The rated power of the evaporative condenser water pump in Watts. This value is used to calculate the power required to pump the water used to evaporatively cool the condenser inlet air. The default value for this input field is zero, but it is autosizable (equivalent to 0.004266 W per watt [15 W/ton] of rated total cooling capacity). This field is not used when Condenser Type = AirCooled.

Below is the input data dictionary description for the object.

```
CoilPerformance:DX:Cooling,
  \min-fields 12
  A1 , \field Name
    \required-field
    \type alpha
    \reference CoilPerformanceDX
  N1 , \field Rated Total Cooling Capacity
    \required-field
    \type real
    \units W
    \minimum> 0.0
    \autosizable
    \note gross capacity excluding supply air fan heat
    \note rating point: air entering the cooling coil at 26.7 C dry-bulb/19.4 C wet-bulb, and
    \note air entering the outdoor condenser coil at 35 C dry-bulb/23.9 C wet-bulb
  N2 , \field Rated Sensible Heat Ratio
    \required-field
    \type real
    \minimum 0.5
    \maximum 1.0
    \autosizable
    \note Rated sensible heat ratio (gross sensible capacity/gross total capacity)
    \note sensible and total capacities do not include supply fan heat
  N3 , \field Rated COP
    \type real
    \minimum> 0.0
    \default 3.0
    \note does not include supply fan heat or supply fan electrical energy input
  N4 , \field Rated Air Flow Rate
    \required-field
    \type real
    \units m3/s
    \minimum> 0.0
    \autosizable
    \note Flow rate corresponding to Rated total Cooling capacity, Rated SHR and Rated COP
```

```

N5 , \field Fraction of Air Flow Bypassed Around Coil
    \type real
    \minimum 0.0
    \maximum 1.0
    \default 0.0
    \note Fraction of Rated Air Flow Rate which bypasses the cooling coil
    \note in this performance mode. The remaining portion of the flow
    \note should be between 0.00004027 m3/s and .00006041 m3/s per watt of rated total cooling
capacity.
    \note This is used to model face-split coils on multi-stage units or bypass dampers.
    \note If total flow rate varies during simulation, the same fraction is bypassed.
A2 , \field Total Cooling Capacity Function of Temperature Curve Name
    \required-field
    \type object-list
    \object-list BiquadraticCurves
    \note curve = a + b*wb + c*wb**2 + d*edb + e*edb**2 + f*wb*edb
    \note wb = entering wet-bulb temperature (C)
    \note edb = dry-bulb temperature seen by the condenser (C)
A3 , \field Total Cooling Capacity Function of Flow Fraction Curve Name
    \required-field
    \type object-list
    \object-list QuadraticCubicCurves
    \note quadratic curve = a + b*ff + c*ff**2
    \note cubic curve = a + b*ff + c*ff**2 + d*ff**3
    \note ff = fraction of the full load flow
A4 , \field Energy Input Ratio Function of Temperature Curve Name
    \required-field
    \type object-list
    \object-list BiquadraticCurves
    \note curve = a + b*wb + c*wb**2 + d*edb + e*edb**2 + f*wb*edb
    \note wb = entering wet-bulb temperature (C)
    \note edb = dry-bulb temperature seen by the condenser (C)
A5 , \field Energy Input Ratio Function of Flow Fraction Curve Name
    \required-field
    \type object-list
    \object-list QuadraticCubicCurves
    \note quadratic curve = a + b*ff + c*ff**2
    \note cubic curve = a + b*ff + c*ff**2 + d*ff**3
    \note ff = fraction of the full load flow
A6 , \field Cooling Capacity Function of Temperature Curve Name
    \required-field
    \type object-list
    \object-list QuadraticCubicCurves
    \note quadratic curve = a + b*PLR + c*PLR**2
    \note cubic curve = a + b*PLR + c*PLR**2 + d*PLR**3
    \note PLR = part load ratio (cooling load/steady-state capacity)
A7 , \field Supply Air Fan Operating Mode
    \required-field
    \type choice
    \key CyclingFanAndCompressor
    \key ContinuousFanWithCyclingCompressor
N6 , \field Nominal Time for Condensate Removal to Begin
    \type real
    \units s
    \minimum 0.0
    \maximum 3000.0
    \default 0.0
    \note The nominal time for condensate to begin leaving the coil's condensate
    \note drain line at the coil's rated air flow rate and temperature conditions.
    \note Nominal time is equal to the ratio of the energy of the coil's maximum
    \note condensate holding capacity (J) to the coil's steady-state latent capacity (W).
    \note Suggested value is 1000; zero value means latent degradation model is disabled.

```

```

N7 , \field Ratio of Initial Moisture Evaporation Rate and Steady State Latent Capacity
    \type real
    \units dimensionless
    \minimum 0.0
    \maximum 5.0
    \default 0.0
    \note Ratio of the initial moisture evaporation rate from the cooling coil (when
    \note the compressor first turns off) and the coil's steady-state latent capacity
    \note at rated air flow rate and temperature conditions. Suggested value is 1.5; zero value
    \note means latent degradation model is disabled.
N8 , \field Maximum Cycling Rate
    \type real
    \units cycles/hr
    \minimum 0.0
    \maximum 5.0
    \default 0.0
    \note The maximum on-off cycling rate for the compressor, which occurs at 50% run time
    \note fraction. Suggested value is 3; zero value means latent degradation model is disabled.
N9 , \field Latent Capacity Time Constant
    \type real
    \units s
    \minimum 0.0
    \maximum 500.0
    \default 0.0
    \note Time constant for the cooling coil's latent capacity to reach steady state after
    \note startup. Suggested value is 45; zero value means latent degradation model is disabled.
A8 , \field Condenser Air Inlet Node Name
    \type alpha
    \note Enter the name of an outdoor air node. This node name is also specified in
    \note an OutdoorAir:Node or OutdoorAir:NodeList object.
A9 , \field Condenser Type
    \type choice
    \key AirCooled
    \key EvaporativelyCooled
    \default AirCooled
N10 , \field Evaporative Condenser Effectiveness
    \type real
    \units dimensionless
    \minimum 0.0
    \maximum 1.0
    \default 0.9
N11, \field Evaporative Condenser Air Flow Rate
    \type real
    \units m3/s
    \minimum > 0.0
    \autosizable
    \note Used to calculate evaporative condenser water use
N12; \field Evaporative Condenser Pump Rated Power Consumption
    \type real
    \units W
    \minimum 0.0
    \default 0.0
    \autosizable
    \note Rated power consumed by the evaporative condenser's water pump

```

Following is an example input for a Coil:Cooling:DX:TwoStageWithHumidityControlMode with 2 capacity stages and one enhanced dehumidification mode so it requires four CoilPerformance:DX:Cooling objects.

```

Coil:Cooling:DX:TwoStageWithHumidityControlMode,
DXSystem 1 Cooling Coil, !- Coil Name
OfficeHeatCoolAvail, !- Availability Schedule
DXSystem 1 Mixed Air Node, !- Coil Air Inlet Node
DXSystem 1 Fan Air Inlet Node, !- Coil Air Outlet Node
, !- Crankcase Heater Capacity {W}
, !- Maximum Outdoor Dry-bulb Temperature for Crankcase Heater Operation {C}
2, !- Number of Capacity Stages
1, !- Number of Enhanced Dehumidification Modes
CoilPerformance:DX:Cooling, !- Normal Mode Stage 1 Coil Performance Object Type
DXSystem 1 DX Coil Standard Mode-Stage 1, !- Normal Mode Stage 1 Coil Performance Object Name
CoilPerformance:DX:Cooling, !- Normal Mode Stage 1+2 Coil Perf Object Type
DXSystem 1 DX Coil Standard Mode-Stage 1&2, !- Normal Mode Stage 1+2 Coil Perf Object Name
CoilPerformance:DX:Cooling, !- Dehumid Mode 1 Stage 1 Coil Perf Object Type
DXSystem 1 DX Coil SubCoolReheat Mode-Stage 1, !- Dehumid Mode 1 Stage 1 Coil Perf Object Name
CoilPerformance:DX:Cooling, !- Dehumid Mode 1 Stage 1+2 Coil Perf Object Type
DXSystem 1 DX Coil SubCoolReheat Mode-Stage 1&2; !- Dehumid Mode 1 Stage 1+2 Coil Perf Object Name

```

```

CoilPerformance:DX:Cooling,
DXSystem 1 DX Coil Standard Mode-Stage 1, !- Coil Performance Specification Name
21327.57812, !- Rated Total Cooling Capacity (gross) {W}
0.68, !- Rated SHR
3.56, !- Rated COP
1.695372105, !- Rated Air Volume Flow Rate {m3/s}
0.4, !- Fraction of Air Flow Bypassed Around Coil
HPACCoolCapFT, !- Total Cooling Capacity Modifier Curve (function of temperature)
HPACCoolCapFFF, !- Total Cooling Capacity Modifier Curve (function of flow fraction)
HPACCOOLEIRFT, !- Energy Input Ratio Modifier Curve (function of temperature)
HPACCOOLEIRFFF, !- Energy Input Ratio Modifier Curve (function of flow fraction)
HPACCOOLPLFFPLR, !- Part Load Fraction Correlation (function of part load ratio)
ContinuousFanWithCyclingCompressor, !- Supply Air Fan Operation Mode
1000, !- Nominal Time for Condensate Removal to Begin {s}
1.5, !- Ratio of Initial Moisture Evaporation Rate and Steady-state Latent Capacity {dimensionless}
3, !- Maximum ON/OFF Cycling Rate {cycles/hr}
45; !- Latent Capacity Time Constant {s}

```

```

CoilPerformance:DX:Cooling,
DXSystem 1 DX Coil Standard Mode-Stage 1&2, !- Coil Performance Specification Name
35545.96484, !- Rated Total Cooling Capacity (gross) {W}
0.68, !- Rated SHR
3.56, !- Rated COP
1.695372105, !- Rated Air Volume Flow Rate {m3/s}
0.0, !- Fraction of Air Flow Bypassed Around Coil
HPACCoolCapFT, !- Total Cooling Capacity Modifier Curve (function of temperature)
HPACCoolCapFFF, !- Total Cooling Capacity Modifier Curve (function of flow fraction)
HPACCOOLEIRFT, !- Energy Input Ratio Modifier Curve (function of temperature)
HPACCOOLEIRFFF, !- Energy Input Ratio Modifier Curve (function of flow fraction)
HPACCOOLPLFFPLR, !- Part Load Fraction Correlation (function of part load ratio)
ContinuousFanWithCyclingCompressor, !- Supply Air Fan Operation Mode
1000, !- Nominal Time for Condensate Removal to Begin {s}
1.5, !- Ratio of Initial Moisture Evaporation Rate and Steady-state Latent Capacity {dimensionless}
3, !- Maximum ON/OFF Cycling Rate {cycles/hr}
45; !- Latent Capacity Time Constant {s}

```

```

CoilPerformance:DX:Cooling,
  DXSystem 1 DX Coil SubCoolReheat Mode-Stage 1,  !- Coil Performance Specification Name
  19962.61328,  !- Rated Total Cooling Capacity (gross) {W}
  0.60,  !- Rated SHR
  3.31,  !- Rated COP
  1.695372105,  !- Rated Air Volume Flow Rate {m3/s}
  0.4,  !- Fraction of Air Flow Bypassed Around Coil
  SubCoolReheatCoolCapFT,  !- Total Cooling Capacity Modifier Curve (function of temperature)
  SubCoolReheatCoolCapFFF,  !- Total Cooling Capacity Modifier Curve (function of flow fraction)
  SubCoolReheatCOOLEIRFT,  !- Energy Input Ratio Modifier Curve (function of temperature)
  SubCoolReheatCoolEIRFFF,  !- Energy Input Ratio Modifier Curve (function of flow fraction)
  SubCoolReheatCoolPLFFPLR,  !- Part Load Fraction Correlation (function of part load ratio)
  ContinuousFanWithCyclingCompressor,  !- Supply Air Fan Operation Mode
  1000,  !- Nominal Time for Condensate Removal to Begin {s}
  1.5,  !- Ratio of Initial Moisture Evaporation Rate and Steady-state Latent Capacity (dimensionless)
  3,  !- Maximum ON/OFF Cycling Rate {cycles/hr}
  45;  !- Latent Capacity Time Constant {s}

CoilPerformance:DX:Cooling,
  DXSystem 1 DX Coil SubCoolReheat Mode-Stage 1&2,  !- Coil Performance Specification Name
  33271.01953,  !- Rated Total Cooling Capacity (gross) {W}
  0.60,  !- Rated SHR
  3.31,  !- Rated COP
  1.695372105,  !- Rated Air Volume Flow Rate {m3/s}
  0.0,  !- Fraction of Air Flow Bypassed Around Coil
  SubCoolReheatCoolCapFT,  !- Total Cooling Capacity Modifier Curve (function of temperature)
  SubCoolReheatCoolCapFFF,  !- Total Cooling Capacity Modifier Curve (function of flow fraction)
  SubCoolReheatCOOLEIRFT,  !- Energy Input Ratio Modifier Curve (function of temperature)
  SubCoolReheatCoolEIRFFF,  !- Energy Input Ratio Modifier Curve (function of flow fraction)
  SubCoolReheatCoolPLFFPLR,  !- Part Load Fraction Correlation (function of part load ratio)
  ContinuousFanWithCyclingCompressor,  !- Supply Air Fan Operation Mode
  1000,  !- Nominal Time for Condensate Removal to Begin {s}
  1.5,  !- Ratio of Initial Moisture Evaporation Rate and Steady-state Latent Capacity (dimensionless)
  3,  !- Maximum ON/OFF Cycling Rate {cycles/hr}
  45;  !- Latent Capacity Time Constant {s}

```

DX Cooling Coil Outputs

```

HVAC,Average,DX Coil Total Cooling Rate[W]
HVAC,Sum,DX Coil Total Cooling Energy[J]
HVAC,Average,DX Coil Sensible Cooling Rate[W]
HVAC,Sum,DX Coil Sensible Cooling Energy[J]
HVAC,Average,DX Coil Latent Cooling Rate[W]
HVAC,Sum,DX Coil Latent Cooling Energy[J]
HVAC,Average,DX Cooling Coil Electric Power[W]
HVAC,Sum,DX Cooling Coil Electric Consumption[J]
HVAC,Average,DX Cooling Coil Runtime Fraction

If not part of UnitarySystem:HeatPump:AirToAir:
HVAC,Average,DX Cooling Coil Crankcase Heater Power[W]
HVAC,Sum,DX Cooling Coil Crankcase Heater Consumption[J]

Evaporative-cooled condenser:
HVAC,Average,DX Cooling Coil Condenser Inlet Temp[C]
HVAC,Sum,DX Cooling Coil Evap Condenser Water Consumption[m3]
HVAC,Average,DX Cooling Coil Evap Condenser Pump Electric Power[W]
HVAC,Sum,DX Cooling Coil Evap Condenser Pump Electric Consumption[J]

Additional variables for Coil:Cooling:DX:TwoStageWithHumidityControlMode
only:
HVAC,Average,DX Cooling Coil Stage 2 Runtime Fraction
HVAC,Average,DX Cooling Coil Dehumidification Mode

HVAC,Average,DX Cooling Coil Condensate Volumetric Flow Rate [m3/s]
Zone,Meter,Condensate:OnSiteWater [m3]
HVAC,Sum,DX Cooling Coil Condensate Volume [m3]

```

DX Coil Total Cooling Rate [W]

This field is the total (sensible and latent) cooling rate output of the DX coil in Watts. This is determined by the coil inlet and outlet air conditions and the air mass flow rate through the coil.

DX Coil Total Cooling Energy [J]

This is the total (sensible plus latent) cooling output of the DX coil in Joules over the timestep being reported. This is determined by the coil inlet and outlet air conditions and the air mass flow rate through the coil. This output is also added to a report meter with Resource Type = EnergyTransfer, End Use Key = CoolingCoils, Group Key = System (Ref. Report Meter).

DX Coil Sensible Cooling Rate [W]

This output is the moist air sensible cooling rate output of the DX coil in Watts. This is determined by the inlet and outlet air conditions and the air mass flow rate through the coil.

DX Coil Sensible Cooling Energy [J]

This is the moist air sensible cooling output of the DX coil in Joules for the timestep being reported. This is determined by the inlet and outlet air conditions and the air mass flow rate through the coil.

DX Coil Latent Cooling Rate [W]

This is the latent cooling rate output of the DX coil in Watts. This is determined by the inlet and outlet air conditions and the air mass flow rate through the coil.

DX Coil Latent Cooling Energy [J]

This is the latent cooling output of the DX coil in Joules for the timestep being reported. This is determined by the inlet and outlet air conditions and the air mass flow rate through the coil.

DX Cooling Coil Electric Power [W]

This output is the electricity consumption rate of the DX coil compressor and condenser fan(s) in Watts.

DX Cooling Coil Electric Consumption [J]

This is the electricity consumption of the DX coil compressor and condenser fan(s) in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Cooling, Group Key = System (Ref. Report Meter).

DX Cooling Coil Runtime Fraction

This is the runtime fraction of the DX coil compressor and condenser fan(s) for the timestep being reported.

DX Cooling Coil Crankcase Heater Power[W]

This is the average electricity consumption rate of the DX coil compressor's crankcase heater in Watts for the timestep being reported.

DX Cooling Coil Crankcase Heater Consumption[J]

This is the electricity consumption of the DX coil compressor's crankcase heater in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Cooling, Group Key = System (ref. Report Meter).

Cooling Coil Condenser Inlet Temp [C]

This is the inlet air temperature to the condenser coil in degrees C. This value can represent the outdoor air dry-bulb temperature, wet-bulb temperature, or somewhere in between from the weather data being used, depending on the value used in the input field "Evaporative

Condenser Effectiveness”. The temperature reported here is used in the various modifier curves related to temperature (e.g., Total Cooling Capacity Modifier Curve [function of temperature]).

DX Cooling Coil Evap Condenser Water Consumption [m3]

This output is the amount of water used to evaporatively cool the condenser coil inlet air, in cubic meters. This output is also added to a report meter with Resource Type = Water, End Use Key = Cooling, Group Key = System (ref. Report Meter).

DX Cooling Coil Evap Condenser Pump Electric Power [W]

This is the average electricity consumption rate of the evaporative condenser water pump in Watts for the timestep being reported.

DX Cooling Coil Evap Condenser Pump Electric Consumption [J]

This is the electricity consumption rate of the evaporative condenser water pump in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Cooling, Group Key = System (ref. Report Meter).

DX Cooling Coil Stage 2 Runtime Fraction

This is the runtime fraction of the stage 2 DX coil compressor and condenser fan(s) for the timestep being reported. Applicable only for COIL Coil:Cooling:DX:TwoStageWithHumidityControlMode when 2 capacity stages are specified. For 2-stage systems, DX Cooling Coil Runtime Fraction is the stage 1 runtime fraction. These runtime fractions overlap, because stage 2 will not run unless stage 1 is already running. For example, a system where stage 1 is 60% of total capacity is passed a load of 70%. The DX Cooling Coil Runtime Fraction (stage 1) will be 1.0, and the DX Cooling Coil Stage 2 Runtime Fraction will be 0.25 $[(70\%-60\%)/(100\%-60\%)]$.

DX Cooling Coil Dehumidification Mode

This is the dehumidification mode for the timestep being reported. Applicable only for Coil:Cooling:DX:TwoStageWithHumidityControlMode when enhanced dehumidification mode is available. A value of 0 indicates normal mode (extra dehumidification not active). A value of 1 indicates dehumidification mode 1 is active. Note that this is an averaged variable, so fractional values are likely to be reported for reporting frequencies longer than "detailed".

DX Cooling Coil Condensate Volumetric Flow Rate [m3/s]

DX Cooling Coil Condensate Volume [m3]

These outputs are the rate and volume of water collected as condensate from the coil. These reports only appear if a water storage tank is named in the input object.

Coil:Cooling:DX:MultiSpeed

This component models a DX cooling unit with multiple discrete levels of cooling capacity. Depending on input choices, the user can model a single compressor with multiple operating speeds, or a unit with a single cooling coil fed by multiple compressors (e.g., row split or intertwined coil circuiting). Currently, this cooling coil can only be referenced by a AirLoopHVAC:UnitaryHeatPump:AirToAir compound object. Refer to Coil:Cooling:DX:TwoStageWithHumidityControlMode if the user wishes to model a cooling coil with discrete levels of cooling and the possibility of air bypass during low speed operation (e.g. face-split coil circuiting), or if cooling coil operation based on dehumidification requirements is desired.

The multispeed DX cooling coil can have from two to four operating speeds. When the coil operates at Speed 1 (the lowest speed), its performance is very similar to the single speed DX coil where the impacts of part-load ratio and latent capacity degradation can be included. When the coil operates at higher speeds (above Speed 1), the linear approximation

methodology is applied. The coil outputs at two consecutive speeds are linearly interpolated to meet the required cooling capacity during an HVAC system timestep. When the coil performs above the lowest speed, the user can choose if they want to include part-load ratio and latent capacity degradation impacts at the higher speeds.

The multispeed unit is described by specifying the performance at different operating speeds. Each speed has its own set of input specifications: full load capacity, SHR, COP and air flow rate at rated conditions, along with modifier curves to determine performance when actual operating conditions are different from the rated conditions.

The coil operates to meet the sensible capacity being requested. When this requested capacity is above the sensible capacity of the highest operating speed, the coil runs continuously at the highest speed. When the requested capacity is between the sensible capacities of two consecutive speeds, the unit will operate a portion of the time at each speed to meet the request. When the requested capacity is less than the low speed (Speed 1) capacity, the unit will cycle on/off as needed.

Field: Name

A unique user-assigned name for an instance of a multispeed DX cooling coil. Any reference to this DX coil by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the DX cooling coil can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Air Inlet Node Name

The name of the HVAC system node from which the DX cooling coil draws its inlet air.

Field: Air Outlet Node Name

The name of the HVAC system node to which the DX cooling coil sends its outlet air.

Field: Supply Air Fan Operating Mode

This input field has 2 choices: `CyclingFanAndCompressor` and `ContinuousFanWithCyclingCompressor`. The parent object `UnitarySystem:MultiSpeedHeatPump:AirToAir` also has an input field that defines a schedule for the supply fan operation mode. Currently, the mode defined in the parent object schedule overrides the fan operation mode defined in this field.

Field: Condenser Air Inlet Node Name

This optional alpha field specifies the outdoor air node name used to define the conditions of the air entering the outdoor condenser. If this field is left blank, the outdoor air temperature entering the condenser (dry-bulb or wet-bulb) is taken directly from the weather data. If this field is not blank, the node name specified must also be specified in an `OutdoorAir:Node` object where the height of the node is taken into consideration when calculating outdoor air temperature from the weather data. Alternately, the node name may be specified in an `OutdoorAir:NodeList` object where the outdoor air temperature is taken directly from the weather data.

Field: Condenser Type

The type of condenser used by the multispeed DX cooling coil. Valid choices for this input field are **AirCooled** or **EvaporativelyCooled**. The default for this field is **AirCooled**.

Field: Supply Water Storage Tank Name

This field is optional. It is used to describe where the coil obtains water used for evaporative cooling. If blank or omitted, then the evaporative cooler will obtain water directly from the

mains. If the name of a Water Storage Tank object is used here, then the cooler will obtain its water from that tank. If a tank is specified, the coil will attempt to obtain all the water it uses from the tank. However if the tank cannot provide all the water the cooler needs, then the cooler will still operate and obtain the rest of the water it needs from the mains (referred to as StarvedWater).

Field: Condensate Collection Water Storage Tank Name

This field is optional. It is used to describe where condensate from the coil is collected. If blank or omitted, then any coil condensate is discarded. Enter the name of Water Storage Tank object defined elsewhere and the condensate will then be collected in that tank.

Field: Apply Part Load Fraction to Speeds Greater than 1

This field determines whether part-load impacts on coil energy use are applied when the coil is operating at speeds greater than speed 1. The allowed choices are Yes or No, with the default being No if this field is left blank. Other input fields in this object allow the user to specify a part-load fraction correlation for each speed to account for compressor start up losses (cycle on/off). For the case of a single multi-speed compressor, the part load losses may only be significant when the compressor cycles between speed 1 and off, but the losses may be extremely small when the compressor operates between speed 1 and speed 2 (or between speeds 2 and 3, etc.). In this case, the user may chose to specify NO for this input field to neglect part-load impacts on energy use at higher operating speeds. If part-load impacts on coil energy use are thought to be significant (e.g., intertwined cooling coil with multiple compressors feeding individual refrigerant circuits), then the user may chose to specify YES and the part-load fraction correlations specified for speeds 2 through 4 will be applied as appropriate. The selection for this input field does not affect part-load impacts when the compressor cycles between speed 1 and off (i.e., the part-load fraction correlation for speed 1 is always applied).

Field: Apply Latent Degradation to Speeds Greater than 1

This field determines whether latent capacity degradation is applied when the coil is operating at speeds greater than speed 1. The allowed choices are Yes or No, with the default being No if this field is left blank. Other input fields in this object allow the user to specify latent capacity degradation at each speed.

The latent capacity degradation model only applies when the ContinuousFanWithCyclingCompressor supply air fan operating mode is specified, to account for moisture evaporation from the wet cooling coil when the compressor cycles off but the supply air fan continues to operate. For the case of a single multi-speed compressor, latent capacity degradation may only be significant when the compressor cycles between speed 1 and off, but the losses may be extremely small when the compressor operates between speed 1 and speed 2 (or between speeds 2 and 3, etc.). In this case, the user may chose to specify NO for this input field to neglect latent capacity degradation impacts at higher operating speeds. If latent capacity degradation is thought to be significant (e.g., intertwined or row-split cooling coil with multiple compressors feeding individual refrigerant circuits), then the user may chose to specify YES and the latent capacity degradation model will be applied for speeds 2 through 4 as appropriate. The selection for this input field does not affect latent capacity degradation between speed 1 and off.

Field: Crankcase Heater Capacity

This numeric field defines the crankcase heater capacity in Watts. When the outdoor air dry-bulb temperature is below the value specified in the input field "Maximum Outdoor Dry-bulb Temperature for Crankcase Heater Operation" (described below), the crankcase heater is enabled during the time that the compressor is not running. The value for this input field must be greater than or equal to 0. If this input field is left blank, the default value is 0. To simulate a unit without a crankcase heater, enter a value of 0.

Field: Maximum Outdoor Dry-Bulb Temperature for Crankcase Heater Operation

This numeric field defines the outdoor air dry-bulb temperature above which the compressor's crankcase heater is disabled. The value for this input field must be greater than or equal to 0.0°C. If this input field is left blank, the default value is 10°C.

Field: Fuel Type

This alpha field determines the type of fuel that this cooling coil uses. This field has seven choices: Electricity, NaturalGas, PropaneGas, Diesel, Gasoline, FuelOil#1, and FuelOil#2. The default is NaturalGas.

Field: Number of Speeds

This field specifies the number of sets of data being entered for rated specifications, performance curves, evaporative condenser data, latent degradation data, and waste heat specifications for each cooling speed. The rated specifications consist of rated capacity, rated SHR, rated COP, and rated air flow rate. The performance curves consist of a total capacity modifier curve as a function of temperature, total capacity modifier curve as a function of flow fraction, energy input ratio modifier curve as a function of temperature, energy input ratio modifier curve as a function of flow fraction, and part load fraction correlation as a function of part load ratio. The evaporative condenser data consists of effectiveness, condenser air volume flow rate, and rated pump power consumption. The latent degradation data consists of nominal time for condensate removal to begin, ratio of initial moisture evaporation rate and steady-state latent capacity, maximum On/Off cycling rate, and latent capacity time constant. The latent degradation data are only applied if the supply air fan operation mode is specified as ContinuousFanWithCyclingCompressor. The waste heat specifications include the fraction of energy input to the cooling coil at the fully loaded and rated conditions, and a temperature modifier. The minimum number of speeds for cooling is 2 and the maximum number is 4. The number of speeds should be the same as the number of speeds for cooling defined in its parent object (UnitarySystem:MultiSpeedHeatPump: AirToAir). The first set of performance inputs is for Speed 1 and should be for low speed, and the last set of performance inputs should be for high speed. For example, if only three cooling speeds are defined, the first set should be for low speed (Speed 1), the second set should be for medium speed (Speed 2), and the third set should be for high speed (Speed 3). In this example, any performance inputs for Speed 4 would be neglected (since this input field specifies that the coil only has three cooling speeds).

Field Group: rated specification, performance curves, latent capacity degradation inputs, and evaporative cooled condenser data

The performance for each cooling speed must be specified as shown below. All inputs for Speed 1 are required first, followed by the inputs for Speed 2, Speed 3 and Speed 4.

Field: Speed <x> Rated Total Cooling Capacity

The total, full load cooling capacity (sensible plus latent) in watts of the DX coil unit for Speed <x> operation at rated conditions (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb¹², and a cooling coil air flow rate defined by field "Rated Air Volume Flow Rate, Speed <x>" below). Capacity should be "gross" (i.e., supply air fan heat is NOT included).

Field: Speed <x> Rated Sensible Heat Ratio

The sensible heat ratio (SHR=sensible capacity divided by total cooling capacity) of the DX cooling coil for Speed <x> operation at rated conditions (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb, and a cooling coil air flow rate defined by field "Rated Air Volume Flow Rate, Speed

¹² The 23.9°C wet-bulb temperature condition is not applicable for air-cooled condensers which do not evaporate condensate.

<x>” below). Both the sensible and total cooling capacities used to define the Rated SHR should be “gross” (i.e., supply air fan heat is NOT included).

Field: Speed <x> Rated COP

The coefficient of performance (COP=cooling power output in watts divided by electrical power input in watts) of the DX cooling coil unit for Speed <x> operation at rated conditions (air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb, and a cooling coil air flow rate defined by field “Rated Air Volume Flow Rate, Speed <x>” below). The input power includes power for the compressor(s) and condenser fan(s) but does not include the power consumption of the supply air fan. The cooling power output is the value entered above in the field “Rated Total Cooling Capacity, Speed <x> (gross)”. If this input field is left blank, the default value is 3.0.

Field: Speed <x> Rated Air Flow Rate

The volumetric air flow rate for Speed <x>, in m³ per second, across the DX cooling coil at rated conditions. The rated air volume flow rate for Speed <x> should be between 0.00004027 m³/s and 0.00006041 m³/s per watt of rated total cooling capacity for Speed <x>. The rated total cooling capacity, rated SHR and rated COP for Speed <x> should be performance information for the unit with air entering the cooling coil at 26.7°C drybulb/19.4°C wetbulb, air entering the outdoor condenser coil at 35°C drybulb/23.9°C wetbulb, and the rated air volume flow rate defined here.

Field: Speed <x> Total Cooling Capacity Function of Temperature Curve Name

The name of a biquadratic performance curve (ref: Performance Curves) that parameterizes the variation of the total cooling capacity for Speed <x> as a function of the wet-bulb temperature of the air entering the cooling coil, and the dry-bulb temperature of the air entering the air-cooled condenser (wet-bulb temperature if modeling an evaporative-cooled condenser). The output of this curve is multiplied by the rated total cooling capacity for Speed <x> to give the total cooling capacity at specific temperature operating conditions (i.e., at temperatures different from the rating point temperatures). The curve is normalized to have the value of 1.0 at the rating point.

Field: Speed <x> Total Cooling Capacity Function of Flow Fraction Curve Name

The name of a quadratic performance curve (ref: Performance Curves) that parameterizes the variation of total cooling capacity for Speed <x> as a function of the ratio of actual air flow rate across the cooling coil to the rated air flow rate for Speed <x> (i.e., fraction of full load flow). The output of this curve is multiplied by the rated total cooling capacity and the total cooling capacity modifier curve (function of temperature) to give the total cooling capacity for Speed <x> at the specific temperature and air flow conditions at which the coil is operating. The curve is normalized to have the value of 1.0 when the actual air flow rate equals the rated air flow rate for Speed <x>.

Field: Speed <x> Energy Input Ratio Function of Temperature Curve Name

The name of a biquadratic performance curve (ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) for Speed <x> as a function of the wetbulb temperature of the air entering the cooling coil and the drybulb temperature of the air entering the air-cooled condenser (wetbulb temperature if modeling an evaporative-cooled condenser). The EIR is the inverse of the COP. The output of this curve is multiplied by the rated EIR for Speed <x> (inverse of rated COP for Speed <x>) to give the EIR for Speed <x> at specific temperature operating conditions (i.e., at temperatures different from the rating point temperatures). The curve is normalized to a value of 1.0 at the rating point.

Field: Speed <x> Energy Input Ratio Function of Flow Fraction Curve Name

The name of a quadratic performance curve (Ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) for Speed <x> as a function of the ratio of actual

air flow rate across the cooling coil to the rated air flow rate for Speed <x> (i.e., fraction of full load flow). The EIR is the inverse of the COP. The output of this curve is multiplied by the rated EIR and the EIR modifier curve (function of temperature) to give the EIR for Speed <x> at the specific temperature and air flow conditions at which the cooling coil is operating. This curve is normalized to a value of 1.0 when the actual air flow rate equals the rated air flow rate for Speed <x>.

Field: Speed <x> Part Load Fraction Correlation Curve Name

This alpha field defines the name of a quadratic or cubic performance curve (Ref: Performance Curves) that parameterizes the variation of electrical power input to the DX unit as a function of the part load ratio (PLR, sensible cooling load/steady-state sensible cooling capacity for Speed <x>). The product of the rated EIR and EIR modifier curves is divided by the output of this curve to give the “effective” EIR for a given simulation timestep for Speed <x>. The part load fraction (PLF) correlation accounts for efficiency losses due to compressor cycling.

The part load fraction correlation should be normalized to a value of 1.0 when the part load ratio equals 1.0 (i.e., no efficiency losses when the compressor(s) run continuously for the simulation timestep). For PLR values between 0 and 1 ($0 \leq \text{PLR} < 1$), the following rules apply:

$$\text{PLF} \geq 0.7 \text{ and } \text{PLF} \geq \text{PLR}$$

If $\text{PLF} < 0.7$ a warning message is issued, the program resets the PLF value to 0.7, and the simulation proceeds. The runtime fraction of the coil is defined as PLR/PLF . If $\text{PLF} < \text{PLR}$, then a warning message is issued and the runtime fraction of the coil is limited to 1.0.

A typical part load fraction correlation for a conventional DX cooling coil (Speed <x>) would be:

$$\text{PLF} = 0.85 + 0.15(\text{PLR})$$

If the user wishes to model no efficiency degradation due to compressor cycling, the part load fraction correlation should be defined as follows:

$$\text{PLF} = 1.0 + 0.0(\text{PLR})$$

Field: Speed <x> Nominal Time for Condensate Removal to Begin

For Speed <x>, the nominal time (in seconds) after startup for condensate to begin leaving the coil's condensate drain line at the coil's rated airflow and temperature conditions, starting with a dry coil. Nominal time is equal to the ratio of the energy of the coil's maximum condensate holding capacity (J) to the coil's steady-state latent capacity (W). Suggested value is 1000; zero value means the latent degradation model is disabled. The default value for this field is zero. The field Supply Air Fan Operation Mode must be “ContinuousFanWithCyclingCompressor”, and this field as well as the next three input fields for this object must have positive values in order to model latent capacity degradation for Speed <x>.

Field: Speed <x> Ratio of Initial Moisture Evaporation Rate and Steady State Latent Capacity

For Speed <x>, the ratio of the initial moisture evaporation rate from the cooling coil (when the compressor first turns off, in Watts) and the coil's steady-state latent capacity (Watts) for Speed <x> at rated airflow and temperature conditions. Suggested value is 1.5; zero value means the latent degradation model is disabled. The default value for this field is zero. The field Supply Air Fan Operation Mode must be “ContinuousFanWithCyclingCompressor”; and this field, the previous field and the next two fields must have positive values in order to model latent capacity degradation for Speed <x>.

Field: Speed <x> Maximum Cycling Rate

For Speed <x>, the maximum on-off cycling rate for the compressor (cycles per hour), which occurs at 50% run time fraction. Suggested value is 3; zero value means latent degradation

model is disabled. The default value for this field is zero. The field Supply Air Fan Operation Mode must be “ContinuousFanWithCyclingCompressor”; and this field, the previous two fields and the next field must have positive values in order to model latent capacity degradation for Speed <x>.

Field: Speed <x> Latent Capacity Time Constant

For Speed <x>, the time constant (in seconds) for the cooling coil's latent capacity to reach steady state after startup. Suggested value is 45; zero value means latent degradation model is disabled. The default value for this field is zero. The field Supply Air Fan Operation Mode must be “ContinuousFanWithCyclingCompressor”, and this field as well as the previous three input fields for this object must have positive values in order to model latent capacity degradation for Speed <x>.

Field: Speed <x> Rated Waste Heat Fraction of Power Input

The fraction of energy input to the cooling coil that is available as recoverable waste heat at full load and rated conditions for Speed <x>.

Field: Speed <x> Waste Heat Function of Temperature Curve Name

The name of a biquadratic performance curve (ref: Performance Curves) that parameterizes the variation of the waste heat recovery as a function of outdoor dry-bulb temperature and the entering coil dry-bulb temperature at Speed <x>. The output of this curve is multiplied by the rated waste heat fraction at specific temperature operating conditions (i.e., at temperatures different from the rating point). The curve is normalized to a value of 1.0 at the rating point. When the fuel type is electricity, this field can remain blank since it is ignored by the program in this instance.

Field: Speed <x> Evaporative Condenser Effectiveness

The effectiveness of the evaporative condenser at Speed <x>, which is used to determine the temperature of the air entering the outdoor condenser coil as follows:

$$T_{cond\ inlet} = (T_{wb, o}) + (1 - EvapCondEffectiveness_{Speed1})(T_{db, o} - T_{wb, o})$$

where

$T_{cond\ inlet}$ = the temperature of the air entering the condenser coil (C)

$T_{wb, o}$ = the wet-bulb temperature of the outdoor air (C)

$T_{db, o}$ = the dry-bulb temperature of the outdoor air (C)

The resulting condenser inlet air temperature is used by the Total Cooling Capacity Modifier Curve, Speed <x> (function of temperature) and the Energy Input Ratio Modifier Curve, Speed <x> (function of temperature). The default value for this field is 0.9, although valid entries can range from 0.0 to 1.0. This field is not used when Condenser Type = Air Cooled.

If the user wants to model an air-cooled condenser, they should simply specify AirCooled in the field Condenser Type. In this case, the Total Cooling Capacity Modifier Curve, Speed <x> (function of temperature) and the Energy Input Ratio Modifier Curve, Speed <x> (function of temperature) input fields for this object should reference performance curves that are a function of outdoor dry-bulb temperature.

If the user wishes to model an evaporative-cooled condenser AND they have performance curves that are a function of the wet-bulb temperature of air entering the condenser coil, then the user should specify Condenser Type = Evap Cooled and the evaporative condenser effectiveness value should be entered as 1.0. In this case, the Total Cooling Capacity Modifier Curve, Speed <x> (function of temperature) and the Energy Input Ratio Modifier Curve, Speed <x> (function of temperature) input fields for this object should reference

performance curves that are a function of the wet-bulb temperature of air entering the condenser coil.

If the user wishes to model an air-cooled condenser that has evaporative media placed in front of it to cool the air entering the condenser coil, then the user should specify Condenser Type = Evap Cooled. The user must also enter the appropriate evaporative effectiveness for the media. In this case, the Total Cooling Capacity Modifier Curve, Speed <x> (function of temperature) and the Energy Input Ratio Modifier Curve, Speed <x> (function of temperature) input fields for this object should reference performance curves that are a function of outdoor dry-bulb temperature. Be aware that the evaporative media will significantly reduce the dry-bulb temperature of the air entering the condenser coil, so the Total Cooling Capacity and EIR Modifier Curves for Speed <x> must be valid for the expected range of dry-bulb temperatures that will be entering the condenser coil.

Field: Speed <x> Evaporative Condenser Air Flow Rate

The air volume flow rate, in m^3 per second, entering the evaporative condenser at Speed <x>. This value is used to calculate the amount of water used to evaporatively cool the condenser inlet air. The minimum value for this field must be greater than zero, and this input field is autosizable (equivalent to $0.000114 \text{ m}^3/\text{s}$ per watt of rated total cooling capacity for Speed <x> [850 cfm/ton]). This field is not used when Condenser Type = Air Cooled.

Field: Speed <x> Rated Evaporative Condenser Pump Power Consumption

The rated power of the evaporative condenser water pump in Watts at Speed <x>. This value is used to calculate the power required to pump the water used to evaporatively cool the condenser inlet air. The default value for this input field is zero, but it is autosizable (equivalent to 0.004266 W per watt [15 W/ton] of rated total capacity for Speed <x>). This field is not used when Condenser Type = Air Cooled.

Below is the input data dictionary description for the Coil:DX:MultiSpeed:Cooling object.

```
Coil:Cooling:DX:MultiSpeed,
  \min-fields 51
  A1 , \field Name
      \required-field
      \type alpha
      \reference CoolingCoilsDX
  A2 , \field Availability Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
  A3 , \field Air Inlet Node Name
      \required-field
      \type alpha
  A4 , \field Air Outlet Node Name
      \required-field
      \type alpha
  A5 , \field Supply Air Fan Operating Mode
      \required-field
      \type choice
      \key CyclingFanAndCompressor
      \key ContinuousFanWithCyclingCompressor
  A6 , \field Condenser Air Inlet Node Name
      \type alpha
      \note Enter the name of an outdoor air node. This node name is also specified in
      \note an OutdoorAir:Node or OutdoorAir:NodeList object.
  A7 , \field Condenser Type
      \type choice
      \key AirCooled
      \key EvaporativelyCooled
      \default AirCooled
  A8 , \field Supply Water Storage Tank Name
      \type object-list
      \object-list WaterStorageTankNames
  A9 , \field Condensate Collection Water Storage Tank Name
      \type object-list
      \object-list WaterStorageTankName
  A10, \field Apply Part Load Fraction to Speeds Greater than 1
      \type choice
      \key Yes
      \key No
      \default No
  A11, \field Apply Latent Degradation to Speeds Greater than 1
      \type choice
      \key Yes
      \key No
      \default No
  N1 , \field Crankcase Heater Capacity
      \type real
      \minimum 0.0
      \default 0.0
      \units W
      \ip-units W
  N2 , \field Maximum Outdoor Dry-Bulb Temperature for Crankcase Heater Operation
      \type real
      \minimum 0.0
      \default 10.0
      \units C
```



```

A12, \field Fuel Type
      \type choice
      \key Electricity
      \key NaturalGas
      \key PropaneGas
      \key Diesel
      \key Gasoline
      \key FuelOil#1
      \key FuelOil#2
      \default NaturalGas
N3 , \field Number of Speeds
      \required-field
      \type integer
      \minimum 2
      \maximum 4
      \note Enter the number of the following sets of data for coil capacity, SHR, COP,
      \note flow rate, and associated curves.
N4 , \field Speed 1 Rated Total Cooling Capacity
      \required-field
      \type real
      \units W
      \minimum > 0.0
      \autosizable
      \note Gross capacity excluding supply air fan heat
      \note Rating point: air entering the cooling coil at 26.7 C dry-bulb/19.4 C wet-bulb, and
      \note air entering the outdoor condenser coil at 35 C dry-bulb/23.9 C wet-bulb
      \note Speed 1 is defined as low speed
N5 , \field Speed 1 Rated Sensible Heat Ratio
      \required-field
      \type real
      \minimum 0.5
      \maximum 1.0
      \autosizable
      \note Rated sensible heat ratio (gross sensible capacity/gross total capacity)
      \note Sensible and total capacities do not include supply fan heat
N6 , \field Speed 1 Rated COP
      \type real
      \minimum > 0.0
      \default 3.0
      \note Does not include supply fan heat or supply fan electrical energy input
N7 , \field Speed 1 Rated Air Flow Rate
      \required-field
      \type real
      \units m3/s
      \minimum > 0.0
      \autosizable
      \note Flow rate corresponding to rated total cooling capacity, rated SHR and rated
      \note COP should be between 0.0004027 m3/s and .00006041 m3/s per watt of rated total
      \note cooling capacity
A13, \field Speed 1 Total Cooling Capacity Function of Temperature Curve Name
      \required-field
      \type object-list
      \object-list BiquadraticCurves
      \note curve = a + b*wb + c*wb**2 + d*edb + e*edb**2 + f*wb*edb
      \note wb = entering wet-bulb temperature (C)
      \note edb = dry-bulb temperature seen by the condenser (C)
A14, \field Speed 1 Total Cooling Capacity Function of Flow Fraction Curve Name
      \required-field
      \type object-list
      \object-list QuadraticCubicCurves
      \note quadratic curve = a + b*ff + c*ff**2
      \note cubic curve = a + b*ff + c*ff**2 + d*ff**3
      \note ff = Fraction of the full load Flow
A15, \field Speed 1 Energy Input Ratio Function of Temperature Curve Name
      \required-field
      \type object-list
      \object-list BiquadraticCurves
      \note curve = a + b*wb + c*wb**2 + d*edb + e*edb**2 + f*wb*edb
      \note wb = entering wet-bulb temperature (C)
      \note edb = dry-bulb temperature seen by the condenser (C)

```

```

A16, \field Speed 1 Energy Input Ratio Function of Flow Fraction Curve Name
\required-field
\type object-list
\object-list QuadraticCubicCurves
\note quadratic curve = a + b*ff + c*ff**2
\note cubic curve = a + b*ff + c*ff**2 + d*ff**3
\note ff = fraction of the full load flow
A17, \field Speed 1 Part Load Fraction Correlation Curve Name
\required-field
\type object-list
\object-list QuadraticCubicCurves
\note quadratic curve = a + b*PLR + c*PLR**2
\note cubic curve = a + b*PLR + c*PLR**2 + d*PLR**3
\note PLR = part load ratio (cooling load/steady-state capacity)
N8 , \field Speed 1 Nominal Time for Condensate Removal to Begin
\type real
\units s
\minimum 0.0
\maximum 3000.0
\default 0.0
\note The nominal time for condensate to begin leaving the coil's condensate
\note drain line at the coil's rated air flow rate and temperature conditions.
\note Nominal time is equal to the ratio of the energy of the coil's maximum
\note condensate holding capacity (J) to the coil's steady-state latent capacity (W).
\note Suggested value is 1000; zero value means latent degradation model is disabled.
N9 , \field Speed 1 Ratio of Initial Moisture Evaporation Rate and Steady State Latent Capacity
\type real
\units dimensionless
\minimum 0.0
\maximum 5.0
\default 0.0
\note Ratio of the initial moisture evaporation Rate from the Cooling Coil (when
\note the compressor first turns off) and the Coil's steady-state latent capacity
\note at rated air flow rate and temperature conditions. Suggested value is 1.5; zero value
\note means latent degradation model is disabled.
N10, \field Speed 1 Maximum Cycling Rate
\type real
\units cycles/hr
\minimum 0.0
\maximum 5.0
\default 0.0
\note The maximum on-off cycling rate for the compressor, which occurs at 50% run time
\note fraction. Suggested value is 3; zero value means latent degradation
\note model is disabled.
N11, \field Speed 1 Latent Capacity Time Constant
\type real
\units s
\minimum 0.0
\maximum 500.0
\default 0.0
\note Time constant for the cooling coil's latent capacity to reach steady state after
\note startup. Suggested value is 45; zero value means latent degradation
\note model is disabled.
N12, \field Speed 1 Rated Waste Heat Fraction of Power Input
\required-field
\type real
\units dimensionless
\minimum> 0.0
\maximum 1.0
\note Recoverable waste heat at full load and rated conditions
A18, \field Speed 1 Waste Heat Function of Temperature Curve Name
\type alpha
\object-list BiQuadraticCurves
\note curve = a + b*odb + c*odb**2 + d*db + e*db**2 + f*odb*db
\note odb = Outdoor air dry-bulb temperature (C)
\note db = entering coil dry-bulb temperature (C)

```

```

N13, \field Speed 1 Evaporative Condenser Effectiveness
      \type real
      \units dimensionless
      \minimum 0.0
      \maximum 1.0
      \default 0.9
N14, \field Speed 1 Evaporative Condenser Air Flow Rate
      \type real
      \units m3/s
      \minimum > 0.0
      \autosizable
      \note Used to calculate evaporative condenser water use
N15, \field Speed 1 Rated Evaporative Condenser Pump Power Consumption
      \type real
      \units W
      \minimum 0.0
      \autosizable
      \note Rated power consumed by the evaporative condenser's water pump at high speed
<continued for the full four (4) speeds available>

```

Following is an example input for this multispeed DX cooling coil.

```

Coil:Cooling:DX:MultiSpeed,
Heat Pump ACDXCoil 1,      !- Coil Name
FanAndCoilAvailSched,    !- Availability Schedule
DX Cooling Coil Air Inlet Node, !- Coil Air Inlet Node
Heating Coil Air Inlet Node, !- Coil Air Outlet Node
CyclingFanAndCompressor, !- Supply Air Fan Operation Mode
Outdoor Condenser Air Node, !- Condenser Air Inlet Node Name
AirCooled,                !- Condenser Type
,                          !- Name of Water Storage Tank for Supply
,                          !- Name of Water Storage Tank for Condensate Collection
No,                       !- Apply Part Load Fraction to Speeds greater than 1
No,                       !- Apply latent degradation to Speeds greater than 1
200.0,                   !- Crankcase Heater Capacity {W}
10.0,                    !- Maximum Outdoor Dry-bulb Temperature for Crankcase Heater Operation
NaturalGas,              !- Fuel Type
4,                        !- Number of speeds
7500,                    !- Rated Total Cooling Capacity, Speed 1 (gross) {W}
0.75,                    !- Rated SHR, Speed 1 {dimensionless}
3.0,                     !- Rated COP, Speed 1 {dimensionless}
0.40,                    !- Rated Air Volume Flow Rate, Speed 1 {m3/s}
HPACCoolCapFT Speed 1,   !- Total Cooling Capacity Modifier Curve, Speed 1 (temperature)
HPACCoolCapFF Speed 1,   !- Total Cooling Capacity Modifier Curve, Speed 1 (flow fraction)
HPACCOOLEIRFT Speed 1,   !- Energy Input Ratio Modifier Curve, Speed 1 (temperature)
HPACCOOLEIRFF Speed 1,   !- Energy Input Ratio Modifier Curve, Speed 1 (flow fraction)
HPACCOOLPLFFPLR Speed 1, !- Part Load Fraction Correlation, Speed 1 (part load ratio)
1000.0,                  !- Nominal Time for Condensate Removal to Begin, Speed 1 {s}
1.5,                     !- Ratio of Initial Moisture Evaporation Rate and Steady-state Latent
3.0,                     !- Maximum ON/OFF Cycling Rate, Speed 1 {cycles/hr}
45.0,                    !- Latent Capacity Time Constant, Speed 1 {s}
0.2,                     !- Rated waste heat fraction of power input, Speed 1 {dimensionless}
HAPCCoolWHFT Speed 1,    !- Waste heat modifier curve, Speed 1 (temperature)
0.9,                     !- Evaporative Condenser Effectiveness, Speed 1 {dimensionless}
0.05,                    !- Evaporative Condenser Air Volume Flow Rate, Speed 1 {m3/s}
50,                      !- Evaporative Condenser Pump Rated Power Consumption, Speed 1 {W}

```

17500,	!- Rated Total Cooling Capacity, Speed 2 (gross) {W}
0.75,	!- Rated SHR, Speed 2 {dimensionless}
3.0,	!- Rated COP, Speed 2 {dimensionless}
0.85,	!- Rated Air Volume Flow Rate, Speed 2 {m3/s}
HPACCoolCapFT Speed 2,	!- Total Cooling Capacity Modifier Curve, Speed 2 (temperature)
HPACCoolCapFF Speed 2,	!- Total Cooling Capacity Modifier Curve, Speed 2 (flow fraction)
HPACCOOLEIRFT Speed 2,	!- Energy Input Ratio Modifier Curve, Speed 2 (temperature)
HPACCOOLEIRFF Speed 2,	!- Energy Input Ratio Modifier Curve, Speed 2 (flow fraction)
HPACCOOLPLFFPLR Speed 1,	!- Part Load Fraction Correlation, Speed 2 (part load ratio)
1000.0,	!- Nominal Time for Condensate Removal to Begin, Speed 2
1.5,	!- Ratio of Initial Moisture Evaporation Rate and Steady-state Latent
3.0,	!- Maximum ON/OFF Cycling Rate, Speed 2
45.0,	!- Latent Capacity Time Constant, Speed 2
0.2,	!- Rated waste heat fraction of power input, Speed 2 {dimensionless}
HAPCCoolWHFT Speed 2,	!- Waste heat modifier curve, Speed 2 (temperature)
0.9,	!- Evaporative Condenser Effectiveness, Speed 2 {dimensionless}
0.1,	!- Evaporative Condenser Air Volume Flow Rate, Speed 2 {m3/s}
60,	!- Evaporative Condenser Pump Rated Power Consumption, Speed 2 {W}
25500,	!- Rated Total Cooling Capacity, Speed 3 (gross) {W}
0.75,	!- Rated SHR, Speed 3 {dimensionless}
3.0,	!- Rated COP, Speed 3 {dimensionless}
1.25,	!- Rated Air Volume Flow Rate, Speed 3 {m3/s}
HPACCoolCapFT Speed 3,	!- Total Cooling Capacity Modifier Curve, Speed 3 (temperature)
HPACCoolCapFF Speed 3,	!- Total Cooling Capacity Modifier Curve, Speed 3 (flow fraction)
HPACCOOLEIRFT Speed 3,	!- Energy Input Ratio Modifier Curve, Speed 3 (temperature)
HPACCOOLEIRFF Speed 3,	!- Energy Input Ratio Modifier Curve, Speed 3 (flow fraction)
HPACCOOLPLFFPLR Speed 1,	!- Part Load Fraction Correlation, Speed 3 (part load ratio)
1000.0,	!- Nominal Time for Condensate Removal to Begin, Speed 3 {s}
1.5,	!- Ratio of Initial Moisture Evaporation Rate and Steady-state Latent
3.0,	!- Maximum ON/OFF Cycling Rate, Speed 3 {cycles/hr}
45.0,	!- Latent Capacity Time Constant, Speed 3 {s}
0.2,	!- Rated waste heat fraction of power input, Speed 3 {dimensionless}
HAPCCoolWHFT Speed 3,	!- Waste heat modifier curve, Speed 3 (temperature)
0.9,	!- Evaporative Condenser Effectiveness, Speed 3 {dimensionless}
0.2,	!- Evaporative Condenser Air Volume Flow Rate, Speed 3 {m3/s}
80,	!- Evaporative Condenser Pump Rated Power Consumption, Speed 3 {W}
35500,	!- Rated Total Cooling Capacity, Speed 4 (gross) {W}
0.75,	!- Rated SHR, Speed 4 {dimensionless}
3.0,	!- Rated COP, Speed 4 {dimensionless}
1.75,	!- Rated Air Volume Flow Rate, Speed 4 {m3/s}
HPACCoolCapFT Speed 4,	!- Total Cooling Capacity Modifier Curve, Speed 4 (temperature)
HPACCoolCapFF Speed 4,	!- Total Cooling Capacity Modifier Curve, Speed 4 (flow fraction)
HPACCOOLEIRFT Speed 4,	!- Energy Input Ratio Modifier Curve, Speed 4 (temperature)
HPACCOOLEIRFF Speed 4,	!- Energy Input Ratio Modifier Curve, Speed 4 (flow fraction)
HPACCOOLPLFFPLR Speed 1,	!- Part Load Fraction Correlation, Speed 4 (part load ratio)
1000.0,	!- Nominal Time for Condensate Removal to Begin, Speed 4 {s}
1.5,	!- Ratio of Initial Moisture Evaporation Rate and Steady-state Latent
	!- Capacity, Speed 4 {dimensionless}
3.0,	!- Maximum ON/OFF Cycling Rate, Speed 4 {cycles/hr}
45.0,	!- Latent Capacity Time Constant, Speed 4 {s}
0.2,	!- Rated waste heat fraction of power input, Speed 4 {dimensionless}
HAPCCoolWHFT Speed 4,	!- Waste heat modifier curve, Speed 4 (temperature)
0.9,	!- Evaporative Condenser Effectiveness, Speed 4 {dimensionless}
0.3,	!- Evaporative Condenser Air Volume Flow Rate, Speed 4 {m3/s}
100;	!- Evaporative Condenser Pump Rated Power Consumption, Speed 4 {W}

Coil:Cooling:DX:MultiSpeed Outputs

HVAC,Average,DX Coil Total Cooling Rate[W]
HVAC,Sum,DX Coil Total Cooling Energy[J]
HVAC,Average,DX Coil Sensible Cooling Rate[W]
HVAC,Sum,DX Coil Sensible Cooling Energy[J]
HVAC,Average,DX Coil Latent Cooling Rate[W]
HVAC,Sum,DX Coil Latent Cooling Energy[J]
HVAC,Average,DX Cooling Coil <FuelType> Power[W]
HVAC,Sum,DX Cooling Coil <FuelType> Consumption[J]
HVAC,Average,DX Cooling Coil Runtime Fraction
HVAC,Average,DX Cooling Coil Condenser Inlet Temp [C]
HVAC,Sum,DX Cooling Coil Evap Condenser Water Consumption [m3]

HVAC,Sum,Mains water for DX Cooling Coil Evap Condenser [m3]
 HVAC,Average,DX Cooling Coil Evap Condenser Pump Electric Power[W]
 HVAC,Sum,DX Cooling Coil Evap Condenser Pump Electric Consumption[J]

DX Coil Total Cooling Rate [W]

This field is the total (sensible and latent) cooling rate output of the multispeed DX coil in Watts. This is determined by the coil inlet and outlet air conditions and the air mass flow rate through the coil.

DX Coil Total Cooling Energy [J]

This is the total (sensible plus latent) cooling output of the multispeed DX coil in Joules over the timestep being reported. This is determined by the coil inlet and outlet air conditions and the air mass flow rate through the coil. This output is also added to a report meter with Resource Type = EnergyTransfer, End Use Key = CoolingCoils, Group Key = System (Ref. Report Meter).

DX Coil Sensible Cooling Rate [W]

This output is the moist air sensible cooling rate output of the multispeed DX coil in Watts. This is determined by the inlet and outlet air conditions and the air mass flow rate through the coil.

DX Coil Sensible Cooling Energy [J]

This is the moist air sensible cooling output of the multispeed DX coil in Joules for the timestep being reported. This is determined by the inlet and outlet air conditions and the air mass flow rate through the coil.

DX Coil Latent Cooling Rate [W]

This is the latent cooling rate output of the multispeed DX coil in Watts. This is determined by the inlet and outlet air conditions and the air mass flow rate through the coil.

DX Coil Latent Cooling Energy [J]

This is the latent cooling output of the multispeed DX coil in Joules for the timestep being reported. This is determined by the inlet and outlet air conditions and the air mass flow rate through the coil.

DX Cooling Coil <FuelType> Power [W]

This output variable is the input fuel type power for the cooling coil in Watts, averaged during the timestep being reported.

DX Cooling Coil <FuelType> Consumption [J]

This output variable is the input fuel consumption for the multispeed cooling coil in the unit of Joules, summed for the timestep being reported. This output is added to a report meter with Resource Type = <FuelType>, End Use Key = Cooling, Group Key = System (ref. Report Meter).

Note: <FuelType> in the above two output variables depends on the user specified input for the Fuel Type field. In addition to Electricity, valid fuel types are NaturalGas, Propane, FuelOil#1, FuelOil#2, Coal, Diesel, and Gasoline.

DX Cooling Coil Runtime Fraction

This output variable is the cooling coil run time fraction (PLR/PLF), averaged for the timestep being reported. When the cooling speed is above 1, this output is the run time fraction for the higher speed.

Cooling Coil Condenser Inlet Temp [C]

This is the inlet air temperature to the condenser coil in degrees C. This value can represent the outdoor air dry-bulb temperature, wet-bulb temperature, or somewhere in between from the weather data being used, depending on the value used in the input field “Evaporative Condenser Effectiveness”. The temperature reported here is used in the various modifier curves related to temperature (e.g., Total Cooling Capacity Modifier Curve [function of temperature]).

DX Cooling Coil Evap Condenser Water Consumption [m3]

This output is the amount of water used to evaporatively cool the condenser coil inlet air, in cubic meters. This output is also added to a report meter with Resource Type = Water, End Use Key = Cooling, Group Key = System (ref. Report Meter).

DX Cooling Coil Evap Condenser Pump Electric Power [W]

This is the average electricity consumption rate of the evaporative condenser water pump in Watts for the timestep being reported.

DX Cooling Coil Evap Condenser Pump Electric Consumption [J]

This is the electricity consumption rate of the evaporative condenser water pump in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Cooling, Group Key = System (ref. Report Meter).

Coil:Heating:DX:SingleSpeed

The single speed heating DX coil model uses performance information at rated conditions along with curve fits for variations in total capacity, energy input ratio and part load fraction to determine performance at part-load conditions. The impacts of various defrost strategies (reverse cycle, resistive, timed or on-demand) are modeled based on a combination of user inputs and empirical models taken from the air-to-air heat pump algorithms in DOE-2.1E.

The single speed heating DX coil input requires an availability schedule, the rated total heating capacity, the rated COP and the rated air volume flow rate. The latter 3 inputs determine the coil performance at the rating point (outdoor air dry-bulb temperature of 8.33 C, outdoor air wet-bulb temperature of 6.11 C, coil entering air dry-bulb temperature of 21.11 C, coil entering air wet-bulb temperature of 15.55 C). The rated air volume flow rate should be between .00004027 m³/s and .00006041 m³/s per watt of rated total heating capacity.

Up to 6 curves are required depending on the defrost strategy selected.

- 1) The total heating capacity modifier curve (function of temperature) can be a function of both the outdoor and indoor air dry-bulb temperature or only the outdoor air dry-bulb temperature. User has the choice of a bi-quadratic curve with two independent variables or a quadratic curve as well as a cubic curve with a single independent variable. The bi-quadratic curve is recommended if sufficient manufacturer data is available as it provides sensitivity to the indoor air dry-bulb temperature and a more realistic output. The output of this curve is multiplied by the rated total heating capacity to give the total heating capacity at specific temperature operating conditions (i.e., at an outdoor or indoor air temperature different from the rating point temperature).
- 2) The total heating capacity modifier curve (function of flow fraction) is a quadratic or cubic curve with the independent variable being the ratio of the actual air flow rate

across the heating coil to the rated air flow rate (i.e., fraction of full load flow). The output of this curve is multiplied by the rated total heating capacity and the total heating capacity modifier curve (function of temperature) to give the total heating capacity at the specific temperature and air flow conditions at which the coil is operating.

- 3) The energy input ratio (EIR) modifier curve (function of temperature) can be a function of both the outdoor and indoor air dry-bulb temperature or only the outdoor air dry-bulb temperature. User has the choice of a bi-quadratic curve with two independent variables or a quadratic curve as well as a cubic curve with a single independent variable. The bi-quadratic curve is recommended if sufficient manufacturer data is available as it provides sensitivity to the indoor air dry-bulb temperature and a more realistic output. The output of this curve is multiplied by the rated EIR (inverse of the rated COP) to give the EIR at specific temperature operating conditions (i.e., at an outdoor or indoor air temperature different from the rating point temperature).
- 4) The energy input ratio (EIR) modifier curve (function of flow fraction) is a quadratic or cubic curve with the independent variable being the ratio of the actual air flow rate across the heating coil to the rated air flow rate (i.e., fraction of full load flow). The output of this curve is multiplied by the rated EIR (inverse of the rated COP) and the EIR modifier curve (function of temperature) to give the EIR at the specific temperature and air flow conditions at which the coil is operating.
- 5) The part load fraction correlation (function of part load ratio) is a quadratic or cubic curve with the independent variable being part load ratio (sensible heating load / steady-state heating capacity). The output of this curve is used in combination with the rated EIR and EIR modifier curves to give the “effective” EIR for a given simulation timestep. The part load fraction correlation accounts for efficiency losses due to compressor cycling.
- 6) The defrost energy input ratio (EIR) modifier curve (function of temperature) is a bi-quadratic curve with two independent variables: outdoor air dry-bulb temperature and the heating coil entering air wet-bulb temperature. The output of this curve is multiplied by the heating coil capacity, the fractional defrost time period and the runtime fraction of the heating coil to give the defrost power at the specific temperatures at which the coil is operating. This curve is only required when a reverse-cycle defrost strategy is specified.

The curves are simply specified by name. Curve inputs are described in the curve manager section of this document (ref. Performance Curves).

The next input item for the HeatingEmpirical DX coil is the supply air fan operation mode. Either the supply air fan runs continuously while the DX coil cycles on/off, or the fan and coil cycle on/off together. The next two inputs define the minimum outdoor dry-bulb temperature that the heat pump compressor will operate and the maximum outdoor dry-bulb temperature for defrost operation. Crankcase heater capacity and cutout temperature are entered in the following two inputs. The final four inputs cover the type of defrost strategy (reverse-cycle or resistive), defrost control (timed or on-demand), the fractional defrost time period (timed defrost control only), and the resistive defrost heater capacity if a resistive defrost strategy is selected.

Field: Name

This alpha field defines a unique user-assigned name for an instance of a DX heating coil. Any reference to this DX heating coil by another object will use this name.

Field: Availability Schedule Name

This alpha field defines the name of the schedule (ref: Schedule) that denotes whether the DX heating coil can run during a given hour. A schedule value greater than 0 (usually 1 is

used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Rated Total Heating Capacity

This numeric field defines the total, full load heating capacity in watts of the DX coil unit at rated conditions (outdoor air dry-bulb temperature of 8.33 C, outdoor air wet-bulb temperature of 6.11 C, heating coil entering air dry-bulb temperature of 21.11 C, heating coil entering air wet-bulb temperature of 15.55 C, and a heating coil air flow rate defined by field “rated air flow volume” below). The value entered here must be greater than 0. Capacity should not include supply air fan heat.

Field: Rated COP

This numeric field defines the coefficient of performance (COP=heating power output in watts divided by electrical power input in watts) of the DX heating coil unit at rated conditions (outdoor air dry-bulb temperature of 8.33 C, outdoor air wet-bulb temperature of 6.11 C, coil entering air dry-bulb temperature of 21.11 C, coil entering air wet-bulb temperature of 15.55 C, and a heating coil air flow rate defined by field “rated air flow volume rate” below). The value entered here must be greater than 0. The input power includes power for the compressor(s) and outdoor fan(s) but does not include the power consumption of the indoor supply air fan. The heating power output is the value entered above in the field “Rated Total Heating Capacity”.

Field: Rated Air Flow Rate

This numeric field defines the volume air flow rate, in m³ per second, across the DX heating coil at rated conditions. The value entered here must be greater than 0. The rated air volume flow rate should be between 0.00004027 m³/s and 0.00006041 m³/s per watt of rated total heating capacity. The rated total heating capacity and rated COP should be performance information for the unit with outdoor air dry-bulb temperature of 8.33 C, outdoor air wet-bulb temperature of 6.11 C, heating coil entering air dry-bulb temperature of 21.11 C, heating coil entering air wet-bulb temperature of 15.55 C, and the rated air volume flow rate defined here.

Field: Air Inlet Node Name

This alpha field defines the name of the HVAC system node from which the DX heating coil draws its inlet air.

Field: Air Outlet Node Name

This alpha field defines the name of the HVAC system node to which the DX heating coil sends its outlet air.

Field: Total Heating Capacity Function of Temperature Curve Name

This alpha field defines the name of a bi-quadratic, quadratic or cubic performance curve (ref: Performance Curves) that parameterizes the variation of the total heating capacity as a function of the both the indoor and outdoor air dry-bulb temperature or just the outdoor air dry-bulb temperature depending on the type of curve selected. The bi-quadratic curve is recommended if sufficient manufacturer data is available as it provides sensitivity to the indoor air dry-bulb temperature and a more realistic output. The output of this curve is multiplied by the rated total heating capacity to give the total heating capacity at specific temperature operating conditions (i.e., at an indoor air dry-bulb temperature or outdoor air dry-bulb temperature different from the rating point temperature). The curve is normalized to have the value of 1.0 at the rating point.

Field: Total Heating Capacity Function of Flow Fraction Curve Name

This alpha field defines the name of a quadratic or cubic performance curve (ref: Performance Curves) that parameterizes the variation of total heating capacity as a function of the ratio of actual air flow rate across the heating coil to the rated air flow rate (i.e., fraction

of full load flow). The output of this curve is multiplied by the rated total heating capacity and the total heating capacity modifier curve (function of temperature) to give the total heating capacity at the specific temperature and air flow conditions at which the coil is operating. The curve is normalized to have the value of 1.0 when the actual air flow rate equals the rated air flow rate.

Field: Energy Input Ratio Function of Temperature Curve Name

This alpha field defines the name of a bi-quadratic, quadratic or cubic performance curve (ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) as a function of the both the indoor and outdoor air dry-bulb temperature or just the outdoor air dry-bulb temperature depending on the type of curve selected. The bi-quadratic curve is recommended if sufficient manufacturer data is available as it provides sensitivity to the indoor air dry-bulb temperature and a more realistic output. The EIR is the inverse of the COP. The output of this curve is multiplied by the rated EIR (inverse of rated COP) to give the EIR at specific temperature operating conditions (i.e., at an indoor air dry-bulb temperature or outdoor air dry-bulb temperature different from the rating point temperature). The curve is normalized to have the value of 1.0 at the rating point.

Field: Energy Input Ratio Function of Flow Fraction Curve Name

This alpha field defines the name of a quadratic or cubic performance curve (ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) as a function of the ratio of actual air flow rate across the heating coil to the rated air flow rate (i.e., fraction of full load flow). The EIR is the inverse of the COP. The output of this curve is multiplied by the rated EIR and the EIR modifier curve (function of temperature) to give the EIR at the specific temperature and air flow conditions at which the coil is operating. This curve is normalized to a value of 1.0 when the actual air flow rate equals the rated air flow rate.

Field: Part Load Fraction Correlation Curve Name

This alpha field defines the name of a quadratic or cubic performance curve (Ref: Performance Curves) that parameterizes the variation of electrical power input to the DX unit as a function of the part load ratio (PLR, sensible cooling load/steady-state sensible cooling capacity). The product of the rated EIR and EIR modifier curves is divided by the output of this curve to give the “effective” EIR for a given simulation timestep. The part load fraction (PLF) correlation accounts for efficiency losses due to compressor cycling.

The part load fraction correlation should be normalized to a value of 1.0 when the part load ratio equals 1.0 (i.e., no efficiency losses when the compressor(s) run continuously for the simulation timestep). For PLR values between 0 and 1 ($0 \leq \text{PLR} < 1$), the following rules apply:

$$\text{PLF} \geq 0.7 \quad \text{and} \quad \text{PLF} \geq \text{PLR}$$

If $\text{PLF} < 0.7$ a warning message is issued, the program resets the PLF value to 0.7, and the simulation proceeds. The runtime fraction of the coil is defined as PLR/PLF . If $\text{PLF} < \text{PLR}$, then a warning message is issued and the runtime fraction of the coil is limited to 1.0.

A typical part load fraction correlation for a conventional, single-speed DX cooling coil (e.g., residential unit) would be:

$$\text{PLF} = 0.85 + 0.15(\text{PLR})$$

If the user wishes to model no efficiency degradation due to compressor cycling, the part load fraction correlation should be defined as follows:

$$\text{PLF} = 1.0 + 0.0(\text{PLR})$$

Field: Defrost Energy Input Ratio Function of Temperature Curve Name

This alpha field defines the name of a bi-quadratic performance curve (ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) during reverse-cycle defrost periods as a function of the outdoor air dry-bulb temperature and the wet-bulb

temperature of the air entering the indoor coil. The EIR is the inverse of the COP. The output of this curve is multiplied by the coil capacity, the fractional defrost time period and the runtime fraction of the heating coil to give the defrost power at the specific temperatures at which the indoor and outdoor coils are operating. This curve is only required when a reverse-cycle defrost strategy is selected. The curve is normalized to a value of 1.0 at the rating point conditions.

Field: Supply Air Fan Operating Mode

This alpha field has two choices: CyclingFanAndCompressor or ContinuousFanWithCyclingCompressor. The first choice stands for “cycling fan cycling compressor”. This means that the unit unloads by cycling both the fan and compressor; that is, both the supply fan and the heating coil compressor cycle on and off together to meet the load. The second choice stands for “continuous fan cycling compressor”. The supply fan runs continuously while the heating coil compressor cycles.

Field: Minimum Outdoor Dry-Bulb Temperature for Compressor Operation

This numeric field defines the minimum outdoor air dry-bulb temperature where the heating coil compressor turns off. The temperature for this input field must be greater than or equal to -20 C. If this input field is left blank, the default value is -8 C.

Field: Maximum Outdoor Dry-Bulb Temperature for Defrost Operation

This numeric field defines the outdoor air dry-bulb temperature above which outdoor coil defrosting is disabled. The temperature for this input field must be greater than or equal to 0 C and less than or equal to 7.22 C. If this input field is left blank, the default value is 5 C.

Field: Crankcase Heater Capacity

This numeric field defines the crankcase heater capacity in Watts. When the outdoor air dry-bulb temperature is below the value specified in the input field “Maximum Outdoor Dry-bulb Temperature for Crankcase Heater Operation” (described below), the crankcase heater is enabled during the time that the compressor is not running. If this heating coil is used as part of an air-to-air heat pump (Ref. UnitarySystem:HeatPump:AirToAir or PackageTerminal:HeatPump:AirToAir), the crankcase heater defined for this DX heating coil is enabled during the time that the compressor is not running for either heating or cooling (and the crankcase heater power defined in the DX cooling coil object is disregarded in this case). The value for this input field must be greater than or equal to 0. If this input field is left blank, the default value is 0. To simulate a unit without a crankcase heater, enter a value of 0.

Field: Maximum Outdoor Dry-Bulb Temperature for Crankcase Heater Operation

This numeric field defines the outdoor air dry-bulb temperature above which the compressor’s crankcase heater is disabled. The value for this input field must be greater than or equal to 0.0 C. If this input field is left blank, the default value is 10 C.

Field: Defrost Strategy

This alpha field has two choices: reverse-cycle or resistive. If the reverse-cycle strategy is selected, the heating cycle is reversed periodically to provide heat to melt frost accumulated on the outdoor coil. If a resistive defrost strategy is selected, the frost is melted using an electric resistance heater. If this input field is left blank, the default defrost strategy is reverse-cycle.

Field: Defrost Control

This alpha field has two choices: timed or on-demand. If timed control is selected, the defrost time period is calculated based on a fixed value or compressor runtime whether or not frost has actually accumulated. For timed defrost control, the fractional amount of time the unit is in defrost is entered in the input field “Defrost Time Period Fraction” described below. If on-demand defrost control is selected, the defrost time period is calculated based on outdoor

weather (humidity ratio) conditions. Regardless of which defrost control is selected, defrost does not occur above the user specified outdoor temperature entered in the input field “Maximum Outdoor Dry-bulb Temperature for Defrost Operation” described above. If this input field is left blank, the default defrost control is timed.

Field: Defrost Time Period Fraction

This numeric field defines the fraction of compressor runtime when the defrost cycle is active, and only applies to “timed” defrost (see Defrost Control input field above). For example, if the defrost cycle is active for 3.5 minutes for every 60 minutes of compressor runtime, then the user should enter $3.5/60 = 0.058333$. The value for this input field must be greater than or equal to 0. If this input field is left blank, the default value is 0.058333.

Field: Resistive Defrost Heater Capacity

This numeric field defines the capacity of the resistive defrost heating element in Watts. This input field is used only when the selected defrost strategy is ‘resistive’ (see input field “Defrost Strategy” above). The value for this input field must be greater than or equal to 0. If this input field is left blank, the default value is 0.

Below is the input data dictionary description of the DX heating coil.

```
Coil:Heating:DX:SingleSpeed,
  \min-fields 22
  A1 , \field Name
      \required-field
      \type alpha
      \reference HeatingCoilsDX
      \reference HeatingCoilsDXSingleSpeed
  A2 , \field Availability Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
  N1 , \field Rated Total Heating Capacity
      \required-field
      \type real
      \units W
      \minimum> 0.0
      \autosizable
      \note capacity excluding supply air fan heat
      \note rating point outdoor dry-bulb temp 8.33 C, outdoor wet-bulb temp 6.11 C
      \note rating point heating coil entering air dry-bulb 21.11 C, coil entering wet-bulb 15.55 C
  N2 , \field Rated COP
      \required-field
      \type real
      \minimum> 0.0
      \note does not include supply air fan heat or supply air fan electrical energy
  N3 , \field Rated Air Flow Rate
      \required-field
      \type real
      \units m3/s
      \minimum> 0.0
      \autosizable
      \note Flow rate corresponding to rated total capacity
      \note should be between 0.00004027 m3/s and .00006041 m3/s per watt of rated total heating capacity
```

```

A3 , \field Air Inlet Node Name
    \required-field
    \type alpha
A4 , \field Air Outlet Node Name
    \required-field
    \type alpha
A5 , \field Total Heating Capacity Function of Temperature Curve Name
    \required-field
    \type object-list
    \object-list BiquatricQuadraticCubicCurves
    \note quadratic curve = a + b*oat + c*oat**2
    \note cubic curve = a + b*oat + c*oat**2 + d*oat**3
    \note biquadratic curve = a + b*iat + c*iat**2 + d*oat + e*oat**2 + f*iat*oat
    \note oat = outdoor air dry-bulb temperature (C)
    \note iat = indoor air dry-bulb temperature (C)
    \note Biquadratic curve is recommended if sufficient manufacturer data is
    \note available for the heating capacity to be sensitive to both iat and oat.
A6 , \field Total Heating Capacity Function of Flow Fraction Curve Name
    \required-field
    \type object-list
    \object-list QuadraticCubicCurves
    \note quadratic curve = a + b*ff + c*ff**2
    \note cubic curve = a + b*ff + c*ff**2 + d*ff**3
    \note ff = fraction of the full load flow
A7 , \field Energy Input Ratio Function of Temperature Curve Name
    \required-field
    \type object-list
    \object-list BiquatricQuadraticCubicCurves
    \note quadratic curve = a + b*oat + c*oat**2
    \note cubic curve = a + b*oat + c*oat**2 + d*oat**3
    \note biquadratic curve = a + b*iat + c*iat**2 + d*oat + e*oat**2 + f*iat*oat
    \note oat = outdoor air dry-bulb temperature (C)
    \note iat = indoor air dry-bulb temperature (C)
    \note biquadratic curve is recommended if sufficient manufacturer data is
    \note available for the energy input ratio to be sensitive to both iat and oat.
A8 , \field Energy Input Ratio Function of Flow Fraction Curve Name
    \required-field
    \type object-list
    \object-list QuadraticCubicCurves
    \note quadratic curve = a + b*ff + c*ff**2
    \note cubic curve = a + b*ff + c*ff**2 + d*ff**3
    \note ff = fraction of the full load flow
A9 , \field Part Load Fraction Correlation Curve Name
    \required-field
    \type object-list
    \object-list QuadraticCubicCurves
    \note quadratic curve = a + b*PLR + c*PLR**2
    \note cubic curve = a + b*PLR + c*PLR**2 + d*PLR**3
    \note PLR = part load ratio (sensible heating load/steady-state heating capacity)
A10, \field Defrost Energy Input Ratio Function of Temperature Curve Name
    \type object-list
    \object-list BiquadraticCurves
    \note biquadratic curve = a + b*wb + c*wb**2 + d*oat + e*oat**2 + f*wb*oat
    \note wb = wet-bulb temperature (C) of air entering the indoor coil
    \note oat = outdoor air dry-bulb temperature (C)
    \note only required if ReverseCycle defrost strategy is specified
A11, \field Supply Air Fan Operating Mode
    \required-field
    \type choice
    \key CyclingFanAndCompressor
    \key ContinuousFanWithCyclingCompressor
N4 , \field Minimum Outdoor Dry-Bulb Temperature for Compressor Operation
    \type real
    \minimum -20.0
    \default -8.0
    \units C

```

```

N5 , \field Maximum Outdoor Dry-Bulb Temperature for Defrost Operation
      \type real
      \minimum 0.0
      \maximum 7.22
      \default 5.0
      \units C
N6, \field Crankcase Heater Capacity
      \type real
      \minimum 0.0
      \default 0.0
      \units W
      \ip-units W
N7, \field Maximum Outdoor Dry-Bulb Temperature for Crankcase Heater Operation
      \type real
      \minimum 0.0
      \default 10.0
      \units C
A12, \field Defrost Strategy
      \type choice
      \key ReverseCycle
      \key Resistive
      \default ReverseCycle
A13, \field Defrost Control
      \type choice
      \key Timed
      \key OnDemand
      \default Timed
N8, \field Defrost Time Period Fraction
      \type real
      \minimum 0.0
      \default 0.058333
      \note Fraction of time in defrost mode
      \note only applicable if timed defrost control is specified
N9; \field Resistive Defrost Heater Capacity
      \type real
      \minimum 0.0
      \default 0.0
      \autosizable
      \units W
      \note only applicable if resistive defrost strategy is specified
      \ip-units W

```

Following is an example input for a Heating Empirical DX coil.

```

Coil:Heating:DX:SingleSpeed,
Heat Pump DX Heating Coil 1, !Name of heating coil
FanAndCoilAvailSched, !Heating coil schedule
35000, !Nominal capacity of the heating coil
2.75, !rated heating COP
1.7, !rated air flow rate (m3/s)
Heating Coil Air Inlet Node, !heating coil air side inlet node
SuppHeating Coil Air Inlet Node, !Heating coil air side outlet node
HPACHeatCapFT, ! heating cap modifier curve (temperature, C)
HPACHeatCapFFF, ! heating cap modifier curve (flow fraction)
HPACHeatEIRFT, ! energy input ratio modifier curve (temperature, C)
HPACHeatEIRFFF, ! energy input ratio modifier curve (flow fraction)
HPACCOOLPLFFPLR, ! part load fraction modifier curve (function of part load ratio)
, ! defrost EIR modifier curve (temp, C) not required for resistive defrost
CycFanCycCoil, ! fan operating mode
-5.0, ! minimum OAT for compressor operation (C)
5.0, ! maximum outdoor dry-bulb temp for defrost operation (C)
200.0, ! Crankcase heater capacity (W)
10.0, ! Maximum outdoor temp for crankcase heater operation (C)
Resistive, ! Defrost strategy (resistive or reverse-cycle)
Timed, ! Defrost control (timed or on-demand)
0.166667, ! Defrost time period fraction (used for timed defrost control only)
20000;! Resistive defrost heater capacity (used for resistive defrost strategy only)

```

DX Heating Coil Outputs

```

HVAC,Average,DX Coil Total Heating Rate[W]
HVAC,Sum,DX Coil Total Heating Energy[J]
HVAC,Average,DX Heating Coil Electric Power[W]
HVAC,Sum,DX Heating Coil Electric Consumption[J]
HVAC,Average,DX Heating Coil Electric Defrost Power[W]
HVAC,Sum,DX Heating Coil Electric Defrost Consumption[J]
HVAC,Average,DX Heating Coil Crankcase Heater Power[W]
HVAC,Sum,DX Heating Coil Crankcase Heater Consumption[J]
HVAC,Average,DX Heating Coil Runtime Fraction

```

DX Coil Total Heating Rate [W]

This field is the total heating rate output of the DX coil in Watts. This is determined by the coil inlet and outlet air conditions and the air mass flow rate through the coil.

DX Coil Total Heating Energy[J]

This is the total heating output of the DX coil in Joules over the timestep being reported. This is determined by the coil inlet and outlet air conditions and the air mass flow rate through the coil. This output is also added to a report meter with Resource Type = EnergyTransfer, End Use Key = CoolingCoils, Group Key = System (ref. Report Meter).

DX Heating Coil Electric Power[W]

This output is the electricity consumption rate of the DX coil compressor and outdoor fan(s) in Watts. This rate is applicable when the unit is providing heating to the conditioned zone(s), and excludes periods when the unit is in reverse-cycle defrost mode.

DX Heating Coil Electric Consumption[J]

This is the electricity consumption of the DX coil compressor and condenser fan(s) in Joules for the timestep being reported. This consumption is applicable when the unit is providing heating to the conditioned zone(s), and excludes periods when the unit is in reverse-cycle defrost mode. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Cooling, Group Key = System (ref. Report Meter).

DX Heating Coil Electric Defrost Power[W]

This is the electricity consumption rate of the DX coil unit in Watts when the unit is in defrost mode (reverse-cycle or resistive).

DX Heating Coil Electric Defrost Consumption[J]

This is the electricity consumption of the DX coil unit in Joules for the timestep being reported. This consumption is applicable when the unit is in defrost mode (reverse-cycle or resistive).

DX Heating Coil Crankcase Heater Power[W]

This is the average electricity consumption rate of the DX coil compressor's crankcase heater in Watts for the timestep being reported.

DX Heating Coil Crankcase Heater Consumption[J]

This is the electricity consumption of the DX coil compressor's crankcase heater in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Miscellaneous, Group Key = System (ref. Report Meter).

DX Heating Coil Runtime Fraction

This is the runtime fraction of the DX heating coil compressor and outdoor fan(s) for the timestep being reported.

Coil:Heating:DX:MultiSpeed

This component models a DX heating unit with multiple discrete levels of heating capacity. Currently, this heating coil can only be referenced by a `AirLoopHVAC:UnitaryHeatPump:AirToAir:MultiSpeed` compound object. The multispeed DX heating coil can have from two to four operating speeds. When the coil operates at Speed 1 (the lowest speed), its performance is very similar to the `Coil:Heating:DX:SingleSpeed` object where the impacts of part-load ratio can be included. When the coil operates at higher speeds (above Speed 1), the linear approximation methodology is applied. The coil outputs at two consecutive speeds are linearly interpolated to meet the required heating capacity during an HVAC system timestep. When the coil performs above the lowest speed, the user can choose if they want to include part-load ratio impacts at the higher speeds.

The multispeed unit is described by specifying the performance at different operating speeds. Each speed has its own set of input specifications: full load capacity, COP and air flow rate at rated conditions, along with modifier curves to determine performance when actual operating conditions are different from the rated conditions.

The coil operates to meet the sensible capacity being requested. When this requested capacity is above the sensible capacity of the highest operating speed, the coil runs continuously at the highest speed. When the requested capacity is between the sensible capacities of two consecutive speeds, the unit will operate a portion of the time at each speed to meet the request. When the requested capacity is less than the low speed (Speed 1) capacity, the unit will cycle on/off as needed.

After inputting the coil name, available schedule, and inlet and outlet air node names, the next input item for the multiSpeed DX heating coil is the supply air fan operation mode. Either the supply air fan runs continuously while the DX coil cycles on/off, or the fan and coil cycle on/off together. The next input defines the minimum outdoor dry-bulb temperature where the compressor will operate. The following two inputs are related to crankcase heater operation: capacity and maximum outdoor dry-bulb temperature for crankcase heater operation. The next six inputs cover defrost operation: defrost EIR modifier curve, the maximum outdoor dry-bulb temperature for defrost operation, the type of defrost strategy (reverse-cycle or resistive), defrost control (timed or on-demand), the fractional defrost time period (timed defrost control only), and the resistive defrost heater capacity if a resistive defrost strategy is selected. The activation of defrost is dependent on outdoor conditions. The capacity reduction and energy use modification are independent of speed. The defrost EIR modifier is described below:

The defrost energy input ratio (EIR) modifier curve (function of temperature) is a bi-quadratic curve with two independent variables: outdoor air dry-bulb temperature and the heating coil entering air wet-bulb temperature. The output of this curve is multiplied by the heating coil capacity, the fractional defrost time period and the runtime fraction of the heating coil to give the defrost power at the specific temperatures at which the coil is operating. This curve is only required when a reverse-cycle defrost strategy is specified.

The next input allows the user to choose whether to apply the part load fraction correlation to speeds greater than 1 or not. The following input is the type of fuel.

Then the number of speed for heating is entered. The rest of inputs are speed dependent. Each set of data consists of rated heating capacity, rated COP, and the rated air volume flow rate. These three inputs determine the coil performance at the rating point (outdoor air dry-bulb temperature of 8.33°C, outdoor air wet-bulb temperature of 6.11°C, coil entering air dry-bulb temperature of 21.11°C, coil entering air wet-bulb temperature of 15.55°C). The rated air volume flow rate should be between .00004027 m³/s and .00006041 m³/s per watt of rated total heating capacity. The rated waste heat fraction is needed to calculate how much waste

heat is available at the rated conditions. In addition, up to 6 modifier curves are required per speed.

- 1) The total heating capacity modifier curve (function of temperature) can be a function of both the outdoor and indoor air dry-bulb temperature or only the outdoor air dry-bulb temperature. User has the choice of a bi-quadratic curve with two independent variables or a quadratic curve as well as a cubic curve with a single independent variable. The bi-quadratic curve is recommended if sufficient manufacturer data is available as it provides sensitivity to the indoor air dry-bulb temperature and a more realistic output. The output of this curve is multiplied by the rated total heating capacity to give the total heating capacity at specific temperature operating conditions (i.e., at an outdoor or indoor air temperature different from the rating point temperature).
- 2) The total heating capacity modifier curve (function of flow fraction) is a quadratic or cubic curve with the independent variable being the ratio of the actual air flow rate across the heating coil to the rated air flow rate (i.e., fraction of full load flow). The output of this curve is multiplied by the rated total heating capacity and the total heating capacity modifier curve (function of temperature) to give the total heating capacity at the specific temperature and air flow conditions at which the coil is operating.
- 3) The energy input ratio (EIR) modifier curve (function of temperature) can be a function of both the outdoor and indoor air dry-bulb temperature or only the outdoor air dry-bulb temperature. User has the choice of a bi-quadratic curve with two independent variables or a quadratic curve as well as a cubic curve with a single independent variable. The bi-quadratic curve is recommended if sufficient manufacturer data is available as it provides sensitivity to the indoor air dry-bulb temperature and a more realistic output. The output of this curve is multiplied by the rated EIR (inverse of the rated COP) to give the EIR at specific temperature operating conditions (i.e., at an outdoor or indoor air temperature different from the rating point temperature).
- 4) The energy input ratio (EIR) modifier curve (function of flow fraction) is a quadratic or cubic curve with the independent variable being the ratio of the actual air flow rate across the heating coil to the rated air flow rate (i.e., fraction of full load flow). The output of this curve is multiplied by the rated EIR (inverse of the rated COP) and the EIR modifier curve (function of temperature) to give the EIR at the specific temperature and air flow conditions at which the coil is operating.
- 5) The part load fraction correlation (function of part load ratio) is a quadratic or cubic curve with the independent variable being part load ratio (sensible heating load / steady-state heating capacity). The output of this curve is used in combination with the rated EIR and EIR modifier curves to give the “effective” EIR for a given simulation timestep. The part load fraction correlation accounts for efficiency losses due to compressor cycling.
- 6) The waste heat modifier curve (function of temperature) is a bi-quadratic curve with two independent variables: outdoor air dry-bulb temperature and the heating coil entering air dry-bulb temperature. The output of this curve is multiplied by the heating input energy, the waste heat fraction of heat input to give the recoverable waste heat.

The curves are simply specified by name. Curve inputs are described in the curve manager section of this document (ref. Performance Curves).

Field: Name

This alpha field defines a unique user-assigned name for an instance of a multispeed DX heating coil. Any reference to this DX heating coil by another object will use this name. The only allowed parent is UnitarySystem:MultiSpeedHeatPump:AirToAir.

Field: Availability Schedule Name

This alpha field defines the name of the schedule (ref: Schedule) that denotes whether the multispeed DX heating coil can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Air Inlet Node name

This alpha field defines the name of the HVAC system node from which the DX heating coil draws its inlet air.

Field: Air Outlet Node Name

This alpha field defines the name of the HVAC system node to which the DX heating coil sends its outlet air.

Field: Supply Air Fan Operation Mode

This alpha field has two choices: `CyclingFanAndCompressor` or `ContinuousFanWithCyclingCompressor`. The first choice stands for “cycling fan cycling compressor”. This means that the unit unloads by cycling both the fan and compressor; that is, both the supply fan and the heating coil compressor cycle on and off together to meet the load. The second choice stands for “continuous fan cycling compressor”. The supply fan runs continuously while the heating coil compressor cycles. The parent object of `UnitarySystem:MultiSpeedHeatPump:AirToAir` has a field as a schedule to define fan operation mode at a given time. The value defined in the parent schedule will override the fan operation mode defined in this field.

Field: Minimum Outdoor Dry-Bulb Temperature for Compressor Operation

This numeric field defines the minimum outdoor air dry-bulb temperature where the heating coil compressor turns off. The temperature for this input field must be greater than or equal to -20°C . If this input field is left blank, the default value is -8°C .

Field: Crankcase Heater Capacity

This numeric field defines the crankcase heater capacity in Watts. When the outdoor air dry-bulb temperature is below the value specified in the input field “Maximum Outdoor Dry-bulb Temperature for Crankcase Heater Operation” (described below), the crankcase heater is enabled during the time that the compressor is not running. The value for this input field must be greater than or equal to 0. If this input field is left blank, the default value is 0. To simulate a unit without a crankcase heater, enter a value of 0.

Field: Maximum Outdoor Dry-Bulb Temperature for Crankcase Heater Operation

This numeric field defines the outdoor air dry-bulb temperature above which the compressor’s crankcase heater is disabled. The value for this input field must be greater than or equal to 0.0°C . If this input field is left blank, the default value is 10°C .

Field: Defrost Energy Input Ratio Function of Temperature Curve Name

This alpha field defines the name of a bi-quadratic performance curve (ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) during reverse-cycle defrost periods as a function of the outdoor air dry-bulb temperature and the wet-bulb temperature of the air entering the indoor coil. The EIR is the inverse of the COP. The output of this curve is multiplied by the coil capacity, the fractional defrost time period and the runtime fraction of the heating coil to give the defrost power at the specific temperatures at which the indoor and outdoor coils are operating. This curve is only required when a reverse-cycle defrost strategy is selected. The curve is normalized to a value of 1.0 at the rating point conditions.

Field: Maximum Outdoor Dry-Bulb Temperature for Defrost Operation

This numeric field defines the outdoor air dry-bulb temperature above which outdoor coil defrosting is disabled. The temperature for this input field must be greater than or equal to 0°C and less than or equal to 7.22°C. If this input field is left blank, the default value is 5°C.

Field: Defrost Strategy

This alpha field has two choices: reverse-cycle or resistive. If the reverse-cycle strategy is selected, the heating cycle is reversed periodically to provide heat to melt frost accumulated on the outdoor coil. If a resistive defrost strategy is selected, the frost is melted using an electric resistance heater. If this input field is left blank, the default defrost strategy is reverse-cycle.

Field: Defrost Control

This alpha field has two choices: timed or on-demand. If timed control is selected, the defrost time period is calculated based on a fixed value or compressor runtime whether or not frost has actually accumulated. For timed defrost control, the fractional amount of time the unit is in defrost is entered in the input field “Defrost Time Period Fraction” described below. If on-demand defrost control is selected, the defrost time period is calculated based on outdoor weather (humidity ratio) conditions. Regardless of which defrost control is selected, defrost does not occur above the user specified outdoor temperature entered in the input field “Maximum Outdoor Dry-bulb Temperature for Defrost Operation” described above. If this input field is left blank, the default defrost control is timed.

Field: Defrost Time Period Fraction

This numeric field defines the fraction of compressor runtime when the defrost cycle is active, and only applies to “timed” defrost (see Defrost Control input field above). For example, if the defrost cycle is active for 3.5 minutes for every 60 minutes of compressor runtime, then the user should enter $3.5/60 = 0.058333$. The value for this input field must be greater than or equal to 0. If this input field is left blank, the default value is 0.058333.

Field: Resistive Defrost Heater Capacity

This numeric field defines the capacity of the resistive defrost heating element in Watts. This input field is used only when the selected defrost strategy is ‘resistive’ (see input field “Defrost Strategy” above). The value for this input field must be greater than or equal to 0. If this input field is left blank, the default value is 0.

Field: Apply Part Load Fraction to Speeds Greater than 1

This field determines whether part-load impacts on coil energy use are applied when the coil is operating at speeds greater than speed 1. The allowed choices are Yes or No, with the default being No if this field is left blank. Other input fields in this object allow the user to specify a part-load fraction correlation for each speed to account for compressor start up losses (cycle on/off). For the case of a single multi-speed compressor, the part load losses may only be significant when the compressor cycles between speed 1 and off, but the losses may be extremely small when the compressor operates between speed 1 and speed 2 (or between speeds 2 and 3, etc.). In this case, the user may chose to specify **No** for this input field to neglect part-load impacts on energy use at higher operating speeds. If part-load impacts on coil energy use are thought to be significant (e.g., intertwined cooling coil with multiple compressors feeding individual refrigerant circuits), then the user may chose to specify **Yes** and the part-load fraction correlations specified for speeds 2 through 4 will be applied as appropriate. The selection for this input field does not affect part-load impacts when the compressor cycles between speed 1 and off (i.e., the part-load fraction correlation for speed 1 is always applied).

Field: Fuel Type

This alpha field determines the type of fuel that the chiller uses. This field has seven choices: Electricity, NaturalGas, PropaneGas, Diesel, Gasoline, FuelOil#1, and FuelOil#2. The default is NaturalGas.

Field: Number of Speeds

This field specifies the number of sets of data being entered for rated specifications, performance curves, and waste heat specifications for each cooling speed. The rated specifications consist of rated capacity, rated COP, and rated air flow rate. The performance curves consist of a total capacity modifier curve as a function of temperature, total capacity modifier curve as a function of flow fraction, energy input ratio modifier curve as a function of temperature, energy input ratio modifier curve as a function of flow fraction, and part load fraction correlation as a function of part load ratio. The waste heat specifications include the fraction of energy input to the heating coil at the fully loaded and rated conditions, and a temperature modifier. The minimum number of speeds for heating is 2 and the maximum number is 4. The number of speeds should be the same as the number of speeds for heating defined in its parent object (UnitarySystem:MultiSpeedHeatPump: AirToAir). The first set of performance inputs is for Speed 1 and should be for low speed, and the last set of performance inputs should be for high speed. For example, if only three heating speeds are defined, the first set should be for low speed (Speed 1), the second set should be for medium speed (Speed 2), and the third set should be for high speed (Speed 3). In this example, any performance inputs for Speed 4 would be neglected (since this input field specifies that the coil only has three heating speeds).

Field Group: rated specification, performance curves, and waste heat data

The performance for each heating speed must be specified as shown below. All inputs for Speed 1 are required first, followed by the inputs for Speed 2, Speed 3 and Speed 4.

Field: Speed <x> Rated Total Heating Capacity

This numeric field defines the total, full load heating capacity in watts of the DX coil unit at rated conditions for Speed <x> operation (outdoor air dry-bulb temperature of 8.33°C, outdoor air wet-bulb temperature of 6.11°C, heating coil entering air dry-bulb temperature of 21.11°C, heating coil entering air wet-bulb temperature of 15.55°C, and a heating coil air flow rate defined by field “Rated Air Volume Flow Rate, Speed <x>” below). The value entered here must be greater than 0. Capacity should not include supply air fan heat.

Field: Speed <x> Rated COP

This numeric field defines the coefficient of performance (COP=heating power output in watts divided by electrical power input in watts) of the DX heating coil unit at rated conditions for Speed <x> operation (outdoor air dry-bulb temperature of 8.33°C, outdoor air wet-bulb temperature of 6.11°C, coil entering air dry-bulb temperature of 21.11°C, coil entering air wet-bulb temperature of 15.55°C, and a heating coil air flow rate defined by field “Speed <x> Rated Air Flow Rate” below). The value entered here must be greater than 0. The input power includes power for the compressor(s) and outdoor fan(s) but does not include the power consumption of the indoor supply air fan. The heating power output is the value entered above in the field “Rated Total Heating Capacity”.

Field: Speed <x> Rated Air Flow Rate

This numeric field defines the volume air flow rate, in m³ per second, across the DX heating coil at rated conditions for Speed <x> operation. The value entered here must be greater than 0. The rated air volume flow rate should be between 0.00004027 m³/s and 0.00006041 m³/s per watt of rated total heating capacity. The rated total heating capacity and rated COP should be performance information for the unit with outdoor air dry-bulb temperature of 8.33°C, outdoor air wet-bulb temperature of 6.11°C, heating coil entering air dry-bulb

temperature of 21.11°C, heating coil entering air wet-bulb temperature of 15.55°C, and the rated air volume flow rate defined here.

Field: Speed <x> Total Heating Capacity Function of Temperature Curve Name

This alpha field defines the name of a bi-quadratic, quadratic or cubic performance curve for Speed <x> (ref: Performance Curves) that parameterizes the variation of the total heating capacity as a function of the both the indoor and outdoor air dry-bulb temperature or just the outdoor air dry-bulb temperature depending on the type of curve selected. The bi-quadratic curve is recommended if sufficient manufacturer data is available as it provides sensitivity to the indoor air dry-bulb temperature and a more realistic output. The output of this curve is multiplied by the rated total heating capacity to give the total heating capacity at specific temperature operating conditions (i.e., at an indoor air dry-bulb temperature or outdoor air dry-bulb temperature different from the rating point temperature). The curve is normalized to have the value of 1.0 at the rating point.

Field: Speed <x> Total Heating Capacity Function of Flow Fraction Curve Name

This alpha field defines the name of a quadratic or cubic performance curve for Speed <x> (ref: Performance Curves) that parameterizes the variation of total heating capacity as a function of the ratio of actual air flow rate across the heating coil to the rated air flow rate (i.e., fraction of full load flow). The output of this curve is multiplied by the rated total heating capacity and the total heating capacity modifier curve (function of temperature) to give the total heating capacity at the specific temperature and air flow conditions at which the coil is operating. The curve is normalized to have the value of 1.0 when the actual air flow rate equals the rated air flow rate.

Field: Speed <x> Energy Input Ratio Function of Temperature Curve Name

This alpha field defines the name of a bi-quadratic, quadratic or cubic performance curve for Speed <x> (ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) as a function of the both the indoor and outdoor air dry-bulb temperature or just the outdoor air dry-bulb temperature depending on the type of curve selected. The bi-quadratic curve is recommended if sufficient manufacturer data is available as it provides sensitivity to the indoor air dry-bulb temperature and a more realistic output. The EIR is the inverse of the COP. The output of this curve is multiplied by the rated EIR (inverse of rated COP) to give the EIR at specific temperature operating conditions (i.e., at an indoor air dry-bulb temperature or outdoor air dry-bulb temperature different from the rating point temperature). The curve is normalized to have the value of 1.0 at the rating point.

Field: Speed <x> Energy Input Ratio Function of Flow Fraction Curve Name

This alpha field defines the name of a quadratic or cubic performance curve for Speed <x> (ref: Performance Curves) that parameterizes the variation of the energy input ratio (EIR) as a function of the ratio of actual air flow rate across the heating coil to the rated air flow rate (i.e., fraction of full load flow). The EIR is the inverse of the COP. The output of this curve is multiplied by the rated EIR and the EIR modifier curve (function of temperature) to give the EIR at the specific temperature and air flow conditions at which the coil is operating. This curve is normalized to a value of 1.0 when the actual air flow rate equals the rated air flow rate.

Field: Speed <x> Part Load Fraction Correlation Curve Name

This alpha field defines the name of a quadratic or cubic performance curve for Speed <x> (Ref: Performance Curves) that parameterizes the variation of electrical power input to the DX unit as a function of the part load ratio (PLR, sensible cooling load/steady-state sensible cooling capacity). The product of the rated EIR and EIR modifier curves is divided by the output of this curve to give the “effective” EIR for a given simulation timestep. The part load fraction (PLF) correlation accounts for efficiency losses due to compressor cycling.

The part load fraction correlation should be normalized to a value of 1.0 when the part load ratio equals 1.0 (i.e., no efficiency losses when the compressor(s) run continuously for the simulation timestep). For PLR values between 0 and 1 ($0 \leq \text{PLR} < 1$), the following rules apply:

$$\text{PLF} \geq 0.7 \text{ and } \text{PLF} \geq \text{PLR}$$

If $\text{PLF} < 0.7$ a warning message is issued, the program resets the PLF value to 0.7, and the simulation proceeds. The runtime fraction of the coil is defined as PLR/PLF . If $\text{PLF} < \text{PLR}$, then a warning message is issued and the runtime fraction of the coil is limited to 1.0.

A typical part load fraction correlation for a conventional DX heating coil (Speed <x>) would be:

$$\text{PLF} = 0.85 + 0.15(\text{PLR})$$

If the user wishes to model no efficiency degradation due to compressor cycling, the part load fraction correlation should be defined as follows:

$$\text{PLF} = 1.0 + 0.0(\text{PLR})$$

Field: Speed <x> Rated Waste Heat Fraction of Power Input

The fraction of heat input to heating that is available as recoverable waste heat at full load and rated conditions for Speed <x> operation.

Field: Speed <x> Waste Heat Function of Temperature Curve Name

The name of a bi-quadratic performance curve (ref: Performance Curves) that parameterizes the variation of the waste heat recovery as a function of outdoor dry-bulb temperature and the entering coil dry-bulb temperature for Speed <x>. The output of this curve is multiplied by the rated recoverable waste heat at specific temperature operating conditions (i.e., at temperatures different from the rating point). The curve is normalized to a value of 1.0 at the rating point. When the fuel type is electricity, the field is either left blank or ignored by the program.

Below is the input data dictionary description of the DX heating coil.

```
Coil:Heating:DX:MultiSpeed,
  \min-fields 37
  A1 , \field Name
      \required-field
      \reference HeatingCoilsDX
      \type alpha
  A2 , \field Availability Schedule Name
      \required-field
      \type object-list
      \object-list ScheduleNames
  A3 , \field Air Inlet Node Name
      \required-field
      \type alpha
  A4 , \field Air Outlet Node Name
      \required-field
      \type alpha
  A5, \field Supply Air Fan Operating Mode
      \required-field
      \type choice
      \key CyclingFanAndCompressor
      \key ContinuousFanWithCyclingCompressor
  N1 , \field Minimum Outdoor Dry-Bulb Temperature for Compressor Operation
      \type real
      \minimum -20.0
      \default -8.0
      \units C
```

```
N2 , \field Crankcase Heater Capacity
    \type real
    \minimum 0.0
    \default 0.0
    \units W
    \ip-units W
N3 , \field Maximum Outdoor Dry-Bulb Temperature for Crankcase Heater Operation
    \type real
    \minimum 0.0
    \default 10.0
    \units C
A6 , \field Defrost Energy Input Ratio Function of Temperature Curve Name
    \type object-list
    \object-list BiquadraticCurves
    \note biquadratic curve =  $a + b*wb + c*wb**2 + d*oat + e*oat**2 + f*wb*oat$ 
    \note wb = wet-bulb temperature (C) of air entering the indoor coil
    \note oat = outdoor air dry-bulb temperature (C)
    \note only required if ReverseCycle defrost strategy is specified
N4 , \field Maximum Outdoor Dry-Bulb Temperature for Defrost Operation
    \type real
    \minimum 0.0
    \maximum 7.22
    \default 5.0
    \units C
A7 , \field Defrost Strategy
    \type choice
    \key ReverseCycle
    \key Resistive
    \default ReverseCycle
A8 , \field Defrost Control
    \type choice
    \key Timed
    \key OnDemand
    \default Timed
N5 , \field Defrost Time Period Fraction
    \type real
    \minimum 0.0
    \default 0.058333
    \note Fraction of time in defrost mode
    \note only applicable if timed defrost control is specified
N6 , \field Resistive Defrost Heater Capacity
    \type real
    \minimum 0.0
    \default 0.0
    \autosizable
    \units W
    \note only applicable if resistive defrost strategy is specified
    \ip-units W
A9 , \field Apply Part Load Fraction to Speeds Greater than 1
    \type choice
    \key Yes
    \key No
    \default No
A10, \field Fuel Type
    \type choice
    \key Electricity
    \key NaturalGas
    \key PropaneGas
    \key Diesel
    \key Gasoline
    \key FuelOil#1
    \key FuelOil#2
    \default NaturalGas
```

```

N7 , \field Number of Speeds
    \required-field
    \type integer
    \minimum 2
    \maximum 4
    \note Enter the number of the following sets of data for coil capacity, COP,
    \note flow rate, and associated curves.
N8 , \field Speed 1 Rated Total Heating Capacity
    \required-field
    \type real
    \units W
    \minimum> 0.0
    \autosizable
    \note capacity excluding supply air fan heat
    \note rating point outdoor dry-bulb temp 8.33 C, outdoor wet-bulb temp 6.11 C
    \note rating point heating coil entering air dry-bulb 21.11 C, coil entering
    \note wet-bulb 15.55 C
N9 , \field Speed 1 Rated COP
    \required-field
    \type real
    \minimum> 0.0
    \note does not include supply air fan heat or supply air fan electrical energy
N10, \field Speed 1 Rated Air Flow Rate
    \required-field
    \type real
    \units m3/s
    \minimum> 0.0
    \autosizable
    \note Flow rate corresponding to rated total capacity
    \note should be between 0.00004027 m3/s and .00006041 m3/s per watt of rated total
    \note heating capacity
A11, \field Speed 1 Total Heating Capacity Function of Temperature Curve Name
    \required-field
    \type object-list
    \object-list BiquadraticQuadraticCubicCurves
    \note quadratic curve = a + b*oat + c*oat**2
    \note cubic curve = a + b*oat + c*oat**2 + d*oat**3
    \note biquadratic curve = a + b*iat + c*iat**2 + d*oat + e*oat**2 + f*iat*oat
    \note oat = outdoor air dry-bulb temperature (C)
    \note iat = indoor air dry-bulb temperature (C)
    \note biquadratic curve is recommended if sufficient manufacturer data is
    \note available for the heating capacity to be sensitive to both iat and oat.
A12, \field Speed 1 Total Heating Capacity Function of Flow Fraction Curve Name
    \required-field
    \type object-list
    \object-list QuadraticCubicCurves
    \note quadratic curve = a + b*ff + c*ff**2
    \note cubic curve = a + b*ff + c*ff**2 + d*ff**3
    \note ff = fraction of the full load flow
A13, \field Speed 1 Energy Input Ratio Function of Temperature Curve Name
    \required-field
    \type object-list
    \object-list BiquadraticQuadraticCubicCurves
    \note quadratic curve = a + b*oat + c*oat**2
    \note cubic curve = a + b*oat + c*oat**2 + d*oat**3
    \note biquadratic curve = a + b*iat + c*iat**2 + d*oat + e*oat**2 + f*iat*oat
    \note oat = outdoor air dry-bulb temperature (C)
    \note iat = indoor air dry-bulb temperature (C)
    \note biquadratic curve is recommended if sufficient manufacturer data is
    \note available for the energy input ratio to be sensitive to both iat and oat.
A14, \field Speed 1 Energy Input Ratio Function of Flow Fraction Curve Name
    \required-field
    \type object-list
    \object-list QuadraticCubicCurves
    \note quadratic curve = a + b*ff + c*ff**2
    \note cubic curve = a + b*ff + c*ff**2 + d*ff**3
    \note ff = fraction of the full load flow

```

```

A15, \field Speed 1 Part Load Fraction Correlation Curve Name
    \required-field
    \type object-list
    \object-list QuadraticCubicCurves
    \note quadratic curve = a + b*PLR + c*PLR**2
    \note cubic curve = a + b*PLR + c*PLR**2 + d*PLR**3
    \note PLR = part load ratio (sensible heating load/steady-state heating capacity)
N11, \field Speed 1 Rated Waste Heat Fraction of Power Input
    \required-field
    \type real
    \units dimensionless
    \minimum> 0.0
    \maximum 1.0
    \note recoverable waste heat at full load and rated conditions
A16, \field Speed 1 Waste Heat Function of Temperature Curve Name
    \required-field
    \type alpha
    \object-list BiQuadraticCurves
    \note curve = a + b*odb + c*odb**2 + d*db + e*db**2 + f*odb*db
    \note odb = Outdoor air dry-bulb temperature (C)
    \note db = entering coil dry-bulb temperature (C)

```

Following is an example input for a multi-speed heating DX coil.

```

COIL:DX:MultiSpeed:Heating,
Heat Pump DX Heating Coil 1,  !- Name of heat pump heating coil
FanAndCoilAvailSched,      !- Availability Schedule
Heating Coil Air Inlet Node, !- Coil Air Inlet Node
SuppHeating Coil Air Inlet Node, !- Coil Air Outlet Node
CyclingFanAndCompressor,   !- Supply Air Fan Operation Mode
-8.0,                      !- Minimum Outdoor Dry-bulb Temperature for Compressor Operation {C}
200.0,                     !- Crankcase Heater Capacity {W}
10.0,                      !- Maximum Outdoor Dry-bulb Temperature for Crankcase Heater
                             !- Operation {C}
HPACDefrostCAPFT,         !- Defrost energy input ratio modifier curve (temperature)
7.22,                     !- Maximum Outdoor Dry-bulb Temperature for Defrost Operation
reverse-cycle,            !- Defrost Strategy
timed,                   !- Defrost Control
0.058333,                !- Defrost Time Period Fraction
2000.0,                  !- Resistive Defrost Heater Capacity {W}
No,                       !- Apply Part Load Fraction to Speeds greater than 1
NaturalGas,              !- Fuel type
4,                       !- Number of speeds
7500,                    !- Rated Total Heating Capacity, Speed 1 {W}
2.75,                    !- Rated COP, Speed 1
0.45,                    !- Rated Air Volume Flow Rate, Speed 1 {m3/s}
HPACHeatCapFT Speed 1,   !- Total Heating Capacity Modifier Curve, Speed 1 (temperature)
HPACHeatCapFF Speed 1,   !- Total Heating capacity modifier curve, Speed 1 (flow fraction)
HPACHeatEIRFT Speed 1,   !- Energy input ratio modifier curve, Speed 1 (temperature)
HPACHeatEIRFF Speed 1,   !- Energy input ratio modifier curve, Speed 1 (flow fraction)
HPACHeatPLFFPLR Speed 1, !- Part load fraction correlation, Speed 1 (part load ratio)
0.2,                     !- Rated waste heat fraction of power input, Speed 1
HAPCHHeatWHFT Speed 1,   !- Waste heat modifier curve, Speed 1 (temperature)

```



```

17500,           !- Rated Total Heating Capacity, Speed 2 {W}
2.75,           !- Rated COP, Speed 2
0.85,           !- Rated Air Volume Flow Rate, Speed 2 {m3/s}
HPACHeatCapFT Speed 2, !- Total Heating Capacity Modifier Curve, Speed 2 (temperature)
HPACHeatCapFF Speed 2, !- Total Heating capacity modifier curve, Speed 2 (flow fraction)
HPACHeatEIRFT Speed 2, !- Energy input ratio modifier curve, Speed 2 (temperature)
HPACHeatEIRFF Speed 2, !- Energy input ratio modifier curve, Speed 2 (flow fraction)
HPACHeatPLFFPLR Speed 2, !- Part load fraction correlation, Speed 2 (part load ratio)
0.2,            !- Rated waste heat fraction of power input, Speed 2
HAPCHeatWHFT Speed 2, !- Waste heat modifier curve, Speed 2 (temperature)
25500,          !- Rated Total Heating Capacity, Speed 3 {W}
2.75,           !- Rated COP, Speed 3
1.25,           !- Rated Air Volume Flow Rate, Speed 3 {m3/s}
HPACHeatCapFT Speed 3, !- Total Heating Capacity Modifier Curve, Speed 3 (temperature)
HPACHeatCapFF Speed 3, !- Total Heating capacity modifier curve, Speed 3 (flow fraction)
HPACHeatEIRFT Speed 3, !- Energy input ratio modifier curve, Speed 3 (temperature)
HPACHeatEIRFF Speed 3, !- Energy input ratio modifier curve, Speed 3 (flow fraction)
HPACHeatPLFFPLR Speed 3, !- Part load fraction correlation, Speed 3 (part load ratio)
0.2,            !- Rated waste heat fraction of power input, Speed 3
HAPCHeatWHFT Speed 3, !- Waste heat modifier curve, Speed 3 (temperature)
35500,          !- Rated Total Heating Capacity, Speed 4 {W}
2.75,           !- Rated COP, Speed 4
1.75,           !- Rated Air Volume Flow Rate, Speed 4 {m3/s}
HPACHeatCapFT Speed 4, !- Total Heating Capacity Modifier Curve, Speed 4 (temperature)
HPACHeatCapFF Speed 4, !- Total Heating capacity modifier curve, Speed 4 (flow fraction)
HPACHeatEIRFT Speed 4, !- Energy input ratio modifier curve, Speed 4 (temperature)
HPACHeatEIRFF Speed 4, !- Energy input ratio modifier curve, Speed 4 (flow fraction)
HPACHeatPLFFPLR Speed 4, !- Part load fraction correlation, Speed 4 (part load ratio)
0.2,            !- Rated waste heat fraction of power input, Speed 4
HAPCHeatWHFT Speed 4; !- Waste heat modifier curve, Speed 4 (temperature)
    
```

DX Heating Coil Outputs

```

HVAC,Average,DX Coil Total Heating Rate[W]
HVAC,Sum,DX Coil Total Heating Energy[J]
HVAC,Average,DX Heating Coil <FuelType> Power[W]
HVAC,Sum,DX Heating Coil <FuelType> Consumption[J]
HVAC,Average,DX Heating Coil Electric Defrost Power[W]
HVAC,Sum,DX Heating Coil Electric Defrost Consumption[J]
HVAC,Average,DX Heating Coil NaturalGas Defrost Power[W]
HVAC,Sum,DX Heating Coil NaturalGas Defrost Consumption[J]
HVAC,Average,DX Heating Coil Crankcase Heater Power[W]
HVAC,Sum,DX Heating Coil Crankcase Heater Consumption[J]
HVAC,Average,DX Heating Coil Runtime Fraction
    
```

DX Coil Total Heating Rate [W]

This field is the total heating rate output of the DX coil in Watts. This is determined by the coil inlet and outlet air conditions and the air mass flow rate through the coil.

DX Coil Total Heating Energy[J]

This is the total heating output of the DX coil in Joules over the timestep being reported. This is determined by the coil inlet and outlet air conditions and the air mass flow rate through the coil. This output is also added to a report meter with Resource Type = EnergyTransfer, End Use Key = HeatingCoil, Group Key = System (ref. Report Meter).

DX Heating Coil <FuelType> Power [W]

This output variable is the input fuel type power for the heating coil in the unit of Watts, averaged during the report period.

DX Cooling Coil <FuelType> Consumption [J]

This output variable is the input fuel type consumption for the multispeed heating coil in the unit of Joules, summed during the report period. This output is also added to a report meter with Resource Type = <FuelType>, End Use Key = Heating, Group Key = System (ref. Report Meter).

Note: The FuelType defined in the above two output variables depends on the input in the fuel type filed. In addition to Electricity, Valid fuel types are NaturalGas, Propane, FuelOil#1, FuelOil#2, Coal, Diesel, and Gasoline.

DX Heating Coil Electric Defrost Power [W]

This is the electricity consumption rate of the DX coil unit in Watts when the unit is in defrost mode (reverse-cycle or resistive). The variable is available when the defrost mode is resistive or the fuel type is electricity.

DX Heating Coil Electric Defrost Consumption [J]

This is the electricity consumption of the DX coil unit in Joules for the timestep being reported. This consumption is applicable when the unit is in defrost mode (reverse-cycle or resistive). The variable is available when the defrost mode is resistive or the fuel type is electricity.

DX Heating Coil <FuelType> Defrost Power [W]

This is the fuel consumption rate of the DX coil unit in Watts when the unit is in defrost mode (reverse-cycle). The variable is available when the defrost mode is reverse-cycle and the fuel type is non-electricity.

DX Heating Coil <FuelType> Defrost Consumption[J]

This is the fuel consumption of the DX coil unit in Joules for the timestep being reported. This consumption is applicable when the unit is in defrost mode (reverse-cycle). The variable is available when the defrost mode is reverse-cycle and the fuel type is non-electricity.

DX Heating Coil Crankcase Heater Power [W]

This is the average electricity consumption rate of the DX coil compressor's crankcase heater in Watts for the timestep being reported. When a companion cooling coil exits, the crankcase heater power of the companion cool coil is also reported in this variable.

DX Heating Coil Crankcase Heater Consumption [J]

This is the electricity consumption of the DX coil compressor's crankcase heater in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Heating, Group Key = System (ref. Report Meter). When a companion cooling coil exits, the crankcase heater power of the companion cool coil is also reported in this variable.

DX Heating Coil Runtime Fraction

This is the runtime fraction of the DX heating coil compressor and outdoor fan(s) for the timestep being reported. When the heating speed is above 1, this output is the run time fraction for the higher speed.

CoilSystem:Cooling:DX:HeatExchangerAssisted

The heat exchanger-assisted DX cooling coil is a "virtual" component consisting of a direct expansion (DX) cooling coil and an air-to-air heat exchanger as shown in Figure 112 below. The air-to-air heat exchanger pre-conditions the air entering the cooling coil, and reuses this

energy to post-condition the supply air leaving the cooling coil. This heat exchange process improves the latent removal performance of the cooling coil by allowing it to dedicate more of its cooling capacity toward dehumidification (lower sensible heat ratio).

This compound object models the basic operation of an air-to-air heat exchanger in conjunction with a cooling coil. The heat exchanger-assisted DX cooling coil does not have an operating schedule of its own; its operating schedule is governed by the availability schedules for the DX cooling coil and the air-to-air heat exchanger. This compound object is used in place of where a DX cooling coil object would normally be used by itself.

To model a heat exchanger-assisted DX cooling coil, the input data file should include the following objects:

- CoilSystem:Cooling:DX:HeatExchangerAssisted object
- Air-to-air heat exchanger object (HeatExchanger:AirToAir:FlatPlate, HeatExchanger:AirToAir:SensibleAndLatent, or HeatExchanger:Desiccant:BalancedFlow)
- DX cooling coil object (Coil:DX:Cooling:SingleSpeed)

In terms of controlling the operation of the heat exchanger, the heat exchanger is assumed to always provide its heat transfer when the associated DX cooling coil is operating and no high humidity control mechanism is specified. However, the heat exchanger's energy transfer may be controlled (i.e., turned on and off) based on a zone air humidity level using either a humidistat (ref. AirLoopHVAC:Unitary:Furnace:HeatCool or AirLoopHVAC:UnitaryHeatCool) or a humidistat and a maximum humidity set point manager to place a humidity ratio set point on the appropriate control node (ref. AirLoopHVAC:UnitaryCoolOnly). This model may also be used with the unitary changeover bypass system and the unitary air-to-air heat pump system (ref. AirLoopHVAC:UnitaryHeatCool:VAVChangeoverBypass and AirLoopHVAC:UnitaryHeatPump:AirToAir); however, the heat exchanger is assumed to always provide its heat transfer when the cooling coil operates and can not be turned on and off based on a zone air humidity set point. Two zone air conditioners may also use this model for improved dehumidification. The first type is the packaged terminal heat pump (ref. ZoneHVAC:PackagedTerminalHeatPump) where the heat exchanger's heat transfer is always active whenever the cooling coil operates. The second type is the window air conditioner (ref. ZoneHVAC:WindowAirConditioner) where the heat exchanger's heat transfer is always active when the cooling coil operates and no high humidity control mechanism is specified, OR the heat exchanger's heat transfer may be controlled based on zone air humidity level if a humidistat and high humidity set point manager are specified (maximum humidity ratio set point placed on the heat exchanger's exhaust air outlet node, ref. Figure 112).

Links to the cooling coil and air-to-air heat exchanger specifications are provided in the input data syntax for this compound object. A description of each input field for this compound object is provided below.

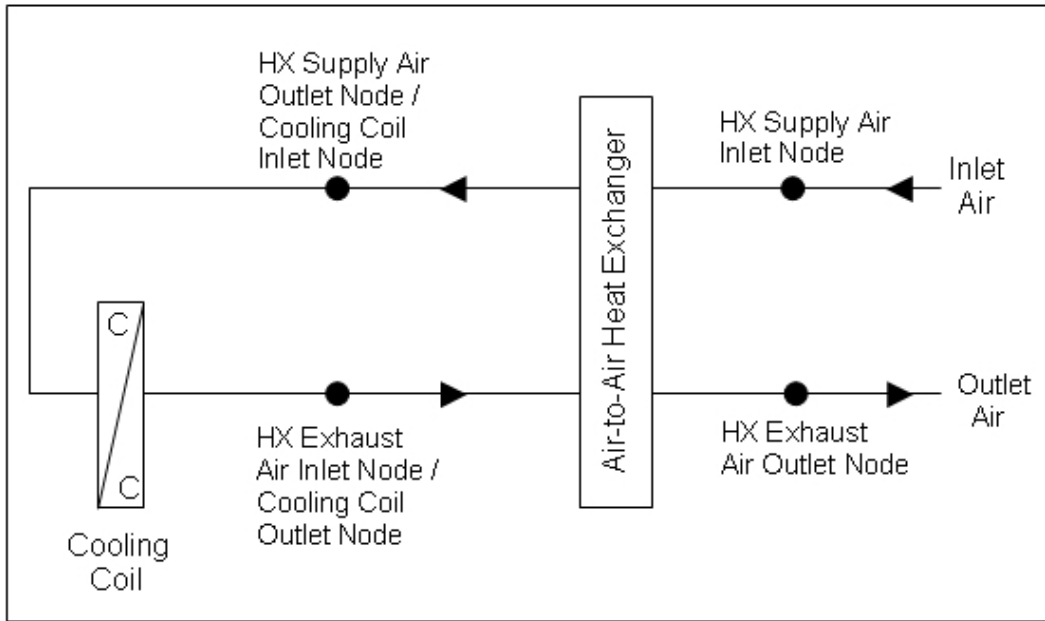


Figure 112. Schematic of the CoilSystem:Cooling:DX:HeatExchangerAssisted compound object

NOTE: Node naming shown in Figure 112 is representative for HeatExchanger:AirToAir:SensibleAndLatent. For HeatExchanger:AirToAir:FlatPlate, the exhaust air nodes are referred to as 'secondary air' nodes. For HeatExchanger:Desiccant:BalancedFlow, the supply air nodes are referred to as 'regeneration air' nodes and the exhaust air nodes as 'process air' nodes.

Field: Name

A unique user-assigned name for the heat exchanger-assisted DX cooling coil. Any reference to this compound component by another object will use this name.

Field: Heat Exchanger Object Type

This alpha field denotes the type of heat exchanger being modeled. Valid choices are:

```
HeatExchanger:AirToAir:FlatPlate
HeatExchanger:AirToAir:SensibleAndLatent
HeatExchanger:Desiccant:BalancedFlow
```

Field: Heat Exchanger Name

This alpha field denotes the name of the air-to-air heat exchanger being modeled.

Field: Cooling Coil Object Type

This alpha field denotes the type of DX cooling coil being modeled. The only valid choice is Coil:Cooling:DX:SingleSpeed.

Field: Cooling Coil Name

This alpha field denotes the name of the DX cooling coil being modeled.

The full IDD specification follows:

```

CoilSystem:Cooling:DX:HeatExchangerAssisted,
  \min-fields 5
A1 , \field Name
    \required-field
    \reference CoolingCoilsDX
    \reference CoolingCoilsDXSingleSpeed
A2 , \field Heat Exchanger Object Type
    \required-field
    \type choice
    \key HeatExchanger:AirToAir:FlatPlate
    \key HeatExchanger:AirToAir:SensibleAndLatent
    \key HeatExchanger:Desiccant:BalancedFlow
A3 , \field Heat Exchanger Name
    \required-field
    \type object-list
    \object-list HXAirToAirNames
A4 , \field Cooling Coil Object Type
    \required-field
    \type choice
    \key Coil:Cooling:DX:SingleSpeed
A5 ; \field Cooling Coil Name
    \required-field
    \type object-list
    \object-list CoolingCoilsDXBypassFactorEmpirical

```

Following is an example input for this compound object:

```

CoilSystem:Cooling:DX:HeatExchangerAssisted,
HeatExchangerAssistedCoolingCoil,          ! Name of the heat exchanger assisted cooling coil
HeatExchanger:AirToAir:SensibleAndLatent,    ! Heat exchanger type
Air to Air Heat Exchanger 1,                ! Heat exchanger name
Coil:DX:Cooling:SingleSpeed,                ! Cooling coil type
DX Cooling Coil 1;                          ! Cooling coil name

HeatExchanger:AirToAir:SensibleAndLatent,
Air to Air Heat Exchanger 1,                !- Heat exchanger name
FanAndCoilAvailSched,                       !- Availability schedule name
1.3,                                         !- Nominal supply air flow rate {m3/s}
.2,                                         !- Sensible effectiveness at 100% airflow heating condition
.0,                                         !- Latent effectiveness at 100% airflow heating condition
.23,                                        !- Sensible effectiveness at 75% airflow heating condition
.0,                                         !- Latent effectiveness at 75% airflow heating condition
.2,                                         !- Sensible effectiveness at 100% airflow cooling condition
.0,                                         !- Latent effectiveness at 100% airflow cooling condition
.23,                                        !- Sensible effectiveness at 75% airflow cooling condition
.0,                                         !- Latent effectiveness at 75% airflow cooling condition
HeatExchangerSupplyAirInletNode,           !- Supply air inlet node name
DX Cooling Coil Air Inlet Node,            !- Supply air outlet node name
HeatExchangerExhaustAirInletNode,          !- Exhaust air inlet node name
HeatExchangerExhaustAirOutletNode,         !- Exhaust air outlet node name
50.0,                                       !- Nominal electric power {W}
No,                                         !- Supply air outlet temperature control
Rotary,                                     !- Heat exchanger type
None;                                       !- Frost control type

```

```

Coil:DX:Cooling:SingleSpeed,
  DX Cooling Coil 1,           !- Coil Name
  FanAndCoilAvailSched,       !- Availability Schedule
  25000,                       !- Rated Total Cooling Capacity (gross) {W}
  0.75,                        !- Rated SHR
  3.0,                         !- Rated COP
  1.3,                         !- Rated Air Volume Flow Rate {m3/s}
  DX Cooling Coil Air Inlet Node, !- Coil Air Inlet Node
  HeatExchangerExhaustAirInletNode, !- Coil Air Outlet Node
  ACCoolCapFT,                !- Total Cooling Capacity Modifier Curve (function of temperature)
  ACCoolCapFFF,               !- Total Cooling Capacity Modifier Curve (function of flow fraction)
  ACEIRFT,                    !- Energy Input Ratio Modifier Curve (function of temperature)
  ACEIRFFF,                   !- Energy Input Ratio Modifier Curve (function of flow fraction)
  ACPLFFPLR,                  !- Part Load Fraction Correlation (function of part load ratio)
  CyclingFanAndCompressor;    !- Supply Air Fan Operation Mode
  
```

CoilSystem:Cooling:DX:HeatExchangerAssisted Outputs

No variables are reported for this compound object. However, outputs are provided by the cooling coil and heat exchanger that are specified.

Coil:Water:CoolingHeatExchangerAssisted

The heat exchanger-assisted water cooling coil is a “virtual” component consisting of a chilled-water cooling coil and an air-to-air heat exchanger as shown in Figure 113 below. The air-to-air heat exchanger precools the air entering the cooling coil, and reuses this energy to reheat the supply air leaving the cooling coil. This heat exchange process improves the latent removal performance of the cooling coil by allowing it to dedicate more of its cooling capacity toward dehumidification (lower sensible heat ratio).

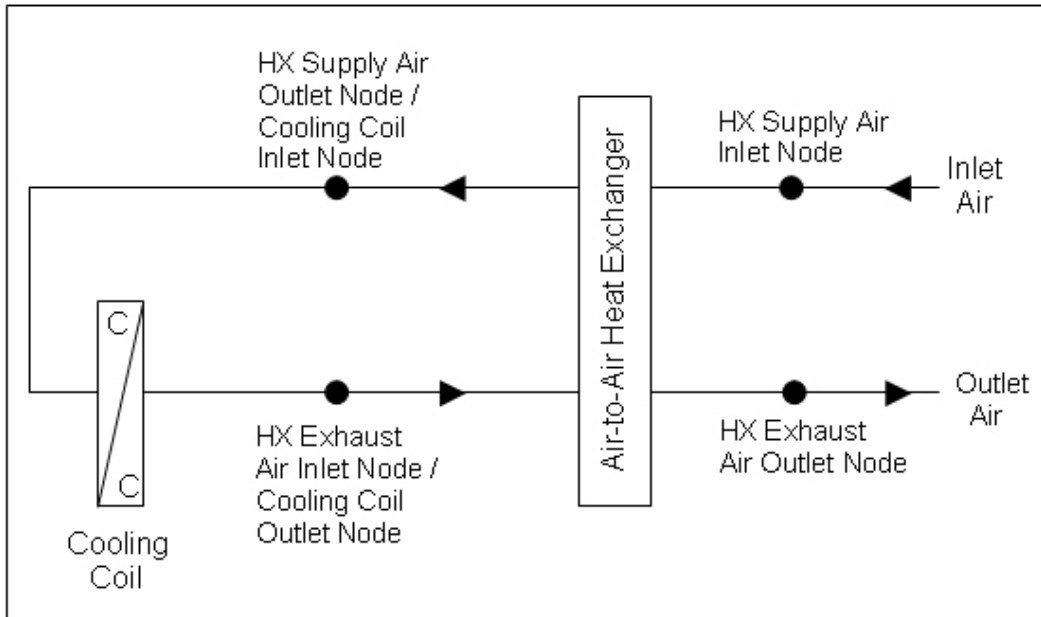


Figure 113. Schematic of the CoilSystem:Cooling:Water:HeatExchangerAssisted compound object

Note: Node naming shown in Figure 113 is representative for HeatExchanger:AirToAir:SensibleAndLatent. For HeatExchanger:AirToAir:FlatPlate, the exhaust air nodes are referred to as ‘secondary air’ nodes.

This compound object models the basic operation of an air-to-air heat exchanger in conjunction with a chilled-water cooling coil. The heat exchanger-assisted water cooling coil does not have an operating schedule of its own; its operating schedule is governed by the

availability schedules for the chilled-water cooling coil and the air-to-air heat exchanger. Heat exchange will occur whenever the heat exchanger is available to operate (via its availability schedule) and a temperature difference exists between the two air streams -- there is currently no method to enable or disable heat exchange based on zone air humidity level. This compound object is used in place of where a chilled-water cooling coil object would normally be used by itself.

To model a heat exchanger-assisted water cooling coil, the input data file should include the following objects:

- CoilSystem:Cooling:Water:HeatExchangerAssisted compound object
- Air-to-air heat exchanger object (HeatExchanger:AirToAir:FlatPlate or HeatExchanger:AirToAir:SensibleAndLatent)
- Chilled-water cooling coil object (Coil:Cooling:Water or Coil:Cooling:Water:DetailedGeometry)

Links to the cooling coil and air-to-air heat exchanger specifications are provided in the input data syntax for this compound object. A description of each input field for this compound object is provided below.

Field: Name

A unique user-assigned name for the heat exchanger-assisted water cooling coil. Any reference to this compound component by another object (e.g., ZoneHVAC:UnitVentilator, ZoneHVAC:FourPipeFanCoil, component in an air loop Branch object) will use this name.

Field: Heat Exchanger Object Type

This alpha field denotes the type of heat exchanger being modeled. Valid choices are:

```
HeatExchanger:AirToAir:FlatPlate
HeatExchanger:AirToAir:SensibleAndLatent
```

Field: Heat Exchanger Name

This alpha field denotes the name of the air-to-air heat exchanger being modeled.

Field: Cooling Coil Object Type

This alpha field denotes the type of chilled-water cooling coil being modeled. Valid choices are:

```
Coil:Cooling:Water
Coil:Cooling:Water:DetailedGeometry
```

Field: Cooling Coil Name

This alpha field denotes the name of the chilled-water cooling coil being modeled.

The full IDD specification follows:

```
CoilSystem:Cooling:Water:HeatExchangerAssisted,
  \min-fields 5
A1 , \field Name
  \required-field
  \reference CoolingCoilsWater
A2 , \field Heat Exchanger Object Type
  \required-field
  \type choice
  \key HeatExchanger:AirToAir:FlatPlate
  \key HeatExchanger:AirToAir:SensibleAndLatent
A3 , \field Heat Exchanger Name
  \required-field
A4 , \field Cooling Coil Object Type
  \required-field
  \type choice
  \key Coil:Cooling:Water
  \key Coil:Cooling:Water:DetailedGeometry
A5 ; \field Cooling Coil Name
  \required-field
  \type object-list
  \object-list CoolingCoilsWaterNoHX
```

Following is an example input for this compound object:

```
CoilSystem:Cooling:Water:HeatExchangerAssisted,
  Heat Exchanger Assisted Cooling Coil 1, !- Name of the heat exchanger assisted cooling coil
  HeatExchanger:AirToAir:FlatPlate,      !- Heat exchanger type
  Heat Exchanger Assisting Cooling Coil, !- Heat exchanger name
  Coil:Cooling:Water:DetailedGeometry,   !- Cooling coil type
  Main Cooling Coil 1;                   !- Cooling coil name

HeatExchanger:AirToAir:FlatPlate,
  Heat Exchanger Assisting Cooling Coil, !- Name
  CoolingCoilAvailSched,                !- Available Schedule
  Counter Flow,                          !- flow arrangement
  Yes,                                   !- Economizer lockout
  1.0,                                   !- hA ratio
  1.32,                                   !- Nominal supply air flow rate {m3/s}
  24.0,                                   !- Nominal supply air inlet temperature {C}
  21.0,                                   !- Nominal supply air outlet temperature {C}
  1.32,                                   !- Nominal secondary air flow rate {m3/s}
  12.0,                                   !- Nominal secondary air inlet temperature {C}
  100.0,                                  !- Nominal electric power {W}
  Mixed Air Node 1,                       !- Supply air inlet node
  Main Cooling Coil 1 Inlet Node,          !- Supply air outlet node
  Main Cooling Coil 1 Outlet Node,        !- Secondary air inlet node
  Main Heating Coil 1 Inlet Node;         !- Secondary air outlet node
```



```

Coil:Cooling:Water:DetailedGeometry,
Main Cooling Coil 1,      !- Coil Name
CoolingCoilAvailSched,   !- Available Schedule
autosize,                 !- Max Water Flow Rate of Coil {m3/s}
autosize,                 !- Tube Outside Surf Area {m2}
autosize,                 !- Total Tube Inside Area {m2}
autosize,                 !- Fin Surface Area {m2}
autosize,                 !- Minimum Air Flow Area {m2}
autosize,                 !- Coil Depth {m}
autosize,                 !- Fin Diameter {m}
autosize,                 !- Fin Thickness {m}
,                          !- Tube Inside Diameter {m}
,                          !- Tube Outside Diameter {m}
,                          !- Tube Thermal Conductivity {W/m-K}
,                          !- Fin Thermal Conductivity {W/m-K}
,                          !- Fin Spacing {m}
,                          !- Tube Depth Spacing {m}
,                          !- Number of Tube Rows
autosize,                 !- Number of Tubes per Row
Main Cooling Coil 1 Water Inlet Node, !- Coil_Water_Inlet_Node
Main Cooling Coil 1 Water Outlet Node, !- Coil_Water_Outlet_Node
Main Cooling Coil 1 Inlet Node,      !- Coil_Air_Inlet_Node
Main Cooling Coil 1 Outlet Node;     !- Coil_Air_Outlet_Node

```

CoilSystem:Cooling:Water:HeatExchangerAssisted Outputs

No variables are reported for this compound object. However, outputs are provided by the cooling coil and heat exchanger that are specified.

Coil:WaterHeating:AirToWaterHeatPump

EnergyPlus can model a heat pump water heater (HPWH) consisting of a water heater tank (e.g., WaterHeater:Mixed), a direct expansion (DX) “coil” (i.e., an air-to-water DX compression system which includes a water heating coil, air coil, compressor, and water pump), and a fan to provide air flow across the air coil associated with the DX compression system. These objects work together to model a system which heats water using zone air, outdoor air, or a combination of zone and outdoor air as the primary heat source.

The WaterHeater:HeatPump compound object, water heater tank object (e.g., WaterHeater:Mixed), and fan object (e.g., Fan:OnOff) are defined elsewhere in this reference document. Coil:WaterHeating:AirToWaterHeatPump object described here models an air-to-water DX compression system to determine its air-side and water-side performance. This DX coil object calculates the air-side sensible and latent cooling capacity at the specific operating conditions for each simulation timestep, as well as the condenser’s water-side temperature difference at a given condenser water flow rate.

The heat pump water heater DX coil model performs the following major functions:

- calculates the electric consumption of the DX compressor and water pump
- calculates the amount of heat delivered to the water tank
- calculates the electric consumption of the compressor’s crankcase heater
- calculates the air-side performance of the DX coil

The input fields for this object are described below in detail:

Field: Name

This alpha field defines a unique user-assigned name for an instance of a heat pump water heater DX coil. Any reference to this coil by another object (e.g., Heat Pump:Water Heater) will use this name.

Field: Rated Heating Capacity

This numeric field defines the DX coil heating capacity in Watts at the rated evaporator inlet air temperatures, rated condenser inlet water temperature, rated evaporator air flow rate, and rated condenser water flow rate specified below. Values must be greater than 0. This value

represents water heating capacity, and it may or may not include the impact of condenser pump heat (see field Condenser Pump Heat Included in Rated Heating Capacity below).

Field: Rated COP

This numeric field defines the DX coil's water heating coefficient of performance (COP=water heating capacity in watts divided by electrical power input in watts) at rated conditions (rated inlet temperatures and flow rates specified below). This input not only determines the electric energy use of the heat pump DX coil, but also the amount of total air cooling provided by the evaporator. The rated COP includes compressor power, and may or may not include condenser pump power or evaporator fan power (see field Evaporator Fan Power Included in Rated COP and field Condenser Pump Power Included in Rated COP). Values must be greater than 0. If this field is left blank, the default value is 3.2.

Field: Rated Sensible Heat Ratio

This numeric field defines the air-side sensible heat ratio (SHR=sensible cooling capacity divided by total cooling capacity) of the DX coil at rated conditions (rated inlet temperatures and flow rates specified below). This value should not include the effect of evaporator fan heat. Values must be greater than or equal to 0.5, and less than or equal to 1.0. The default value is 0.85.

Field: Rated Evaporator Inlet Air Dry-Bulb Temperature

This numeric field defines the evaporator inlet air dry-bulb temperature, in degrees Celsius, that corresponds to rated coil performance (heating capacity, COP and SHR). Values must be greater than 5°C. If this field is left blank, the default value is 19.7°C.

Field: Rated Evaporator Inlet Air Wet-Bulb Temperature

This numeric field defines the evaporator inlet air wet-bulb temperature, in degrees Celsius, that corresponds to rated coil performance (heating capacity, COP and SHR). Values must be greater than 5°C. If this field is left blank, the default value is 13.5°C.

Field: Rated Condenser Inlet Water Temperature

This numeric field defines the condenser inlet water temperature, in degrees Celsius, that corresponds to rated coil performance (heating capacity, COP and SHR). Values must be greater than 25°C. If this field is left blank, the default value is 57.5°C.

Field: Rated Evaporator Air Flow Rate

This numeric field defines the evaporator air volume flow rate in cubic meters per second at rated conditions. Values must be greater than 0. If this field is left blank or autocalculated (field value = **autocalculate**), the default value is 5.035E-5 m³/s/W (31.25 cfm/MBH) multiplied by the Rated Heating Capacity specified above. When autocalculating the rated evaporator air volumetric flow rate, a zone sizing object is not required.

Field: Rated Condenser Water Flow Rate

This numeric field defines the condenser water volumetric flow rate in cubic meters per second at rated conditions. Values must be greater than 0. If this field is left blank or autocalculated (field value = **autocalculate**), the default value is 4.487E-8 m³/s/W (0.208 gpm/MBH) multiplied by the Rated Heating Capacity specified above. When autocalculating the rated condenser water volumetric flow rate, a zone sizing object is not required. A warning message will be issued if the ratio of Rated Condenser Water Volumetric Flow Rate to Rated Heating Capacity is less than 1.79405E-8 m³/s/W (0.083 gpm/MBH) or greater than 8.97024E-8 m³/s/W (0.417 gpm/MBH), but the simulation will continue.

Field: Evaporator Fan Power Included in Rated COP

This choice field specifies if evaporator fan power is included in the rated COP defined above. This input impacts the calculation of compressor electric power and total air cooling

provided by the evaporator for each simulation timestep. If Yes is selected, the evaporator fan power is subtracted from the total electric heating power when calculating total evaporator cooling capacity. If No is selected, it is assumed that the total heating power does not include evaporator fan power. If this field is left blank, the default is Yes. See the Engineering Reference section for Coil:WaterHeating:AirToWaterHeatPump for further details.

Field: Condenser Pump Power Included in Rated COP

This choice field specifies if condenser pump power is included in the rated COP defined above. This input impacts the calculation of compressor electric power which then impacts the total air cooling provided by the evaporator for each simulation timestep. If Yes is selected, the condenser pump power is subtracted from the total electric heating power when calculating total evaporator cooling capacity. If No is selected, it is assumed that the total heating power does not include the condenser pump. If this field is left blank, the default is No. See Engineering Reference section for Coil:WaterHeating:AirToWaterHeatPump for further details.

Field: Condenser Pump Heat Included in Rated Heating Capacity and Rated COP

This choice field specifies if condenser pump heat is included in the rated heating capacity and rated COP defined above. This input impacts the calculation of compressor electric power and total air cooling provided by the evaporator for each simulation timestep. If Yes is selected, the condenser pump heat is already included in the rated heating capacity and rated COP. If No is selected, it is assumed that the rated heating capacity and rated COP do not include the condenser pump heat, and pump heat is added to the total water heating capacity based on the Condenser Water Pump Power and Fraction of Condenser Pump Heat to Water fields below. If this field is left blank, the default is No. See Engineering Reference section for Coil:WaterHeating:AirToWaterHeatPump for further details.

Field: Condenser Water Pump Power

This numeric field defines the DX coil's condenser pump power in Watts. This is the operating pump power as installed. Values must be greater than or equal to 0. If this field is left blank, the default value is 0. A warning message will be issued if the ratio of Condenser Water Pump Power to Rated Heating Capacity exceeds 0.1422 W/W (41.67 Watts/MBH), but the simulation will continue.

Field: Fraction of Condenser Pump Heat to Water

This numeric field defines the fraction of condenser pump heat that is transferred to the condenser water. The pump is assumed to be downstream of the condenser water coil, and this field is used to determine the water temperature at the condenser outlet node when the field Condenser Pump Power Included in Rated Heating Capacity is set to No. Values must be greater than or equal to 0 and less than or equal to 1. If this field is left blank, the default value is 0.2.

Field: Evaporator Air Inlet Node Name

This alpha field defines the name of the air node from which the evaporator coil draws its inlet air.

Field: Evaporator Air Outlet Node Name

This alpha field defines the name of the air node to which the evaporator coil sends its outlet air.

Field: Condenser Water Inlet Node Name

This alpha field defines the name of the node from which the DX coil condenser draws its inlet water. This node name must also match the source side outlet node name for the water heater tank connected to this DX coil (ref: Water Heaters).

Field: Condenser Water Outlet Node Name

This alpha field defines the name of the node to which the heat pump condenser sends its outlet water. This node name must also match the source side inlet node name for the water heater tank connected to this DX coil (ref: Water Heaters).

Field: Crankcase Heater Capacity

This numeric field defines the compressor's crankcase heater capacity in Watts. The crankcase heater only operates when the compressor is off and the air surrounding the compressor is below the Maximum Ambient Temperature for Crankcase Heater Operation specified below.

Field: Maximum Ambient Temperature for Crankcase Heater Operation

This numeric field defines the maximum ambient temperature for crankcase heater operation in degree Celsius. The crankcase heater only operates when the air surrounding the compressor is below this maximum temperature value and the compressor is off. The ambient temperature surrounding the compressor is set by the Heat Pump:Water Heater parent object (field Compressor Location).

Field: Evaporator Air Temperature Type for Curve Objects

This choice field specifies the air temperature type used for the heating capacity and COP modifier curve objects below. The valid selections are Dry-bulb Temperature and Wet-bulb Temperature. If dry-bulb temperature is selected, the inlet air dry-bulb temperature entering the heat pump DX coil and fan section is used to evaluate the curve objects. If wet-bulb temperature is selected, the inlet air wet-bulb temperature entering the heat pump DX coil and fan section is used to evaluate the curve objects. If this field is left blank and the following curve names are defined, the default value is wet-bulb temperature. If the following curve names are not defined, this field is not used.

Field: Heating Capacity Function of Temperature Curve Name

This alpha field specifies the name of a **biquadratic** or **cubic** performance curve object (ref: Performance Curves) that defines the variation in DX coil heating capacity as a function of inlet fluid (air and water) temperatures. The biquadratic curve uses evaporator inlet air temperature (dry-bulb or wet-bulb temperature based on the field Evaporator Air Temperature Type for Curve Objects defined above) and condenser inlet water temperature as the independent variables. The cubic curve uses evaporator inlet air (dry-bulb or wet-bulb) temperature as the independent variable. The output of this curve is multiplied by the rated heating capacity to give the heating capacity at specific operating conditions (i.e., at temperatures different from the rating point temperatures). The curve should be normalized to have the value of 1.0 at the rating point temperatures. If this field is left blank, the heating capacity remains constant (curve value assumed to be 1.0 for all conditions).

Field: Heating Capacity Function of Air Flow Fraction Curve Name

This alpha field specifies the name of a **quadratic** or **cubic** performance curve object (ref: Performance Curves) that defines the variation in DX coil heating capacity as a function of the ratio of actual air flow rate across the evaporator coil to the rated evaporator air flow rate. The output of this curve is multiplied by the rated heating capacity and the heating capacity modifier curve (function of temperature) to give the DX coil heating capacity at the specific inlet fluid temperatures and air flow rate at which the coil is operating. The curve should be normalized to have the value of 1.0 at the rated evaporator air flow rate (air flow fraction of 1.0). If this field is left blank, the heating capacity remains constant (curve value assumed to be 1.0 for all air flow rates).

Field: Heating Capacity Function of Water Flow Fraction Curve Name

This alpha field specifies the name of a **quadratic** or **cubic** performance curve object (ref: Performance Curves) that defines the variation in DX coil heating capacity as a function of

the ratio of actual water flow rate through the condenser to the rated condenser water flow rate. The output of this curve is multiplied by the rated heating capacity and the output from the two other heating capacity modifier curves (function of temperature and function of air flow fraction) to give the DX coil heating capacity at the specific inlet fluid temperatures and flow rates at which the coil is operating. The curve should be normalized to have the value of 1.0 at the rated condenser water flow rate (water flow fraction of 1.0). If this field is left blank, the heating capacity remains constant (curve value assumed to be 1.0 for all water flow rates).

Field: Heating COP Function of Temperature Curve Name

This alpha field specifies the name of a **biquadratic** or **cubic** performance curve object (ref: Performance Curves) that defines the variation in DX coil heating COP as a function of inlet fluid (air and water) temperatures. The biquadratic curve uses evaporator inlet air temperature (dry-bulb or wet-bulb temperature based on the field Evaporator Air Temperature Type for Curve Objects defined above) and condenser inlet water temperature as the independent variables. The cubic curve uses evaporator inlet air (dry-bulb or wet-bulb) temperature as the independent variable. The output of this curve is multiplied by the rated COP to give the heating COP at specific operating conditions (i.e., at temperatures different from the rating point temperatures). The curve should be normalized to have the value of 1.0 at the rating point temperatures. If this field is left blank, the COP remains constant (curve value assumed to be 1.0 for all conditions).

Field: Heating COP Function of Air Flow Fraction Curve Name

This alpha field specifies the name of a **quadratic** or **cubic** performance curve object (ref: Performance Curves) that defines the variation in DX coil heating COP as a function of the ratio of actual air flow rate across the evaporator coil to the rated evaporator air flow rate. The output of this curve is multiplied by the rated COP and the heating COP modifier curve (function of temperature) to give the heating COP at the specific inlet fluid temperatures and air flow rate at which the coil is operating. The curve should be normalized to have the value of 1.0 at the rated evaporator air flow rate (air flow fraction of 1.0). If this field is left blank, the heating COP remains constant (curve value assumed to be 1.0 for all air flow rates).

Field: Heating COP Function of Water Flow Fraction Curve Name

This alpha field specifies the name of a **quadratic** or **cubic** performance curve object (ref: Performance Curves) that defines the variation in DX coil heating COP as a function of the ratio of actual water flow rate through the condenser to the rated condenser water flow rate.. The output of this curve is multiplied by the rated COP and the output from the two other heating COP modifier curves (function of temperature and function of air flow fraction) to give the DX coil heating COP at the specific inlet fluid temperatures and flow rates at which the coil is operating. The curve should be normalized to have the value of 1.0 at the rated condenser water flow rate (water flow fraction of 1.0). If this field is left blank, the heating COP remains constant (curve value assumed to be 1.0 for all water flow rates).

Field: Part Load Fraction Correlation Curve Name

This alpha field defines the name of a **quadratic** or **cubic** performance curve (Ref: Performance Curves) that parameterizes the variation of electrical power input to the DX unit as a function of the part load ratio (PLR, sensible cooling load/steady-state sensible cooling capacity). The product of the rated EIR and EIR modifier curves is divided by the output of this curve to give the “effective” EIR for a given simulation timestep. The part load fraction (PLF) correlation accounts for efficiency losses due to compressor cycling.

The part load fraction correlation should be normalized to a value of 1.0 when the part load ratio equals 1.0 (i.e., no efficiency losses when the compressor(s) run continuously for the simulation timestep). For PLR values between 0 and 1 ($0 \leq \text{PLR} < 1$), the following rules apply:

$$\text{PLF} \geq 0.7 \quad \text{and} \quad \text{PLF} \geq \text{PLR}$$

If $PLF < 0.7$ a warning message is issued, the program resets the PLF value to 0.7, and the simulation proceeds. The runtime fraction of the coil is defined as PLR/PLF . If $PLF < PLR$, then a warning message is issued and the runtime fraction of the coil is limited to 1.0.

A typical part load fraction correlation for a conventional, single-speed DX cooling coil (e.g., residential unit) would be:

$$PLF = 0.85 + 0.15(PLR)$$

If the user wishes to model no efficiency degradation due to compressor cycling, the part load fraction correlation should be defined as follows:

$$PLF = 1.0 + 0.0(PLR)$$

Below is the IDD Definition for the Heat Pump Water Heater DX Coil.

```

Coil:WaterHeating:AirToWaterHeatPump,
  \min-fields 21
A1 , \field Name
  \required-field
  \type alpha
  \reference HeatPumpWaterHeaterDXCoils
  \note Unique name for this instance of a heat pump water heater DX coil.
N1 , \field Rated Heating Capacity
  \required-field
  \type real
  \units W
  \minimum> 0
  \note Heating capacity at the rated inlet air temperatures, rated condenser inlet
  \note water temperature, rated air flow rate, and rated water flow rate.
  \note Can optionally include condenser pump heat.
N2 , \field Rated COP
  \type real
  \units W/W
  \minimum> 0
  \default 3.2
  \note Heating coefficient of performance at the rated inlet air temperatures,
  \note rated condenser inlet water temperature, rated air flow rate, and rated water flow rate.
  \note Can optionally include condenser pump power and evaporator fan power.
N3 , \field Rated Sensible Heat Ratio
  \type real
  \minimum 0.5
  \maximum 1
  \default 0.85
  \note Gross air-side sensible heat ratio at the rated inlet air temperatures,
  \note rated condenser inlet water temperature, rated air flow rate, and rated water flow rate.
  \note Sensible heat ratio equals gross sensible cooling capacity divided by gross total cooling
  \note capacity. Rated SHR (gross) should not include evaporator fan heat, only sensible cooling
  \note and dehumidification by the coil alone.
N4 , \field Rated Evaporator Inlet Air Dry-Bulb Temperature
  \type real
  \units C
  \minimum> 5
  \default 19.7
  \note Evaporator inlet air dry-bulb temperature corresponding to rated coil performance
  \note (heating capacity, COP and SHR).
N5 , \field Rated Evaporator Inlet Air Wet-Bulb Temperature
  \type real
  \units C
  \minimum> 5
  \default 13.5
  \note Evaporator inlet air wet-bulb temperature corresponding to rated coil performance
  \note (heating capacity, COP and SHR).
N6 , \field Rated Condenser Inlet Water Temperature
  \type real
  \units C
  \minimum> 25
  \default 57.5
  \note Condenser inlet water temperature corresponding to rated coil performance
  \note (heating capacity, COP and SHR).

```

```

N7 , \field Rated Evaporator Air Flow Rate
    \type real
    \units m3/s
    \minimum> 0
    \autocalculatable
    \note Evaporator air flow rate corresponding to rated coil performance
    \note (heating capacity, COP and SHR).
    \note Default is 5.035E-5 m3/s/W (31.25 cfm/MBH) of rated heating capacity when autocalculated.
N8 , \field Rated Condenser Water Flow Rate
    \type real
    \units m3/s
    \minimum> 0
    \autocalculatable
    \note Condenser water flow rate corresponding to rated coil performance
    \note (heating capacity, COP and SHR).
    \note Default is 4.487E-8 m3/s/W (0.208 gpm/MBH) of rated heating capacity when autocalculated.
    \note A warning message will be issued if the ratio of Rated Condenser Water Flow Rate
    \note to Heating Capacity is less than 1.79405E-8 m3/s/W (0.083 gpm/MBH)
    \note or greater than 8.97024E-8 m3/s/W (0.417 gpm/MBH), but the simulation will continue.
A2 , \field Evaporator Fan Power Included in Rated COP
    \type choice
    \key Yes
    \key No
    \default Yes
    \note Select Yes if the evaporator fan power is included in the rated COP. This choice field
    \note impacts the calculation of compressor electric power.
A3 , \field Condenser Pump Power Included in Rated COP
    \type choice
    \key Yes
    \key No
    \default No
    \note Select Yes if the condenser pump power is included in the rated COP. This choice field
    \note impacts the calculation of compressor electric power.
A4 , \field Condenser Pump Heat Included in Rated Heating Capacity and Rated COP
    \type choice
    \key Yes
    \key No
    \default No
    \note Select Yes if the condenser pump heat is included in the rated heating capacity and
    \note rated COP. This choice field impacts the calculation of water heating capacity.
N9 , \field Condenser Water Pump Power
    \type real
    \units W
    \minimum 0
    \default 0
    \note A warning message will be issued if the ratio of Condenser Water Pump Power to Rated
    \note Heating Capacity exceeds 0.1422 W/W (41.67 Watts/MBH), but the simulation will continue.
N10, \field Fraction of Condenser Pump Heat to Water
    \type real
    \minimum 0
    \maximum 1
    \default 0.2
    \note Fraction of pump heat transferred to the condenser water. The pump is assumed
    \note to be located downstream of the condenser.
A5 , \field Evaporator Air Inlet Node Name
    \required-field
    \type alpha
    \note The node from which the DX coil draws its inlet air.
A6 , \field Evaporator Air Outlet Node Name
    \required-field
    \type alpha
    \note The node to which the DX coil sends its outlet air.
A7 , \field Condenser Water Inlet Node Name
    \required-field
    \type alpha
    \note The node from which the DX coil condenser draws its inlet water.
    \note This name should match the source side outlet node name in the associated
    \note water heater tank object.

```



```

A8 , \field Condenser Water Outlet Node Name
    \required-field
    \type alpha
    \note The node to which the DX coil condenser sends its outlet water.
    \note This name should match the source side inlet node name in the associated
    \note water heater tank object.
N11, \field Crankcase Heater Capacity
    \type real
    \minimum 0
    \default 0
    \units W
    \note The compressor crankcase heater only operates when the dry-bulb temperature of air
    \note surrounding the compressor is below the Maximum Ambient Temperature for Crankcase
    \note Heater Operation and the DX coil is off. The ambient temperature surrounding the
    \note compressor is set by the Heat Pump:Water Heater parent object (field Compressor Location).
N12, \field Maximum Ambient Temperature for Crankcase Heater Operation
    \type real
    \minimum 0
    \default 10
    \units C
    \note The compressor crankcase heater only operates when the dry-bulb temperature of air
    \note surrounding the compressor is below the Maximum Outdoor Temperature for Crankcase
    \note Heater Operation and the unit is off. The ambient temperature surrounding the
    \note compressor is set by the WaterHeater:HeatPump parent object (field Compressor Location).
A9 , \field Evaporator Air Temperature Type for Curve Objects
    \type choice
    \key DryBulbTemperature
    \key WetBulbTemperature
    \default WetBulbTemperature
    \note Determines temperature type for heating capacity curves and
    \note heating COP curves. This input determines whether
    \note the inlet air dry-bulb or wet-bulb temperature is used to evaluate these curves.
A10, \field Heating Capacity Function of Temperature Curve Name
    \type object-list
    \object-list BiQuadraticCubicCurves
    \note Heating capacity modifier curve (function of temperature) should be biquadratic or cubic.
    \note Biquadratic curve =  $a + b(ta) + c(ta)^2 + d(tw) + e(tw)^2 + f(ta)(tw)$ .
    \note Cubic curve =  $a + b(ta) + c(ta)^2 + d(ta)^3$ .
    \note  $ta$  = evaporator inlet air [dry-bulb or wet-bulb] temperature (C).
    \note  $tw$  = condenser inlet water temperature (C).
    \note The field Evaporator Air Temperature Type for Curve Objects determines if dry-bulb or wet-
bulb
    \note is used as the evaporator inlet air temperature ( $ta$ ).
A11, \field Heating Capacity Function of Air Flow Fraction Curve Name
    \type object-list
    \object-list QuadraticCubicCurves
    \note Heating capacity modifier curve (function of air flow fraction) should be quadratic or cubic.
    \note Quadratic curve =  $a + b(ff) + c(ff)^2$ .
    \note Cubic curve =  $a + b(ff) + c(ff)^2 + d(ff)^3$ .
    \note  $ff$  = fraction of the rated evaporator air flow rate.
    \note Use curve coefficients of 1,0,0 or leave this field blank when neglecting performance impacts
    \note due to variations in air flow rate fraction.
A12, \field Heating Capacity Function of Water Flow Fraction Curve Name
    \type object-list
    \object-list QuadraticCubicCurves
    \note Heating capacity modifier curve (function of water flow fraction) should be quadratic or
cubic.
    \note Quadratic curve =  $a + b(ff) + c(ff)^2$ .
    \note Cubic curve =  $a + b(ff) + c(ff)^2 + d(ff)^3$ .
    \note  $ff$  = fraction of the rated condenser water flow rate.
    \note Use curve coefficients of 1,0,0 or leave this field blank when neglecting performance impacts
    \note due to variations in water flow rate fraction.

```

```

A13, \field Heating COP Function of Temperature Curve Name
\type object-list
\object-list BiQuadraticCubicCurves
\note Heating COP modifier curve (function of temperature) should be biquadratic or cubic.
\note Biquadratic curve =  $a + b(ta) + c(ta)^2 + d(tw) + e(tw)^2 + f(ta)(tw)$ .
\note Cubic curve =  $a + b(ta) + c(ta)^2 + d(ta)^3$ .
\note ta = evaporator inlet air [dry-bulb or wet-bulb] temperature (C).
\note tw = condenser inlet water temperature (C).
\note The field Evaporator Air Temperature Type for Curve Objects determines if dry-bulb or wet-
bulb
\note is used as the evaporator inlet air temperature (ta).
A14, \field Heating COP Function of Air Flow Fraction Curve Name
\type object-list
\object-list QuadraticCubicCurves
\note Heating COP modifier curve (function of air flow fraction) should be quadratic or cubic.
\note Quadratic curve =  $a + b(ff) + c(ff)^2$ .
\note Cubic curve =  $a + b(ff) + c(ff)^2 + d(ff)^3$ .
\note ff = fraction of the rated evaporator air flow rate.
\note Use curve coefficients of 1,0,0 or leave this field blank when neglecting performance impacts
\note due to variations in air flow rate fraction.
A15, \field Heating COP Function of Water Flow Fraction Curve Name
\type object-list
\object-list QuadraticCubicCurves
\note Heating COP modifier curve (function of water flow fraction) should be quadratic or cubic.
\note Quadratic curve =  $a + b(ff) + c(ff)^2$ .
\note Cubic curve =  $a + b(ff) + c(ff)^2 + d(ff)^3$ .
\note ff = fraction of the rated condenser water flow rate.
\note Use curve coefficients of 1,0,0 or leave this field blank when neglecting performance impacts
\note due to variations in water flow rate fraction.
A16; \field Part Load Fraction Correlation Curve Name
\type object-list
\object-list QuadraticCubicCurves
\note Part Load Fraction Correlation (function of part load ratio) should be quadratic or cubic.
\note Quadratic curve =  $a + b(PLR) + c(PLR)^2$ .
\note Cubic curve =  $a + b(PLR) + c(PLR)^2 + d(PLR)^3$ .
\note PLR = part load ratio (heating delivered/steady-state heating capacity).
\note Use curve coefficients of 1,0,0 or leave this field blank when neglecting performance impacts
\note due to variations in part load ratio.

```

Following is an example input for the Coil:WaterHeating:AirToWaterHeatPump object.

Coil:WaterHeating:AirToWaterHeatPump,	
Zone4HPWHDXCoil,	!- Coil Name
4000.0,	!- Heating Capacity {W}
3.2,	!- Rated COP {W/W}
0.6956,	!- Rated SHR (gross)
19.7,	!- Rated Evaporator Inlet Air Dry-Bulb Temperature {C}
13.5,	!- Rated Evaporator Inlet Air Wet-Bulb Temperature {C}
57.5,	!- Rated Condenser Inlet Water Temperature {C}
autocalculate,	!- Rated Evaporator Air Volumetric Flow Rate {m3/s}
autocalculate,	!- Rated Condenser Water Volumetric Flow Rate {m3/s}
No,	!- Evaporator Fan Power Included in Rated COP
No,	!- Condenser Pump Power Included in Rated COP
No,	!- Condenser Pump Heat Included in Rated Heating Capacity and Rated COP
150.0,	!- Condenser Water Pump Power {W}
0.1,	!- Fraction of Condenser Pump Heat to Water
Zone4AirOutletNode,	!- Evaporator Air Inlet Node Name
Zone4DXCoilAirOutletNode,	!- Evaporator Air Outlet Node Name
Zone4WaterInletNode,	!- Condenser Water Inlet Node Name
Zone4WaterOutletNode,	!- Condenser Water Outlet Node Name
100.0,	!- Crankcase Heater Capacity {W}
5.0,	!- Maximum Ambient Temperature for Crankcase Heater Operation {C}
wet-bulb temperature,	!- Evaporator Air Temperature Type for Curve Objects
HPWHHeatingCapFTemp,	!- Heating Capacity Modifier Curve Name (function of temperature)
,	!- Heating Capacity Modifier Curve Name (function of air flow fraction)
,	!- Heating Capacity Modifier Curve Name (function of water flow fraction)
HPWHHeatingCOPFTemp,	!- Heating COP Modifier Curve Name (function of temperature)
,	!- Heating COP Modifier Curve Name (function of air flow fraction)
,	!- Heating COP Modifier Curve Name (function of water flow fraction)
HPWHPLFFPLR;	!- Part Load Fraction Correlation Name (function of part load ratio)

Coil:WaterHeating:AirToWaterHeatPump Outputs

HVAC,Average,DX Coil Total Cooling Rate[W]
HVAC,Sum,DX Coil Total Cooling Energy[J]
HVAC,Average,DX Coil Sensible Cooling Rate[W]
HVAC,Sum,DX Coil Sensible Cooling Energy[J]
HVAC,Average,DX Coil Latent Cooling Rate[W]
HVAC,Sum,DX Coil Latent Cooling Energy[J]
HVAC,Average,DX Cooling Coil Runtime Fraction
HVAC,Average,DX Cooling Coil Crankcase Heater Power[W]
HVAC,Sum,DX Cooling Coil Crankcase Heater Consumption[J]
HVAC,Average,DX Coil Total Water Heating Rate[W]
HVAC,Sum,DX Coil Total Water Heating Energy[J]
HVAC,Average,DX Coil Water Heating Electric Power[W]
HVAC,Sum,DX Coil Water Heating Electric Consumption[J]

DX Coil Total Cooling Rate[W]

This output field is the average total (sensible and latent) cooling rate output of the DX coil in Watts for the timestep being reported. This is determined by the coil inlet and outlet air conditions and the air mass flow rate through the coil.

DX Coil Total Cooling Energy[J]

This output field is the total (sensible plus latent) cooling output of the DX coil in Joules for the timestep being reported. This is determined by the coil inlet and outlet air conditions and the air mass flow rate through the coil.

DX Coil Sensible Cooling Rate[W]

This output field is the average moist air sensible cooling rate output of the DX coil in Watts for the timestep being reported. This is determined by the inlet and outlet air conditions and the air mass flow rate through the coil.

DX Coil Sensible Cooling Energy[J]

This output field is the moist air sensible cooling output of the DX coil in Joules for the timestep being reported. This is determined by the inlet and outlet air conditions and the air mass flow rate through the coil.

DX Coil Latent Cooling Rate[W]

This output field is the average latent cooling rate output of the DX coil in Watts for the timestep being reported. This is determined by the inlet and outlet air conditions and the air mass flow rate through the coil.

DX Coil Latent Cooling Energy[J]

This output field is the latent cooling output of the DX coil in Joules for the timestep being reported. This is determined by the inlet and outlet air conditions and the air mass flow rate through the coil.

DX Coil Runtime Fraction

This output field is the average runtime fraction of the DX coil compressor for the timestep being reported. This also represents the runtime fraction of the condenser water pump.

DX Coil Crankcase Heater Power[W]

This output field is the average electricity consumption rate of the DX coil compressor's crankcase heater in Watts for the timestep being reported. The crankcase heater operates only when the compressor is off and the air surrounding the compressor is below the Maximum Ambient Temperature for Crankcase Heater Operation, otherwise this report variable is set equal to 0.

DX Coil Crankcase Heater Consumption[J]

This output field is the total electricity consumption of the DX coil compressor's crankcase heater in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = DHW, Group Key = Plant (ref. Report Meter).

DX Coil Total Water Heating Rate[W]

This output field is the average water heating rate output of the DX coil (condenser coil plus condenser water pump) in Watts for the timestep being reported. This is determined using the inlet and outlet water temperatures and the water mass flow rate through the condenser coil.

DX Coil Total Water Heating Energy[J]

This output field is the total water heating output of the DX coil (condenser coil plus condenser water pump) in Joules for the timestep being reported. This is determined using the inlet and outlet water temperatures and the water mass flow rate through the condenser coil.

DX Coil Water Heating Electric Power[W]

This output field is the average electricity consumption rate of the DX coil compressor and condenser pump in Watts for the timestep being reported.

DX Coil Water Heating Electric Consumption[J]

This output field is the electricity consumption of the DX coil compressor and condenser pump in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = DHW, Group Key = Plant (ref. Report Meter).

Coil:Cooling:WaterToAirHeatPump:ParameterEstimation

The **Coil:Cooling:WaterToAirHeatPump:ParameterEstimation** coil is a deterministic model that requires parameters to describe the operating conditions of the heat pump's components. The parameters are generated from the manufacturer catalog data using multi-variable optimization method. In addition, the cooling coil model can be used for 3 type of compressors: **reciprocating**, **rotary** and **scroll**. Descriptions and strength of each respective model is available in the following references:

Jin, Hui. 2002. Parameter Estimation Based Models of Water Source Heat Pumps. Phd. Thesis, Department of Mechanical and Aerospace Engineering, Oklahoma State University. (downloadable from <http://www.hvac.okstate.edu/>)

Tang,C. C. 2005. Modeling Packaged Heat Pumps in Quasi-Steady State Energy Simulation Program. M.S. Thesis. Department of Mechanical and Aerospace Engineering, Oklahoma State University. (downloadable from <http://www.hvac.okstate.edu/>)

Field: Name

This alpha field contains the identifying name for the water-to-air heat pump

Field: Compressor Type

Type of compressor mode used for the heat pump. Choices available are reciprocating, rotary and scroll compressor. Note that the parameters vary for different compressor.

Field: Source Side Fluid Name

This alpha field contains the name of fluid used at the source side.

Field: Refrigerant Type

This alpha field contains the type of refrigerant used by the heat pump.

Field: Design Source Side Flow Rate

This numeric field defines the water flow rate though the coil in m³/sec

Field: Nominal Cooling Coil Capacity

This numeric field defines the nominal cooling capacity for the WatertoAirHP cooling coil in Watts.

Field: Nominal Time for Condensate Removal to Begin

This numeric field defines the nominal time (in seconds) after startup for condensate to begin leaving the coil's condensate drain line at the coil's rated airflow and temperature conditions, starting with a dry coil. Nominal time is equal to the ratio of the energy of the coil's maximum condensate holding capacity (J) to the coil's steady-state latent capacity (W). Suggested value is 1000; zero value means the latent degradation model is disabled. The default value for this field is zero.

Field: Ratio of Initial Moisture Evaporation Rate and Steady State Latent Capacity

This numeric field defines ratio of the initial moisture evaporation rate from the cooling coil (when the compressor first turns off, in Watts) and the coil's steady-state latent capacity (Watts) at rated airflow and temperature conditions. Suggested value is 1.5; zero value means the latent degradation model is disabled. The default value for this field is zero.

Field: High Pressure Cutoff

This numeric field defines the compressor's maximum allowable pressure in Pascal (N/m²)

Field: Low Pressure Cutoff

This numeric field defines the compressor's minimum allowable pressure in Pascal (N/m²)

Field: Water Inlet Node Name

This alpha field contains the cooling coil source side inlet node name.

Field: Water Outlet Node Name

This alpha field contains the cooling coil source side outlet node name.

Field: Air Inlet Node Name

This alpha field contains the cooling coil air inlet node name.

Field: Air Outlet Node Name

This alpha field contains the cooling coil air outlet node name.

Cooling Coil Parameters

Depending on the type of compressor and the source side fluid specified, the type of parameters and values also differs. An Excel Spreadsheet is developed to estimate the parameters based on the manufacturer data. The general parameters (1-5) are listed first followed by specific parameters (6-8) required by the respective compressor model. Lastly, parameters (9-10) are listed based on the type of source side fluid used.

Field: Parameter 1

This numeric field defines the estimated parameter **load side total heat transfer coefficient** in W/K.

Field: Parameter 2

This numeric field defines the estimated parameter **load side outside surface heat transfer coefficient** in W/K.

Field: Parameter 3

This numeric field defines the estimated parameter **superheat temperature** at the evaporator outlet in °C.

Field: Parameter 4

This numeric field defines the estimated parameter **compressor power losses**, which accounts for the loss of work due to mechanical and electrical losses in the compressor in Watts.

Field: Parameter 5

This numeric field defines the estimated parameter of the **compressor's efficiency**. The compressor efficiency is formulated as the equation below:

$$\eta = \frac{\dot{W}_{Theoretical}}{\dot{W}_{CompInput} - \dot{W}_{Loss}}$$

Reciprocating Compressor:**Field: Parameter 6**

This numeric field defines the estimated parameter **piston displacement of the compressor** in m³/s.

Field: Parameter 7

This numeric field defines the estimated parameter **pressure drop** at the compressor suction and discharge in Pascals (N/m²)

Field: Parameter 8

This numeric field defines the estimated parameter **clearance factor of the compressor**. This parameter is dimensionless.

Rotary Compressor:**Field: Parameter 6**

This numeric field defines the estimated parameter **piston displacement** of the compressor in m³/s.

Field: Parameter 7)

This numeric field defines the estimated parameter **pressure drop** at the compressor suction and discharge in Pascal (N/m²)

Field: Parameter 8)

Only 7 parameters are needed for Rotary Compressor.

Scroll Compressor:**Field: Parameter 6**

This numeric field defines the **refrigerant volume flow rate** at the beginning of the compression [m³/s]

Field: Parameter 7

This numeric field defines the built-in-**volume ratio**.

Field: Parameter 8

This numeric field defines the **leak rate coefficient** for the relationship between pressure ratio and leakage rate.

If pure water is used as the source side fluid:**Field: Parameter 9**

This numeric field defines the estimated parameter **source side heat transfer coefficient** in W/K.

Field: Parameter 10

Not Required

If antifreeze is used as the source side fluid:**Field: Parameter 9**

This numeric field defines the estimated parameter **source side heat transfer resistance 1**. Unit is dimensionless

Field: Parameter 10

This numeric field defines the estimated parameter **source side heat transfer resistance 2**. Unit is W/K.

Below is the idd description for Coil:WatertoAirHP:ParameterEstimation:Cooling coil.

```

Coil: Cooling: WaterToAirHeatPump: ParameterEstimation,
A1, \field Name
    \required-field
    \type alpha
    \reference CoolingCoilsWaterToAirHP
A2, \field Compressor Type
    \required-field
    \type choice
    \key Reciprocating
    \key Rotary
    \key Scroll
    \note Parameters 1-5 are as named below.
    \note Parameters 6-10 depend on the type of compressor and fluid.
    \note Refer to the InputOutputReference on the parameters required
A3, \field Source Side Fluid Name
    \note (Water, ethylene glycol, etc.)
    \type object-list
    \object-list GlycolConcentrations
    \required-field
    \default Water
A4, \field Refrigerant Type
    \type object-list
    \object-list FluidNames
    \required-field
    \default R22
N1, \field Design Source Side Flow Rate
    \required-field
    \type real
    \minimum> 0.0
    \units m3/s
N2, \field Nominal Cooling Coil Capacity
    \required-field
    \type real
    \minimum> 0.0
    \autosizable
    \units W
N3, \field Nominal Time for Condensate Removal to Begin
    \type real
    \units s
    \minimum 0.0
    \maximum 3000.0
    \default 0.0
    \note The nominal time for condensate to begin leaving the coil's condensate
    \note drain line at the coil's rated air flow rate and temperature conditions.
    \note Nominal time is equal to the ratio of the energy of the coil's maximum
    \note condensate holding capacity (J) to the coil's steady-state latent capacity (W).
    \note Suggested value is 1000; zero value means latent degradation model is disabled.
N4, \field Ratio of Initial Moisture Evaporation Rate and Steady State Latent Capacity
    \type real
    \units dimensionless
    \minimum 0.0
    \maximum 5.0
    \default 0.0
    \note Ratio of the initial moisture evaporation rate from the cooling coil (when
    \note the compressor first turns off) and the coil's steady-state latent capacity
    \note at rated air flow rate and temperature conditions. Suggested value is 1.5; zero value
    \note means latent degradation model is disabled.
N5, \field High Pressure Cutoff
    \required-field
    \minimum> 0.0
    \units Pa
N6, \field Low Pressure Cutoff
    \required-field
    \type real
    \minimum 0.0
    \units Pa

```



```

A5, \field Water Inlet Node Name
    \required-field
    \type alpha
A6, \field Water Outlet Node Name
    \required-field
    \type alpha
A7, \field Air Inlet Node Name
    \required-field
    \type alpha
A8, \field Air Outlet Node Name
    \required-field
    \type alpha
N7, \field Parameter 1
    \required-field
    \minimum> 0.0
    \type real
    \units W/K
N8, \field Parameter 2
    \required-field
    \minimum> 0.0
    \type real
    \units W/K
N9, \field Parameter 3
    \required-field
    \minimum> 0.0
    \type real
    \units C
N10, \field Parameter 4
    \required-field
    \minimum> 0.0
    \type real
    \units W
N11, \field Parameter 5
    \required-field
    \minimum> 0.0
    \type real
N12, \field Parameter 6
    \note for Compressor Type=Reciprocating, Compressor Piston Displacement, units m3/s
    \note for Compressor Type=Rotary, Compressor Piston Displacement, units m3/s
    \note for Compressor Type=Scroll, Compressor Piston Displacement, units m3/s
    \required-field
    \minimum> 0.0
    \type real
N13, \field Parameter 7
    \note for Compressor Type=Reciprocating, Compressor Clearance Factor, units dimensionless
    \note for Compressor Type=Rotary, Compressor Suction/Discharge Pressure drop, units Pa
    \note for Compressor Type=Scroll, Volume Ratio, units dimensionless
    \required-field
    \minimum> 0.0
    \type real
N14, \field Parameter 8
    \note for Compressor Type=Reciprocating, Compressor Suction/Discharge Pressure drop, units Pa
    \note for Compressor Type=Rotary, N/A,
    \note for Compressor Type=Scroll, Leak Rate Coefficient, units dimensionless
    \minimum 0.0
    \type real
N15, \field Parameter 9
    \note for source side fluid=pure water, Source Side Heat Transfer Coefficient, units W/K
    \note for source side fluid=water + antifreeze, Source Side Heat Transfer Resistancel, units
dimensionless
    \minimum 0.0
    \type real
N16; \field Parameter 10
    \note for source side fluid=pure water, N/A
    \note for source side fluid=water + antifreeze, Source Side Heat Transfer Resistance2, units W/K
    \minimum 0.0
    \type real

```

Following is an example for COIL:WaterToAirHP:ParameterEstimation:Cooling coil input

```

Coil:Cooling:WaterToAirHeatPump:ParameterEstimation,
Heat Pump Cooling Mode,  !- Heat Pump Cooling Coil Name
Scroll,                  !- Compressor Type
Water,                  !- Source Side Fluid Name
R22,                    !- Refrigerant Type
0.0015,                 !- Design water flow rate of HP {m3/sec}
38000,  !- Nominal HP cooling coil capacity {W}
0,  !- Nominal Time for Condensate Removal to Begin
0,  !- Ratio of Initial Moisture Evaporation Rate and Steady-state Latent Capacity
3000000,  !- High Pressure CutOff {Pa}
0,  !- Low Pressure CutOff {Pa}
Water to Air Heat Pump Source Sidel Inlet Node,  !- Heat Pump Cooling Coil Water Inlet Node Name
Water to Air Heat Pump Source Sidel Outlet Node,  !- Heat Pump Cooling Coil Water Outlet Node Name
Cooling Coil Air Inlet Node,  !- Cooling Coil Air Inlet Node Name
Heating Coil Air Inlet Node,  !- Cooling Coil Air Outlet Node Name
3.78019E+03,!- Parameter 1 (Load Side Outside Surface Heat Transfer Coeffi {W/K}
2.80303E+03,!- Parameter 2 (Load Side Total Heat Transfer Coefficient) {W/K}
7.93591E-01,!- Parameter 3 (Superheat Temperature) {C}
1.91029E+03,!- Parameter 4 (Compressor Power Losses) {W}
2.66127E+00,!- Parameter 5 (Compressor Efficiency)
1.06009E-02,!- Parameter 6
1.65103E+00,!- Parameter 7
9.73887E-03,!- Parameter 8
1.04563E+03;!- Parameter 9

```

Coil:Cooling:WaterToAirHeatPump:EquationFit

The Coil:Cooling:WaterToAirHeatPump:EquationFit is a simple curve-fit model that requires coefficients generated from the heat pump catalog data. This is an equation-fit model that resembles a black box with no usage of heat transfer equations. The performance of the heat pump is modeled using curves fitted from the catalog data. Description of the equation-fit model is available in the following reference:

Tang,C. C. 2005. Modeling Packaged Heat Pumps in Quasi-Steady State Energy Simulation Program. M.S. Thesis. Department of Mechanical and Aerospace Engineering, Oklahoma State University. (downloadable from <http://www.hvac.okstate.edu/>)

Field: Name

This alpha field contains the identifying name for the Coil:WatertoAirHPSimple:Cooling

Field: Water Inlet Node Name

This alpha field contains the cooling coil source side inlet node name.

Field: Water Outlet Node Name

This alpha field contains the cooling coil source side outlet node name.

Field: Air Inlet Node Name

This alpha field contains the cooling coil air inlet node name.

Field: Air Outlet Node Name

This alpha field contains the cooling coil air outlet node name.

Field: Rated Air Flow Rate

This numeric field contains the rated volumetric air flow rate on the load side of the heat pump in m3/s.

Field: Rated Water Flow Rate

This numeric field contains the rated volumetric water flow rate on the source side of the heat pump in m3/s.

Field: Rated Total Cooling Capacity

This numeric field contains the rated total cooling capacity of the heat pump in W.

Field: Rated Sensible Cooling Capacity

This numeric field contains the rated sensible capacity of the heat pump in W.

Field: Rated Cooling Power Consumption

This numeric field contains the rated heating power consumption of the heat pump in W.

Field: Total Cooling Capacity Coefficient 1 to 5

These numeric fields contain the first to fifth coefficient for the heat pump total cooling capacity.

Field: Sensible Cooling Capacity Coefficient 1 to 6

These numeric fields contain the first to sixth coefficient for the heat pump sensible cooling capacity.

Field: Cooling Power Consumption Coefficient 1 to 5

These numeric fields contain the first to fifth coefficient for the heat pump power consumption.

Field: Nominal Time for Condensate Removal to Begin

This numeric field defines the nominal time (in seconds) after startup for condensate to begin leaving the coil's condensate drain line at the coil's rated airflow and temperature conditions, starting with a dry coil. Nominal time is equal to the ratio of the energy of the coil's maximum condensate holding capacity (J) to the coil's steady-state latent capacity (W). Suggested value is 1000; zero value means the latent degradation model is disabled. The default value for this field is zero.

Field: Ratio of Initial Moisture Evaporation Rate and Steady State Latent Capacity

This numeric field defines ratio of the initial moisture evaporation rate from the cooling coil (when the compressor first turns off, in Watts) and the coil's steady-state latent capacity (Watts) at rated airflow and temperature conditions. Suggested value is 1.5; zero value means the latent degradation model is disabled. The default value for this field is zero.

Below is the idd description for the Coil:WatertoAirHP:EquationFit:Cooling coil.

```

Coil: Cooling: WaterToAirHeatPump: EquationFit,
A1, \field Name
    \required-field
    \type alpha
A2, \field Water Inlet Node Name
    \required-field
    \type alpha
A3, \field Water Outlet Node Name
    \required-field
    \type alpha
A4, \field Air Inlet Node Name
    \required-field
    \type alpha
A5, \field Air Outlet Node Name
    \required-field
    \type alpha
N1, \field Rated Air Flow Rate
    \required-field
    \type real
    \minimum> 0.0
    \units m3/s
N2, \field Rated Water Flow Rate
    \required-field
    \type real
    \minimum> 0.0
    \units m3/s
N3, \field Rated Total Cooling Capacity
    \required-field
    \type real
    \minimum> 0.0
    \units W
N4, \field Rated Sensible Cooling Capacity
    \required-field
    \type real
    \minimum> 0.0
    \units W
N5, \field Rated Cooling Power Consumption
    \required-field
    \type real
    \minimum> 0.0
    \units W
N6, \field Total Cooling Capacity Coefficient 1
    \required-field
    \type real
N7, \field Total Cooling Capacity Coefficient 2
    \required-field
    \type real
N8, \field Total Cooling Capacity Coefficient 3
    \required-field
    \type real
N9, \field Total Cooling Capacity Coefficient 4
    \required-field
    \type real
N10, \field Total Cooling Capacity Coefficient 5
    \required-field
    \type real
N11, \field Sensible Cooling Capacity Coefficient 1
    \required-field
    \type real
N12, \field Sensible Cooling Capacity Coefficient 2
    \required-field
    \type real
N13, \field Sensible Cooling Capacity Coefficient 3
    \required-field
    \type real
N14, \field Sensible Cooling Capacity Coefficient 4
    \required-field
    \type real

```

```

N15, \field Sensible Cooling Capacity Coefficient 5
      \required-field
      \type real
N16, \field Sensible Cooling Capacity Coefficient 6
      \required-field
      \type real
N17, \field Cooling Power Consumption Coefficient 1
      \required-field
      \type real
N18, \field Cooling Power Consumption Coefficient 2
      \required-field
      \type real
N19, \field Cooling Power Consumption Coefficient 3
      \required-field
      \type real
N20, \field Cooling Power Consumption Coefficient 4
      \required-field
      \type real
N21, \field Cooling Power Consumption Coefficient 5
      \required-field
      \type real
N22, \field Nominal Time for Condensate Removal to Begin
      \type real
      \units s
      \minimum 0.0
      \maximum 3000.0
      \default 0.0
      \note The nominal time for condensate to begin leaving the coil's condensate
      \note drain line at the coil's rated air flow and temperature conditions.
      \note Nominal time is equal to the ratio of the energy of the coil's maximum
      \note condensate holding capacity (J) to the coil's steady-state latent capacity (W).
      \note Suggested value is 1000; zero value means latent degradation model is disabled.
N23; \field Ratio of Initial Moisture Evaporation Rate and Steady State Latent Capacity
      \type real
      \units dimensionless
      \minimum 0.0
      \maximum 5.0
      \default 0.0
      \note Ratio of the initial moisture evaporation rate from the cooling coil (when
      \note the compressor first turns off) and the coil's steady-state latent capacity
      \note at rated air flow rate and temperature conditions. Suggested value is 1.5; zero value
      \note means latent degradation model is disabled.

```

Following is an example of the input for COIL:WaterToAirHP:EquationFit:Cooling coil

```
Coil:Cooling:WaterToAirHeatPump:EquationFit,
Heat Pump Cooling Mode,!- Name of Coil
Water to Air Heat Pump Source Sidel Inlet Node,!- Coil Water Inlet Node Name
Water to Air Heat Pump Source Sidel Outlet Node,!- Coil Water Outlet Node Name
Cooling Coil Air Inlet Node,!- Coil Air Inlet Node Name
Heating Coil Air Inlet Node,!- Coil Air Outlet Node Name
4.6015E-01,!- Rated Air Volumetric Flow Rate
2.8391E-04,!- Rated Water Volumetric Flow Rate
23125.59,!- Rated Total Cooling Capacity
16267.05,!- Rated Sensible Cooling Capacity
3300.00,!- Rated Cooling Power Consumption
-0.68126221,!- Total Cooling Capacity Coefficient 1
1.99529297,!- Total Cooling Capacity Coefficient 2
-0.93611888,!- Total Cooling Capacity Coefficient 3
0.02081177,!- Total Cooling Capacity Coefficient 4
0.008438868,!- Total Cooling Capacity Coefficient 5
2.24209455,!- Sensible Cooling Capacity Coefficient 1
7.28913391,!- Sensible Cooling Capacity Coefficient 2
-9.06079896,!- Sensible Cooling Capacity Coefficient 3
-0.36729404,!- Sensible Cooling Capacity Coefficient 4
0.218826161,!- Sensible Cooling Capacity Coefficient 5
0.00901534,!- Sensible Cooling Capacity Coefficient 6
-3.20456384,!- Cooling Power Consumption Coefficient 1
0.47656454,!- Cooling Power Consumption Coefficient 2
3.16734236,!- Cooling Power Consumption Coefficient 3
0.10244637,!- Cooling Power Consumption Coefficient 4
-0.038132556,!- Cooling Power Consumption Coefficient 5
0,!- Nominal Time for Condensate Removal to Begin
0;!- Ratio of Initial Moisture Evaporation Rate and Steady-state Latent Capacity
```

Water to Air Heat Pump Cooling Coil (Parameter Estimation and Equation Fit) Outputs

Coil:Cooling:WaterToAirHeatPump:ParameterEstimation and
 Coil:Cooling:WaterToAirHeatPump:EquationFit have the same output variables listed as follows;

```
HVAC, Average, WatertoAirHP Power [W]
HVAC, Average, WatertoAirHP Load Side Total Heat Transfer Rate [W]
HVAC, Average, WatertoAirHP Load Side Sensible Heat Transfer Rate [W]
HVAC, Average, WatertoAirHP Source Side Heat Transfer Rate [W]
HVAC, Average, WatertoAirHP Part Load Ratio
HVAC, Average, WatertoAirHP Duty Factor

HVAC, Average, WatertoAirHP Load Side Mass Flow Rate[kg/s]
HVAC, Average, WatertoAirHP Load Side Inlet Dry Bulb Temperature [C]
HVAC, Average, WatertoAirHP Load Side Inlet Humidity Ratio [kg/kg]
HVAC, Average, WatertoAirHP Load Side Outlet Dry Bulb Temperature [C]
HVAC, Average, WatertoAirHP Load Side Outlet Humidity Ratio [kg/kg]

HVAC, Average, WatertoAirHP Source Side Mass Flow Rate[kg/s]
HVAC, Average, WatertoAirHP Source Side Inlet Temperature [C]
HVAC, Average, WatertoAirHP Source Side Outlet Temperature [C]

HVAC, Sum, WatertoAirHP Cooling Electric Consumption [J]
HVAC, Sum, WatertoAirHP Load Side Total Cooling Energy [J]
HVAC, Sum, WatertoAirHP Load Side Sensible Cooling Energy [J]
HVAC, Sum, WatertoAirHP Load Side Latent Cooling Energy [J]
HVAC, Sum, WatertoAirHP Source Side Cooling Energy [J]
```

WatertoAirHP Power [W]

This output variable is the average electric consumption rate of the heat pump in Watts over the timestep being reported.

WatertoAirHP Load Side Total Heat Transfer Rate [W]

The output variable is the average total cooling load provide by the heat pump which includes the sensible and latent load in Watts over the timestep being reported.

WatertoAirHP Load Side Sensible Heat Transfer Rate [W]

The output variable is the average sensible cooling load provide by the heat pump in Watts over the timestep being reported.

WatertoAirHP Source Side Total Heat Transfer Rate [W]

The output variable is the average heat rejected to the water at the heat pump condenser in Watts over the timestep being reported.

WatertoAirHP Part-Load Ratio

This output variable is the ratio of the part-load capacity to the steady state capacity of the WatertoAirHP coil. For the cycling fan mode, the runtime fraction for the heat pump compressor may be different from the compressor part-load ratio reported here due to the part-load performance of the WatertoAirHP coil (delay at start-up to reach steady-state output). In general, runtime fractions are reported by individual components where appropriate.

WatertoAirHP Duty Factor

This output variable is the function of the part load ratio (PLR, part-load capacity/ steady state capacity). The duty factor or part load fraction accounts for efficiency losses due to compressor cycling.

WatertoAirHP Load Side Mass Flow Rate [kg/s]

The output variable is the average air mass flow rate going through the heat pump over the timestep being reported.

WatertoAirHP Load Side Inlet Dry Bulb Temperature [C]

The output variable is the average entering air dry-bulb temperature over the timestep being reported.

WatertoAirHP Load Side Inlet Humidity Ratio [kg/kg]

The output variable is the average entering air dry humidity ratio over the timestep being reported.

WatertoAirHP Load Side Outlet Dry Bulb Temperature [C]

The output variable is the average leaving air dry-bulb temperature over the timestep being reported.

WatertoAirHP Load Side Outlet Humidity Ratio [kg/kg]

The output variable is the average leaving air dry humidity ratio over the timestep being reported.

WatertoAirHP Source Side Mass Flow Rate [kg/s]

The output variable is the average water mass flow rate going through the heat pump over the timestep being reported.

WatertoAirHP Source Side Inlet Temperature [C]

The output variable is the average entering water temperature over the timestep being reported.

WatertoAirHP Source Side Outlet Temperature [C]

The output variable is the average leaving water temperature over the timestep being reported.

WatertoAirHP Cooling Electric Consumption [J]

The output variable is the electric consumption of the heat pump in Joules over the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Cooling, Group Key = System (ref. Report Meter).

WatertoAirHP Load Side Total Cooling Energy [J]

The output variable is the total cooling output of the coil in Joules over the timestep being reported. Resource Type = EnergyTransfer, End Use Key = CoolingCoils, Group Key = System (ref. Report Meter).

WatertoAirHP Load Side Sensible Cooling Energy [J]

The output variable is the total sensible cooling output of the coil in Joules over the timestep being reported

WatertoAirHP Load Side Latent Cooling Energy [J]

The output variable is the total latent cooling output of the coil in Joules over the timestep being reported.

WatertoAirHP Source Side Cooling Energy [J]

The output variable is the total source side heat transfer of the coil in Joules over the timestep being reported

Coil:Heating:WaterToAirHeatPump:ParameterEstimation

The Water to Air heat pump heating coil is a deterministic model that requires parameters to describe the operating conditions of the heat pump's components. The parameters are generated from the manufacturer catalog data using multi-variable optimization method. However, the parameters required for WatertoAirHP heating coil is similar to WatertoAirHP cooling except (source side outside heat transfer coefficient) parameter is not required for heating. In addition, the heating coil model can be used for 3 type of compressors which are **reciprocating**, **rotary** and **scroll**.

Field: Name

This alpha field contains the identifying name for the water-to-air heat pump

Field: Compressor Type

Type of compressor mode used for the heat pump. Choices available are reciprocating, rotary and scroll compressor. Note that the parameters vary for different compressor.

Field: Source Side Fluid Name

This alpha field contains the name of fluid used at the source side.

Field: Refrigerant Type

This alpha field contains the type of refrigerant used by the heat pump.

Field: Design Source Side Flow Rate

This numeric field defines the water flow rate though the coil in m3/sec

Field: Nominal Heating Coil Capacity

This numeric field defines the nominal heating capacity for the WatertoAirHP heating coil in Watts.

Field: High Pressure Cutoff

This numeric field defines the compressor's maximum allowable pressure in Pascal (N/m²)

Field: Low Pressure Cutoff

This numeric field defines the compressor's minimum allowable pressure in Pascal (N/m²)

Field: Water Inlet Node Name

This alpha field contains the heating coil source side inlet node name.

Field: Water Outlet Node Name

This alpha field contains the heating coil source side outlet node name.

Field: Air Inlet Node Name

This alpha field contains the heating coil air inlet node name.

Field: Air Outlet Node Name

This alpha field contains the heating coil air outlet node name.

Heating Coil Parameters

Depending on the type of compressor specified, the type of parameters and values also differs. An Excel Spreadsheet is in the final stage of development that is capable of estimating the parameters based on the manufacturer data. The general parameters (1-4) are listed first followed by specific parameters (5-7) required by the respective compressor model. Lastly, parameters (8-9) are listed based on the type of source side fluid used.

Field: Parameter 1

This numeric field defines the estimated parameter **load side total heat transfer coefficient** in W/K.

Field: Parameter 2

This numeric field defines the estimated parameter **superheat temperature** at the evaporator outlet in °C.

Field: Parameter 3

This numeric field defines the estimated parameter **compressor power losses**, which accounts for the loss of work due to mechanical and electrical losses in the compressor in Watts.

Field: Parameter 4

This numeric field defines the estimated parameter of the **compressor's efficiency**. The compressor efficiency is formulated as the equation below:

$$\eta = \frac{\dot{W}_{Theoretical}}{\dot{W}_{CompInput} - \dot{W}_{Loss}}$$

Reciprocating Compressor:**Field: Parameter 5**

This numeric field defines the estimated parameter **piston displacement of the compressor** in m³/s.

Field: Parameter 6

This numeric field defines the estimated parameter **pressure drop at the compressor suction** and discharge in Pascals (N/m²)

Field: Parameter 7)

This numeric field defines the estimated parameter **clearance factor of the compressor**. This parameter is dimensionless.

Rotary Compressor:**Field: Parameter 5**

This numeric field defines the estimated parameter **piston displacement of the compressor** in m³/s.

Field: Parameter 6

This numeric field defines the estimated parameter **pressure drop at the compressor suction** and discharge in Pascal (N/m²)

Field: Parameter 7

Only 6 parameters are needed for Rotary Compressor.

Scroll Compressor:**Field: Parameter 5**

This numeric field defines the **refrigerant volume flow rate** at the beginning of the compression [m³/s]

Field: Parameter 6

This numeric field defines the **built-in-volume ratio**.

Field: Parameter 7 (Leak Rate Coefficient)

This numeric field defines the coefficient for the relationship between **pressure ratio and leakage rate**.

If pure water is used as the source side fluid:**Field: Parameter 8**

This numeric field defines the estimated parameter **source side heat transfer coefficient** in W/K.

Field: Parameter 9

Not Required

If antifreeze is used as the source side fluid:**Field: Parameter 8**

This numeric field defines the estimated parameter **source side heat transfer resistance 1**. Unit is dimensionless

Field: Parameter 9)

This numeric field defines the estimated **parameter source side heat transfer resistance 2**. Unit is W/K.

Below is the idd description for the Coil:WatertoAirHP:ParameterEstimation:Heating.

```

Coil:Heating:WaterToAirHeatPump:ParameterEstimation,
A1, \field Name
    \required-field
    \type alpha
    \reference HeatingCoilsWaterToAirHP
A2, \field Compressor Type
    \required-field
    \type choice
    \key Reciprocating
    \key Rotary
    \key Scroll
    \note Parameters 1-4 are as named below.
    \note Parameters 5-9 depend on the type of compressor.
    \note Refer to the InputOutputReference on the parameters required
A3, \field Source Side Fluid Name
    \note (Water, ethylene glycol, etc.)
    \type object-list
    \object-list GlycolConcentrations
    \required-field
    \default Water
A4, \field Refrigerant Type
    \type object-list
    \object-list FluidNames
    \required-field
    \default R22
N1, \field Design Source Side Flow Rate
    \required-field
    \type real
    \minimum> 0.0
    \units m3/s
N2, \field Nominal Heating Coil Capacity
    \required-field
    \type real
    \minimum> 0.0
    \autosizable
    \units W
N3, \field High Pressure Cutoff
    \required-field
    \type real
    \minimum> 0.0
N4, \field Low Pressure Cutoff
    \required-field
    \type real
    \minimum 0.0
    \units Pa
A5, \field Water Inlet Node Name
    \required-field
    \type alpha
A6, \field Water Outlet Node Name
    \required-field
    \type alpha
A7, \field Air Inlet Node Name
    \required-field
    \type alpha
A8, \field Air Outlet Node Name
    \required-field
    \type alpha
N5, \field Parameter 1
    \required-field
    \minimum> 0.0
    \type real
    \units W/K
N6, \field Parameter 2
    \required-field
    \minimum> 0.0
    \type real
    \units C
N7, \field Parameter 3
    \required-field
    \minimum> 0.0
    \type real

```

```

\units W
N8, \field Parameter 4
    \required-field
    \minimum> 0.0
    \type real
N9, \field Parameter 5
    \note for Compressor Type=Reciprocating, Compressor Piston Displacement, units m3/s
    \note for Compressor Type=Rotary, Compressor Piston Displacement, units m3/s
    \note for Compressor Type=Scroll, Compressor Piston Displacement, units m3/s
    \required-field
    \minimum> 0.0
    \type real
N10, \field Parameter 6
    \note for Compressor Type=Reciprocating, Compressor Clearance Factor, units dimensionless
    \note for Compressor Type=Rotary, Compressor Suction/Discharge Pressure drop, units Pa
    \note for Compressor Type=Scroll, Volume Ratio, units dimensionless
    \required-field
    \minimum> 0.0
    \type real
N11, \field Parameter 7
    \note for Compressor Type=Reciprocating, Compressor Suction/Discharge Pressure drop, units Pa
    \note for Compressor Type=Rotary, Not Required, Enter 0
    \note for Compressor Type=Scroll, Leak Rate Coefficient, units dimensionless
    \minimum 0.0
    \type real
N12, \field Parameter 8
    \note for source side fluid=pure water, Source Side Heat Transfer Coefficient, units W/K
    \note for source side fluid=water + antifreeze, Source Side Heat Transfer Resistance1, units
dimensionless
    \minimum 0.0
    \type real
N13; \field Parameter 9
    \note for source side fluid=pure water, Not Required, Enter 0
    \note for source side fluid=water + antifreeze, Source Side Heat Transfer Resistance2, units W/K
    \minimum 0.0
    \type real

```

Following is an example input for Coil:WatertoAirHP:ParameterEstimation:Heating

```

Coil:Heating:WaterToAirHeatPump:ParameterEstimation,
Heat Pump HEATING Mode,  !- Heat Pump Heating Coil Name
Scroll,                  !- Compressor Type
Water,                   !- Source Side Fluid Name
R22,                     !- Refrigerant Type
0.0015,                  !- Design water flow rate of HP {m3/sec}
38000,                   !- Nominal HP Heating Coil Capacity {W}
3000000,                 !- High Pressure CutOff
0,                       !- Low Pressure CutOff {Pa}
Water to Air Heat Pump Source Side2 Inlet Node, !- Heat Pump Heating Coil Water Inlet Node Name
Water to Air Heat Pump Source Side2 Outlet Node, !- Heat Pump Heating Coil Water Outlet Node Name
Heating Coil Air Inlet Node, !- Heating Coil Air Inlet Node Name
SuppHeating Coil Air Inlet Node, !- Heating Coil Air Outlet Node Name
3.91379E+03, !- Parameter 1 (Load Side Total Heat Transfer Coefficient) {W/K}
5.94753E-01, !- Parameter 2 (Superheat Temperature) {C}
2.49945E+03, !- Parameter 3 (Compressor Power Losses) {W}
8.68734E-01, !- Parameter 4 (Compressor Efficiency)
7.23595E-03, !- Parameter 5
3.69126E+00, !- Parameter 6
1.75701E-05, !- Parameter 7
3.65348E+03; !- Parameter 8

```

Coil:Heating:WaterToAirHeatPump:EquationFit

The Water to Air Heating Equation Fit Coil is a simple curve-fit model that requires coefficients generated from the heat pump catalog data. This is an equation-fit model that resembles a black box with no usage of heat transfer equations. The performance of the heat pump is modeled using curves fitted from the catalog data.

Field: Name

This alpha field contains the identifying name for the Coil:WatertoAirHP:EquationFit:Heating

Field: Water Inlet Node Name

This alpha field contains the heating coil source side inlet node name.

Field: Water Outlet Node Name

This alpha field contains the heating coil source side outlet node name.

Field: Air Inlet Node Name

This alpha field contains the heating coil air inlet node name.

Field: Air Outlet Node Name

This alpha field contains the heating coil air outlet node name.

Field: Rated Air Flow Rate

This numeric field contains the rated volumetric air flow rate on the load side of the heat pump in m³/s.

Field: Rated Water Flow Rate

This numeric field contains the rated volumetric water flow rate on the source side of the heat pump in m³/s.

Field: Rated Heating Capacity

This numeric field contains the rated heating capacity of the heat pump in W.

Field: Rated Heating Power Consumption

This numeric field contains the rated heating power consumption of the heat pump in W.

Field: Heating Capacity Coefficient 1-5

These numeric fields contain the first to fifth coefficient for the heat pump capacity.

Field: Heating Power Consumption Coefficient 1-5

These numeric fields contain the first to fifth coefficient for the heat pump power consumption.

```

Coil:Heating:WaterToAirHeatPump:EquationFit,
  A1, \field Name
      \required-field
      \type alpha
  A2, \field Water Inlet Node Name
      \required-field
      \type alpha
  A3, \field Water Outlet Node Name
      \required-field
      \type alpha
  A4, \field Air Inlet Node Name
      \required-field
      \type alpha
  A5, \field Air Outlet Node Name
      \required-field
      \type alpha
  N1, \field Rated Air Flow Rate
      \required-field
      \type real
      \minimum> 0.0
      \units m3/s
  N2, \field Rated Water Flow Rate
      \required-field
      \type real
      \minimum> 0.0
      \units m3/s
  N3, \field Rated Heating Capacity
      \required-field
      \type real
      \minimum> 0.0
      \units W
  N4, \field Rated Heating Power Consumption
      \required-field
      \type real
      \minimum> 0.0
      \units W
  N5, \field Heating Capacity Coefficient 1
      \required-field
      \type real
  N6, \field Heating Capacity Coefficient 2
      \required-field
      \type real
  N7, \field Heating Capacity Coefficient 3
      \required-field
      \type real
  N8, \field Heating Capacity Coefficient 4
      \required-field
      \type real
  N9, \field Heating Capacity Coefficient 5
      \required-field
      \type real
  N10, \field Heating Power Consumption Coefficient 1
      \required-field
      \type real
  N11, \field Heating Power Consumption Coefficient 2
      \required-field
      \type real
  N12, \field Heating Power Consumption Coefficient 3
      \required-field
      \type real
  N13, \field Heating Power Consumption Coefficient 4
      \required-field
      \type real
  N14, \field Heating Power Consumption Coefficient 5
      \required-field
      \type real

```

**Water to Air Heat Pump Heating Coil (parameter Estimation and Equation Fit)
Outputs**

Coil:Heating:WaterToAirHeatPump:ParameterEstimation and
 Coil:Heating:WaterToAirHeatPump:EquationFit have the same output variables listed as follows;

```

HVAC, Average, WatertoAirHP Power [W]
HVAC, Average, WatertoAirHP Load Side Total Heat Transfer Rate [W]
HVAC, Average, WatertoAirHP Load Side Sensible Heat Transfer Rate [W]
HVAC, Average, WatertoAirHP Source Side Heat Transfer Rate [W]
HVAC, Average, WatertoAirHP Part Load Ratio
HVAC, Average, WatertoAirHP Duty Factor

HVAC, Average, WatertoAirHP Load Side Mass Flow Rate[kg/s]
HVAC, Average, WatertoAirHP Load Side Inlet Dry Bulb Temperature [C]
HVAC, Average, WatertoAirHP Load Side Inlet Humidity Ratio [kg/kg]
HVAC, Average, WatertoAirHP Load Side Outlet Dry Bulb Temperature [C]
HVAC, Average, WatertoAirHP Load Side Outlet Humidity Ratio [kg/kg]

HVAC, Average, WatertoAirHP Source Side Mass Flow Rate[kg/s]
HVAC, Average, WatertoAirHP Source Side Inlet Temperature [C]
HVAC, Average, WatertoAirHP Source Side Outlet Temperature [C]

HVAC, Sum, WatertoAirHP Heating Electric Consumption [J]
HVAC, Sum, WatertoAirHP Load Side Total Heating Energy [J]
HVAC, Sum, WatertoAirHP Source Side Heating Energy [J]
  
```

WatertoAirHP Power [W]

This output variable is the average electric consumption rate of the heat pump in Watts over the timestep being reported.

WatertoAirHP Load Side Total Heat Transfer Rate [W]

The output variable is the average total heating capacity provide by the heat pump which includes the sensible and latent capacity in Watts over the timestep being reported.

WatertoAirHP Load Side Sensible Heat Transfer Rate [W]

The output variable is the average sensible heating capacity provide by the heat pump in Watts over the timestep being reported. For heating mode, the sensible capacity is equal to the total capacity.

WatertoAirHP Source Side Total Heat Transfer Rate [W]

The output variable is the average heat absorbed at the heat pump evaporator in Watts over the timestep being reported.

WatertoAirHP Part-Load Ratio

This output variable is the ratio of the part-load capacity to the steady state capacity of the WatertoAirHP coil. For the cycling fan mode, the runtime fraction for the heat pump compressor may be different from the compressor part-load ratio reported here due to the part-load performance of the WatertoAirHP coil (delay at start-up to reach steady-state output). In general, runtime fractions are reported by individual components where appropriate.

WatertoAirHP Duty Factor

This output variable is the function of the part load ratio (PLR, part-load capacity/ steady state capacity). The duty factor or part load fraction accounts for efficiency losses due to compressor cycling.

WatertoAirHP Load Side Mass Flow Rate [kg/s]

The output variable is the average air mass flow rate going through the heat pump over the timestep being reported.

WatertoAirHP Load Side Inlet Dry Bulb Temperature [C]

The output variable is the average entering air dry-bulb temperature over the timestep being reported.

WatertoAirHP Load Side Inlet Humidity Ratio [kg/kg]

The output variable is the average entering air dry humidity ratio over the timestep being reported.

WatertoAirHP Load Side Outlet Dry Bulb Temperature [C]

The output variable is the average leaving air dry-bulb temperature over the timestep being reported.

WatertoAirHP Load Side Outlet Humidity Ratio [kg/kg]

The output variable is the average leaving air dry humidity ratio over the timestep being reported.

WatertoAirHP Source Side Mass Flow Rate [kg/s]

The output variable is the average water mass flow rate going through the heat pump over the timestep being reported.

WatertoAirHP Source Side Inlet Temperature [C]

The output variable is the average entering water temperature over the timestep being reported.

WatertoAirHP Source Side Outlet Temperature [C]

The output variable is the average leaving water temperature over the timestep being reported.

WatertoAirHP Heating Electric Consumption [J]

The output variable is the total electric consumption of the heat pump in Joules over the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Heating, Group Key = System (ref. Report Meter).

WatertoAirHP Load Side Total Heating Energy [J]

The output variable is the total cooling output of the coil in Joules over the timestep being reported. Resource Type = EnergyTransfer, End Use Key = HeatingCoils, Group Key = System (ref. Report Meter).

WatertoAirHP Source Side Heating Energy [J]

The output variable is the total source side heat transfer of the coil in Joules over the timestep being reported

Coil:WaterHeating:Desuperheater

A simplified approach is used to determine the performance of this water heating coil. The model assumes that the heating energy provided by this coil is reclaimed from the superheated refrigerant gas leaving a compressor (i.e., a desuperheating refrigerant-to-water heating coil) and does not impact the performance of the compressor. This coil must be used with a water heater tank (e.g., WaterHeater:Mixed) which can supply heated potable water and/or hot water for use in a plant loop (e.g., hydronic air reheat coils).

Since detailed refrigeration system models do not currently exist in EnergyPlus, the amount of available superheat is simply a percentage of the total heat being rejected by the DX system's condenser. Approximately 25-30% of the energy rejected by typical refrigeration system condensers is to reduce the superheated refrigerant vapor temperature to the condensing temperature. Recovery efficiencies higher than 30% may cause the refrigerant gas to condense which in turn impacts the performance of the refrigeration system. For this reason, the maximum heat reclaim recovery efficiency for this coil is 30%. The model includes the ability to modify the heat reclaim recovery efficiency based on variations in inlet water temperature and outdoor air dry-bulb temperature.

This coil model performs the following major functions:

- calculates the amount of heat delivered to the water tank
- calculates the electricity consumption of the integral water pump and on/off-cycle parasitic loads

The input fields for this object are described below in detail:

Field: Name

This alpha field contains a unique user-assigned name for an instance of a desuperheater water heating coil. Any reference to this desuperheater coil by another object will use this name.

Field: Availability Schedule Name

This alpha field contains the name of the schedule (ref: Schedule) that denotes whether the desuperheater coil is available to operate during a given time period. A schedule value equal to 0 denotes that the desuperheater coil is off for that time period. A value other than 0 denotes that the desuperheater coil is available to operate during that time period. During times when the desuperheater coil is scheduled off, the heater (element or burner) in the water tank object operates based on its tank set point temperature schedule and the desuperheater coil's parasitic electric power is also off for that time period.

Field: Setpoint Temperature Schedule Name

This alpha field contains the name of the schedule (ref: Schedule) that specifies the set point (or "cut-out") temperature for the desuperheater coil. Temperature values used in this schedule should be in degrees Celsius. The desuperheater coil turns off when the tank water reaches this set point temperature. Once the desuperheater coil is off, the tank water temperature floats downward until it falls below the set point temperature minus the dead band temperature difference defined below (i.e., the "cut-in" temperature). At this point, the desuperheater coil turns on and remains on until the desuperheater coil set point temperature is reached.

Field: Dead Band Temperature Difference

This numeric field contains the dead band temperature difference in degrees Celsius. The desuperheater coil "cut-in" temperature is defined as the desuperheater coil set point temperature defined above minus this dead band temperature difference. The desuperheater coil turns on when the water temperature in the tank falls below the "cut-in" temperature. The desuperheater coil remains on until the water temperature in the tank rises above the desuperheater coil set point ("cut-out") temperature defined above. The dead band temperature difference must be greater than 0°C and less than or equal to 20°C. If this field is left blank, the default value is 5°C.

Desuperheater water heating coils are typically used to offset energy consumption by the water tank's heater (element or burner). Therefore, the cut-in temperature for the desuperheater coil (set point minus dead band temperature difference) is usually higher than the set point temperature for the heater (element or burner) in the associated water heater tank object. At times when the water heater tank set point

temperature is greater than the cut-in temperature of the desuperheater coil, the model disables the desuperheater coil and the tank's heater is used to heat the water.

Field: Rated Heat Reclaim Recovery Efficiency

This numeric field defines the ratio of recovered waste heat from the superheated refrigerant gas to the total rejected waste heat from the heating source (as if no heat reclaim occurred). Input values must be greater than 0 up to a maximum of 0.3. If this input field is left blank, the default value is 0.25.

Field: Rated Inlet Water Temperature

This numeric field defines the coil inlet water temperature, in degrees Celsius, that corresponds to the rated heat reclaim recovery efficiency. Also see field "Heat Reclaim Efficiency Modifier Curve Name (function of temperature)" below.

Field: Rated Outdoor Air Temperature

This numeric field defines the outdoor air dry-bulb temperature, in degrees Celsius, that corresponds to the rated heat reclaim recovery efficiency. The outdoor air dry-bulb temperature impacts the desuperheater coil refrigerant temperature and the amount of heat available for reclaim. Also see field "Heat Reclaim Efficiency Modifier Curve Name(function of temperature)" below.

Field: Maximum Inlet Water Temperature for Heat Reclaim

This numeric field defines the maximum coil inlet water temperature in degrees Celsius. Any time the inlet water temperature to the desuperheater coil is above this maximum allowed temperature, heat reclaim is restricted so that the tank water does not exceed this temperature.

Field: Heat Reclaim Efficiency Function of Temperature Curve Name

This alpha field specifies the name of a **biquadratic** curve object (ref: Performance Curves) that defines the variation in heat reclaim efficiency as a function of inlet fluid (air and water) temperatures. The biquadratic curve uses the coil inlet water temperature and outdoor air dry-bulb temperature (entering the DX coil condenser) as the independent variables. The output of this curve is multiplied by the rated heat reclaim recovery efficiency to give the heat reclaim efficiency at specific operating conditions (i.e., at temperatures different from the rating point temperatures). The curve should be normalized to have the value of 1.0 at the rating point temperatures. If this field is left blank, the heat reclaim efficiency remains constant (curve value assumed to be 1.0 for all conditions). The model restricts the product of the output of this curve and the rated heat reclaim recovery efficiency to a maximum of 0.3.

Field: Water Inlet Node Name

This alpha field defines the name of the water node from which the desuperheater heating coil draws its inlet water. This node name must also match the source side outlet node name for the water heater tank used with this coil (ref. Water Heaters).

Field: Water Outlet Node Name

This alpha field defines the name of the water node to which the desuperheater heating coil sends its outlet water. This node name must also match the source side inlet node name for the water heater tank used with this coil (ref. Water Heaters).

Field: Tank Object Type

This alpha (choice) field contains the type of water heater tank used by this desuperheater heating coil. Currently, the only valid choice is WaterHeater:Mixed.

Field: Tank Name

This alpha field contains the name of the specific water heater tank (WaterHeater:Mixed object) used by this desuperheater heating coil.

Field: Heating Source Object Type

This alpha (choice) field defines the source of superheated refrigerant gas from which the desuperheater water heating coil recovers energy through heat reclaim. Valid choices are:

Coil:Cooling:DX:SingleSpeed Coil:Cooling:DX:TwoSpeed Coil:Cooling:DX:TwoStageWithHumidityControlMode Refrigeration:CompressorRack Refrigeration:Condenser

Field: Heating Source Name

This alpha field defines the name of the desuperheater coil's heat source which provides waste heat to this desuperheater water heating coil.

Field: Water Flow Rate

This numeric field defines the desuperheater coil's water flow rate in cubic meters per second. The model assumes that this flow rate is constant (throughout the simulation period) when the desuperheater coil operates, and that it corresponds to the heat reclaim recovery efficiency performance specified by the user. This water flow rate must be greater than zero.

Field: Water Pump Power

This numeric field defines the coil's water circulation pump power in Watts. This is the operating pump power as installed. Values must be greater than or equal to 0. If this field is left blank, the default value is 0. A warning message will be issued if the ratio of water pump power to desuperheater water volumetric flow rate exceeds $7.9264E6 \text{ W/m}^3/\text{s}$, but the simulation will continue using the user-defined values. The model assumes that this integral pump (i.e., no need to define a separate pump object) cycles on and off with the desuperheater heating coil.

Field: Fraction of Pump Heat to Water

This numeric field defines the fraction of water circulation pump heat that is transferred to the water. The pump is assumed to be downstream of the desuperheater water heating coil, and this field is used to determine the desuperheater water outlet temperature. Values must be greater than or equal to 0 and less than or equal to 1. If this field is left blank, the default value is 0.2.

Field: On-Cycle Parasitic Electric Load

This optional numeric field contains the on-cycle parasitic electric power in Watts. This is the parasitic electric power consumed by controls or other electrical devices associated with the desuperheater water heating coil. This parasitic electric load is consumed whenever the desuperheater coil is operating, and the model assumes that this parasitic power does not contribute to heating the water nor does it affect the zone air heat balance. The minimum value for this field is 0.0, and the default value is also 0.0 if this field is left blank.

Field: Off-Cycle Parasitic Electric Load

This optional numeric field contains the off-cycle parasitic electric power in Watts. This is the parasitic electric power consumed by controls or other electrical devices associated with the desuperheater water heating coil. This parasitic electric load is consumed whenever the desuperheater coil is available but is not operating, and the model assumes that this parasitic power does not contribute to heating the water nor does it affect the zone air heat balance. The minimum value for this field is 0.0, and the default value is also 0.0 if this field is left blank.

Below is the IDD definition for the Coil:Water:DesuperheaterHeating object:

```

Coil:WaterHeating:Desuperheater,
  \min-fields 18
A1 , \field Name
  \required-field
  \type alpha
  \reference WaterHeatingCoilsDesuperheater
  \note Unique name for this instance of a desuperheater water heating coil.
A2 , \field Availability Schedule Name
  \type alpha
  \note Schedule values of 0 denote the desuperheater heating coil is off and the parasitic electric
  \note energy is also off.
A3 , \field Setpoint Temperature Schedule Name
  \required-field
  \type alpha
  \note Defines the cut-out temperature where the desuperheater water heating coil turns off.
  \note The desuperheater heating coil setpoint temperature should always be greater
  \note than the water tank's heater (element or burner) setpoint temperature. Temperature
  \note schedule values should be in degrees C.
N1 , \field Dead Band Temperature Difference
  \type real
  \units deltaC
  \minimum> 0
  \maximum 20
  \default 5
  \note Setpoint temperature minus the dead band temperature difference defines
  \note the cut-in temperature where the desuperheater water heating coil turns on.
  \note The water tank's heater (element or burner) setpoint temperature
  \note should always be less than the desuperheater heating coil cut-in temperature.
N2 , \field Rated Heat Reclaim Recovery Efficiency
  \type real
  \minimum> 0.0
  \maximum 0.3
  \default 0.25
  \note Enter the fraction of waste heat reclaimed by the desuperheater water heating coil.
N3 , \field Rated Inlet Water Temperature
  \required-field
  \type real
  \units C
  \note The inlet water temperature corresponding to the rated heat reclaim recovery efficiency.
N4 , \field Rated Outdoor Air Temperature
  \required-field
  \type real
  \units C
  \note The outdoor air dry-bulb temperature corresponding to the
  \note rated heat reclaim recovery efficiency.
N5 , \field Maximum Inlet Water Temperature for Heat Reclaim
  \required-field
  \type real
  \units C
  \note The desuperheater water heating coil is off when the inlet water temperature is above
  \note the maximum inlet water temperature for heat reclaim.
A4 , \field Heat Reclaim Efficiency Function of Temperature Curve Name
  \type object-list
  \object-list CubicCurves
  \note A biquadratic curve defining the performance of the desuperheater heating coil.
  \note Performance can be specified as a function of inlet water temperature, outdoor air
  \note dry-bulb temperature, or both.
  \note Curve = a + b*Tw + c*Tw**2 + d*odb + e*odb**2 + f*Tw*odb.
  \note Tw = desuperheater heating coil entering water temperature (C).
  \note Odb = outdoor dry-bulb temperature at DX system condenser (C).

```

```

A5 , \field Water Inlet Node Name
    \required-field
    \type alpha
    \note The node from which the desuperheater heating coil draws its inlet water.
    \note This name should match the source side outlet node name in the associated
    \note water heater tank object.
A6 , \field Water Outlet Node Name
    \required-field
    \type alpha
    \note The node to which the desuperheater heating coil sends its outlet water.
    \note This name should match the source side inlet node name in the associated
    \note water heater tank object.
A7 , \field Tank Object Type
    \required-field
    \type choice
    \key WaterHeater:Mixed
    \default WaterHeater:Mixed
    \note Specify the type of water heater tank used by this desuperheater water heating coil.
A8 , \field Tank Name
    \required-field
    \type alpha
    \note The name of the water heater tank used by this desuperheater water heating coil.
    \note Needs to match the name used in the corresponding water heater object.
A9 , \field Heating Source Object Type
    \required-field
    \type choice
    \key Coil:Cooling:DX:SingleSpeed
    \key Coil:Cooling:DX:TwoSpeed
    \key Coil:Cooling:DX:TwoStageWithHumidityControlMode
    \key Refrigeration:CompressorRack
    \key Refrigeration:Condenser
    \note The type of DX system that is providing waste heat for reclaim.
A10, \field Heating Source Name
    \required-field
    \type object-list
    \object-list DesuperHeatingCoilSources
    \note The name of the DX system used for heat reclaim.
N6 , \field Water Flow Rate
    \required-field
    \type real
    \units m3/s
    \minimum > 0
    \note The operating water flow rate.
N7 , \field Water Pump Power
    \type real
    \units W
    \minimum 0.0
    \default 0.0
    \note The water circulation pump electric power.
N8 , \field Fraction of Pump Heat to Water
    \type real
    \minimum 0
    \maximum 1
    \default 0.2
    \note The fraction of pump heat transferred to the water. The pump is assumed to be downstream of
    \note the desuperheater water heating coil.
N9 , \field On-Cycle Parasitic Electric Load
    \type real
    \units W
    \minimum 0
    \default 0
    \note Parasitic electric power consumed when the desuperheater water heating coil operates.
    \note Parasitic electric load does not contribute to water heating or the zone air heat balance.
    \ip-units W

```

```

N10; \field Off-Cycle Parasitic Electric Load
      \type real
      \units W
      \minimum 0
      \default 0
      \note Parasitic electric load consumed when the desuperheater water heating coil is off.
      \note Parasitic electric load does not contribute to water heating or the zone air heat balance.
      \note Off-cycle parasitic power is 0 when the availability schedule is 0.
      \ip-units W

```

Following is an example input for a desuperheater water heating coil.

```

Coil:WaterHeating:Desuperheater,
  WaterHeatingCoil,           !- Coil Name
  DesuperheaterSched,         !- Availability Schedule Name
  DesuperheaterTempSch,       !- Desuperheater Coil Set Point Temperature Schedule Name
  5.0,                         !- Dead Band Temperature Difference {deltaC}
  0.25,                       !- Rated Heat Reclaim Recovery Efficiency
  50.0,                      !- Rated Inlet Water Temperature {C}
  35.0,                      !- Rated Outdoor Air Temperature {C}
  60.0,                      !- Maximum Inlet Water Temperature for Heat Reclaim {C}
  HEffFTemp,                 !- Heat Reclaim Efficiency Modifier Curve Name (function of temperature)
  WaterHeatingCoilInletNode,  !- Desuperheater Water Inlet Node Name
  WaterHeatingCoilOutletNode, !- Desuperheater Water Outlet Node Name
  WaterHeater:Mixed,          !- Water Heater Tank Type
  WaterHeatingCoilTank,       !- Water Heater Tank Name
  Coil:DX:Cooling:SingleSpeed, !- Heating Source Type
  Furnace ACDXCoil 1,         !- Heating Source Name
  0.0001,                    !- Desuperheater Water Volumetric Flow Rate {m3/s}
  100.0,                    !- Water Pump Power {W}
  0.2,                      !- Fraction of Pump Heat to Water
  10.0,                      !- On-Cycle Parasitic Electric Load {W}
  10.0;                      !- Off-Cycle Parasitic Electric Load {W}

```

Coil:WaterHeating:Desuperheater Outputs

```

HVAC,Average,Desuperheater PLR
HVAC,Average,Desuperheater Water Heating Rate [W]
HVAC,Sum,Desuperheater Water Heating Energy [J]
HVAC,Average,Desuperheater Pump Electric Power [W]
HVAC,Sum,Desuperheater Pump Electric Consumption [J]
HVAC,Average,Desuperheater Heat Reclaim Efficiency Modifier Curve Output
HVAC,Average,Desuperheater On-Cycle Parasitic Electric Power [W]
HVAC,Sum,Desuperheater On-Cycle Parasitic Electric Consumption [J]
HVAC,Average,Desuperheater Off-Cycle Parasitic Electric Power [W]
HVAC,Sum,Desuperheater Off-Cycle Parasitic Electric Consumption [J]

```

Desuperheater Part Load Ratio

This output field contains the part load ratio of the desuperheater heating coil for the timestep being reported. This ratio represents the fraction of the timestep that the desuperheater heating coil is operating.

Desuperheater Water Heating Rate [W]

This output field contains the average heating rate output of the desuperheater heating coil in Watts for the timestep being reported. This value includes the portion of circulation pump heat attributed to heating the water.

Desuperheater Water Heating Energy [J]

This output field contains the total heating output of the desuperheater heating coil in Joules for the timestep being reported. This value includes the portion of circulation pump heat attributed to heating the water.

Desuperheater Pump Electric Power [W]

This output field contains the average electricity consumption rate for the water circulation pump in Watts for the timestep being reported.

Desuperheater Pump Electric Consumption [J]

This output field contains the electricity consumption of the water circulation pump in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key= DHW, Group Key= Plant (ref. Report Meter).

Desuperheater Heat Reclaim Efficiency Modifier Curve Output

This output field contains the average output of the Heat Reclaim Efficiency Modifier Curve (function of temperature) for the timestep being reported.

Desuperheater On-Cycle Parasitic Electric Power [W]***Desuperheater On-Cycle Parasitic Electric Consumption [J]******Desuperheater Off-Cycle Parasitic Electric Power [W]******Desuperheater Off-Cycle Parasitic Electric Consumption [J]***

These outputs are the parasitic electric power and consumption associated with the desuperheater water heating coil. Specific outputs represent parasitic electrical usage during the coil on and off cycles. These outputs represent electronic controls or other electric component. The model assumes that the parasitic power does not contribute to heating the water nor does it impact the zone air heat balance. The parasitic electric consumption outputs are also added to a report meter with Resource Type = Electricity, End Use Key = DHW, Group Key = Plant (ref. Report Meter).

Group – Fans

A fan may be defined either in the air loop or as a zone equipment component. The data that is common to the fan types shown below include an identifying name, an availability schedule name, a total efficiency rating, a rated pressure rise, and inlet and outlet air node names. In the case of a variable volume fan, additional input includes parameters for modeling fan performance over a range of speeds. See the engineering documentation for the variable speed fan for a further description of what these coefficients represent. Suggested values for different variable volume systems are shown in the following table.

Table 26. Fan Coefficient Values

Type of Fan	Fan Coeff. 1	Fan Coeff. 2	Fan Coeff. 3	Fan Coeff. 4	Fan Coeff. 5
Inlet Vane Dampers	0.35071223	0.30850535	-0.54137364	0.87198823	0.000
Discharge Dampers	0.37073425	0.97250253	-0.34240761	0.000	0.000
Var. Speed Motor	0.0015302446	0.0052080574	1.1086242	-0.11635563	0.000

Fan:ConstantVolume

This object models a constant air volume fan that is intended to operate continuously based on a time schedule. This fan will not cycle on and off based on cooling/heating load or other control signals (Ref: Fan:OnOff).

Field: Name

A unique user-assigned name for an instance of a Fan:ConstantVolume. Any reference to this fan by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the fan can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the fan can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the fan must be off for the hour.

Field: Fan Efficiency

The ratio of the power delivered to the fluid to the electrical input power. It is the product of the motor efficiency and the fan efficiency. The motor efficiency is the power delivered to the shaft divided by the electrical power input to the motor. The fan efficiency is power delivered to the fluid (air) divided by the shaft power. The power delivered to the fluid is the mass flow rate of the air multiplied by the pressure rise divided by the air density. Must be between 0 and 1.

Field: Pressure Rise

The pressure rise in Pascals at full flow and standard (sea level) conditions (20°C and 101325 Pa).

Field: Maximum Flow Rate

The full load air volumetric flow rate (m³/sec) at standard temperature and pressure (dry air at 20°C drybulb). The program does use local barometric pressure to account for altitude using equation for "standard atmospheric" pressure on p 6.1 of the ASHRAE 1997 HOF (SI edition) to initialize the air systems being simulated.

$$p=101325*(1-2.25577E-05*Z)**5.2559$$

where p=pressure in Pa and Z=altitude in m

Field: Motor Efficiency

The shaft power divided by the electrical power consumed. Must be between 0 and 1.

Field: Motor In Airstream Fraction

The fraction of the motor heat that is added to the air stream. A value of 0 means that the motor is completely outside the air stream. A value of 1 means that all of the motor heat loss will go into the air stream and act to cause a temperature rise. Must be between 0 and 1.

Field: Air Inlet Node Name

The name of the HVAC system node which supplies the inlet air conditions to the fan.

Field: Air Outlet Node Name

The name of the HVAC system node to which the fan sends its outlet air.

Field: End-Use Subcategory

Allows you to specify a user-defined end-use subcategory, e.g., "Central System", etc. A new meter for reporting is created for each unique subcategory (ref: Report Meter). Subcategories are also reported in the ABUPS table. If this field is omitted or blank, the fan will be assigned to the "General" end-use subcategory.


```

Fan:ConstantVolume,
  A1 , \field Name
        \required-field
        \reference Fans
        \reference FansCV
        \reference FansCVandOnOff
        \reference FansCVandVAV
  A2 , \field Availability Schedule Name
        \type object-list
        \object-list ScheduleNames
  N1 , \field Fan Efficiency
        \type real
        \minimum> 0.0
        \maximum 1.0
  N2 , \field Pressure Rise
        \units Pa
        \ip-units inH2O
  N3 , \field Maximum Flow Rate
        \units m3/s
        \minimum 0.0
        \autosizable
  N4 , \field Motor Efficiency
        \type real
        \minimum> 0.0
        \maximum 1.0
  N5 , \field Motor In Airstream Fraction
        \note 0.0 means fan motor outside of air stream, 1.0 means motor inside of air stream
        \type real
        \minimum 0.0
        \maximum 1.0
  A3 , \field Air Inlet Node Name
  A4 , \field Air Outlet Node Name
  A5 ; \field End-Use Subcategory
        \type alpha
        \retaincase
        \default General

```

Constant Volume Fan Outputs

```

HVAC,Average,Fan Electric Power[W]
HVAC,Average,Fan Delta Temp[C]
HVAC,Sum,Fan Electric Consumption[J]

```

Fan Electric Power [W]

This output field contains the average electricity consumption rate for the fan in Watts for the timestep being reported.

Fan Delta Temp [C]

This output field contains the average rise in air temperature across the fan (outlet air temperature minus inlet air temperature) in degrees Celsius for the timestep being reported.

Fan Electric Consumption [J]

This output field contains the electricity consumption of the fan in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key= Fans, Group Key= System (ref. Report Meter).

Fan:OnOff

This object models a constant air volume fan that is intended to cycle on and off in tandem with a cooling or heating system (i.e., AUTO fan control mode). The fan can also operate continuously like Fan:ConstantVolume. If modeling continuous operation and this object is used as part of a system that utilizes Coil:Heating:Gas, Coil:Cooling:DX:SingleSpeed or Coil:Heating:DX:SingleSpeed, the user should confirm proper air flow rates (coil and fan max

flows are equal) and that the coil part-load fraction correlation(s) are appropriate (e.g., part-load fraction is less than or equal to 1 for all values of coil part-load ratio). If modeling multi-speed fan operation, this object must be used as part of a compound object that allows multiple fan speeds (e.g., AirLoopHVAC:Unitary:Furnace:HeatCool, ZoneHVAC:PackagedTerminalAirConditioner, etc.). In this case, the ratio of the compound object air flow rate to the fan's maximum air flow rate is used to determine the power at alternate fan speeds. The optional input for Fan Power Ratio Function of Speed Ratio Curve Name must be entered to model multi-speed fan operation. An optional fan total efficiency ratio curve is also available to model efficiency differences at alternate fan speeds.

Field: Name

A unique user-assigned name for an instance of a Fan:OnOff. Any reference to this fan by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the fan can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the fan can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the fan must be off for the hour.

Field: Fan Efficiency

The ratio of the power delivered to the fluid to the electrical input power. It is the product of the motor efficiency and the fan efficiency. The motor efficiency is the power delivered to the shaft divided by the electrical power input to the motor. The fan efficiency is power delivered to the fluid (air) divided by the shaft power. The power delivered to the fluid is the mass flow rate of the air multiplied by the pressure rise divided by the air density. Must be between 0 and 1.

Field: Pressure Rise

The pressure rise in Pascals at full flow and standard (sea level) conditions (20°C and 101325 Pa).

Field: Maximum Flow Rate

The full load air volumetric flow rate (m³/sec) at standard temperature and pressure (dry air at 20°C drybulb). The program does use local barometric pressure to account for altitude using equation for "standard atmospheric" pressure on p 6.1 of the ASHRAE 1997 HOF (SI edition) to initialize the air systems being simulated.

$$p=101325*(1-2.25577E-05*Z)**5.2559$$

where p=pressure in Pa and Z=altitude in m

Field: Motor Efficiency

The shaft power divided by the electrical power consumed. Must be between 0 and 1.

Field: Motor In Airstream Fraction

The fraction of the motor heat that is added to the air stream. A value of 0 means that the motor is completely outside the air stream. A value of 1 means that all of the motor heat loss will go into the air stream and act to cause a temperature rise. Must be between 0 and 1.

Field: Air Inlet Node Name

The name of the HVAC system node which supplies the inlet air conditions to the fan.

Field: Air Outlet Node Name

The name of the HVAC system node to which the fan sends its outlet air.

Field: Fan Power Ratio Function of Speed Ratio Curve Name

Enter the name of an exponent performance curve. This optional alpha field must be used to simulate multi-speed fan motors. This curve represents the ratio of actual fan power to rated fan power when a change in fan speed occurs. Leave this field blank when simulating constant-speed fan motors.

Field: Fan Efficiency Ratio Function of Speed Ratio Curve Name

Enter the name of a quadratic or cubic performance curve. This optional alpha field is used to simulate multi-speed fan motors. This curve represents the ratio of actual fan total efficiency to rated fan total efficiency when a change in fan speed occurs. Leave this field blank when simulating constant-speed fan motors.

Field: End-Use Subcategory

Allows you to specify a user-defined end-use subcategory, e.g., "Main Fans", etc. A new meter for reporting is created for each unique subcategory (ref: Report Meter). Subcategories are also reported in the ABUPS table. If this field is omitted or blank, the fan will be assigned to the "General" end-use subcategory.

Below is the input data dictionary description for the OnOff fan:

```

Fan:OnOff,
A1 , \field Name
    \required-field
    \reference Fans
    \reference FansCVandOnOff
    \reference FansOnOff
A2 , \field Availability Schedule Name
    \type object-list
    \object-list ScheduleNames
N1 , \field Fan Efficiency
    \type real
    \minimum> 0.0
    \maximum 1.0
N2 , \field Pressure Rise
    \units Pa
    \ip-units inH2O
N3 , \field Maximum Flow Rate
    \units m3/s
    \minimum 0.0
    \autosizable
N4 , \field Motor Efficiency
    \type real
    \minimum> 0.0
    \maximum 1.0
N5 , \field Motor In Airstream Fraction
    \note 0.0 means fan motor outside of air stream, 1.0 means motor inside of air stream
    \type real
    \minimum 0.0
    \maximum 1.0
A3 , \field Air Inlet Node Name
A4 , \field Air Outlet Node Name
A5 , \field Fan Power Ratio Function of Speed Ratio Curve Name
    \type object-list
    \object-list ExponentCurves
A6 , \field Fan Efficiency Ratio Function of Speed Ratio Curve Name
    \type object-list
    \object-list QuadraticCubicCurves
A7 ; \field End-Use Subcategory
    \type alpha
    \retaincase
    \default General

```

Following is an example input for an OnOff Fan.

```

Fan:OnOff,
  Supply Fan 1,          ! Fan Name
  FanAndCoilAvailSched, ! Fan Schedule
  0.7,                  ! Fan Efficiency
  600.0,                ! Delta Pressure [N/M^2]
  1.3,                  ! Max Flow Rate [m^3/Sec]
  0.9,                  ! Motor Efficiency
  1.0,                  ! Motor in Airstream Fraction (1.0 means motor in air stream)
  Air Loop Inlet Node, Cooling Coil Air Inlet Node; !Inlet Node, Outlet Node

```

OnOff Fan Outputs

```

HVAC,Average,Fan Electric Power[W]
HVAC,Average,Fan Delta Temp[C]
HVAC,Sum,Fan Electric Consumption[J]
HVAC,Average,On/Off Fan Runtime Fraction

```

Fan Electric Power [W]

This output field contains the average electricity consumption rate for the fan in Watts for the timestep being reported.

Fan Delta Temp [C]

This output field contains the average rise in air temperature across the fan (outlet air temperature minus inlet air temperature) in degrees Celsius for the timestep being reported.

Fan Electric Consumption [J]

This output field contains the electricity consumption of the fan in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key= Fans, Group Key= System (ref. Report Meter).

On/Off Fan Runtime Fraction

This output field contains the fraction of time that this fan operated for the timestep being reported.

Fan:VariableVolume

Field: Name

A unique user-assigned name for an instance of a Fan:VariableVolume. Any reference to this fan by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the fan can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the fan can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the fan must be off for the hour.

Field: Fan Efficiency

The ratio of the power delivered to the fluid to the electrical input power at maximum flow. It is the product of the motor efficiency and the fan efficiency. The motor efficiency is the power delivered to the shaft divided by the electrical power input to the motor. The fan efficiency is power delivered to the fluid (air) divided by the shaft power. The power delivered to the fluid is the mass flow rate of the air multiplied by the pressure rise divided by the air density. Must be between 0 and 1.

Field: Pressure Rise

The pressure rise in Pascals at full flow and standard (sea level) conditions (20°C and 101325 Pa).

Field: Maximum Flow Rate

The full load air volumetric flow rate (m³/sec) at standard temperature and pressure (dry air at 20°C drybulb). The program does use local barometric pressure to account for altitude using equation for "standard atmospheric" pressure on p 6.1 of the ASHRAE 1997 HOF (SI edition) to initialize the air systems being simulated.

$$p=101325*(1-2.25577E-05*Z)**5.2559$$

where p=pressure in Pa and Z=altitude in m

Field: Minimum Flow Rate

The minimum air volumetric flow rate (m³/sec) for the fan at standard temperature and pressure (see Maximum Flow Rate field above for details).

Field: Motor Efficiency

The shaft power divided by the electrical power consumed. Must be between 0 and 1.

Field: Motor In Airstream Fraction

The fraction of the motor heat that is added to the air stream. A value of 0 means that the motor is completely outside the air stream. A value of 1 means that all of the motor heat loss will go into the air stream and act to cause a temperature rise. Must be between 0 and 1.

Field: Fan Coefficient 1

The constant coefficient (C₁) in a fourth order polynomial curve giving the fraction of full load power (PLF) as a function of flow fraction (FF). Flow fraction is the air mass flow rate divided by the maximum air mass flow rate. The curve is:

$$PLF = C_1 + C_2 \cdot FF + C_3 \cdot FF^2 + C_4 \cdot FF^3 + C_5 \cdot FF^4$$

Field: Fan Coefficient 2

The linear coefficient (C₂) in a fourth order polynomial curve giving the fraction of full load power (PLF) as a function of flow fraction (FF). Flow fraction is the air mass flow rate divided by the maximum air mass flow rate. The curve is:

$$PLF = C_1 + C_2 \cdot FF + C_3 \cdot FF^2 + C_4 \cdot FF^3 + C_5 \cdot FF^4$$

Field: Fan Coefficient 3

The quadratic coefficient (C₃) in a fourth order polynomial curve giving the fraction of full load power (PLF) as a function of flow fraction (FF). Flow fraction is the air mass flow rate divided by the maximum air mass flow rate. The curve is:

$$PLF = C_1 + C_2 \cdot FF + C_3 \cdot FF^2 + C_4 \cdot FF^3 + C_5 \cdot FF^4$$

Field: Fan Coefficient 4

The cubic coefficient (C₄) in a fourth order polynomial curve giving the fraction of full load power (PLF) as a function of flow fraction (FF). Flow fraction is the air mass flow rate divided by the maximum air mass flow rate. The curve is:

$$PLF = C_1 + C_2 \cdot FF + C_3 \cdot FF^2 + C_4 \cdot FF^3 + C_5 \cdot FF^4$$

Field: Fan Coefficient 5

The coefficient C₅ in a fourth order polynomial curve giving the fraction of full load power (PLF) as a function of flow fraction (FF). Flow fraction is the air mass flow rate divided by the maximum air mass flow rate. The curve is:

$$PLF = C_1 + C_2 \cdot FF + C_3 \cdot FF^2 + C_4 \cdot FF^3 + C_5 \cdot FF^4$$

Field: Air Inlet Node Name

The name of the HVAC system node which supplies the inlet air conditions to the fan.

Field: Air Outlet Node Name

The name of the HVAC system node to which the fan sends its outlet air.

Field: End-Use Subcategory

Allows you to specify a user-defined end-use subcategory, e.g., "Central System", etc. A new meter for reporting is created for each unique subcategory (ref: Report Meter). Subcategories are also reported in the ABUPS table. If this field is omitted or blank, the fan will be assigned to the "General" end-use subcategory.

```

Fan:VariableVolume,
  A1 , \field Name
        \required-field
        \reference Fans
        \reference FansVAV
        \reference FansCVandVAV
  A2 , \field Availability Schedule Name
        \type object-list
        \object-list ScheduleNames
  N1 , \field Fan Efficiency
        \type real
        \minimum> 0.0
        \maximum 1.0
  N2 , \field Pressure Rise
        \units Pa
        \ip-units inH2O
  N3 , \field Maximum Flow Rate
        \units m3/s
        \minimum 0.0
        \autosizable
  N4 , \field Minimum Flow Rate
        \units m3/s
        \minimum 0.0
        \autosizable
  N5 , \field Motor Efficiency
        \type real
        \minimum> 0.0
        \maximum 1.0
  N6 , \field Motor In Airstream Fraction
        \note 0.0 means fan motor outside of air stream, 1.0 means motor inside of air stream
        \type real
        \minimum 0.0
        \maximum 1.0
  N7 , \field Fan Coefficient 1
        \note all FanCoefficients should not be 0.0 or no fan power will be consumed.
  N8 , \field Fan Coefficient 2
  N9 , \field Fan Coefficient 3
  N10, \field Fan Coefficient 4
  N11, \field Fan Coefficient 5
  A3 , \field Air Inlet Node Name
  A4 , \field Air Outlet Node Name
  A5 ; \field End-Use Subcategory
        \type alpha
        \retaincase
        \default General

```

Variable Volume Fan Outputs

```

HVAC,Average,Fan Electric Power[W]
HVAC,Average,Fan Delta Temp[C]
HVAC,Sum,Fan Electric Consumption[J]

```

Fan Electric Power [W]

This output field contains the average electricity consumption rate for the fan in Watts for the timestep being reported.

Fan Delta Temp [C]

This output field contains the average rise in air temperature across the fan (outlet air temperature minus inlet air temperature) in degrees Celsius for the timestep being reported.

Fan Electric Consumption [J]

This output field contains the electricity consumption of the fan in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key= Fans, Group Key= System (ref. Report Meter).

Fan:ZoneExhaust***Field: Name***

A unique user-assigned name for an instance of a Fan:ZoneExhaust. Any reference to this fan by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the fan can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the fan can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the fan must be off for the hour

Field: Fan Efficiency

The ratio of the power delivered to the fluid to the electrical input power at maximum flow. It is the product of the motor efficiency and the fan efficiency. The motor efficiency is the power delivered to the shaft divided by the electrical power input to the motor. The fan efficiency is power delivered to the fluid (air) divided by the shaft power. The power delivered to the fluid is the mass flow rate of the air multiplied by the pressure rise divided by the air density. Must be between 0 and 1.

Field: Pressure Rise

The pressure rise in Pascals at full flow and standard (sea level) conditions (20°C and 101325 Pa).

Field: Maximum Flow Rate

The full load air volumetric flow rate (m³/sec) at standard temperature and pressure (dry air at 20°C drybulb). The program does use local barometric pressure to account for altitude using equation for "standard atmospheric" pressure on p 6.1 of the ASHRAE 1997 HOF (SI edition) to initialize the air systems being simulated.

$$p=101325*(1-2.25577E-05*Z)**5.2559$$

where p=pressure in Pa and Z=altitude in m

Field: Air Inlet Node Name

The name of the HVAC system node which supplies the inlet air conditions to the fan.

Field: Air Outlet Node Name

The name of the HVAC system node to which the fan sends its outlet air.

Field: End-Use Subcategory

Allows you to specify a user-defined end-use subcategory, e.g., "Kitchen Exhaust", "Fume Hoods", etc. A new meter for reporting is created for each unique subcategory (ref: Report Meter). Subcategories are also reported in the ABUPS table. If this field is omitted or blank, the fan will be assigned to the "General" end-use subcategory.

```
Fan: ZoneExhaust,
  A1 , \field Name
      \required-field
  A2 , \field Availability Schedule Name
      \type object-list
      \object-list ScheduleNames
  N1 , \field Fan Efficiency
      \type real
      \minimum> 0.0
      \maximum 1.0
  N2 , \field Pressure Rise
      \units Pa
      \ip-units inH2O
  N3 , \field Maximum Flow Rate
      \units m3/s
      \minimum 0.0
  A3 , \field Air Inlet Node Name
  A4 , \field Air Outlet Node Name
  A5 ; \field End-Use Subcategory
      \type alpha
      \retaincase
      \default General
```

Zone Exhaust Fan Outputs

```
HVAC,Average,Fan Electric Power[W]
HVAC,Average,Fan Delta Temp[C]
HVAC,Sum,Fan Electric Consumption[J]
```

Fan Electric Power [W]

This output field contains the average electricity consumption rate for the fan in Watts for the timestep being reported.

Fan Delta Temp [C]

This output field contains the average rise in air temperature across the fan (outlet air temperature minus inlet air temperature) in degrees Celsius for the timestep being reported.

Fan Electric Consumption [J]

This output field contains the electricity consumption of the fan in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key= Fans, Group Key= System (ref. Report Meter).

Examples of fans in an IDF are:

```
Fan:ConstantVolume,
  Supply Fan 1,  !- Name
  FanAndCoilAvailSched,  !- Availability Schedule Name
  0.7,  !- Fan Efficiency
  600.0,  !- Pressure Rise {Pa}
  1.3,  !- Maximum Flow Rate {m3/sec}
  0.9,  !- Motor Efficiency
  1.0,  !- Motor in Airstream Fraction
  Air Loop Inlet Node, Cooling Coil Air Inlet Node;  !- Air Inlet Node Name, Air Outlet Node Name
```



```

Fan:VariableVolume,
  Var Vol Supply Fan 1,  !- Name
  FanAndCoilAvailSched, !- Availability Schedule Name
  0.7,                   !- Fan Efficiency
  600.0,                 !- Pressure Rise {Pa}
  1.3,                   !- Maximum Flow Rate {m3/s}
  0.20,                  !- Minimum Flow Rate {m3/s}
  0.9,                   !- Motor Efficiency
  1.0,                   !- Motor in Airstream Fraction
  0.35071223,           !- Fan Coefficient 1
  0.30850535,           !- Fan Coefficient 2
  -0.54137364,          !- Fan Coefficient 3
  0.87198823,           !- Fan Coefficient 4
  0.000,                 !- Fan Coefficient 5
  Air Loop Inlet Node, Cooling Coil Air Inlet Node; !- Air Inlet Node Name, Air Outlet Node Name

```

```

Fan:ZoneExhaust,
  Zone 2 Exhaust Fan,           !- Name
  FanAndCoilAvailSched,        !- Availability Schedule Name
  0.6,                           !- Fan Efficiency
  125,                           !- Pressure Rise {Pa}
  0.1,                           !- Maximum Flow Rate {m3/s}
  Zone 2 Exhaust Node,          !- Air Inlet Node Name
  Zone 2 Exhaust Fan Outlet Node, !- Air Outlet Node Name
  Kitchen Exhaust;              !- End-Use Subcategory

```

```

Fan:OnOff,
  AHU 1 Supply Fan,             !- Name
  FanAvailSched,                !- Availability Schedule Name
  0.7,                           !- Fan Efficiency
  600.0,                         !- Pressure Rise {Pa}
  2.0,                           !- Maximum Flow Rate {m3/s}
  0.9,                           !- Motor Efficiency
  1.0,                           !- Motor in Airstream Fraction
  AHU 1 Air Loop Inlet,         !- Air Inlet Node Name
  AHU 1 Supply Fan Outlet;      !- Air Outlet Node Name

```

FanPerformance:NightVentilation

This object is used for specifying an alternate set of performance parameters for a fan. These alternate parameters are used when a system manager (such as *AvailabilityManager:NightVentilation*) sets a specified flow rate for a central forced air system. The fan model checks whether a fixed flow rate has been set; if it has the fan model will use these alternate performance parameters. Note that it is assumed that the fan will run at a fixed speed in the alternate mode. The inputs needed by this object are the fan name, fan total efficiency, pressure rise, flow rate, motor efficiency, and motor in airstream fraction.

Field: Fan Name

This is the name of a fan defined elsewhere in the input file. The night vent performance parameters will be applied to the named fan when a system manager has set the air system flow rate.

Field: Fan Efficiency

The power delivered to the fluid divided by the electrical input power. It is the product of the motor efficiency and the fan efficiency. The motor efficiency is the power delivered to the shaft divided by the electrical power input to the motor. The fan efficiency is power delivered to the fluid (air) divided by the shaft power. The power delivered to the fluid is the mass flow rate of the air multiplied by the pressure rise divided by the air density. Must be between 0 and 1.

Field: Pressure Rise

The pressure rise in Pascals at full flow and standard (sea level) conditions (20°C and 101325 Pa).

Field: Maximum Flow Rate

The design volumetric flow rate of the fan (m³/sec) at standard conditions. This input is not currently used by the night ventilation manager.

Field: Motor Efficiency

The shaft power divided by the electrical power consumed. Must be between 0 and 1.

Field: Motor in Airstream Fraction

The fraction of the motor heat that is added to the air stream. A value of 0 means that the motor is completely outside the air stream. A value of 1 means that all of the motor heat loss will go into the air stream and act to cause a temperature rise. Must be between 0 and 1.

The IDD for this object follows:

```
FanPerformance:NightVentilation,
  A1 , \field Fan Name
      \required-field
      \type object-list
      \object-list FansCVandVAV
  N1 , \field Fan Efficiency
      \type real
      \minimum > 0.0
      \maximum 1.0
  N2 , \field Pressure Rise
      \units Pa
      \ip-units inH2O
  N3 , \field Maximum Flow Rate
      \units m3/s
      \minimum 0.0
      \autosizable
  N4 , \field Motor Efficiency
      \type real
      \minimum >0
      \maximum 1.0
  N5 ; \field Motor in Airstream Fraction
      \type real
      \minimum 0.0
      \maximum 1.0
      \note 0.0 means fan motor outside of airstream
      \note 1.0 means fan motor inside of airstream
```

An example of use in an IDF:

```

Fan:VariableVolume,
  Supply Fan 1,           !- Name
  FanAvailSched,         !- Availability Schedule Name
  0.7,                   !- Fan Efficiency
  600.0,                 !- Pressure Rise {Pa}
  autosize,              !- Maximum Flow Rate {m3/s}
  autosize,              !- Minimum Flow Rate {m3/s}
  0.9,                   !- Motor Efficiency
  1.0,                   !- Motor In Airstream Fraction
  0.35071223,           !- Fan Coefficient 1
  0.30850535,           !- Fan Coefficient 2
  -0.54137364,          !- Fan Coefficient 3
  0.87198823,           !- Fan Coefficient 4
  0.000,                 !- Fan Coefficient 5
  Main Heating Coil 1 Outlet Node, !- Air Inlet Node Name
  VAV Sys 1 Outlet Node; !- Air Outlet Node Name

FanPerformance:NightVentilation,
  Supply Fan 1,           !- Fan Name
  0.7,                   !- Fan Efficiency
  67.0,                  !- Pressure Rise {Pa}
  autosize,              !- Maximum Flow Rate {m3/s}
  0.9,                   !- Motor Efficiency
  1.0;                   !- Motor in Airstream Fraction

```

Group – Humidifiers

Humidifier:Steam:Electric

The electric steam humidifier is a component that represents an electrically heated, self contained steam humidifier. The component uses electrical energy to convert ordinary tap water to steam which it then injects into the supply air stream by means of a blower fan. The actual unit might be an electrode-type humidifier or a resistance-type humidifier.

The humidifier model includes local control of the humidifier unit to meet a humidity ratio setpoint on its air outlet node. A set point manager is needed to put a setpoint on the exit node but no other local controllers are needed. The humidifier will add moisture to meet the humidity ratio setpoint.

Field: Name

A unique user assigned name for a particular humidifier unit. Any reference to this unit by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the unit can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Rated Capacity

The nominal full output water addition rate of the unit in m³/sec of water at 5.05 C.

Field: Rated Power

The nominal full output power consumption of the unit in watts, exclusive of the blower fan power consumption and any standby power.

Field: Rated Fan Power

The nominal full output power consumption of the blower fan in watts.

Field: Standby Power

The standby power consumption in watts. This amount of power will be consumed whenever the unit is available (as defined by the availability schedule).

Field: Air Inlet Node Name

The name of the HVAC system node from which the unit draws inlet air.

Field: Air Outlet Node Name

The name of the HVAC system node to which the unit sends its outlet air.

Field: Water Storage Tank Name

This field is optional. If left blank or omitted, then the humidifier obtains its water directly from the mains water. If the name of a Water Storage Tank is specified, then the humidifier will try to obtain its water from that tank. If the tank can't provide all the water then the rest will be drawn from the mains and the humidifier will still operate.

The full IDD specification follows:

```
Humidifier:SteamElectric,
A1, \field Name
    \required-field
A2, \field Availability Schedule Name
    \type object-list
    \object-list ScheduleNames
N1, \field Rated Capacity
    \note Capacity is m3/s of water at 5.05 C
    \type real
    \units m3/s
    \minimum 0.0
N2, \field Rated Power
    \type real
    \units W
    \minimum 0.0
    \ip-units W
N3, \field Rated Fan Power
    \type real
    \units W
    \minimum 0.0
    \ip-units W
N4, \field Standby Power
    \type real
    \units W
    \minimum 0.0
    \ip-units W
A3, \field Air Inlet Node Name
    \type alpha
A4, \field Air Outlet Node Name
    \type alpha
A5; \field Water Storage Tank Name
    \type object-list
    \object-list WaterStorageTankNames
```

An IDF example:

```
Humidifier:Steam:Electric,
Humidifier 1,           !- Name
FanAndCoilAvailSched,  !- Availability Schedule Name
0.00000379,           !- Rated Capacity {m3/s}
10200.,                !- Rated Power {W}
27.,                  !- Rated Fan Power {W}
2.,                   !- Standby Power {W}
Cooling Coil Air Outlet Node, !- Air Inlet Node Name
Air Loop Outlet Node;  !- Air Outlet Node Name
```

Humidifier:Steam:Electric Outputs

```
HVAC,Average,Humidifier Water Consumption Rate[m3/s]
HVAC,Sum,Humidifier Water Consumption[m3]
HVAC,Average,Humidifier Electric Power[W]
HVAC,Sum,Humidifier Electric Consumption[J]
Zone,Meter,Humidifier:Water [m3]
Zone,Meter,Humidifier:Electricity [J]
HVAC,Average,Humidifier Water From Storage Tank Rate [m3/s]
HVAC,Sum,Humidifier Water From Storage Tank [m3]
HVAC,Average,Humidifier Water Starved By Storage Tank Rate [m3/s]
HVAC,Sum,Humidifier Water Starved By Storage Tank [m3]
Zone,Meter,Humidifier:MainsWater [m3]
HVAC,Sum,Humidifier Water Mains Draw [m3]
```

Humidifier Water Consumption Rate[m3/s]

This field reports the water consumption rate of the steam humidifier in cubic meters of water per second.

Humidifier Water Consumption[m3]

This output is the cubic meters of water consumed by the steam humidifier over the timestep being reported.

Humidifier Electric Power[W]

This output is the electricity consumption rate in Watts of the steam humidifier.

Humidifier Electric Consumption[J]

This is the electricity consumption in Joules of the steam humidifier over the timestep being reported.

Humidifier:Water [m3]

This meter output contains the sum of the water consumed (in cubic meters of water during the report timestep) by all the steam humidifiers at the HVAC level in the simulation.

Humidifier:Electricity [J]

This meter output contains the sum of the electricity consumed (in Joules during the report timestep) by all the steam humidifiers at the HVAC level in the simulation.

Humidifier Water From Storage Tank Rate [m3/s]

Humidifier Water From Storage Tank [m3]

These outputs contain the rate and volume of water obtained from water storage tank. These are only present if the humidifier is connected to a Water Storage Tank for its water supply.

Humidifier Water Starved By Storage Tank Rate [m3/s]

Humidifier Water Starved By Storage Tank [m3]

These outputs contain the rate and volume of water that could not be obtained from the water storage tank. The component will still operate as if it did get all the water with the balance obtained directly from the mains

Humidifier Water Mains Draw [m3]

This output contains the volume of water obtained from the mains.

Group – Desiccant Dehumidifiers**Dehumidifier:Desiccant:NoFans**

This object models a solid desiccant dehumidifier (excluding associated fans). The process air stream is the air which is dehumidified. The regen air stream is the air which is heated to regenerate the desiccant. This object determines the process air outlet conditions, the load on the regeneration heating coil, the electric power consumption for the wheel rotor motor, and the regeneration air fan mass flow rate. All other heat exchangers are modeled as separate objects connected to the inlet and outlet nodes of the dehumidifier. The solid desiccant dehumidifier is typically used in an AirLoopHVAC:OutdoorAirSystem object, but can also be specified in any AirLoopHVAC.

Field: Name

This alpha field contains the identifying name for the desiccant dehumidifier.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the desiccant unit can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Process Air Inlet Node Name

The name of the node entering the process side of the desiccant wheel.

Field: Process Air Outlet Node Name

The name of the node leaving the process side of the desiccant wheel.

Field: Regeneration Air inlet Node Name

The name of the node entering the regeneration side of the desiccant wheel after the regeneration coil.

Field: Regeneration Fan Inlet Node Name

Node name for air entering the regeneration fan, mass flow is set by this desiccant dehumidifier model.

Field: Control Type

Type of setpoint control. Options are LeavingMaximumHumidityRatioSetpoint and SystemNodeMaximumHumidityRatioSetpoint.

LeavingMaximumHumidityRatioSetpoint means that the unit is controlled to deliver air at the *Leaving Maximum Humidity Ratio Setpoint*, using bypass dampers to prevent overdrying.

SystemNodeMaximumHumidityRatioSetpoint means that the unit is controlled to deliver air at the maximum humidity ratio setpoint (System Node Humidity Ratio Max) on the *Process Air outlet node*, using bypass dampers to prevent overdrying. This setpoint must be established using a set point manager which sets the MaximumHumidityRatio control variable, such as SetpointManager:SingleZone:Humidity:Maximum which also requires the use of a ZoneControl:Humidistat object. If the dehumidifier is located in the outdoor air stream, it may also be necessary to use SetpointManager:OutdoorAirPretreat.

Field: Leaving Maximum Humidity Ratio Setpoint

Fixed setpoint for maximum process air leaving humidity ratio. Applicable only when Control Type = LeavingMaximumHumidityRatioSetpoint.

Field: Nominal Process Air Flow Rate

Process air flow rate in m³/s at nominal conditions.

Field: Nominal Process Air Velocity

Process air velocity in m/s at nominal flow.

Field: Rotor Power

Power input to wheel rotor motor in W.

Field: Regeneration Coil Object Type

Type of heating coil object for regeneration air. Must be one of Coil:Heating:Electric or Coil:Heating:Gas.

Field: Regeneration Coil Name

Name of heating coil object for regeneration air.

Field: Regeneration Fan Object Type

Type of fan object for regeneration air. For UserCurves performance (see below) Fan:VariableVolume and Fan:ConstantVolume are valid. For Default performance (see below) only Fan:VariableVolume is valid.

Field: Regeneration Fan Name

Name of fan object for regeneration air.

Field: Performance Model Type

Specifies whether the Default performance model or UserCurves curves should be used to model the performance. The default model is a generic solid desiccant wheel using performance curves of the form:

$$\begin{aligned} \text{curve} = & C1 + C2*\text{edb} + C3*\text{edb}^2 + C4*\text{ew} + C5*\text{ew}^2 + \\ & C6*\text{vel} + C7*\text{vel}^2 + C8*\text{edb}*\text{ew} + C9*\text{edb}^2*\text{ew}^2 + \\ & C10*\text{edb}*\text{vel} + C11*\text{edb}^2*\text{vel}^2 + C12*\text{ew}*\text{vel} + C13*\text{ew}^2*\text{vel}^2 + \\ & C14*\text{ALOG}(\text{edb}) + C15*\text{ALOG}(\text{ew}) + C16*\text{ALOG}(\text{vel}) \end{aligned}$$

edb = process entering drybulb temperature [C]

ew = process entering humidity ratio [kg/kg]

vel = process air velocity [m/s]

The Default curves are valid for the following range of process inlet conditions: dry-bulb temperatures of 1.67C (35F) to 48.9C (120F) and humidity ratios of 0.002857 kg/kg (20 gr/lb) to 0.02857 kg/kg (200 gr/lb). If the process inlet conditions are outside this range, the dehumidifier will not operate.

If UserCurves are specified, then performance is calculated as follows:

Leaving Dry-bulb = (Leaving Dry-Bulb Function of Entering Dry-Bulb and Humidity Ratio Curve) * (Leaving Dry-Bulb Function of Air Velocity Curve)

Leaving Humidity Ratio = (Leaving Humidity Ratio Function of Entering Dry-Bulb and Humidity Ratio Curve) * (Leaving Humidity Ratio Function of Air Velocity Curve)

Regeneration Energy = (Regeneration Energy Function of Entering Dry-Bulb and Humidity Ratio Curve) * (Regeneration Energy Function of Air Velocity Curve)

Regeneration Velocity = (Regeneration Velocity Function of Entering Dry-Bulb and Humidity Ratio Curve) * (Regeneration Velocity Function of Air Velocity Curve)

The UserCurves are limited to the following range of process inlet conditions (essentially not limited): dry-bulb temperatures of -73.3C (-100F) to 65.6C (150F) and humidity ratios of 0.0 kg/kg (0 gr/lb) to 0.21273 kg/kg (1490 gr/lb). If the process inlet conditions are outside this range, the dehumidifier will not operate.

When the Default performance model is selected, the remaining fields are ignored.

Field: Leaving Dry-Bulb Function of Entering Dry-Bulb and Humidity Ratio Curve Name

This field is applicable only when UserCurves performance model type is specified.

Leaving dry-bulb of process air as a function of entering dry-bulb and entering humidity ratio, biquadratic curve.

$$\text{curve} = C1 + C2*\text{edb} + C3*\text{edb}^2 + C4*\text{ew} + C5*\text{ew}^2 + C6*\text{edb}*\text{ew}$$

edb = process entering drybulb temperature [C]

ew = process entering humidity ratio [kg/kg]

Field: Leaving Dry-Bulb Function of Air Velocity Curve Name

This field is applicable only when UserCurves performance model type is specified.

Leaving dry-bulb of process air as a function of air velocity, quadratic curve.

$$\text{curve} = C1 + C2*v + C3*v^2$$

v = process air velocity [m/s]

Field: Leaving Humidity Ratio Function of Entering Dry-Bulb and Humidity Ratio Curve Name

This field is applicable only when UserCurves performance model type is specified.

Leaving humidity ratio of process air as a function of entering dry-bulb and entering humidity ratio, biquadratic curve

$$\text{curve} = C1 + C2*\text{edb} + C3*\text{edb}^2 + C4*\text{ew} + C5*\text{ew}^2 + C6*\text{edb}*\text{ew}$$

edb = process entering drybulb temperature [C]

ew = process entering humidity ratio [kg/kg]

Field: Leaving Humidity Ratio Function of Air Velocity Curve Name

This field is applicable only when UserCurves performance model type is specified.

Leaving humidity ratio of process air as a function of process air velocity, quadratic curve.

$$\text{curve} = C1 + C2*v + C3*v^2$$

v = process air velocity [m/s]

Field: Regeneration Energy Function of Entering Dry-Bulb and Humidity Ratio Curve Name

This field is applicable only when UserCurves performance model type is specified.

Regeneration energy [J/kg of water removed] as a function of entering dry-bulb and entering humidity ratio, biquadratic curve

$$\text{curve} = C1 + C2*\text{edb} + C3*\text{edb}^2 + C4*\text{ew} + C5*\text{ew}^2 + C6*\text{edb}*\text{ew}$$

edb = process entering drybulb temperature [C]

ew = process entering humidity ratio [kg/kg]

Field: Regeneration Energy Function of Air Velocity Curve Name

This field is applicable only when UserCurves performance model type is specified.

Regeneration energy [J/kg of water removed] as a function of process air velocity, quadratic curve.

$$\text{curve} = C1 + C2*v + C3*v^2$$

v = process air velocity [m/s]

Field: Regeneration Velocity Function of Entering Dry-Bulb and Humidity Ratio Curve Name

This field is applicable only when UserCurves performance model type is specified.

Regeneration velocity [m/s] as a function of entering dry-bulb and entering humidity ratio, biquadratic curve

$$\text{curve} = C1 + C2*\text{edb} + C3*\text{edb}^2 + C4*\text{ew} + C5*\text{ew}^2 + C6*\text{edb}*\text{ew}$$

edb = process entering drybulb temperature [C]

ew = process entering humidity ratio [kg/kg]

Field: Regeneration Velocity Function of Air Velocity Curve Name

This field is applicable only when UserCurves performance model type is specified.

Regeneration velocity [m/s] as a function of process air velocity, quadratic curve.

$$\text{curve} = C1 + C2*v + C3*v^2$$

v = process air velocity [m/s]

Field: Nominal Regeneration Temperature

This field is applicable only when UserCurves performance model type is specified.

Nominal regeneration temperature upon which the regeneration energy modifier curve is based. This input is ignored when Performance Model Type = Default, which assume a regeneration temperature of 121C.

Dehumidifier:Desiccant:NoFans,

```

\memo This object models a solid desiccant dehumidifier. The process
\memo air stream is the air which is dehumidified. The regeneration air
\memo stream is the air which is heated to regenerate the desiccant.
\memo This object determines the process air outlet conditions, the
\memo load on the regeneration heating coil, the electric power consumption
\memo for the wheel rotor motor, and the regeneration air fan mass flow rate.
\memo All other heat exchangers are modeled as separate objects connected
\memo to the inlet and outlet nodes of the dehumidifier. The solid
\memo desiccant dehumidifier is typically used in an AirLoopHVAC:OutdoorAirSystem,
\memo but can also be specified in any AirLoopHVAC.
A1, \field Name
\required-field
A2, \field Availability Schedule Name
\type object-list
\object-list ScheduleNames
A3, \field Process Air Inlet Node Name
\note This is the node entering the process side of the desiccant wheel.
\type alpha
A4, \field Process Air Outlet Node Name
\note This is the node leaving the process side of the desiccant wheel.
\type alpha
A5, \field Regeneration Air Inlet Node Name
\note This is the node entering the regeneration side of the desiccant wheel
\note after the regeneration coil.
\type alpha
A6, \field Regeneration Fan Inlet Node Name
\note Node for air entering the regeneration fan, mass flow is set
\note by the desiccant dehumidifier module.
\type alpha
A7, \field Control Type
\note Type of setpoint control:
\note LeavingMaximumHumidityRatioSetpoint means that the unit is controlled
\note to deliver air at the Leaving Max Humidity Ratio Setpoint (see below),
\note SystemNodeMaximumHumidityRatioSetpoint means that the leaving humidity
\note ratio setpoint is the System Node Humidity Ratio Max property
\note of the Process Air Outlet Node. A Setpoint
\note object must be used to control this setpoint.
\note Both control types use bypass dampers to prevent overdrying.
\type choice
\key LeavingMaximumHumidityRatioSetpoint
\key SystemNodeMaximumHumidityRatioSetpoint
N1, \field Leaving Maximum Humidity Ratio Setpoint
\note Fixed setpoint for maximum process air leaving humidity ratio
\note Applicable only when Control Type = LeavingMaximumHumidityRatioSetpoint.
\type real
\units kg-H2O/kg-air
N2, \field Nominal Process Air Flow Rate
\note Process air flow rate at nominal conditions
\type real
\units m3/s
\minimum> 0.0
N3, \field Nominal Process Air Velocity
\note Process air velocity at nominal flow
\note When using Performance Model Type of Default, must be 2.032 to 4.064 m/s (400 to 800 fpm)
\type real
\units m/s
\minimum> 0.0
\maximum 6
N4, \field Rotor Power
\note Power input to wheel rotor motor
\type real
\units W
\minimum 0.0
\ip-units W

```

```

A8, \field Regeneration Coil Object Type
    \note heating coil type
    \type choice
    \key Coil:Heating:Electric
    \key Coil:Heating:Gas
A9, \field Regeneration Coil Name
    \note Name of heating coil object for regeneration air
    \type object-list
    \object-list HeatingCoilsGasElec
A10, \field Regeneration Fan Object Type
    \note Type of fan object for regeneration air. When using the Default
    \note Performance Model Type (see below), only Fan:VariableVolume is valid.
    \type choice
    \key Fan:VariableVolume
    \key Fan:ConstantVolume
A11, \field Regeneration Fan Name
    \note Name of fan object for regeneration air
    \type object-list
    \object-list FansCVandVAV
A12, \field Performance Model Type
    \note Specifies whether the default performance model or user-specified
    \note curves should be used to model the performance. The default model
    \note is a generic solid desiccant wheel using performance curves of the form:
    \note curve = C1 + C2*edb + C3*edb**2 + C4*ew + C5*ew**2 + C6*vel + C7*vel**2
    \note + C8*edb*ew + C9*edb**2*ew**2 + C10*edb*vel + C11*edb**2*vel**2
    \note + C12*ew*vel + C13*ew**2*vel**2 + C14*ALOG(edb) + C15*ALOG(ew) + C16*ALOG(vel)
    \note edb = process entering dry-bulb temperature [C]
    \note ew = process entering humidity ratio [kg/kg]
    \note vel = process air velocity [m/s]
    \note If UserCurves are specified, then performance is calculated as follows:
    \note Leaving Dry-Bulb = (Leaving Dry-Bulb fTW Curve) * (Leaving Dry-Bulb fV Curve)
    \note Leaving Humidity Ratio = (Leaving Humidity Ratio fTW Curve) * (Leaving Humidity Ratio fV
Curve)
    \note Regen Energy = (Regen Energy fTW Curve) * (Regen Energy fV Curve)
    \note Regen Velocity = (Regen Velocity fTW Curve) * (Regen Velocity fV Curve)
    \type choice
    \key Default
    \key UserCurves
A13, \field Leaving Dry-Bulb Function of Entering Dry-Bulb and Humidity Ratio Curve Name
    \note Leaving dry-bulb of process air as a function of entering dry-bulb
    \note and entering humidity ratio, biquadratic curve
    \type object-list
    \object-list BiquadraticCurves
    \note curve = C1 + C2*edb + C3*edb**2 + C4*ew + C5*ew**2 + C6*edb*ew
    \note edb = process entering dry-bulb temperature [C]
    \note ew = process entering humidity ratio [kg/kg]
A14, \field Leaving Dry-Bulb Function of Air Velocity Curve Name
    \note Leaving dry-bulb of process air as a function of air velocity,
    \note quadratic curve.
    \type object-list
    \object-list QuadraticCurves
    \note curve = C1 + C2*v + C3*v**2
    \note v = process air velocity [m/s]
A15, \field Leaving Humidity Ratio Function of Entering Dry-Bulb and Humidity Ratio Curve Name
    \note Leaving humidity ratio of process air as a function of entering dry-bulb
    \note and entering humidity ratio, biquadratic curve
    \type object-list
    \object-list BiquadraticCurves
    \note curve = C1 + C2*edb + C3*edb**2 + C4*ew + C5*ew**2 + C6*edb*ew
    \note edb = process entering dry-bulb temperature [C]
    \note ew = process entering humidity ratio [kg/kg]
A16, \field Leaving Humidity Ratio Function of Air Velocity Curve Name
    \note Leaving humidity ratio of process air as a function of
    \note process air velocity, quadratic curve.
    \type object-list
    \object-list QuadraticCurves
    \note curve = C1 + C2*v + C3*v**2
    \note v = process air velocity [m/s]

```

```

A17, \field Regeneration Energy Function of Entering Dry-Bulb and Humidity Ratio Curve Name
\note Regeneration energy [J/kg of water removed] as a function of
\note entering dry-bulb and entering humidity ratio, biquadratic curve
\type object-list
\object-list BiquadraticCurves
\note curve = C1 + C2*edb + C3*edb**2 + C4*ew + C5*ew**2 + C6*edb*ew
\note edb = process entering dry-bulb temperature [C]
\note ew = process entering humidity ratio [kg/kg]
A18, \field Regeneration Energy Function of Air Velocity Curve Name
\note Regeneration energy [J/kg of water removed] as a function of
\note process air velocity, quadratic curve.
\type object-list
\object-list QuadraticCurves
\note curve = C1 + C2*v + C3*v**2
\note v = process air velocity [m/s]
A19, \field Regeneration Velocity Function of Entering Dry-Bulb and Humidity Ratio Curve Name
\note Regeneration velocity [m/s] as a function of
\note entering dry-bulb and entering humidity ratio, biquadratic curve
\type object-list
\object-list BiquadraticCurves
\note curve = C1 + C2*edb + C3*edb**2 + C4*ew + C5*ew**2 + C6*edb*ew
\note edb = process entering dry-bulb temperature [C]
\note ew = process entering humidity ratio [kg/kg]
A20, \field Regeneration Velocity Function of Air Velocity Curve Name
\note Regeneration velocity [m/s] as a function of
\note process air velocity, quadratic curve.
\type object-list
\object-list QuadraticCurves
\note curve = C1 + C2*v + C3*v**2
\note v = process air velocity [m/s]
N5; \field Nominal Regeneration Temperature
\note Nominal regen temperature upon which the regen energy modifier
\note curve is based. Not used if Default if chosen for the field Performance Mode Type.
\note 121 C is a commonly used value.
\type real
\units C
\minimum 40
\maximum 250

```

An example of this statement in an IDF is:

```

Dehumidifier:Desiccant:NoFans,
  Desiccant 1,           !- Name
  FanAndCoilAvailSched, !- Availability Schedule Name
  Outside Air Inlet Node, !- Process Air Inlet Node Name
  Desiccant Process Outlet Node, !- Process Air Outlet Node Name
  Regen Coil Out Node,   !- Regeneration Air Inlet Node Name
  Outside Air Inlet Node 2, !- Regeneration Fan Inlet Node Name
  SystemNodeMaximumHumidityRatioSetpoint, !- Control Type
  0.007,                 !- Leaving Maximum Humidity Ratio Setpoint {kg-H2O/kg-air}
  1,                     !- Nominal Process Air Flow Rate {m3/s}
  2.5,                   !- Nominal Process Air Velocity {m/s}
  10,                    !- Rotor Power {W}
  Coil:Heating:Gas,      !- Regeneration Coil Object Type
  Desiccant Regen Coil,  !- Regeneration Coil Name
  Fan:VariableVolume,    !- Regeneration Fan Object Type
  Desiccant Regen Fan,   !- Regeneration Fan Name
  UserCurves,           !- Performance Model Type
  Desiccant DryBulb fTW Curve, !- Leaving Dry-Bulb Function of Entering Dry-Bulb and Humidity Ratio
  Curve Name
  Desiccant DryBulb fV Curve, !- Leaving Dry-Bulb Function of Air Velocity Curve Name
  Desiccant HumRat fTW Curve, !- Leaving Humidity Ratio Function of Entering Dry-Bulb and Humidity
  Ratio Curve Name
  Desiccant HumRat fV Curve, !- Leaving Humidity Ratio Function of Air Velocity Curve Name
  Desiccant RegenEnergy fTW Curve, !- Regeneration Energy Function of Entering Dry-Bulb and Humidity
  Ratio Curve Name
  Desiccant RegenEnergy fV Curve, !- Regeneration Energy Function of Air Velocity Curve Name
  Desiccant RegenVel fTW Curve, !- Regeneration Velocity Function of Entering Dry-Bulb and Humidity
  Ratio Curve Name
  Desiccant RegenVel fV Curve, !- Regeneration Velocity Function of Air Velocity Curve Name
  121;                    !- Nominal Regeneration Temperature {C}

```

Dehumidifier:Desiccant:NoFans Outputs

```

HVAC,Sum,Desiccant Dehumidifier Water Removed [kg]
HVAC,Average,Desiccant Dehumidifier Water Removal Rate[kg/s]
HVAC,Average,Desiccant Dehumidifier Part Load Ratio[]
HVAC,Average,Desiccant Dehumidifier Electric Power [W]
HVAC,Sum,Desiccant Dehumidifier Electric Consumption [J]
HVAC,Average,Desiccant Dehumidifier Specific Regen Energy [J/kg H2O]
HVAC,Average,Desiccant Dehumidifier Regen Energy Rate[W]
HVAC,Sum,Desiccant Dehumidifier Regen Energy[J]
HVAC,Average,Desiccant Dehumidifier Regen Air Velocity[m/s]
HVAC,Average,Desiccant Dehumidifier Regen Air Mass Flow Rate[kg/s]
HVAC,Average,Desiccant Dehumidifier Process Air Mass Flow Rate[kg/s]

```

Desiccant Dehumidifier Water Removed [kg]

Mass of water removed from process air stream.

Desiccant Dehumidifier Water Removal Rate[kg/s]

Rate of water removal from process air stream.

Desiccant Dehumidifier Part Load Ratio[]

Dehumidifier water removal rate divided by full-load water removal rate.

Desiccant Dehumidifier Electric Power [W]

Dehumidifier rotor electric power.

Desiccant Dehumidifier Electric Consumption [W]

Dehumidifier rotor electric energy.

Desiccant Dehumidifier Specific Regen Energy [J/kg H2O]

Regeneration heating coil energy divided by water removed.

Desiccant Dehumidifier Regen Energy Rate[W]

Regeneration heating coil output rate.

Desiccant Dehumidifier Regen Energy [J]

Regeneration heating coil output energy.

Desiccant Dehumidifier Regen Air Velocity[m/s]

Regeneration air velocity.

Desiccant Dehumidifier Regen Air Mass Flow Rate[kg/s]

Regeneration air mass flow rate.

Desiccant Dehumidifier Process Air Mass Flow Rate[kg/s]

Process air mass flow rate.

Dehumidifier:Desiccant:System

The Dehumidifier:Desiccant:System object models the dehumidification of an air stream, normally called the process air stream. A second heated air stream, called the regeneration air stream, is used to remove the collected moisture from the desiccant heat exchanger and this moisture-laden air is then usually exhausted from the building. This Dehumidifier:Desiccant:System object is similar to the Dehumidifier:Desiccant:NoFans object but has some additional modeling capabilities.

The Dehumidifier:Desiccant:System object in EnergyPlus is a compound object that can be placed anywhere in an air loop (AirLoopHVAC). Common locations for this object are in an AirLoopHVAC:OutdoorAirSystem or in the main air loop (AirLoopHVAC) downstream of a cooling coil (postcooling desiccant dehumidifier). This compound object coordinates the operation of several 'children' objects: a desiccant heat exchanger, a regeneration air fan, and an optional regeneration air heater. If this dehumidifier is placed in the main air loop immediately downstream of a direct expansion (DX) cooling coil, then the dehumidifier's operation can be coordinated with the operation of the companion DX coil and it is also possible to specify that the DX system's condenser waste heat can be used to help regenerate the desiccant heat exchanger. For the case of condenser waste heat regeneration, an optional exhaust fan can also be modeled by this desiccant dehumidifier compound object to help maintain a set point temperature for air entering the regeneration side of the desiccant heat exchanger.

It is important to note that the optional exhaust air fan is modeled internal to the Dehumidifier:Desiccant:System and a separate fan object should not be added to the input data file (idf) for this fan. On the other hand, a separate fan object is required in the input data file for the regeneration air fan.

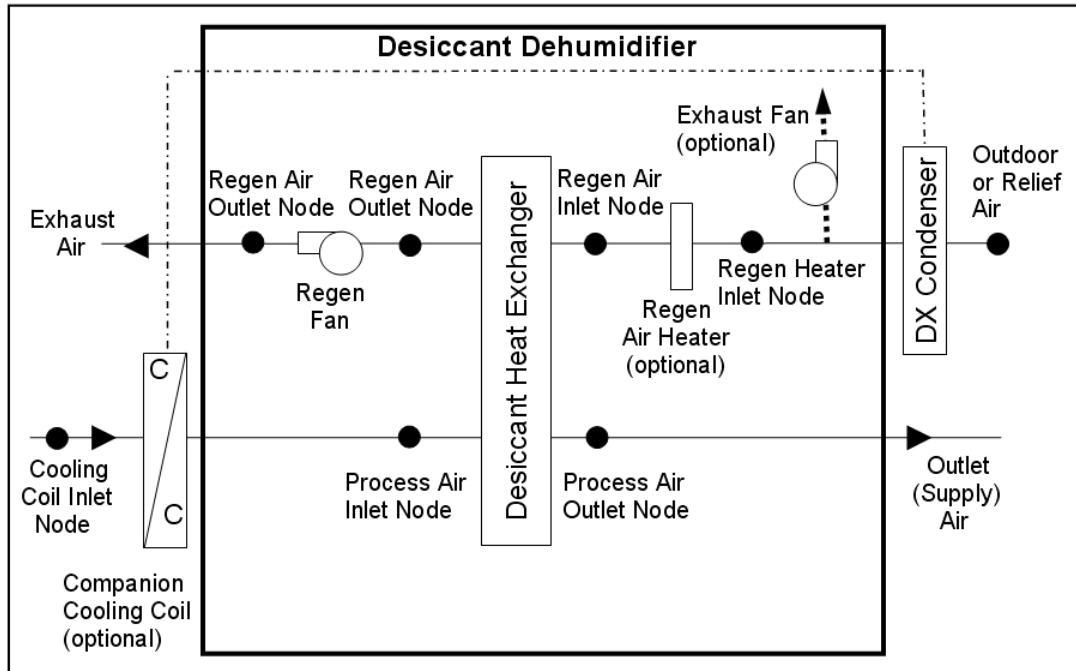


Figure 114. Schematic of Dehumidifier:Desiccant:System with Draw Through Regeneration Fan Placement

A schematic of the compound object Dehumidifier:Desiccant:System is shown in Figure 114 with the draw through regeneration air fan placement. Figure 115 shows the Dehumidifier:Desiccant:System object configured with the blow through regeneration air fan placement.

NOTE: As with any air loop compound object, the Dehumidifier:Desiccant:System object itself is specified on the AirLoopHVAC Branch or in the AirLoopHVAC:OutdoorAirSystem:EquipmentList for an AirLoopHVAC:OutdoorAirSystem. The children objects (e.g., desiccant heat exchanger, regeneration air fan, and optional regeneration air heater) must be specified separately in the input data file and their inlet/outlet connections must be as shown in Figure 114 or Figure 115.

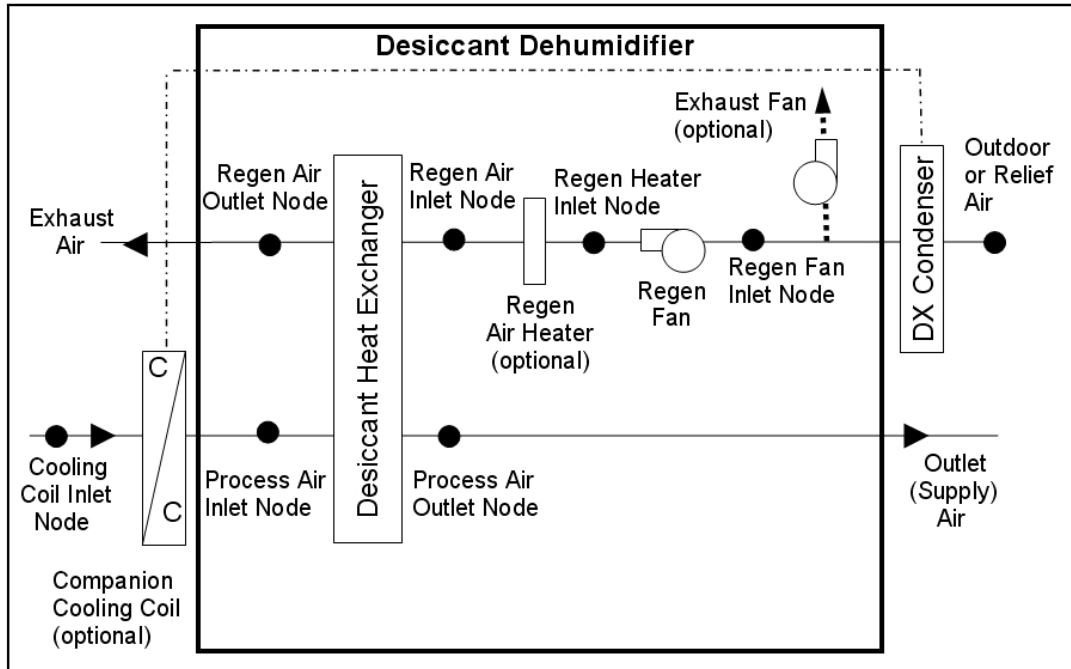


Figure 115. Schematic of Dehumidifier:Desiccant:System with Blow Through Regeneration Fan Placement

Currently the only heat exchanger choice for this object is HeatExchanger:Desiccant:BalancedFlow. So to model a Dehumidifier:Desiccant:System located in an air loop, the input data file should include the following objects:

- Dehumidifier:Desiccant:System (in an air loop (AirLoopHVAC) Branch or AirLoopHVAC:OutdoorAirSystem:EquipmentList for an AirLoopHVAC:OutdoorAirSystem)
- HeatExchanger:Desiccant:BalancedFlow (desiccant heat exchanger child object)
- HeatExchanger:Desiccant:BalancedFlow:PerformanceDataType1 (desiccant heat exchanger data object)
- ZoneControl:Humidistat, and SetpointManager:SingleZone:Humidity:Maximum (when in an air loop (AirLoopHVAC) Branch) or SetpointManager:OutdoorAirPretreat (when in an AirLoopHVAC:OutdoorAirSystem) to place a maximum humidity ratio set point on the sensor node, typically the process air outlet node
- Fan:OnOff or Fan:ConstantVolume (regeneration air fan)
- Coil:Heating:Electric or Coil:Heating:Gas (optional regeneration air heater)
- Coil:Cooling:DX:SingleSpeed or Coil:Cooling:DX:TwoStageWithHumidityControlMode (optional companion cooling coil)

If the user wants to model the Dehumidifier:Desiccant:System in an AirLoopHVAC:OutdoorAirSystem, then the process air path of the dehumidifier should be located in the outdoor air stream and the regeneration air path may be placed in the relief air stream or modeled by the desiccant dehumidifier itself where the first node for the regeneration inlet air stream must be an outdoor air node. If the user wants to model the Dehumidifier:Desiccant:System in an air loop (AirLoopHVAC) Branch, then the process air path of the dehumidifier should be located in the air loop Branch object. For this case, the regeneration air stream is modeled by the desiccant dehumidifier object itself (i.e., not part of an air loop Branch statement) and the first node for the regeneration inlet air stream must be an outdoor air node (ref. Figure 114 or Figure 115).

A description of each input field for this object is provided below:

Field: Name

A unique, user-assigned name for a particular Dehumidifier:Desiccant:System. Any reference to this dehumidifier by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the dehumidifier can operate during a given time period. A schedule value greater than 0 (usually 1 is used) indicates that the dehumidifier can operate. A value less than or equal to 0 (usually 0 is used) denotes that the dehumidifier will not operate (i.e., no heat exchange will take place and the regeneration air fan does not operate). For the case where companion cooling coil regeneration air heating has been specified, the desiccant dehumidifier's exhaust fan serves as the condenser air fan for the cooling coil system so this availability schedule will not disable exhaust fan operation.

Field: Desiccant Heat Exchanger Object Type

This alpha field contains the type of desiccant heat exchanger used with this dehumidifier. Currently, the only valid choice is HeatExchanger:Desiccant:BalancedFlow.

Field: Desiccant Heat Exchanger Name

This alpha field contains the name of the desiccant heat exchanger used with this dehumidifier.

Field: Sensor Node Name

This alpha field specifies the name of the air loop node used to control desiccant heat exchanger operation. A set point manager must be used to place a maximum humidity ratio set point on this node (e.g., SetpointManager:SingleZone:Humidity:Maximum or SetpointManager:OutdoorAirPretreat).

Field: Regeneration Air Fan Object Type

This alpha field contains the type of regeneration air fan used. Available fan types are Fan:OnOff and Fan:ConstantVolume.

Field: Regeneration Air Fan Name

This alpha field contains the name of the regeneration air fan used with this dehumidifier.

Field: Regeneration Air Fan Placement

This alpha field specifies the fan configuration used in the desiccant dehumidifier. Valid choices are 'BlowThrough' and 'DrawThrough', with a default of 'DrawThrough' if this field is left blank.

Field: Regeneration Air Heater Object Type

This alpha field contains the type of heating coil used to heat the regeneration air stream. Valid choices are Coil:Heating:Electric and Coil:Heating:Gas. This field may be left blank when no regeneration air heater is required.

Field: Regeneration Air Heater Name

This alpha field contains the name of the heating coil used to heat the regeneration air stream. This field may be left blank when no regeneration air heater is required.

Field: Regeneration Inlet Air Setpoint Temperature

This optional numeric field specifies the regeneration air inlet temperature setpoint in Celsius. The regeneration air heater and/or the companion coil regeneration air heating will be controlled to this temperature to the extent possible. This field may be left blank when no

regeneration air heater is required or when control of the exhaust fan used with the companion coil regeneration air heating option is not required.

Field: Companion Cooling Coil Object Type

This optional alpha field contains the type of companion cooling coil used with this desiccant dehumidifier. The only valid choices are Coil:Cooling:DX:SingleSpeed and Coil:Cooling:DX:TwoStageWithHumidityControlMode.

Field: Companion Cooling Coil Name

This optional alpha field contains the name of the companion cooling coil used with this desiccant dehumidifier. This field may be left blank when no companion cooling coil is being modeled.

Field: Companion Cooling Coil Upstream of Dehumidifier Process Inlet

This choice field specifies if the companion cooling coil is located immediately upstream of the dehumidifier's process inlet. Valid choices are Yes and No. If Yes is selected, then the outlet air node for the companion cooling coil must be the same as the dehumidifier's process air inlet node (i.e., the process air inlet node name for the desiccant heat exchanger specified for this desiccant dehumidifier). For this case, the companion cooling coil and the desiccant dehumidifier are assumed to operate "in tandem"; that is, if the simulation determines that the companion cooling coil is unable to meet the humidity set point specified on the sensor node based on its own operation, then the desiccant dehumidifier operates at the same time and for the same duration as the cooling coil to provide improved dehumidification. If No is selected, then the dehumidifier will control to the humidity set point specified on the sensor node to the extent possible. The default value is No if this field is left blank.

Field: Companion Coil Regeneration Air Heating

This choice field determines if the companion cooling coil's condenser waste heat is used to heat the regeneration inlet air. Valid choices are Yes and No. The default value is No if this field is left blank.

Field: Exhaust Fan Maximum Flow Rate

This optional numeric field contains the maximum fan volumetric flow rate for the exhaust fan in cubic meters per second. As noted previously, this exhaust fan is modeled internally by the Dehumidifier:Desiccant:System object and a separate fan object should NOT be specified in the input data file for this fan. This field is used only when a companion cooling coil is specified and the 'Companion Coil Regeneration Air Heating' field is set to 'Yes'. This field must be used in conjunction with the 'Exhaust Fan Maximum Power' and the 'Exhaust Fan Power Curve Name' input fields. The model assumes that the exhaust fan will operate as needed to maintain the 'Regeneration Inlet Air Setpoint Temperature', up to the maximum flow rate specified in this input field. If the desiccant dehumidifier is OFF for a simulation timestep but its companion cooling coil is operating and is specified to provide regeneration air heating, then the exhaust fan operates at this maximum air flow rate (i.e., this fan serves as the condenser fan for the companion cooling coil system when regeneration air heating is specified, so the inputs to the companion cooling coil object should not include the condenser fan energy since the condenser fan energy is modeled by the Dehumidifier:Desiccant:System object).

Field: Exhaust Fan Maximum Power

This optional numeric field contains the maximum power for the exhaust fan in Watts (i.e., at the Exhaust Fan Maximum Flow Rate). This field is used only when a companion cooling coil is used and the 'Companion Coil Regeneration Air Heating' field is set to 'Yes'. This field must be used in conjunction with the 'Exhaust Fan Maximum Flow Rate' and the 'Exhaust Fan Power Curve Name' input fields.

Field: Exhaust Fan Power Curve Name

This optional alpha field contains the name of the exhaust fan power modifier curve. This field is used only when a companion cooling coil is used and the 'Companion Coil Regeneration Air Heating' field is set to 'Yes'. This field must be used in conjunction with the 'Exhaust Fan Maximum Flow Rate' and the 'Exhaust Fan Maximum Power' input fields. If this field is blank, the exhaust fan operates (when required) at the maximum power specified in the field above. The curve object type for this Exhaust Fan Power Curve Name must be Curve:Cubic or Curve:Quadratic. The curve object (Curve:Cubic or Curve:Quadratic) defines the change in exhaust fan power as a function of the ratio of the actual exhaust air flow rate divided by the maximum flow rate.

Dehumidifier:Desiccant:System,

```

\memo This compound object models a desiccant heat exchanger, an optional
\memo heater, and associated fans. The process air stream is the air which
\memo is dehumidified. The regeneration air stream is the air which is
\memo heated to regenerate the desiccant. The desiccant heat exchanger
\memo transfers both sensible and latent energy between the process and
\memo regeneration air streams. The desiccant dehumidifier is typically used
\memo in an AirLoopHVAC:OutdoorAirSystem, but can also be specified in any AirLoopHVAC.
\min-fields 8
A1, \field Name
    \required-field
    \type alpha
A2, \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
    \type alpha
A3, \field Desiccant Heat Exchanger Object Type
    \required-field
    \type choice
    \key HeatExchanger:Desiccant:BalancedFlow
A4, \field Desiccant Heat Exchanger Name
    \required-field
    \type object-list
    \object-list HXDesiccantBalanced
A5, \field Sensor Node Name
    \required-field
    \type alpha
A6, \field Regeneration Air Fan Object Type
    \required-field
    \type choice
    \key Fan:OnOff
    \key Fan:ConstantVolume
A7, \field Regeneration Air Fan Name
    \required-field
    \type alpha
A8, \field Regeneration Air Fan Placement
    \type choice
    \key BlowThrough
    \key DrawThrough
    \default DrawThrough
A9, \field Regeneration Air Heater Object Type
    \type choice
    \key Coil:Heating:Electric
    \key Coil:Heating:Gas
A10, \field Regeneration Air Heater Name
    \type alpha
N1, \field Regeneration Inlet Air Setpoint Temperature
    \type real
    \units C
A11, \field Companion Cooling Coil Object Type
    \type choice
    \key Coil:Cooling:DX:SingleSpeed
    \key Coil:Cooling:DX:TwoStageWithHumidityControlMode
A12, \field Companion Cooling Coil Name
    \type alpha

```

```

A13, \field Companion Cooling Coil Upstream of Dehumidifier Process Inlet
      \type choice
      \key Yes
      \key No
      \default No
      \note Select Yes if the companion cooling coil is located directly upstream
      \note of the desiccant heat exchanger's process air inlet node.
A14, \field Companion Coil Regeneration Air Heating
      \type choice
      \key Yes
      \key No
      \default No
N2,  \field Exhaust Fan Maximum Flow Rate
      \type real
      \units m3/s
N3,  \field Exhaust Fan Maximum Power
      \type real
      \units W
A15; \field Exhaust Fan Power Curve Name
      \type alpha
      \note Curve object type must be Curve:Quadratic or Curve:Cubic

```

Following is an example input for this object:

```

Dehumidifier:Desiccant:System,
  Desiccant 1,                !- Name
  FanAvailSched,              !- Availability Schedule Name
  HeatExchanger:Desiccant:BalancedFlow, !- Desiccant Heat Exchanger Object Type
  Desiccant Heat Exchanger 1, !- Desiccant Heat Exchanger Name
  HX Process Outlet Node,    !- Sensor Node Name
  Fan:ConstantVolume,        !- Regeneration Air Fan Object Type
  Desiccant Regen Fan,       !- Regeneration Air Fan Name
  DrawThrough,               !- Regeneration Air Fan Placement
  Coil:Heating:Gas,          !- Regeneration Air Heater Object Type
  Desiccant Regen Coil,      !- Regeneration Air Heater Name
  46.111111,                 !- Regeneration Inlet Air Setpoint Temperature {C}
  Coil:Cooling:DX:SingleSpeed, !- Companion Cooling Coil Object Type
  Desiccant DXSystem Cooling Coil, !- Companion Cooling Coil Name
  Yes,                        !- Companion Cooling Coil Upstream of Dehumidifier Process Inlet
  Yes,                        !- Companion Coil Regeneration Air Heating
  1.05,                       !- Exhaust Fan Maximum Flow Rate {m3/s}
  50,                         !- Exhaust Fan Maximum Power {W}
  EXHAUSTFANPLF;             !- Exhaust Fan Power Curve Name

```

Desiccant Dehumidifier Outputs

```

HVAC,Sum,Desiccant Dehumidifier Water Removed [kg]
HVAC,Average,Desiccant Dehumidifier Water Removal Rate [kg/s]
HVAC,Average,Desiccant Dehumidifier Part Load Ratio []
HVAC,Average,Desiccant Dehumidifier Exhaust Fan Electric Power [W]
HVAC,Sum,Desiccant Dehumidifier Exhaust Fan Electric Consumption [J]

```

Desiccant Dehumidifier Water Removed [kg]

This output is the mass of water removed from the process air stream in kilograms for the timestep being reported.

Desiccant Dehumidifier Water Removal Rate [kg/s]

This output is the average rate of water removal from the process air stream in kilograms per second for the timestep being reported.

Desiccant Dehumidifier Part Load Ratio []

This output is the fraction of time that the desiccant heat exchanger (and associated regeneration air heater and fans, if appropriate) operate for the timestep being reported.

Desiccant Dehumidifier Exhaust Fan Electric Power [W]

This output is the average electric consumption rate for the exhaust fan in Watts for the timestep being reported.

Desiccant Dehumidifier Exhaust Fan Electric Consumption [J]

This output is the electric consumption for the exhaust fan in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, EndUseKey = Cooling, GroupKey = System (ref. Report Meter).

Group – System Availability Managers

System Availability Managers are one of the high-level control constructs in EnergyPlus. An System Availability Manager is able to access data from any of the HVAC system nodes and use this data to to make a decision on whether an entire AirLoopHVAC or PlantLoop should be on or off.

System Availability Managers are executed at the start of each HVAC timestep. They reside outside the HVAC system iteration loops. Thus, the System Availability Managers are executed once per HVAC timestep, and they use previous timestep information (except for zone load) to calculate their set points.

Some of the managers monitor the temperature at an air or plant node to determine whether the system should be on or off. If the system is to be controlled on the outdoor dry-bulb temperature, an OutdoorAir:NodeList object can be used to define a node which will have the current outdoor air conditions.

The output from each System Availability Manager is an availability status flag. This flag can have the values *NoAction*, *ForceOff*, *CycleOn*, or *CycleOnZoneFansOnly*. The availability status flags for the System Availability Managers referenced by an air or plant loop are used to set the availability status flag for each loop. For the air loops, *ForceOff* takes precedence: if any of the loop's availability managers are showing status *ForceOff*, the loop status will be *ForceOff*. Next in precedence is *CycleOnZoneFansOnly*, followed by *CycleOn*, and *NoAction*. For the plant loops, there is no precedence among the System Availability Manager status flag values. Instead, the first availability manager giving a status flag value other than *NoAction* sets the status for the loop. The System Availability Managers are executed in AvailabilityManagerAssignmentList order.

The actual action of turning on or off a loop is taken by the loop prime movers: fans for AirLoopHVACs and pumps for plant loops. For instance when a fan is deciding whether it is on or off, it checks its on/off schedule and whether the loop availability status flag is *CycleOn* or *ForceOff*. If the schedule is on and the status flag is *ForceOff*, the fan will be off. If the fan schedule says off and the status flag is *CycleOn*, the fan will be on. Thus the availability managers overrule the fan on/off schedule. The availability managers, air loops, and plant loops all have report variables which may be used to verify the action of the loop.

Availability managers for AirLoopHVAC systems also control the availability of zone exhaust fans (Ref. Fan:ZoneExhaust) and terminal unit fans (Ref. AirTerminal:SingleDuct:SeriesPIU:Reheat, AirTerminal:SingleDuct: ParallelPIU:Reheat, and AirTerminal:SingleDuct:VAV:Reheat:VariableSpeedFan) in the zones served by the AirLoopHVAC system.

AvailabilityManager:Scheduled

The simplest System Availability Manager is when the availability is determined by an on/off schedule. The syntax for implementing such an availability manager is shown below. The identifying name refers back to the name recorded in the AvailabilityManagerAssignmentList statement described in the **Group – Air Distribution** section. The schedule must be the name of a schedule defined elsewhere in the input.

Field: Name

The unique, user-assigned name of an instance of a scheduled availability manager. Other objects that use this scheduled availability manager will reference it by this name.

Field: Schedule Name

The name of a schedule defined elsewhere in the input. Schedule values greater than zero (usually 1 is used) indicate that the system is on. Schedule values less than or equal to zero (usually 0 is used) denote that the system is off. This schedule overrides the central fan schedule for determining whether the fan is on.

The IDD specification for this object is:

```
AvailabilityManager:Scheduled,
  \min-fields 2
  \memo Determines the availability of a loop or system: whether it is on or off.
  \memo Schedule overrides fan/pump schedule.
A1 , \field Name
  \required-field
  \type alpha
  \reference SystemAvailabilityManagers
A2 ; \field Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
```

An example of this statement in an IDF is:

```
AvailabilityManager:Scheduled,
  VAV Sys 1 Avail, !- Name
  FanAvailSched; !- Schedule Name
```

AvailabilityManager:ScheduledOn

The Schedule On Availability Manager is used when equipment must be turned on during a given time period. This availability manager will not turn the equipment off, a separate availability manager must be used to disable the equipment as necessary. The scheduled on availability is determined by an on schedule. Schedule values other than 0 set a *CycleOn* availability status. Schedule values equal to 0 set a *NoAction* availability status. The syntax for implementing such an availability manager is shown below. The identifying name refers back to the name recorded in the *AvailabilityManagerAssignmentList* statement described in the **Group – Air Distribution** section. The schedule must be the name of a schedule defined elsewhere in the input.

Field: Name

The unique, user-assigned name of an instance of a scheduled on availability manager. Other objects that use this scheduled on availability manager will reference it by this name.

Field: Schedule Name

The name of a schedule defined elsewhere in the input. Schedule values greater than zero (usually 1 is used) indicate that the system is on. Schedule values less than or equal to zero (usually 0 is used) denote that *NoAction* is desired. This schedule overrides the central fan schedule for determining whether the fan is on.

The IDD specification for this object is:

```

AvailabilityManager:ScheduledOn,
  \min-fields 2
  \memo Determines the availability of a loop or system: only controls the turn on action.
  \memo Schedule overrides fan/pump schedule.
A1 , \field Name
  \required-field
  \type alpha
  \reference SystemAvailabilityManagers
A2 ; \field Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames

```

An example of this statement in an IDF is:

```

AvailabilityManager:ScheduledOn,
  VAV Sys 1 Avail On,  !- Name
  FanAvailSched;      !- Schedule Name

```

AvailabilityManager:ScheduledOff

The Schedule Off Availability Manager is used when equipment must be turned off during a given time period. This availability manager will not turn the equipment on, a separate availability manager must be used to enable the equipment as necessary. The scheduled off availability is determined by an off schedule. Schedule values equal to 0 set a *ForceOff* availability status. Schedule values other than 0 (usually a 1 is used) set a *NoAction* availability status. The syntax for implementing such an availability manager is shown below. The identifying name refers back to the name recorded in the *AvailabilityManagerAssignmentList* statement described in the **Group – Air Distribution** section. The schedule must be the name of a schedule defined elsewhere in the input.

Field: Name

The unique, user-assigned name of an instance of a scheduled off availability manager. Other objects that use this scheduled off availability manager will reference it by this name.

Field: Schedule Name

The name of a schedule defined elsewhere in the input. Schedule values equal to zero indicate that the system is off. Schedule values other than (usually 0 is used) denote that *NoAction* is desired.

The IDD specification for this object is:

```

AvailabilityManager:ScheduledOff,
  \min-fields 2
  \memo Determines the availability of a loop or system: only controls the turn off action.
  \memo Schedule overrides fan/pump schedule.
A1 , \field Name
  \required-field
  \type alpha
  \reference SystemAvailabilityManagers
A2 ; \field Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames

```

An example of this statement in an IDF is:


```
AvailabilityManager:ScheduledOff,
VAV Sys 1 Avail Off,      !- Name
FanAvailSched;           !- Schedule Name
```

AvailabilityManager:NightCycle

This manager is used for cycling on an air system when one or more zones become too hot or too cold. The usual situation is that the central air handler is turned off at night. However if the building gets too cold there might be condensation on the walls and other damage. Thus the control system is usually programmed to turn the system on if 1 control thermostat or any thermostat shows a zone temperature of less than a night time set point. Similarly there might be a concern about a building getting too hot. Again the control system is programmed to turn the air handler back on if one or any zone temperature exceeds a night time cooling set point.

This object gives the user considerable flexibility in determining how the night time on/off decision will be made. The manager can look at the temperature in 1 zone or it can sample all the zones connected to the air handler. The user can specify a temperature tolerance and a run time for the system once it switches on. There is also an applicability schedule – the user can schedule whether or not this availability manager itself is being applied.

Field: Name

A unique, user-assigned name for an instance of a night cycle availability manager. Other objects that use this availability manager will reference it by this name.

Field: Applicability Schedule Name

The name of a schedule defined elsewhere in the input file. This schedule determines whether or not for a given time period this availability manager is to be applied. Schedule values greater than zero (usually 1 is used) indicate the availability manager is to be applied. Schedule values less than or equal to zero (usually 0 is used) denote that the availability manager is not used for this time period.

Field: Fan Schedule Name

The name of the central fan on/off schedule for the air system that this availability manager will affect.

Field: Control Type

The possible inputs are *StayOff*, *CycleOnAny*, *CycleOnControlZone*, *CycleOnAnyZoneFansOnly*. *StayOff* means the availability manager will have no effect – air handler on/off will be determined by the fan schedule. *CycleOnAny* means that if any zone served by a system whose *AvailabilityManagerAssignmentList* references this system availability manager has an air temperature outside the cooling or heating set points the central fan will turn on even though the fan schedule indicates the fan is off. *CycleOnControlZone* means the same thing except the availability manager looks at the temperature in only one zone. *CycleOnAnyZoneFansOnly* is the same as *CycleOnAny* except that only the zone fans are cycled on and the central air handler fan is left off. The default is *StayOff*.

Field: Thermostat Tolerance

This is the amount in degrees Celsius by which the zone temperature must exceed the cooling set point or fall below the heating set point in order for the availability manager to signal that the system should turn on. The default is 1 degree C.

Field: Cycling Run Time

The time in seconds for which the system will run after it has cycled on. The default is 3600 seconds (1 hour).

Field: Control Zone Name

For the option *CycleOnControlZone* this is the name of the control zone.

The IDD specification for this object is:

```
AvailabilityManager:NightCycle,
  \min-fields 6
  \memo Determines the availability of a loop or system: whether it is on or off.
  \memo Depending on zone temperatures, overrides Schedules and forces system Fans on.
A1 , \field Name
  \required-field
  \type alpha
  \reference SystemAvailabilityManagers
A2 , \field Applicability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
A3 , \field Fan Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
```

```
A4 , \field Control Type
  \type choice
  \key StayOff
  \key CycleOnAny
  \key CycleOnControlZone
  \key CycleOnAnyZoneFansOnly
  \default StayOff
N1 , \field Thermostat Tolerance
  \default 1.0
  \units deltaC
N2 , \field Cycling Run Time
  \default 3600.
  \units s
A5 ; \field Control Zone Name
  \type object-list
  \object-list ZoneNames
```

An example of this statement in an IDF is:

```
AvailabilityManager:NightCycle,
VAV Sys 1 Avail,      ! Name
SysAvailApplicSch,   ! Applicability Schedule Name
FanAvailSched,       ! Fan Schedule Name
CycleOnAny,          ! Control Type
4.0,                 ! Temperature Tolerance {delta C}
7200.;               ! Cycle Run Time {s}
```

AvailabilityManager:DifferentialThermostat

The differential thermostat compares the temperatures at two different system nodes. If the temperature difference (ΔT) is above the *Temperature Difference On Limit*, the system is turned on. If the ΔT is below the *Temperature Difference Off Limit*, the system is turned off. Between the *On Limit* and *Off Limit* the system is either on or off depending on the previous state of the thermostat. Unlike other availability managers, the differential thermostat is always either "On" or "Off"; it does not use the "No Action" state. Therefore, the differential thermostat must be the last manager in the *AvailabilityManagerAssignmentList*. Any availability managers after the differential thermostat manager will never be simulated.

One application of the differential thermostat is to ensure a useful heat gain for solar heating systems, i.e. the system is only turned on when there is a significant temperature difference between the solar collector outlet node and the storage tank outlet node.

Field: Name

The name of the object. This is referenced in the *AvailabilityManagerAssignmentList*.

Field: Hot Node Name

The sensor node with the higher temperature.

Field: Cold Node Name

The sensor node with the colder temperature.

Field: Temperature Difference On Limit

Temperature difference [deltaC] between hot and cold nodes necessary to turn the system on.

Field: Temperature Difference Off Limit

Temperature difference [deltaC] between hot and cold nodes necessary to turn the system off. This field defaults to the *Temperature Difference On Limit*.

The IDD specification for this object is:

```
AvailabilityManager:DifferentialThermostat,
  \memo Overrides fan/pump schedules depending on temperature difference between two nodes.
  A1 , \field Name
        \required-field
        \type alpha
        \reference SystemAvailabilityManagers
  A2 , \field Hot Node Name
        \required-field
        \type alpha
  A3 , \field Cold Node Name
        \required-field
        \type alpha
  N1 , \field Temperature Difference On Limit
        \required-field
        \type real
        \units deltaC
  N2 ; \field Temperature Difference Off Limit
        \type real
        \units deltaC
        \note Defaults to Temperature Difference On Limit.
```

An example of this object in an IDF is:

```
AvailabilityManager:DifferentialThermostat,
  Differential Thermostat Availability Manager,  !- Name
  Collector Outlet Node,  !- Hot Node Name
  Water Heater Source Outlet Node,  !- Cold Node Name
  10.0,  !- Temperature Difference On Limit {delta C}
  2.0;  !- Temperature Difference Off Limit {delta C}
```

AvailabilityManager:HighTemperatureTurnOff

This manager turns the system off if the temperature at the sensor node is above the specified setpoint temperature.

Field: Name

The name of the object. This is referenced in the AvailabilityManagerAssignmentList.

Field: Sensor Node Name

The air or plant node where the temperature is monitored.

Field: Temperature

The setpoint temperature [C] at which the system is turned off.

The IDD specification for this object is:

```
AvailabilityManager:HighTemperatureTurnOff,
  \memo Overrides fan/pump schedules depending on temperature at sensor node.
A1 , \field Name
  \required-field
  \type alpha
  \reference SystemAvailabilityManagers
A2 , \field Sensor Node Name
  \required-field
  \type alpha
N1 ; \field Temperature
  \required-field
  \type real
  \units C
```

An example of this object in an IDF is:

```
AvailabilityManager:HighTemperatureTurnOff,
High Temperature Turn Off Availability Manager, !- Name
Water Heater Use Outlet Node, !- Sensor Node Name
60.0; !- Temperature {C}
```

AvailabilityManager:HighTemperatureTurnOn

This manager turns the system on if the temperature at the sensor node is above the specified setpoint temperature.

Field: Name

The name of the object. This is referenced in the AvailabilityManagerAssignmentList.

Field: Sensor Node Name

The air or plant node where the temperature is monitored.

Field: Temperature

The setpoint temperature [C] at which the system is turned on.

The IDD specification for this object is:

```
AvailabilityManager:HighTemperatureTurnOn,
  \memo Overrides fan/pump schedules depending on temperature at sensor node.
A1 , \field Name
  \required-field
  \type alpha
  \reference SystemAvailabilityManagers
A2 , \field Sensor Node Name
  \required-field
  \type alpha
N1 ; \field Temperature
  \required-field
  \type real
  \units C
```

An example of this object in an IDF is:

```
AvailabilityManager:HighTemperatureTurnOn,
High Temperature Turn On Availability Manager, !- Name
Outside Air Inlet Node, !- Sensor Node
30.0; !- Temperature {C}
```

AvailabilityManager:LowTemperatureTurnOff

This manager turns the system off if the temperature at the sensor node is below the specified setpoint temperature.

Field: Name

The name of the object. This is referenced in the AvailabilityManagerAssignmentList.

Field: Sensor Node Name

The air or plant node where the temperature is monitored.

Field: Temperature

The setpoint temperature [C] at which the system is turned off.

Field: Applicability Schedule Name

The name of a schedule defined elsewhere in the input file. This schedule determines whether or not for a given time period this availability manager is to be applied. Schedule values greater than zero (usually 1 is used) indicate the availability manager is to be applied. Schedule values less than or equal to zero (usually 0 is used) denote that the availability manager is not used for this time period. If this field is left blank, this availability manager is always active.

The IDD specification for this object is:

```
AvailabilityManager:LowTemperatureTurnOff,
  \memo Overrides fan/pump schedules depending on temperature at sensor node.
A1 , \field Name
  \required-field
  \type alpha
  \reference SystemAvailabilityManagers
A2 , \field Sensor Node Name
  \required-field
  \type alpha
N1 , \field Temperature
  \required-field
  \type real
  \units C
A3 ; \field Applicability Schedule Name
  \type object-list
  \object-list ScheduleNames
  \note If blank, defaults to always active
```

An example of this object in an IDF is:

```
AvailabilityManager:LowTemperatureTurnOff,
Low Temperature Turn Off Availability Manager,  !- Name
Outside Air Inlet Node,  !- Sensor Node Name
0.0,  !- Temperature {C}
Low Temp Control Schedule;  !- Applicability Schedule Name
```

AvailabilityManager:LowTemperatureTurnOn

This manager turns the system on if the temperature at the sensor node is below the specified setpoint temperature.

Field: Name

The name of the object. This is referenced in the AvailabilityManagerAssignmentList.

Field: Sensor Node Name

The air or plant node where the temperature is monitored.

Field: Temperature

The setpoint temperature [C] at which the system is turned on.

The IDD specification for this object is:

```

AvailabilityManager:LowTemperatureTurnOn,
  \memo Overrides fan/pump schedules depending on temperature at sensor node.
  A1 , \field Name
      \required-field
      \type alpha
      \reference SystemAvailabilityManagers
  A2 , \field Sensor Node Name
      \required-field
      \type alpha
  N1 ; \field Temperature
      \required-field
      \type real
      \units C

```

An example of this object in an IDF is:

```

AvailabilityManager:LowTemperatureTurnOn,
  Low Temperature Turn On Availability Manager,  !- Name
  Collector Outlet Node,  !- Sensor Node Name
  0.0;  !- Temperature {C}

```

System Availability Manager:Night Ventilation

This manager allows the user to implement a strategy for precooling a building at night using outdoor air. This strategy can consist of running the system fans with the outdoor air dampers open when outdoor conditions are favorable for a precooling strategy. The zone terminal unit air dampers may also be held at their fully open position to minimize fan energy consumption while precooling. Fan energy consumption is the critical parameter in deciding whether a precooling strategy will save energy.

The inputs for the night ventilation manager consist of an applicability schedule name (determining when the manager is active), a fan schedule name (for the fan(s) that the manager can switch on), a ventilation temperature schedule name (one zone must be above this temperature for night venting to be active), a ventilation temperature difference (indoor – outdoor temperature difference for night venting), a low limit temperature (no conditioned zone may fall below this temperature during night venting), a night venting flow fraction (fraction of the design flow rate at which the fans run during night venting), and the zone name of a control zone.

The night ventilation manager is used in conjunction with another object: *FanPerformance:NightVentilation*. The performance of the fan during night venting may be very different than during normal operation (a different fan might even be used). The *FanPerformance:NightVentilation* object allows the user to specify alternate fan performance parameters for use during night ventilation.

Field: Name

A unique, user-assigned name for an instance of a night ventilation availability manager. Other objects that use this availability manager will reference it by this name.

Field: Applicability Schedule Name

The name of a schedule defined elsewhere in the input file. This schedule determines whether or not for a given time period this availability manager is to be applied. Schedule values greater than zero (usually 1 is used) indicate the availability manager is to be applied. Schedule values less than or equal to zero (usually 0 is used) denote that the availability manager is not used for this time period.

Field: Fan Schedule Name

The name of the central fan on/off schedule for the air system that this availability manager will affect.

Field: Ventilation Temperature Schedule Name

The name of a temperature schedule defined elsewhere in the input file. At least one conditioned zone in the forced air system using this availability manager must be above the current temperature specified in this schedule for night ventilation to occur or to continue occurring.

Field: Ventilation Temperature Difference

This field specifies an indoor / outdoor temperature difference (in degrees C). The control zone temperature minus the outdoor air temperature must be greater than the Ventilation Temperature Difference for night ventilation to occur or to continue occurring. The default is 2 degrees C.

Field: Ventilation Temperature Low Limit

This field specifies a lower limit (in degrees C) on zone temperatures for night ventilation. If any conditioned zone served by the air system using this availability manager is below the ventilation temperature low limit, night ventilation will not occur or will switch off. The default is 15 degrees C.

Field: Night Venting Flow Fraction

The fraction (could be greater than 1) of the design flow rate at which the night ventilation will be done. The default is 1.

Field: Control Zone Name

The name of the control zone used in the ventilation temperature difference check.

The IDD specification for this object is:

```

AvailabilityManager:NightVentilation,
  \min-fields 7
  \memo depending on zone and outdoor conditions overrides fan schedule to do
  \memo precooling with outdoor air
A1 , \field Name
  \required-field
  \type alpha
  \reference SystemAvailabilityManagers
A2 , \field Applicability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
A3 , \field Fan Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
A4 , \field Ventilation Temperature Schedule Name
  \type object-list
  \object-list ScheduleNames
  \note One zone temperature must be above this scheduled temperature
  \note for night ventilation to be enabled
N1 , \field Ventilation Temperature Difference
  \units deltaC
  \default 2.0
  \note The outdoor air temperature minus the control zone temperature
  \note must be greater than the ventilation delta T
N2 , \field Ventilation Temperature Low Limit
  \units C
  \default 15.
  \note Night ventilation is disabled if any conditioned zone served by
  \note the system falls below this temperature
N3 , \field Night Venting Flow Fraction
  \minimum 0.0
  \default 1.
  \note the fraction (could be > 1) of the design system Flow Rate at which
  \note night ventilation will be done
A5 ; \field Control Zone Name
  \type object-list
  \object-list ZoneNames
  \required-field

```

An example of this object in an input file:

```

AvailabilityManager:NightVentilation,
VAV Sys 1 Avail,      !- Name
NightVentSched,      !- Applicability Schedule Name
FanAvailSched,       !- Fan Schedule Name
VentTempSched,       !- Ventilation Temperature Schedule Name
2.0,                  !- Ventilation Temperature Difference {C}
15.,                  !- Ventilation Temperature Low Limit
0.3333,              !- Night Venting Flow Fraction
SPACE3-1;            !- Control Zone Name

```

AvailabilityManager:HybridVentilation

This availability manager is executed at the start of each HVAC system timestep, before EnergyPlus calculates airflows defined in the objects ZoneInfiltration, ZoneVentilation, ZoneMixing, and ZoneCrossMixing, and before the AirflowNetwork model calculates multizone airflows. It serves two purposes: 1) prevents simultaneous natural ventilation and HVAC system operation, and 2) allows users to examine various ventilation strategies to maximize natural ventilation in order to reduce heating/cooling loads. The natural ventilation objects controlled by this availability manager have two groups: simple airflow group and AirflowNetwork group. The simple airflow group consists of the ZoneVentilation and ZoneMixing objects. The AirflowNetwork group consists of AirflowNetwork:MultiZone:Component:DetailedOpening and AirflowNetwork:MultiZone:Component:SimpleOpening objects used in the AirflowNetwork model. These two groups are not allowed to work simultaneously (see restrictions in the

Airflow Network model section). Basically, this object overrides the controls for these opening objects or ZoneVentilation and ZoneMixing objects, closing the “openings” or shutting off ventilation/mixing airflows under certain conditions and allowing the HVAC system (AirLoopHVAC) to operate. If the availability manager determines that conditions are favorable for natural ventilation, then the HVAC system (AirLoopHVAC) is disabled and the “opening” objects or ventilation/mixing objects are able to operate based on the controls specified for those objects.

Each AirLoopHVAC can have a corresponding hybrid ventilation availability manager. Each hybrid ventilation manager can control natural ventilation in the zones served by the AirLoopHVAC. The hybrid ventilation availability manager is triggered by zone air conditions for the controlled zone specified in an object input field. Presently, this availability manager must be used either with the ZoneVentilation and ZoneMixing objects or with the AirflowNetwork model.

The inputs for this availability manager consist of the name for the air loop (AirLoopHVAC) being controlled, the controlled zone name to determine which zone air conditions are used to determine system availability, a ventilation control mode schedule, maximum wind speed and rain indicator to determine whether natural ventilation is allowed or not, a low limit and high limit for dry-bulb temperature, enthalpy and dewpoint temperature to determine the hybrid ventilation control, and a minimum outdoor air ventilation schedule. The last control allows user to use a wind speed modifier to adjust openness when the AirflowNetwork opening objects are selected. The other inputs include how to control simple airflow objects and AirflowNetwork opening objects.

The hybrid ventilation availability manager works independently of all other system availability manager objects, so this manager is not a valid system availability manager type in the AvailabilityManagerAssignmentList object.

Field: Name

A unique, user-assigned name for an instance of a hybrid ventilation availability manager. Other objects that use this availability manager will reference it by this name.

Field: HVAC Air Loop Name

The name of the air loop (AirLoopHVAC object) to be controlled by this system availability manager.

Field: Controlled Zone Name

The name of a controlled zone served by the air loop defined in the previous field. The air conditions in this zone are used to determine if natural ventilation should be provided.

Field: Ventilation Control Mode Schedule Name

The name of a schedule defined elsewhere in the input file. This schedule determines whether or not for a given time the hybrid ventilation control mode is to be applied. Schedule values equal to zero indicate no ventilation control, resulting in natural ventilation and HVAC system operation being performed based on their own controls. Schedule values equal to one denote temperature control for either cooling or heating, which is determined internally based on thermostat set point and temperature control type. The temperature control is restricted between the minimum and maximum outdoor temperatures provided in two additional input fields (below). Schedule values equal to two denote enthalpy control, which is restricted between minimum and maximum outdoor enthalpy values given in two additional input fields (below). Schedule values equal to three denote dewpoint control for either dehumidification or humidification. Schedule values equal to four represent outdoor ventilation air control. The outdoor ventilation air control works with AirflowNetwork opening objects only, and is not allowed to work with ZoneVentilation and ZoneMixing objects.

The detailed control logic is given in the EnergyPlus Engineering Reference.

Field: Use Weather File Rain Indicators

This logical alpha field indicates whether or not the rain indicator is used to shut off natural ventilation or not. The valid choices for Rain Indicator are Yes and No, with the default being Yes. This can help simulate conditions where one would normally close windows to avoid rain penetration in a space. Any possible rain getting into a space will not be counted as a zone load.

Field: Maximum Wind Speed

This is the wind speed (m/s) above which hybrid ventilation is shut off. This can help simulate conditions where one would normally close windows to avoid wind problems in a space (papers blowing around, etc).

Field: Minimum Outdoor Temperature

This is the outdoor temperature (in Celsius) below which hybrid ventilation is shut off when the ventilation control mode = 1 (Temperature). This lower temperature limit is intended to avoid overcooling a space, which could result in a heating load.

Field: Maximum Outdoor Temperature

This is the outdoor temperature (in Celsius) above which hybrid ventilation is shut off when the ventilation control mode = 1 (Temperature). This upper temperature limit is intended to avoid overheating a space, which could result in a cooling load.

Field: Minimum Outdoor Enthalpy

This is the outdoor enthalpy (in J/kg) below which hybrid ventilation is shut off when the ventilation control mode = 2 (Enthalpy).

Field: Maximum Outdoor Enthalpy

This is the outdoor enthalpy (in J/kg) above which hybrid ventilation is shut off when the ventilation control mode = 2 (Enthalpy).

Field: Minimum Outdoor Dewpoint

This is the outdoor dewpoint (in Celsius) below which hybrid ventilation is shut off when the ventilation control mode = 3 (Dewpoint). This lower dewpoint temperature limit is intended to avoid dehumidifying a space.

Field: Maximum Outdoor Dewpoint

This is the outdoor dewpoint temperature (in Celsius) above which hybrid ventilation is shut off when the ventilation control mode = 3 (Dewpoint). This upper dewpoint temperature limit is intended to avoid humidifying a space.

Field: Minimum Outdoor Ventilation Air Schedule Name

The name of a schedule defined elsewhere in the input file. This field applies only if Ventilation Control Mode = 4 (Outdoor Ventilation Air Control). This schedule determines the minimum outdoor ventilation air for a given time in the units of air change per hour (ACH). The program calculates the natural (outdoor) ventilation in the controlled zone first and compares the amount of outdoor air introduced by opening windows or doors and other small openings to this minimum value. If the amount of outdoor air from natural ventilation is less than the minimum value, the natural ventilation is shut off (i.e., the window or door openings are closed) and the HVAC system may operate if needed. Otherwise, the natural ventilation is on and the HVAC system is shut off. The amount of outdoor ventilation air entering the controlled zone is determined as air from outdoors and not from other adjacent zones. Therefore, this option is only applied to a zone having a window or door exposed to outdoors.

Field: Opening Factor Function of Wind Speed Curve Name

The name of a linear or quadratic performance curve (ref: Performance Curves) that parameterizes the variation of opening factor as a function of outdoor wind speed. The output of this curve is multiplied by the opening factor of opening objects to give the final openness. This field only works with the AirflowNetwork opening objects.

Field: AirflowNetwork Control Type Schedule Name

The name of a schedule defined elsewhere in the input file. This field works with the AirflowNetwork opening objects only. This schedule determines for a given simulation timestep how the opening objects respond to the hybrid ventilation control when the hybrid ventilation control allows the objects to operate.

Schedule values equal to zero indicate individual ventilation control based on the control requirements specified for each individual AirflowNetwork opening object. Schedule values equal to one denote "group" control. The opening objects exposed to outdoors in the controlled zone served by the primary air loop (Ref. Field "HVAC Air Loop Name") will be considered as a master to provide group control.

Field: Simple Airflow Control Type Schedule Name

The name of a schedule defined elsewhere in the input file. This field works with ZoneVentilation and ZoneMixing objects only. This schedule determines for a given simulation timestep how the ZoneVentilation and ZoneMixing objects respond to the hybrid ventilation control when the hybrid ventilation control allows the objects to operate.

Schedule values equal to zero indicate the individual ventilation control based on the control requirements from their own objects. Schedule values equal to one denote group control. The ZoneVentilation and ZoneMixing objects in the zones served by the primary air loop defined in a previous input field (Ref. Field "HVAC Air Loop Name") are controlled by a single object, whose name is provided in the following input field.

Field: ZoneVentilation Object Name

The name of a ZoneVentilation object whose zone name is the controlled zone name defined in a previous input field for this availability manager object (Ref. Field "Controlled Zone Name"). The controls defined for this specific ZoneVentilation object to enable ventilation air will be applied to other ZoneVentilation and ZoneMixing objects served by the air loop controlled by this availability manager, regardless of the controls defined for the other ZoneVentilation and ZoneMixing objects. In other words, when ventilation is enabled by this specific ZoneVentilation object, the other ZoneVentilation and ZoneMixing objects in the zones served by the primary air loop are also enabled.

Below is the input data dictionary description for the AvailabilityManager:HybridVentilation object.

```

AvailabilityManager:HybridVentilation,
  \min-fields 13
  \memo Depending on zone and outdoor conditions overrides window/door opening controls
  \memo to maximize natural ventilation and turn off an HVAC system when ventilation control
  \memo conditions are met.
A1 , \field Name
  \required-field
  \type alpha
  \reference SystemAvailabilityManagers
A2 , \field HVAC Air Loop Name
  \note Enter the name of an AirLoopHVAC object.
  \required-field
  \type object-list
  \object-list AirPrimaryLoops
A3 , \field Controlled Zone Name
  \required-field
  \type object-list
  \object-list ZoneNames
  \note the controlled zone name should be a zone where a thermostat or humidistat is located
  \note served by an air primary loop.
A4 , \field Ventilation Control Mode Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
  \note The Ventilation control mode contains appropriate integer control types.
  \note 0 - uncontrolled (Natural ventilation and HVAC system are controlled by themselves)
  \note 1 = Temperature control
  \note 2 = Enthalpic control
  \note 3 = Dewpoint control
  \note 4 = Outdoor ventilation air control
  \required-field
  \type object-list
  \object-list ScheduleNames
A5 , \field Use Weather File Rain Indicators
  \type choice
  \key Yes
  \key No
  \default Yes
  \note If Yes, ventilation is shutoff when there is rain
  \note If No, there is no rain control
N1 , \field Maximum Wind Speed
  \type real
  \units m/s
  \minimum 0.0
  \maximum 40.0
  \default 40.0
  \note this is the wind speed above which ventilation is shutoff
N2 , \field Minimum Outdoor Temperature
  \note this is the outdoor temperature below which ventilation is shutoff
  \units C
  \type real
  \minimum -100
  \maximum 100
  \default -100

```

```

N3 , \field Maximum Outdoor Temperature
    \note this is the outdoor temperature above which ventilation is shutoff
    \units C
    \type real
    \minimum -100
    \maximum 100
    \default 100
N4 , \field Minimum Outdoor Enthalpy
    \note this is the outdoor Enthalpy below which ventilation is shutoff
    \units J/kg
    \type real
    \minimum> 0.0
    \maximum< 300000.0
N5 , \field Maximum Outdoor Enthalpy
    \note this is the outdoor Enthalpy above which ventilation is shutoff
    \units J/kg
    \type real
    \minimum> 0
    \maximum< 300000.0
N6 , \field Minimum Outdoor Dewpoint
    \note this is the outdoor temperature below which ventilation is shutoff
    \units C
    \type real
    \minimum -100
    \maximum 100
    \default -100
    \note Applicable only if Ventilation Control Mode = 3
N7 , \field Maximum Outdoor Dewpoint
    \note this is the outdoor dewpoint above which ventilation is shutoff
    \units C
    \type real
    \minimum -100
    \maximum 100
    \default 100
    \note Applicable only if Ventilation Control Mode = 3
A6 , \field Minimum Outdoor Ventilation Air Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note Used only if Ventilation Control Mode = 4
A7 , \field Opening Factor Function of Wind Speed Curve Name
    \type object-list
    \object-list LinearQuadratic Curves
    \note linear curve = a + b*WS
    \note quadratic curve = a + b*WS + c*WS**2
    \note WS = wind speed (m/s)
A8 , \field AirflowNetwork Control Type Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note The schedule is used to incorporate operation of AirflowNetwork large opening
    \note objects and HVAC system operation.
A9 , \field Simple Airflow Control Type Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note The schedule is used to incorporate operation of simple airflow objects and HVAC
    \note system operation.
    \note The simple airflow objects are Ventilation and Mixing only
A10; \field ZoneVentilation Object Name
    \type object-list
    \object-list VentilationNames
    \note The other ventilation and mixing objects controlled in the same air primary loop
    \note will work in the same way as this ventilation object.

```

AvailabilityManager:HybridVentilation Outputs

The hybrid ventilation availability manager has two output variables.

HVAC,Average,Hybrid Ventilation Control Mode HVAC,Average,Hybrid Ventilation Control Status
--

Hybrid Ventilation Control Mode

This is the hybrid ventilation control mode given in the Ventilation Control Mode Schedule.

Hybrid Ventilation Control Status

This is the hybrid ventilation control status, which can have three integer values: 0, 1, and 2. A zero value indicates no hybrid ventilation control, corresponding to zero value defined in the previous output variable. A value of one indicates that natural ventilation is allowed. A value of two denotes that the natural ventilation is not allowed, so all window/door openings are closed.

Group – Setpoint Managers

Setpoint Managers are one of the high-level control constructs in EnergyPlus. A Setpoint Manager is able to access data from any of the HVAC system nodes and use this data to calculate a setpoint (usually a temperature setpoint) for one or more other HVAC system nodes. Setpoints are then used by Controllers or Plant or Condenser Loops as a goal for their control actions.

Setpoint Managers are executed at the start of each HVAC timestep, and they reside outside the HVAC system iteration loops. Thus, the Setpoint Managers are executed once per HVAC timestep, and they use previous timestep information (except for zone load) to calculate their setpoints.

The following situations require the use of a Setpoint Manager:

- 1) any use of Controller:WaterCoil; either in "Temperature" control only or 2 Setpoint Managers for the " TemperatureAndHumidityRatio " control variable option.
- 2) use of Controller:OutdoorAir with *Economizer Control Type* set to anything but *NoEconomizer*;
- 3) use of Coil:Heating:Gas or Coil: Heating: Electric with the field *Temperature Setpoint Node Name* set to a node name;
- 4) any use of AirLoopHVAC:UnitaryCoolOnly;
- 5) any use of Humidifier:Steam:Electric.
- 6) Any use of PlantLoop or CondenserLoop

Setpoint managers will place a calculated or scheduled setpoint value on the setpoint node and overwrite any previous value. This value may represent one of several control types (e.g., Temperature, HumidityRatio, MassFlowRate, etc.). No two setpoint managers should use the same setpoint node for like control types.

For the case when two setpoint managers place a setpoint on the same setpoint node (e.g., a temperature setpoint placed on the same node by two different setpoint managers), the setpoint value on the node is calculated by the last setpoint manager simulated. Within a specific type of setpoint manager (e.g., Scheduled), the setpoint managers are simulated in the order found in the input data file (idf) when viewed using a text editor. It is also possible for two different types of setpoint managers to place setpoints of like control variable on the same node. In this case, the order of simulation for the type of setpoint manager determines which setpoint manager is the last to write a setpoint value to the node. This conflict in setpoint node data is most likely to cause inaccurate simulation results. For this reason, a conflicting setpoint node name warning message is issued so that the conflict can be resolved. Duplicate setpoint node names found within a specific node list will not typically cause problems with the simulation (the same value is written twice to the same node). In this case a duplicate setpoint node name warning is issued, however, this could be an error in the spelling of the node name and should be corrected.

Simulation order for setpoint managers:

- SetpointManager:Scheduled
- SetpointManager:Scheduled:DualSetpoint
- SetpointManager:OutdoorAirReset
- SetpointManager:SingleZone:Reheat
- SetpointManager:SingleZone:Heating
- SetpointManager:SingleZone:Cooling
- SetpointManager:SingleZone:Humidity:Minimum
- SetpointManager:SingleZone:Humidity:Maximum
- SetpointManager:Warmest
- SetpointManager:Coldest
- SetpointManager:WarmestTemperatureFlow
- SetpointManager:ReturnAirBypassFlow
- SetpointManager:MixedAir
- SetpointManager:OutdoorAirPretreat

SetpointManager:Scheduled

The simplest Setpoint Manager simply uses a schedule to determine one or more setpoints. No node data is used as input. The input consists of the Setpoint Manager name, the control variable, the schedule name, and the name of a node list. The node list contains the name of those nodes at which the setpoint is to be applied. Of course, a node list name can always be simply the name of a single node.

Note that although this object provides a very general method of setting the values of many different control variables on nodes, the component models and system solvers may or may not be able to use them. Therefore, it is important to understand that simply setting a control variable using this object will not necessarily always produce the desired behavior.

Field: Name

A unique, user-assigned name for an instance of a scheduled setpoint manager. Anywhere in the input that this setpoint manager is used, it is referred to by this name.

Field: Control Variable

The type of variable that will be controlled. There are several choices for this type of set point manager. The most common control variable is Temperature but other major choices include: HumidityRatio and MassFlowRate. The versatility of control variables available here (probably) exceeds what is actually available in the component and systems models. However, a large number of possible control variables are made available here for maximum flexibility and because some (but not all) component models will be able to use them. The complete list of key words and the units required in the associated schedules follow.

- Temperature Temperature of fluid at node (°C)
- MaximumTemperature Maximum temperature of fluid at node (°C)
- MinimumTemperature Minimum temperature of fluid at node (°C)
- HumidityRatio Humidity ratio of fluid at node (kg water/ kg dry air)
- MaximumHumidityRatio Maximum humidity ratio of fluid at node (kg water/kg dry air)
- MinimumHumidityRatio Minimum humidity ratio of fluid at node (kg water/kg dry air)
- MassFlowRate Mass flow rate of fluid at node (kg/s)
- MaximumMassFlowRate Maximum mass flow rate of fluid at node (kg/s)
- MinimumMassFlowRate Minimum mass flow rate of fluid at node (kg/s)

Field: Schedule Name

The name of a schedule whose values are to be used as setpoints on the node or node list. The schedule value for each time period is the setpoint for this type of setpoint manager. The schedule must have values that are in the appropriate units as defined in the previous field.

Field: Setpoint Node or NodeList Name

The name of a NodeList object containing the names of the HVAC system nodes or the HVAC System Node Name for which setpoints will be established by this setpoint manager.

Below is the Input Data Dictionary definition of a Scheduled Setpoint Manager.

```
SetpointManager:Scheduled,
  A1 , \field Name
      \required-field
      \reference SetpointManagers
  A2 , \field Control Variable
      \type choice
      \key Temperature
      \key MaximumTemperature
      \key MinimumTemperature
      \key HumidityRatio
      \key MaximumHumidityRatio
      \key MinimumHumidityRatio
      \key MassFlowRate
      \key MaximumMassFlowRate
      \key MinimumMassFlowRate
      \required-field
  A3 , \field Schedule Name
      \type object-list
      \object-list ScheduleNames
      \required-field
  A4 ; \field Setpoint Node or NodeList Name
      \note Node(s) at which temperature will be set
      \required-field
```

Following is an example of the input for a Scheduled Setpoint Manager.

```
SetpointManager:Scheduled,
  Supply Air Temp Manager 1,  !- Name
  Temperature,                !- Control Variable
  Seasonal Reset Supply Air Temp Sch,  !- Schedule Name
  VAV Sys 1 Outlet Node;      !- Setpoint Node or NodeList Name
```

SetpointManager:Scheduled:DualSetpoint

This setpoint manager places a high and low schedule value on one or more nodes. The input consists of the Setpoint Manager name, the control variable, the high and low set point schedule names, and the name of a node list. The node list contains the name of those nodes at which the setpoint is to be applied. Of course, a node list name can simply be the name of a single node. Currently the DualSetpoint Manager will be used with PlantLoop when the Plant Loop Demand Calculation Scheme is set to “DualSetpointDeadband”.

Field: Name

A unique, user-assigned name for an instance of this scheduled setpoint manager. Anywhere in the input that this setpoint manager is used, it is referred to by this name.

Field: Control Variable

The type of variable that will be controlled. There is only one choice for this type of setpoint manager: Temperature.

Field: High Setpoint Schedule Name

The name of a schedule that contains the high setpoint values. The schedule value for each time period is the high setpoint for this type of setpoint manager.

Field: Low Setpoint Schedule Name

The name of a schedule that contains the low setpoint values. The schedule value for each time period is the low setpoint for this type of setpoint manager.

Field: Setpoint Node or NodeList Name

The name of a NodeList object containing the names of the HVAC system nodes or the HVAC System Node Name for which temperature setpoints will be established by this setpoint manager.

Below is the Input Data Dictionary definition for SetpointManager:Scheduled:DualSetpoint.

```
SetpointManager:Scheduled:DualSetpoint,
  A1 , \field Name
      \required-field
      \reference SetpointManagers
  A2 , \field Control Variable
      \type choice
      \key Temperature
      \default Temperature
  A3 , \field High Setpoint Schedule Name
      \type object-list
      \object-list ScheduleNames
      \required-field
  A4 , \field Low Setpoint Schedule Name
      \type object-list
      \object-list ScheduleNames
      \required-field
  A5 ; \field Setpoint Node or NodeList Name
      \note Node(s) at which temperature will be set
      \required-field
```

Following is an example of the input for a SetpointManager:Scheduled:DualSetpoint object.

```
SetpointManager:Scheduled:DualSetpoint,
  Water Loop Setpoint Manager,    !- Name
  Temperature,                   !- Control Variable
  Plant Loop High Temp Schedule,  !- High Setpoint Schedule Name
  Plant Loop Low Temp Schedule,   !- Low Setpoint Schedule Name
  Plant Supply Outlet Node;       !- Setpoint Node or NodeList Name
```

SetpointManager:OutdoorAirReset

The Outdoor Air Reset Setpoint Manager sets the supply air temperature according to the outdoor air temperature using a reset rule. The reset rule is determined by 2 points: the supply air setpoint temperature at the outdoor high temperature (SATOH) and the supply air setpoint temperature at the outdoor low temperature (SATOL). If the outdoor temperature is above the outdoor high temperature, the supply air temperature is set to SATOH. If the outdoor temperature is below the outdoor low temperature, the supply air temperature is set to SATOL. If the outdoor temperature is between the outdoor high and outdoor low temperatures, the supply air temperature is linearly interpolated between SATOH and SATOL.

The input consists of the setpoint manager name, the type of control variable, a node list name of the nodes affected by the setpoint, and the data for the reset rule: the supply air setpoint temperature at the outdoor low temperature, the outdoor low temperature, the supply air setpoint temperature at the outdoor high temperature, and the outdoor high temperature.

There are optional inputs for a second reset rule. First there is the name of a schedule that indicates which rule to use: a schedule value of 1 means use the first rule; a schedule value of 2 means use the second rule. Next, there are the 4 inputs specifying the second reset rule.

Field: Name

A unique, user-assigned name for an instance of an outdoor air reset setpoint manager. Anywhere in the input that this setpoint manager is used, it is referred to by this name.

Field: Control Variable

The type of variable that will be controlled. There is only one choice for this type of setpoint manager: Temperature.

Field: Setpoint at Outdoor Low Temperature

The supply air temperature setpoint in °C at the outdoor low temperature for the first reset rule.

Field: Outdoor Low Temperature

The outdoor air low temperature in °C for the first supply air temperature reset rule. Generally, at this outdoor air temperature the supply temperature is at its maximum.

Field: Setpoint at Outdoor High Temperature

The supply air temperature setpoint in °C at the outdoor high temperature for the first reset rule.

Field: Outdoor High Temperature

The outdoor air high temperature in °C for the first supply air temperature reset rule. Generally, at this outdoor air temperature the supply temperature is at its minimum.

Field: Setpoint Node or NodeList Name

The name of a NodeList object containing the names of the HVAC system nodes or the HVAC System Node Name for which temperature setpoints will be established by this setpoint manager.

Field: Schedule Name

The name of a schedule whose values indicate which reset rule to use. Schedule values of 1 indicate that the first reset rule will be used. Schedule values of 2 select the second reset rule.

Field: Setpoint at Outdoor Low Temperature 2

The supply air temperature setpoint in °C at the outdoor low temperature for the second reset rule.

Field: Outdoor Low Temperature 2

The outdoor air low temperature in °C for the second supply air temperature reset rule. Generally, at this outdoor air temperature the supply temperature is at its maximum.

Field: Setpoint at Outdoor High Temperature 2

The supply air temperature setpoint in °C at the outdoor high temperature for the second reset rule.

Field: Outdoor High Temperature 2

The outdoor air high temperature in °C for the second supply air temperature reset rule. Generally, at this outdoor air temperature the supply temperature is at its minimum.

Following is the Input Data Dictionary description of the Outdoor Air Reset Setpoint Manager:

```

SetpointManager:OutdoorAirReset,
  A1 , \field Name
      \required-field
      \reference SetpointManagers
  A2 , \field Control Variable
      \type choice
      \key Temperature
      \default Temperature
  N1 , \field Setpoint at Outdoor Low Temperature
      \units C
      \required-field
  N2 , \field Outdoor Low Temperature
      \units C
      \required-field
  N3 , \field Setpoint at Outdoor High Temperature
      \units C
      \required-field
  N4 , \field Outdoor High Temperature
      \units C
      \required-field
  A3 , \field Setpoint Node or NodeList Name
      \note Node(s) at which temperature will be set
      \required-field
  A4 , \field Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Optional input.
      \note Schedule allows scheduling of the outdoor air reset rule - a schedule value
      \note of 1 means use the first rule; a value of 2 means use the second rule.
  N5 , \field Setpoint at Outdoor Low Temperature 2
      \note 2nd outdoor air temperature reset rule
      \units C
  N6 , \field Outdoor Low Temperature 2
      \note 2nd outdoor air temperature reset rule
      \units C
  N7 , \field Setpoint at Outdoor High Temperature 2
      \note 2nd outdoor air temperature reset rule
      \units C
  N8 ; \field Outdoor High Temperature 2
      \note 2nd outdoor air temperature reset rule
      \units C

```

Below is an example of the input for an Outdoor Air Reset Setpoint Manager:

```

SetpointManager:OutdoorAirReset,
  Supply Air Temp Manager 1, !- Name
  Temperature, !- Control Variable
  16.7, !- Setpoint at Outdoor Low Temperature {C}
  0.0, !- Outdoor Low Temperature {C}
  12.8, !- Setpoint at Outdoor High Temperature {C}
  32.0, !- Outdoor High Temperature {C}
  Supply Air Temp Nodes; !- Setpoint Node or NodeList Name

NodeList,
  Supply Air Temp Nodes, !- Name
  Air Loop Outlet Node; !- Node 1 Name

```

SetpointManager:SingleZone:Reheat

The Single Zone Reheat Setpoint Manager allows the simulation of a single zone reheat system. This setpoint manager detects the control zone load, zone inlet node flow rate, and zone node temperature and calculates a setpoint temperature for the supply air that will satisfy the zone load for the control zone. This setpoint manager creates a variable temperature system. The input consists of the setpoint manager name, the control variable type, the minimum and maximum supply air temperatures, the name of the control zone, the name of the control zone node, the name of the control zone inlet node, and the name of a node or node list containing the nodes whose setpoint temperatures are to be set by this manager.

Field: Name

A unique, user-assigned name for an instance of this setpoint manager. Anywhere in the input that this setpoint manager is used, it is referred to by this name.

Field: Control Variable

The type of variable that will be controlled. There is only one choice for this type of setpoint manager: Temperature.

Field: Minimum Supply Air Temperature

The minimum supply air temperature (in °C) that is allowed for this system (as set by this setpoint manager).

Field: Maximum Supply Air Temperature

The maximum supply air temperature (in °C) that is allowed for this system (as set by this setpoint manager)

Field: Control Zone Name

The name of the control zone for this single zone reheat system. The heating or cooling load for this zone determines the supply air temperature setpoint.

Field: Zone Node Name

The name of the zone node for the control zone.

Field: Zone Inlet Node Name

The name of the zone inlet node that is supplying air to the control zone.

Field: Setpoint Node or NodeList Name

The name of a NodeList object containing the names of the HVAC system nodes or the HVAC System Node Name for which temperature setpoints will be established by this setpoint manager.

The following shows the Input Data Dictionary description of the SetpointManager:SingleZone:Reheat object.

```
SetpointManager:SingleZone:Reheat,
A1 , \field Name
    \required-field
    \reference SetpointManagers
A2 , \field Control Variable
    \type choice
    \key Temperature
    \default Temperature
N1 , \field Minimum Supply Air Temperature
    \units C
    \default -99
N2 , \field Maximum Supply Air Temperature
    \units C
    \default 99
A3 , \field Control Zone Name
    \type object-list
    \object-list ZoneNames
    \required-field
A4 , \field Zone Node Name
    \required-field
A5 , \field Zone Inlet Node Name
    \required-field
A6 ; \field Setpoint Node or NodeList Name
    \note Node(s) at which the temperature will be set
    \required-field
```

Below is an example input for a SetpointManager:SingleZone:Reheat object.

```

SetpointManager:SingleZone:Reheat,
  Supply Air Temp Manager,  !- Name
  Temperature,  !- Control Variable
  13.,  !- Minimum Supply Air Temperature {C}
  45.,  !- Maximum Supply Air Temperature {C}
  NORTH ZONE,  !- Control Zone Name
  Zone 3 Node,  !- Zone Node Name
  Zone 3 Inlet Node,  !- Zone Inlet Node Name
  Supply Air Temp Nodes;  !- Setpoint Node or NodeList Name

NodeList,
  Supply Air Temp Nodes,  !- Name
  Heating Coil Air Inlet Node,  !- Node 1 Name
  Air Loop Outlet Node;  !- Node 2 Name

```

SetpointManager:SingleZone:Heating

The Single Zone Heating Setpoint Manager allows a component to be controlled based on the load required to meet the zone heating setpoint. This setpoint manager detects the control zone load to meet the current heating setpoint, zone inlet node flow rate, and zone node temperature, and calculates a setpoint temperature for the supply air that will satisfy the zone heating load for the control zone. This setpoint manager creates a variable temperature system. The input consists of the setpoint manager name, the controlled variable type, the minimum and maximum supply air temperatures, the name of the control zone, the name of the control zone node, the name of the control zone inlet node, and the name of a node or node list containing the nodes whose setpoint temperatures are to be set by this manager.

Field: Name

A unique, user-assigned name for an instance of a single zone heating setpoint manager. Anywhere in the input that this setpoint manager is used, it is referred to by this name.

Field: Control Variable

The type of variable that will be controlled. There is only one choice for this type of setpoint manager: Temperature.

Field: Minimum Supply Air Temperature

The minimum supply air temperature (in °C) that is allowed for this system (as set by this setpoint manager).

Field: Maximum Supply Air Temperature

The maximum supply air temperature (in °C) that is allowed for this system (as set by this setpoint manager)

Field: Control Zone Name

The name of the control zone for this setpoint manager. The heating load for this zone (to meet the zone heating setpoint) determines the supply air temperature setpoint.

Field: Zone Node Name

The name of the zone node for the control zone.

Field: Zone Inlet Node Name

The name of the zone inlet node that is supplying air to the control zone.

Field: Setpoint Node or NodeList Name

The name of a NodeList object containing the names of the HVAC system nodes or the HVAC System Node Name for which temperature setpoints will be established by this setpoint manager.

The following shows the Input Data Dictionary description of the Single Zone Heating Setpoint Manager.

```
SetpointManager:SingleZone:Heating,
  \min-fields 8
A1 , \field Name
  \required-field
  \reference SetpointManagers
A2 , \field Control Variable
  \type choice
  \key Temperature
  \default Temperature
N1 , \field Minimum Supply Air Temperature
  \units C
  \default -99
N2 , \field Maximum Supply Air Temperature
  \units C
  \default 99
A3 , \field Control Zone Name
  \type object-list
  \object-list ZoneNames
  \required-field
A4 , \field Zone Node Name
  \required-field
A5 , \field Zone Inlet Node Name
  \required-field
A6 ; \field Setpoint Node or NodeList Name
  \note Node(s) at which the temperature will be set
  \required-field
```

Below is an example input for a SetpointManager:SingleZone:Heating object.

```
SetpointManager:SingleZone:Heating,
  Zone 1 Heating Supply Air Temp Manager,  !- Name
  Temperature,                             !- Control Variable
  7.22,                                     !- Minimum Supply Air Temperature {C}
  45.,                                      !- Maximum Supply Air Temperature {C}
  Zone 1,                                   !- Control Zone Name
  Zone 1 Zone Node,                        !- Zone Node Name
  Zone 1 Supply Inlet,                     !- Zone Inlet Node Name
  Zone 1 Heating Coil Outlet;               !- Setpoint Node or NodeList Name
```

SetpointManager:SingleZone:Cooling

The Single Zone Cooling Setpoint Manager allows a component to be controlled based on the load required to meet the zone cooling setpoint. This setpoint manager detects the control zone load to meet the current cooling setpoint, zone inlet node flow rate, and zone node temperature, and calculates a setpoint temperature for the supply air that will satisfy the zone cooling load for the control zone. This setpoint manager creates a variable temperature system. The input consists of the setpoint manager name, the controlled variable type, the minimum and maximum supply air temperatures, the name of the control zone, the name of the control zone node, the name of the control zone inlet node, and the name of a node or node list containing the nodes whose setpoint temperatures are to be set by this manager.

Field: Name

A unique, user-assigned name for an instance of a single zone cooling setpoint manager. Anywhere in the input that this setpoint manager is used, it is referred to by this name.

Field: Control Variable

The type of variable that will be controlled. There is only one choice for this type of setpoint manager: Temperature.

Field: Minimum Supply Air Temperature

The minimum supply air temperature (in °C) that is allowed for this system (as set by this setpoint manager).

Field: Maximum Supply Air Temperature

The maximum supply air temperature (in °C) that is allowed for this system (as set by this setpoint manager)

Field: Control Zone Name

The name of the control zone for this setpoint manager. The cooling load of this zone (to meet the zone cooling set point) determines the supply air temperature setpoint.

Field: Zone Node Name

The name of the zone node for the control zone.

Field: Zone Inlet Node Name

The name of the zone inlet node that is supplying air to the control zone.

Field: Setpoint Node or NodeList Name

The name of a Node List object containing the names of the HVAC system nodes or the HVAC System Node Name for which temperature setpoints will be established by this setpoint manager.

The following shows the Input Data Dictionary description of the SetpointManager:SingleZone:Cooling object.

```
SetpointManager:SingleZone:Cooling,
  \min-fields 8
A1 , \field Name
  \required-field
  \reference SetpointManagers
A2 , \field Control Variable
  \type choice
  \key Temperature
  \default Temperature
N1 , \field Minimum Supply Air Temperature
  \units C
  \default -99
N2 , \field Maximum Supply Air Temperature
  \units C
  \default 99
A3 , \field Control Zone Name
  \type object-list
  \object-list ZoneNames
  \required-field
A4 , \field Zone Node Name
  \required-field
A5 , \field Zone Inlet Node Name
  \required-field
A6 ; \field Setpoint Node or NodeList Name
  \note Node(s) at which the temperature will be set
  \required-field
```

Below is an example input for a SetpointManager:SingleZone:Cooling object.

```
SetpointManager:SingleZone:Cooling,
Zone 1 Cooling Supply Air Temp Manager, !- Name
Temperature, !- Control Variable
7.22, !- Minimum Supply Air Temperature {C}
45., !- Maximum Supply Air Temperature {C}
Zone 1, !- Control Zone Name
Zone 1 Zone Node, !- Zone Node Name
Zone 1 Supply Inlet, !- Zone Inlet Node Name
Zone 1 Cooling Coil Outlet; !- Setpoint Node or NodeList Name
```

SetpointManager:SingleZone:Humidity:Minimum

The Single Zone Minimum Humidity Setpoint Manager allows the control of a single zone minimum humidity level. This setpoint manager detects the humidity level in a control zone and, using air and moisture mass balance, calculates the supply air humidity ratio needed to maintain the zone relative humidity at or above a given setpoint. The calculated supply air humidity ratio is then used as the setpoint for the designated setpoint node. A humidifier component placed upstream of the setpoint node can then use the humidity ratio setpoint to control its moisture addition rate.

The use of this object requires that a “ZoneControl:Humidistat” object be specified with a humidifying relative humidity schedule for the controlling zone. The humidistat’s controlling zone must correspond with the control zone air node name specified in this setpoint manager.

Field: Name

A unique, user-assigned name for an instance of a single zone minimum humidity setpoint manager. Anywhere in the input that this setpoint manager is used, it is referred to by this name.

Field: Control Variable

Deprecated Field. This field is not used and will be deleted in a future release.

Field: Schedule Name

Deprecated Field. This field is not used and will be deleted in a future release.

Field: Setpoint Node or NodeList Name

The name of the HVAC system node where the calculated humidity ratio setpoint is set. If the setpoint is being placed on more than one node, this input should be the name of a NodeList.

Field: Control Zone Air Node Name

The name of the zone node for the humidity control zone (as specified in the object ZoneHVAC:EquipmentConnections).

The IDD description for the setpoint manager is shown below:

```
SetpointManager:SingleZone:Humidity:Minimum,
A1 , \field Name
    \required-field
    \reference SetpointManagers
A2 , \field Control Variable
    \note Deprecated Field. This field is not used
A3 , \field Schedule Name
    \note Deprecated Field. This field is not used
A4 , \field Setpoint Node or NodeList Name
    \required-field
    \note Node(s) at which humidity ratio setpoint will be set
A5 ; \field Control Zone Air Node Name
    \required-field
    \note Name of the zone air node for the humidity control zone
```

An IDF example for this setpoint manager is shown below with the required humidistat:


```

SetpointManager:SingleZone:Humidity:Minimum,
  Zone Min Set Point Manager,  !- Name
  ,  !- Control Variable
  ,  !- Schedule Name
  Air Loop Outlet Node,  !- Setpoint Node or NodeList Name
  Zone 2 Node;  !- Control Zone Air Node Name

ZoneControl:Humidistat,
  Zone 2 Humidistat,  !- Name
  ZONE 2,  !- Zone Name
  Min rel Hum Set Sch2;  !- Humidifying Relative Humidity Setpoint Schedule Name

```

SetpointManager:SingleZone:Humidity:Maximum

The Single Zone Maximum Humidity Setpoint Manager allows the control of a single zone maximum humidity level. This setpoint manager, used in conjunction with object ZoneControl:Humidistat, detects the air humidity level in a single control zone and uses air/moisture mass balances to calculate the supply air humidity ratio needed to maintain the zone relative humidity at or below a given setpoint. The calculated supply air humidity ratio is then used as the setpoint for the designated setpoint node. A dehumidification component placed upstream of this node can then use the humidity ratio setpoint to control its moisture removal rate (e.g., desiccant dehumidifiers).

In the case of a chilled water coil which is used for both temperature and high humidity control, this setpoint manager works in conjunction with a Controller:WaterCoil object to determine the minimum supply air temperature required to meet both the temperature (sensible) and humidity (latent) load in the control zone. See object Controller:WaterCoil in the EnergyPlus Engineering Reference for a detailed discussion of how this is achieved.

The use of this object requires that a “ZoneControl:Humidistat” object be specified with a relative humidity setpoint schedule for the controlling zone. The humidistat’s controlling zone must correspond with the control zone air node name specified in this setpoint manager..

Field: Name

A unique, user-assigned name for an instance of a single zone maximum humidity setpoint manager. Anywhere in the input that this setpoint manager is used, it is referred to by this name.

Field: Control Variable

Deprecated Field. This field is not used and will be deleted in a future release.

Field: Schedule Name

Deprecated Field. This field is not used and will be deleted in a future release.

Field: Setpoint Node or NodeList Name

The name of the HVAC system node where the calculated humidity ratio setpoint is set. If the setpoint is being placed on more than one node, this input should be the name of a NodeList.

Field: Control Zone Air Node Name

The name of the zone air node for the humidity control zone (as specified in the object ZoneHVAC:EquipmentConnections).

The IDD description for this object is shown below:

```

SetpointManager:SingleZone:Humidity:Maximum,
  \min-fields 5
A1 , \field Name
    \required-field
    \reference SetpointManagers
A2 , \field Control Variable
    \note Deprecated Field. This field is not used
A3 , \field Schedule Name
    \note Deprecated Field. This field is not used
A4 , \field Setpoint Node or NodeList Name
    \required-field
    \note Node(s) at which humidity ratio setpoint will be set
A5 ; \field Control Zone Air Node Name
    \required-field
    \note Name of the zone air node for the humidity control zone

```

An example of this object in an input data file (IDF), along with a temperature set point manager, humidistat, and a simple controller, is shown below:

```

SetpointManager:SingleZone:Humidity:Maximum,
  Zone Max Set Point Manager,      !- Name
  ,                                !- Control Variable
  ,                                !- Schedule Name
  VAV Sys 1 Outlet Node,          !- Setpoint Node or NodeList Name
  Zone 2 Node;                   !- Control Zone Air Node Name

SetpointManager:Scheduled,
  Scheduled Set Point Manager 1,   !- Name
  Temperature,                   !- Control Variable
  Seasonal Reset Supply Air Temp Sch, !- Schedule Name
  VAV Sys 1 Outlet Node;         !- Setpoint Node or NodeList Name

ZoneControl:Humidistat,
  Zone 2 Humidistat,             !- Name
  ZONE 2,                        !- Zone Name
  Min rel Hum Set Sch2;         !- Humidifying Relative Humidity Setpoint Schedule Name

Controller:WaterCoil,
  Central Cooling Coil Contoller 1, !- Name
  TEMPandHUMRAT,                 !- Control Variable
  Reverse,                       !- Action
  FLOW,                           !- Actuator Variable
  VAV Sys 1 Outlet Node,         !- Sensor Node Name
  Main Cooling Coil 1 Water Inlet Node, !- Actuator Node Name
  0.002,                         !- Controller Convergence Tolerance {deltaC}
  0.025,                         !- Maximum Actuated Flow {m3/s}
  0.0;                           !- Minimum Actuated Flow {m3/s}

```

SetpointManager:MixedAir

The Mixed Air Setpoint Manager is meant to be used in conjunction with a Controller:OutdoorAir object. This setpoint manager is used to establish a temperature setpoint at the mixed air node. The Controller:OutdoorAir then operates the outdoor air damper to attempt to meet this setpoint.

In EnergyPlus the relief and outdoor air dampers, the economizer, and any outdoor air conditioning equipment form a separate subsystem of an air loop system (ref. AirLoopHVAC). The outdoor air controller operates within the subsystem. Consequently the mixed air temperature setpoint must take into account any downstream system fan heat if it is to meet a desired system supply air leaving temperature. The Mixed Air Setpoint Manager accomplishes this by referencing a supply air setpoint set by another setpoint manager (most likely at the AirLoopHVAC outlet node). The supply fan inlet and outlet nodes are also inputs to the Mixed Air Setpoint Manager. From this information the Mixed Air Setpoint Manager calculates the supply fan air temperature rise, subtracts it from the reference setpoint temperature, and sets the result as the mixed air node setpoint temperature.

Of course any type of setpoint manager can be used to establish a temperature setpoint at the mixed air node. But the Mixed Air Setpoint Manager is likely to be the most useful.

Field: Name

A unique, user-assigned name for an instance of a mixed air setpoint manager. Anywhere in the input that this setpoint manager is used, it is referred to by this name.

Field: Control Variable

The type of variable that will be controlled. There is only one choice for this type of setpoint manager: Temperature.

Field: Reference Setpoint Node Name

The name of an HVAC system node where the system supply air temperature is set. Normally this would be the AirLoopHVAC outlet node. The temperature setpoint at this reference node is set by a different setpoint manager.

Field: Fan Inlet Node Name

The name of the supply fan inlet node.

Field: Fan Outlet Node Name

The name of the supply fan outlet node.

Field: Setpoint Node or NodeList Name

The name of a NodeList object containing the names of the HVAC system nodes or the HVAC System Node Name where temperature setpoints will be established by this setpoint manager.

The Input Data Dictionary description for the SetpointManager:MixedAir object is.

```
SetpointManager:MixedAir,
A1 , \field Name
    \required-field
    \reference SetpointManagers
A2 , \field Control Variable
    \type choice
    \key Temperature
    \default Temperature
A3 , \field Reference Setpoint Node Name
    \required-field
A4 , \field Fan Inlet Node Name
    \required-field
A5 , \field Fan Outlet Node Name
    \required-field
A6 ; \field Setpoint Node or NodeList Name
    \required-field
    \note Node(s) at which the temperature will be set
```

Below is an example input for a Mixed Air Setpoint Manager.

```

SetpointManager:SingleZone:Reheat, ! establishes the setpoint at the system outlet node
  Supply Air Temp Manager, !- Name
  Temperature, !- Control Variable
  13., !- Minimum Supply Air Temperature
  45., !- Maximum Supply Air Temperature
  NORTH_ZONE, !- Control Zone Name
  Zone 3 Node, !- Zone Node Name
  Zone 3 Inlet Node, !- Zone Inlet Node Name
  Supply Air Temp Nodes; !- Setpoint Node or NodeList Name

SetpointManager:MixedAir, ! uses the system outlet setpoint to establish the mixed air setpoint
  Mixed Air Temp Manager 1, !- Name
  Temperature, !- Control Variable
  Air Loop Outlet Node, !- Reference Setpoint Node Name
  Heating Coil Air Outlet Node, !- Fan Inlet Node Name
  Air Loop Outlet Node, !- Fan Outlet Node Name
  Mixed Air Nodes; !- Setpoint Node or NodeList Name

NodeList, Supply Air Temp Nodes,
  Air Loop Outlet Node; ! Setpoint Nodes
NodeList, Mixed Air Nodes,
  Mixed Air Node; ! Setpoint Nodes

```

SetpointManager:OutdoorAirPretreat

The Outdoor air Pretreat Setpoint Manager is meant to be used in conjunction with an OutdoorAir:Mixer object. The Outdoor air Pretreat Setpoint Manager is used to establish a temperature or humidity ratio setpoint in the outdoor air stream flowing into the "Outdoor Air Stream Node" of an OutdoorAir:Mixer object. This setpoint manager determines the required setpoint in the outdoor air stream to produce the reference setpoint in the mixed air stream after mixing with return air. For example, if the temperature setpoint at the mixed air node is 15°C, the return air temperature is 20°C, and the outdoor air flow fraction is 0.5, the Outdoor Air Pretreat setpoint would be set to 10°C.

Of course any type of setpoint manager can be used to establish setpoints in the outdoor air stream, but this setpoint manager is likely to be the most useful for systems which precondition outdoor air with equipment such as a DX cooling coil or desiccant dehumidifier.

Field: Name

A unique, user-assigned name for an instance of an outdoor air pretreat setpoint manager. Anywhere in the input that this setpoint manager is used, it is referred to by this name.

Field: Control Variable

The type of variable that will be controlled. The choices are:

- Temperature – references and sets the "System Node Setpoint Temp" property. This single temperature setpoint is set and used by all temperature setpoint managers and equipment controls except dual-setpoint equipment.
- MaximumHumidityRatio – references and sets the "System Node Humidity Ratio Max" property. This type of reference setpoint may be set using SetpointManager:SingleZone:Humidity:Maximum and is used by equipment such as Controller:WaterCoil (with control variable "TemperatureAndHumidityRatio") and Dehumidifier:Desiccant:NoFans.
- MinimumHumidityRatio – references and sets the "System Node Humidity Ratio Min" property. This type of reference setpoint may be set using SetpointManager:SingleZone:Humidity:Minimum and is used by equipment such as Humidifier:Steam:Electric.
- HumidityRatio – references and sets the "System Node Setpoint Humidity Ratio" property. This type of reference setpoint may be set using (no applicable setpoint

managers at this time) and is used by equipment such as Controller:WaterCoil (with control variable "HumidityRatio").

The system node properties listed above are all available as an Output:Variable to facilitate tracking these setpoints both at the reference node and the setpoint nodes.

Field: Minimum Setpoint Temperature

The minimum temperature (in °C) that is allowed by this setpoint manager. Applicable only if Control variable is Temperature.

Field: Maximum Setpoint Temperature

The maximum temperature (in °C) that is allowed by this setpoint manager. Applicable only if Control variable is Temperature.

Field: Minimum Setpoint Humidity Ratio

The minimum humidity ratio (in kg/kg) that is allowed by this setpoint manager. Applicable only if Control variable is MaximumHumidityRatio, MinimumHumidityRatio, or HumidityRatio. Note that zero is not allowed as the computed setpoint humidity ratio, because zero is used as a special value to indicate that no humidification or dehumidification is needed. If the reference humidity ratio setpoint value is zero, the zero value will be passed directly to the Set Point Node(s).

Field: Maximum Setpoint Humidity Ratio

The maximum humidity ratio (in kg/kg) that is allowed by this set point manager. Applicable only if Control variable is MaximumHumidityRatio, MinimumHumidityRatio, or HumidityRatio.

Field: Reference Setpoint Node Name

The name of an HVAC system node where the desired mixed air condition has been set. Normally this would be the mixed air node leaving the OutdoorAir:Mixer. The temperature or humidity setpoint at this reference node must be set by a different setpoint manager of the appropriate type (see Control Variable above).

Field: Mixed Air Stream Node Name

The name of the mixed air node. This node is used to obtain the flow rate of the combined air stream. This node is usually the same node at the Reference Setpoint Node Name, but does not have to be.

Field: Outdoor Air Stream Node Name

The name of a node in the outdoor air stream. This node is used to obtain the flow rate of the outdoor air stream.

Field: Return Air Stream Node Name

The name of a node in the return air stream. This node is used to obtain the flow rate of the return air stream.

Field: Setpoint Node or NodeList Name

The name of a NodeList object containing the names of the HVAC system nodes or the HVAC System Node Name for which temperature or humidity ratio setpoints will be established by this setpoint manager.

The following shows the Input Data Dictionary description of the Outdoor Air Pretreat Setpoint Manager.

```

SetpointManager:OutdoorAirPretreat,
  \min-fields 11
  \memo This setpoint manager determines the required
  \memo conditions at the outdoor air stream node which will
  \memo produce the reference setpoint condition at the
  \memo mixed air node when mixed with the return air stream
A1 , \field Name
  \required-field
  \reference SetpointManagers
A2 , \field Control Variable
  \type choice
  \key Temperature
  \key HumidityRatio
  \key MaximumHumidityRatio
  \key MinimumHumidityRatio
N1 , \field Minimum Setpoint Temperature
  \units C
  \default -99
  \note Applicable only if Control variable is Temperature
N2 , \field Maximum Setpoint Temperature
  \units C
  \default 99
  \note Applicable only if Control variable is Temperature
N3 , \field Minimum Setpoint Humidity Ratio
  \units kg/kg
  \maximum 1.0
  \default 0.00001
  \note Applicable only if Control variable is
  \note MaximumHumidityRatio, MinimumHumidityRatio, or HumidityRatio - then minimum is 0.00001
N4 , \field Maximum Setpoint Humidity Ratio
  \units kg/kg
  \maximum 1.0
  \default 1.0
  \note Applicable only if Control variable is
  \note MaximumHumidityRatio, MinimumHumidityRatio, or HumidityRatio - then minimum is 0.00001
A3 , \field Reference Setpoint Node Name
  \note The current setpoint at this node is the
  \note desired condition for the Mixed Air Node
  \note This node must have a valid setpoint
  \note which has been set by another setpoint manager
A4 , \field Mixed Air Stream Node Name
  \note Name of Mixed Air Node
  \required-field
A5 , \field Outdoor Air Stream Node Name
  \note Name of Outdoor Air Stream Node
  \required-field
A6 , \field Return Air Stream Node Name
  \note Name of Return Air Stream Node
  \required-field
A7 ; \field Setpoint Node or NodeList Name
  \required-field
  \note Node(s) at which the temperature or humidity
  \note ratio will be set

```

Below is an example input for an Outdoor Air Pretreat Setpoint Manager.

```

SetpointManager:OutdoorAirPretreat,
  DXSystem 1 Desiccant Set Point Manager,  !- Name
  MaximumHumidityRatio,                   !- Control Variable
  -99,                                     !- Minimum Setpoint Temperature {C}
  99,                                       !- Maximum Setpoint Temperature {C}
  0.00001,                                  !- Minimum Setpoint Humidity Ratio {kg/kg}
  1.0,                                      !- Maximum Setpoint Humidity Ratio {kg/kg}
  DXSystem 1 Fan Air Inlet Node,           !- Reference Setpoint Node Name
  DXSystem 1 Mixed Air Node,               !- Mixed Air Stream Node Name
  Heat Recovery Outlet Node,               !- Outdoor Air Stream Node Name
  DXSystem 1 Air Loop Inlet Node,          !- Return Air Stream Node Name
  Desiccant Process Outlet Node;          !- Setpoint Node or NodeList Name

```

SetpointManager:Warmest

The Warmest Setpoint Manager resets the cooling supply air temperature of a central forced air HVAC system according to the cooling demand of the warmest zone. For each zone in the system at each system timestep, the manager calculates a supply air temperature that will meet the zone cooling load at the maximum zone supply air flow rate. The lowest of the possible supply air temperatures becomes the new supply air temperature setpoint, subject to minimum and maximum supply air temperature constraints. The resulting temperature setpoint is the highest supply air temperature that will meet the cooling requirements of all the zones. When compared to a fixed cooling supply air temperature setpoint, this strategy minimizes zone reheat coil energy (or overcooling) and central chiller energy consumption (if the chilled water temperature is also reset) at the cost of possible increased fan energy.

Field: Name

A unique, user-assigned name for an instance of a warmest setpoint manager. Anywhere in the input that this setpoint manager is used, it is referred to by this name.

Field: Control Variable

The type of variable that will be controlled. Currently there is only one choice: Temperature.

Field: HVAC Air Loop Name

The name of the AirLoopHVAC object (the central air system) which will use this setpoint manager to set its cooling supply air temperature.

Field: Minimum Setpoint Temperature

The minimum allowed setpoint temperature in degrees C. If the calculated setpoint temperature is less than this minimum, the setpoint is set to the minimum.

Field: Maximum Setpoint Temperature

The maximum allowed setpoint temperature in degrees C. If the calculated setpoint is greater than this value the setpoint is set to the maximum. This value is also used as the setpoint temperature when none of the zones have a cooling load.

Field: Strategy

Currently, the only choice for this field is MaximumTemperature.

Field: Setpoint Node or NodeList Name

The name of a NodeList object containing the names of the HVAC system nodes or the HVAC System Node Name for which temperature setpoints will be established by this setpoint manager.

The following shows the Input Data Dictionary description of the Warmest Setpoint Manager.

```

SetpointManager:Warmest,
  A1 , \field Name
      \required-field
      \reference SetpointManagers
  A2 , \field Control Variable
      \type choice
      \key Temperature
      \default Temperature
  A3 , \field HVAC Air Loop Name
      \note Enter the name of an AirLoopHVAC object
      \required-field
      \type object-list
      \object-list AirPrimaryLoops
  N1 , \field Minimum Setpoint Temperature
      \units C
      \type real
      \minimum> 0.0
      \default 12.
  N2 , \field Maximum Setpoint Temperature
      \units C
      \type real
      \minimum> 0.0
      \default 18.
  A4 , \field Strategy
      \type choice
      \key MaximumTemperature
      \default MaximumTemperature
  A5 ; \field Setpoint Node or NodeList Name
      \required-field
      \note Node(s) at which the temperature will be set

```

Below is an example input for a Warmest Setpoint Manager.

```

SetpointManager:Warmest,
  Supply Air Temperature Manager 1,  !- Name
  Temperature,  !- Control Variable
  VAV Sys 1,  !- HVAC Air Loop Name
  11.2,  !- Minimum Setpoint Temperature
  16.,  !- Maximum Setpoint Temperature
  MaximumTemperature,  !- Strategy
  Supply Air Temp Nodes 1;  !- Setpoint Node or NodeList Name

SetpointManager:MixedAir,
  Mixed Air Temp Manager 1,  !- Name
  Temperature,  !- Control Variable
  VAV Sys 1 Outlet Node,  !- Reference Setpoint Node Name
  Main Heating Coil 1 Outlet Node,  !- Fan Inlet Node Name
  VAV Sys 1 Outlet Node,  !- Fan Outlet Node Name
  Mixed Air Node 1;  !- Setpoint Node or NodeList Name

NodeList, Supply Air Temp Nodes 1,
  VAV Sys 1 Outlet Node;  ! Setpoint Node

```

Set Point Manager:Coldest

The Coldest Setpoint Manager is used in dual duct systems to reset the setpoint temperature of the air in the heating supply duct. Usually it is used in conjunction with a Warmest Setpoint Manager resetting the temperature of the air in the cooling supply duct. For each zone in the system at each system timestep, the manager calculates a supply air temperature that will meet the zone heating load at the maximum zone supply air flow rate. The highest of the possible supply air temperatures becomes the new supply air temperature setpoint, subject to minimum and maximum supply air temperature constraints. The resulting temperature setpoint is the lowest supply air temperature that will meet the heating requirements of all the zones. When compared to a fixed heating supply air temperature setpoint, this strategy minimizes central boiler energy consumption (if the hot water temperature is also reset or there are variable speed pumps) at the cost of possible increased fan energy (if there is variable volume control in the air system).

Field: Name

A unique, user-assigned name for an instance of a coldest setpoint manager. Anywhere in the input that this setpoint manager is used, it is referred to by this name.

Field: Control Variable

The type of variable that will be controlled. Currently there is only one choice: Temperature.

Field: HVAC Air Loop Name

The name of the AirLoopHVAC object (the central air system) which will use this setpoint manager to set its heating supply air temperature.

Field: Minimum Setpoint Temperature

The minimum allowed setpoint temperature in degrees C. If the calculated setpoint temperature is less than this minimum, the setpoint is set to the minimum. This value is also used as the setpoint temperature when none of the zones have a heating load.

Field: Maximum Setpoint Temperature

The maximum allowed setpoint temperature in degrees C. If the calculated setpoint is greater than this value the setpoint is set to the maximum.

Field: Strategy

Currently, the only choice for this field is MinimumTemperature.

Field: Setpoint Node or NodeList Name

The name of a NodeList object containing the names of the HVAC system nodes or the HVAC System Node Name for which temperature setpoints will be established by this setpoint manager.

The following shows the Input Data Dictionary description of the Coldest Setpoint Manager.

```
SetpointManager:Coldest,
  A1 , \field Name
      \required-field
      \reference SetpointManagers
  A2 , \field Control Variable
      \type choice
      \key Temperature
      \default Temperature
  A3 , \field HVAC Air Loop Name
      \note Enter the name of an AirLoopHVAC object.
      \required-field
      \type object-list
      \object-list AirPrimaryLoops
  N1 , \field Minimum Setpoint Temperature
      \units C
      \type real
      \minimum> 0.0
      \default 20.
  N2 , \field Maximum Setpoint Temperature
      \units C
      \type real
      \minimum> 0.0
      \default 50.
  A4 , \field Strategy
      \type choice
      \key MinimumTemperature
      \default MinimumTemperature
  A5 ; \field Setpoint Node or NodeList Name
      \required-field
      \note Node(s) at which the temperature will be set
```

Below is an example input for a Coldest Setpoint Manager.

```

Controller:Simple,
  Central Cooling Coil Controller 1,  !- Name
  Temperature,  !- Control Variable
  Reverse,  !- Action
  Flow,  !- Actuator Variable
  VAV Sys 1 Cold Outlet Node,  !- Sensor Node Name
  Main Cooling Coil 1 Water Inlet Node,  !- Actuator Node Name
  0.001,  !- Controller Convergence Tolerance {deltaC}
  autosize,  !- Maximum Actuated Flow {m3/s}
  0.0;  !- Minimum Actuated Flow {m3/s}

Controller:WaterCoil,
  Central Heating Coil Controller 1,  !- Name
  Temperature,  !- Control Variable
  Normal,  !- Action
  Flow,  !- Actuator Variable
  VAV Sys 1 Hot Outlet Node,  !- Sensor Node Name
  Main Heating Coil 1 Water Inlet Node,  !- Actuator Node Name
  0.001,  !- Controller Convergence Tolerance {deltaC}
  autosize,  !- Maximum Actuated Flow {m3/s}
  0.0;  !- Minimum Actuated Flow {m3/s}

SetpointManager:Warmest,
  Supply Air Temperature Manager 1,  !- Name
  Temperature,  !- Control Variable
  VAV Sys 1,  !- HVAC Air Loop Name
  11.2,  !- Minimum Setpoint Temperature {C}
  16.,  !- Maximum Setpoint Temperature {C}
  MaximumTemperature,  !- Strategy
  Supply Air Temp Nodes 1;  !- Setpoint Node or NodeList Name

NodeList,
  Supply Air Temp Nodes 1,  !- Name
  VAV Sys 1 Cold Outlet Node;  !- Node 1 Name

SetpointManager:Coldest,
  Supply Air Temperature Manager 2,  !- Name
  Temperature,  !- Control Variable
  VAV Sys 1,  !- HVAC Air Loop Name
  25.,  !- Minimum Setpoint Temperature {C}
  50.,  !- Maximum Setpoint Temperature {C}
  MinimumTemperature,  !- Strategy
  Supply Air Temp Nodes 2;  !- Setpoint Node or NodeList Name

NodeList,
  Supply Air Temp Nodes 2,  !- Name
  VAV Sys 1 Hot Outlet Node;  !- Node 1 Name

```

Set Point Manager:Return Air Bypass Flow

This manager is user in conjunction with a return air bypass configuration. This type of air system is basically a standard single duct system with the addition of a bypass duct that bypasses return air around the main system components – in particular, the central cooling coil. This allows the central cooling coil to sufficiently dehumidify the mixed air; the bypassed air is then added to the supply air stream to bring the supply air temperature up to the desired temperature set point. This scheme is very useful in situations where an higher than normal supply air temperature is used – for instance, in underfloor air distribution systems.

This manager relies on the program to figure out the system configuration and to extract the needed data from the system nodes. All the user needs to input is the name of the air system and a schedule giving the desired supply air temperature setpoint. No node names are required. The manager will establish a bypass air flow rate that upon mixing with the non-bypassed air will yield the temperature given in the schedule.

Field: Name

A unique, user-assigned name for an instance of an Return Air Bypass Flow setpoint manager. Anywhere in the input that this setpoint manager is used, it is referred to by this name.

Field: Control Variable

The type of variable that will be controlled. Currently there is only one choice: Flow.

Field: HVAC Air Loop Name

The name of the AirLoopHVAC object (the central air system) which will use this setpoint manager to set its return air bypass flow rate.

Field: Temperature Setpoint Schedule Name

The name of a schedule whose values are temperatures in °C. The schedule value for the time period is the setpoint for this type of setpoint manager. The setpoint is assumed to be at the air handler outlet.

Below is the IDD definition for the SetpointManager:ReturnAirBypassFlow object.

```
SetpointManager:ReturnAirBypassFlow,
  \min-fields 4
  \memo This setpoint manager determines the required
  \memo mass flow rate through a return air bypass duct
  \memo to meet the specified temperature setpoint
A1 , \field Name
  \required-field
  \reference SetpointManagers
A2 , \field Control Variable
  \type choice
  \key Flow
  \default Flow
A3 , \field HVAC Air Loop Name
  \note Enter the name of an AirLoopHVAC object.
  \required-field
  \type object-list
  \object-list AirPrimaryLoops
A4 ; \field Temperature Setpoint Schedule Name
  \type object-list
  \object-list ScheduleNames
```

The following shows an example input for SetpointManager:ReturnAirBypassFlow.

```
SetpointManager:ReturnAirBypassFlow,
  RETURN AIR BYPASS Manager 1, !- Name
  Flow, !- Control Variable
  VAV Sys 1, !- HVAC Air Loop Name
  Seasonal Reset Supply Air Temp Sch; !- Temperature Setpoint Schedule Name
```

SetpointManager:WarmestTemperatureFlow

The Warmest Temperature Flow Setpoint Manager resets the cooling supply air temperature of a central forced air HVAC system according to the cooling demand of the warmest zone. The user can select on of two strategies: 'Temperature First' or 'Flow First'. For each zone in the system at each system timestep, the manager calculates a supply air temperature that will meet the zone cooling load at the minimum zone supply air flow rate ('Temperature First') or at the maximum zone supply air flow rate ('Flow First'). The lowest of the possible supply air temperatures becomes the new supply air temperature setpoint, subject to minimum and maximum supply air temperature constraints. The resulting temperature setpoint is the highest supply air temperature that will meet the cooling requirements of all the zones. When compared to a fixed cooling supply air temperature setpoint, the 'Temperature First' strategy minimizes fan energy at the cost of possible increased zone reheat coil energy (or overcooling) and central chiller energy consumption, whereas the 'Flow First' strategy

minimizes zone reheat coil energy (or overcooling) and central chiller energy consumption at the cost of possible increased fan energy.

Field: Name

A unique, user-assigned name for an instance of this setpoint manager. Anywhere in the input that this setpoint manager is used, it is referred to by this name.

Field: Control Variable

The type of variable that will be controlled. For this setpoint manager, this input should be Temperature.

Field: HVAC Air Loop Name

The name of the AirLoopHVAC object (the central air system) which will use this setpoint manager to set its cooling supply air temperature.

Field: Minimum Setpoint Temperature

The minimum allowed setpoint temperature in degrees C. If the calculated setpoint temperature is less than this minimum, the setpoint is set to the minimum.

Field: Maximum Setpoint Temperature

The maximum allowed setpoint temperature in degrees C. If the calculated setpoint is greater than this value the setpoint is set to the maximum. This value is also used as the setpoint temperature when none of the zones have a cooling load.

Field: Strategy

The choices for this field are *TemperatureFirst* and *FlowFirst*.

Field: Setpoint Node or NodeList Name

The name of a NodeList object containing the names of the HVAC system nodes or the HVAC System Node Name for which temperature setpoints will be established by this setpoint manager.

Field: Minimum Turndown

The minimum value of the ratio of the actual air flow rate to the maximum air flow rate, either for the supply fan if there are no VAV terminal boxes, or for the VAV boxes if present. If there are VAV boxes, it is assumed that the same value of minimum turndown applies to all boxes.

The following shows the Input Data Dictionary description of the SetpointManager:WarmestTemperatureFlow.

```

SetpointManager:WarmestTemperatureFlow,
A1 , \field Name
    \required-field
    \reference SetpointManagers
A2 , \field Control Variable
    \type choice
    \key Temperature
A3 , \field HVAC Air Loop Name
    \note Enter the name of an AirLoopHVAC object.
    \required-field
    \type object-list
    \object-list AirPrimaryLoops
N1 , \field Minimum Setpoint Temperature
    \units C
    \type real
    \minimum> 0.0
    \default 12.
N2 , \field Maximum Setpoint Temperature
    \units C
    \type real
    \minimum> 0.0
    \default 18.
A4 , \field Strategy
    \type choice
    \key TemperatureFirst
    \key FlowFirst
    \default TemperatureFirst
A5 , \field Setpoint Node or NodeList Name
    \required-field
    \note Node(s) at which the temperature will be set
N3 ; \field Minimum Turndown
    \units dimensionless
    \type real
    \minimum> 0.0
    \default 1.

```

Below is an example input for a SetpointManager:WarmestTemperatureFlow object.

```

SetpointManager:WarmestTemperatureFlow,
    Supply Air Temperature Manager 1,  !- Name
    Temperature,  !- Control Variable
    VAV Sys 1,  !- HVAC Air Loop Name
    11.2,  !- Minimum Setpoint Temperature
    16.,  !- Maximum Setpoint Temperature
    TemperatureFirst,  !- Strategy
    Supply Air Temp Nodes 1,  !- Setpoint Node or NodeList Name
    0.3;  !- Minimum Turndown

SetpointManager:MixedAir,
    Mixed Air Temp Manager 1,  !- Name
    Temperature,  !- Control Variable
    VAV Sys 1 Outlet Node,  !- Reference Setpoint Node Name
    Main Heating Coil 1 Outlet Node,  !- Fan Inlet Node Name
    VAV Sys 1 Outlet Node,  !- Fan Outlet Node Name
    Mixed Air Node 1;  !- Setpoint Node or NodeList Name

NodeList, Supply Air Temp Nodes 1,
    VAV Sys 1 Outlet Node;  ! Set Point Node

```

Group – Controllers

Controls (Air Loop and Zone Equipment)

A controller mimics the function of an actual physical controller in a somewhat rudimentary way. It can sense one node variable, compare it with its setpoint, and determine the desired value for another node variable. It should be noted that a controller cannot span a loop manager boundary (but a Setpoint Manager can). Thus, in an air loop (AirLoopHVAC), the

sensed node and the controlled device must be in the air loop simulation. This means that a single zone system cannot be modeled with a simple controller sensing zone temperature and controlling coil water flow. Instead this must be modeled as a Setpoint Manager sensing a zone temperature and resetting the supply air temperature setpoint each timestep. This is artificial but should simplify the control modeling task. It should also be noted that there are various types of controllers and that each controller might hook into loops in a slightly different way. As a result, each controller type is described separately below.

Controller:WaterCoil

This controller is really a solution inverter. For a water coil the simulation cannot be inverted where the mass flow rate of the water through the coil can be solved directly given an air temperature. Thus, this “controller” will numerically step through all of the water flow possibilities by an interval-halving technique until the mass flow rate is determined to meet the specified outlet air temperature within a specified user tolerance.

As the reader probably noted when reading the descriptions of the coil syntax shown earlier in this section, there were no controls attached directly to a particular component. This is because the input can be simplified somewhat by entering node names to be controlled. This avoids having to search through multiple lists of component types for the sake of simply controlling components. The Controller:WaterCoil shown below is a way of controlling variables at one node based on conditions at another node. After the identifying name for the controller, the user must define which control variable the controller is managing. These options include Temperature, Humidity Ratio, TemperatureAndHumidityRatio, or Flow.

The next parameter in the input syntax is the Action of the control, which determines how the controlled variable (e.g., mass flow rate through a water coil) is changed based on the control signal. The following input parameter is the actuator variable, which is currently limited to mass flow through a water coil.

The next two parameters in the input syntax are node names corresponding to the node that is being sensed and the actuated node which controls the water mass flow through the coil. For example, in the case of a cooling coil the control variable might be the outlet air temperature of the coil while the actuated variable might be the water flow rate through the coil. These two parameters are followed by the controller convergence tolerance. Finally, the last two input parameters represent the maximum and minimum values allowed for the actuated variable at the actuated node.

Field: Name

This is the unique name of the controller.

Field: Control Variable

This was setup to be generic but to date has only been used for temperature control, or temperature and humidity ratio control, of a water coil in the air loop simulation. The keyword Temperature is used for air temperature control and is normally specified for the coil’s outlet air node. The keyword TemperatureAndHumidityRatio is used for controlling both air temperature and high humidity levels, and is normally specified for a cooling coil’s outlet air node. The keyword HumidityRatio is used for humidity control and would normally be specified for a dehumidifier outlet node. The keyword Flow is used to control flow for pumps or fans and would typically be specified at the equipment’s outlet node.

Field: Action

The next input refers to the “action” of the control. This can be best described by an example. In a coil where water mass flow rate is to be controlled, a coil will increase the mass flow rate through the coil when more heating or cooling is requested. In a heating coil, this increases the value of heat transfer from the water to the air stream. As a result, this is considered a “Normal” action controller. In a cooling coil, an increase in water mass flow rate through the coil decreases the value of heat transfer from the water to the air stream (absolute value increases, but since cooling is traditionally described as a negative number, an increase in

absolute value results in a decrease in the actual heat transfer value). Thus, the cooling coil controller has “Reverse” action since an increase in flow rate results in a decrease in heat transfer.

Field: Actuator Variable

This was again meant to be more generic but currently has only been used to control the water mass flow rate of a heating or cooling coil. This actuator variable must be set to the keyword Flow to control the water mass flow rate.

Field: Sensor Node Name

Name of the node where the temperature, humidity ratio or flow is sensed.

Field: Actuator Node Name

Name of the actuated node that controls the water mass flow rate through the coil.

Field: Controller Convergence Tolerance

The coil is controlled by knowing the outlet temperature and/or humidity ratio specified by the setpoint managers, and setting the outlet conditions from the coil to meet these setpoints. The hot and chilled water coils use complex models that cannot be inverted directly. Therefore, to determine the correct mass flow rate for the hot or cold water the models are inverted numerically using an iterative procedure. The iterative solution uses an interval-halving routine and needs a termination criteria that is set with the Controller Convergence Tolerance parameter. The convergence tolerance is the maximum difference between the actual temperature at the setpoint node and the setpoint temperature. This control offset is set to a small temperature difference, such as 0.01 to denote 1/100 degree C. The default is 0.1 degree C.

Field: Maximum Actuated Flow

This is the maximum water flow (m^3/sec) through the coil. Set to the maximum design water flow for the coil.

Field: Minimum Actuated Flow

Set to the minimum design water flow (m^3/sec) for the water coil, normally a shut off valve that is set to zero.

```

Controller:WaterCoil,
  \min-fields 9
  A1 , \field Name
        \type alpha
        \required-field
        \reference AirLoopControllers
  A2 , \field Control Variable
        \type choice
        \key Temperature
        \key HumidityRatio
        \key TemperatureAndHumidityRatio
        \key Flow
        \note TemperatureAndHumidityRatio requires a SetpointManager:SingleZone:Humidity:Maximum object
  A3 , \field Action
        \type choice
        \key Normal
        \key Reverse
  A4 , \field Actuator Variable
        \type choice
        \key Flow
  A5 , \field Sensor Node Name
        \type alpha
  A6 , \field Actuator Node Name
        \type alpha
  N1 , \field Controller Convergence Tolerance
        \units deltaC
        \type real
        \default Autosize
        \autosizable
  N2 , \field Maximum Actuated Flow
        \type real
        \units m3/s
        \autosizable
  N3 ; \field Minimum Actuated Flow
        \type real
        \default 0.000001
        \units m3/s

```

An example of this object in an IDF, along with appropriate setpoint managers, is shown below:

```

Controller:WaterCoil,
  Central Cooling Coil Contoller 1,      !- Name
  TemperatureAndHumidityRatio,          !- Control Variable
  Reverse,                               !- Action
  Flow,                                  !- Actuator Variable
  VAV Sys 1 Outlet Node,                 !- Sensor Node Name
  Main Cooling Coil 1 Water Inlet Node, !- Actuator Node Name
  0.002,                                 !- Controller Convergence Tolerance {deltaC}
  0.025,                                 !- Maximum Actuated Flow {m3/s}
  0.0;                                   !- Minimum Actuated Flow {m3/s}

SetpointManager:SingleZone:Humidity:Maximum,
  Zone Max Set Point Manager,           !- Name
  ,                                     !- Control Variable
  ,                                     !- Schedule name
  VAV Sys 1 Outlet Node,                 !- Setpoint Node or NodeList Name
  Zone 2 Node;                           !- Control Zone Air Node Name

SetpointManager:Scheduled,
  Scheduled Set Point Manager 1,         !- Name
  Temperature,                           !- Control Variable
  Seasonal Reset Supply Air Temp Sch,    !- Schedule Name
  VAV Sys 1 Outlet Node;                 !- Setpoint Node or NodeList Name

```


Controller:OutdoorAir

A mixed air box has its own controller type called Controller:OutdoorAir. The purpose of the outdoor air controller is to provide outdoor air for ventilation and also provide free cooling (through additional outdoor air and/or bypassing an air-to-air heat exchanger) whenever possible. The outdoor air controller includes a number of user-selectable limit controls. If any of the selected limits are exceeded, the outdoor airflow rate is set to the minimum.

If all the limits are satisfied, the outdoor air controller does the following for continuous air flow systems: if the outdoor air temperature is greater than or equal to the mixed air temperature setpoint, the outdoor air flow rate is set to the maximum; if the outdoor air temperature is less than the mixed air temperature setpoint, the outdoor air controller will modulate the outdoor air flow so that the mixed air temperature will match the mixed air setpoint temperature.

A time-of-day schedule may also be used to simulate an increase in outdoor air flow rate for “push-button” type economizer applications. When the schedule permits (i.e., schedule values are greater than 0), the outdoor air flow rate is increased to the user-specified maximum outdoor air flow rate.

The outdoor air controller can also account for changes in the outdoor air flow rate during times when indoor humidity levels are high. A zone humidistat must be used with this control option. During high indoor humidity, the outdoor air flow rate is modified in response to a high indoor humidity condition. If high humidity control is based on the outdoor air humidity ratio and the outdoor humidity ratio is greater than the indoor humidity ratio, high humidity control is terminated. When the economizer is used in conjunction with the high humidity control option, high humidity control has priority and controls the change in air flow rates. The Night Cycle Availability Manager has priority over high humidity control and will use the controller’s maximum outdoor air flow rate when this Availability Manager cycles the fan on (Ref. System Availability Managers)

The mixed air box connections are defined separately in the **OutdoorAir:Mixer** object.

Although the mixer will commonly be connected directly to the outdoor air, other components may be placed on the outdoor air path upstream of the mixer. When this is the case, any modulation will be determined by the conditions at the inlet node of the mixer rather than the outdoor air. This means that the controller will account for any heat recovery or other preheating/precooling components that may modify the condition of outdoor air before it reaches the mixer.

If all the limits are satisfied, the outdoor air controller does the following for cycling fan systems: the outdoor air flow rate is set to the maximum when the fan cycles on. If the limits are not satisfied, the outdoor air flow rate is at the minimum when the fan cycles on.

Field: Name

The unique user-assigned name for an instance of an outdoor air controller. Any other object referencing this outdoor air controller will use this name.

Field: Relief Air Outlet Node Name

The name of the relief air node of the outdoor air mixer associated with this outdoor air controller.

Field: Return Air Node Name

The name of the return air node of the outdoor air mixer associated with this outdoor air controller.

Field: Mixed Air Node Name

Name of the node where the mixed air setpoint is set. The outdoor air controller senses the temperature at this node and attempts to control that temperature to the node setpoint.

Field: Actuator Node Name

The name of the node that is associated with the outdoor air damper. This should be the outermost air node on the outdoor air path connected to the outdoor air stream for the mixer associated with this outdoor air controller.

Field: Minimum Outdoor Air Flow Rate

Input for this field is the minimum outdoor air flow rate for the system in cubic meters per second.

Field: Maximum Outdoor Air Flow Rate

Input for this field is the maximum outdoor air flow rate for the system in cubic meters per second.

Field: Economizer Control Type

The options for this field are

- FixedDryBulb
- DifferentialDryBulb
- FixedEnthalpy
- DifferentialEnthalpy
- ElectronicEnthalpy
- FixedDewPointAndDryBulb
- DifferentialDryBulbAndEnthalpy
- NoEconomizer

Choosing **NoEconomizer** means the economizer will not operate and the outdoor airflow rate will be at the minimum for the entire simulation.

Choosing **FixedDryBulb** means the economizer will set the outdoor airflow rate at minimum if the outdoor air temperature is higher than a specified dry-bulb temperature limit.

Choosing **DifferentialDryBulb** will trigger the outdoor airflow to minimum when the dry-bulb temperature of outdoor air is higher than the dry-bulb temperature of the return air.

FixedEnthalpy checks the upper limit of the enthalpy given as a field input against the enthalpy content of outdoor air and will set the outdoor airflow rate to minimum if the latter is greater than the former.

DifferentialEnthalpy does the same thing but compares the return air enthalpy with the enthalpy of outdoor air. When the enthalpy of outdoor air is greater than the enthalpy of the return air, the outdoor air flow rate is set to minimum.

Choosing **ElectronicEnthalpy** enables the simulation to calculate the humidity ratio limit of outdoor air based on the dry-bulb temperature of outdoor air and a quadratic/cubic curve, and compare it to the actual outdoor air humidity ratio. If the actual outdoor humidity ratio is greater than the calculated humidity ratio limit, then the outdoor airflow rate is set to minimum.

Choosing **FixedDewPointAndDryBulb** compares both the outdoor dewpoint temperature and the outdoor dry-bulb temperature to their specified high limit values. If either outdoor temperature exceeds the high limit value, the outdoor airflow rate is set to minimum.

Another option **DifferentialDryBulbAndEnthalpy** enables the control strategy to be based on both the DifferentialDryBulb and DifferentialEnthalpy economizer control strategies.

In addition to all economizer control types listed above, each control type checks for user-entered values for the upper limit of dry-bulb temperature, enthalpy limit, humidity ratio limit and dewpoint limit. The outdoor air flow rate is set to minimum if any of these entered limits are exceeded.

The default for this field is **NoEconomizer**.

Field: Economizer Control Action Type

There are two choices for this field: **MinimumFlowWithBypass** and **ModulateFlow**, with the default being **ModuleFlow** if this input field is left blank.

ModulateFlow means the outdoor air flow rate will be increased to meet the mixed air setpoint temperature, subject to the limits imposed via other inputs for this object (e.g., Economizer Maximum Limit Dry-Bulb Temperature, Maximum Outdoor Air Flow Rate, etc.).

MinimumFlowWithBypass is used exclusively in conjunction with air-to-air heat exchanger:objects (Ref. HeatExchanger:*) for providing free cooling operation in the absence of a conventional air-side economizer (i.e., when outdoor air flow rate is not increased during economizer mode). The MinimumFlowWithBypass choice forces the outdoor air flow rate to always remain at the minimum. However, when high humidity control is used, the outdoor air flow rate is set to the product of the maximum outdoor air flow rate multiplied by the high humidity outdoor air flow ratio. The heat exchanger uses the limit checking in the outdoor air controller to decide whether or not to bypass the outdoor air around the heat exchanger – or turn off the wheel motor in the case of a rotary heat exchanger. Heat exchange is also suspended when high humidity control is active.

The **ModulateFlow** option can also be used with the HeatExchanger:AirToAir:FlatPlate or HeatExchanger:AirToAir:SensibleAndLatent objects.

Field: Economizer Maximum Limit Dry-Bulb Temperature

Input for this field is the outdoor air temperature high limit (°C) for economizer operation. If the outdoor air temperature is above this limit, the outdoor airflow rate will be set to the minimum. This field is required if Economizer Control Type 'FixedDryBulb' or 'FixedDewPointAndDryBulb' has been specified.

No input (blank) in this field means that there is no outdoor air temperature high limit control. This limit applies to the conditions at the Actuator Node regardless of whether or not there are any other components in the outdoor air path upstream of the mixer.

Field: Economizer Maximum Limit Enthalpy

Input for this field is the outdoor air enthalpy limit (in J/kg) for economizer operation. If the outdoor air enthalpy is above this value, the outdoor airflow rate will be set to the minimum. This field is required if Economizer Control Type 'FixedEnthalpy' has been specified.

No input (blank) in this field means that there is no outdoor air enthalpy limit control. This limit applies to the conditions at the Actuator Node regardless of whether or not there are any other components in the outdoor air path upstream of the mixer.

Field: Economizer Maximum Limit Dewpoint Temperature

Input for this field is the outdoor air dewpoint limit (°C) for economizer operation. If the outdoor air dewpoint temperature is above this value, the outdoor airflow rate will be set to the minimum. This field is required if the Economizer Control Type 'FixedDewPointAndDryBulb' has been specified.

No input (blank) in this field means that there is no outdoor air dewpoint limit control. This limit applies to the conditions at the Actuator Node regardless of whether or not there are any other components in the outdoor air path upstream of the mixer.

Field: Electronic Enthalpy Limit Curve Name

Input for this field is the name of a quadratic or cubic curve which provides the maximum outdoor air humidity ratio (function of outdoor air dry-bulb temperature) for economizer operation. If the outdoor air humidity ratio is greater than the curve's maximum humidity ratio (evaluated at the outdoor air dry-bulb temperature), the outdoor air flow rate will be set to the minimum. This limit applies to the conditions at the Actuator Node regardless of whether or not there are any other components in the outdoor air path upstream of the mixer. No input (blank) in this field means that there is no electronic enthalpy limit control.

Field: Economizer Minimum Limit Dry-Bulb Temperature

Input for this field is the outdoor air temperature low limit (°C) for economizer operation. If the outdoor air temperature is below this limit, the outdoor airflow rate will be set to the minimum.

No input (blank) in this field means that there is no outdoor air temperature low limit control. This limit applies to the conditions at the Actuator Node regardless of whether or not there are any other components in the outdoor air path upstream of the mixer.

Field: Lockout Type

Choices for this field are NoLockout, LockoutWithHeating, and LockoutWithCompressor. This field is used for packaged systems with DX coils. LockoutWithHeating means that if the packaged unit is in heating mode, the economizer is locked out – i.e., the economizer dampers are closed and there is minimum outdoor air flow. LockoutWithCompressor means that in addition to locking out the economizer when the unit is in heating mode the economizer is locked out when the DX unit compressor is operating to provide cooling. In other words, the economizer must meet the entire cooling load – it isn't allowed to operate in conjunction with the DX cooling coil. This option (LockoutWithCompressor) is sometimes called a “nonintegrated” economizer.

The default is NoLockout.

Field: Minimum Limit Type

Choices for this field are FixedMinimum or ProportionalMinimum. FixedMinimum means that the minimum outdoor airflow rate is fixed no matter what the actual system flow rate is. ProportionalMinimum means the minimum outdoor airflow rate varies in proportion to the total system air flow rate. The default is ProportionalMinimum.

Field: Minimum Outdoor Air Schedule Name

The name of a schedule whose values are decimal fractions (0.0 – 1.0) that multiply the minimum outdoor air fraction. This schedule is useful for reducing the outdoor air flow rate to zero during unoccupied or start up hours. If this field is not input, the minimum outdoor air flow rate remains constant during the simulation period.

Field: Minimum Fraction of Outdoor Air Schedule Name

This is an optional field with the schedule values in decimal fractions (0.0-1.0). This field enables the user to limit the minimum amount of outdoor air permissible and thus also helps in getting at least the minimum amount of air in.

Field: Maximum Fraction of Outdoor Air Schedule Name

This is an optional field with the schedule values in decimal fractions (0.0-1.0). This field enables the user to limit the maximum of amount of outdoor air permissible and thus also limits the permissible maximum outdoor air into the system.

If both the above schedules are given values of 1.0, the system works at 100% outdoor air, so in a system if 100% outdoor air is required regardless of any other condition, these fields are helpful.

Field: Mechanical Ventilation Controller Name

This optional field is the name of the mechanical ventilation controller object to be used in conjunction with this outdoor air controller. The Controller:MechanicalVentilation object allows the user to define the minimum outdoor air flow rate based on air flow per unit floor area and air flow per person (occupant) for the zones being served by the air loop that utilizes this controller.

This feature allows the user to perform a first-order evaluation of carbon dioxide(CO₂)-based demand controlled ventilation (outdoor ventilation varied according to occupancy levels).

If a valid name for a Controller:MechanicalVentilation object is entered in this field, the minimum outdoor air flow rate delivered will be the greater of:

- the minimum outdoor air flow rate calculated by the fields Minimum Outdoor Air Flow Rate, Minimum Limit Type, and Minimum Outdoor Air Schedule Name as defined for this outdoor air controller, or
- the outdoor air flow rate calculated using the Controller:MechanicalVentilation object named in this input field.

Leaving this input field blank will bypass the Controller:MechanicalVentilation object calculations and the minimum outdoor air flow rate will be based on the other inputs associated with this outdoor air controller object. Actual outdoor air flow rates may be higher than the minimum if free cooling is available and the object inputs are properly selected. Regardless, the maximum outdoor air flow rate is limited by the field Maximum Outdoor Air Flow Rate.

Field: Time of Day Economizer Control Schedule Name

This alpha field is the name of a schedule which controls the outdoor air flow rate based on a time-of-day economizer. Schedule values equal to 0 disable this feature. Schedule values greater than 0 cause the outdoor air flow rate to increase to the maximum. When an economizer is used in conjunction with the high humidity control option, high humidity control has priority.

Field: High Humidity Control

This choice field establishes whether or not the outdoor air flow rate is modified in response to high indoor relative humidity. Valid choices are Yes and No. If Yes is selected, the outdoor air flow rate may be modified when the indoor relative humidity is above the humidstat setpoint. If No is selected, this option is disabled and the following three fields are not used.

Field: Humidistat Control Zone Name

This input defines the zone name where the humidistat is located. This is the same name used in the ZoneControl:Humidistat object. This field is required when the input field High Humidity Control is specified as Yes.

Field: High Humidity Outdoor Air Flow Ratio

This input is the ratio of the modified outdoor air flow rate to the maximum outdoor air flow rate. When the high humidity control algorithm determines that the outdoor air flow rate will be changed (i.e., increased or decreased), the operating outdoor air flow rate is equal to the maximum outdoor air flow rate multiplied by this ratio. The minimum value for this field is 0. If this field is blank, the default value is 1. This field is used only when the input field High Humidity Control is specified as Yes. When an economizer is used in conjunction with the high humidity control option, high humidity control has priority.

Field: Control High Indoor Humidity Based on Outdoor Humidity Ratio

This choice field determines if high humidity control is activated based on high indoor relative humidity alone or is activated only when the indoor relative humidity is above the humidstat setpoint *and* the indoor humidity ratio is greater than the outdoor humidity ratio. Valid choices are Yes and No. If No is selected, high humidity control is active any time the zone humidistat senses a moisture load. If Yes is selected, the model also verifies that the outdoor humidity ratio is less than the humidistat's zone air humidity ratio. This field is used only when the input field High Humidity Control is specified as Yes.

The default value is Yes.

The full IDD Specifications follows:

```

Controller:OutdoorAir,
  \min-fields 16
  A1 , \field Name
        \type alpha
        \required-field
        \reference AirLoopControllers
  A2 , \field Relief Air Outlet Node Name
        \type alpha
        \required-field
  A3 , \field Return Air Node Name
        \type alpha
        \required-field
  A4 , \field Mixed Air Node Name
        \type alpha
        \required-field
  A5 , \field Actuator Node Name
        \type alpha
        \required-field
        \note Outdoor air inlet node entering the first pre-treat component if any
  N1 , \field Minimum Outdoor Air Flow Rate
        \type real
        \required-field
        \units m3/s
        \autosizable
  N2 , \field Maximum Outdoor Air Flow Rate
        \type real
        \required-field
        \units m3/s
        \autosizable
  A6 , \field Economizer Control Type
        \type choice
        \key FixedDryBulb
        \key FixedEnthalpy
        \key DifferentialDryBulb
        \key DifferentialEnthalpy
        \key FixedDewPointAndDryBulb
        \key ElectronicEnthalpy
        \key DifferentialDryBulbAndEnthalpy
        \key NoEconomizer
        \default NoEconomizer
  A7 , \field Economizer Control Action Type
        \type choice
        \key ModulateFlow
        \key MinimumFlowWithBypass
        \default ModulateFlow
  N3 , \field Economizer Maximum Limit Dry-Bulb Temperature
        \type real
        \units C
        \note Enter the maximum outdoor dry-bulb temperature limit for FixedDryBulb
        \note economizer control type. No input or blank input means this limit is
        \note not operative. Limit is applied regardless of economizer control type.
  N4 , \field Economizer Maximum Limit Enthalpy
        \type real
        \units J/kg
        \note Enter the maximum outdoor enthalpy limit for FixedEnthalpy economizer control type.
        \note No input or blank input means this limit is not operative
        \note Limit is applied regardless of economizer control type.
  N5 , \field Economizer Maximum Limit Dewpoint Temperature
        \type real
        \units C
        \note Enter the maximum outdoor dewpoint temperature limit for FixedDewPointAndDryBulb
        \note economizer control type. No input or blank input means this limit is not operative.
        \note Limit is applied regardless of economizer control type.
  A8 , \field Electronic Enthalpy Limit Curve Name
        \type object-list
        \object-list QuadraticCubicCurves
        \note Enter the name of a quadratic or cubic curve which defines the maximum outdoor
        \note humidity ratio (function of outdoor dry-bulb temperature) for ElectronicEnthalpy
        \note economizer control type. No input or blank input means this limit is not operative
        \note Limit is applied regardless of economizer control type.
  N6 , \field Economizer Minimum Limit Dry-Bulb Temperature

```

```

\type real
\units C
\note Enter the minimum outdoor dry-bulb temperature limit for economizer control.
\note No input or blank input means this limit is not operative
\note Limit is applied regardless of economizer control type.
A9 , \field Lockout Type
\type choice
\key NoLockout
\key LockoutWithHeating
\key LockoutWithCompressor
\default NoLockout
A10, \field Minimum Limit Type
\type choice
\key FixedMinimum
\key ProportionalMinimum
\default ProportionalMinimum
A11, \field Minimum Outdoor Air Schedule Name
\type object-list
\object-list ScheduleNames
\note Schedule values multiply the minimum outdoor air flow rate
A12, \field Minimum Fraction of Outdoor Air Schedule Name
\type object-list
\object-list ScheduleNames
\note schedule values multiply the design/mixed air flow rate
A13, \field Maximum Fraction of Outdoor Air Schedule Name
\type object-list
\object-list ScheduleNames
\note schedule values multiply the design/mixed air flow rate
A14, \field Mechanical Ventilation Controller Name
\note Enter the name of a Controller:MechanicalVentilation object.
\type alpha
\note Optional field for defining outdoor ventilation air based on flow rate per unit floor
\note area and flow rate per person. Simplified method of demand-controlled ventilation.
A15, \field Time of Day Economizer Control Schedule Name
\type object-list
\object-list ScheduleNames
\note Optional schedule to simulate "push-button" type economizer control.
\note Schedule values greater than 0 indicate time-of-day economizer control is enabled.
\note Economizer control may be used with or without the high humidity control option.
\note When used together, high humidity control has priority over economizer control.
\note If the field Economizer Control Type = NoEconomizer, then this option is disabled.
A16, \field High Humidity Control
\type choice
\key Yes
\key No
\default No
\note Optional field to enable modified outdoor air flow rates based on zone relative humidity.
\note Select Yes to modify outdoor air flow rate based on a zone humidistat.
\note Select No to disable this feature.
\note If the field Economizer Control Type = NoEconomizer, then this option is disabled.
A17, \field Humidistat Control Zone Name
\type object-list
\object-list ZoneNames
\note Enter the name of the zone where the humidistat is located.
\note This field is only used when the field High Humidity Control = Yes.
N7 , \field High Humidity Outdoor Air Flow Ratio
\type real
\minimum> 0.0
\default 1.0
\note Enter the ratio of outdoor air to the maximum outdoor air flow rate when modified air
\note flow rates are active based on high indoor humidity.
\note The minimum value must be greater than 0.
\note This field is only used when the field High Humidity Control = Yes.
A18; \field Control High Indoor Humidity Based on Outdoor Humidity Ratio
\type choice
\key Yes
\key No
\default Yes
\note If No is selected, the outdoor air flow rate is modified any time indoor relative
\note humidity is above the humidistat setpoint. If Yes is selected, the outdoor air
\note flow rate is modified any time the indoor relative humidity is above the humidistat

```

\note setpoint and the outdoor humidity ratio is less than the indoor humidity ratio.
 \note This field is only used when the field High Humidity Control = Yes.

An Example IDF specification:

```

Controller:OutdoorAir,
  OA Controller 1,           !- Name
  Relief Air Outlet Node,    !- Relief Air Outlet Node Name
  Outdoor Air Mixer Inlet Node, !- Return Air Node Name
  Mixed Air Node,           !- Mixed Air Node Name
  Outdoor Air Inlet Node,    !- Actuator Node Name
  0.25,                     !- Minimum Outdoor Air Flow Rate {m3/s}
  1.6,                      !- Maximum Outdoor Air Flow Rate {m3/s}
  ElectronicEnthalpy,       !- Economizer Control Type
  ModulateFlow,             !- Economizer Control Action Type
  23.,                      !- Economizer Maximum Limit Dry-Bulb Temperature (C)
  ,                          !- Economizer Maximum Limit Enthalpy {J/kg}
  13.5,                    !- Economizer Maximum Limit Dewpoint Temperature (C)
  ElectronicEnthalpyCurveA, !- Electronic Enthalpy Limit Curve Name
  14.,                      !- Economizer Minimum Limit Dry-Bulb Temperature (C)
  NoLockout,               !- Lockout Type
  FixedMinimum,            !- Minimum Limit Type
  OAFractionSched,         !- Minimum Outdoor Air Schedule Name
  ,                          !- Minimum Fraction of Outdoor Air Schedule Name
  ,                          !- Maximum Fraction of Outdoor Air Schedule Name
  ,                          !- Mechanical Ventilation Controller Name
  TimeOfDayEconomizerSch,  !- Time of Day Economizer Control Schedule Name
  Yes,                     !- High Humidity Control
  EAST_ZONE,               !- Humidistat Control Zone Name
  0.9,                     !- High Humidity Outdoor Air Flow Ratio
  Yes;                     !- Control High Indoor Humidity Based on Outdoor Humidity Ratio

Curve:Cubic,
  ElectronicEnthalpyCurveA, !- Name
  0.01342704,              !- Coefficient1 Constant
  -0.00047892,            !- Coefficient2 x
  0.000053352,            !- Coefficient3 x**2
  -0.0000018103,          !- Coefficient4 x**3
  16.6,                   !- Minimum Value of x
  29.13;                  !- Maximum Value of x

```

Controller:OutdoorAir Outputs

```

HVAC,Average,AirLoopHVAC Outdoor Air Economizer Status
HVAC,Average,AirLoopHVAC Outdoor Air High Humidity Control Status
HVAC,Average,AirLoopHVAC Actual Outdoor Air Fraction
HVAC,Average,AirLoopHVAC Minimum Outdoor Air Fraction
HVAC,Average,AirLoopHVAC Outdoor Air Mass Flow Rate [kg/s]
HVAC,Average,AirLoopHVAC Mixed Air Mass Flow Rate [kg/s]

```

Field: AirLoopHVAC Outdoor Air Economizer Status

Reports the average operating status of an air economizer over the reporting interval. The economizer status is set to 1 when the conditions are favorable for the economizer to operate (i.e., none of the control limits have been exceeded). While conditions may be favorable for economizer operation, it does not guarantee that the air-side economizer has increased outdoor air flow above the minimum level since the actual outdoor air flow rate is also governed by other controls (e.g., mixed air set point temperature, time of day economizer control, maximum humidity setpoint, etc.). This variable is set to 0 if conditions disable economizer operation or NoEconomizer (Economizer Control Type) is specified.

Field: AirLoopHVAC Outdoor Air High Humidity Control Status

Reports the average operating status of the controller's high humidity control over the reporting interval. The high humidity control status is set to 1 when the controller determines that a zone high humidity condition exists *according to the settings specified in the controller*.

This variable is set to 0 if conditions disable high humidity control operation or High Humidity Control is specified as No.

Field: AirLoopHVAC Actual Outdoor Air Fraction

Reports the average actual outdoor air fraction for the outdoor air controller over the reporting interval.

Field: AirLoopHVAC Minimum Outdoor Air Fraction

Reports the average minimum limit of the outdoor air fraction for the outdoor air controller over the reporting interval.

Field: AirLoopHVAC Outdoor Air Mass Flow Rate [kg/s]

Reports the average outdoor air mass flow rate introduced by the outdoor air controller over the reporting interval.

Field: AirLoopHVAC Mixed Air Mass Flow Rate [kg/s]

Reports the average mixed air mass flow rate of the HVAC air loop associated with this outdoor air controller over the reporting interval.

Controller:MechanicalVentilation

This object is used in conjunction with an outdoor air controller (Ref. Controller:OutdoorAir, Field: Mechanical Ventilation Controller Name) to establish the minimum outdoor air flow rate provided by a mixed air box.

Ventilation standards provide guidance on appropriate levels of outdoor ventilation air required for acceptable indoor air quality. The Ventilation Rate Procedure (VRP) of ASHRAE Standard 62.1-2007 (www.ashrae.org) requires outdoor ventilation rates to be determined based on the floor area of each occupied zone plus the number of people in each zone and considers the zone air distribution effectiveness and system ventilation efficiency. The outdoor air ventilation rate can be reset dynamically as operating conditions change (e.g., variations in occupancy). The Controller:MechanicalVentilation object implements the VRP for calculating these outdoor air ventilation requirements and resetting them based on varying occupancy levels and zone diversification. This is particularly useful for large air distribution systems that serve a number of different zone types with varying occupancy levels.

The first four inputs for this object are the name, the availability schedule, the zone outdoor air method, and the system outdoor air method. The next six input fields define the zone name (or zone list name), the ventilation rate per unit floor area, the ventilation rate per occupant, zone air distribution effectiveness in cooling mode, zone air distribution effectiveness in heating mode, and zone air distribution effectiveness schedule name to be applied to this zone (or zone list). The last six fields are extensible. If the zone air distribution effectiveness schedule is specified, the other two filed inputs will be ignored - zone air distribution effectiveness in cooling mode, and zone air distribution effectiveness in heating mode.

Field: Name

The unique user assigned name for an instance of mechanical ventilation. Any other object referencing this mechanical ventilation object will use this name.

Field: Availability Schedule Name

The name of a schedule whose values are greater than 0 when mechanical ventilation, as calculated by this object, is desired. If this field is left blank, outdoor ventilation occurs according to the parameters specified in the Controller:OutdoorAir object as if the Controller:MechanicalVentilation object has not been specified. This schedule is useful for purging the building of contaminants prior to occupancy (i.e., ventilation rate per unit floor area will be provided even if the occupancy is zero).

Field: Zone Outdoor Air Method

The method used to calculate the zone minimum outdoor air flow. Two choices are Sum and Maximum of the occupant based outdoor air flow and the floor area based outdoor air flow.

Field: System Outdoor Air Method

The method used to calculate the system minimum outdoor air flow. Two choices are ZoneSum and VRP. ZoneSum sums the outdoor air flows across all zones served by the system, which is the method used in EnergyPlus 3.0. VRP uses the multi-zone equations defined in 62.1-2007 to calculate the system outdoor air flow. VRP considers zone air distribution effectiveness and zone diversification of outdoor air fractions.

Field Set (Zone Name, Ventilation Rate per Unit Floor Area, Ventilation Rate Per Occupant, Zone Air Distribution Effectiveness in Cooling Mode, Zone Air Distribution Effectiveness in Heating Mode, and Zone Air Distribution Effectiveness Schedule Name)

The following six fields are needed to define the parameters for the ventilation. This object is extensible by duplicating these six fields.

Field: Zone<x> Name

The zone name or zone list to apply the ventilation rates specified in the next two input fields.

Field: Ventilation Rate per Unit Floor Area <x>

The numeric input for this field is the volumetric air flow rate ($\text{m}^3/\text{s}\cdot\text{m}^2$) of outdoor air to be delivered per square meter of floor area for the zone specified in the previous field. This field helps determine the minimum outdoor air flow that is provided by the air loop that utilizes this mechanical ventilation object in conjunction with an outdoor air controller. The model automatically determines the total zone floor area based on the Zone object(s), the zone and zone list multipliers (Zone and ZoneGroup objects), and the air loop connections to the occupied zones.

Field: Ventilation Rate per Occupant <x>

The numeric input for this field is the volumetric air flow rate ($\text{m}^3/\text{sec}\cdot\text{person}$) of outdoor air to be delivered per occupant. This field helps establish the minimum outdoor air flow that is provided by the air loop that utilizes this mechanical ventilation object in conjunction with an outdoor air controller. The model automatically determines the total number of occupants based on the People object(s), the zone and zone list multipliers (Zone and ZoneGroup objects), and the air loop connections to the occupied zones.

Field: Zone Air Distribution Effectiveness in Cooling Mode <x>

The positive numeric input for this field is the zone air distribution effectiveness when the zone is in cooling mode. ASHRAE Standard 62.1-2007 provides typical values.

Field: Zone Air Distribution Effectiveness in Heating Mode <x>

The positive numeric input for this field is the zone air distribution effectiveness when the zone is in heating mode. ASHRAE Standard 62.1-2007 provides typical values as follows:

Zone Air Distribution Effectiveness

Air Distribution Configuration	E_z
Ceiling supply of cool air	1.0
Ceiling supply of warm air and floor return	1.0
Ceiling supply of warm air 15°F (8°C) or more above space temperature and ceiling return.	0.8
Ceiling supply of warm air less than 15°F (8°C) above space temperature and ceiling return provided that the 150 fpm (0.8 m/s) supply air jet reaches to within 4.5 ft (1.4 m) of floor level. Note: For lower velocity supply air, $E_z = 0.8$.	1.0
Floor supply of cool air and ceiling return provided that the 150 fpm (0.8 m/s) supply jet reaches 4.5 ft (1.4 m) or more above the floor. Note: Most underfloor air distribution systems comply with this proviso.	1.0
Floor supply of cool air and ceiling return, provided low-velocity displacement ventilation achieves unidirectional flow and thermal stratification	1.2
Floor supply of warm air and floor return	1.0
Floor supply of warm air and ceiling return	0.7

Figure 116. Controller:MechanicalVentilation Zone Air Distribution Effectiveness (Source: ASHRAE Standard 62.1-2007)

Field: Zone Air Distribution Effectiveness Schedule Name <x>

This optional field input points to a schedule with values of zone air distribution effectiveness. It provides a more flexible way of specifying zone air distribution effectiveness if it changes with time and/or system operating status and controls. If the schedule is specified, the zone air distribution effectiveness in cooling mode and heating mode will be ignored.

As described previously, the Controller:MechanicalVentilation object works in conjunction with Controller:OutdoorAir. As such, the minimum quantity of outdoor air delivered via the mixed air box will be the greater of:

- the minimum outdoor air flow rate calculated by the fields Minimum Outdoor Air Flow Rate, Minimum Limit and Minimum Outdoor Air Schedule Name in the associated Controller:OutdoorAir object, or
- the outdoor air flow rate calculated by the VRP (details in the Engineering Reference) with inputs specified in this object.

The actual outdoor air flow rate may be higher than the minimum if free cooling is available. Regardless, the outdoor air flow rate will not exceed the Maximum Outdoor Air Flow Rate specified in the associated Controller:OutdoorAir object.

The full IDD specification follows:

Controller:MechanicalVentilation,

```

\memo This object is used in conjunction with Controller:OutdoorAir to specify outdoor
\memo ventilation air based on flow rate per unit floor area and flow rate per person.
\memo The Controller:OutdoorAir object is associated with a specific air loop, so the
\memo outdoor air flow rates specified in Controller:MechanicalVentilation correspond to the zones
\memo attached to that specific air loop.
\min-fields 10
\extensible:6 - repeat last six fields, remembering to remove ; from "inner" fields.
\note Duplicate groups of Zone name, Ventilation rate per unit floor area, Ventilation rate per
\note occupant, Zone Air Distribution Effectiveness in cooling mode, Zone Air Distribution
\note Effectiveness in heating mode, and Zone Air Distribution Effectiveness Schedule to increase
\note allowable number of entries
A1, \field Name
    \required-field
    \type alpha
A2, \field Availability Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
    \note Schedule values greater than 0 indicate mechanical ventilation is enabled
A3, \field Zone Outdoor Air Method
    \type choice
    \key Sum
    \key Maximum
A4, \field System Outdoor Air Method
    \type choice
    \key ZoneSum
    \key VRP
A5, \field Zone 1 Name
    \required-field
    \type object-list
    \object-list ZoneAndZoneListNames
    \note A zone name or a zone list name may be used here
N1, \field Ventilation Rate per Unit Floor Area 1
    \required-field
    \type real
    \units m3/s-m2
    \minimum 0.0
    \note 0.000508 m3/s-m2 corresponds to 0.1 ft3/min-ft2
N2, \field Ventilation Rate per Occupant 1
    \required-field
    \type real
    \units m3/s-person
    \minimum 0.0
    \note 0.00236 m3/s-person corresponds to 5 ft3/min-person
N3, \field Zone Air Distribution Effectiveness in Cooling Mode 1
    \type real
    \default 1.0
    \minimum> 0.0
    \units dimensionless
N4, \field Zone Air Distribution Effectiveness in Heating Mode 1
    \type real
    \default 1.0
    \minimum> 0.0
    \units dimensionless
A6, \field Zone Air Distribution Effectiveness Schedule Name 1
    \type object-list
    \object-list ScheduleNames
    \note optionally used to replace Zone Air Distribution Effectiveness in Cooling and
    \note Heating Mode
A7, \field Zone 2 Name
    \type object-list
    \object-list ZoneAndZoneListNames
    \note A zone name or a zone list name may be used here
N5, \field Ventilation Rate per Unit Floor Area 2
    \type real
    \units m3/s-m2
    \minimum 0.0
    \note 0.000508 m3/s-m2 corresponds to 0.1 ft3/min-ft2
N6, \field Ventilation Rate per Occupant 2
    \type real

```

```

\units m3/s-person
\minimum 0.0
\note 0.00236 m3/s-person corresponds to 5 ft3/min-person
N7, \field Zone Air Distribution Effectiveness in Cooling Mode 2
\type real
\default 1.0
\minimum> 0.0
\units dimensionless
N8, \field Zone Air Distribution Effectiveness in Heating Mode 2
\type real
\default 1.0
\minimum> 0.0
\units dimensionless
A8, \field Zone Air Distribution Effectiveness Schedule Name 2
\type object-list
\object-list ScheduleNames
\note optionally used to replace Zone Air Distribution Effectiveness in Cooling and
\note Heating Mode
..continues up to 50 groups and is extensible

```

An example input for this object is shown below:

```

Controller:MechanicalVentilation,
  VentObject,          !- Name
  VentSchedule,       !- Availability Schedule Name
  Sum,                 !- Zone Outdoor Air Method
  VRP,                 !- System Outdoor Air Method
  Resistive Zone,     !- Zone 1 Name
  0.000381,           !- Ventilation Rate Per Unit Floor Area 1 {m3/s-m2}
  0.002952,           !- Ventilation Rate Per Occupant 1 {m3/s-person}
  1.0,                !- Zone Air Distribution Effectiveness in Cooling Mode 1
  1.0,                !- Zone Air Distribution Effectiveness in Heating Mode 1
  ,                   !- Zone Air Distribution Effectiveness Schedule Name 1
  DCV Zone List,      !- Zone 2 Name
  0.000407,           !- Ventilation Rate Per Unit Floor Area 2 {m3/s-m2}
  0.003149,           !- Ventilation Rate Per Occupant 2 {m3/s-person}
  1.2,                !- Zone Air Distribution Effectiveness in Cooling Mode 2
  0.7,                !- Zone Air Distribution Effectiveness in Heating Mode 2
  ;                   !- Zone Air Distribution Effectiveness Schedule Name 2

ZoneList,
  DCV Zone List,      !- Zone List Name
  East Zone,          !- Zone Name 1
  North Zone;         !- Zone Name 2

```

ZoneHVAC:EnergyRecoveryVentilator:Controller

This controller object is used exclusively by the stand alone energy recovery ventilator (ZoneHVAC:EnergyRecoveryVentilator, see Figure 117). The purpose of this controller is to simulate economizer operation for the stand alone ERV and provide free cooling whenever possible or modify the outdoor air flow rate during high indoor humidity conditions. During economizer operation, if all of the limits are satisfied, the controller activates economizer mode (fully bypassing the fixed-plate air-to-air heat exchanger or stopping the rotation of a rotary heat exchanger). If any of the selected limits are exceeded, economizer operation is terminated. A time-of-day schedule may also be used to simulate a “push-button” type economizer controller.

In addition, the outdoor air flow rate may be modified and heat exchange suspended in response to high indoor relative humidities. When the indoor relative humidity exceeds the zone humidistat’s relative humidity set point, high humidity control is activated. When activated, if high humidity control is based on the outdoor air humidity ratio and the outdoor humidity ratio is greater than the indoor humidity ratio, high humidity control is terminated.

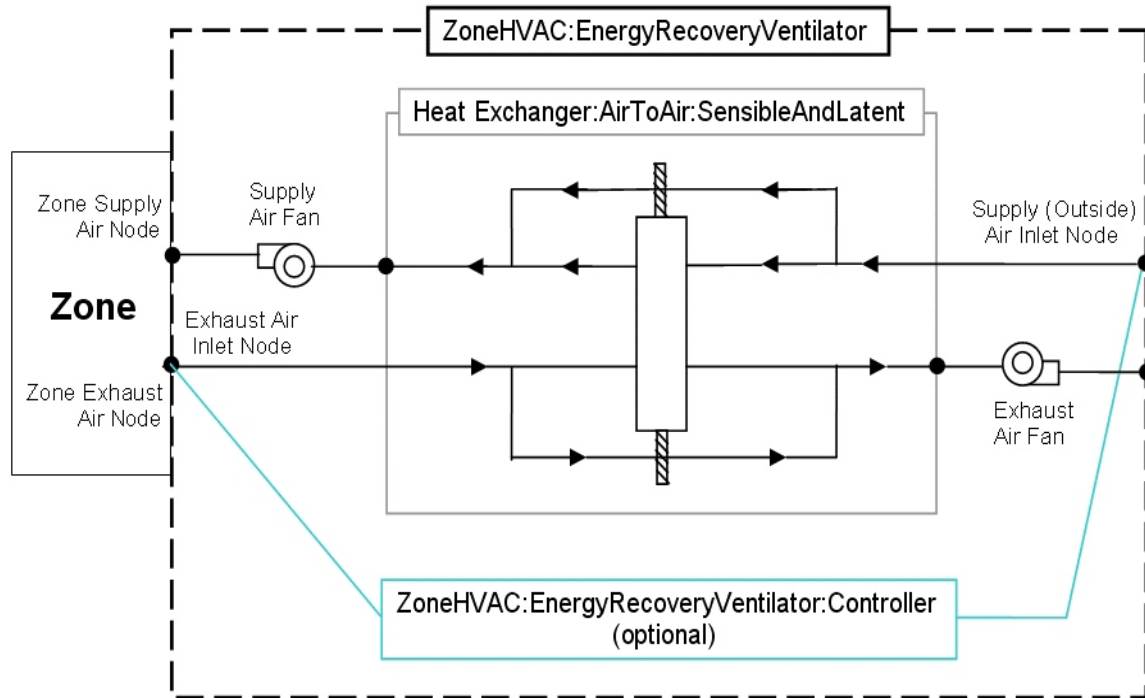


Figure 117. Schematic of the ZoneHVAC:EnergyRecoveryVentilator compound object

Field: Name

A unique user-assigned name for the stand alone ERV controller. Any reference to this controller by another object will use this name.

Field: Temperature High Limit

The input for this field is the outdoor air temperature high limit ($^{\circ}\text{C}$) for economizer operation. If the outdoor air temperature is above this limit, economizer (free cooling) operation is terminated. No input (blank) in this field means that there is no outdoor air temperature high limit control.

Field: Temperature Low Limit

The input for this field is the outdoor air temperature low limit ($^{\circ}\text{C}$) for economizer operation. If the outdoor air temperature is below this limit, economizer (free cooling) operation is terminated. No input (blank) in this field means that there is no outdoor air temperature low limit control.

Field: Enthalpy High Limit

The input for this field is the outdoor air enthalpy limit (in J/kg) for economizer operation. If the outdoor air enthalpy is above this value, economizer (free cooling) operation is terminated. No input (blank) in this field means that there is no outdoor air economizer limit control.

Field: Dewpoint Temperature Limit

Input for this field is the outdoor air dewpoint limit ($^{\circ}\text{C}$) for economizer operation. If the outdoor air dewpoint temperature is above this value, the outdoor airflow rate will be set to the minimum. No input (blank) in this field means that there is no outdoor air dewpoint limit control. This limit applies to the conditions at the Actuated Node regardless of whether or not there are any other components on the outdoor air path upstream of the mixer.

Field: Electronic Enthalpy Limit Curve Name

Input for this field is the name of a quadratic or cubic curve which provides the maximum outdoor air humidity ratio (function of outdoor air dry-bulb temperature) for economizer operation. If the outdoor air humidity ratio is greater than the curve's maximum humidity ratio (evaluated at the outdoor air dry-bulb temperature), the outdoor air flow rate will be set to the minimum. This limit applies to the conditions at the Actuated Node regardless of whether or not there are any other components on the outdoor air path upstream of the mixer. No input (blank) in this field means that there is no electronic enthalpy limit control.

Field: Exhaust Air Temperature Limit

This input establishes whether or not there is a limit control on the exhaust air temperature. The choices are **ExhaustAirTemperatureLimit** or **NoExhaustAirTemperatureLimit**. If **ExhaustAirTemperatureLimit** is chosen, the controller deactivates economizer mode whenever the outdoor air temperature is greater than the exhaust air temperature. If **NoExhaustAirTemperatureLimit** is chosen, no limit check on the exhaust air temperature is performed.

Field: Exhaust Air Enthalpy Limit

This input establishes whether or not there is a limit control on the exhaust air enthalpy. The choices are **ExhaustAirEnthalpyLimit** or **NoExhaustAirEnthalpyLimit**. If **ExhaustAirEnthalpyLimit** is chosen, the controller deactivates economizer mode whenever the outdoor air enthalpy is greater than the exhaust air enthalpy. If **NoExhaustAirEnthalpyLimit** is chosen, no limit check on the exhaust air enthalpy is performed.

Field: Time of Day Economizer Flow Control Schedule Name

This alpha field is the name of a schedule which controls the change in air flow rate based on time-of-day. Schedule values equal to 0 disable this feature. Schedule values greater than 0 activate the economizer. Note that heat exchange between the air streams is suspended when the economizer is active. This schedule can be used with or without the high humidity control option. When an economizer is used in conjunction with the high humidity control option, high humidity control has priority.

Field: High Humidity Control Flag

This optional choice field establishes whether or not the supply and exhaust air flow rates are modified in response to high indoor relative humidity. Valid choices are Yes and No. If Yes is selected, the supply and exhaust air flow rates may be modified when the indoor relative humidity is above the humidstat set point. If No is selected, this option is disabled and the following three fields are not used. Note that heat exchange between the air streams is suspended during times when high humidity control is active. The default value is No.

Field: Humidistat Control Zone Name

This optional input defines the zone name where the humidistat is located. This is the same zone name used in the Zone Control:Humidistat object. This field is required when the High Humidity Control Flag is specified as Yes.

Field: High Humidity Outdoor Air Flow Ratio

This optional input is the ratio of the modified supply (outdoor) air flow rate to the supply air flow rate specified in the Energy Recovery Ventilator:Stand Alone ERV object. When the high humidity control algorithm determines that the supply air flow rate will be changed (i.e. increased or decreased), the operating supply air flow rate is equal to the supply air flow rate specified in the Energy Recovery Ventilator:Stand Alone ERV object multiplied by this ratio. The minimum value for this field is 0. This field is used to modify both the supply and exhasut air flow rates when high humidity control is active. The supply and exhasut air fan volumetric

flow rates must be able to account for the increase in air flow when this input is greater than 1. The default value is 1.

Field: Control High Indoor Humidity based on Outdoor Humidity Ratio

This optional choice field determines if high humidity control is activated based on high indoor relative humidity alone or is activated only when the indoor relative humidity is above the humidstat set point *and* the outdoor humidity ratio is less than the indoor humidity ratio. Valid choices are Yes and No. If No is selected, high humidity control is active any time the zone humidstat senses a moisture load. If yes is selected, the model also verifies that the outdoor humidity ratio is less than the humidstat's zone air humidity ratio. This field is used only when the High Humidity Control Flag is specified as Yes. The default value is Yes.

The full IDD specification follows:

```

ZoneHVAC:EnergyRecoveryVentilator:Controller,
    \memo This controller is used exclusively by the ZoneHVAC:EnergyRecoveryVentilator object
    \memo to allow economizer (free cooling) operation when possible.
    \min-fields 3
A1 , \field Name
    \required-field
    \type alpha
    \reference ControllerStandAloneEnergyRecoveryVentilator
N1 , \field Temperature High Limit
    \type real
    \units C
    \note Enter the maximum outdoor dry-bulb temperature limit for economizer operation.
    \note No input or blank input means this limit is not operative
N2 , \field Temperature Low Limit
    \type real
    \units C
    \note Enter the minimum outdoor dry-bulb temperature limit for economizer operation.
    \note No input or blank input means this limit is not operative
N3 , \field Enthalpy High Limit
    \type real
    \units J/kg
    \note Enter the maximum outdoor enthalpy limit for economizer operation.
    \note No input or blank input means this limit is not operative
N4 , \field Dewpoint Temperature Limit
    \type real
    \units C
    \note Enter the maximum outdoor dewpoint temperature limit for economizer operation.
    \note No input or blank input means this limit is not operative
A2 , \field Electronic Enthalpy Limit Curve Name
    \type object-list
    \object-list QuadraticCubicCurves
    \note Enter the name of a quadratic or cubic curve which defines the maximum outdoor
    \note humidity ratio (function of outdoor dry-bulb temperature) for economizer operation.
    \note No input or blank input means this limit is not operative
A3 , \field Exhaust Air Temperature Limit
    \type choice
    \key ExhaustAirTemperatureLimit
    \key NoExhaustAirTemperatureLimit
    \default NoExhaustAirTemperatureLimit
A4 , \field Exhaust Air Enthalpy Limit
    \type choice
    \key ExhaustAirEnthalpyLimit
    \key NoExhaustAirEnthalpyLimit
    \default NoExhaustAirEnthalpyLimit

```



```

A5 , \field Time of Day Economizer Flow Control Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Schedule values greater than 0 indicate economizer operation is active. This
      \note schedule may be used with or without the High Humidity Control option.
      \note When used together, high humidity control has priority over economizer control.
A6 , \field High Humidity Control Flag
      \type choice
      \key Yes
      \key No
      \default No
      \note Select Yes to modify air flow rates based on a zone humidistat.
      \note Select No to disable this feature.
A7 , \field Humidistat Control Zone Name
      \type object-list
      \object-list ZoneNames
      \note Enter the name of the zone where the humidistat is located.
N5 , \field High Humidity Outdoor Air Flow Ratio
      \type real
      \minimum> 0.0
      \default 1.0
      \note Enter the ratio of supply (outdoor) air to the maximum supply air flow rate when modified
      \note air flow rates are active based on high indoor humidity.
A8 ; \field Control High Indoor Humidity Based on Outdoor Humidity Ratio
      \type choice
      \key Yes
      \key No
      \default Yes
      \note If NO is selected, the air flow rate is modified any time indoor relative
      \note humidity is above humidistat setpoint. If YES is selected, outdoor air flow
      \note rate is modified any time indoor relative humidity is above the humidistat
      \note setpoint AND the outdoor humidity ratio is less than the indoor humidity ratio.

```

Following is an example input for this stand alone ERV controller object:

```

ZoneHVAC:EnergyRecoveryVentilator:Controller,
  ERV OA Controller 1,      !- ERV controller name
  19.,                     !- Temperature high limit {C}
  14.,                     !- Temperature low limit {C}
  ,                         !- Enthalpy high limit {J/kg}
  15.55,                   !- dew point temperature limit (C)
  ElectronicEnthalpyCurveA, !- electronic enthalpy limit curve name
  NoExhaustAirTemperatureLimit, !- Exhaust air temperature limit
  NoExhaustAirEnthalpyLimit, !- Exhaust air enthalpy limit
  OutsideAirFlowSchedule,  !- Time of Day Economizer Flow Control Schedule Name
  Yes,                     !- High Humidity Control Flag
  East Zone,               !- Humidistat Control Zone Name
  1.2,                     !- High Humidity Outdoor air Flow Ratio
  Yes;                     !- Control High Indoor Humidity based on Outdoor Humidity Ratio

Curve:Cubic,
  ElectronicEnthalpyCurveA, !- Name
  0.01342704,               !- Coefficient1 Constant
  -0.00047892,              !- Coefficient2 x
  0.000053352,              !- Coefficient3 x**2
  -0.0000018103,           !- Coefficient4 x**3
  16.6,                     !- Minimum Value of x
  29.13;                    !- Maximum Value of x

```

Group – Evaporative Coolers

This group of objects describes the properties and configuration for the evaporative coolers models for the HVAC section.

EvaporativeCooler:Direct:CelDekPad

The direct stage, shown in the figure below, consists of a rigid media evaporative pad, with water recirculated from a reservoir. The water is pumped from the reservoir to a water distribution header, for water feed by gravity from above the media. The evaporative pad

provides the area for the adiabatic saturation of the air. While the process provides a lower dry-bulb temperature, the moisture content of the leaving air is higher than the entering condition. The direct stage is used for comfort cooling in a building where adding humidity to the air can be tolerated.

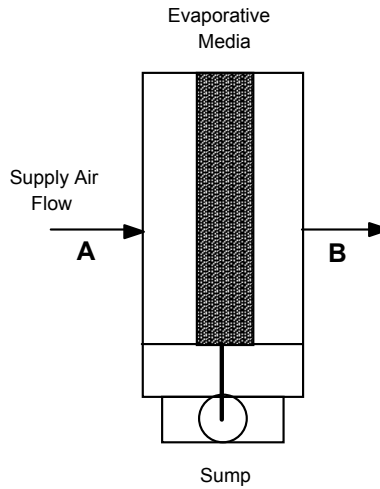


Figure 118. Direct Stage Evaporative Cooler

The thermodynamic process is a simultaneous heat and mass transfer, or adiabatic cooling, and follows a constant enthalpy line on the psychrometric chart, it is shown in the figure below as a process from A to B. Since the deviation of the constant wet-bulb line and the constant enthalpy line is small, it is assumed that the wet-bulb temperature is constant across the direct evaporative stage.

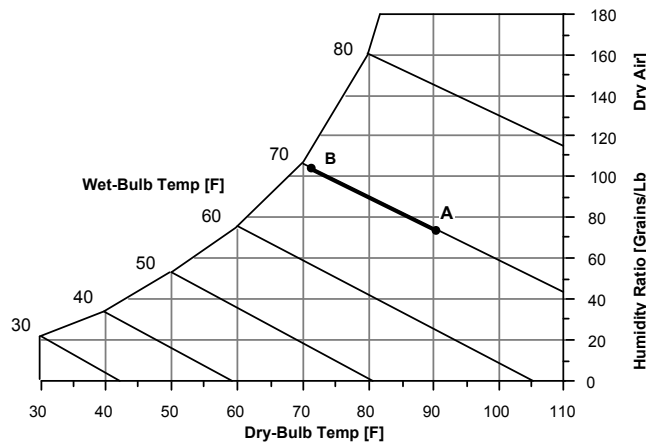


Figure 119. Psychrometric Chart -- Constant Enthalpy

If the direct evaporative process were 100% efficient, the leaving dry-bulb temperature would equal the entering wet-bulb temperature. The efficiency of the direct evaporative process is less than 100% and by defining saturation efficiency (ϵ_{se}) for the direct stage or evaporative pad, the leaving dry-bulb temperature can be expressed by the following equation.

$$T_{db\,supout} = T_{db\,supin} - \epsilon_{se} \cdot (T_{db\,supin} - T_{wb\,supin})$$

Field: Name

A unique identifying name for each evaporative cooler.

Field: Availability Schedule Name

The name of a schedule which defines when the evaporative cooler is available.

Field: Direct Pad Area

The face area of the evaporative pad in m². With the area and mass flow rate, the air velocity is calculated and is used to determine the saturation efficiency.

Field: Direct Pad Depth

The depth of the evaporative pad in meters. The pad depth is used to determine the saturation efficiency.

Field: Recirculating Water Pump Power Consumption

This field is used to specify the power consumed by the evaporative cooler recirculating pump in Watts.

Field: Air Inlet Node Name

The name of the evaporative cooler air inlet node from the Air Loop Simulation.

Field: Air Outlet Node Name

The name of the evaporative cooler air outlet node from the Air Loop Simulation.

Field: Control Type

This input field is currently unused and can be left blank.

Field: Water Supply Storage Tank Name

This field is optional. It is used to describe where the cooler obtains water used for evaporative cooling. If blank or omitted, then the cooler will obtain water directly from the mains. If the name of a WaterUse:Storage object is used here, then the cooler will obtain its water from that tank. If a tank is specified, the cooler will attempt to obtain all the water it uses from the tank. However if the tank cannot provide all the water the cooler needs, then the cooler will still operate and obtain the rest of the water it needs from the mains.

```
EvaporativeCooler:Direct:CelDekPad,
  A1 , \field Name
      \type alpha
  A2 , \field Availability Schedule Name
      \type object-list
      \object-list ScheduleNames
  N1 , \field Direct Pad Area
      \units m2
      \minimum 0.0
  N2 , \field Direct Pad Depth
      \units m
      \minimum 0.0
  N3 , \field Recirculating Water Pump Power Consumption
      \units W
      \ip-units W
  A3 , \field Air Inlet Node Name
  A4 , \field Air Outlet Node Name
  A5 , \Field Control Type
  A6 ; \Field Water Supply Storage Tank Name
      \type object-list
      \object-list WaterStorageTankNames
```

And an IDF example showing how this object is:

```

EvaporativeCooler:Direct:CeIDekPad,
  Evaporative Cooler,          !- Name
  System Availability Schedule, !- Availability Schedule Name
  0.6,                          !- Direct Pad Area {m2}
  0.2,                          !- Direct Pad Depth {m}
  225,                          !- Recirculating Water Pump Power Consumption {W}
  Evap Cooler Inlet Node,       !- Air Inlet Node Name
  Supply Outlet Node,          !- Air Outlet Node Name
  Constant;                    !- Control Type

```

EvaporativeCooler:Direct:CeIDekPad Outputs

The output variables that are available for this direct evaporative cooler are shown below:

```

HVAC,Average, Direct Evap Saturation Efficiency
HVAC,Average, Evap Cooler Electric Power[W]
HVAC,Sum, Evap Cooler Electric Energy[J]
HVAC,Sum, Evap Cooler Water Consumption[m3]
HVAC,Sum,Evap Cooler Mains Water Mains Draw [m3]
HVAC,Sum,Evap Cooler Tank Water Consumption [m3]
HVAC,Sum,Evap Cooler Starved Water Consumption [m3]
HVAC,Sum,Evap Cooler Starved Water Mains Draw [m3]

```

Direct Evap Saturation Efficiency

The saturation efficiency is the temperature change of the supply air divided by the difference between the inlet air dry-bulb and wet-bulb temperatures. In other words, it is a measure of the approach to the inlet air wet-bulb temperature.

Evap Cooler Electric Power[W]

Evap Cooler Electric Energy[J]

These output variables report the electric power and electric energy required to operate the water pump.

Evap Cooler Water Consumption [m3]

The water consumption is the water evaporated from the pad. This water consumption is only from the direct thermodynamics of water evaporation and does not include other sources of consumption such as drift or concentration blow down. This report variable appears when mains water is supplied to the cooler.

Evap Cooler Mains Water Mains Draw [m3]

This is the source of the water consumed. This report variable appears when mains water is supplied to the cooler.

Evap Cooler Tank Water Consumption [m3]

The water consumption is the water evaporated from the pad. This water consumption is only from the direct thermodynamics of water evaporation and does not include other sources of consumption such as drift or concentration blow down. This report variable appears when storage tank water is supplied to the cooler.

Evap Cooler Starved Water Consumption [m3]

This is the water consumed by the evaporative cooler that could not actually be met by the storage tank. This report variable appears when storage tank water is supplied to the cooler.

Evap Cooler Starved Water Mains Draw [m3]

This is the source (mains) of water consumed by the evaporative cooler that could not actually be met by the storage tank. This report variable appears when storage tank water is supplied to the cooler.

EvaporativeCooler:Direct:ResearchSpecial

This cooler is similar in principal to the EvaporativeCooler:Direct:CelDekPad. The model differs in that it gives the user a simple way of specify the cooler effectiveness. Using the ResearchSpecial input object also allows the cooler to control the amount of cooling based on node setpoints (controlled by SetpointManagers). This avoid problems from over cooling when conditions are such that loads are low and cooling power is high. Water pump power is assumed to vary linearly when the cooler is operating at less than full capacity.

Field: Name

A unique identifying name for each cooler.

Field: Availability Schedule Name

The name of a schedule that defines when the evaporative cooler is available.

Field: Cooler Effectiveness

This field specifies the effectiveness that is applied to the wetbulb depression to determine the conditions leaving the cooler. This model assumes that the effectiveness is constant.

Field: Recirculating Water Pump Power Consumption

This field is used to specify the power consumed by the water pump that circulates water in Watts.

Field: Air Inlet Node Name

The name of the air inlet node for the primary air flow path through the cooler.

Field: Air Outlet Node Name

The name of the air outlet node for the primary air flow path through the cooler.

Field: Sensor Node Name

This field specifies the name of a node that will provide system air temperature setpoint information. A separate SetpointManager object should be setup to update this node.

Field: Water Supply Storage Tank Name

This field is optional. It is used to describe where the cooler obtains water used for evaporative cooling. If blank or omitted, then the cooler will obtain water directly from the mains. If the name of a WaterUse:Storage object is used here, then the cooler will obtain its water from that tank. If a tank is specified, the cooler will attempt to obtain all the water it uses from the tank. However, if the tank cannot provide all the water the cooler needs, then the cooler will still operate and obtain the rest of the water it needs from the mains.

Field: Drift Loss Fraction

This field is optional and can be used to model additional water consumed by the cooler from drift. Drift is water that leaves the cooling media as droplets and does not evaporate into the process air stream. For example, water may get blown off the evaporative media by winds and escape the air system. The value entered here is a simple fraction of the water consumed by the cooler for normal process evaporation. The amount of drift is this fraction times the water evaporated for the normal cooling process. This field can be left blank and then there will be no added water consumption from drift.

Field: Blowdown Concentration Ratio

This field is optional and can be used to model additional water consumed by the cooler from blowdown. Blowdown is water that is intentionally drained from the cooler's sump to offset the build up of solids in the water that would otherwise occur because of evaporation. The

value entered here is dimensionless. It can be characterized as the ratio of solids in the blowdown water to solids in the make up water. Typical values are 3 to 5. The default is 3.0.

The IDD entry for this model is.

```

EvaporativeCooler:Direct:ResearchSpecial,
  A1 , \field Name
        \type alpha
  A2 , \field Availability Schedule Name
        \type object-list
        \object-list ScheduleNames
  N1 , \field Cooler Effectiveness
        \note effectiveness with respect to wetbulb depression
        \type real
        \minimum 0.0
        \maximum 1.0
  N2 , \field Recirculating Water Pump Power Consumption
        \units W
        \ip-units W
        \minimum 0.0
  A3 , \field Air Inlet Node Name
        \type alpha
  A4 , \field Air Outlet Node Name
        \type alpha
  A5 , \Field Sensor Node Name
        \type alpha
  A6 , \Field Water Supply Storage Tank Name
        \type object-list
        \object-list WaterStorageTankNames
  N3 , \field Drift Loss Fraction
        \type real
        \minimum 0.0
        \note Rate of drift loss as a fraction of evaporated water flow rate
  N4 ; \field Blowdown Concentration Ratio
        \type real
        \minimum 2.0
        \default 3.0
        \note Characterizes the rate of blowdown in the evaporative cooler.
        \note Blowdown is water intentionally drained from the cooler in order
to offset the build up
        \note of solids in the water that would otherwise occur because of
evaporation.
        \note Ratio of solids in the blowdown water to solids in the make up
water.
        \note The default value is 3. If left blank then there is no blowdown.

```

An example IDF entry is

```

EvaporativeCooler:Direct:ResearchSpecial,
  Direct Evap Cooler, !- Name
  ALWAYS_ON, !- Availability Schedule Name
  0.7 , !- Cooler Effectiveness
  30.0 , !- Recirculating Water Pump Power Consumption
  OAIndRDD Evap Cooler- OADirect Evap CoolerNode , !- Air Inlet Node Name
  OADirect Evap Cooler- OAMixing BoxNode, !- Air Outlet Node Name
  OADirect Evap Cooler- OAMixing BoxNode, !- Sensor Node Name
  , !- Water Supply Storage Tank Name
  0.0, !- Drift Loss Fraction
  3; !- Blowdown Concentration Ratio

```

EvaporativeCooler:Direct:ResearchSpecial Outputs

The output variables that are available for this direct evaporative cooler are shown below:

```
HVAC,Average, Evap Cooler Electric Power[W]
HVAC,Sum, Evap Cooler Electric Energy[J]
HVAC,Sum, Evap Cooler Water Consumption[m3]
HVAC,Sum,Evap Cooler Mains Water Mains Draw [m3]
HVAC,Sum,Evap Cooler Tank Water Consumption [m3]
HVAC,Sum,Evap Cooler Starved Water Consumption [m3]
HVAC,Sum,Evap Cooler Starved Water Mains Draw [m3]
```

Evap Cooler Electric Power[W]

Evap Cooler Electric Energy[J]

These output variables report the electric power and electric energy required to operate the water pump.

Evap Cooler Water Consumption [m3]

The water consumption is the water evaporated from the pad. This water consumption is only from the direct thermodynamics of water evaporation and does not include other sources of consumption such as drift or concentration blow down. This report variable appears when mains water is supplied to the cooler.

Evap Cooler Mains Water Mains Draw [m3]

This is the source of the water consumed. This report variable appears when mains water is supplied to the cooler.

Evap Cooler Tank Water Consumption [m3]

The water consumption is the water evaporated from the pad. This water consumption is only from the direct thermodynamics of water evaporation and does not include other sources of consumption such as drift or concentration blow down. This report variable appears when storage tank water is supplied to the cooler.

Evap Cooler Starved Water Consumption [m3]

This is the water consumed by the evaporative cooler that could not actually be met by the storage tank. This report variable appears when storage tank water is supplied to the cooler.

Evap Cooler Starved Water Mains Draw [m3]

This is the source (mains) of water consumed by the evaporative cooler that could not actually be met by the storage tank. This report variable appears when storage tank water is supplied to the cooler.

EvaporativeCooler:Indirect:CelDekPad

The dry coil indirect evaporative cooler, shown in the figure below, has a rigid media pad, similar to the direct evaporative stage, where the adiabatic cooling takes place. The secondary air leaves the rigid media pad and enters an air to air heat exchanger where it cools the supply air flowing through the heat exchanger tubes. The moist secondary air is then exhausted to the environment. The secondary air stream has its own fan and consists of a rigid media evaporative pad, with water recirculated from a reservoir. The water is pumped from the reservoir to a water distribution header, for water feed by gravity from above the media. The evaporative pad provides the area for the adiabatic saturation of the air.

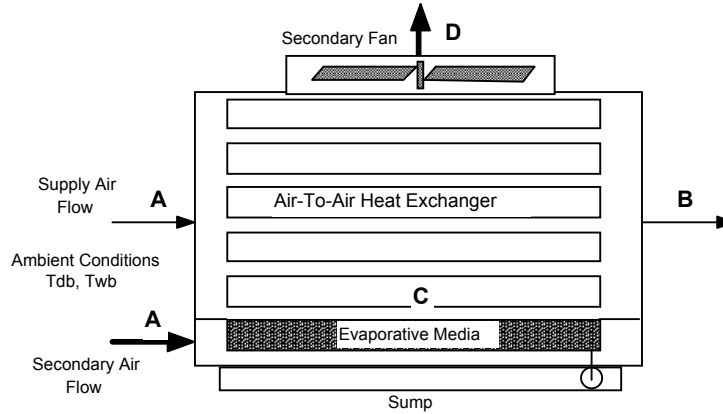


Figure 120. Evaporative Cooler -- Indirect Dry Coil

The process that the secondary air goes through, A to C to D, is shown by the dashed lines in the following figure. Process A to C is adiabatic cooling in the rigid media pad. Then the air enters the shell side of the heat exchanger and is sensibly heated from C to D by the warm supply air passing through the tube side. The secondary air inlet is modeled as a separate stream of outdoor air and the user has the option of defining the name of an outdoor air node.

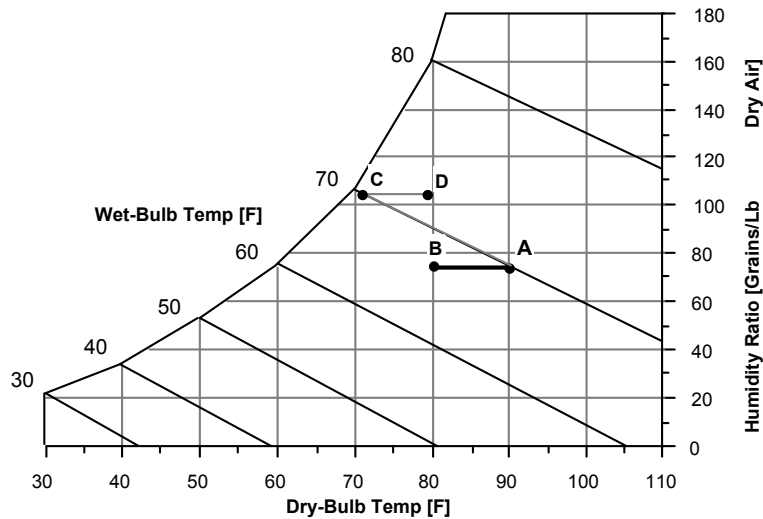


Figure 121. Secondary Air Process -- Indirect Dry Coil Evap Cooler

The advantage of the dry coil heat exchanger is that the heat exchanger does not have the evaporation taking place on the outside of the tubes, thus no mineral deposits are left on the heat exchange surface to reduce the efficiency of the heat exchanger. The rigid media pads are designed to flush the mineral deposits to the sump, so the saturation efficiency of the pad stays relatively constant.

Field: Name

A unique identifying name for each evaporative cooler.

Field: Availability Schedule Name

The name of a schedule which defines when the evaporative cooler is available.

Field: Direct Pad Area

The face area of the evaporative pad in m². With the area and mass flow rate, the air velocity is calculated and is used to determine the saturation efficiency on the secondary side of the evaporative cooler.

Field: Direct Pad Depth

The depth of the evaporative pad in meters. The pad depth is used to determine the saturation efficiency on the secondary side of the evaporative cooler.

Field: Recirculating Water Pump Power Consumption

This field is used to specify the power consumed by the evaporative cooler recirculating pump in Watts.

Field: Secondary Fan Flow Rate

This field is used to specify the secondary fan flow rate and is specified in m³/sec.

Field: Secondary Fan Efficiency

This field is used to specify the efficiency of the fan and is used to calculate the power consumed by the evaporative cooler secondary fan. Input values should be > 0.0 and <= 1.0.

Field: Secondary Fan Delta Pressure

This field is used to specify the delta pressure across the secondary stage of the evaporative cooler in Pascals.

Field: Indirect Heat Exchanger Effectiveness

This field is used to specify the effectiveness of the indirect heat exchanger between the primary and secondary air flow.

Field: Primary Air Inlet Node Name

The name of the evaporative cooler's primary air inlet node from the Air Loop Simulation. This is the air flow being cooled indirectly.

Field: Primary Air Outlet Node Name

The name of the evaporative cooler's primary air outlet node from the Air Loop Simulation.

Field: Control Type

This input field is currently unused and can be left blank.

Field: Water Supply Storage Tank Name

This field is optional. It is used to describe where the cooler obtains water used for evaporative cooling. If blank or omitted, then the cooler will obtain water directly from the mains. If the name of a WaterUse:Storage object is used here, then the cooler will obtain its water from that tank. If a tank is specified, the cooler will attempt to obtain all the water it uses from the tank. However if the tank cannot provide all the water the cooler needs, then the cooler will still operate and obtain the rest of the water it needs from the mains.

Field: Secondary Air Inlet Node Name

This field is optional. It is used to explicitly define an outdoor air node for the inlet for secondary air stream. Defining an outdoor air node here allows using the height-dependent model for outdoor air conditions.

```

EvaporativeCooler:Indirect:CelDekPad,
  A1 , \field Name
      \required-field
      \type alpha
  A2 , \field Availability Schedule Name
      \type object-list
      \object-list ScheduleNames
  N1 , \field Direct Pad Area
      \units m2
      \minimum 0.0
  N2 , \field Direct Pad Depth
      \units m
      \minimum 0.0
  N3 , \field Recirculating Water Pump Power Consumption
      \units W
      \ip-units W
  N4 , \field Secondary Fan Flow Rate
      \units m3/s
      \minimum 0.0
  N5 , \field Secondary Fan Efficiency
      \type real
      \minimum 0.0
      \maximum 1.0
  N6 , \field Secondary Fan Delta Pressure
      \units Pa
      \minimum 0.0
      \ip-units inH2O
  N7 , \field Indirect Heat Exchanger Effectiveness
      \type real
      \minimum 0.0
  A3 , \field Primary Air Inlet Node Name
  A4 , \field Primary Air Outlet Node Name
  A5 , \Field Control Type
  A6 , \Field Water Supply Storage Tank Name
      \type object-list
      \object-list WaterStorageTankNames
  A7 ; \field Secondary Air Inlet Node Name
      \type alpha
      \note Enter the name of an outdoor air node

```

And an IDF example showing how this object is specified:

```

EvaporativeCooler:Indirect:CelDekPad,
  IndirectEvapCooler1,      !- Name
  FanAndCoilAvailSched,    !- Availability Schedule Name
  0.6,                      !- Direct Pad Area {m2}
  0.2,                      !- Direct Pad Depth {m}
  225.,                     !- Recirculating Water Pump Power Consumption {W}
  1.0,                      !- Secondary Fan Flow Rate {m3/s}
  0.7,                      !- Secondary Fan Efficiency
  200.0,                    !- Secondary Fan Delta Pressure {Pa}
  0.67,                     !- Indirect Heat Exchanger Effectiveness
  EvapCoolerIndirectInletAirNode, !- Primary Air Inlet Node Name
  EvapCoolerDirectInletAirNode, !- Primary Air Outlet Node Name
  Constant,                 !- Control Type
  ,                          !- Water Supply Storage Tank Name
  Secondary side OA inlet node; !- Secondary Air Inlet Node Name

```

EvaporativeCooler:Indirect:CelDekPad Outputs

The output variables that are available for the indirect dry evaporative cooler are shown below:

HVAC,Average, Indirect Dry Evap Saturation Efficiency
HVAC,Average, Indirect Dry Evap Total Stage Efficiency
HVAC,Average, Evap Cooler Electric Power[W]
HVAC,Sum, Evap Cooler Electric Energy[J]
HVAC,Sum, Evap Cooler Water Consumption[m3]
HVAC,Sum,Evap Cooler Mains Water Mains Draw [m3]
HVAC,Sum,Evap Cooler Tank Water Consumption [m3]
HVAC,Sum,Evap Cooler Starved Water Consumption [m3]
HVAC,Sum,Evap Cooler Starved Water Mains Draw [m3]

Indirect Dry Evap Saturation Efficiency

The dry evaporation saturation efficiency is the saturation efficiency of the secondary or wet side air stream defined as the temperature change of the supply air divided by the difference between the outdoor dry-bulb and wet-bulb temperatures. In other words, it is a measure of the approach to the outdoor wet-bulb temperature.

Indirect Dry Evap Total Stage Efficiency

The total stage efficiency includes the sensible heat exchanger effectiveness of the heat exchanger in the supply air stream. It is the saturation efficiency multiplied by the heat exchanger effectiveness.

Evap Cooler Electric Power[W]

Evap Cooler Electric Energy[J]

These output variables report the electric power and energy consumed by the secondary air fan and the sump pump.

Evap Cooler Water Consumption[m3]

The water consumption is the water evaporated from the pad. This water consumption is only from the direct thermodynamics of water evaporation and does not include other sources of consumption such as drift or concentration blow down. This report variable appears when mains water is supplied to the cooler.

Evap Cooler Mains Water Mains Draw [m3]

This is the source of the water consumed. This report variable appears when mains water is supplied to the cooler.

Evap Cooler Tank Water Consumption [m3]

The water consumption is the water evaporated from the pad. This water consumption is only from the direct thermodynamics of water evaporation and does not include other sources of consumption such as drift or concentration blow down. This report variable appears when storage tank water is supplied to the cooler.

Evap Cooler Starved Water Consumption [m3]

This is the water consumed by the evaporative cooler that could not actually be met by the storage tank. This report variable appears when storage tank water is supplied to the cooler.

Evap Cooler Starved Water Mains Draw [m3]

This is the source (mains) of water consumed by the evaporative cooler that could not actually be met by the storage tank. This report variable appears when storage tank water is supplied to the cooler.

EvaporativeCooler:Indirect:WetCoil

The wetted coil evaporative cooler shown in the figure below, has water sprayed directly on the tubes of the heat exchanger where latent cooling takes place. The vaporization of the water on the outside of the heat exchanger tubes allows the simultaneous heat and mass

transfer which removes heat from the supply air on the tube side. Then the moist secondary air is exhausted. The secondary air stream has its own fan.

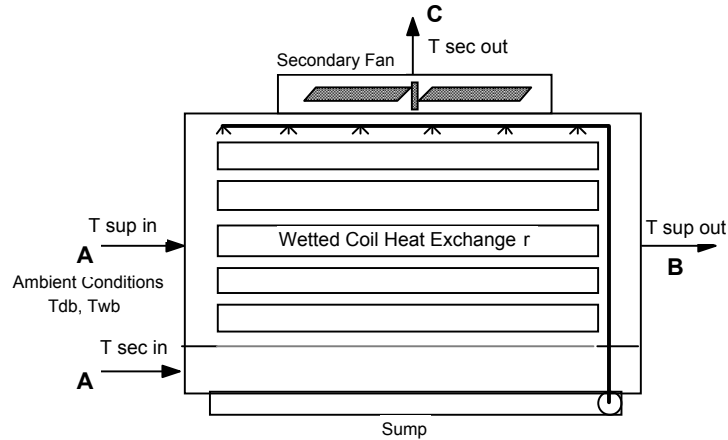


Figure 122. Evaporative Cooler – Indirect Wet Coil

The process that the secondary air goes through, A to C on the following figure, is a path of simultaneous heat and mass transfer, but it does not follow a line of constant enthalpy as in the direct stage. The process is not adiabatic due to the heat gain from the supply air flowing through the tubes of the heat exchanger.

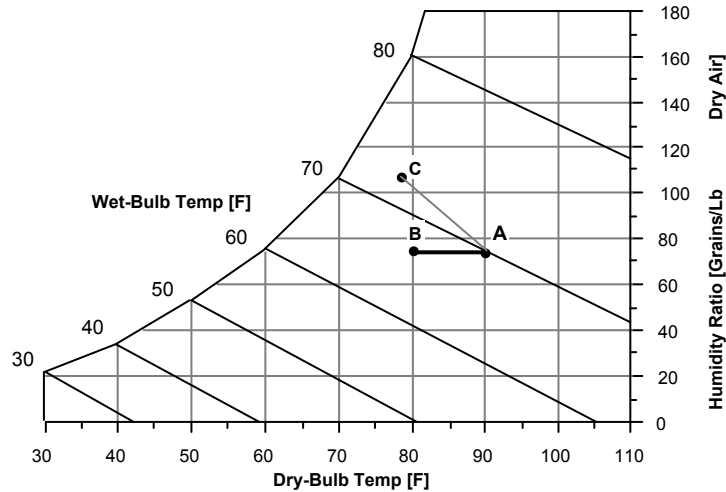


Figure 123. Secondary Air Process – Indirect Wet Coil Evap Cooler

The wet coil heat exchanger can have a higher stage efficiency than the dry coil due to a higher heat transfer rate on the outside of the heat exchanger tubes. Over the operating lifetime of the heat exchanger, the vaporization taking place on the heat exchange surface can leave mineral deposits which will decrease the effectiveness of the heat exchanger.

Field: Name

A unique identifying name for each evaporative cooler.

Field: Availability Schedule Name

The name of a schedule which defines when the evaporative cooler is available.

Field: Coil Maximum Efficiency

The maximum efficiency of the stage is a combination of the efficiency due to the simultaneous heat and mass transfer on the outside of the tube and the efficiency of the heat

exchanger. This value can be higher than the dry coil overall efficiency since the convective coefficients on the outside of the tube are larger.

Field: Coil Flow Ratio

The Coil Flow Ratio is determined from performance data. The Coil Flow Ratio tells how quickly the efficiency of the stage would decrease with a mismatch of the supply and secondary flows.

Field: Recirculating Water Pump Power Consumption

This field is used to specify the power consumed by the evaporative cooler recirculating pump in Watts.

Field: Secondary Fan Flow Rate

This field is used to specify the secondary fan flow rate and is specified in m³/sec.

Field: Secondary Fan Efficiency

This field is used to specify the efficiency of the fan and is used to calculate the power consumed by the evaporative cooler secondary fan. Input values should be > 0.0 and <= 1.0.

Field: Secondary Fan Delta Pressure

This field is used to specify the delta pressure across the secondary stage of the evaporative cooler in Pascals.

Field: Primary Air Inlet Node Name

The name of the evaporative cooler air inlet from the Air Loop Simulation.

Field: Primary Air Outlet Node Name

The name of the evaporative cooler air outlet from the Air Loop Simulation.

Field: Control Type

This input field is currently unused and can be left blank.

Field: Water Supply Storage Tank Name

This field is optional. It is used to describe where the cooler obtains water used for evaporative cooling. If blank or omitted, then the cooler will obtain water directly from the mains. If the name of a WaterUse:Storage object is used here, then the cooler will obtain its water from that tank. If a tank is specified, the cooler will attempt to obtain all the water it uses from the tank. However if the tank cannot provide all the water the cooler needs, then the cooler will still operate and obtain the rest of the water it needs from the mains.

Field: Secondary Air Inlet Node Name

This field is optional. It is used to explicitly define an outdoor air node for the inlet for secondary air stream. Defining an outdoor air node here allows using the height-dependent model for outdoor air conditions.

Field: Drift Loss Fraction

This field is optional and can be used to model additional water consumed by the cooler from drift. Drift is water that leaves the cooling media as droplets and does not evaporate into the process air stream. For example, water may get blown off the evaporative media by winds and escape the air system. The value entered here is a simple fraction of the water consumed by the cooler for normal process evaporation. The amount of drift is this fraction times the water evaporated for the normal cooling process. This field can be left blank and then there will be no added water consumption from drift.

Field: Blowdown Concentration Ratio

This field is optional and can be used to model additional water consumed by the cooler from blowdown. Blowdown is water that is intentionally drained from the cooler's sump to offset the build up of solids in the water that would otherwise occur because of evaporation. The value entered here is dimensionless. It can be characterized as the ratio of solids in the blowdown water to solids in the make up water. Typical values are 3 to 5. The default is 3.0.

```

EvaporativeCooler:Indirect:WetCoil,
  A1 , \field Name
        \type alpha
  A2 , \field Availability Schedule Name
        \type object-list
        \object-list ScheduleNames
  N1 , \field Coil Maximum Efficiency
        \type real
        \minimum 0.0
        \maximum 1.0
  N2 , \field Coil Flow Ratio
        \type real
  N3 , \field Recirculating Water Pump Power Consumption
        \units W
        \ip-units W
  N4 , \field Secondary Fan Flow Rate
        \units m3/s
        \minimum 0.0
  N5 , \field Secondary Fan Efficiency
        \type real
        \minimum 0.0
        \maximum 1.0
  N6 , \field Secondary Fan Delta Pressure
        \units Pa
        \minimum 0.0
        \ip-units inH2O
  A3 , \field Primary Air Inlet Node Name
        \type alpha
  A4 , \field Primary Air Outlet Node Name
        \type alpha
  A5 , \Field Control Type
  N7 , \field Dewpoint Effectiveness Factor
  A6 , \Field Secondary Air Inlet Node Name
        \type alpha
  A7 , \Field Sensor Node Name
        \type alpha
  A8 , \Field Relief Air Inlet Node Name
        \type alpha
  A9 , \Field Water Supply Storage Tank Name
        \type object-list
        \object-list WaterStorageTankNames
  N8 , \field Drift Loss Fraction
        \type real
        \minimum 0.0
        \note Rate of drift loss as a fraction of evaporated water flow rate
  N9 ; \field Blowdown Concentration Ratio
        \type real
        \minimum 2.0
        \default 3.0
        \note Characterizes the rate of blowdown in the evaporative cooler.
        \note Blowdown is water intentionally drained from the cooler in order to offset the build up
        \note of solids in the water that would otherwise occur because of evaporation.
        \note Ratio of solids in the blowdown water to solids in the make up water.
        \note The default value is 3. If left blank then there is no blowdown.

```

And an IDF example showing how this object is specified:

```

EvaporativeCooler:Indirect:WetCoil,
  IndirectEvapCooler1,      !- Name
  FanAndCoilAvailSched,    !- Availability Schedule Name
  0.8,                      !- Coil Maximum Efficiency
  0.16,                    !- Coil Flow Ratio
  225.,                     !- Recirculating Water Pump Power Consumption {W}
  1.0,                     !- Secondary Fan Flow Rate {m3/s}
  0.7,                     !- Secondary Fan Efficiency
  200.0,                   !- Secondary Fan Delta Pressure {Pa}
  EvapCoolerIndirectInletAirNode, !- Primary Air Inlet Node Name
  EvapCoolerDirectInletAirNode, !- Primary Air Outlet Node Name
  Constant,                !- Control Type
  ,                          !- Water Supply Storage Tank Name
  Secondary side OA inlet node; !- Secondary Air Inlet Node Name

```

EvaporativeCooler:Indirect:WetCoil Outputs

The output variables that are available for the wet indirect evaporative cooler are shown below:

```

HVAC,Average, Indirect Wet Evap Total Stage Efficiency
HVAC,Average, Evap Cooler Electric Power[W]
HVAC,Sum, Evap Cooler Electric Energy[J]
HVAC,Sum, Evap Cooler Water Consumption[m3]
HVAC,Sum,Evap Cooler Mains Water Mains Draw [m3]
HVAC,Sum,Evap Cooler Tank Water Consumption [m3]
HVAC,Sum,Evap Cooler Starved Water Consumption [m3]
HVAC,Sum,Evap Cooler Starved Water Mains Draw [m3]

```

Indirect Wet Evap Total Stage Efficiency

The Total Stage Efficiency is defined as the temperature change of the supply air divided by the difference between the outdoor dry-bulb and wet-bulb temperatures, including the effect of the reduction in flow because of the secondary air stream. In other words, it is a measure of the approach to the outdoor wet-bulb temperature.

Evap Cooler Electric Power[W]

Evap Cooler Electric Energy[J]

These output variables report the electric power and energy that are consumed by the secondary air fan and the sump pump.

Evap Cooler Water Consumption[m3]

The water consumption is the water evaporated from the pad. This water consumption is only from the direct thermodynamics of water evaporation and does not include other sources of consumption such as drift or concentration blow down. This report variable appears when mains water is supplied to the cooler.

Evap Cooler Mains Water Mains Draw [m3]

This is the source of the water consumed. This report variable appears when mains water is supplied to the cooler.

Evap Cooler Tank Water Consumption [m3]

The water consumption is the water evaporated from the pad. This water consumption is only from the direct thermodynamics of water evaporation and does not include other sources of consumption such as drift or concentration blow down. This report variable appears when storage tank water is supplied to the cooler.

Evap Cooler Starved Water Consumption [m3]

This is the water consumed by the evaporative cooler that could not actually be met by the storage tank. This report variable appears when storage tank water is supplied to the cooler.

Evap Cooler Starved Water Mains Draw [m3]

This is the source (mains) of water consumed by the evaporative cooler that could not actually be met by the storage tank. This report variable appears when storage tank water is supplied to the cooler.

EvaporativeCooler:Indirect:ResearchSpecial

This cooler is similar in principal to the EvaporativeCooler:Indirect:CelDekPad and EvaporativeCooler:Indirect:WetCoil (see Figure 121, Figure 122, and Figure 123). The model differs in that it gives the user more flexibility to specify the source of secondary air. The cooler effectiveness with respect to wetbulb depression is allowed to go beyond 1.0. Using the ResearchSpecial input object also allows the cooler to control the amount of cooling based on node setpoints (controlled by SetpointManagers). This avoids problems from over cooling when conditions are such that loads are low and cooling power is high. Fan power is assumed to vary linearly when the cooler is operating at less than full capacity.

Field: Name

A unique identifying name for each cooler.

Field: Availability Schedule Name

The name of a schedule that defines when the evaporative cooler is available.

Field: Cooler Maximum Effectiveness

This field specifies the maximum effectiveness that is applied to the wetbulb depression to determine the conditions leaving the cooler. This effectiveness is a complicated function of the efficiency with which heat and mass are transferred on the secondary side and the efficiency of heat exchange between the secondary and primary flows. The model assumes that the effectiveness is constant.

Field: Cooler Flow Ratio

Not used in this model.

Field: Recirculating Water Pump Power Consumption

This field is used to specify the power consumed by the water pump that circulates water in Watts. The pump power and energy consumption is reduced by cycling when the amount of cooling needs to be restricted for control purposes.

Field: Secondary Fan Flow Rate

This field is used to specify the secondary fan flow rate and is specified in m^3/s . This flow rate would typically be similar in magnitude to the flow through the primary side. This field can be autosized. When it is autosized, the program detects if the component is in the main air loop or on an outdoor air path. If it is on the main air loop, then the flow rate is set to the AirLoopHVAC system's design supply air flow rate (which is the maximum required for heating and cooling). If it is on the outdoor air path, then the flow rate is set to the larger of either the design minimum outdoor air flow rate or one-half of the main air loop design flow rate. The flow rate is used to determine parasitic fan energy and does not impact the modeling of cooler effectiveness. The flow rate (and fan power) is effectively reduced by cycling when the amount of cooling needs to be restricted for control purposes.

Field: Secondary Fan Efficiency

This field is used to specify the total efficiency for the secondary fan. This efficiency is used to calculate the energy use for the secondary fan and should be a value >0.0 and ≤ 1.0 .

Field: Secondary Fan Delta Pressure

This field is used to specify the pressure difference in Pascals experienced by the secondary fan as it moves air through the wet side of the cooler.

Field: Primary Air Inlet Node Name

The name of the air inlet node for the primary air flow path through the cooler.

Field: Primary Air Outlet Node Name

The name of the air outlet node for the primary air flow path through the cooler.

Field: Control Type

This input field is not used by this model. But using this model does implement controlling of the primary outlet temperature.

Field: Dewpoint Effectiveness Factor

This field specifies an effectiveness that is applied to the dewpoint depression to determine a bound for the conditions leaving the cooler. The model uses the warmer of the two temperatures determined from wetbulb depression and dewpoint depression.

Field: Secondary Air Inlet Node Name

This field specifies the name of the node providing air to the secondary/wet side of the cooler. Typically this node could appear in an outdoor air node list or be part of an air system loop.

Field: Sensor Node Name

This field specifies the name of a node that will provide system air temperature setpoint information. A separate SetpointManager object should be setup to update this node.

Field: Relief Air Inlet Node Name

This field is optional, but can be used to feed two sources of secondary air into the wet side of the cooler. Typical use is to run the air system relief air into the system. The model first uses all of the air flow available from this node and then adds the air flow from the secondary air inlet node to make up the total defined by Secondary Fan Flow Rate.

Field: Water Supply Storage Tank Name

This field is optional. It is used to describe where the cooler obtains water used for evaporative cooling. If blank or omitted, then the cooler will obtain water directly from the mains. If the name of a WaterUse:Storage object is used here, then the cooler will obtain its water from that tank. If a tank is specified, the cooler will attempt to obtain all the water it uses from the tank. However, if the tank cannot provide all the water the cooler needs, then the cooler will still operate and obtain the rest of the water it needs from the mains.

Field: Drift Loss Fraction

This field is optional and can be used to model additional water consumed by the cooler from drift. Drift is water that leaves the cooling media as droplets and does not evaporate into the process air stream. For example, water may get blown off the evaporative media by winds and escape the air system. The value entered here is a simple fraction of the water consumed by the cooler for normal process evaporation. The amount of drift is this fraction times the water evaporated for the normal cooling process. This field can be left blank and then there will be no added water consumption from drift.

Field: Blowdown Concentration Ratio

This field is optional and can be used to model additional water consumed by the cooler from blowdown. Blowdown is water that is intentionally drained from the cooler's sump to offset the build up of solids in the water that would otherwise occur because of evaporation. The

value entered here is dimensionless. It can be characterized as the ratio of solids in the blowdown water to solids in the make up water. Typical values are 3 to 5. The default is 3.0.

The IDD definition for the model is shown below:

```

EvaporativeCooler:Indirect:ResearchSpecial,
A1 , \field Name
    \type alpha
A2 , \field Availability Schedule Name
    \type object-list
    \object-list ScheduleNames
N1 , \field Cooler Maximum Effectiveness
    \type real
    \minimum 0.0
    \maximum 2.0
N2 , \field Cooler Flow Ratio
    \type real
N3 , \field Recirculating Water Pump Power Consumption
    \units W
    \ip-units W
N4 , \field Secondary Fan Flow Rate
    \units m3/s
    \minimum 0.0
    \autosizable
N5 , \field Secondary Fan Efficiency
    \type real
    \minimum 0.0
    \maximum 1.0
N6 , \field Secondary Fan Delta Pressure
    \units Pa
    \minimum 0.0
    \ip-units inH2O
A3 , \field Primary Air Inlet Node Name
    \type alpha
A4 , \field Primary Air Outlet Node Name
    \type alpha
A5 , \Field Control Type
N7 , \field Dewpoint Effectiveness Factor
A6 , \Field Secondary Air Inlet Node Name
    \type alpha
A7 , \Field Sensor Node Name
    \type alpha
A8 , \Field Relief Air Inlet Node Name
    \type alpha
A9 , \Field Water Supply Storage Tank Name
    \type object-list
    \object-list WaterStorageTankNames
N8 , \field Drift Loss Fraction
    \type real
    \minimum 0.0
    \note Rate of drift loss as a fraction of evaporated water flow rate
N9 ; \field Blowdown Concentration Ratio
    \type real
    \minimum 2.0
    \default 3.0
    \note Characterizes the rate of blowdown in the evaporative cooler.
    \note Blowdown is water intentionally drained from the cooler in order to offset the build up
    \note of solids in the water that would otherwise occur because of evaporation.
    \note Ratio of solids in the blowdown water to solids in the make up water.
    \note The default value is 3. If left blank then there is no blowdown.

```

And an IDF example is shown below:

```

EvaporativeCooler:Indirect:ResearchSpecial,
  Indirect Evap ZN1,      !- Name
  On_Except_Winter_Night, !- Availability Schedule Name
  1.2,                   !- Cooler Maximum Effectiveness
  ,                       !- Cooler Flow Ratio
  30,                    !- Recirculating Water Pump Power Consumption {W}
  autosize,              !- Secondary Fan Flow Rate {m3/s}
  0.7,                   !- Secondary Fan Efficiency
  300,                   !- Secondary Fan Delta Pressure {Pa}
  Mixed Air Node ZN1,    !- Primary Air Inlet Node Name
  Evap Cooler Outlet Node ZN1, !- Primary Air Outlet Node Name
  ,                       !- Control Type
  0.9,                   !- Dewpoint Effectiveness Factor
  Purge Air Inlet ZN1,   !- Secondary Air Inlet Node Name
  Air Loop Outlet Node ZN1, !- Sensor Node Name
  Relief Air Outlet Node ZN1; !- Relief Air Inlet Node Name

```

EvaporativeCooler:Indirect:ResearchSpecial Outputs

The output variables that are available for the EvaporativeCooler:Indirect:ResearchSpecial object are shown below:

```

HVAC,Average,Indirect Wet Evap Total Stage Efficiency
HVAC,Average,Indirect Wet Evap Part Load Fract
HVAC,Average,IEC RDDSpecial Dewpoint Bound
HVAC,Sum,Evap Cooler Electric Energy [J]
HVAC,Average,Evap Cooler Electric Power [W]
HVAC,Sum,Evap Cooler Tank Water Consumption [m3]
HVAC,Sum,Evap Cooler Starved Water Consumption [m3]
HVAC,Sum,Evap Cooler Starved Water Mains Draw [m3]

```

Indirect Wet Evap Total Stage Efficiency

The Total Stage Efficiency is defined as the temperature change of the supply air divided by the difference between the outdoor dry-bulb and wet-bulb temperatures, including the effect of the reduction in flow because of the secondary air stream. In other words, it is a measure of the approach to the outdoor wet-bulb temperature.

Indirect Wet Evap Part Load Fract

This report variable provides the part load fraction of the indirect cooler. The ResearchSpecial cooler model is able to modulate to meet a temperature set point to avoid over cooling. This report variable is the fraction formed by the ratio of the capacity needed over the maximum cooling capacity available. A value of 1.0 corresponds to full capacity cooling.

IEC RDDSpecial Dewpoint Bound

This report variable is a flag that indicates if the modeling was based on dewpoint effectiveness rather than wetbulb effectiveness. The ResearchSpecial model is usually based on wet-bulb approach, but since values in excess of 1.0 are allowed, there is a secondary constraint imposed by dewpoint. If the dewpoint effectiveness was applied, then this flag variable will have the value 1.0, otherwise it is 0.0.

Evap Cooler Electric Power[W]

Evap Cooler Electric Energy[J]

These output variables report the electric power and energy that are consumed by the secondary air fan and the sump pump.

Evap Cooler Water Consumption[m3]

The water consumption is the water evaporated from the pad. This water consumption is only from the direct thermodynamics of water evaporation and does not include other sources

of consumption such as drift or concentration blow down. This report variable appears when mains water is supplied to the cooler.

Evap Cooler Mains Water Mains Draw [m3]

This is the source of the water consumed. This report variable appears when mains water is supplied to the cooler.

Evap Cooler Tank Water Consumption [m3]

The water consumption is the water evaporated from the pad. This water consumption is only from the direct thermodynamics of water evaporation and does not include other sources of consumption such as drift or concentration blow down. This report variable appears when storage tank water is supplied to the cooler.

Evap Cooler Starved Water Consumption [m3]

This is the water consumed by the evaporative cooler that could not actually be met by the storage tank. This report variable appears when storage tank water is supplied to the cooler.

Evap Cooler Starved Water Mains Draw [m3]

This is the source (mains) of water consumed by the evaporative cooler that could not actually be met by the storage tank. This report variable appears when storage tank water is supplied to the cooler.

Group – Heat Recovery

HeatExchanger:AirToAir:FlatPlate

The air-to-air flat plate heat exchanger is an HVAC component typically used for exhaust or relief air heat recovery. The user can choose the flow arrangement type: counter flow, parallel flow, or cross flow with both streams unmixed. The input requires no geometric data. Performance is defined by specifying primary outlet air temperature at nominal (user specified) inlet conditions. In addition, the ratio $(hA)_p / (hA)_s$ at nominal flow needs to be input, where h is the convective heat transfer coefficient, A is the surface area, p stands for primary side, s for secondary side.

If the heat exchanger is operated in conjunction with an outdoor air economizer (economizer lockout set to Yes), the nominal supply air flow rate should be set equal to the minimum outdoor air flow rate specified in the Controller:OutdoorAir. The heat exchanger detects that the economizer is operating by the fact that its inlet air flow rate is greater than its nominal supply air flow rate.

Field: Name

A unique user-assigned name for a particular air-to-air flat plate heat exchanger unit. Any reference to this unit by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the unit can run during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit can be on during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit must be off for the hour.

Field: Flow Arrangement Type

The user specified flow arrangement of the heat exchanger. The possible inputs are *CounterFlow*, *ParallelFlow*, or *CrossFlowBothUnmixed*.

Field: Economizer Lockout

This input denotes whether the heat exchanger unit is locked out (bypassed) when the air-side economizer is operating. Both the economizer and high humidity control (Ref. Controller:OutdoorAir) activate the heat exchanger lockout as specified by this input. The input choices are *Yes* (meaning locked out) or *No*. The default input for this field is *Yes*.

Field: Ratio of Supply to Secondary hA Values

The ratio $(hA)_p / (hA)_s$ at nominal flow. h is the surface convective heat transfer coefficient, A is the heat transfer area, and p and s stand for primary side and secondary side respectively. A typical value for this ratio is 1.0.

Field: Nominal Supply Air Flow Rate

The nominal primary side air flow rate in cubic meters per second. If the unit is operated in conjunction with an outdoor air economizer this should be equal to the minimum outdoor air flow rate.

Field: Nominal Supply Air Inlet Temperature

The nominal primary side air inlet temperature in Celsius.

Field: Nominal Supply Air Outlet Temperature

The nominal primary side air outlet temperature in Celsius.

Field: Nominal Secondary Air Flow Rate

The nominal secondary side air flow rate in cubic meters per second.

Field: Nominal Secondary Air Inlet Temperature

The nominal secondary side air inlet temperature in Celsius.

Field: Nominal Electric Power

The electric consumption rate of the unit in watts. Electric power is considered constant whenever the unit operates. This input can be used to model electric power consumption by controls (transformers, relays, etc.) and/or a motor for a rotary heat exchanger. None of this electric power contributes thermal load to the supply or exhaust air streams. The default value for this field is 0.

Field: Supply Air Inlet Node Name

The name of the HVAC system node from which the unit draws its primary inlet air.

Field: Supply Air Outlet Node Name

The name of the HVAC system node to which the unit sends its primary outlet air.

Field: Secondary Air Inlet Node Name

The name of the HVAC system node from which the unit draws its secondary inlet air.

Field: Secondary Air Outlet Node Name

The name of the HVAC system node to which the unit sends its secondary outlet air.

The full IDD specification follows:

```

HeatExchanger:AirToAir:FlatPlate,
A1, \field Name
    \required-field
    \type alpha
    \reference HXAirToAirNames
    \reference HXAirToAirFlatPlateNames
A2, \field Availability Schedule Name
    \type object-list
    \object-list ScheduleNames
A3, \field Flow Arrangement Type
    \type choice
    \key CounterFlow
    \key ParallelFlow
    \key CrossFlowBothUnmixed
A4, \field Economizer Lockout
    \type choice
    \key Yes
    \key No
    \default Yes
    \note Yes means that the heat exchanger will be locked out (off)
    \note when the economizer is operating
N1, \field Ratio of Supply to Secondary hA Values
    \type real
    \note Ratio of h*A for supply side to h*A for exhaust side
    \minimum 0.0
N2, \field Nominal Supply Air Flow Rate
    \type real
    \minimum 0.0
    \units m3/s
N3, \field Nominal Supply Air Inlet Temperature
    \type real
    \units C
N4, \field Nominal Supply Air Outlet Temperature
    \type real
    \units C
N5, \field Nominal Secondary Air Flow Rate
    \type real
    \minimum 0.0
    \units m3/s
N6, \field Nominal Secondary Air Inlet Temperature
    \type real
    \units C
N7, \field Nominal Electric Power
    \type real
    \units W
    \ip-units W
A5, \field Supply Air Inlet Node Name
    \type alpha
A6, \field Supply Air Outlet Node Name
    \type alpha
A7, \field Secondary Air Inlet Node Name
    \type alpha
A8, \field Secondary Air Outlet Node Name
    \type alpha

```

An IDF example:

```

HeatExchanger:AirToAir:FlatPlate,
  OA Heat Recovery 1,      !- Name
  FanAndCoilAvailSched,   !- Availability Schedule Name
  CounterFlow,            !- Flow Arrangement Type
  Yes,                     !- Economizer Lockout
  1.0,                     !- Ratio of Supply to Secondary hA Values
  0.4333,                  !- Nominal Supply Air Flow Rate {m3/s}
  5.0,                     !- Nominal Supply Air Inlet Temperature {C}
  15.0,                    !- Nominal Supply Air Outlet Temperature {C}
  0.4333,                  !- Nominal Secondary Air Flow Rate {m3/s}
  20.0,                    !- Nominal Secondary Air Inlet Temperature {C}
  0.0,                     !- Nominal Electric Power {W}
  Desiccant Process Outlet Node, !- Supply Air Inlet Node Name
  Heat Recovery Outlet Node,  !- Supply Air Outlet Node Name
  Relief Air Outlet Node,    !- Secondary Air Inlet Node Name
  Heat Recovery Secondary Outlet Node; !- Secondary Air Outlet Node Name

```

HeatExchanger:AirToAir:FlatPlate Outputs

```

HVAC,Average,Heat Exchanger Sensible Heating Rate[W]
HVAC,Sum,Heat Exchanger Sensible Heating Energy[J]
HVAC,Average,Heat Exchanger Latent Heating Rate[W]
HVAC,Sum,Heat Exchanger Latent Heating Energy[J]
HVAC,Average,Heat Exchanger Total Heating Rate[W]
HVAC,Sum,Heat Exchanger Total Heating Energy[J]
HVAC,Average,Heat Exchanger Sensible Cooling Rate[W]
HVAC,Sum,Heat Exchanger Sensible Cooling Energy[J]
HVAC,Average,Heat Exchanger Latent Cooling Rate[W]
HVAC,Sum,Heat Exchanger Latent Cooling Energy[J]
HVAC,Average,Heat Exchanger Total Cooling Rate[W]
HVAC,Sum,Heat Exchanger Total Cooling Energy[J]
HVAC,Average,Heat Recovery Electric Power[W]
HVAC,Sum,Heat Recovery Electric Consumption[J]

```

Heat Exchanger Sensible Heating Rate [W]

This output is the sensible heating rate of the supply air by the heat exchanger in Watts. This rate is determined using the supply air mass flow rate through the heat exchanger unit, the supply air inlet and outlet conditions, and the specific heat of the inlet supply air. A positive value is reported if the supply air is heated by the heat exchanger, else the rate is set to zero.

Heat Exchanger Sensible Heating Energy [J]

This output is the sensible heating energy added to the supply air by the heat exchanger in Joules over the timestep being reported.

Heat Exchanger Latent Heating Rate [W]

This output is the latent heating rate (humidification) of the supply air by the heat exchanger in Watts. This rate is determined by taking the difference between the Heat Exchanger Total Heating Rate and the Heat Exchanger Sensible Heating Rate. A positive value is reported if the supply air is humidified by the heat exchanger, else the rate is set to zero.

Heat Exchanger Latent Heating Energy [J]

This output is the latent heating energy added to the supply air by the heat exchanger in Joules over the timestep being reported.

Heat Exchanger Total Heating Rate [W]

This output is the total heating rate of the supply air by the heat exchanger in Watts. This rate is determined using the supply air mass flow rate through the heat exchanger unit, and the enthalpy of the supply air entering and leaving the unit. A positive value is reported if the enthalpy of the supply air is increased by the heat exchanger, else the rate is set to zero.

Heat Exchanger Total Heating Energy [J]

This output is the total heating energy added to the supply air by the heat exchanger in Joules over the timestep being reported. This output is also added to a report meter with ResourceType = EnergyTransfer, EndUseKey = HeatRecoveryforHeating, GroupKey = System (ref. Report Meter).

Heat Exchanger Sensible Cooling Rate [W]

This output is the sensible cooling rate of the supply air by the heat exchanger in Watts. This rate is determined using the supply air mass flow rate through the heat exchanger unit, the supply air inlet and outlet conditions, and the specific heat of the inlet supply air. A positive value is reported if the supply air is cooled by the heat exchanger, else the rate is set to zero.

Heat Exchanger Sensible Cooling Energy [J]

This output is the sensible cooling energy added to the supply air by the heat exchanger in Joules over the timestep being reported.

Heat Exchanger Latent Cooling Rate [W]

This output is the latent cooling rate (dehumidification) of the supply air by the heat exchanger in Watts. This rate is determined by taking the difference between the Heat Exchanger Total Cooling Rate and the Heat Exchanger Sensible Cooling Rate. A positive value is reported if the supply air is dehumidified by the heat exchanger, else the rate is set to zero.

Heat Exchanger Latent Cooling Energy [J]

This output is the latent cooling energy added to the supply air by the heat exchanger in Joules over the timestep being reported.

Heat Exchanger Total Cooling Rate [W]

This output is the total cooling rate of the supply air by the heat exchanger in Watts. This rate is determined using the supply air mass flow rate through the heat exchanger unit, and the enthalpy of the supply air entering and leaving the unit. A positive value is reported if the enthalpy of the supply air is decreased by the heat exchanger, else the rate is set to zero.

Heat Exchanger Total Cooling Energy [J]

This output is the total cooling energy added to the supply air by the heat exchanger in Joules over the timestep being reported. This output is also added to a report meter with ResourceType = EnergyTransfer, EndUseKey = HeatRecoveryforCooling, GroupKey = System (ref. Report Meter).

Heat Recovery Electric Power [W]

This output is the electric consumption rate of the unit in Watts. This rate is applicable whenever the unit operates (i.e., whenever the unit is scheduled to be available and supply and exhaust air flows exist).

Heat Recovery Electric Consumption [J]

This output is the electric consumption of the unit in Joules for the timestep being reported. This output is also added to a report meter with ResourceType = Electricity, EndUseKey = HeatRecovery, GroupKey = System (ref. Report Meter).

HeatExchanger:AirToAir:SensibleAndLatent

The sensible and latent air-to-air heat exchanger is an HVAC component typically used for exhaust or relief air heat recovery (Figure 124). Heat exchanger performance can be specified to transfer sensible energy, latent energy or both between the supply and exhaust air streams. The input requires no geometric data. Performance is defined by specifying sensible and/or latent effectiveness at 75% and 100% of the nominal (rated) supply air flow rate at two operating conditions as shown in Table 27.

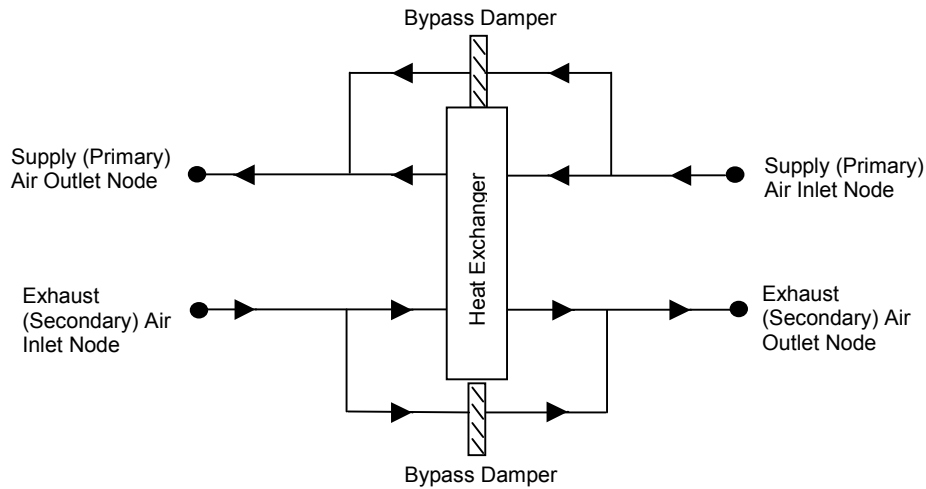


Figure 124. Schematic of the Sensible and Latent Air-to-Air Heat Exchanger

Table 27. Operating Conditions for Defining Heat Exchanger Performance

Parameter	Conditions	
	Heating	Cooling
Entering supply air temperature:		
Dry-bulb	1.7°C (35°F)	35°C (95°F)
Wet-bulb	0.6°C (33°F)	26°C (78°F)
Entering exhaust air temperature:		
Dry-bulb	21°C (70°F)	24°C (75°F)
Wet-bulb	14°C (58°F)	17°C (63°F)

Note: Conditions consistent with the Air-Conditioning and Refrigeration Institute’s (ARI) Standard 1060-2001.

This object models the basic operation of an air-to-air heat exchanger. Heat exchange between the supply and exhaust air streams occurs whenever the unit is scheduled to be available (Availability schedule) and supply/exhaust air flow is present. This heat exchanger object can be used in conjunction with a conventional air-side economizer (i.e., specify `ModulateFlow` in the `Controller:OutdoorAir` object), whereby heat exchange is suspended whenever the air-side economizer (or high humidity control) is active (i.e., air flow is fully bypassed around a fixed-plate heat exchanger or the rotation of a rotary heat exchanger is stopped). This object is also able to suspend heat exchange for the purpose of providing free cooling operation in the absence of a conventional air-side economizer (i.e., specify `MinimumFlowWithBypass` in the `Controller:OutdoorAir` object).

During winter weather, humid exhaust air entering the heat exchanger can form frost on the cold heat exchanger surfaces, which can reduce air flow and the amount of energy recovery. Several methods are used to control or eliminate frost formation, and the following types can be modeled for this heat exchanger object: supply air preheat, minimum exhaust air temperature, exhaust air recirculation and exhaust only. For preheat frost control, a separate heating coil object must be placed in the supply inlet air stream to keep the air temperature above the frost threshold temperature. The other frost control types are modeled within this object itself (i.e., do not require a separate object to be defined) based on alpha and numeric inputs to this heat exchanger object.

Air-to-air heat exchangers are sometimes controlled to maintain a fixed supply air outlet temperature to avoid overheating. To model this control in EnergyPlus, a set point manager object is used to establish a temperature set point at the supply air outlet node of the heat exchanger. Wheel speed modulation or plate supply air bypass is used to control the supply air exiting conditions to this set point. The set point for supply air temperature control should be set at the minimum economizer temperature set point if an air-side economizer is also being used by the air system. If frost control and supply air outlet temperature control are used, frost control takes precedence over supply air temperature control (e.g., frost control defrost time fraction is determined as if wheel speed modulation or plate supply air bypass is not used).

To model a sensible and latent air-to-air heat exchanger located in an air loop, the input data file should include the following objects:

- AirLoopHVAC:OutdoorAirSystem
- Controller:OutdoorAir
- OutdoorAir:Mixer
- HeatExchanger:AirToAir:SensibleAndLatent
- Coil:Heating:Water, Coil:Heating:Electric or Coil:Heating:Gas (if preheat frost control is to be modeled)
- SetpointManager:Scheduled (if supply air outlet temperature control is used)

The sensible and latent air-to-air heat exchanger can also be used in a number of other applications, including conditioning outdoor ventilation air and supplying it directly to a zone without an air loop. See object ZoneHVAC:EnergyRecoveryVentilator for further details on this specific application.

A description of each input field for this object is provided below.

Field: Name

A unique user-assigned name for a particular sensible/latent air-to-air heat exchanger. Any reference to this heat exchanger by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the unit can operate during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the unit can operate during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the unit will not operate (i.e., no heat exchange will take place).

Field: Nominal Supply Air Flow Rate

The nominal primary side (supply) air flow rate in cubic meters per second. The actual supply and exhaust air flow rates must be between 50% and 130% of this value or a warning will be issued.

Field: Sensible Effectiveness at 100% Heating Air Flow

The sensible heat exchange effectiveness at the *heating* condition defined in Table 27 above with both the supply and exhaust air volume flow rates equal to 100% of the nominal supply air flow rate specified in the previous input field. The default value for this field is 0.

Field: Latent Effectiveness at 100% Heating Air Flow

The latent heat exchange effectiveness at the *heating* condition defined in Table 27 with both the supply and exhaust air volume flow rates equal to 100% of the nominal supply air flow rate. Specify this value as 0.0 if the heat exchanger does not transfer latent energy. The default value for this field is 0.

Field: Sensible Effectiveness at 75% Heating Air Flow

The sensible heat exchange effectiveness at the *heating* condition defined in Table 27 with both the supply and exhaust air volume flow rates equal to 75% of the nominal supply air flow rate. The default value for this field is 0.

Field: Latent Effectiveness at 75% Heating Air Flow

The latent heat exchange effectiveness at the *heating* condition defined in Table 27 with both the supply and exhaust air volume flow rates equal to 75% of the nominal supply air flow rate. Specify this value as 0.0 if the heat exchanger does not transfer latent energy. The default value for this field is 0.

Field: Sensible Effectiveness at 100% Cooling Air Flow

The sensible heat exchange effectiveness at the *cooling* condition defined in Table 27 with both the supply and exhaust air volume flow rates equal to 100% of the nominal supply air flow rate. The default value for this field is 0.

Field: Latent Effectiveness at 100% Cooling Air Flow

The latent heat exchange effectiveness at the *cooling* condition defined in Table 27 with both the supply and exhaust air volume flow rates equal to 100% of the nominal supply air flow rate. Specify this value as 0.0 if the heat exchanger does not transfer latent energy. The default value for this field is 0.

Field: Sensible Effectiveness at 75% Cooling Air Flow

The sensible heat exchange effectiveness at the *cooling* condition defined in Table 27 with both the supply and exhaust air volume flow rates equal to 75% of the nominal supply air flow rate. The default value for this field is 0.

Field: Latent Effectiveness at 75% Cooling Air Flow

The latent heat exchange effectiveness at the *cooling* condition defined in Table 27 with both the supply and exhaust air volume flow rates equal to 75% of the nominal supply air flow rate. Specify this value as 0.0 if the heat exchanger does not transfer latent energy. The default value for this field is 0.

Field: Supply Air Inlet Node Name

The name of the HVAC system node from which the unit draws its supply (primary) inlet air.

Field: Supply Air Outlet Node Name

The name of the HVAC system node to which the unit sends its supply (primary) outlet air.

Field: Exhaust Air Inlet Node Name

The name of the HVAC system node from which the unit draws its exhaust (secondary) inlet air.

Field: Exhaust Air Outlet Node Name

The name of the HVAC system node to which the unit sends its exhaust (secondary) outlet air.

Field: Nominal Electric Power

The electric consumption rate of the unit in watts. Electric power is considered constant whenever the unit operates. This numeric input can be used to model electric power consumption by controls (transformers, relays, etc.) and/or a motor for a rotary heat exchanger. None of this electric power contributes thermal load to the supply or exhaust air streams. The default value for this field is 0.

Field: Supply Air Outlet Temperature Control

This alpha field determines if the heat exchanger's supply air outlet is controlled to a temperature set point. The choices for this input field are "Yes" or "No", with the default being "No". When supply air outlet temperature control is used, the wheel rotational speed modulates or supply air is bypassed around the plate heat exchanger to maintain the desired setpoint temperature. A setpoint manager object is required to establish the desired set point at the supply air outlet node (reference: SetpointManager:Scheduled). When an air-side economizer is also being modeled for this air system, the set point for the supply air outlet temperature control should be equal to the economizer outdoor air temperature lower limit (reference: Controller:OutdoorAir, field Economizer Minimum Limit Dry-Bulb Temperature).

Field: Heat Exchanger Type

This alpha field denotes the type of heat exchanger being modeled: Plate (e.g., fixed plate) or Rotary (e.g., rotating cylinder or wheel). The default choice for this field is "Plate". The heat exchanger type affects the modeling of frost control options and supply air outlet temperature control. For rotary heat exchangers, rotational speed is varied to control frost formation or the supply air outlet temperature. For plate exchangers, air bypass around the heat exchanger is used to obtain the desired effect.

Field: Frost Control Type

This alpha field has four choices: None, ExhaustAirRecirculation, ExhaustOnly and MinimumExhaustTemperature. If this field is left blank, the default frost control type is "None". For modeling preheat frost control, specify "None" for this input field and insert a separate heating coil object in the supply inlet air stream to keep the air temperature above the desired frost threshold temperature.

ExhaustAirRecirculation: dampers are used to direct exhaust air back into the zone through the supply side of the heat exchanger when the supply (outdoor) air inlet temperature falls below a threshold temperature (defined in the next input field). The fraction of time that exhaust air is circulated through the supply side of the heat exchanger is dependent on the supply (outdoor) air inlet temperature with respect to the threshold temperature, the initial defrost time fraction, and the rate of change of defrost time fraction (see *Field: Rate of Defrost Time Fraction Increase*). When exhaust air is being recirculated, no supply (outdoor ventilation) air is being provided through the heat exchanger unit (which may or may not be acceptable regarding ventilation for occupants).

ExhaustOnly (supply air bypass): this control cycles off the supply air flow through the heat exchanger for a certain period of time while the exhaust air continues to flow through the exhaust side of the heat exchanger. The fraction of time that the supply flow through the heat exchanger is cycled off is dependent on the supply (outdoor) air inlet temperature with respect to the threshold temperature, the initial defrost time fraction, and the rate of change of defrost time fraction (see *Field: Rate of Defrost Time Fraction Increase*). When implemented in real applications, provisions are usually made to avoid building depressurization when this frost control is operating (automatic or pressure-operated dampers, or a bypass air damper around the supply side of the heat exchanger). For this frost control type, it is assumed that the supply air is bypassed around the heat exchanger during frost control operation (i.e., the total supply flow is not reduced during defrost, but merely bypassed around the heat exchanger).

MinimumExhaustTemperature: the temperature of the exhaust air leaving the heat exchanger is monitored and the heat exchanger effectiveness is decreased (by slowing heat exchanger rotation or bypassing supply air around the plate exchanger) to keep the exhaust air from falling below the threshold temperature.

Field: Threshold Temperature

This numeric field defines the dry-bulb temperature of air which is used to initiate frost control. The default value is 1.7°C. For ExhaustAirRecirculation and ExhaustOnly frost control, the threshold temperature defines the supply (outdoor) air inlet temperature below which frost control is active. For MinimumExhaustTemperature frost control, heat exchanger effectiveness is controlled to keep the exhaust air outlet temperature from falling below this threshold temperature value.

The appropriate threshold temperature varies with exhaust (inlet) air temperature and humidity, frost control type, heat exchanger type, and whether the heat exchanger transfers sensible energy alone or both sensible and latent energy (enthalpy). Typical threshold temperatures are provided in Table 28 below. However, it is recommended that the user consult manufacturer’s information for the specific air-to-air heat exchanger being modeled.

Table 28. Typical threshold temperatures

Frost control type	Heat exchanger type	Energy exchange	Threshold temperature
Exhaust air recirculation	Plate	Sensible-only	-1.1°C (30°F)
		Sensible + latent	-12.2°C (10°F)
	Rotary	Sensible-only	-12.2°C (10°F)
		Sensible + latent	-23.3°C (-10°F)
Exhaust only	Plate	Sensible-only	-1.1°C (30°F)
		Sensible + latent	-12.2°C (10°F)
	Rotary	Sensible-only	-12.2°C (10°F)
		Sensible + latent	-23.3°C (-10°F)
Minimum exhaust temperature	Plate	Sensible-only	1.7°C (35°F)
		Sensible + latent	1.7°C (35°F)
	Rotary	Sensible-only	1.7°C (35°F)
		Sensible + latent	1.7°C (35°F)
Preheat**	Plate	Sensible-only	-1.1°C (30°F)
		Sensible + latent	-12.2°C (10°F)
	Rotary	Sensible-only	-12.2°C (10°F)
		Sensible + latent	-23.3°C (-10°F)

Source: Indoor Humidity Assessment Tool, U.S. Environmental Protection Agency, <http://www.epa.gov/iaq/schooldesign/saves.html>

** To model preheat frost control, specify frost control type as “None” and place a heating coil in the supply inlet air stream controlled to the keep the air temperature above the frost threshold temperature.

Field: Initial Defrost Time Fraction

This numeric field defines the fraction of the simulation timestep when frost control will be invoked when the threshold temperature is reached. This field is only used for the ExhaustAirRecirculation and ExhaustOnly frost control types. The value for this field must be ≥ 0 and ≤ 1 . The default time fraction is 0.083 (e.g., 5 min / 60 min) which is typical for ExhaustAirRecirculation frost control. Higher initial defrost time fractions (e.g., 0.167 = 10 min / 60 min) are typically required for ExhaustOnly frost control. For best results, the user should obtain this information from the manufacturer.

Field: Rate of Defrost Time Fraction Increase

This numeric field defines the rate of increase in the defrost time fraction as the supply (outdoor) air inlet temperature falls below the threshold temperature. This field is only used for the ExhaustAirRecirculation and ExhaustOnly frost control types. The value for this field must be ≥ 0 . The default value is 0.012 (e.g., 0.72 min / 60 min per degree C temperature difference) which is typical for ExhaustAirRecirculation frost control. Higher values (e.g., 0.024 = 1.44 min / 60 min per degree C temperature difference) are typically required for ExhaustOnly frost control. For best results, the user should obtain this information from the manufacturer.

This value is used to determine the total defrost time fraction as follows:

Total defrost time fraction = Initial Defrost Time Fraction +

$$\text{Rate of Defrost Time Fraction Increase} * (T_{\text{threshold}} - T_{\text{supply air inlet}})$$

The model does not allow the total defrost time fraction to exceed 1.0 or be less than 0.

Field: Economizer Lockout

This input denotes whether the heat exchanger unit is locked out (bypassed for plate type heat exchangers or the rotation is suspended for rotoray type heat exchangers) when the air-side economizer is operating. Both the economizer and high humidity control (Ref. Controller:OutdoorAir) activate the heat exchanger lockout as specified by this input. The input choices are Yes (meaning locked out) or No. The default input for this field is Yes.

The full IDD specification follows:

```
HeatExchanger:AirToAir:SensibleAndLatent,
  \memo This object models an air-to-air heat exchanger using effectiveness relationships.
  \memo The heat exchanger can transfer sensible energy, latent energy, or both between the
  \memo supply (primary) and exhaust (secondary) air streams.
  \min-fields 19
A1, \field Name
  \required-field
  \type alpha
  \reference HXAirToAirNames
  \reference HXAirToAirSensibleAndLatentNames
A2, \field Availability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
N1, \field Nominal Supply Air Flow Rate
  \required-field
  \type real
  \autosizable
  \minimum > 0.0
  \units m3/s
N2, \field Sensible Effectiveness at 100% Heating Air Flow
  \type real
  \units dimensionless
  \minimum 0.0
  \maximum 1.0
  \default 0.0
```

```

N3, \field Latent Effectiveness at 100% Heating Air Flow
  \type real
  \units dimensionless
  \minimum 0.0
  \maximum 1.0
  \default 0.0
N4, \field Sensible Effectiveness at 75% Heating Air Flow
  \type real
  \units dimensionless
  \minimum 0.0
  \maximum 1.0
  \default 0.0
N5, \field Latent Effectiveness at 75% Heating Air Flow
  \type real
  \units dimensionless
  \minimum 0.0
  \maximum 1.0
  \default 0.0
N6, \field Sensible Effectiveness at 100% Cooling Air Flow
  \type real
  \units dimensionless
  \minimum 0.0
  \maximum 1.0
  \default 0.0
N7, \field Latent Effectiveness at 100% Cooling Air Flow
  \type real
  \units dimensionless
  \minimum 0.0
  \maximum 1.0
  \default 0.0
N8, \field Sensible Effectiveness at 75% Cooling Air Flow
  \type real
  \units dimensionless
  \minimum 0.0
  \maximum 1.0
  \default 0.0
N9, \field Latent Effectiveness at 75% Cooling Air Flow
  \type real
  \units dimensionless
  \minimum 0.0
  \maximum 1.0
  \default 0.0
A3, \field Supply Air Inlet Node Name
  \required-field
  \type alpha
A4, \field Supply Air Outlet Node Name
  \required-field
  \type alpha
A5, \field Exhaust Air Inlet Node Name
  \required-field
  \type alpha
A6, \field Exhaust Air Outlet Node Name
  \required-field
  \type alpha
N10, \field Nominal Electric Power
  \type real
  \units W
  \ip-units W
  \minimum 0.0
  \default 0.0
A7, \field Supply Air Outlet Temperature Control
  \type choice
  \key No
  \key Yes
  \default No
A8, \field Heat Exchanger Type
  \type choice
  \key Plate
  \key Rotary
  \default Plate

```

```

A9, \field Frost Control Type
    \type choice
    \key None
    \key ExhaustAirRecirculation
    \key ExhaustOnly
    \key MinimumExhaustTemperature
    \default None
N11, \field Threshold Temperature
    \type real
    \units C
    \default 1.7
    \note Supply (outdoor) air inlet temp threshold for exhaust air recirculation and
    \note exhaust only frost control types. Exhaust air outlet threshold Temperature for
    \note minimum exhaust temperature frost control type.
N12, \field Initial Defrost Time Fraction
    \type real
    \units dimensionless
    \minimum 0.0
    \maximum 1.0
    \default 0.083
    \note Fraction of the time when frost control will be invoked at the threshold temperature.
    \note This field only used for exhaust air recirc and exhaust-only frost control types.
N13, \field Rate of Defrost Time Fraction Increase
    \type real
    \units 1/K
    \minimum 0.0
    \default 0.012
    \note Rate of increase in defrost time fraction as actual temp falls below threshold temperature.
    \note This field only used for exhaust air recirc and exhaust-only frost control types.
A10, \field Economizer Lockout
    \type choice
    \key Yes
    \key No
    \default Yes
    \note Yes means that the heat exchanger will be locked out (off)
    \note when the economizer is operating

```

Following is an example input for this heat exchanger object:

```

HeatExchanger:AirToAir:SensibleAndLatent,
OA Heat Recovery 1,      !- Name
FanAndCoilAvailSched,  !- Availability Schedule Name
0.4333,                !- Nominal Supply Air Flow Rate {m3/s}
.76,                   !- Sensible Effectiveness at 100% Heating Air Flow {dimensionless}
.68,                   !- Latent Effectiveness at 100% Heating Air Flow {dimensionless}
.81,                   !- Sensible Effectiveness at 75% Heating Air Flow {dimensionless}
.73,                   !- Latent Effectiveness at 75% Heating Air Flow {dimensionless}
.76,                   !- Sensible Effectiveness at 100% Cooling Air Flow {dimensionless}
.68,                   !- Latent Effectiveness at 100% Cooling Air Flow {dimensionless}
.81,                   !- Sensible Effectiveness at 75% Cooling Air Flow {dimensionless}
.73,                   !- Latent Effectiveness at 75% Cooling Air Flow {dimensionless}
Outside Air Inlet Node Preheated, !- Supply Air Inlet Node Name
Heat Recovery Outlet Node, !- Supply Air Outlet Node Name
Relief Air Outlet Node, !- Exhaust Air Inlet Node Name
Heat Recovery Secondary Outlet Node, !- Exhaust Air Outlet Node Name
200.0,                 !- Nominal Electric Power {W}
No,                    !- Supply Air Outlet Temperature Control
Plate,                 !- Heat Exchanger Type
None;                  !- Frost Control Type

```


HeatExchanger:AirToAir:SensibleAndLatent Outputs

```

HVAC,Average,Heat Exchanger Sensible Heating Rate[W]
HVAC,Sum,Heat Exchanger Sensible Heating Energy[J]
HVAC,Average,Heat Exchanger Latent Heating Rate[W]
HVAC,Sum,Heat Exchanger Latent Heating Energy[J]
HVAC,Average,Heat Exchanger Total Heating Rate[W]
HVAC,Sum,Heat Exchanger Total Heating Energy[J]
HVAC,Average,Heat Exchanger Sensible Cooling Rate[W]
HVAC,Sum,Heat Exchanger Sensible Cooling Energy[J]
HVAC,Average,Heat Exchanger Latent Cooling Rate[W]
HVAC,Sum,Heat Exchanger Latent Cooling Energy[J]
HVAC,Average,Heat Exchanger Total Cooling Rate[W]
HVAC,Sum,Heat Exchanger Total Cooling Energy[J]
HVAC,Average,Heat Recovery Electric Power[W]
HVAC,Sum,Heat Recovery Electric Consumption[J]
HVAC,Average,Heat Recovery Sensible Effectiveness[-]
HVAC,Average,Heat Recovery Latent Effectiveness[-]
HVAC,Average,Heat Recovery Supply Air Bypass Mass Flow [kg/s]
HVAC,Average,Heat Recovery Exhaust Air Bypass Mass Flow [kg/s]
HVAC,Average,Heat Recovery Defrost Time Fraction[-]

```

Heat Exchanger Sensible Heating Rate [W]

This output is the sensible heating rate of the supply air by the heat exchanger in Watts. This rate is determined using the supply air mass flow rate through the heat exchanger unit, the supply air inlet and outlet conditions, and the specific heat of the inlet supply air. A positive value is reported if the supply air is heated by the heat exchanger, else the rate is set to zero.

Heat Exchanger Sensible Heating Energy [J]

This output is the sensible heating energy added to the supply air by the heat exchanger in Joules over the timestep being reported.

Heat Exchanger Latent Heating Rate [W]

This output is the latent heating rate (humidification) of the supply air by the heat exchanger in Watts. This rate is determined by taking the difference between the Heat Exchanger Total Heating Rate and the Heat Exchanger Sensible Heating Rate. A positive value is reported if the supply air is humidified by the heat exchanger, else the rate is set to zero.

Heat Exchanger Latent Heating Energy [J]

This output is the latent heating energy added to the supply air by the heat exchanger in Joules over the timestep being reported.

Heat Exchanger Total Heating Rate [W]

This output is the total heating rate of the supply air by the heat exchanger in Watts. This rate is determined using the supply air mass flow rate through the heat exchanger unit, and the enthalpy of the supply air entering and leaving the unit. A positive value is reported if the enthalpy of the supply air is increased by the heat exchanger, else the rate is set to zero.

Heat Exchanger Total Heating Energy [J]

This output is the total heating energy added to the supply air by the heat exchanger in Joules over the timestep being reported. This output is also added to a report meter with ResourceType = EnergyTransfer, EndUseKey = HeatRecoveryforHeating, GroupKey = System (ref. Report Meter).

Heat Exchanger Sensible Cooling Rate [W]

This output is the sensible cooling rate of the supply air by the heat exchanger in Watts. This rate is determined using the supply air mass flow rate through the heat exchanger unit, the supply air inlet and outlet conditions, and the specific heat of the inlet supply air. A positive value is reported if the supply air is cooled by the heat exchanger, else the rate is set to zero.

Heat Exchanger Sensible Cooling Energy [J]

This output is the sensible cooling energy added to the supply air by the heat exchanger in Joules over the timestep being reported.

Heat Exchanger Latent Cooling Rate [W]

This output is the latent cooling rate (dehumidification) of the supply air by the heat exchanger in Watts. This rate is determined by taking the difference between the Heat Exchanger Total Cooling Rate and the Heat Exchanger Sensible Cooling Rate. A positive value is reported if the supply air is dehumidified by the heat exchanger, else the rate is set to zero.

Heat Exchanger Latent Cooling Energy [J]

This output is the latent cooling energy added to the supply air by the heat exchanger in Joules over the timestep being reported.

Heat Exchanger Total Cooling Rate [W]

This output is the total cooling rate of the supply air by the heat exchanger in Watts. This rate is determined using the supply air mass flow rate through the heat exchanger unit, and the enthalpy of the supply air entering and leaving the unit. A positive value is reported if the enthalpy of the supply air is decreased by the heat exchanger, else the rate is set to zero.

Heat Exchanger Total Cooling Energy [J]

This output is the total cooling energy added to the supply air by the heat exchanger in Joules over the timestep being reported. This output is also added to a report meter with ResourceType = EnergyTransfer, EndUseKey = HeatRecoveryforCooling, GroupKey = System (ref. Report Meter).

Heat Recovery Electric Power [W]

This output is the electric consumption rate of the unit in Watts. This rate is applicable whenever the unit operates (i.e., whenever the unit is scheduled to be available and supply and exhaust air flows exist).

Heat Recovery Electric Consumption [J]

This output is the electric consumption of the unit in Joules for the timestep being reported. This output is also added to a report meter with ResourceType = Electricity, EndUseKey = HeatRecovery, GroupKey = System (ref. Report Meter).

Heat Recovery Sensible Effectiveness [-]

This output is the average sensible effectiveness of the heat exchanger (excluding bypass air, if any) over the timestep being reported.

Heat Recovery Latent Effectiveness [-]

This output is the average latent effectiveness of the heat exchanger (excluding bypass air, if any) over the timestep being reported.

Heat Recovery Supply Air Bypass Mass Flow [kg/s]

This output is the average mass flow rate in kg/second of the supply (primary) air stream that is bypassing the heat exchanger over the timestep being reported. This flow rate is equal to

the total supply mass flow rate through the heat exchanger **unit** minus the amount passing through the supply side of the heat exchanger **core**.

Heat Recovery Exhaust Air Bypass Mass Flow [kg/s]

This output is the average mass flow rate in kg/second of the exhaust (secondary) air stream that is bypassing the heat exchanger over the timestep being reported. This flow rate is equal to the total exhaust mass flow rate through the heat exchanger **unit** minus the amount passing through the exhaust side of the heat exchanger **core**.

Heat Recovery Defrost Time Fraction [-]

This output is the average fraction of the reporting timestep when frost control is being implemented.

HeatExchanger:Desiccant:BalancedFlow

This desiccant heat exchanger object is an HVAC component used to model both temperature (sensible) and moisture (latent) heat exchange between two air streams (Figure 125). The model assumes balanced air flow through the regeneration and process sides of the heat exchanger (i.e., regeneration and process air volume flow rates and face velocities are the same). Heat exchanger performance is specified through a performance data type object (e.g., HeatExchanger:Desiccant:BalancedFlow:PerformanceData1).

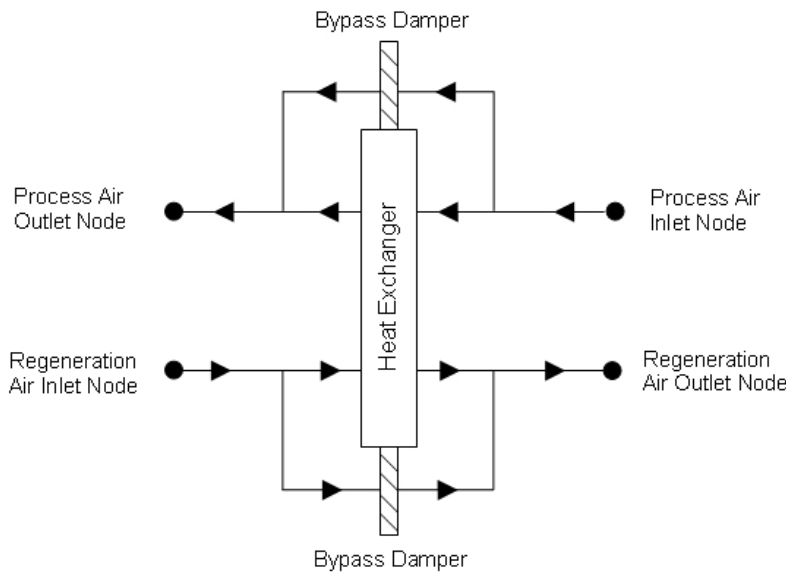


Figure 125. Schematic of the Balanced Flow Desiccant Heat Exchanger

Currently, this desiccant heat exchanger model can be referenced by two compound objects: CoilSystem:Cooling:DX:HeatExchangerAssisted and Dehumidifier:Desiccant:System, both of which are used to provide enhanced dehumidification over conventional systems. If this heat exchanger is referenced by a compound object, the compound object will control heat exchanger operation (i.e., tell the heat exchanger if heat exchange is needed or not for each simulation timestep).

This desiccant heat exchanger object may also be specified directly in an AirLoopHVAC (air loop BranchList) or in an AirLoopHVAC:OutdoorAirSystem (AirLoopHVAC:OutdoorAirSystem:EquipmentList) without being referenced by a compound object. If specified directly in an AirLoopHVAC or AirLoopHVAC:OutdoorAirSystem, then the heat exchanger can be controlled to provide heat exchange based on a maximum and/or minimum humidity set point placed on the process air outlet node (ref. Setpoint Managers). If no humidity set points are provided on this node, then heat exchange will be provided

whenever the heat exchanger is available to operate (via its availability schedule) and there is a temperature and/or humidity ratio difference between the two air streams.

Inputs to this model include an availability schedule name, inlet and outlet air node names, and the type and name of the heat exchanger performance data object. A description of each input field for this object is provided below.

Field: Name

A unique, user-assigned name for a particular balanced flow desiccant heat exchanger. Any reference to this heat exchanger by another object will use this name.

Field: Availability Schedule Name

The name of the schedule (ref: Schedule) that denotes whether the heat exchanger can operate during a given hour. A schedule value greater than 0 (usually 1 is used) indicates that the heat exchanger can operate during the hour. A value less than or equal to 0 (usually 0 is used) denotes that the heat exchanger will not operate (i.e., no heat exchange will take place).

Field: Regeneration Air Inlet Node Name

The name of the HVAC system node from which the unit draws its regeneration inlet air.

Field: Regeneration Air Outlet Node Name

The name of the HVAC system node to which the unit sends its regeneration outlet air.

Field: Process Air Inlet Node Name

The name of the HVAC system node from which the unit draws its process inlet air.

Field: Process Air Outlet Node Name

The name of the HVAC system node to which the unit sends its process outlet air.

Field: Heat Exchanger Performance Object Type

This alpha field contains the type of model used to simulate the desiccant heat exchanger's thermal performance and electrical energy use. Currently, the only valid choice is HeatExchanger:Desiccant:BalancedFlow:PerformanceDataType1.

Field: Heat Exchanger Performance Name

This alpha field contains the identifying name of the specific heat exchanger performance type object (e.g., HeatExchanger:Desiccant:BalancedFlow:PerformanceDataType1) that defines the performance for this heat exchanger. A single heat exchanger performance type object may be used to define performance for many HeatExchanger:Desiccant:BalancedFlow objects (i.e., the same name may be used in this input field for more than one balanced flow desiccant heat exchanger).

Field: Economizer Lockout

This input denotes whether the heat exchanger unit is locked out (heat exchanger rotation is suspended) when the air-side economizer is operating. Both the economizer and high humidity control (Ref. Controller:OutdoorAir) activate the heat exchanger lockout as specified by this input. The input choices are *Yes* (meaning locked out) or *No*. Economizer lockout is typically *not* used for this type of heat exchanger. For this reason, the default input for this field is *No*.

The full IDD specification follows:

```

HeatExchanger:Desiccant:BalancedFlow,
  \memo This object models a balanced desiccant heat exchanger.
  \memo The heat exchanger transfers both sensible and latent energy between the
  \memo process and regeneration air streams. The air flow rate and face velocity
  \memo are assumed to be the same on both the process and regeneration sides of the
  \memo heat exchanger.
  \min-fields 8
A1, \field Name
  \required-field
  \type alpha
  \reference HXDesiccantBalanced
  \reference HXAirToAirNames
A2, \field Availability Schedule Name
  \required-field
  \type object-list
  \object-list ScheduleNames
A3, \field Regeneration Air Inlet Node Name
  \required-field
  \type alpha
A4, \field Regeneration Air Outlet Node Name
  \required-field
  \type alpha
A5, \field Process Air Inlet Node Name
  \required-field
  \type alpha
A6, \field Process Air Outlet Node Name
  \required-field
  \type alpha
A7, \field Heat Exchanger Performance Object Type
  \type choice
  \key HeatExchanger:Desiccant:BalancedFlow:PerformanceDataType1
  \default HeatExchanger:Desiccant:BalancedFlow:PerformanceDataType1
A8, \field Heat Exchanger Performance Name
  \required-field
  \type object-list
  \object-list DesiccantHXPerfData
A9; \field Economizer Lockout
  \type choice
  \key Yes
  \key No
  \default No
  \note Yes means that the heat exchanger will be locked out (off)
  \note when the economizer is operating

```

Following is an example input for this heat exchanger object:

```

HeatExchanger:Desiccant:BalancedFlow,
Desiccant Heat Exchanger 1,           !- Name
OfficeHeatCoolAvail,                 !- Availability Schedule Name
DXSystem 1 Mixed Air Node,           !- Regeneration Air Inlet Node Name
DX Cooling Coil Air Inlet Node,       !- Regeneration Air Outlet Node Name
DX Cooling Coil Air Outlet Node,      !- Process Air Inlet Node Name
DXSystem 1 Fan Air Inlet Node,        !- Process Air Outlet Node Name
HeatExchanger:Desiccant:BalancedFlow:PerformanceDataType1, !- Heat Exchanger Performance Object Type
HXDesPerf1;                           !- Heat Exchanger Performance Name

```

HeatExchanger:Desiccant:BalancedFlow Outputs

```

HVAC,Average,Heat Exchanger Sensible Heating Rate[W]
HVAC,Sum,Heat Exchanger Sensible Heating Energy[J]
HVAC,Average,Heat Exchanger Latent Heating Rate[W]
HVAC,Sum,Heat Exchanger Latent Heating Energy[J]
HVAC,Average,Heat Exchanger Total Heating Rate[W]
HVAC,Sum,Heat Exchanger Total Heating Energy[J]
HVAC,Average,Heat Exchanger Sensible Cooling Rate[W]
HVAC,Sum,Heat Exchanger Sensible Cooling Energy[J]
HVAC,Average,Heat Exchanger Latent Cooling Rate[W]
HVAC,Sum,Heat Exchanger Latent Cooling Energy[J]
HVAC,Average,Heat Exchanger Total Cooling Rate[W]
HVAC,Sum,Heat Exchanger Total Cooling Energy[J]
HVAC,Average,Heat Recovery Electric Power[W]
HVAC,Sum,Heat Recovery Electric Consumption[J]

```

Heat Exchanger Sensible Heating Rate [W]

This output is the sensible heating rate of the process air by the heat exchanger in Watts. This rate is determined using the process air mass flow rate through the heat exchanger unit, the process air inlet and outlet temperatures, and the specific heat of the inlet process air. A positive value is reported if the process air is heated by the heat exchanger, else the rate is set to zero.

Heat Exchanger Sensible Heating Energy [J]

This output is the sensible heating energy added to the process air by the heat exchanger in Joules over the timestep being reported.

Heat Exchanger Latent Heating Rate [W]

This output is the latent heating rate (humidification) of the process air by the heat exchanger in Watts. This rate is determined by taking the difference between the heat exchanger's total heat recovery rate and the sensible heat recovery rate. A positive value is reported if the process air is humidified by the heat exchanger, else the rate is set to zero.

Heat Exchanger Latent Heating Energy [J]

This output is the latent heating energy added to the process air by the heat exchanger in Joules over the timestep being reported.

Heat Exchanger Total Heating Rate [W]

This output is the total heating rate of the process air by the heat exchanger in Watts. This rate is determined using the process air mass flow rate through the heat exchanger unit and the enthalpy of the air entering and leaving the process side of the unit. A positive value is reported if the enthalpy of the process air is increased by the heat exchanger, else the rate is set to zero.

Heat Exchanger Total Heating Energy [J]

This output is the total heating energy added to the process air by the heat exchanger in Joules over the timestep being reported. This output is also added to a report meter with

ResourceType = EnergyTransfer, EndUseKey = HeatRecoveryforHeating, GroupKey = System (ref. Report Meter).

Heat Exchanger Sensible Cooling Rate [W]

This output is the sensible cooling rate of the process air by the heat exchanger in Watts. This rate is determined using the process air mass flow rate through the heat exchanger unit, the process air inlet and outlet temperatures, and the specific heat of the inlet process air. A positive value is reported if the process air is cooled by the heat exchanger, else the rate is set to zero.

Heat Exchanger Sensible Cooling Energy [J]

This output is the sensible cooling energy added to the process air by the heat exchanger in Joules over the timestep being reported.

Heat Exchanger Latent Cooling Rate [W]

This output is the latent cooling rate (dehumidification) of the process air by the heat exchanger in Watts. This rate is determined by taking the difference between the heat exchanger's total heat recovery rate and the sensible heat recovery rate. A positive value is reported if the process air is dehumidified by the heat exchanger, else the rate is set to zero.

Heat Exchanger Latent Cooling Energy [J]

This output is the latent cooling energy added to the process air by the heat exchanger in Joules over the timestep being reported.

Heat Exchanger Total Cooling Rate [W]

This output is the total cooling rate of the process air by the heat exchanger in Watts. This rate is determined using the process air mass flow rate through the heat exchanger unit and the enthalpy of the air entering and leaving the process side of the unit. A positive value is reported if the enthalpy of the process air is decreased by the heat exchanger, else the rate is set to zero.

Heat Exchanger Total Cooling Energy [J]

This output is the total cooling energy added to the process air by the heat exchanger in Joules over the timestep being reported. This output is also added to a report meter with ResourceType = EnergyTransfer, EndUseKey = HeatRecoveryforCooling, GroupKey = System (ref. Report Meter).

Heat Recovery Electric Power [W]

This output is the average electric consumption rate of the unit in Watts. This average rate includes portions of the simulation timestep when the heat exchanger may be cycled off (i.e., average of on and off periods, as appropriate).

Heat Recovery Electric Consumption [J]

This output is the electric consumption of the unit in Joules for the timestep being reported. This output is also added to a report meter with ResourceType = Electricity, EndUseKey = HeatRecovery, GroupKey = System (ref. Report Meter).

HeatExchanger:Desiccant:BalancedFlow:PerformanceDataType1

This object specifies a performance model and model coefficients for a balanced flow desiccant heat exchanger. A HeatExchanger:Desiccant:BalancedFlow object will reference a HeatExchanger:Desiccant:BalancedFlow:PerformanceDataType1 object. This performance data object is used to specify the thermal performance and electric consumption of the heat exchanger. Some representative inputs for this object are provided in the EnergyPlus Reference DataSets (PerfCurves.idf and AllDataSets.idf).

This model predicts the regeneration air stream outlet temperature and humidity ratio values based on the entering regeneration and process air stream temperature, humidity ratio and face velocity. The process air stream outlet humidity ratio and temperatures are calculated based on a simple heat and moisture balance. The model requires that the user enter the nominal volumetric flow rate and a nominal face velocity, electric power consumption, empirical model coefficients for the regeneration outlet air temperature and humidity ratio equations, and the applicable minimum and maximum values for both the independent and dependent variables for the empirical model coefficients provided. This model is based on the following equations:

- The dry-bulb temperature of the regeneration outlet air is defined using the following equation:

$$RTO = B1 + B2 * RWI + B3 * RTI + B4 * \left(\frac{RWI}{RTI} \right) + B5 * PWI + B6 * PTI + B7 * \left(\frac{PWI}{PTI} \right) + B8 * RFV$$

where,

RTO = Regeneration outlet air dry-bulb temperature (C)

RWI = Regeneration inlet air humidity ratio (kg/kg)

RTI = Regeneration inlet air dry-bulb temperature (C)

PWI = Process inlet air humidity ratio (kg/kg)

PTI = Process inlet air dry-bulb temperature (C)

RFV = Regeneration (and process) face velocity (m/s)

- The humidity ratio of the regeneration outlet air is defined using the same empirical equation form; however, different coefficients are used as follows:

$$RWO = C1 + C2 * RWI + C3 * RTI + C4 * \left(\frac{RWI}{RTI} \right) + C5 * PWI + C6 * PTI + C7 * \left(\frac{PWI}{PTI} \right) + C8 * RFV$$

where,

RWO = Regeneration outlet air humidity ratio (kg/kg)

- The process outlet air conditions are then calculated based on the regeneration outlet air conditions (temperature or humidity ratio) calculated above, the actual regeneration inlet air conditions entering the heat exchanger, and assuming the same amount of sensible and total energy transfer across both the process and regeneration sides of the heat exchanger. The difference between the actual inlet air conditions and *RTI/RWI/PTI/PWI* is made here because user-defined limits for *RTI/RWI/PTI/PWI* may result in a difference between the actual conditions and those used in the equations shown above (see the EnergyPlus Engineering Reference for further discussion).

A description of each input field for this object is provided below.

Field: Name

This alpha field contains the identifying name for this set of desiccant heat exchanger performance data. Any reference to this performance data set by another object (e.g., HeatExchanger:Desiccant:BalancedFlow) will use this name.

Field: Nominal Air Flow Rate

The nominal air volume flow rate in cubic meters per second. This model assumes balanced air flow (i.e., the same air volume flow rate across the process and regeneration sides of the heat exchanger). The minimum value should be greater than 0.

Field: Nominal Air Face Velocity

This numeric field contains the nominal air velocity across the heat exchanger face area in meters per second. It is assumed that this air velocity is the same for both sides of the heat exchanger. This value, along with the Nominal Air Flow Rate sets the heat exchanger face area. With this fixed face area, the air face velocity is calculated every simulation timestep based on the actual air volume flow rate for the timestep. The minimum value should be greater than 0 and less than or equal to 6.

Field: Nominal Electric Power

This numeric field contains the nominal electric consumption rate of the heat exchanger in watts. This electric power is considered constant and is consumed only when the heat exchanger operates (e.g., for all or a portion of the simulation timestep, as appropriate). This numeric input can be used to model electric power consumption by controls (transformers, relays, etc.) and/or a motor for a rotary heat exchanger. None of this electric power contributes thermal load to the process or regeneration air streams. The minimum value should be greater than or equal to 0. The default value for this field is also 0.

The coefficients for the regeneration air outlet temperature equation described above are defined in the following eight fields:

Field: Temperature Equation Coefficient 1

The constant coefficient (B_1) in the temperature equation shown above (RTO).

Field: Temperature Equation Coefficient 2

The coefficient (B_2) in the temperature equation shown above (RTO).

Field: Temperature Equation Coefficient 3

The coefficient (B_3) in the temperature equation shown above (RTO).

Field: Temperature Equation Coefficient 4

The coefficient (B_4) in the temperature equation shown above (RTO).

Field: Temperature Equation Coefficient 5

The coefficient (B_5) in the temperature equation shown above (RTO).

Field: Temperature Equation Coefficient 6

The coefficient (B_6) in the temperature equation shown above (RTO).

Field: Temperature Equation Coefficient 7

The coefficient (B_7) in the temperature equation shown above (RTO).

Field: Temperature Equation Coefficient 8

The coefficient (B_8) in the temperature equation shown above (RTO).

The following 16 fields are used to establish the valid range for the dependent and independent variables associated with the coefficients defined above (B_1 through B_8) for the regeneration outlet air temperature equation.

Field: Minimum Regeneration Inlet Air Humidity Ratio for Temperature Equation

The minimum allowable value of RWI in the temperature equation shown above (kg/kg). Values of RWI less than the minimum will be replaced by this minimum when calculating the regeneration outlet air temperature and a warning message will be issued. The valid range for this input field is 0.0 to 1.0.

Field: Maximum Regeneration Inlet Air Humidity Ratio for Temperature Equation

The maximum allowable value of RWI in the temperature equation shown above (kg/kg). Values of RWI greater than the maximum will be replaced by this maximum when calculating the regeneration outlet air temperature and a warning message will be issued. The valid range for this input field is 0.0 to 1.0.

Field: Minimum Regeneration Inlet Air Temperature for Temperature Equation

The minimum allowable value of RTI in the temperature equation shown above (C). Values of RTI less than the minimum will be replaced by this minimum when calculating the regeneration outlet air temperature and a warning message will be issued.

Field: Maximum Regeneration Inlet Air Temperature for Temperature Equation

The maximum allowable value of RTI in the temperature equation shown above (C). Values of RTI greater than the maximum will be replaced by this maximum when calculating the regeneration outlet air temperature and a warning message will be issued.

Field: Minimum Process Inlet Air Humidity Ratio for Temperature Equation

The minimum allowable value of PWI in the temperature equation shown above (kg/kg). Values of PWI less than the minimum will be replaced by this minimum when calculating the regeneration outlet air temperature and a warning message will be issued. The valid range for this input field is 0.0 to 1.0.

Field: Maximum Process Inlet Air Humidity Ratio for Temperature Equation

The maximum allowable value of PWI in the temperature equation shown above (kg/kg). Values of PWI greater than the maximum will be replaced by this maximum when calculating the regeneration outlet air temperature and a warning message will be issued. The valid range for this input field is 0.0 to 1.0.

Field: Minimum Process Inlet Air Temperature for Temperature Equation

The minimum allowable value of PTI in the temperature equation shown above (C). Values of PTI less than the minimum will be replaced by this minimum when calculating the regeneration outlet air temperature and a warning message will be issued.

Field: Maximum Process Inlet Air Temperature for Temperature Equation

The maximum allowable value of PTI in the temperature equation shown above (C). Values of PTI greater than the maximum will be replaced by this maximum when calculating the regeneration outlet air temperature and a warning message will be issued.

Field: Minimum Regeneration Air Velocity for Temperature Equation

The minimum allowable value of RFV in the temperature equation shown above (m/s). Values of RFV less than the minimum will be replaced by this minimum when calculating the regeneration outlet air temperature and a warning message will be issued. The minimum value for this input field should be greater than 0.

Field: Maximum Regeneration Air Velocity for Temperature Equation

The maximum allowable value of RFV in the temperature equation shown above (m/s). Values of RFV greater than the maximum will be replaced by this maximum value when calculating the regeneration outlet air temperature and a warning message will be issued. The minimum value for this input field should be greater than 0.

Field: Minimum Regeneration Outlet Air Temperature for Temperature Equation

The minimum value of RTO resulting from the temperature equation shown above (C). If RTO is less than this value, RTO will be replaced by this minimum value and a warning message will be issued.

Field: Maximum Regeneration Outlet Air Temperature for Temperature Equation

The maximum value of RTO resulting from the temperature equation shown above (C). If RTO is greater than this value, RTO will be replaced by this maximum value and a warning message will be issued.

Field: Minimum Regeneration Inlet Air Relative Humidity for Temperature Equation

The minimum relative humidity of the regeneration inlet air for the temperature equation shown above (percent). If the relative humidity of the regeneration inlet air is below this value, a warning message will be issued. The valid range for this input field is 0.0 to 100.0.

Field: Maximum Regeneration Inlet Air Relative Humidity for Temperature Equation

The maximum relative humidity of the regeneration inlet air for the temperature equation shown above (percent). If the relative humidity of the regeneration inlet air is above this value, a warning message will be issued. The valid range for this input field is 0.0 to 100.0.

Field: Minimum Process Inlet Air Relative Humidity for Temperature Equation

The minimum relative humidity of the process inlet air for the temperature equation shown above (percent). If the relative humidity of the process inlet air is below this value, a warning message will be issued. The valid range for this input field is 0.0 to 100.0.

Field: Maximum Process Inlet Air Relative Humidity for Temperature Equation

The maximum relative humidity of the process inlet air for the temperature equation shown above (percent). If the relative humidity of the process inlet air is above this value, a warning message will be issued. The valid range for this input field is 0.0 to 100.0.

The coefficients for the regeneration outlet air humidity ratio equation are defined in the following eight fields:

Field: Humidity Ratio Equation Coefficient 1

The constant coefficient (C_1) in the humidity ratio equation shown above (RWO).

Field: Humidity Ratio Equation Coefficient 2

The coefficient (C_2) in the humidity ratio equation shown above (RWO).

Field: Humidity Ratio Equation Coefficient 3

The coefficient (C_3) in the humidity ratio equation shown above (RWO).

Field: Humidity Ratio Equation Coefficient 4

The coefficient (C_4) in the humidity ratio equation shown above (RWO).

Field: Humidity Ratio Equation Coefficient 5

The coefficient (C_5) in the humidity ratio equation shown above (RWO).

Field: Humidity Ratio Equation Coefficient 6

The coefficient (C_6) in the humidity ratio equation shown above (RWO).

Field: Humidity Ratio Equation Coefficient 7

The coefficient (C_7) in the humidity ratio equation shown above (RWO).

Field: Humidity Ratio Equation Coefficient 8

The coefficient (C_8) in the humidity ratio equation shown above (RWO).

The following 16 fields are used to establish the valid range for the dependent and independent variables associated with the coefficients defined above (C_1 through C_8) for the regeneration outlet air humidity ratio equation.

Field: Minimum Regeneration Inlet Air Humidity Ratio for Humidity Ratio Equation

The minimum allowable value of RWI in the humidity ratio equation shown above (kg/kg). Values of RWI less than the minimum will be replaced by this minimum when calculating the regeneration outlet air humidity ratio and a warning message will be issued. The valid range for this input field is 0.0 to 1.0.

Field: Maximum Regeneration Inlet Air Humidity Ratio for Humidity Ratio Equation

The maximum allowable value of RWI in the humidity ratio equation shown above (kg/kg). Values of RWI greater than the maximum will be replaced by this maximum when calculating the regeneration outlet air humidity ratio and a warning message will be issued. The valid range for this input field is 0.0 to 1.0.

Field: Minimum Regeneration Inlet Air Temperature for Humidity Ratio Equation

The minimum allowable value of RTI in the humidity ratio equation shown above (C). Values of RTI less than the minimum will be replaced by this minimum when calculating the regeneration outlet air humidity ratio and a warning message will be issued.

Field: Maximum Regeneration Inlet Air Temperature for Humidity Ratio Equation

The maximum allowable value of RTI in the humidity ratio equation shown above (C). Values of RTI greater than the maximum will be replaced by this maximum when calculating the regeneration outlet air humidity ratio and a warning message will be issued.

Field: Minimum Process Inlet Air Humidity Ratio for Humidity Ratio Equation

The minimum allowable value of PWI in the humidity ratio equation shown above (kg/kg). Values of PWI less than the minimum will be replaced by this minimum when calculating the regeneration outlet air humidity ratio and a warning message will be issued. The valid range for this input field is 0.0 to 1.0.

Field: Maximum Process Inlet Air Humidity Ratio for Humidity Ratio Equation

The maximum allowable value of PWI in the humidity ratio equation shown above (kg/kg). Values of PWI greater than the maximum will be replaced by this maximum when calculating the regeneration outlet air humidity ratio and a warning message will be issued. The valid range for this input field is 0.0 to 1.0.

Field: Minimum Process Inlet Air Temperature for Humidity Ratio Equation

The minimum allowable value of PTI in the humidity ratio equation shown above (C). Values of PTI less than the minimum will be replaced by this minimum when calculating the regeneration outlet air humidity ratio and a warning message will be issued.

Field: Maximum Process Inlet Air Temperature for Humidity Ratio Equation

The maximum allowable value of PTI in the humidity ratio equation shown above (C). Values of PTI greater than the maximum will be replaced by this maximum when calculating the regeneration outlet air humidity ratio and a warning message will be issued.

Field: Minimum Regeneration Air Velocity for Humidity Ratio Equation

The minimum allowable value of RFV in the humidity ratio equation shown above (m/s). Values of RFV less than the minimum will be replaced by this minimum when calculating the regeneration outlet air humidity ratio and a warning message will be issued. The minimum value for this input field should be greater than 0.

Field: Maximum Regeneration Air Velocity for Humidity Ratio Equation

The maximum allowable value of RFV in the humidity ratio equation shown above (m/s). Values of RFV greater than the maximum will be replaced by this maximum when calculating the regeneration outlet air humidity ratio and a warning message will be issued. The minimum value for this input field should be greater than 0.

Field: Minimum Regeneration Outlet Air Humidity Ratio for Humidity Ratio Equation

The minimum value of RWO resulting from the humidity ratio equation shown above (kg/kg). If RWO is less than this value, RWO will be replaced by this minimum value and a warning message will be issued. The valid range for this input field is 0.0 to 1.0.

Field: Maximum Regeneration Outlet Air Humidity Ratio for Humidity Ratio Equation

The maximum value of RWO resulting from the humidity ratio equation shown above (kg/kg). If RWO is greater than this value, RWO will be replaced by this maximum value and a warning message will be issued. The valid range for this input field is 0.0 to 1.0.

Field: Minimum Regeneration Inlet Air Relative Humidity for Humidity Ratio Equation

The minimum relative humidity of the regeneration inlet air for the humidity ratio equation shown above (percent). If the relative humidity of the regeneration inlet air is below this value, a warning message will be issued. The valid range for this input field is 0.0 to 100.0.

Field: Maximum Regeneration Inlet Air Relative Humidity for Humidity Ratio Equation

The maximum relative humidity of the regeneration inlet air for the humidity ratio equation shown above (percent). If the relative humidity of the regeneration inlet air is above this value, a warning message will be issued. The valid range for this input field is 0.0 to 100.0.

Field: Minimum Process Inlet Air Relative Humidity for Humidity Ratio Equation

The minimum relative humidity of the process inlet air for the humidity ratio equation shown above (percent). If the relative humidity of the process inlet air is below this value, a warning message will be issued. The valid range for this input field is 0.0 to 100.0.

Field: Maximum Process Inlet Air Relative Humidity for Humidity Ratio Equation

The maximum relative humidity of the process inlet air for the humidity ratio equation shown above (percent). If the relative humidity of the process inlet air is above this value, a warning message will be issued. The valid range for this input field is 0.0 to 100.0.

The full IDD specification follows:

```
HeatExchanger:Desiccant:BalancedFlow:PerformanceDataType1,
  \memo RTO = B1 + B2*RWI + B3*RTI + B4*(RWI/RTI) + B5*PWI + B6*PTI + B7*(PWI/PTI)
  \memo      + B8*RFV
  \memo RWO = C1 + C2*RWI + C3*RTI + C4*(RWI/RTI) + C5*PWI + C6*PTI + C7*(PWI/PTI)
  \memo      + C8*RFV
  \memo where,
  \memo RTO = Dry-bulb temperature of the regeneration outlet air (C)
  \memo RWO = Humidity ratio of the regeneration outlet air (kg/kg)
  \memo RWI = Humidity ratio of the regeneration inlet air (kg/kg)
  \memo RTI = Dry-bulb temperature of the regeneration inlet air (C)
  \memo PWI = Humidity ratio of the process inlet air (kg/kg)
  \memo PTI = Dry-bulb temperature of the process inlet air (C)
  \memo RFV = Regeneration Face Velocity (m/s)
  \min-fields 52
A1 , \field Name
  \required-field
  \type alpha
  \reference DesiccantHXPerfData
```

```

N1, \field Nominal Air Flow Rate
    \note Air flow rate at nominal conditions (assumed to be the same for both sides
    \note of the heat exchanger).
    \type real
    \units m3/s
    \minimum> 0.0
N2 , \field Nominal Air Face Velocity
    \required-field
    \type real
    \units m/s
    \minimum> 0.0
    \maximum 6.0
N3 , \field Nominal Electric Power
    \note Parasitic electric power (e.g., desiccant wheel motor)
    \type real
    \units W
    \ip-units W
    \minimum 0.0
    \default 0.0
N4 , \field Temperature Equation Coefficient 1
    \required-field
    \type real
N5 , \field Temperature Equation Coefficient 2
    \required-field
    \type real
N6 , \field Temperature Equation Coefficient 3
    \required-field
    \type real
N7 , \field Temperature Equation Coefficient 4
    \required-field
    \type real
N8 , \field Temperature Equation Coefficient 5
    \required-field
    \type real
N9 , \field Temperature Equation Coefficient 6
    \required-field
    \type real
N10, \field Temperature Equation Coefficient 7
    \required-field
    \type real
N11, \field Temperature Equation Coefficient 8
    \required-field
    \type real
N12, \field Minimum Regeneration Inlet Air Humidity Ratio for Temperature Equation
    \required-field
    \type real
    \units kg/kg
    \minimum 0.0
    \maximum 1.0
N13, \field Maximum Regeneration Inlet Air Humidity Ratio for Temperature Equation
    \required-field
    \type real
    \units kg/kg
    \minimum 0.0
    \maximum 1.0
N14, \field Minimum Regeneration Inlet Air Temperature for Temperature Equation
    \required-field
    \type real
    \units C
N15, \field Maximum Regeneration Inlet Air Temperature for Temperature Equation
    \required-field
    \type real
    \units C
N16, \field Minimum Process Inlet Air Humidity Ratio for Temperature Equation
    \required-field
    \type real
    \units kg/kg
    \minimum 0.0
    \maximum 1.0

```

```
N17, \field Maximum Process Inlet Air Humidity Ratio for Temperature Equation
\required-field
\type real
\units kg/kg
\minimum 0.0
\maximum 1.0
N18, \field Minimum Process Inlet Air Temperature for Temperature Equation
\required-field
\type real
\units C
N19, \field Maximum Process Inlet Air Temperature for Temperature Equation
\required-field
\type real
\units C
N20, \field Minimum Regeneration Air Velocity for Temperature Equation
\required-field
\type real
\units m/s
\minimum> 0.0
N21, \field Maximum Regeneration Air Velocity for Temperature Equation
\required-field
\type real
\units m/s
\minimum> 0.0
N22, \field Minimum Regeneration Outlet Air Temperature for Temperature Equation
\required-field
\type real
\units C
N23, \field Maximum Regeneration Outlet Air Temperature for Temperature Equation
\required-field
\type real
\units C
N24, \field Minimum Regeneration Inlet Air Relative Humidity for Temperature Equation
\required-field
\type real
\units percent
\minimum 0.0
\maximum 100.0
N25, \field Maximum Regeneration Inlet Air Relative Humidity for Temperature Equation
\required-field
\type real
\units percent
\minimum 0.0
\maximum 100.0
N26, \field Minimum Process Inlet Air Relative Humidity for Temperature Equation
\required-field
\type real
\units percent
\minimum 0.0
\maximum 100.0
N27, \field Maximum Process Inlet Air Relative Humidity for Temperature Equation
\required-field
\type real
\units percent
\minimum 0.0
\maximum 100.0
N28, \field Humidity Ratio Equation Coefficient 1
\required-field
\type real
N29, \field Humidity Ratio Equation Coefficient 2
\required-field
\type real
N30, \field Humidity Ratio Equation Coefficient 3
\required-field
\type real
N31, \field Humidity Ratio Equation Coefficient 4
\required-field
\type real
N32, \field Humidity Ratio Equation Coefficient 5
\required-field
\type real
```

```
N33, \field Humidity Ratio Equation Coefficient 6
    \required-field
    \type real
N34, \field Humidity Ratio Equation Coefficient 7
    \required-field
    \type real
N35, \field Humidity Ratio Equation Coefficient 8
    \required-field
    \type real
N36, \field Minimum Regeneration Inlet Air Humidity Ratio for Humidity Ratio Equation
    \required-field
    \type real
    \units kg/kg
    \minimum 0.0
    \maximum 1.0
N37, \field Maximum Regeneration Inlet Air Humidity Ratio for Humidity Ratio Equation
    \required-field
    \type real
    \units kg/kg
    \minimum 0.0
    \maximum 1.0
N38, \field Minimum Regeneration Inlet Air Temperature for Humidity Ratio Equation
    \required-field
    \type real
    \units C
N39, \field Maximum Regeneration Inlet Air Temperature for Humidity Ratio Equation
    \required-field
    \type real
    \units C
N40, \field Minimum Process Inlet Air Humidity Ratio for Humidity Ratio Equation
    \required-field
    \type real
    \units kg/kg
    \minimum 0.0
    \maximum 1.0
N41, \field Maximum Process Inlet Air Humidity Ratio for Humidity Ratio Equation
    \required-field
    \type real
    \units kg/kg
    \minimum 0.0
    \maximum 1.0
N42, \field Minimum Process Inlet Air Temperature for Humidity Ratio Equation
    \required-field
    \type real
    \units C
N43, \field Maximum Process Inlet Air Temperature for Humidity Ratio Equation
    \required-field
    \type real
    \units C
N44, \field Minimum Regeneration Air Velocity for Humidity Ratio Equation
    \required-field
    \type real
    \units m/s
    \minimum> 0.0
N45, \field Maximum Regeneration Air Velocity for Humidity Ratio Equation
    \required-field
    \type real
    \units m/s
    \minimum> 0.0
N46, \field Minimum Regeneration Outlet Air Humidity Ratio for Humidity Ratio Equation
    \required-field
    \type real
    \units kg/kg
    \minimum 0.0
    \maximum 1.0
N47, \field Maximum Regeneration Outlet Air Humidity Ratio for Humidity Ratio Equation
    \required-field
    \type real
    \units kg/kg
    \minimum 0.0
    \maximum 1.0
```



```

N48, \field Minimum Regeneration Inlet Air Relative Humidity for Humidity Ratio Equation
\required-field
\type real
\units percent
\minimum 0.0
\maximum 100.0
N49, \field Maximum Regeneration Inlet Air Relative Humidity for Humidity Ratio Equation
\required-field
\type real
\units percent
\minimum 0.0
\maximum 100.0
N50, \field Minimum Process Inlet Air Relative Humidity for Humidity Ratio Equation
\required-field
\type real
\units percent
\minimum 0.0
\maximum 100.0
N51, \field Maximum Process Inlet Air Relative Humidity for Humidity Ratio Equation
\required-field
\type real
\units percent
\minimum 0.0
\maximum 100.0

```

Following is an example input for this heat exchanger performance data type object:

```

HeatExchanger:Desiccant:BalancedFlow:PerformanceDataType1,
HXDesPerf1,      !- Name
1.05,            !- Nominal Air Flow Rate {m3/s}
3.25,            !- Nominal Air Face Velocity {m/s}
50.0,            !- Nominal Electric Power {W}
-2.53636E+00,    !- Temperature Equation Coefficient 1
2.13247E+01,    !- Temperature Equation Coefficient 2
9.23308E-01,     !- Temperature Equation Coefficient 3
9.43276E+02,    !- Temperature Equation Coefficient 4
-5.92367E+01,   !- Temperature Equation Coefficient 5
-4.27465E-02,   !- Temperature Equation Coefficient 6
1.12204E+02,    !- Temperature Equation Coefficient 7
7.78252E-01,    !- Temperature Equation Coefficient 8
0.007143,       !- Minimum Regeneration Inlet Air Humidity Ratio for Temperature Equation {kg/kg}
0.024286,       !- Maximum Regeneration Inlet Air Humidity Ratio for Temperature Equation {kg/kg}
46.111110,      !- Minimum Regeneration Inlet Air Temperature for Temperature Equation {C}
46.111112,      !- Maximum Regeneration Inlet Air Temperature for Temperature Equation {C}
0.005000,       !- Minimum Process Inlet Air Humidity Ratio for Temperature Equation {kg/kg}
0.015714,       !- Maximum Process Inlet Air Humidity Ratio for Temperature Equation {kg/kg}
4.583333,       !- Minimum Process Inlet Air Temperature for Temperature Equation {C}
21.83333,       !- Maximum Process Inlet Air Temperature for Temperature Equation {C}
2.286,          !- Minimum Regeneration Air Velocity for Temperature Equation {m/s}
4.826,          !- Maximum Regeneration Air Velocity for Temperature Equation {m/s}
35.0,           !- Minimum Regeneration Outlet Air Temperature for Temperature Equation {C}
50.0,           !- Maximum Regeneration Outlet Air Temperature for Temperature Equation {C}
5.0,            !- Minimum Regeneration Inlet Air Relative Humidity for Temperature Equation {percent}
45.0,           !- Maximum Regeneration Inlet Air Relative Humidity for Temperature Equation {percent}
80.0,           !- Minimum Process Inlet Air Relative Humidity for Temperature Equation {percent}
100.0,          !- Maximum Process Inlet Air Relative Humidity for Temperature Equation {percent}

```

```

-2.25547E+01,  !- Humidity Ratio Equation Coefficient 1
9.76839E-01,   !- Humidity Ratio Equation Coefficient 2
4.89176E-01,   !- Humidity Ratio Equation Coefficient 3
-6.30019E-02,  !- Humidity Ratio Equation Coefficient 4
1.20773E-02,   !- Humidity Ratio Equation Coefficient 5
5.17134E-05,   !- Humidity Ratio Equation Coefficient 6
4.94917E-02,   !- Humidity Ratio Equation Coefficient 7
-2.59417E-04,  !- Humidity Ratio Equation Coefficient 8
0.007143,      !- Minimum Regeneration Inlet Air Humidity Ratio for Humidity Ratio Equation {kg/kg}
0.024286,      !- Maximum Regeneration Inlet Air Humidity Ratio for Humidity Ratio Equation {kg/kg}
46.111110,     !- Minimum Regeneration Inlet Air Temperature for Humidity Ratio Equation {C}
46.111112,     !- Maximum Regeneration Inlet Air Temperature for Humidity Ratio Equation {C}
0.005000,      !- Minimum Process Inlet Air Humidity Ratio for Humidity Ratio Equation {kg/kg}
0.015714,      !- Maximum Process Inlet Air Humidity Ratio for Humidity Ratio Equation {kg/kg}
4.583333,      !- Minimum Process Inlet Air Temperature for Humidity Ratio Equation {C}
21.83333,      !- Maximum Process Inlet Air Temperature for Humidity Ratio Equation {C}
2.286,         !- Minimum Regeneration Air Velocity for Humidity Ratio Equation {m/s}
4.826,         !- Maximum Regeneration Air Velocity for Humidity Ratio Equation {m/s}
0.007914,      !- Minimum Regeneration Outlet Air Humidity Ratio for Humidity Ratio Equation {kg/kg}
0.026279,      !- Maximum Regeneration Outlet Air Humidity Ratio for Humidity Ratio Equation {kg/kg}
5.0,           !- Minimum Regeneration Inlet Air Relative Humidity for Humidity Ratio Equation {percent}
45.0,          !- Maximum Regeneration Inlet Air Relative Humidity for Humidity Ratio Equation {percent}
80.0,          !- Minimum Process Inlet Air Relative Humidity for Humidity Ratio Equation {percent}
100.0;         !- Maximum Process Inlet Air Relative Humidity for Humidity Ratio Equation {percent}

```

HeatExchanger:Desiccant:BalancedFlow:PerformanceDataType1 Outputs

No variables are reported for this object. However, outputs are provided by the HeatExchanger:Desiccant:BalancedFlow object that references this PerformanceDataType1 object.

Group – Demand Limiting Controls

Demand limiting, or demand management, is a strategy for reducing a building's demand for utilities, e.g., electricity. Utility companies typically charge a monthly fee for "demand charges" that is based on the peak demand during a certain time period. Often the peak demand charge is set by one exceptional day that is much higher than the peak demand for an average day during the month. Therefore, to save utility costs, it is in the interest of building owners to find ways to manage the demand on peak days. While demand management is generally concerned with the demand for electricity, the future will likely see demand management of other utilities, such as natural gas or water.

Demand limiting controls shut off or reduce the power to non-essential loads in order to reduce the overall building demand. Some typical controls:

- shut off or dim electric lights, equipment, or HVAC systems
- reset the thermostatic set points on HVAC systems
- reduce the load of a set of similar components by rotating one or more components "off" for a short time interval
- turn on generators to meet some or all of the building's demand.

The demand limiting controls implemented in EnergyPlus are intended to allow some of the more common demand limiting strategies. Currently, only Exterior:Lights, Lights, ElectricEquipment, and ZoneControl:Thermostat objects can be demand limited. Additional components will be demand limited in future releases.

DemandManagerAssignmentList

The DemandManagerAssignmentList object is a high level control that makes demand limiting decisions based on a list of possible demand limiting strategies. Each demand limiting strategy is described in a separate DemandManager object. (This is structured like the relationship between the AvailabilityManagerAssignmentList and the AvailabilityManager objects.)

Each DemandManagerAssignmentList monitors and demand limits one meter. Only electricity meters are currently allowed. In many cases, the meter will be *Electricity:Facility*. A schedule and safety factor are used to set the demand limit above which the DemandManagers become activated. The billing month schedule and demand window are also taken into account when calculating the demand limit.

DemandManagers in the list are activated based on the *Demand Manager Priority*. If the **Sequential** option is used, each manager in the list is activated in sequence from first to last until demand is reduced below the limit or until all managers are activated. If the **All** option is used, all managers are activated simultaneously to achieve the maximum demand reduction.

A DemandManager is skipped if it cannot reduce the demand. Possible reasons that a manager cannot reduce demand include:

- not enough load to limit
- not available because of its *Availability Schedule*
- already activated; load limited during a previous timestep.

```

DemandManagerAssignmentList,
  \extensible:2 Duplicate the last two fields DemandManager Object Type and DemandManager Name
A1 , \field Name
  \required-field
  \type alpha
A2 , \field Meter Name
  \required-field
  \type alpha
A3 , \field Demand Limit Schedule Name
  \type object-list
  \object-list ScheduleNames
N1 , \field Demand Limit Safety Fraction
  \required-field
  \type real
  \minimum 0.0
A4 , \field Billing Period Schedule Name
  \type object-list
  \object-list ScheduleNames
  \note This field should reference the same schedule as the month schedule name field of the
  \note UtilityCost:Tariff object, if used.
  \note If blank, defaults to regular divisions between months.
A5 , \field Peak Period Schedule Name
  \type object-list
  \object-list ScheduleNames
  \note This field should reference the same schedule as the period schedule name field of the
  \note UtilityCost:Tariff object, if used.
  \note If blank, defaults to always on peak.
N2 , \field Demand Window Length
  \required-field
  \type integer
  \minimum > 0
  \units minutes
A6 , \field Demand Manager Priority
  \required-field
  \type choice
  \key Sequential
  \key All
A7 , \field DemandManager 1 Object Type
  \type choice
  \key DemandManager:ExteriorLights
  \key DemandManager:Lights
  \key DemandManager:ElectricEquipment
  \key DemandManager:Thermostats
A8 , \field DemandManager 1 Name
  \type object-list
  \object-list DemandManagerNames
A9 , \field DemandManager 2 Object Type
  \type choice
  \key DemandManager:ExteriorLights
  \key DemandManager:Lights
  \key DemandManager:ElectricEquipment
  \key DemandManager:Thermostats
A10, \field DemandManager 2 Name
  \type object-list
  \object-list DemandManagerNames
A11, \field DemandManager 3 Object Type
  \type choice
  \key DemandManager:ExteriorLights
  \key DemandManager:Lights
  \key DemandManager:ElectricEquipment
  \key DemandManager:Thermostats
A12, \field DemandManager 3 Name
  \type object-list
  \object-list DemandManagerNames
<reduced for brevity>

```

Field: Name

The name of the DemandManagerAssignmentList object.

Field: Meter Name

This field references the meter that is to be monitored and demand limited. Only electricity meters are currently allowed.

Field: Demand Limit Schedule Name

The reference to the schedule object specifying the target demand limits [schedule values should be in Watts].

Field: Demand Limit Safety Fraction

This field is a multiplier that is applied to the target demand limit (above). When the metered demand exceeds (target demand limit * safety fraction), the DemandManagers begin to limit the demand. This helps to ensure that the target limit is not exceeded.

Field: Billing Period Schedule Name

The reference to the schedule object that defines the monthly billing periods. The peak demand during the peak period of the billing period typically determines the demand charge. This should reference the same schedule that is used in the *Month Schedule Name* field of the UtilityCost:Tariff object. If left blank, it defaults to the regular divisions between months.

Field: Peak Period Schedule Name

The reference to the schedule object that defines the peak/off-peak time-of-use periods. The peak demand during the peak period of the billing period typically determines the demand charge. This should reference the same schedule that is used in the *Time of Use Period Schedule Name* field of the UtilityCost:Tariff object. A value of 1 indicates the peak period; any other value is off-peak. If left blank, it defaults to always on the peak period. The DemandManagerAssignmentList only attempts to demand limit during peak periods.

Field: Demand Window Length

This field is similar to the field of the same name in the UtilityCost:Tariff object. However, the user may not want to limit using the same demand window as the utility company. This field allows the user to input the number of minutes over which to calculate the current demand. The minutes are rounded to match the nearest multiple of time steps.

Field: Demand Manager Priority

This field indicates what logic should be used to activate the individual DemandManagers in the list. **Sequential** treats the list of DemandManagers as a sequential priority list, i.e., the first DemandManager in the list is activated first, then the second, etc., until the demand falls below the limit. **All** activates all demand managers to achieve the maximum demand reduction.

Field: Demand Manager Type 1

The key word defining the type of DemandManager.

Field: Demand Manager Name 1

The name of a DemandManager object defined elsewhere in the input file.

DemandManagers are listed by pairs of data items: *Demand Manager Type* and *Demand Manager Name*. Ten managers are accommodated in the list by default. The IDD specification, however, is extensible and additional pairs may be added by directly editing the IDD.

An example IDF showing how this object is used is provided below:

```

DemandManagerAssignmentList,
Demand Manager,           !- Name
Electricity:Facility,     !- Meter Name
Limit Schedule,          !- Demand Limit Schedule Name
1.0,                      !- Demand Limit Safety Fraction
,                          !- Billing Period Schedule Name
,                          !- Peak Period Schedule Name
15,                       !- Demand Window Length {minutes}
Sequential,              !- Demand Manager Priority
DemandManager:ExteriorLights, !- DemandManager 1 Object Type
Ext Lights Manager,      !- DemandManager 1 Name
DemandManager:ElectricEquipment, !- DemandManager 2 Object Type
Eq Mgr Stage 1,         !- DemandManager 2 Name
DemandManager:ElectricEquipment, !- DemandManager 3 Object Type
Eq Mgr Stage 2,         !- DemandManager 3 Name
DemandManager:ElectricEquipment, !- DemandManager 4 Object Type
Eq Mgr Stage 3,         !- DemandManager 4 Name
DemandManager:Lights,   !- DemandManager 5 Object Type
Lights Manager,         !- DemandManager 5 Name
DemandManager:Thermostats, !- DemandManager 6 Object Type
Thermostats Manager;    !- DemandManager 6 Name

```

DemandManagerAssignmentList Outputs

The following output variables are reported for the DemandManagerAssignmentList object:

```

Zone,Average,Demand Manager Meter Demand [W]
Zone,Average,Demand Manager Average Demand [W]
Zone,Average,Demand Manager Peak Demand [W]
Zone,Average,Demand Manager Scheduled Limit [W]
Zone,Average,Demand Manager Demand Limit [W]
Zone,Average,Demand Manager Avoided Demand [W]
Zone,Average,Demand Manager Over Limit [W]
Zone,Sum,Demand Manager Over Limit Duration [hr]
Zone,Sum,Demand Manager Exterior Energy Iterations []
Zone,Sum,Demand Manager Heat Balance Iterations []
Zone,Sum,Demand Manager HVAC Iterations []

```

Demand Manager Meter Demand [W]

The current demand for the designated meter.

Demand Manager Average Demand [W]

The current demand for the designated meter averaged over the *Demand Window Length*.

Demand Manager Peak Demand [W]

The peak demand in the billing month so far.

Demand Manager Scheduled Limit [W]

The scheduled target demand limit from the *Demand Limit Schedule*.

Demand Manager Demand Limit [W]

The actual demand limit after multiplication by the *Demand Limit Safety Fraction*.

Demand Manager Avoided Demand [W]

The demand that was avoided by the active DemandManagers.

Demand Manager Over Limit [W]

The difference between the demand limit and the average demand.

Demand Manager Over Limit Duration [hr]

The number of hours that the demand limit was exceeded.

Demand Manager Exterior Energy Iterations []

The number times that the exterior energy use was resimulated for demand limiting.

Demand Manager Heat Balance Iterations []

The number times that the zone heat balance was resimulated for demand limiting.

Demand Manager HVAC Iterations []

The number times that the HVAC system was resimulated for demand limiting.

DemandManager:ExteriorLights

The DemandManager:ExteriorLights object is used for demand limiting Exterior:Lights objects.

```

DemandManager:ExteriorLights,
  \extensible:1 Duplicate the last field Exterior:Lights Name
A1 , \field Name
    \required-field
    \type alpha
    \reference DemandManagerNames
A2 , \field Availability Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note If blank, defaults to always on
A3 , \field Limit Control
    \required-field
    \type choice
    \key Off
    \key Fixed
N1 , \field Minimum Limit Duration
    \type integer
    \minimum> 0
    \units minutes
    \note If blank, duration defaults to the timestep
N2 , \field Maximum Limit Fraction
    \type real
    \minimum 0.0
    \maximum 1.0
N3 , \field Limit Step Change
    \note Not yet implemented
    \type real
A4 , \field Selection Control
    \required-field
    \type choice
    \key All
    \key RotateMany
    \key RotateOne
N4 , \field Rotation Duration
    \type integer
    \minimum 0
    \units minutes
    \note If blank, duration defaults to the timestep
A5 , \field Exterior Lights 1 Name
    \note Enter the name of an Exterior:Lights object.
    \required-field
    \type object-list
    \object-list ExteriorLightsNames
A6 , \field Exterior Lights 2 Name
    \note Enter the name of an Exterior:Lights object.
    \type object-list
    \object-list ExteriorLightsNames
A7 , \field Exterior Lights 3 Name
    \note Enter the name of an Exterior:Lights object.
    \type object-list
    \object-list ExteriorLightsNames
<reduced for brevity>

```

Field: Name

The name of the DemandManager:ExteriorLights object.

Field: Availability Schedule Name

The reference to the schedule object specifying the availability of this DemandManager.

Field: Limit Control

This field specifies the type of limiting control. The **Fixed** option reduces the power to the controlled loads by a fixed amount determined by the *Maximum Limit Fraction* field. The **Off** option disables the DemandManager in the simulation.

Field: Minimum Limit Duration

The minimum amount of time [minutes] that the DemandManager will continue to demand limit after being activated. This prevents loads from turning on and off every time step.

Field: Maximum Limit Fraction

This field specifies a fraction of the *Design Level* power for the load that determines the lowest allowable power level. With *Limit Control* set to **Fixed**, the power is reduced to $Maximum\ Limit\ Fraction * Design\ Level$ whenever the manager is activated. For example, if the *Maximum Limit Fraction* is 0.8, then a 100 W design level load is reduced to 80 W when limiting. A *Maximum Limit Fraction* of zero means that the load can be shut off entirely.

Field: Limit Step Change

NOT YET IMPLEMENTED.

Field: Selection Control

This field specifies which loads are selected to be limited. The **All** option simultaneously limits all of the loads listed in this DemandManager. The **RotateMany** option limits all loads except for one which rotates sequentially through the loads listed. The **RotateOne** limits only one load which rotates sequentially through the loads listed. The time interval between rotations is set by the *Rotation Duration* field.

Field: Rotation Duration

If the **RotateOne** or **RotateMany** option is used for *Selection Control*, this field sets the time interval [minutes] between rotations.

Field: Exterior Lights 1-10 Name

The names of Exterior:Lights objects defined elsewhere in the input file. These are the loads to be limited by this DemandManager.

Ten objects are accommodated in the list by default. The IDD specification, however, is extensible and additional fields may be added by directly editing the IDD.

An example IDF showing how this object is used is provided below:

```
DemandManager:ExteriorLights,
  Ext Lights Manager,      !- Name
  ,                        !- Availability Schedule Name
  Fixed,                  !- Limit Control
  60,                     !- Minimum Limit Duration {minutes}
  0.0,                    !- Maximum Limit Fraction
  ,                        !- Limit Step Change
  All,                    !- Selection Control
  ,                        !- Rotation Duration {minutes}
  Exterior Lights;        !- Exterior Lights 1 Name
```

DemandManager:ExteriorLights Outputs

There are no output variables reported for the DemandManager:ExteriorLights object.

DemandManager:Lights

The DemandManager:Lights object is used for demand limiting Lights objects.

```

DemandManager:Lights,
  \extensible:1 Duplicate the last field Lights Name
A1 , \field Name
    \required-field
    \type alpha
    \reference DemandManagerNames
A2 , \field Availability Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note If blank, defaults to always on
A3 , \field Limit Control
    \required-field
    \type choice
    \key Off
    \key Fixed
N1 , \field Minimum Limit Duration
    \type integer
    \minimum> 0
    \units minutes
    \note If blank, duration defaults to the timestep
N2 , \field Maximum Limit Fraction
    \type real
    \minimum 0.0
    \maximum 1.0
N3 , \field Limit Step Change
    \note Not yet implemented
    \type real
A4 , \field Selection Control
    \required-field
    \type choice
    \key All
    \key RotateMany
    \key RotateOne
N4 , \field Rotation Duration
    \type integer
    \minimum 0
    \units minutes
    \note If blank, duration defaults to the timestep
A5 , \field Lights 1 Name
    \required-field
    \type object-list
    \object-list LightsNames
A6 , \field Lights 2 Name
    \type object-list
    \object-list LightsNames
A7 , \field Lights 3 Name
    \type object-list
<reduced for brevity>

```

Field: Name

The name of the DemandManager:Lights object.

Field: Availability Schedule Name

The reference to the schedule object specifying the availability of this DemandManager.

Field: Limit Control

This field specifies the type of limiting control. The **Fixed** option reduces the power to the controlled loads by a fixed amount determined by the *Maximum Limit Fraction* field. The **Off** option disables the DemandManager in the simulation.

Field: Minimum Limit Duration

The minimum amount of time [minutes] that the DemandManager will continue to demand limit after being activated. This prevents loads from turning on and off every time step.

Field: Maximum Limit Fraction

This field specifies a fraction of the *Design Level* power for the load that determines the lowest allowable power level. With *Limit Control* set to **Fixed**, the power is reduced to *Maximum Limit Fraction * Design Level* whenever the manager is activated. For example, if the *Maximum Limit Fraction* is 0.8, then a 100 W design level load is reduced to 80 W when limiting. A *Maximum Limit Fraction* of zero means that the load can be shut off entirely.

Field: Limit Step Change

NOT YET IMPLEMENTED.

Field: Selection Control

This field specifies which loads are selected to be limited. The **All** option simultaneously limits all of the loads listed in this DemandManager. The **RotateMany** option limits all loads except for one which rotates sequentially through the loads listed. The **RotateOne** limits only one load which rotates sequentially through the loads listed. The time interval between rotations is set by the *Rotation Duration* field.

Field: Rotation Duration

If the **RotateOne** or **RotateMany** option is used for *Selection Control*, this field sets the time interval [minutes] between rotations.

Field: Lights 1-10 Name

The names of Lights objects defined elsewhere in the input file. These are the loads to be limited by this DemandManager.

Ten objects are accommodated in the list by default. The IDD specification, however, is extensible and additional fields may be added by directly editing the IDD.

An example IDF showing how this object is used is provided below:

```
DemandManager:Lights,
Lights Manager,          !- Name
,                        !- Availability Schedule Name
Fixed,                  !- Limit Control
60,                     !- Minimum Limit Duration {minutes}
0.5,                    !- Maximum Limit Fraction
,                        !- Limit Step Change
All,                     !- Selection Control
,                        !- Rotation Duration {minutes}
Space1-1 Lights 1,      !- Lights 1 Name
Space2-1 Lights 1,      !- Lights 2 Name
Space3-1 Lights 1,      !- Lights 3 Name
Space4-1 Lights 1,      !- Lights 4 Name
Space5-1 Lights 1;      !- Lights 5 Name
```

DemandManager:Lights Outputs

There are no output variables reported for the DemandManager:Lights object.

DemandManager:ElectricEquipment

The DemandManager:ElectricEquipment object is used for demand limiting ElectricEquipment objects.

```

DemandManager:ElectricEquipment,
  \extensible:1 Duplicate the last field ElectricEquipment Name
A1 , \field Name
    \required-field
    \type alpha
    \reference DemandManagerNames
A2 , \field Availability Schedule Name
    \type object-list
    \object-list ScheduleNames
    \note If blank, defaults to always on
A3 , \field Limit Control
    \required-field
    \type choice
    \key Off
    \key Fixed
N1 , \field Minimum Limit Duration
    \type integer
    \minimum> 0
    \units minutes
    \note If blank, duration defaults to the timestep
N2 , \field Maximum Limit Fraction
    \type real
    \minimum 0.0
    \maximum 1.0
N3 , \field Limit Step Change
    \note Not yet implemented
    \type real
A4 , \field Selection Control
    \required-field
    \type choice
    \key All
    \key RotateMany
    \key RotateOne
N4 , \field Rotation Duration
    \type integer
    \minimum 0
    \units minutes
    \note If blank, duration defaults to the timestep
A5 , \field Electric Equipment 1 Name
    \note Enter the name of an ElectricEquipment object.
    \required-field
    \type object-list
    \object-list ElectricEquipmentNames
A6 , \field Electric Equipment 2 Name
    \note Enter the name of an ElectricEquipment object.
    \type object-list
    \object-list ElectricEquipmentNames
A7 , \field Electric Equipment 3 Name
    \note Enter the name of an ElectricEquipment object.
    \type object-list
    \object-list ElectricEquipmentNames
<reduced for brevity>

```

Field: Name

The name of the DemandManager:ElectricEquipment object.

Field: Availability Schedule Name

The reference to the schedule object specifying the availability of this DemandManager.

Field: Limit Control

This field specifies the type of limiting control. The **Fixed** option reduces the power to the controlled loads by a fixed amount determined by the *Maximum Limit Fraction* field. The **Off** option disables the DemandManager in the simulation.

Field: Minimum Limit Duration

The minimum amount of time [minutes] that the DemandManager will continue to demand limit after being activated. This prevents loads from turning on and off every time step.

Field: Maximum Limit Fraction

This field specifies a fraction of the *Design Level* power for the load that determines the lowest allowable power level. With *Limit Control* set to **Fixed**, the power is reduced to *Maximum Limit Fraction * Design Level* whenever the manager is activated. For example, if the *Maximum Limit Fraction* is 0.8, then a 100 W design level load is reduced to 80 W when limiting. A *Maximum Limit Fraction* of zero means that the load can be shut off entirely.

Field: Limit Step Change

NOT YET IMPLEMENTED.

Field: Selection Control

This field specifies which loads are selected to be limited. The **All** option simultaneously limits all of the loads listed in this DemandManager. The **RotateMany** option limits all loads except for one which rotates sequentially through the loads listed. The **RotateOne** limits only one load which rotates sequentially through the loads listed. The time interval between rotations is set by the *Rotation Duration* field.

Field: Rotation Duration

If the **RotateOne** or **RotateMany** option is used for *Selection Control*, this field sets the time interval [minutes] between rotations.

Field: Electric Equipment 1-10 Name

The names of ElectricEquipment objects defined elsewhere in the input file. These are the loads to be limited by this DemandManager.

Ten objects are accommodated in the list by default. The IDD specification, however, is extensible and additional fields may be added by directly editing the IDD.

An example IDF showing how this object is used is provided below:

```
DemandManager:ElectricEquipment,
Eq Mgr Stage 3,      !- Name
,                   !- Availability Schedule Name
Fixed,              !- Limit Control
60,                 !- Minimum Limit Duration {minutes}
0.0,                !- Maximum Limit Fraction
,                   !- Limit Step Change
All,                !- Selection Control
,                   !- Rotation Duration {minutes}
Space5-1 ElecEq 1;  !- Electric Equipment 1 Name
```

DemandManager:ElectricEquipment Outputs

There are no output variables reported for the DemandManager:ElectricEquipment object.

DemandManager:Thermostats

The DemandManager:Thermostats object is used for demand limiting ZoneControl:Thermostat objects.

```

DemandManager:Thermostats,
  \extensible:1 Duplicate the last field ZoneControl:Thermostat Name
A1 , \field Name
  \required-field
  \type alpha
  \reference DemandManagerNames
A2 , \field Availability Schedule Name
  \type object-list
  \object-list ScheduleNames
  \note If blank, defaults to always on
A3 , \field Reset Control
  \required-field
  \type choice
  \key Off
  \key Fixed
N1 , \field Minimum Reset Duration
  \type integer
  \minimum> 0
  \units minutes
  \note If blank, duration defaults to the timestep
N2 , \field Maximum Heating Setpoint Reset
  \required-field
  \type real
  \units C
N3 , \field Maximum Cooling Setpoint Reset
  \required-field
  \type real
  \units C
N4 , \field Reset Step Change
  \note Not yet implemented
  \type real
A4 , \field Selection Control
  \required-field
  \type choice
  \key All
  \key RotateMany
  \key RotateOne
N5 , \field Rotation Duration
  \type integer
  \minimum 0
  \units minutes
  \note If blank, duration defaults to the timestep
A5 , \field Thermostat 1 Name
  \note Enter the name of a ZoneControl:Thermostat object.
  \required-field
  \type object-list
  \object-list ZoneControlThermostaticNames
A6 , \field Thermostat 2 Name
  \note Enter the name of a ZoneControl:Thermostat object.
  \type object-list
  \object-list ZoneControlThermostaticNames
<reduced for brevity>

```

Field: Name

The name of the DemandManager:Thermostats object.

Field: Availability Schedule Name

The reference to the schedule object specifying the availability of the DemandManager.

Field: Reset Control

This field specifies the type of limiting control. The **Fixed** option resets the thermostats to a fixed temperature determined by the *Maximum Heating Setpoint Reset* and *Maximum Cooling Setpoint Reset* fields. The **Off** option disables the DemandManager in the simulation.

Field: Minimum Reset Duration

The minimum amount of time [minutes] that the DemandManager will continue to demand limit after being activated. This prevents thermostats from resetting on and off every time step.

Field: Maximum Heating Setpoint Reset

This field specifies the thermostat heating setpoint temperature [C] that represents the largest allowable temperature reset or setback. With *Reset Control* set to **Fixed**, the setpoint temperature is reset to the *Maximum Heating Setpoint Reset* whenever the manager is activated. For example, if the heating setpoint is normally 22 C and the *Maximum Heating Setpoint Reset* is 20 C, then the setpoint is reset to 20 C when limiting.

Field: Maximum Cooling Setpoint Reset

This field specifies the thermostat cooling setpoint temperature [C] that represents the largest allowable temperature reset or setback. With *Reset Control* set to **Fixed**, the setpoint temperature is reset to the *Maximum Cooling Setpoint Reset* whenever the manager is activated. For example, if the cooling setpoint is normally 22 C and the *Maximum Cooling Setpoint Reset* is 24 C, then the setpoint is reset to 24 C when limiting.

Field: Reset Step Change

NOT YET IMPLEMENTED.

Field: Selection Control

This field specifies which loads are selected to be limited. The **All** option simultaneously limits all of the loads listed in this DemandManager. The **RotateMany** option limits all loads except for one which rotates sequentially through the loads listed. The **RotateOne** limits only one load which rotates sequentially through the loads listed. The time interval between rotations is set by the *Rotation Duration* field.

Field: Rotation Duration

If the **RotateOne** or **RotateMany** option is used for *Selection Control*, this field sets the time interval [minutes] between rotations.

Field: Thermostat 1-10 Name

The names of ZoneControl:Thermostat objects defined elsewhere in the input file. These are the loads to be limited by this DemandManager.

Ten objects are accommodated in the list by default. The IDD specification, however, is extensible and additional fields may be added by directly editing the IDD.

An example IDF showing how this object is used is provided below:

```
DemandManager:Thermostats,
  Thermostats Manager,      !- Name
  ,                          !- Availability Schedule Name
  Fixed,                    !- Reset Control
  60,                       !- Minimum Reset Duration {minutes}
  19,                       !- Maximum Heating Setpoint Reset {C}
  26,                       !- Maximum Cooling Setpoint Reset {C}
  ,                          !- Reset Step Change
  All,                      !- Selection Control
  ,                          !- Rotation Duration {minutes}
  SPACE1-1 Control,        !- Thermostat 1 Name
  SPACE2-1 Control,        !- Thermostat 2 Name
  SPACE3-1 Control,        !- Thermostat 3 Name
  SPACE4-1 Control,        !- Thermostat 4 Name
  SPACE5-1 Control;        !- Thermostat 5 Name
```

DemandManager:Thermostats Outputs

There are no output variables reported for the DemandManager:Thermostats object.

Group – Electric Load Center-Generator Specifications**ElectricLoadCenter:Distribution**

ElectricLoadCenter:Distribution objects are used to include on-site electricity generators in a simulation. The electric load center dispatches generators according to operation schemes and tracks and reports the amount of electricity generated and purchased. When using on-site generators, the program provides a “net” report where the total electricity used is reduced by the amount generated on site. Electrical demand tracking is done by the internal or custom meters used by EnergyPlus for reporting. The thermal demand tracking uses internal load calculations from the plant simulation. The dispatching of different generators is based on expectations based on their nominal generating capacities. If the current conditions are such that the generator model determines that generation was higher or lower, then the results of the dispatch may differ from expectations.

Multiple different ElectricLoadCenter:Distribution objects can be included in an input file. A great deal of flexibility is available by mixing different load centers and operating schemes. If multiple load centers are used, the supervisory control will dispatch generators sequentially across the load centers. Therefore, the order of these input objects in the IDF file becomes important with the generators associated with first load center in the file being the first to be managed. A certain amount of caution is needed to avoid conflicting operating schemes.

The electricity produced from photovoltaic arrays will be reported in the electricity produced report variable and will reduce the demand that the generators will try to meet for that timestep.

Field: Name

This alpha field contains the identifying name for the electric load center.

Field: Generator List Name

This alpha field contains the identifying name for the list of generators in the set.

Field: Generator Operation Scheme Type

This alpha field specifies the type of operating scheme for the generator set. The available operating schemes are “Baseload,” “DemandLimit,” “TrackElectrical,” “TrackSchedule,” “TrackMeter,” “FollowThermal,” and “FollowThermalLimitElectrical.” The Baseload scheme operates the generators at their rated capacity when the generator is scheduled ON. The DemandLimit scheme limits the amount of purchased electrical from the utility to the amount specified in the input object. The DemandLimit scheme tries to have the generators meet all of the demand above the purchased electric limit set by the user in the next field. The TrackElectrical scheme tries to have the generators meet all of the electrical demand for the building. The TrackSchedule scheme tries to have the generators meet all of the electrical demand determined in a user-defined schedule. The TrackMeter scheme tries to have the generators meet all the electrical demand from a meter, which could also be a user-defined custom meter.

The DemandLimit, TrackElectrical, TrackSchedule, and TrackMeter schemes will sequentially load the available generators. All demand not met by available generator capacity will be met by purchased electrical. Therefore, if DemandLimit, TrackElectrical, TrackSchedule, or TrackMeter is utilized and the available generators are not enough to meet demand, then purchased electrical will offset the difference. If a generator is needed in the simulation for a small load and it is less than the minimum part load ratio the generator will operate at the

minimum part load ratio and the excess will either reduce demand or the excess energy will be available for returning to the electric grid.

The FollowThermal and FollowThermalLimitElectrical schemes are for heat following cogeneration and run the generators to meet the thermal demand. The FollowThermal schemes allow excess electrical generation to be exported to the grid, while the FollowThermalLimitElectrical scheme restricts generator output to a maximum of the building's current electrical demand (so that no electricity is exported). The thermal demand is determined from the plant modeling and depends on the flow requested by other components on the demand side of the plant loop, the loop temperatures, and the loop temperature set point. The electric load center converts the thermal load to an electrical load using a nominal ratio of the thermal to electrical power production for each generator. For these schemes, the generator needs to be connected to the supply side of a plant loop and supply components that request hot water need to be on the demand side of the plant loop. This is different than the usual configuration for electrical following schemes where the generator is put on the demand side and request flow for the purposes of cooling the generator. Therefore a switch from one of the electrical-based operating schemes to one of the thermal-based operating schemes requires a substantial change in plant topology.

If the load center includes electrical storage, then the choice of operating schemes will also affect how storage is managed.

Field: Demand Limit Scheme Purchased Electric Demand Limit

This numerical field is the user input for the demand limit above which the generators will try and meet the entire electrical load on the building minus the photovoltaic array if available.

Field: Track Schedule Name Scheme Schedule Name

This alpha field is the user input for the name of a schedule defined elsewhere in the input file that contains values for the "demand" loads placed on the generator(s). The schedule values should be in Watts.

Field: Track Meter Scheme Meter Name

This alpha field is the user input for the name of a meter. Any valid meter name can be used here to control the loads that the generator(s) will try to meet. Many different meters are automatically generated by the program and will depend on the objects used throughout the input file. The typical process of determining the exact name to enter in this field involves doing an initial run of EnergyPlus and then examining the *.rdd file which will list the meters and their resulting names. The *.mtd file will also be useful to understand what exactly is included in a meter. The user can also use the Output:CustomMeter objects to redefine meter names and to control what electrical loads are included on them in a flexible manner.

Field: Electrical Buss Type

This alpha field is used to describe how the electric load center is configured with respect to any power conditioning and/or storage equipment. There are five configurations for load centers available by using one of these keywords:

- AlternatingCurrent
- AlternatingCurrentWithStorage
- DirectCurrentWithInverter
- DirectCurrentWithInverterDCStorage
- DirectCurrentWithInverterACStorage

AlternatingCurrent is the default. All the generators connected to a specific load center need to be of the same type (all AC or all DC). If the generators are DC, then an inverter is needed to convert the DC to AC. If there are DC generators and a DC electrical storage device on the buss along with an inverter, then use DirectCurrentWithInverterDCStorage in this field.

See the Engineering Reference for more information including diagrams of the load center configurations.

Field: Inverter Object Name

This field is used to identify the inverter connected to this load center (if any). This field is only used if the Electrical Buss Type is set to DirectCurrentWithInverter and should contain the user-defined name of an inverter object. There are three types of inverter models available—see ElectricLoadCenter:Inverter:Simple, ElectricLoadCenter:Inverter:LookUpTable, or ElectricLoadCenter:Inverter:FunctionOfPower. Enter the name of one of these types of inverter objects defined elsewhere in the input file.

Field: Electrical Storage Object Name

This field is used to identify the electrical storage connected to this load center (if any). This field is only used if the Electrical Buss Type is set to DirectCurrentWithInverterDCStorage or DirectCurrentWithInverterACStorage. Enter the name of an ElectricLoadCenter:Storage:Simple object defined elsewhere in the input file.

The IDD entry for this object is:

```
ElectricLoadCenter:Distribution,
  A1 , \field Name
      \required-field
  A2 , \field Generator List Name
      \reference GeneratorLists
  A3, \field Generator Operation Scheme Type
      \type choice
      \key Baseload
      \key DemandLimit
      \key TrackElectrical
      \key TrackSchedule
      \key TrackMeter
      \key FollowThermal
      \key FollowThermalLimitElectrical
  N1, \field Demand Limit Scheme Purchased Electric Demand Limit
      \type real
      \units W
  A4, \field Track Schedule Name Scheme Schedule Name
      \type object-list
      \object-list ScheduleNames
  A5, \field Track Meter Scheme Meter Name
  A6, \field Electrical Buss Type
      \type choice
      \key AlternatingCurrent
      \key AlternatingCurrentWithStorage
      \key DirectCurrentWithInverter
      \key DirectCurrentWithInverterDCStorage
      \key DirectCurrentWithInverterACStorage
      \default AlternatingCurrent
  A7, \field Inverter Object Name
      \reference InverterList
  A8; \field Electrical Storage Object Name
      \reference ElecStorageList
```

Examples of this object are:

```

ElectricLoadCenter:Distribution,
  SOFC Electric Load Center,  !- Name
  Micro-Generators,          !- Generator List Name
  Baseload,                  !- Generator Operation Scheme Type
  0.0,                       !- Demand Limit Scheme Purchased Electric Demand Limit {W}
  ,                           !- Track Schedule Name Scheme Schedule Name
  ,                           !- Track Meter Scheme Meter Name
  AlternatingCurrent,        !- Electrical Buss Type
  ,                           !- Inverter Object Name
  ;                           !- Electrical Storage Object Name

ElectricLoadCenter:Distribution,
  Electric Load Center,      !- Name
  Backup Generators,         !- Generator List Name
  DemandLimit,              !- Generator Operation Scheme Type
  10000.0,                   !- Demand Limit Scheme Purchased Electric Demand Limit {W}
  ,                           !- Track Schedule Name Scheme Schedule Name
  ,                           !- Track Meter Scheme Meter Name
  AlternatingCurrent,        !- Electrical Buss Type
  ,                           !- Inverter Object Name
  ;                           !- Electrical Storage Object Name

```

ElectricLoadCenter Outputs

There are three levels of results reporting related to electric load centers and generators. The top level of reporting provides results across the whole building and all the different electric load centers and generators. The second level of reporting provides results for individual load centers. The third level is for each type of generator (see individual generator descriptions). This section discusses the first two levels.

The whole-building summary report variables are:

```

HVAC,Average,Total Electric Power Produced [W]
HVAC,Sum,Total Electric Energy Produced [J]
HVAC,Average,Total Electric Power Purchased [W]
HVAC,Sum,Total Electric Energy Purchased [J]
HVAC,Average,Total Building Electric Demand [W]
HVAC,Average,Total HVAC Electric Demand [W]
HVAC,Average,Total Electric Demand [W]

```

These report variables all use a default keyword "Whole Building."

These report variables can also be accessed without specifying generation equipment by including the syntax shown below:

```

ElectricLoadCenter:Distribution,
  Electric Load Center; !- Name

```

Even if no ElectricLoadCenter:Distribution object is included, these report variables are also available for all simulations that have any electricity consuming equipment with the default keyword name "Electrical Service."

Total Electric Power Produced [W]

Total Electric Energy Produced [J]

These outputs are the total generator and photovoltaic electricity produced for the entire model, and they are both in Power and Energy units.

Total Electric Power Purchased [W]

Total Electric Energy Purchased [J]

These outputs are the total of electricity purchased for the entire model in both Power and Energy units. This value is always positive and indicates the amount of energy is purchased from the utility.

Total Electric Energy Surplus [J]

This output is the excess electricity produced and sent out to the electrical grid. This value is always positive and indicates the surplus electricity from generation that exceeds whole-building demand and fed into the grid.

Total Building Electric Demand [W]

This report variable includes all of the electric demand from the building (non-HVAC) portion of the simulation, which would contain lights, electrical equipment, exterior lights and equipment, etc.

Total HVAC Electric Demand [W]

This report variable includes all of the electric demand from the HVAC portion of the simulation, which would contain fans, electric coils, pumps, chillers, cooling towers, etc.

Total Electric Demand [W]

This is the total of the whole Building and HVAC electric demands.

Net Electric Power Purchased [W]**Net Electric Energy Purchased [J]**

These outputs are the net electricity purchased in both Power and Energy units. This value can be either positive or negative. Positive values are defined as electricity purchased from the utility. Negative values are defined as surplus electricity fed back into the grid.

Each ElectricLoadCenter also collects results from the individual generators that are connected to that load center. The report variables available at the ElectricLoadCenter level are:

```
HVAC,Average,Load Center Electric Power Produced [W]
HVAC,Sum,Load Center Electric Energy Produced [J]
HVAC,Average,Load Center Thermal Power Produced [W]
HVAC,Sum,Load Center Thermal Energy Produced [J]
```

Load Center Electric Power Produced [W]**Load Center Electric Energy Produced [J]**

These outputs are the sum of electrical energy and power produced by the generators attached to a particular load center. The keywords for these reports are the unique names of ElectricLoadCenter:Distribution objects.

Load Center Thermal Power Produced [W]**Load Center Thermal Energy Produced [J]**

These outputs are the sum of the thermal energy and power produced by the generators attached to a particular load center. The keywords for these reports are the unique names of ElectricLoadCenter:Distribution objects.

ElectricLoadCenter:Generators

The ElectricLoadCenter:Generators object is used to provide a list of the generators to include in the simulation. The list includes the names and types of all the generators along with separate availability schedules, the rated power output, and thermal-to-electrical power ratio for each. Sets of five input fields are repeated for each generator. If more than 30 generators are needed the user will need to extend the associated entry in the Energy+.idd file.

Field: Name

This alpha field contains the identifying name for the generators in the set.

FieldSet: Name, Object Type, Rated Power Output, Availability, Thermal Ratio up to 30

Each generator is specified by a set of 5 input fields that contain an identifying name, a keyword that indicates the type of generator, the rated output of the generator, the availability schedule of the generator, and the thermal to electrical power production ratio.

Field: Generator 1 Name

This alpha field contains the identifying name for the first generator in the list.

Field: Generator 1 Object Type

This alpha field contains the keyword for the type of generator. The available types include:

- Generator:InternalCombustionEngine
- Generator:CombustionTurbine
- Generator:Photovoltaic
- Generator:FuelCell
- Generator:MicroCHP
- Generator:MicroTurbine

These keywords are the names of the input objects for the type of generator.

Field: Generator 1 Rated Electric Power Output

This numeric field contains the nominal rated electric output of the generator in Watts. This value is used only for supervisory control and dispatch; the actual power is determined by the generator models.

Field: Generator 1 Availability Schedule

This alpha field is used as an identifying field for the generator availability Schedule. This field should contain the name of Schedule defined elsewhere in the input file. A value of 0.0 indicate the generator is not available.

Field: Generator 1 Rated Thermal to Electrical Power Ratio

This numeric field contains the ratio of the rated thermal output to the rated electric output. It is only needed and used if the operation scheme is set to **FollowThermal** or **FollowThermalLimitElectrical**. This nominal ratio is only used for control and dispatch decisions. This value should be generally consistent with the more detailed performance input for the individual generator component models but it is not used in those component models.

The idd entry for this object follows.

```

ElectricLoadCenter:Generators,
  \extensible:5 - repeat set of five fields, remembering to remove ; from "inner" fields.
  \min-fields 6
A1 , \field Name
  \required-field
  \type object-list
  \object-list GeneratorLists
A2 , \field Generator 1 Name
  \required-field
  \type object-list
  \object-list GeneratorNames
A3 , \field Generator 1 Object Type
  \required-field
  \type choice
  \key Generator:InternalCombustionEngine
  \key Generator:CombustionTurbine
  \key Generator:Photovoltaic
  \key Generator:FuelCell
  \key Generator:MicroCHP
  \key Generator:MicroTurbine
N1 , \field Generator 1 Rated Electric Power Output
A4 , \field Generator 1 Availability Schedule Name
  \type object-list
  \object-list ScheduleNames
N2 , \field Generator 1 Rated Thermal to Electrical Power Ratio
-- reduced for brevity --

```

An example IDF showing how this object is used is provided below:

```

ElectricLoadCenter:Generators,
Backup Generators,      !- Name
Cat Diesel,             !- Generator 1 Name
Generator:InternalCombustionEngine, !- Generator 1 Object Type
50000,                 !- Generator 1 Rated Electric Power Output
ON PEAK GENERATOR SCHEDULE, !- Generator 1 Availability Schedule Name
,                       !- Generator 1 Rated Thermal to Electrical Power Ratio
Solar Turbine,         !- Generator 2 Name
Generator:CombustionTurbine, !- Generator 2 Object Type
30000,                 !- Generator 2 Rated Electric Power Output
OFF PEAK GENERATOR SCHEDULE, !- Generator 2 Availability Schedule Name
,                       !- Generator 2 Rated Thermal to Electrical Power Ratio
Capstone C65,         !- Generator 3 Name
Generator:Microturbine, !- Generator 3 Object Type
65000,                 !- Generator 3 Rated Electric Power Output
MID PEAK GENERATOR SCHEDULE, !- Generator 3 Availability Schedule Name
;                       !- Generator 3 Rated Thermal to Electrical Power Ratio

```

ElectricLoadCenter:Inverter:Simple

This input object is used to model conversion from Direct Current (DC) to Alternating Current (AC) in an electric load center that contains photovoltaic modules. Such a load center has an array of photovoltaic modules that feed an inverter DC power and the inverter produces AC power. This input object is for the simplest inverter model and uses a fixed efficiency. There are two other types of inverters with more complex models described below.

Field: Name

This field contains a unique name for the inverter. The name entered must also be unique across all other types of inverters that may also be in the input file.

Field: Availability Schedule Name

This field contains the name of a schedule that describes when the inverter is available. If the inverter is scheduled to not be available, by scheduling a value of 0, then it cannot produce AC power and will not consume ancillary power during standby. Any non-zero schedule value means the inverter is available to produce AC power and consume ancillary power during standby. If the Inverter is schedule to be unavailable but it is being supplied with DC power anyway, then the energy is dissipated as heat.

Field: Zone Name

This field contains the name of the thermal zone where the inverter is located. Entering a valid name of zone here will direct EnergyPlus to include the inverter's losses as heat gains to the named thermal zone. If the inverter is not within a thermal zone, then this field can be left blank (and the thermal energy associated with inverter losses is removed from the building model).

Field: Radiative Fraction

This field contains the fraction of inverter thermal losses that enter the zone as long-wave thermal radiation. This should be a factor between 0.0 and 1.0. The balance of the losses is convective. This field is not used if the previous field for zone name is left blank.

Field: Inverter Efficiency

This field contains the value for inverter efficiency. In the simple model, efficiency is a constant. This is the so-called 1-term model. Input data for different types of inverters is available at http://www.gosolarcalifornia.org/equipment/inverter_tests/summaries where the "CEC Efficiency" would be the value to enter here.

The IDD entry for this object is:

```
ElectricLoadCenter:Inverter:Simple,
  A1 , \field Name
        \type object-list
        \object-list InverterList
  A2 , \field Availability Schedule Name
  A3 , \field Zone Name
        \note enter name of zone to receive inverter losses as heat
        \note if blank then inverter is assumed to be outdoors
  N1 , \field Radiative Fraction
        \minimum 0
        \maximum 1.0
  N2 ; \field Inverter Efficiency
        \minimum 0
        \maximum 1.0
```

An example IDF showing how this object is used is provided below:

```
ElectricLoadCenter:Inverter:Simple,
  Simple Ideal Inverter,    !- Name
  Always On,                !- Availability Schedule Name
  ,                          !- Zone Name
  0.0,                      !- Radiative Fraction
  1.0;                      !- Inverter Efficiency
```

ElectricLoadCenter:Inverter:FunctionOfPower

This input object is used to model conversion from Direct Current (DC) to Alternating Current (AC) in an electric load center that contains photovoltaic modules. Such a load center has an array of photovoltaic modules that feed an inverter DC power and the inverter produces AC power. This input object is for an inverter model where efficiency is a function of normalized power.

Field: Name

This field contains a unique name for the inverter. The name entered must also be unique across all other types of inverters that may also be in the input file.

Field: Availability Schedule Name

This field contains the name of a schedule that describes when the inverter is available. If the inverter is scheduled to not be available, by scheduling a value of 0, then it cannot produce AC power, nor contribute heat gains to the zone, and will not consume ancillary power during standby. Any non-zero schedule value means the inverter is available to

produce AC power, contribute heat gains to the zone and consume ancillary power during standby.

Field: Zone Name

This field contains the name of the thermal zone where the inverter is located. Entering a valid name of zone here will direct EnergyPlus to include the inverter's losses as heat gains to the named thermal zone. If the inverter is not within a thermal zone, then this field can be left blank (and the thermal energy associated with inverter losses is removed from the building model).

Field: Radiative Fraction

This field contains the fraction of inverter thermal losses that enter the zone as long-wave thermal radiation. This should be a factor between 0.0 and 1.0. The balance of the losses is convective. This field is not used if the previous field for zone name is left blank.

Field: Efficiency Function of Power Curve Name

This field contains the name of curve representing the relationship between DC power input into the inverter and the efficiency with which that power is converted to AC. The curve can be either a Curve:Linear, Curve:Quadratic, or Curve:Cubic. The curve's "x" value is DC power input normalized by the following field. The result of the curve should be power conversion efficiency expressed as a fraction between 0.0 and 1.0.

Field: Rated Maximum Continuous Input Power

This field contains the rated power input in watts. This is value used to normalize input power for use with the curve named in the previous field. This is DC power from the PV arrays going into the inverter.

Field: Minimum Efficiency

This field contains a minimum bound on the inverter efficiency. This value will be used as a limit on the curve's result.

Field: Maximum Efficiency

This field contains a maximum bound on the inverter efficiency. This value will be used as a limit on the curve's result.

Field: Minimum Power Output

This field contains a lower limit on the AC power produced by the inverter. If the resulting power output would be below this level, then the inverter is assumed to not produce any power and is in stand by mode. All DC power input is lost (unless it is going into storage).

Field: Maximum Power

This field contains an upper limit on the AC power produced by the inverter. If the resulting power output would be above this level, then the power produced is capped at this level with the rest of input power converted to losses (unless it is going into storage).

Field: Ancillary Power Consumed In Standby

This field contains the ancillary power in watts used by the inverter when not producing AC power. This is AC electricity consumed in standby mode. Standby mode occurs when the inverter is scheduled to be available but the incoming DC power is too low.

The IDD entry for this object is:


```

ElectricLoadCenter:Inverter:FunctionOfPower,
  A1 , \field Name
        \type object-list
        \object-list InverterList
  A2 , \field Availability Schedule Name
  A3 , \field Zone Name
        \note Enter name of zone to receive inverter losses as heat
        \note if blank then inverter is assumed to be outdoors
  N1 , \field Radiative Fraction
  A4 , \field Efficiency Function of Power Curve Name
        \note curve describes efficiency as a function of power
        \note curve is normalized relative to rated power in next field
  N2, \field Rated Maximum Continuous Input Power
        \units W
  N3 , \field Minimum Efficiency
        \minimum 0
        \maximum 1.0
  N4 , \field Maximum Efficiency
        \minimum 0
        \maximum 1.0
  N5 , \field Minimum Power Output
        \units W
  N6 , \field Maximum Power Output
        \units W
  N7 ; \field Ancillary Power Consumed In Standby
        \units W

```

An example IDF showing how this object is used is provided below:

```

ElectricLoadCenter:Inverter:FunctionOfPower,
  Curve Inverter,          !- Name
  ALWAYS_ON,              !- Availability Schedule Name
  ,                        !- Zone Name
  0.3,                    !- Radiative Fraction
  Inverter Curve,        !- Efficiency Function of Power Curve Name
  15000,                  !- Rated Maximum Continuous Input Power {W}
  0.0,                   !- Minimum Efficiency
  1.0,                   !- Maximum Efficiency
  200,                   !- Minimum Power Output {W}
  20000,                 !- Maximum Power Output {W}
  0.0;                   !- Ancillary Power Consumed In Standby {W}

```

ElectricLoadCenter:Inverter:LookUpTable

This input object is used to model conversion from Direct Current (DC) to Alternating Current (AC) in an electric load center that contains photovoltaic modules. Such a load center has an array of photovoltaic modules that feed an inverter DC power and the inverter produces AC power. This input object is for an inverter model where efficiency is interpolated using a look up table.

This object was designed for use with data contained in the Inverter Performance Test Summaries available at http://www.gosolarcalifornia.org/equipment/inverter_tests/summaries. All of the data needed for this object can be found there by make and model of inverter. The core of the data set is a 3x6 matrix of efficiency at different voltage and power levels. These form the look up table used in the model. Note that EnergyPlus' PV models currently model only power and not the voltage and current situation. Therefore, only the nominal voltage data are used. This is the middle row of data in the Go Solar summaries.

Field: Name

This field contains a unique name for the inverter. The name entered must also be unique across all other types of inverters that may also be in the input file.

Field: Availability Schedule Name

This field contains the name of a schedule that describes when the inverter is available. If the inverter is scheduled to not be available, by setting a value of 0, then it cannot produce AC power, nor contribute heat gains to the zone, and will not consume ancillary power during

standby. Any non-zero schedule value means the inverter is available to produce AC power, contribute heat gains to the zone and consume ancillary power during standby.

Field: Zone Name

This field contains the name of the thermal zone where the inverter is located. Entering a valid name of zone here will direct EnergyPlus to include the inverter's losses as heat gains to the named thermal zone. If the inverter is not within a thermal zone, then this field can be left blank (and the thermal energy associated with inverter losses is removed from the building model).

Field: Radiative Fraction

This field contains the fraction of inverter thermal losses that enter the zone as long-wave thermal radiation. This should be a factor between 0.0 and 1.0. The balance of the losses is convective. This field is not used if the previous field for zone name is left blank.

Field: Rated Maximum Continuous Output Power

This field contains the rated maximum continuous output power in watts.

Field: Night Tare Loss Power

This field contains the "night tare loss" in watts. This is modeled as ancillary power consumed during standby.

Field: Nominal Voltage Input

This field contains the nominal DC input voltage in volts. This is "Vnom" in the Go Solar test summaries.

Field: Efficiency at 10% Power and Nominal Voltage

This field contains the fractional efficiency at nominal voltage and 10% power.

Field: Efficiency at 20% Power and Nominal Voltage

This field contains the fractional efficiency at nominal voltage and 20% power.

Field: Efficiency at 30% Power and Nominal Voltage

This field contains the fractional efficiency at nominal voltage and 30% power.

Field: Efficiency at 50% Power and Nominal Voltage

This field contains the fractional efficiency at nominal voltage and 50% power.

Field: Efficiency at 75% Power and Nominal Voltage

This field contains the fractional efficiency at nominal voltage and 75% power.

Field: Efficiency at 100% Power and Nominal Voltage

This field contains the fractional efficiency at nominal voltage and 100% power.
The IDD entry for this object is:

```

ElectricLoadCenter:Inverter:LookUpTable,
  \memo California Energy Commission tests and publishes data on inverters
  \memo This inverter model interpolates using CEC test data
  \memo Input data are at http://www.gosolarcalifornia.org/equipment/inverter_tests/summaries
A1 , \field Name
  \type object-list
  \object-list InverterList
A2 , \field Availability Schedule Name
A3 , \field Zone Name
  \note Enter name of zone to receive inverter losses as heat
  \note if blank then inverter is assumed to be outdoors
N1 , \field Radiative Fraction
  \minimum 0
  \maximum 1.0
N2 , \field Rated Maximum Continuous Output Power
  \units W
N3 , \field Night Tare Loss Power
  \units W
N4 , \field Nominal Voltage Input
  \units V
N5 , \field Efficiency at 10% Power and Nominal Voltage
  \minimum 0
  \maximum 1.0
N6 , \field Efficiency at 20% Power and Nominal Voltage
  \minimum 0
  \maximum 1.0
N7 , \field Efficiency at 30% Power and Nominal Voltage
  \minimum 0
  \maximum 1.0
N8 , \field Efficiency at 50% Power and Nominal Voltage
  \minimum 0
  \maximum 1.0
N9 , \field Efficiency at 75% Power and Nominal Voltage
  \minimum 0
  \maximum 1.0
N10; \field Efficiency at 100% Power and Nominal Voltage
  \minimum 0
  \maximum 1.0

```

An example IDF showing how this object is used is provided below:

```

ElectricLoadCenter:Inverter:LookUpTable,
  PV Inverter,           !- Name
  ALWAYS_ON,            !- Availability Schedule Name
  ,                      !- Zone Name
  0.25,                 !- Radiative Fraction
  14000,                 !- Rated Maximum Continuous Output Power {W}
  200.0,                 !- Night Tare Loss Power {W}
  368,                  !- Nominal Voltage Input {V}
  0.839,                 !- Efficiency at 10% Power and Nominal Voltage
  0.897,                 !- Efficiency at 20% Power and Nominal Voltage
  0.916,                 !- Efficiency at 30% Power and Nominal Voltage
  0.931,                 !- Efficiency at 50% Power and Nominal Voltage
  0.934,                 !- Efficiency at 75% Power and Nominal Voltage
  0.930;                 !- Efficiency at 100% Power and Nominal Voltage

```

Inverter Outputs

Each inverter can report the following seven output variables.

```

HVAC,Average,Inverter DC to AC Efficiency [ ]
HVAC,Average,Inverter DC Power Input [W]
HVAC,Sum,Inverter DC Energy Input [J]
HVAC,Average,Inverter AC Power Output [W]
HVAC,Sum,Inverter AC Energy Output [J]
HVAC,Average,Inverter Thermal Loss Rate [W]
HVAC,Sum,Inverter Thermal Loss Energy [J]

```

Inverter DC to AC Efficiency []

This is the efficiency with which DC power is converted to AC power by the inverter.

Inverter DC Power Input [W]***Inverter DC Energy Input [J]***

These outputs are total electricity power or energy fed into the inverter. This is Direct Current from photovoltaics (or DC-based electrical storage) going into the inverter.

Inverter AC Power Output [W]***Inverter AC Energy Output [J]***

These outputs are the total electricity power or energy produced by the inverter. This is Alternating Current going out of the inverter.

Inverter Thermal Loss Rate [W]***Inverter Thermal Loss Energy [J]***

These outputs are the thermal power or energy losses in the inverter that stem from converting from DC to AC.

Inverter Ancillary AC Consumed Rate [W]***Inverter Ancillary AC Consumed Energy [J]***

These outputs are the Alternating Current electricity consumed by the inverter. These are ancillary, or night tare loss, power uses by the inverter and modeled as if powered by the building's grid connection. These ancillary power draws generally occur when the inverter is not generating power but waiting in a standby mode ready to begin generating power.

ElectricLoadCenter:Storage:Simple

This input object is used to model storage of electricity in an electric load center. This is a simple model that does not attempt to represent any of the characteristics of a real storage device such as a battery. The type of power, AC or DC, depends on the configuration chosen as the Electrical Buss Type in the ElectricLoadCenter:Distribution object.

Field: Name

This field contains a unique name for the electric storage device.

Field: Availability Schedule Name

This field contains the name of a schedule that describes when the storage device is available. If storage is not available, by scheduling a value of 0, then no electrical energy can be stored or drawn from the device. Any non-zero schedule value means the devices is available.

Field: Zone Name

This field contains the name of the thermal zone where the storage device is located. Entering a valid name of a zone here will direct EnergyPlus to include the storage losses as heat gains to the name thermal zone. If the storage is not within a thermal zone, then this field can be left blank.

Field: Radiative Fraction for Zone Heat Gains

This field contains the fraction of storage losses that enter the zone as long-wave thermal radiation. This should be a factor between 0.0 and 1.0. The balance of the losses are convective. This field is not used if the previous field for zone name is left blank.

Field: Nominal Energetic Efficiency for Charging

This field contains the charging efficiency. This is the energetic efficiency of storing electrical energy in the storage device. A value of 1.0 means the device does not lose any energy when charging.

Field: Nominal Discharging Energetic Efficiency

This field contains the discharging efficiency. This is the energetic efficiency of drawing electrical energy from the storage device. A value of 1.0 means the device does not lose any energy when drawing power.

Field: Maximum Storage Capacity

This field describes the maximum amount of energy that can be stored in the device in Joules. Once the storage device is full, no additional energy can be stored in it.

Field: Maximum Power for Discharging

This field describes the maximum rate at which electrical power can be discharged from the storage device in watts.

Field: Maximum Power for Charging

This field describes the maximum rate at which electrical power can be stored in the device in watts.

Field: Initial State of Charge

This field describes the value for the initial state of charge in Joules. This is used to model the storage device as having some amount of stored energy at the beginning of the simulation period.

```
ElectricLoadCenter:Storage:Simple,
A1, \field Name
    \type object-list
    \object-list ElecStorageList
A2, \field Availability Schedule Name
A3, \field Zone Name
    \note Enter name of zone to receive storage losses as heat
    \note if blank then storage is assumed to be outdoors
N1 , \field Radiative Fraction for Zone Heat Gains
    \maximum 1.0
    \minimum 0.0
N2, \field Nominal Energetic Efficiency for Charging
    \maximum 1.0
    \minimum 0.0
N3, \field Nominal Discharging Energetic Efficiency
    \maximum 1.0
    \minimum 0.0
N4, \field Maximum Storage Capacity
    \units J
N5, \field Maximum Power for Discharging
    \units W
N6, \field Maximum Power for Charging
    \units W
N7; \field Initial State of Charge
    \units J
```

An example IDF showing how this object is used is provided below:

```

ElectricLoadCenter:Storage:Simple,
  Battery,                !- Name
  ALWAYS_ON,              !- Availability Schedule Name
  ,                        !- Zone Name
  0.0,                    !- Radiative Fraction for Zone Heat Gains
  0.7,                    !- Nominal Energetic Efficiency for Charging
  0.7,                    !- Nominal Discharging Energetic Efficiency
  1.0E11,                 !- Maximum Storage Capacity {J}
  50000,                  !- Maximum Power for Discharging {W}
  25000,                  !- Maximum Power for Charging {W}
  1.0E10;                 !- Initial State of Charge {J}

```

ElectricLoadCenter:Storage:Simple Outputs

Each electrical storage device can report the following seven output variables.

```

HVAC,Average,Electrical Storage State of Charge [J]
HVAC,Average,Electrical Storage Power Into Storage [W]
HVAC,Sum,Electrical Storage Energy Into Storage [J]
HVAC,Average,Electrical Storage Power From Storage [W]
HVAC,Sum,Electrical Storage Energy From Storage [J]
HVAC,Average,Electrical Storage Thermal Loss Rate [W]
HVAC,Sum,Electrical Storage Thermal Loss Energy [J]

```

Electrical Storage State of Charge [J]

This output is the state of charge of the storage device. State of charge is the amount of electrical energy stored in the device at a point of time. The amount of energy stored is tracked in Joules.

Electrical Storage Power Into Storage [W]

Electrical Storage Energy Into Storage [J]

These outputs are total electricity power or energy fed into the storage device. This is the rate or amount of charging.

Electrical Storage Power From Storage [W]

Electrical Storage Energy From Storage [J]

These outputs are total electricity power or energy drawn from the storage device. This is the rate or amount of discharging.

Electrical Storage Thermal Loss Rate [W]

Electrical Storage Thermal Loss Energy [J]

These outputs are the thermal power or energy losses from both charging and drawing electrical power in or out of the storage device.

Generator:InternalCombustionEngine

The Internal Combustion (IC) Engine generator uses a modified Otto cycle. This generator model uses the electrical load and rated engine generator size to compute part-load ratios (PLR). Fuel energy input and recoverable jacket and lube oil heat are then computed. Finally, the recoverable exhaust heat is calculated.

Manufacturer's curves or tables must be obtained for IC engine generators to derive the equipment performance parameters that are specified in the quadratic curve fits. Note that simple transformation of the form of the manufacturer's curves may be required. Electric energy output/fuel energy input is related to the part-load ratio (i.e., electric/load generator capacity) with a polynomial. Recoverable jacket heat/fuel energy equipment, recoverable lube oil heat/fuel energy input equipment performance, total exhaust heat/fuel energy input equipment, exhaust gas temperature/fuel energy input equipment performance parameters are all specified with a quadratic curve fit.

When the heat recovery curve fits = 0.0, this means that no heat recovery is done on the IC engine generator exhaust gas; and no heat recovery is specified.

Field: Name

This alpha field contains the identifying name for the IC engine generator.

Field: Rated Power Output

The design nominal capacity of the generator in Watts [W].

Field: Electric Circuit Node Name

This named node contains where the electric power is put in the program simulation for use by the electric equipment in the Load Center.

Field: Minimum Part Load Ratio

This field contains the minimum allowed operating fraction of full load.

Field: Maximum Part Load Ratio

This field contains the maximum allowed operating fraction of full load.

Field: Optimum Part Load Ratio

This alpha field contains the optimal operating fraction of full load. This is the part load ratio that gives the optimal production of electric power with the least amount of fuel usage.

Field: Shaft Power Curve Name

This alpha field contains the name of the shaft power curve. The curve itself is specified separately using a curve object (see **Curve:Quadratic**). The Shaft Power Curve is a quadratic equation that determines the electric output versus the fuel used. Used to calculate the electric energy output divided by the fuel energy consumption as a function of part-load ratio. The defining equation is:

$$\text{ShaftPowerToFuelRatio} = C_1 + C_2RL + C_3RL^2$$

where RL is the Ratio of Load to Rated Power Output.

Field: Jacket Heat Recovery Curve Name

This alpha field contains the name of the Recovery Jacket Heat curve. The curve itself is specified separately using a curve object (see **Curve:Quadratic**). The Jacket Heat Recovery Curve is a quadratic equation that determines the ratio of recovery jacket heat to fuel energy. Used to calculate the recoverable jacket heat as a function of part-load ratio.

The defining equation is:

$$\text{RecoveryJacketHeatToFuelRatio} = C_1 + C_2RL + C_3RL^2$$

where RL is the Ratio of Load to Rated Power Output.

Field: Lube Heat Recovery Curve Name

This alpha field contains the name of the Recovery Lube Heat curve. The curve itself is specified separately using a curve object (see **Curve:Quadratic**). The Lube Heat Recovery Curve is a quadratic equation that determines the ratio of recovery lube heat to fuel energy. Used to calculate the recoverable lube oil heat as a function of part-load ratio. The defining equation is:

$$\text{RecoveryLubeHeatToFuelRatio} = C_1 + C_2RL + C_3RL^2$$

where RL is the Ratio of Load to Rated Power Output.

Field: Total Exhaust Energy Curve Name

This alpha field contains the name of the Total Exhaust Energy curve. The curve itself is specified separately using a curve object (see **Curve:Quadratic**). The Total Exhaust Energy Curve is a quadratic equation that determines the ratio of total exhaust energy to fuel energy. Used to calculate the total exhaust heat as a function of part-load ratio. The defining equation is:

$$TotalExhaustToFuelRatio = C_1 + C_2RL + C_3RL^2$$

where RL is the Ratio of Load to Rated Power Output.

Field: Exhaust Temperature Curve Name

This alpha field contains the name of the Exhaust Temperature curve. The curve itself is specified separately using a curve object (see **Curve:Quadratic**). The Exhaust Temperature Curve is a quadratic equation that determines the absolute exhaust temperature. Used to determine the exhaust gas temperature as a function of part-load ratio. The defining equation is:

$$AbsoluteExhaustTemperature = C_1 + C_2RL + C_3RL^2$$

where RL is the Ratio of Load to Rated Power Output.

U-Factor Times Area (UA) Curve

The UA curve applies to the exhaust gas heat exchanger. The curve is an equation that determines the overall heat transfer coefficient for the exhaust gases with the stack. The heat transfer coefficient ultimately helps determine the exhaust stack temperature. The defining equation is:

$$UAToCapacityRatio = C_1GeneratorRatedPowerOutput^{C_2}$$

The following two fields contain the coefficients for the equation.

Field: Coefficient 1 of U-Factor Times Area Curve

This numeric field contains the first coefficient for the overall heat transfer coefficient curve.

Field: Coefficient 2 of U-Factor Times Area Curve

This numeric field contains the second (exponential) coefficient for the overall heat transfer coefficient curve.

Field: Maximum Exhaust Flow per Unit of Power Output

Maximum exhaust flow per unit capacity for the generator. The parameter sets an upper limit on exhaust gas flow and exhaust gas heat recovery for the generator. Units: kg/sec per kW capacity

Field: Design Minimum Exhaust Temperature

This is the design engine stack saturated steam temperature in degrees C.

Field: Fuel Higher Heating Value

This numeric field contains the higher heating value of the fuel used in kJ/kg.

Field: Design Heat Recovery Water Flow Rate

Design water volumetric flow rate through heat recovery loop in m³/sec.

Field: Heat Recovery Inlet Node Name

This alpha field contains the identifying name for the generator's heat recovery side inlet node.

Field: Heat Recovery Outlet Node Name

This alpha field contains the identifying name for the generator's heat recovery side outlet node.

Field: Fuel Type

This alpha field determines the type of fuel that the generator uses. The default is Diesel.

Field: Heat Recovery Maximum Temperature

This field sets the maximum temperature that this piece of equipment can produce for heat recovery. The idea behind this field is that the current models do not take temperatures into account for availability and they just pass Q's around the loop without a temperature limit. This temperature limit puts an upper bound on the recovered heat and limits the max temperatures leaving the component.

As temperatures in the loop approach the maximum temperature, the temperature difference between the entering water and the surfaces in the piece of equipment becomes smaller. For the given heat recovery flow rate and that temperature difference the amount of heat recovered will be reduced, and eventually there will be no heat recovered when the entering water temperature is equal to the maximum temperature specified by the user in this field. The reduced amount of heat recovered will diminish if the temperature of the loop approach is the maximum temperature, and this will show up in the reporting. This allows the user to set the availability or the quality of the heat recovered for usage in other parts of the system or to heat domestic hot water supply.

The temperature is specified in degrees C.

```

Generator:InternalCombustionEngine,
  \memo This generator model is the empirical model from the Building Loads
  \memo and System Thermodynamics (BLAST) program. Engine performance
  \memo curves are generated by fitting catalog data to second order
  \memo polynomial equations. Three sets of coefficients are required.
A1, \field Name
  \required-field
  \reference GeneratorNames
N1, \field Rated Power Output
  \units W
A2, \field Electric Circuit Node Name
N2, \field Minimum Part Load Ratio
N3, \field Maximum Part Load Ratio
N4, \field Optimum Part Load Ratio
A3, \field Shaft Power Curve Name
  \type object-list
  \object-list QuadraticCurves
  \note curve = a + b*PLR + c*PLR**2
  \note PLR = Ratio of Generator Load to Rated Power Output
A4, \field Jackage Heat Recovery Curve Name
  \type object-list
  \object-list QuadraticCurves
  \note curve = a + b*PLR + c*PLR**2
  \note PLR = Ratio of Generator Load to Rated Power Output
A5, \field Lube Heat Recovery Curve Name
  \type object-list
  \object-list QuadraticCurves
  \note curve = a + b*PLR + c*PLR**2
  \note PLR = Ratio of Generator Load to Rated Power Output
A6, \field Total Exhaust Energy Curve Name
  \type object-list
  \object-list QuadraticCurves
  \note curve = a + b*PLR + c*PLR**2
  \note PLR = Ratio of Generator Load to Rated Power Output
A7, \field Exhaust Temperature Curve Name
  \type object-list
  \object-list QuadraticCurves
  \note curve = a + b*PLR + c*PLR**2
  \note PLR = Ratio of Generator Load to Rated Power Output
N5, \field Coefficient 1 of U-Factor Times Area Curve
  \note curve = C1 * Generator Rated Power Output**C2
N6, \field Coefficient 2 of U-Factor Times Area Curve
  \note curve = C1 * Generator Rated Power Output**C2
N7, \field Maximum Exhaust Flow per Unit of Power Output
  \units (kg/s)/W
N8, \field Design Minimum Exhaust Temperature
  \units C
N9, \field Fuel Higher Heating Value
  \units kJ/kg
N10, \field Design Heat Recovery Water Flow Rate
  \units m3/s
  \minimum 0.0
  \default 0.0
  \note if non-zero, then inlet, outlet nodes must be entered.
  \ip-units gal/min
A8, \field Heat Recovery Inlet Node Name
A9, \field Heat Recovery Outlet Node Name
A10, \field Fuel Type
  \required-field
  \type choice
  \key NaturalGas
  \key PropaneGas
  \key Diesel
  \key Gasoline
  \key FuelOil#1
  \key FuelOil#2
  \default Diesel
N11, \field Heat Recovery Maximum Temperature
  \units C
  \maximum 100.0
  \minimum 0.0

```

```
\default 80.0
```

An IDF example showing how it is used is provided below:

```
Generator:InternalCombustionEngine,
  Cat Diesel,           !- Name
  50000,                !- Rated Power Output {W}
  Generator Diesel Electric Node, !- Electric Circuit Node Name
  0.15,                !- Minimum Part Load Ratio
  1.0,                 !- Maximum Part Load Ratio
  0.65,                !- Optimum Part Load Ratio
  BG Shaft Power Curve, !- Shaft Power Curve Name
  BG Recovery Jacket Heat Curve, !- Jacket Heat Recovery Curve Name
  BG Recovery Lube Heat Curve, !- Lube Heat Recovery Curve Name
  BG Total Exhaust Energy Curve, !- Total Exhaust Energy Curve Name
  BG Exhaust Temperature Curve, !- Exhaust Temperature Curve Name
  0.00952329,          !- Coefficient 1 of U-Factor Times Area Curve
  0.9,                 !- Coefficient 2 of U-Factor Times Area Curve
  0.00000063,          !- Maximum Exhaust Flow per Unit of Power Output {(kg/s)/W}
  150,                 !- Design Minimum Exhaust Temperature {C}
  45500,               !- Fuel Higher Heating Value {kJ/kg}
  0.0,                 !- Design Heat Recovery Water Flow Rate {m3/s}
  ,                    !- Heat Recovery Inlet Node Name
  ,                    !- Heat Recovery Outlet Node Name
  Diesel;              !- Fuel Type

Curve:Quadratic,
  BG Shaft Power Curve, !- Name
  0.09755,              !- Coefficient1 Constant
  0.6318,              !- Coefficient2 x
  -0.4165,             !- Coefficient3 x**2
  0,                   !- Minimum Value of x
  1;                   !- Maximum Value of x

Curve:Quadratic,
  BG Recovery Jacket Heat Curve, !- Name
  0.25,                !- Coefficient1 Constant
  0,                   !- Coefficient2 x
  0,                   !- Coefficient3 x**2
  0,                   !- Minimum Value of x
  1;                   !- Maximum Value of x

Curve:Quadratic,
  BG Recovery Lube Heat Curve, !- Name
  0.15,                !- Coefficient1 Constant
  0,                   !- Coefficient2 x
  0,                   !- Coefficient3 x**2
  0,                   !- Minimum Value of x
  1;                   !- Maximum Value of x

Curve:Quadratic,
  BG Total Exhaust Energy Curve, !- Name
  0.1,                 !- Coefficient1 Constant
  0,                   !- Coefficient2 x
  0,                   !- Coefficient3 x**2
  0,                   !- Minimum Value of x
  1;                   !- Maximum Value of x

Curve:Quadratic,
  BG Exhaust Temperature Curve, !- Name
  425,                 !- Coefficient1 Constant
  0,                   !- Coefficient2 x
  0,                   !- Coefficient3 x**2
  0,                   !- Minimum Value of x
  1;                   !- Maximum Value of x
```

Generator:InternalCombustionEngine Outputs

The output variables that are available for the IC engine generator are:

```
HVAC,Average,Generator Electric Power Produced [W]
HVAC,Sum,Generator Electric Energy Produced [J]
```

```

Zone,Meter,ElectricityProduced:Plant [J]
Zone,Meter,ElectricityProduced:Facility [J]
Zone,Meter,Cogeneration:ElectricityProduced [J]

HVAC,Average,Generator Lube Heat Recovery Rate [W]
HVAC,Sum,Generator Lube Heat Recovery [J]

HVAC,Average,Generator Jacket Heat Recovery Rate [W]
HVAC,Sum,Generator Jacket Heat Recovery [J]

HVAC,Average,Generator Exhaust Heat Recovery Rate [W]
HVAC,Sum,Generator Exhaust Heat Recovery [J]

HVAC,Average,Generator Total Heat Recovery Rate [W]
HVAC,Sum,Generator Total Heat Recovery [J]

HVAC,Average,Generator Exhaust Stack Temp [C]

HVAC,Average,Generator Heat Recovery Inlet Temp [C]
HVAC,Average,Generator Heat Recovery Outlet Temp [C]
HVAC,Average,Generator Heat Recovery Mass Flow Rate [kg/s]

HVAC,Average,Generator Diesel Consumption Rate [W]
HVAC,Sum,Generator Diesel Consumption [J]
Zone,Meter,Cogeneration:Diesel [J]
HVAC,Average,Generator Diesel Mass Flow Rate [kg/s]

```

Generator Electric Power Produced [W]**Generator Electric Energy Produced [J]**

These outputs are the electric power output from the electric generator. Energy is metered on Cogeneration:ElectricityProduced, ElectricityProduced:Plant, and ElectricityProduced:Facility.

Generator Lube Heat Recovery Rate [W]**Generator Lube Heat Recovery [J]****Generator Jacket Heat Recovery Rate [W]****Generator Jacket Heat Recovery [J]****Generator Exhaust Heat Recovery Rate [W]****Generator Exhaust Heat Recovery [J]****Generator Thermal Power Produced [W]****Generator Thermal Energy Produced [J]**

For electric generators with heat recovery these outputs are the components of recoverable energy available. For the IC engine generator, the following heat recovery components are reported: Lube (engine lubricant), Jacket (engine coolant), and Exhaust (engine exhaust). These components are totaled together for Generator Thermal Power Produced and Generator Thermal Energy Produced reports. Generator Lube Heat Recovery, Generator Jacket Heat Recovery, and Generator Exhaust Heat Recovery are metered on HeatRecovery:EnergyTransfer, EnergyTransfer:Plant, and EnergyTransfer:Facility.

Generator Exhaust Stack Temp [C]

This is the exhaust temperature leaving the engine.

Generator Heat Recovery Inlet Temp [C]**Generator Heat Recovery Outlet Temp [C]****Generator Heat Recovery Mass Flow Rate [kg/s]**

These outputs are the heat recovery inlet and outlet temperatures and flow rate for generators with heat recovery.

Generator Fuel Consumption Rate HHV Basis [W]**Generator Fuel Consumption HHV Basis [J]**

These outputs are the generator's fuel energy and use rate. The energy content of the fuel is based on the higher heating value (HHV).

Generator Diesel Consumption Rate [W]**Generator Diesel Consumption [J]****Generator Diesel Mass Flow Rate [kg/s]**

These outputs are available if the fuel type was selected to be diesel and are the diesel fuel input to the electric generator. Consumption is metered on Cogeneration:Diesel, Diesel:Plant, and Diesel:Facility.

Generator NaturalGas Consumption Rate [W]**Generator NaturalGas Consumption [J]****Generator NaturalGas Mass Flow Rate [kg/s]**

These outputs are available if the fuel type was selected to be NaturalGas and are the natural gas fuel input to the electric generator. Consumption is metered on Cogeneration:NaturalGas, NaturalGas:Plant, and NaturalGas:Facility.

Generator PropaneGas Consumption Rate [W]**Generator PropaneGas Consumption [J]****Generator PropaneGas Mass Flow Rate [kg/s]**

These outputs are available if the fuel type was selected to be PropaneGas and are the propane fuel input to the electric generator. Consumption is metered on Cogeneration:PropaneGas, PropaneGas:Plant, and PropaneGas:Facility.

Generator Gasoline Consumption Rate [W]**Generator Gasoline Consumption [J]****Generator Gasoline Mass Flow Rate [kg/s]**

These outputs are available if the fuel type was selected to be Gasoline and are the gasoline fuel input to the electric generator. Consumption is metered on Cogeneration:Gasoline, Gasoline:Plant, and Gasoline:Facility.

Generator FuelOil#1 Consumption Rate [W]**Generator FuelOil#1 Consumption [J]****Generator FuelOil#1 Mass Flow Rate [kg/s]**

These outputs are available if the fuel type was selected to be FuelOil#1 and are the fuel oil input to the electric generator. Consumption is metered on Cogeneration:FuelOil#1, FuelOil#1:Plant, and FuelOil#1:Facility.

Generator FuelOil#2 Consumption Rate [W]**Generator FuelOil#2 Consumption [J]****Generator FuelOil#2 Mass Flow Rate [kg/s]**

These outputs are available if the fuel type was selected to be FuelOil#2 and are the fuel oil input to the electric generator. Consumption is metered on Cogeneration:FuelOil#2, FuelOil#2:Plant, and FuelOil#2:Facility.

Generator:CombustionTurbine

EnergyPlus has two different models for combustion turbine style generators. This one stems for a model that was originally in the BLAST computer program. A newer model with a different formulation is also available—see the Generator:MicroTurbine input object. The basic combustion-turbine cycle is the Brayton Cycle or open cycle, which consists of an adiabatic compression, constant pressure heating, and adiabatic expansion. The Combustion turbine model uses the electrical load and engine generator size to compute part-load ratios (PLR). Fuel energy input and recoverable lube oil heat are then computed. Finally, the recoverable exhaust heat is calculated.

Combustion turbine generators use performance parameters to compute fuel energy consumption as a function of part-load and ambient (entering) air temperature. Recoverable fuel energy equipment, recoverable lube oil heat/fuel energy input equipment performance, total exhaust heat/fuel energy input equipment, exhaust gas temperature/fuel energy input equipment performance parameters are all specified with a quadratic curve fit.

When the heat recovery curve fits = 0.0, this means that no heat recovery is done on the diesel generator exhaust gas; and no heat recovery is specified.

Field: Name

Unique name to identify this combustion turbine generator.

Field: Rated Power Output

The design nominal capacity of the combustion turbine generator in Watts [W].

Field: Electric Circuit Node Name

This Named node contains where the electric power is put in the program simulation for use by the electric equipment in the Load Center.

Field: Minimum Part Load Ratio

This field contains the minimum allowed operating fraction of full load.

Field: Maximum Part Load Ratio

This field contains the maximum allowed operating fraction of full load.

Field: Optimum Part Load Ratio

This alpha field contains the optimal operating fraction of full load. This is the part load ratio that gives the optimal production of electric power with the least amount of fuel usage.

Field: Part Load Based Fuel Input Curve Name

Needs a Curve:Quadratic object to be specified.

Fuel Input = $a + b \cdot \text{PLR} + c \cdot \text{PLR}^2$

PLR = Ratio of Generator Load to Rated Power Output. This curve is multiplied to the Temperature Based Fuel Input Curve to determine Fuel Energy In.

Field: Temperature Based Fuel Input Curve Name

Needs a Curve:Quadratic object to be specified.

Fuel Input = a + b*AT + c*AT**2 where: AT = Ambient Delta T

Field: Exhaust Flow Curve Name

The Total Exhaust Energy Curve is a quadratic equation that needs to be specified by a curve object. Used to calculate the total exhaust heat as a function of part-load ratio.

Field: Part Load Based Exhaust Temperature Curve Name

The Exhaust Temperature Curve is a quadratic equation that needs to be specified by a curve object. Used to determine the exhaust gas temperature as a function of part-load ratio.

Field: Temperature Based Exhaust Temperature Curve Name

The Exhaust Temperature Curve is a quadratic equation that needs to be specified by a curve object. Used to determine the exhaust gas temperature as a function of part-load ratio.

Field: Heat Recovery Lube Energy Curve Name

This alpha field contains the name of the Recovery Lube Heat curve. The curve itself is specified separately using a curve object (see **Curve:Quadratic**). The Recovery Lubricant Heat Curve is a quadratic equation that determines the ratio of recovery lube heat to fuel energy. Used to calculate the recoverable lube oil heat as a function of part-load ratio. The defining equation is:

$$RecoveryLubeHeatToFuelRatio = C_1 + C_2RL + C_3RL^2$$

where RL is the Ratio of Load to Rated Power Output.

U-Factor Times Area (UA) Curve

The UA curve applies to the exhaust gas heat exchanger. The curve is an equation that determines the overall heat transfer coefficient for the exhaust gases with the stack. The heat transfer coefficient ultimately helps determine the exhaust stack temperature. The defining equation is:

$$UAToCapacityRatio = C_1GeneratorRatedPowerOutput^{C_2}$$

The following two fields contain the coefficients for the equation.

Field: Coefficient 1 of U-Factor Times Area Curve

This numeric field contains the first coefficient for the overall heat transfer coefficient curve.

Field: Coefficient 2 of U-Factor Times Area Curve

This numeric field contains the second (exponential) coefficient for the overall heat transfer coefficient curve.

Field: Maximum Exhaust Flow per Unit of Power Output

Maximum exhaust flow per unit capacity for diesel engines. The parameter sets an upper limit on exhaust gas flow and exhaust gas heat recovery for diesel engines. Units: kg/sec per kW capacity

Field: Design Minimum Exhaust Temperature

This is the design engine stack saturated steam temperature in degrees C.

Field: Design Air Inlet Temperature

Design air inlet temperature in degrees C.

Field: Fuel Higher Heating Value

This numeric field contains the higher heating value of the fuel used in kJ/kg.

Field: Design Heat Recovery Water Flow Rate

Design water volumetric flow rate through heat recovery loop in m³/sec.

Field: Heat Recovery Inlet Node Name

This alpha field contains the identifying name for the combustion turbine generator heat recovery side inlet node.

Field: Heat Recovery Outlet Node Name

This alpha field contains the identifying name for the combustion turbine generator heat recovery side outlet node.

Field: Fuel Type

This alpha field determines the type of fuel that the generator uses. The default is Natural Gas.

Field: Heat Recovery Maximum Temperature

This field sets the maximum temperature that this piece of equipment can produce for heat recovery. The idea behind this field is that the current models do not take temperatures into account for availability and they just pass Q's around the loop without a temperature limit. This temperature limit puts an upper bound on the recovered heat and limits the max temperatures leaving the component.

As temperatures in the loop approach the maximum temperature, the temperature difference between the entering water and the surfaces in the piece of equipment becomes smaller. For the given heat recovery flow rate and that temperature difference the amount of heat recovered will be reduced, and eventually there will be no heat recovered when the entering water temperature is equal to the maximum temperature specified by the user in this field. The reduced amount of heat recovered will diminish if the temperature of the loop approach is the maximum temperature, and this will show up in the reporting. This allows the user to set the availability or the quality of the heat recovered for usage in other parts of the system or to heat domestic hot water supply.

The temperature is specified in degrees C.

Field: Outdoor Air Inlet Node Name

This field is optional. It is used to explicitly define an outdoor air node for the inlet for combustion air stream. Defining an outdoor air node here allows using the height-dependent model for outdoor air conditions.


```

Generator:CombustionTurbine,
  \memo This generator model is the empirical model from the Building Loads
  \memo and System Thermodynamics (BLAST) program. Generator performance
  \memo curves are generated by fitting catalog data to second order
  \memo polynomial equations. Three sets of coefficients are required.
A1, \field Name
  \required-field
  \reference GeneratorNames
N1, \field Rated Power Output
  \units W
A2, \field Electric Circuit Node Name
N2, \field Minimum Part Load Ratio
N3, \field Maximum Part Load Ratio
N4, \field Optimum Part Load Ratio
A3, \field Part Load Based Fuel Input Curve Name
  \type object-list
  \object-list QuadraticCurves
  \note curve = a + b*PLR + c*PLR**2
  \note PLR = Ratio of Generator Load to Rated Power Output
  \note this curve is multiplied to the Temperature Based Fuel Input Curve
  \note to determine Fuel Energy In
A4, \field Temperature Based Fuel Input Curve Name
  \type object-list
  \object-list QuadraticCurves
  \note curve = a + b*AT + c*AT**2
  \note AT = Ambient Delta T
  \note this curve is multiplied to the Part Load Based Fuel Input Curve
  \note to determine Fuel Energy In
A5, \field Exhaust Flow Curve Name
  \type object-list
  \object-list QuadraticCurves
  \note curve = a + b*AT + c*AT**2
  \note AT = Ambient Delta T
A6, \field Part Load Based Exhaust Temperature Curve Name
  \type object-list
  \object-list QuadraticCurves
  \note curve = a + b*PLR + c*PLR**2
  \note PLR = Ratio of Generator Load to Rated Power Output
  \note this curve is multiplied to the Temperature Based Exhaust Temperature Curve
  \note to determine Exhaust Temperature
A7, \field Temperature Based Exhaust Temperature Curve Name
  \type object-list
  \object-list QuadraticCurves
  \note curve = a + b*AT + c*AT**2
  \note AT = Ambient Delta T
  \note this curve is multiplied to the Part Load Based Exhaust Temperatuer Curve
  \note to determine Exhaust Temperature
A8, \field Heat Recovery Lube Energy Curve Name
  \type object-list
  \object-list QuadraticCurves
  \note curve = a + b*PLR + c*PLR**2
  \note PLR = Ratio of Generator Load to Rated Power Output
N5, \field Coefficient 1 of U-Factor Times Area Curve
  \note curve = C1 * Rated Power Output**C2
N6, \field Coefficient 2 of U-Factor Times Area Curve
  \note curve = C1 * Rated Power Output**C2
N7, \field Maximum Exhaust Flow per Unit of Power Output
  \units (Kg/s)/W
N8, \field Design Minimum Exhaust Temperature
  \units C
N9, \field Design Air Inlet Temperature
  \units C
N10, \field Fuel Higher Heating Value
  \units kJ/kg
N11, \field Design Heat Recovery Water Flow Rate
  \units m3/s
  \minimum 0.0
  \default 0.0
  \note if non-zero, then inlet, outlet nodes must be entered.
  \ip-units gal/min
A9, \field Heat Recovery Inlet Node Name

```

```
A10, \field Heat Recovery Outlet Node Name
A11, \field Fuel Type
      \required-field
      \type choice
      \key NaturalGas
      \key PropaneGas
      \key Diesel
      \key Gasoline
      \key FuelOil#1
      \key FuelOil#2
      \default NaturalGas
N12, \field Heat Recovery Maximum Temperature
      \units C
      \maximum 100.0
      \minimum 0.0
      \default 80.0
A12; \field Outdoor Air Inlet Node Name
      \type alpha
      \note Enter the name of an outdoor air node
```

An IDF example showing how it is used is provided below:

```

Generator:CombustionTurbine,
  Solar Turbine,          !- Name
  30000,                  !- Rated Power Output {W}
  GT gen Electric Node,  !- Electric Circuit Node Name
  0.15,                  !- Minimum Part Load Ratio
  1.0,                   !- Maximum Part Load Ratio
  0.65,                  !- Optimum Part Load Ratio
  BG PL Based Fuel Input Curve, !- Part Load Based Fuel Input Curve Name
  BG Temp Based Fuel Input Curve, !- Temperature Based Fuel Input Curve Name
  BG Exhaust Flow Curve, !- Exhaust Flow Curve Name
  BG PL Based Exhaust Temp Curve, !- Part Load Based Exhaust Temperature Curve Name
  BG Temp Based Exhaust Temp Curve, !- Temperature Based Exhaust Temperature Curve Name
  BG Tur Recovery Lube Heat Curve, !- Heat Recovery Lube Energy Curve Name
  0.01907045,           !- Coefficient 1 of U-Factor Times Area Curve
  0.9,                  !- Coefficient 2 of U-Factor Times Area Curve
  0.00000504,          !- Maximum Exhaust Flow per Unit of Power Output {(Kg/s)/W}
  150,                  !- Design Minimum Exhaust Temperature {C}
  25,                   !- Design Air Inlet Temperature {C}
  43500,                !- Fuel Higher Heating Value {kJ/kg}
  0.0,                  !- Design Heat Recovery Water Flow Rate {m3/s}
  ,                      !- Heat Recovery Inlet Node Name
  ,                      !- Heat Recovery Outlet Node Name
  NaturalGas,           !- Fuel Type
  ,                      !- Heat Recovery Maximum Temperature {C}
  CT OA inlet;          !- Outdoor Air Inlet Node Name

Curve:Quadratic,
  BG PL Based Fuel Input Curve, !- Name
  9.41,                  !- Coefficient1 Constant
  -9.48,                 !- Coefficient2 x
  4.32,                  !- Coefficient3 x**2
  0,                     !- Minimum Value of x
  1;                     !- Maximum Value of x

Curve:Quadratic,
  BG Temp Based Fuel Input Curve, !- Name
  1.0044,                !- Coefficient1 Constant
  -0.0008,               !- Coefficient2 x
  0,                     !- Coefficient3 x**2
  -30,                   !- Minimum Value of x
  +30;                   !- Maximum Value of x

Curve:Quadratic,
  BG Exhaust Flow Curve, !- Name
  0.05,                  !- Coefficient1 Constant
  0.0,                   !- Coefficient2 x
  0.0,                   !- Coefficient3 x**2
  0,                     !- Minimum Value of x
  1;                     !- Maximum Value of x

Curve:Quadratic,
  BG PL Based Exhaust Temp Curve, !- Name
  450,                   !- Coefficient1 Constant
  0,                     !- Coefficient2 x
  0,                     !- Coefficient3 x**2
  0,                     !- Minimum Value of x
  1;                     !- Maximum Value of x

Curve:Quadratic,
  BG Temp Based Exhaust Temp Curve, !- Name
  1.005,                 !- Coefficient1 Constant
  0.0018,                !- Coefficient2 x
  0,                     !- Coefficient3 x**2
  -30,                   !- Minimum Value of x
  +30;                   !- Maximum Value of x

Curve:Quadratic,
  BG Tur Recovery Lube Heat Curve, !- Name
  0.223,                 !- Coefficient1 Constant
  -0.4,                  !- Coefficient2 x
  0.2286,                !- Coefficient3 x**2

```

0,	!- Minimum Value of x
1;	!- Maximum Value of x

Generator:CombustionTurbine Outputs

The output variables that are available for the combustion turbine generator are:

```

HVAC,Average,Generator Electric Power Produced [W]
HVAC,Sum,Generator Electric Energy Produced [J]
Zone,Meter,ElectricityProduced:Facility [J]
Zone,Meter,ElectricityProduced:Plant [J]
Zone,Meter,Cogeneration:ElectricityProduced [J]

HVAC,Average,Generator Lube Heat Recovery Rate [W]
HVAC,Sum,Generator Lube Heat Recovery [J]

HVAC,Average,Generator Exhaust Heat Recovery Rate [W]
HVAC,Sum,Generator Exhaust Heat Recovery [J]

HVAC,Average,Generator Total Heat Recovery Rate [W]
HVAC,Sum,Generator Total Heat Recovery [J]

HVAC,Average,Generator Exhaust Stack Temp [C]

HVAC,Average,Generator Heat Recovery Inlet Temp [C]
HVAC,Average,Generator Heat Recovery Outlet Temp [C]
HVAC,Average,Generator Heat Recovery Mass Flow Rate [kg/s]

HVAC,Average,Generator Gas Consumption Rate [W]
Zone,Meter,Cogeneration:Gas [J]
HVAC,Sum,Generator Gas Consumption [J]
HVAC,Average,Generator Gas Mass Flow Rate [kg/s]

```

All of these outputs, except for the Combustion use outputs, are described above under "Generator:IC Engine Outputs."

Generator Gas Consumption Rate [W]

Generator Gas Consumption [J]

Generator Gas Mass Flow Rate [kg/s]

These outputs are the natural gas fuel input to the electric generator. Consumption is metered on Cogeneration:Gas, Gas:Plant, and Gas:Facility.

Generator:MicroTurbine

MicroTurbine generators are small combustion turbines that produce electricity on a relatively small scale (e.g., 25kW to 500kW). This model uses nominal performance at reference conditions along with several modifier curves to determine electrical power output and fuel use at non-reference conditions. Standby and ancillary power can also be taken into account. Furthermore, energy recovery from exhaust air can be used to heat water. Similar to electrical power output, thermal power (heat recovery) output is calculated using nominal performance at reference conditions with modifier curves to account for variations at non-reference conditions.

The following inputs define the MicroTurbine electric generator. The ElectricLoadCenter:Generators and ElectricLoadCenter:Distribution objects are used to define the availability and control of all electric generators included in the simulation (ref. ElectricLoadCenter:Generators and ElectricLoadCenter:Distribution).

Field: Name

This alpha field specifies a unique user-defined name to identify this generator. This is a required input.

Field: Reference Electrical Power Output

This numeric field specifies the full-load electrical power output of the microturbine generator in Watts at reference conditions. The reference conditions are defined via additional input fields for this object (see below). This is a required input, and the value entered in this field must be greater than zero.

Field: Minimum Full Load Electrical Power Output

This numeric field specifies the minimum electrical power output in Watts at full-load conditions. The electrical power output of the generator is determined by multiplying the Reference Electrical Power Output by the Electrical Power Function of Temperature and Elevation modifier curve. If the result is less than the numeric value specified in this input field, then the generator's electrical power output is reset to the minimum full-load value specified in this input field. The value entered in this field must be greater than or equal to zero. If this field is left blank, the default value of 0.0 will be used.

Field: Maximum Full Load Electrical Power Output

This numeric field specifies the maximum electrical power output in Watts at full-load conditions. The electrical power output of the generator is determined by multiplying the Reference Electrical Power Output by the Electrical Power Function of Temperature and Elevation Modifier curve. If the result is greater than the numeric value specified in this input field, then the generator's electrical power output is reset to the maximum full-load value specified in this input field. The value entered in this field must be greater than zero. If this field is left blank, then the value entered for the Reference Electrical Power Output field (above) will be used as the Maximum Full Load Electrical Power Output.

Field: Reference Electrical Efficiency Using Lower Heating Value

This numeric field contains the electrical efficiency of the generator at reference conditions, based on the lower heating value of the fuel. The electrical efficiency is the electric power output divided by the fuel energy consumption rate (LHV basis). The reference conditions are defined via additional input fields for this object (see below). This is a required input, and the value entered in this field must be greater than zero and less than or equal to 1.0.

Field: Reference Combustion Air Inlet Temperature

This numeric field specifies the reference temperature for the combustion inlet air in degrees Celsius. If this field is left blank, the default value of 15°C will be used.

Field: Reference Combustion Air Inlet Humidity Ratio

This numeric field specifies the reference humidity ratio for the combustion inlet air in kg-H₂O/kg-air. The value specified for this field must be greater than zero. If this field is left blank, the default value of 0.00638 kg-H₂O/kg-air will be used.

Field: Reference Elevation

This numeric field specifies the reference elevation in meters (relative to sea level). The value specified for this field must be greater than or equal to -300.0 meters. If this field is left blank, the default value of 0.0 meters will be used.

Field: Electrical Power Function of Temperature and Elevation Curve Name

This alpha field specifies the name of a bi-quadratic performance curve (ref: Performance Curves) that parameterizes the variation of electrical power output as a function of the combustion air inlet temperature and elevation. The output of this curve is multiplied by the Reference Electrical Power Output to give the full-load power output at a specific combustion air inlet temperature and elevation (i.e., at values different from the reference conditions). This curve should be normalized to have a value of 1.0 at the reference conditions, and the curve should be valid for the range of inlet air temperatures anticipated for the simulation period and for the actual elevation of the generator.

Field: Electrical Efficiency Function of Temperature Curve Name

This alpha field specifies the name of a quadratic or cubic performance curve (ref: Performance Curves) that parameterizes the variation of electrical efficiency as a function of the combustion air inlet temperature. The output of this curve is multiplied by the Reference Electrical Efficiency Using Lower Heating Value to give the full-load electrical efficiency at specific combustion air inlet temperatures (i.e., at inlet air temperatures different from the Reference Combustion Air Inlet Temperature). This curve should be normalized to have a value of 1.0 at the Reference Combustion Air Inlet Temperature, and the curve should be valid for the range of inlet air temperatures anticipated for the simulation period.

Field: Electrical Efficiency Function of Part Load Ratio Curve Name

This alpha field specifies the name of a quadratic or cubic performance curve (ref: Performance Curves) that parameterizes the variation of electrical efficiency as a function of the generator's part-load ratio (part-load ratio is the actual electrical power output divided by the full-load electrical power output at the current operating conditions). The output of this curve is multiplied by the Reference Electrical Efficiency Using Lower Heating Value and the output of the Electrical Efficiency Function of Temperature modifier curve to give the electrical efficiency at specific part-load and combustion air inlet (temperature) conditions. This curve should be normalized to have a value of 1.0 when the generator's part-load ratio is 1.0, and the curve should be valid for the range of part-load ratios anticipated for the simulation period.

Field: Fuel Type

This choice field specifies the type of fuel used by the generator. If the field is left blank, the fuel type will be assumed to be NaturalGas.

Field: Fuel Higher Heating Value

This numeric field specifies the higher heating value of the fuel used in kJ/kg. The value specified for this field must be greater than zero and greater than the specified Fuel Lower Heating Value. If this field is left blank, the default value of 50,000 kJ/kg will be used.

Field: Fuel Lower Heating Value

This numeric field specifies the lower heating value of the fuel used in kJ/kg. The value specified for this field must be greater than zero but less than the specified Fuel Higher Heating Value. If this field is left blank, the default value of 45,450 kJ/kg will be used.

Field: Standby Power

This numeric field specifies the standby electric power consumed by the generator in Watts. The standby power is the electrical power consumed by the generator (e.g., air fans and controls) when the generator is available to operate but the generator electrical power output is zero (power output is not being requested by the electric load center). The value specified for this field must be greater than or equal to zero. If this field is left blank, the default value of 0.0 W will be used.

Field: Ancillary Power

This numeric field specifies the ancillary electric power consumed by the generator in Watts. The ancillary power is the electrical power consumed by other associated equipment (e.g., external fuel pressurization pumps) when the generator is operating. Specify this input as 0.0 if the Reference Electrical Power Output and Reference Electrical Efficiency Using Lower Heating Value input fields and associated modifier curves reflect the "net" electrical power output from the generator (i.e., ancillary power already deducted from the generator's gross electrical power output). A value greater than zero indicates that this electrical power is consumed whenever the generator is operating and will be deducted from the generator's overall electrical power output (Generator Electric Power Produced). The value specified for

this field must be greater than or equal to zero. If this field is left blank, the default value of 0.0 W will be used.

Field: Ancillary Power Function of Fuel Input Curve Name

This alpha field specifies the name of a quadratic performance curve (ref: Performance Curves) that parameterizes the variation of ancillary power as a function of the generator's input fuel mass flow rate (kg/s). The output of this curve is multiplied by the ancillary power to give the ancillary power at a specific fuel mass flow rate. If this field is left blank, the model assumes that the modifier curve is 1.0 for the entire simulation (i.e., the ancillary power is constant whenever the generator operates).

Field: Heat Recovery Water Inlet Node Name

This alpha field specifies the identifying name for the generator's heat recovery water inlet node.

Field: Heat Recovery Water Outlet Node Name

This alpha field specifies the identifying name for the generator's heat recovery water outlet node.

Field: Reference Thermal Efficiency Using Lower Heat Value

This numeric field specifies the thermal efficiency (heat recovery to water) at reference conditions, based on the lower heating value of the fuel. The thermal efficiency is the thermal power output (to water) divided by the fuel energy consumption rate (LHV basis). The reference conditions are defined via additional input fields for this object. This value must be from 0.0 to 1.0. If this field is left blank, the default value of 0.0 will be used.

Field: Reference Inlet Water Temperature

This numeric field specifies the reference temperature for the inlet water to the heat recovery heat exchanger in degrees Celsius.

Field: Heat Recovery Water Flow Operating Mode

This field is used to choose between different modes of controlling the mass flow rate of water being heated by energy recovered from exhaust air. There are two options available for this field: "PlantControl" or "InternalControl." The "PlantControl" option indicates that the heat recovery water flow rate through the generator is determined externally (by the wider balance of plant). In this case, the generator will request the Reference Heat Recovery Water Flow Rate whenever it operates but the actual flow rate may be limited by other plant components (e.g., pump). The "InternalControl" option indicates the flow of water is controlled inside the generator based on current operating conditions. For InternalControl, the generator should (probably) include a bypass branch when connecting to the plant loop.

Field: Reference Heat Recovery Water Flow Rate

This numeric field is the reference heat recovery (volumetric) water flow rate in cubic meters per second. Entered values must be greater than zero.

Field: Heat Recovery Water Flow Rate Function of Temperature and Power Curve Name

This alpha field specifies the name of a bi-quadratic performance curve (ref: Performance Curves) that parameterizes the variation of heat recovery water flow rate as a function of the inlet water temperature and net electrical power output. This field is only used if the Heat Recovery Water Flow Operating Mode is 'InternalControl'. The output of this curve is multiplied by the Reference Heat Recovery Water Flow Rate to give the water flow rate at the specific inlet water temperature and net power operating conditions. This curve should be normalized to have a value of 1.0 at the reference conditions, and the curve should be valid for the range of inlet water temperatures and net electrical power output anticipated for the

simulation period. If this field is left blank, the model assumes that the modifier curve is 1.0 for the entire simulation.

Field: Thermal Efficiency Function of Temperature and Elevation Curve Name

This alpha field specifies the name of a bi-quadratic performance curve (ref: Performance Curves) that parameterizes the variation of thermal efficiency as a function of the combustion air inlet temperature and elevation. The output of this curve is multiplied by the Reference Thermal Efficiency Using Lower Heating Value to give the full-load thermal efficiency at a specific combustion air inlet temperature and elevation (i.e., at values different from the reference conditions). This curve should be normalized to have a value of 1.0 at the reference conditions, and the curve should be valid for the range of inlet air temperatures anticipated for the simulation period and for the actual elevation of the generator. If this field is left blank, the model assumes that the modifier curve is 1.0 for the entire simulation.

Field: Heat Recovery Rate Function of Part Load Ratio Curve Name

This alpha field specifies the name of a quadratic or cubic performance curve (ref: Performance Curves) that parameterizes the variation of heat recovery to water (thermal power output) as a function of the generator's part-load ratio (part-load ratio is the actual electrical power output divided by the full-load electrical power output at the current operating conditions). The output of this curve is multiplied by the steady-state heat recovery at the current combustion inlet air temperature and elevation to give the heat recovery rate (thermal power output) at specific part-load operating conditions. This curve should be normalized to have a value of 1.0 when the generator's part-load ratio is 1.0, and the curve should be valid for the range of part-load ratios anticipated for the simulation period. If this field is left blank, the model assumes that the modifier curve is 1.0 for the entire simulation.

Field: Heat Recovery Rate Function of Inlet Water Temperature Curve Name

This alpha field specifies the name of a quadratic performance curve (ref: Performance Curves) that parameterizes the variation of heat recovery to water (thermal power output) as a function of the inlet water temperature. The output of this curve is multiplied by the steady-state heat recovery at the current combustion inlet air temperature and elevation to give the heat recovery rate (thermal power output) at non-reference inlet water conditions. This curve should be normalized to have a value of 1.0 at the Reference Inlet Water Temperature, and the curve should be valid for the range of inlet water temperatures anticipated for the simulation period. If this field is left blank, the model assumes that the modifier curve is 1.0 for the entire simulation.

Field: Heat Recovery Rate Function of Water Flow Rate Curve Name

This alpha field specifies the name of a quadratic performance curve (ref: Performance Curves) that parameterizes the variation of heat recovery to water (thermal power output) as a function of the heat recovery water flow rate. The output of this curve is multiplied by the steady-state heat recovery at the current combustion inlet air temperature and elevation to give the heat recovery rate (thermal power output) at non-reference heat recovery water flow rates. This curve should be normalized to have a value of 1.0 at the Reference Heat Recovery Water Flow Rate, and the curve should be valid for the range of water flow rates anticipated for the simulation period. If this field is left blank, the model assumes that the modifier curve is 1.0 for the entire simulation.

Field: Minimum Heat Recovery Water Flow Rate

This numeric field specifies the minimum (volumetric) water flow rate through the heat recovery heat exchanger in cubic meters per second. The minimum input value is 0.0, and a value of 0.0 is assumed if this field is left blank.

Field: Maximum Heat Recovery Water Flow Rate

This numeric field specifies the maximum (volumetric) water flow rate through the heat recovery heat exchanger in cubic meters per second. The minimum input value for this field is 0.0, and a value of 0.0 is assumed if this field is left blank. The maximum heat recovery water flow rate must be greater than or equal to the minimum heat recovery water flow rate.

Field: Maximum Heat Recovery Water Temperature

This field sets the maximum water temperature, in degrees Celsius, that this generator can produce via heat recovery. This temperature limit puts an upper bound on the recovered heat and limits the max temperatures leaving the component.

As temperatures in the water loop approach this maximum temperature, the temperature difference between the entering water and the surfaces in generator's heat recovery heat exchanger becomes smaller. For the given heat recovery flow rate and that temperature difference the amount of heat recovered will be reduced, and eventually there will be no heat recovered when the entering water temperature is equal to the maximum temperature specified by the user in this field. The amount of heat recovered will diminish if the inlet water temperature approaches the maximum temperature, and this will show up in the reporting.

Field: Combustion Air Inlet Node Name

This alpha field specifies the name of the combustion air inlet node. If a node name is specified, this node must be an outdoor air node and must also be specified elsewhere in the input (ref: OutdoorAir:Node and OutdoorAir:NodeList). If this field is left blank, the combustion air inlet conditions are assumed to be the outdoor weather conditions used for the simulation.

Field: Combustion Air Outlet Node Name

This alpha field specifies the name of the combustion air outlet node.

Field: Reference Exhaust Air Mass Flow Rate

This numeric field is the reference exhaust air mass flow rate in kilograms per second. Entered values must be greater than zero.

Field: Exhaust Air Flow Rate Function of Temperature Curve Name

This alpha field specifies the name of a quadratic or cubic performance curve (ref: Performance Curves) that parameterizes the variation of exhaust air flow rate as a function of the combustion air inlet temperature. The output of this curve is multiplied by the Reference Exhaust Air Mass Flow Rate to give the exhaust air mass flow rate at non-reference combustion air inlet temperatures. This curve should be normalized to have a value of 1.0 at the Reference Combustion Air Inlet Temperature, and the curve should be valid for the range of inlet air temperatures anticipated for the simulation period. If this field is left blank, the model assumes that the modifier curve is 1.0 for the entire simulation.

Field: Exhaust Air Flow Rate Function of Part Load Ratio Curve Name

This alpha field specifies the name of a quadratic or cubic performance curve (ref: Performance Curves) that parameterizes the variation of exhaust air flow rate as a function of the generator's part-load ratio (part-load ratio is the actual electrical power output divided by the full-load electrical power output at the current operating conditions). The output of this curve is multiplied by the Reference Exhaust Air Mass Flow Rate to give the exhaust air mass flow rate at specific part-load operating conditions. This curve should be normalized to have a value of 1.0 when the generator's part-load ratio is 1.0, and the curve should be valid for the range of part-load ratios anticipated for the simulation period. If this field is left blank, the model assumes that the modifier curve is 1.0 for the entire simulation.

Field: Nominal Exhaust Air Outlet Temperature

This numeric field is the exhaust air outlet temperature at nominal (reference) conditions in degrees Celsius.

Field: Exhaust Air Temperature Function of Temperature Curve Name

This alpha field specifies the name of a quadratic or cubic performance curve (ref: Performance Curves) that parameterizes the variation of exhaust air outlet temperature as a function of the combustion air inlet temperature. The output of this curve is multiplied by the Nominal Exhaust Air Outlet Temperature to give the exhaust air temperature at non-reference combustion air inlet temperatures. This curve should be normalized to have a value of 1.0 at the Reference Combustion Air Inlet Temperature, and the curve should be valid for the range of inlet air temperatures anticipated for the simulation period. If this field is left blank, the model assumes that the modifier curve is 1.0 for the entire simulation.

Field: Exhaust Air Temperature Function of Part Load Ratio Curve Name

This alpha field specifies the name of a quadratic or cubic performance curve (ref: Performance Curves) that parameterizes the variation of exhaust air outlet temperature as a function of the generator's part-load ratio (part-load ratio is the actual electrical power output divided by the full-load electrical power output at the current operating conditions). The output of this curve is multiplied by the Nominal Exhaust Air Outlet Temperature to give the exhaust air temperature at specific part-load operating conditions. This curve should be normalized to have a value of 1.0 when the generator's part-load ratio is 1.0, and the curve should be valid for the range of part-load ratios anticipated for the simulation period. If this field is left blank, the model assumes that the modifier curve is 1.0 for the entire simulation.

```

Generator:MicroTurbine,
  \min-fields 11
A1, \field Name
  \required-field
  \type alpha
  \reference GeneratorNames
N1, \field Reference Electrical Power Output
  \required-field
  \type real
  \units W
  \minimum> 0.0
N2, \field Minimum Full Load Electrical Power Output
  \type real
  \units W
  \minimum 0.0
  \default 0.0
N3, \field Maximum Full Load Electrical Power Output
  \type real
  \units W
  \minimum> 0.0
  \note If left blank, Maximum Full Load Electrical Power Output will be set
  \note equal to the Reference Electrical Power Output.
N4, \field Reference Electrical Efficiency Using Lower Heating Value
  \required-field
  \type real
  \minimum> 0.0
  \maximum 1.0
  \note Electric power output divided by fuel energy input (LHV basis)
  \note at reference conditions.
N5, \field Reference Combustion Air Inlet Temperature
  \type real
  \units C
  \default 15.0
N6, \field Reference Combustion Air Inlet Humidity Ratio
  \type real
  \units kg-H2O/kg-air
  \minimum> 0.0
  \default 0.00638
N7, \field Reference Elevation
  \type real
  \units m
  \minimum -300.0
  \default 0.0
A2, \field Electrical Power Function of Temperature and Elevation Curve Name
  \required-field
  \type object-list
  \object-list BiQuadraticCurves
  \note curve = a + b*T + c*T**2 + d*Elev + e*Elev**2 + f*T*Elev
  \note T = combustion air inlet temperature (C)
  \note Elev = elevation (m)
A3, \field Electrical Efficiency Function of Temperature Curve Name
  \required-field
  \type object-list
  \object-list QuadraticCubicCurves
  \note Quadratic curve = a + b*T + c*T**2
  \note Cubic curve = a + b*T + c*T**2 + d*T**3
  \note T = combustion air inlet temperature (C)
A4, \field Electrical Efficiency Function of Part Load Ratio Curve Name
  \required-field
  \type object-list
  \object-list QuadraticCubicCurves
  \note Quadratic curve = a + b*PLR + c*PLR**2
  \note Cubic curve = a + b*PLR + c*PLR**2 + d*PLR**3
  \note PLR = ratio of Generator Load to Steady-State Electrical Power Output at
  \note current operating conditions
A5, \field Fuel Type
  \type choice
  \key NaturalGas
  \key PropaneGas
  \default NaturalGas
N8, \field Fuel Higher Heating Value

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\type real
\units kJ/kg
\default 50000
\minimum> 0.0
N9, \field Fuel Lower Heating Value
\type real
\units kJ/kg
\default 45450
\minimum> 0.0
N10, \field Standby Power
\type real
\units W
\default 0.0
\minimum 0.0
\note Electric power consumed when the generator is available but not being called
\note by the Electric Load Center.
N11, \field Ancillary Power
\type real
\units W
\default 0.0
\minimum 0.0
\note Electric power consumed by ancillary equipment (e.g., external fuel pressurization pump).
\note Set to zero if Reference Electrical Power Output is the 'net' value (ancillary power
\note already deducted). Input value is positive, but indicates negative electric generation.
A6, \field Ancillary Power Function of Fuel Input Curve Name
\type object-list
\object-list QuadraticCurves
\note Quadratic curve =  $a + b \cdot \dot{m} + c \cdot \dot{m}^2$ 
\note  $\dot{m}$  = fuel mass flow rate (kg/s)
\note If left blank, model assumes ancillary power defined in previous field is constant
\note whenever the generator is operating.
A7, \field Heat Recovery Water Inlet Node Name
\type alpha
A8, \field Heat Recovery Water Outlet Node Name
\type alpha
N12, \field Reference Thermal Efficiency Using Lower Heat Value
\type real
\minimum 0.0
\maximum 1.0
\default 0.0
\note Reference thermal efficiency (heat recovery to water) based on the
\note Lower Heating Value (LHV) of the fuel.
N13, \field Reference Inlet Water Temperature
\type real
\units C
A9, \field Heat Recovery Water Flow Operating Mode
\type choice
\key PlantControl
\key InternalControl
\default PlantControl
\note PlantControl means the heat recovery water flow rate is determined by the plant,
\note but the user needs to supply a heat recovery water flow rate.
\note InternalControl means the heat recovery water flow rate is controlled by this generator.
\note If 'InternalControl' is selected, then the user needs to supply a reference heat
\note recovery water flow rate and optionally the name of a heat recovery flow rate modifier curve.
N14, \field Reference Heat Recovery Water Flow Rate
\type real
\units m3/s
\minimum> 0.0
A10, \field Heat Recovery Water Flow Rate Function of Temperature and Power Curve Name
\type object-list
\object-list BiQuadraticCurves
\note curve =  $a + b \cdot T + c \cdot T^2 + d \cdot P_{net} + e \cdot P_{net} + f \cdot T \cdot P_{net}$ 
\note T = heat recovery inlet water temperature
\note  $P_{net}$  = net power output = electric power output - ancillary power
\note If left blank, model assumes the heat recovery water flow rate is constant whenever the
\note generator is operating, at the Reference HR Water Flow Rate defined in the previous field.
A11, \field Thermal Efficiency Function of Temperature and Elevation Curve Name
\type object-list
\object-list Bicubic BiquadraticCurves

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\note Bicubic curve = a + b*T + c*T**2 + d*Elev + e*Elev**2 + f*T*Elev + g*T**3 + h*Elev**3 +
i*T**2*Elev + j*T*Elev**2
\note Biquadratic curve = a + b*T + c*T**2 + d*Elev + e*Elev**2 + f*T*Elev
\note T = combustion air inlet temperature (C)
\note Elev = elevation (m)
\note If field is left blank, model assumes this modifier equals 1 for entire simulation.
A12, \field Heat Recovery Rate Function of Part Load Ratio Curve Name
\type object-list
\object-list QuadraticCubicCurves
\note Quadratic curve = a + b*PLR + c*PLR**2
\note Cubic curve = a + b*PLR + c*PLR**2 + d*PLR**3
\note PLR = ratio of Generator Load to Steady-State Electrical Power Output at
\note current operating conditions
\note If field is left blank, model assumes this modifier equals 1 for entire simulation.
A13, \field Heat Recovery Rate Function of Inlet Water Temperature Curve Name
\type object-list
\object-list QuadraticCurves
\note Quadratic curve = a + b*T + c*T**2
\note T = inlet water temperature (C)
\note If field is left blank, model assumes this modifier equals 1 for entire simulation.
A14, \field Heat Recovery Rate Function of Water Flow Rate Curve Name
\type object-list
\object-list QuadraticCurves
\note Quadratic curve = a + b*Flow + c*Flow**2
\note Flow = flow rate of water through the heat exchanger (m3/s)
\note If field is left blank, model assumes this modifier equals 1 for entire simulation.
N15, \field Minimum Heat Recovery Water Flow Rate
\type real
\units m3/s
\minimum 0.0
\default 0.0
N16, \field Maximum Heat Recovery Water Flow Rate
\type real
\units m3/s
\minimum 0.0
\default 0.0
N17, \field Maximum Heat Recovery Water Temperature
\type real
\units C
A15, \field Combustion Air Inlet Node Name
\type alpha
\note Must be an outdoor air node.
A16, \field Combustion Air Outlet Node Name
\type alpha
N18, \field Reference Exhaust Air Mass Flow Rate
\type real
\units kg/s
\minimum > 0.0
A17, \field Exhaust Air Flow Rate Function of Temperature Curve Name
\type object-list
\object-list QuadraticCubicCurves
\note Quadratic curve = a + b*T + c*T**2
\note Cubic curve = a + b*T + c*T**2 + d*T**3
\note T = combustion air inlet temperature (C)
\note If field is left blank, model assumes this modifier equals 1 for entire simulation.
A18, \field Exhaust Air Flow Rate Function of Part Load Ratio Curve Name
\type object-list
\object-list QuadraticCubicCurves
\note Quadratic curve = a + b*PLR + c*PLR**2
\note Cubic curve = a + b*PLR + c*PLR**2 + d*PLR**3
\note PLR = ratio of Generator Load to Steady-State Electrical Power Output at
\note current operating conditions.
\note If field is left blank, model assumes this modifier equals 1 for entire simulation.
N19, \field Nominal Exhaust Air Outlet Temperature
\type real
\note Exhaust air outlet temperature at reference conditions.
A19, \field Exhaust Air Temperature Function of Temperature Curve Name
\type object-list
\object-list QuadraticCubicCurves
\note Quadratic curve = a + b*T + c*T**2
\note Cubic curve = a + b*T + c*T**2 + d*T**3

```

```
\note T = combustion air inlet temperature (C)
\note If field is left blank, model assumes this modifier equals 1 for entire simulation.
A20; \field Exhaust Air Temperature Function of Part Load Ratio Curve Name
\type object-list
\object-list QuadraticCubicCurves
\note Quadratic curve = a + b*PLR + c*PLR**2
\note Cubic curve = a + b*PLR + c*PLR**2 + d*PLR**3
\note PLR = ratio of Generator Load to Steady-State Electrical Power Output at
\note current operating conditions.
\note If field is left blank, model assumes this modifier equals 1 for entire simulation.
```

An example IDF showing how this object is used is provided below:

```

Generator:MicroTurbine,
Generator 3,           !- Name
65000,                !- Reference Electrical Power Output {W}
29900,                !- Minimum Full Load Electrical Power Output {W}
65000,                !- Maximum Full Load Electrical Power Output {W}
0.29,                 !- Reference Electrical Efficiency Using Lower Heating Value
15.0,                 !- Reference Combustion Air Inlet Temperature {C}
0.00638,              !- Reference Combustion Air Inlet Humidity Ratio {kg-H2O/kg-air}
0.0,                  !- Reference Elevation {m}
Power_vs_Temp_Elev,   !- Electrical Power Function of Temperature and Elevation Curve Name
Efficiency_vs_Temp,   !- Electrical Efficiency Function of Temperature Curve Name
Efficiency_vs_PLR,    !- Electrical Efficiency Function of Part Load Ratio Curve Name
NaturalGas,           !- Fuel Type
50000,                !- Fuel Higher Heating Value {kJ/kg}
45450,                !- Fuel Lower Heating Value {kJ/kg}
300,                  !- Standby Power {W}
4500;                 !- Ancillary Power {W}

! Electrical Power Modifier Curve (function of temperature and elevation)
! x = Dry-Bulb Temperature of Combustion Inlet Air (C) and y = Elevation (meters)
Curve:Biquadratic,
Power_vs_Temp_Elev,   !- Name
1.2027697,            !- Coefficient1 Constant
-9.671305E-03,        !- Coefficient2 x
-4.860793E-06,        !- Coefficient3 x**2
-1.542394E-04,        !- Coefficient4 y
9.111418E-09,         !- Coefficient5 y**2
8.797885E-07,         !- Coefficient6 x*y
-17.8,                !- Minimum Value of x
50.0,                 !- Maximum Value of x
0.0,                  !- Minimum Value of y
3050.;                !- Maximum Value of y

! Electrical Efficiency Modifier Curve (function of temperature)
! x = Dry-Bulb Temperature of Combustion Inlet Air (C)
Curve:Cubic,
Efficiency_vs_Temp,   !- Name
1.0402217,            !- Coefficient1 Constant
-0.0017314,           !- Coefficient2 x
-6.497040E-05,        !- Coefficient3 x**2
5.133175E-07,         !- Coefficient4 x**3
-20.0,                !- Minimum Value of x
50.0;                 !- Maximum Value of x

! Electrical Efficiency Modifier Curve (function of part-load ratio)
! x = Part-Load Ratio (electrical load/steady-state electrical power output)
Curve:Cubic,
Efficiency_vs_PLR,    !- Name
0.215290,             !- Coefficient1 Constant
2.561463,             !- Coefficient2 x
-3.24613,             !- Coefficient3 x**2
1.497306,             !- Coefficient4 x**3
0.03,                 !- Minimum Value of x
1.0;                  !- Maximum Value of x!

ElectricLoadCenter:Distribution,
Electric Load Center, !- Name
Backup Generators,    !- Generator List Name
DemandLimit,          !- Generator Operation Scheme Type
10000.0,              !- Demand Limit Scheme Purchased Electric Demand Limit {W}
,                     !- Track Schedule Name Scheme Schedule Name
,                     !- Track Meter Scheme Meter Name
AlternatingCurrent,   !- Electrical Buss Type
,                     !- Inverter Object Name
;                     !- Electrical Storage Object Name

ElectricLoadCenter:Generators,
Backup Generators,    !- Name
Generator 1,          !- Generator 1 Name
Generator:InternalCombustionEngine, !- Generator 1 Object Type
50000,                !- Generator 1 Rated Electric Power Output

```

```

ON PEAK GENERATOR SCHEDULE,  !- Generator 1 Availability Schedule Name
,                               !- Generator 1 Rated Thermal to Electrical Power Ratio
Generator 2,                   !- Generator 2 Name
Generator:CombustionTurbine,    !- Generator 2 Object Type
30000,                          !- Generator 2 Rated Electric Power Output
OFF PEAK GENERATOR SCHEDULE,  !- Generator 2 Availability Schedule Name
,                               !- Generator 2 Rated Thermal to Electrical Power Ratio
Generator 3,                   !- Generator 3 Name
Generator:MicroTurbine,        !- Generator 3 Object Type
65000,                          !- Generator 3 Rated Electric Power Output
MID PEAK GENERATOR SCHEDULE,  !- Generator 3 Availability Schedule Name
;                               !- Generator 3 Rated Thermal to Electrical Power Ratio

```

Generator:MicroTurbine Outputs

The output variables that are available for the microturbine generator are:

```

HVAC,Average,Generator Electric Power Produced [W]
HVAC,Sum,Generator Electric Energy Produced [J]
HVAC,Average,Generator Electric Efficiency LHV Basis [-]
HVAC,Average,Generator <Fuel Type> Consumption Rate HHV Basis [W]
HVAC,Average,Generator Fuel Consumption Rate HHV Basis [W]
HVAC,Sum,Generator <Fuel Type> Consumption HHV Basis [J]
HVAC,Sum,Generator Fuel Consumption HHV Basis [J]
HVAC,Average,Generator <Fuel Type> Mass Flow Rate [kg/s]

If Standby Power input field > 0.0:
HVAC,Average,Generator Standby Electric Power [W]
HVAC,Sum,Generator Standby Electric Consumption [J]

If Ancillary Power input field > 0.0:
HVAC,Average,Generator Ancillary Electric Power [W]
HVAC,Sum,Generator Ancillary Electric Consumption [J]

If heat recovery water inlet and outlet node names are entered (and valid):
HVAC,Average,Generator Thermal Power Produced [W]
HVAC,Sum,Generator Thermal Energy Produced [J]
HVAC,Average,Generator Thermal Efficiency LHV Basis [-]
HVAC,Average,Generator Heat Recovery Inlet Temperature [C]
HVAC,Average,Generator Heat Recovery Outlet Temperature [C]
HVAC,Average,Generator Heat Recovery Water Mass Flow Rate [kg/s]

```

Generator Electric Power Produced [W]

This output variable is the average electric power produced by the generator in Watts for the timestep being reported. This is the “net” electric power produced, accounting for ancillary electric power consumed during generator operation.

Generator Electric Energy Produced [J]

This output variable is the electric energy produced by the generator in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = ElectricityProduced, End Use Key = Cogeneration, Group Key = Plant (Ref. Report Meter). This is the “net” electric energy produced, accounting for ancillary electric consumption during generator operation.

Generator Electric Efficiency LHV Basis [-]

This output variable is the average electric efficiency of the generator (lower heating value basis) for the timestep being reported. The electric efficiency is the Generator Electric Power Produced in Watts divided by the generator’s fuel energy consumption rate in Watts (lower heating value basis).

Generator <FuelType> Consumption Rate HHV Basis [W]

This output variable is the average fuel-specific energy consumption rate of the electric generator in Watts (higher heating value basis) for the timestep being reported. <FuelType> is the name of the fuel used by this electric generator. <FuelType> can be one of the following: Natural Gas (=> 'Gas') or Propane Gas (=>'Propane').

Generator Fuel Consumption Rate HHV Basis [W]

This output variable is the average fuel energy consumption rate of the electric generator in Watts (higher heating value basis) for the timestep being reported. The output variable name is non-fuel specific.

Generator <FuelType> Consumption HHV Basis [J]

This output variable is the fuel-specific energy consumption of the electric generator in Joules (higher heating value basis) for the timestep being reported. This output is also added to a report meter with Resource Type = <FuelType>, End Use Key = Cogeneration, Group Key = Plant (Ref. Report Meter). <FuelType> is the name of the fuel used by this electric generator. <FuelType> can be one of the following: Natural Gas (=> 'Gas') or Propane Gas (=>'Propane').

Generator Fuel Consumption HHV Basis [J]

This output variable is the fuel energy consumption of the electric generator in Joules (higher heating value basis) for the timestep being reported. The output variable name is non-fuel specific.

Generator <FuelType> Mass Flow Rate [kg/s]

This output variable is the average mass flow rate of fuel being consumed by the electric generator in kg/s for the timestep being reported. <FuelType> is the name of the fuel used by this electric generator. <FuelType> can be one of the following: Natural Gas (=> 'Gas') or Propane Gas (=>'Propane').

Generator Standby Electric Power [W]

This output variable is the average standby electric power consumed by the generator in Watts for the timestep being reported. Standby power is electrical power consumed by the generator (e.g., air fans and controls) when the generator is available to operate but the generator electrical power output is zero (power output is not being requested by the electric load center). This output variable is only produced when the user enters a value greater than 0.0 for the input field Standby Power.

Generator Standby Electric Consumption [J]

This output variable is the standby electric energy consumption for the generator in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = Electricity, End Use Key = Cogeneration, Group Key = Plant (Ref. Report Meter). This output variable is only produced when the user enters a value greater than 0.0 for the input field Standby Power.

Generator Ancillary Electric Power [W]

This output variable is the average ancillary electric power consumed by the generator in Watts for the timestep being reported. Ancillary power is the electrical power consumed by other associated equipment (e.g., external fuel pressurization pumps) when the generator is operating. This output variable is only produced when the user enters a value greater than 0.0 for the input field Ancillary Power.

Generator Ancillary Electric Consumption [J]

This output variable is the ancillary electric energy consumption for the generator in Joules for the timestep being reported. This energy consumption is already deducted from the output

variable Generator Electric Energy Produced (“net” electric energy produced by the generator). This output variable is only produced when the user enters a value greater than 0.0 for the input field Ancillary Power.

Generator Thermal Power Produced [W]

This output variable is the average thermal power produced (i.e., exhaust energy recovery to heat water) in Watts for the timestep being reported.

Generator Thermal Energy Produced [J]

This output variable is the thermal energy produced (i.e., exhaust energy recovery to heat water) in Joules for the timestep being reported. This output is also added to a report meter with Resource Type = EnergyTransfer, End Use Key = HeatRecovery, Group Key = Plant (Ref. Report Meter).

Generator Thermal Efficiency LHV Basis [-]

This output variable is the average thermal efficiency of the generator (lower heating value basis) for the timestep being reported. The thermal efficiency is the Generator Thermal Power Produced in Watts divided by the generator’s fuel energy consumption rate in Watts (lower heating value basis).

Generator Heat Recovery Inlet Temperature [C]

This output variable is the average heat recovery inlet water temperature in degrees Celsius for the timestep being reported.

Generator Heat Recovery Outlet Temperature [C]

This output variable is the average heat recovery outlet water temperature in degrees Celsius for the timestep being reported.

Generator Heat Recovery Water Mass Flow Rate [kg/s]

This output variable is the average heat recovery water mass flow rate in kilograms per second for the timestep being reported.

Generator:MicroCHP

This object is used to model small-scale combined heat and power (micro CHP) electric generators using the model developed by IEA/ECBCS Annex 42 – see www.cogen-sim.net. The model was developed for both internal combustion and Stirling cycle engines, but might be used for other types of residential CHP devices.

Note that unlike other component models in EnergyPlus, this model is not normalized. Therefore, performance coefficients developed for one type and capacity of CHP device cannot be used for a device with a different capacity.

This model is an empirical, curve fit model. This object describes the connections to the rest of the building model and includes a reference to another object called Generator:MicroCHP:NonNormalizedParameters that provides the operating characteristics.

```

Generator:MicroCHP,
  A1, \field Name
      \reference MicroCHPNames
  A2, \field Performance Parameters Name
      \Note Enter the name of a Generator:MicroCHP:NonNormalizedParameters object.
      \object-list MicroCHPParametersNames
  A3, \field Zone Name
      \object-list ZoneNames
  A4, \field Cooling Water Inlet Node Name
  A5, \field Cooling Water Outlet Node Name
  A6, \field Air Inlet Node Name
  A7, \field Air Outlet Node Name
  A8, \field Generator Fuel Supply Name
      \object-list GenFuelSupNames
      \Note Enter the name of a Generator:FuelSupply object.
  A9; \field Availability Schedule Name
      \object-list ScheduleNames

```

Field: Name

This field contains a unique name for the residential CHP device.

Field: Performance Parameters Name

This field contains the name of a Generator:MicroCHP:NonNormalizedParameters object defined elsewhere in the input.

Field: Zone Name

This field contains the name of the thermal zone where the CHP device is located in the model. If the device is outdoors, or you do not want skin losses to be added to a zone, then leave this field blank.

Field: Cooling Water Inlet Node Name

This field provides the name of a node that is the inlet to the CHP device. The node should be on the plant loop that will receive the heat from the residential CHP unit. This inlet serves as the cooling water for the CHP device.

Field: Cooling Water Outlet Node Name

This field provides the name of a node that is the outlet to the CHP device. The node should be on the plant loop that will receive the heat from the residential CHP unit. This outlet serves as the exit of the cooling water leaving the CHP unit.

Field: Air Inlet Node Name

The name of an air node that supplies the CHP unit with air for use inside the generator.

Field: Air Outlet Node Name

The name of an air node that receives the exhaust from the CHP unit.

Field: Generator Fuel Supply Name

This field contains the name of a Generator:FuelSupply object defined elsewhere in the input file.

Field: Availability Schedule Name

This field contains the name of a schedule used to control whether or not the unit is available. It is "available" any time the value is greater than zero. If it is available, it may consume standby power at times when there is no request for power from the Electric Load Center. If it is not available (schedule value = 0.0) then the CHP unit is in a completely off "mode" and will not consume standby power.

An example IDF showing how this object is used is provided below:

```

Generator:MicroCHP,
  MicroCoGen1,           !- Name
  SENERTECH5_5KW,       !- Performance Parameters Name
  ZN_1_FLR_1_SEC_1,     !- Zone Name
  MICROCHP SENERTECH Pump-MicroCoGen1Node, !- Cooling Water Inlet Node Name
  MICROCHP SENERTECH Supply Equipment Outlet Node, !- Cooling Water Outlet Node Name
  MicroCoGen1 air inlet node, !- Air Inlet Node Name
  ,                     !- Air Outlet Node Name
  NATURALGAS,           !- Generator Fuel Supply Name
  ALWAYS_ON;           !- Availability Schedule Name

```

Generator:MicroCHP:NonNormalizedParameters

This object is referenced by a Generator:MicroCHP object and provides the non-normalized parameters for the MicroCHP generator model.

```

Generator:MicroCHP:NonNormalizedParameters,
  A1, \field Name
      \reference MicroCHPParametersNames
  N1, \field Maximum Electric Power
      \units W
  N2, \field Minimum Electric Power
      \units W
  N3, \field Minimum Cooling Water Flow Rate
      \units kg/s
  N4, \field Maximum Cooling Water Temperature
      \units C
  A2, \field Electrical Efficiency Curve Name
      \note TriQuadratic
      \object-list TriQuadraticCurves
  A3, \field Thermal Efficiency Curve Name
      \note TriQuadratic
      \object-list TriQuadraticCurves
  A4, \field Cooling Water Flow Rate Mode
      \type choice
      \key PlantControl
      \key InternalControl
  A5, \field Cooling Water Flow Rate Curve Name
      \object-list BiquadraticCurves
  A6, \field Air Flow Rate Curve Name
      \object-list QuadraticCurves
  N5, \field Maximum Net Electrical Power Rate of Change
      \units W/s
  N6, \field Maximum Fuel Flow Rate of Change
      \units kg/s2
  N7, \field Heat Exchanger U-Factor Times Area Value
      \units W/K
  N8, \field Skin Loss U-Factor Times Area Value
      \units W/K
  N9, \field Skin Loss Radiative Fraction
      \type real
  N10, \field Aggregated Thermal Mass of Energy Conversion Portion of Generator
      \units W/K
  N11, \field Aggregated Thermal Mass of Heat Recovery Portion of Generator
      \units W/K
  N12, \field Standby Power
      \units W

```

```

A7, \field Warm Up Mode
    \type choice
    \key NominalEngineTemperature
    \key TimeDelay
    \note Stirling engines use Nominal Engine Temperature
    \note Internal combustion engines use Time Delay
N13, \field Warm Up Fuel Flow Rate Coefficient
N14, \field Nominal Engine Operating Temperature
    \units C
N15, \field Warm Up Power Coefficient
N16, \field Warm Up Fuel Flow Rate Limit Ratio
N17, \field Warm Up Delay Time
    \units s
N18, \field Cool Down Power
    \units W
N19, \field Cool Down Delay Time
    \units s
A8; \field Restart Mode
    \type choice
    \key MandatoryCoolDown
    \key OptionalCoolDown

```

Field: Name

Unique name to identify this set of parameter data.

Field: Maximum Electric Power

This is the size of the CHP unit in terms of the maximum electrical power it can produce [W]. If the electric load center requests more power than this maximum, then the unit will restrict its output to this level.

Field: Minimum Electric Power

This is the size of the CHP unit in terms of the minimum electrical power it can produce [W]. If the electric load center requests less power than this minimum, then the unit will hold its output to this level.

Field: Minimum Cooling Water Flow Rate

This is the minimum flow rate of cooling water that must be available for the unit to operate [kg/s]. If the plant loop is not providing this flow of water, the unit will shut down to protect it from overheating.

Field: Maximum Cooling Water Temperature

This is the maximum temperature of cooling water inlet or outlet that can occur without the unit shutting down to protect from overheating [°C].

Field: Electrical Efficiency Curve Name

This is the name of Curve:Triquadratic object that defines the steady-state net electrical efficiency. The electrical efficiency, η_e , is a function of the cooling water mass flow rate, \dot{m}_{cw} , the temperature of the cooling water at the inlet, T_{cw} , the steady-state net electrical power produced, $P_{net,ss}$.

$$\eta_e = f(P_{net,ss}, \dot{m}_{cw}, T_{cw})$$

The associated Curve:Triquadratic object should be defined with the independent variables $P_{net,ss}$, \dot{m}_{cw} , T_{cw} corresponding to x, y, and z, respectively.

Field: Thermal Efficiency Curve Name

This is the name of a Curve:Triquadratic object that defines the steady-state net thermal efficiency. The thermal efficiency, η_q , is a function of the cooling water mass flow rate, \dot{m}_{cw} , the temperature of the cooling water at the inlet, T_{cw} , the steady-state net electrical power produced, $P_{net,ss}$.

$$\eta_q = f(P_{net,ss}, \dot{m}_{cw}, T_{cw})$$

The associated Curve:Triquadratic object should be defined with the independent variables $P_{net,ss}$, \dot{m}_{cw} , T_{cw} corresponding to x, y, and z, respectively.

Field: Cooling Water Flow Rate Mode

This field is used to choose between different modes of controlling the mass flow rate of cooling water. There are two options available for this field: "PlantControl" or "InternalControl." The "PlantControl" option indicates that the cooling water flow rate through the CHP device is determined externally (by the wider balance of plant). The "InternalControl" option indicates the flow of cooling water is controlled inside the CHP device (e.g., like an automobile's thermostat).

For internal control, the following field is used to define a Biquadratic curve that will determine the cooling water flow rate. For internal control, the CHP device should (probably) include a bypass branch when connecting to the plant loop.

Field: Cooling Water Flow Rate Curve Name

This field contains the name of a Curve:Biquadratic object that defines the mass flow rate of cooling water, \dot{m}_{cw} . This field is only used if the prior field is set to "InternalControl." The mass flow of cooling water is a function of steady-state power, $P_{net,ss}$, and the inlet temperature of the cooling water, T_{cw} . The associated Curve:Biquadratic should be defined with the independent variables $P_{net,ss}$ and T_{cw} corresponding to x and y, respectively.

Field: Air Flow Rate Curve Name

This is the name of a Curve:Quadratic object that defines the steady state air flow into the CHP device as a function of the mass flow rate of fuel.

Field: Maximum Net Electrical Power Rate of Change

This field contains input on the limits for how fast the generator can ramp up or down in terms of the net electrical power.

Field: Maximum Fuel Flow Rate of Change

This field contains input on the limits for how fast the generator can ramp up or down in terms of the fuel flow rates.

Field: Heat Exchanger U-Factor Times Area Value

This field describes the effective UA value for the heat exchanger that transfers heat from the generator to the cooling water.

Field: Skin Loss U-Factor Times Area Value

This field describes the effective UA value for the heat transfer from the generator to the surrounding air.

Field: Skin Loss Radiative Fraction

This field describes the split between thermal radiation and thermal convection for the heat losses from the skin of the generator.

Field: Aggregated Thermal Mass of Energy Conversion Portion of Generator

This field describes the aggregated thermal mass of the energy conversion portion of the generator. This includes the engine block in an internal combustion engine.

Field: Aggregated Thermal Mass of Heat Recovery Portion of Generator

This field describes the aggregated thermal mass of the heat recovery portion of the generator. This includes the encapsulated cooling water and heat exchanger shell in immediate thermal contact.

Field: Standby Power

This field describes the power used by the CHP unit's control systems while in standby operation. Standby operation mode occurs whenever the unit is available but not being called upon to produce power. Power is entered as a positive value but indicates negative generation.

Field: Warm Up Mode

This field is used to choose between different modes of controlling the warm up characteristics. Residential CHP units such as Stirling engines have different warm up characteristics than internal combustion engines. There are two warm up modes available: "NominalEngineTemperature" or "TimeDelay." If the former mode is input in this field, then the next three fields are used to model warm up. If the later mode is input, then the fourth field below is used to model warm up.

Field: Warm Up Fuel Flow Rate Coefficient

This field describes the value for the coefficient used to determine the rate of fuel flow during warm up. The coefficient, k_f , is used in the following relation,

$$\dot{m}_{fuel, warm-up} = \dot{m}_{fuel, ss-max} + k_f \dot{m}_{fuel, ss-max} \left(\frac{T_{eng, nom} - T_{room}}{T_{eng} - T_{room}} \right)$$

Field: Nominal Engine Operating Temperature

This field describes the nominal engine temperature during normal, steady-state operation, $T_{eng, nom}$ [°C].

Field: Warm Up Power Coefficient

This field describes the value for the coefficient used to determine the rate of power production during warm up. The coefficient k_p is used in the following relation,

$$P_{net, warm-up} = P_{max} k_p \left(\frac{T_{eng} - T_{room}}{T_{eng, nom} - T_{room}} \right)$$

Field: Warm Up Fuel Flow Rate Limit Ratio

This field is used to describe a limit to the fuel flow rate during warm up. The limit is a ratio multiplied by the maximum fuel flow rate during normal operation (corresponding to the fuel flow for maximum electrical power). If the warm up operating fuel flow rate is twice the steady state fuel flow at maximum power, then a value of 2.0 would be entered in this field. This field

is only used with the nominal engine temperature warm up mode and is intended for Stirling engines.

Field: Warm Up Delay Time

This field is used to model the warm up operation when the warm up mode is “TimeDelay.” Enter the time between activation and power generation in seconds.

Field: Cool Down Power

This field describes the power used by the CHP unit’s ancillary systems while in cool down operation mode. Cool down operation mode occurs whenever the unit has recently been told to stop producing power. Power here is consumed and entered as a positive value that indicates negative generation. For example, a component such as a cooling fan might continue to run during cool down.

Field: Cool Down Delay Time

This field is used to describe the time it takes for the CHP unit to cool off and complete the cool down operation. Enter the time between deactivation and the end of a cool down period in seconds.

Field: Restart Mode

This field is used to choose between two different control situations for the cool down operation. The two options for this field are “MandatoryCoolDown” and “OptionalCoolDown.” The former is used to direct the model to complete the entire cool down period before the generator can subsequently enter warm up mode. The latter directs the model to allow immediately switching to warm up mode, if power is requested before the cool down period is completed.

An example IDF showing how this object is used is provided below:

```
Generator:MicroCHP:NonNormalizedParameters,
SENERTECH5_5KW,           !- Name
5500.0000,                !- Maximum Electric Power {W}
0.0000,                  !- Minimum Electric Power {W}
0.0000,                  !- Minimum Cooling Water Flow Rate {kg/s}
80.0000,                  !- Maximum Cooling Water Temperature {C}
SenerTechElEff,           !- Electrical Efficiency Curve Name
SenerTechThermEff,        !- Thermal Efficiency Curve Name
InternalControl,          !- Cooling Water Flow Rate Mode
SenerTechCoolWaterflow,  !- Cooling Water Flow Rate Curve Name
SenerTechAirFlow,         !- Air Flow Rate Curve Name
1000000000.0000,         !- Maximum Net Electrical Power Rate of Change {W/s}
1000000000.0000,         !- Maximum Fuel Flow Rate of Change {kg/s2}
741.0000,                 !- Heat Exchanger U-Factor Times Area Value {W/K}
13.7000,                 !- Skin Loss U-Factor Times Area Value {W/K}
0.5000,                  !- Skin Loss Radiative Fraction
63605.6000,              !- Aggregated Thermal Mass of Energy Conversion Portion of Generator {W/K}
1000.7000,               !- Aggregated Thermal Mass of Heat Recovery Portion of Generator {W/K}
0.0000,                  !- Standby Power {W}
TimeDelay,                !- Warm Up Mode
,                          !- Warm Up Fuel Flow Rate Coefficient
,                          !- Nominal Engine Operating Temperature {C}
,                          !- Warm Up Power Coefficient
,                          !- Warm Up Fuel Flow Rate Limit Ratio
60.0000,                 !- Warm Up Delay Time {s}
0.0000,                  !- Cool Down Power {W}
60.0000,                 !- Cool Down Delay Time {s}
OptionalCoolDown;        !- Restart Mode
```

Generator:MicroCHP Outputs

```
HVAC,Sum,Generator Time in Off Mode [s]
HVAC,Sum,Generator Time in Standby Mode [s]
HVAC,Sum,Generator Time in Warm up Mode [s]
```



```

HVAC,Sum,Generator Time in Normal Operating Mode [s]
HVAC,Sum,Generator Time in Cool Down Mode [s]
HVAC,Average,Generator Electric Power Produced [W]
HVAC,Sum,Generator Electric Energy Produced [J]
HVAC,Average,Generator Electrical Efficiency [ ]
HVAC,Average,Generator Thermal Efficiency [ ]
HVAC,Average,Generator Gross Heat Input Rate to Engine [W]
HVAC,Average,Generator Steady-State Rate of Heat Generation in Engine [W]
HVAC,Average,Generator Rate of Heat Recovery [W]
HVAC,Average,Generator Air Flow Rate [kg/s]
HVAC,Average,Generator Molar Fuel Flow Rate [kmol/s]
HVAC,Average,Generator Fuel Flow Rate [kg/s]
HVAC,Average,Generator Engine Temperature [C]
HVAC,Average,Generator Coolant Inlet Temperature [C]
HVAC,Average,Generator Coolant Outlet Temperature [C]
HVAC,Sum,Generator Fuel Energy Use HHV [J]
HVAC,Average,Generator Fuel Energy Use Rate HHV [W]
HVAC,Sum,Generator Fuel Energy Use LHV [J]
HVAC,Average,Generator Fuel Energy Use Rate LHV [W]
HVAC,Average,Generator Fuel Compressor Electrical Power [W]
HVAC,Sum,Generator Fuel Compressor Electrical Energy [J]
HVAC,Average,Generator Fuel Compressor Skin Losses [W]
HVAC,Average,Generator Heat Loss Rate to Zone [W]
HVAC,Sum,Generator Heat Loss Energy to Zone [J]
HVAC,Average,Generator Convection Heat Loss Rate to Zone [W]
HVAC,Average,Generator Radiation Heat Loss Rate to Zone [W]

```

Generator Time in Off Mode [s]

This report is the amount of time the generator spent in “Off” mode in seconds.

Generator Time in Standby Mode [s]

This report is the amount of time the generator spent in “Stand By” mode in seconds.

Generator Time in Warm Up Mode [s]

This report is the amount of time the generator spent in “Warm Up” mode in seconds.

Generator Time in Normal Operating Mode [s]

This report is the amount of time the generator spent in “Normal Operating” mode in seconds.

Generator Time in Cool Down Mode [s]

This report is the amount of time the generator spent in “Cool Down” mode in seconds.

Generator Electric Power Produced [W]

This report is the net electrical power produced by the generator in watts.

Generator Electric Energy Produced [J]

This report is the net electrical energy produced by the generator in joules. This report variable is also put on the meter for on-site production.

Generator Electrical Efficiency []

This is the result for electrical efficiency.

Generator Thermal Efficiency []

This is the result for thermal efficiency.

Generator Gross Heat Input Rate to Engine [W]

This is the gross rate of heat input (from fuel consumption) into the engine control volume.

Generator Steady-State Rate of Heat Generation in Engine [W]

This is an interim value in the dynamic thermal calculation that describes the steady-state heat generation in the engine.

Generator Thermal Power Produced [W]**Generator Thermal Energy Produced [J]**

These are the rate and energy of thermal heat transferred from the engine to the heat recovery fluid in the coolant control volume.

Generator Air Flow Rate [kg/s]

This is the rate of air flow thru the engine on a mass basis.

Generator Molar Fuel Flow Rate [kmol/s]

This is the rate of fuel flow thru the engine on a molar basis.

Generator Fuel Flow Rate [kg/s]

This is the rate of fuel flow thru the engine on a mass basis.

Generator Engine Temperature [C]

This is the model result for engine temperature in C. This is the lumped temperature for the engine control volume.

Generator Coolant Inlet Temperature [C]

This is the temperature of the inlet water used for heat recovery. It is determined by the balance of plant connected to the generator.

Generator Coolant Outlet Temperature [C]

This report is the model prediction for the leaving temperature of water used for heat recovery. If there is no flow this is the modeled prediction for the mass of cooling water in contact with the engine.

Generator Fuel Consumption HHV Basis [J]

This is the energy used by the cogeneration device in terms of higher heating value in joules. This is the report variable is also put on the meter for natural gas.

Generator Fuel Consumption Rate HHV Basis [W]

This is the rate of fuel energy use by the cogeneration device in terms of higher heating value in watts.

Generator Fuel Consumption LHV Basis [J]

This is the fuel energy used by the cogeneration device in terms of lower heating value in joules.

Generator Fuel Consumption Rate LHV Basis [W]

This is the rate of fuel energy use by the cogeneration device in terms of lower heating value in watts

Generator Heat Loss Rate to Zone [W]

Rate of heat gain to zone from cogeneration unit.

Generator Heat Loss Energy to Zone [J]

Heat gains to zone from cogeneration unit.

Generator Convection Heat Loss Rate to Zone [W]

Portion of rate of heat gain to zone in the form of surface convection heat transfer.

Generator Radiation Heat Loss Rate to Zone [W]

Portion of heat gains to zone in the form of surface radiation heat transfer (to other surfaces in zone).

Generator:FuelCell

This object is used to model small Fuel Cell (FC) generators. IEA/ECBCS Annex 42 – see www.cogen-sim.net, developed the FC model implemented in EnergyPlus. The model can be used for two general types of fuel cells, solid oxide fuel cells (SOFC) and proton exchange membrane fuel cells (PEMFC). Warning! This is a complicated model, intended primarily for research. Because fuel cells for cogeneration (producing both heat and electricity) are not yet a mature product for building systems, the input data for this model are extremely difficult to obtain. However, the model is designed to allow investigating the relative implications of a broad array of subsystems and interactions with the building.

There should be one Generator:FuelCell object for each individual FC generator in the model. Multiple fuel cell generators can be included in a given simulation. Because there are a large number of inputs to the FC model and numerous, somewhat separable subsystems within a fuel cell, the EnergyPlus input objects have been organized into a number of separate input objects. This object simply refers to the names of all the other input objects that provide the input details for individual subsystems within the fuel cell cogeneration device. The following figure diagrams these separate subsystems. (not shown is an optional stack cooler with separate connections to heat recovery water loop and surrounding zone air).

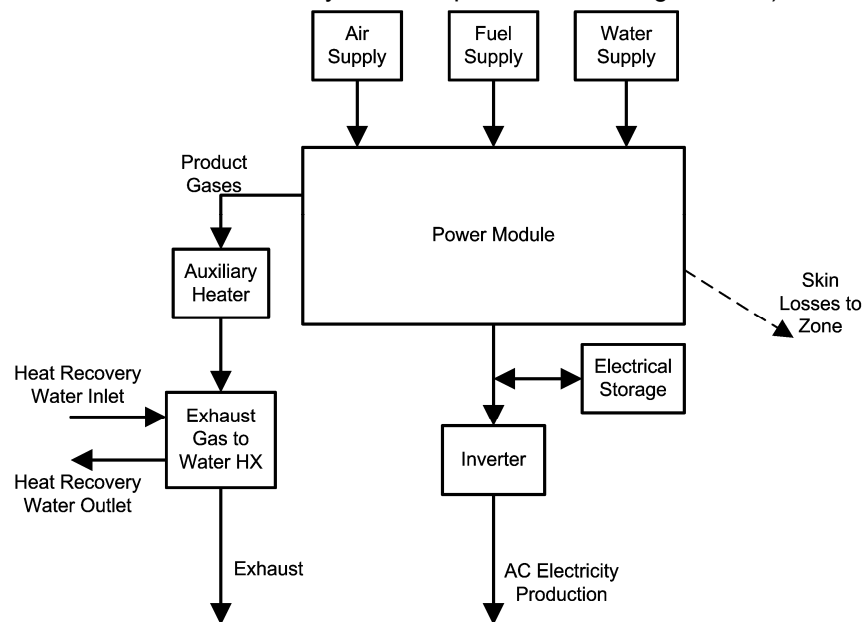


Figure 126. Fuel cell subsystems.

Note that the FC model is formulated using the Lower Heating Value (LHV) of the fuel, whereas most other parts of EnergyPlus use the Higher Heating Value (HHV). LHV has important advantages over HHV in the context of the quality of heat recovered. While model coefficients for input performance descriptions are to be based on LHV, energy consumption and tariff calculations are also reported on HHV basis when using this model.

```

Generator:FuelCell,
  \memo This generator model is the FC model from IEA Annex 42
A1, \field Name
  \required-field
  \reference GeneratorNames
A2, \field Power Module Name
  \note Enter then name of a Generator:FuelCell:PowerModule object.
  \required-field
  \object-list FCPMNames
A3, \field Air Supply Name
  \note Enter then name of a Generator:FuelCell:AirSupply object.
  \required-field
  \object-list FCAirSupNames
A4, \field Fuel Supply Name
  \note Enter then name of a Generator:FuelSupply object.
  \required-field
  \object-list GenFuelSupNames
A5, \field Water Supply Name
  \note Enter then name of a Generator:FuelCell:WaterSupply object.
  \required-field
  \object-list FCWaterSupNames
A6, \field Auxiliary Heater Name
  \note Enter the name of a Generator:FuelCell:AuxiliaryHeater object.
  \required-field
  \object-list FCAuxHeatNames
A7, \field Heat Exchanger Name
  \note Enter the name of a Generator:FuelCell:ExhaustGasToWaterHeatExchanger object.
  \required-field
  \object-list FCExhaustHXNames
A8, \field Electrical Storage Name
  \note Enter the name of a Generator:FuelCell:ElectricalStorage object.
  \required-field
  \object-list FCStorageNames
A9, \field Inverter Name
  \note Enter the name of a Generator:FuelCell:Inverter object.
  \required-field
  \object-list FCInverterNames
A10; \field Stack Cooler Name
  \note Enter the name of a Generator:FuelCell:StackCooler object.
  \note optional, used for PEMFC
  \object-list FCStackCoolerNames

```

Field: Name

This field contains a unique name for the fuel cell.

Field: Power Module Name

This field contains the name of a Generator:FuelCell:PowerModule input object.

Field: Air Supply Name

This field contains the name of a Generator:FuelCell:AirSupply input object.

Field: Fuel Supply Name

This field contains the name of a Generator:FuelSupply input object.

Field: Water Supply Name

This field contains the name of a Generator:FuelCell:WaterSupply input object.

Field: Auxiliary Heater Name

This field contains the name of a Generator:FuelCell:AuxiliaryHeater input object.

Field: Heat Exchanger Name

This field contains the name of a Generator:FuelCell:ExhaustGasToWaterHeatExchanger input object.

Field: Electrical Storage Name

This field contains the name of a Generator:FuelCell:ElectricalStorage input object.

Field: Inverter Name

This field contains the name of a Generator:FuelCell:Inverter input object.

Field: Stack Cooler Name

This field contains the name of a Generator:FuelCell:StackCooler input object. This is optional. The presence of a stack cooler distinguishes between SOFC and PEMFC with PEMFC operating at lower temperatures and requiring a separate subsystem to maintain stack temperatures.

An example input data file (IDF) entry for this object is provided below:

```
Generator:FuelCell,
  FCT SOFC,           !- Name
  FCT SOFC Power Module, !- Power Module Name
  FCT SOFC Air Supply, !- Air Supply Name
  FCT SOFC Fuel Supply, !- Fuel Supply Name
  FCT SOFC Water Supply, !- Water Supply Name
  FCT SOFC Auxiliary Heater, !- Auxiliary Heater Name
  FCT SOFC Exhaust HX, !- Heat Exchanger Name
  FCT SOFC Battery, !- Electrical Storage Name
  FCT SOFC Inverter; !- Inverter Name
```

Generator:FuelCell Outputs

The following report variables are available for the fuel cell model.

```
Report Variable,*,Generator Electric Power Produced,hourly; !- HVAC Average [W]
Report Variable,*,Generator Electric Energy Produced,hourly; !- HVAC Sum [J]
Report Variable,*,Generator Thermal Power Produced,hourly; !- HVAC Average [W]
Report Variable,*,Generator Thermal Energy Produced,hourly; !- HVAC Sum [J]
Report Variable,*,Generator Fuel Consumption HHV Basis,hourly; !- HVAC Sum [J]
Report Variable,*,Generator Fuel Consumption Rate HHV Basis,hourly; !- HVAC Average [W]
Report Variable,*,Generator Fuel Consumption LHV Basis,hourly; !- HVAC Sum [J]
Report Variable,*,Generator Fuel Consumption Rate LHV Basis,hourly; !- HVAC Average [W]
Report Variable,*,FuelCell Heat Loss Rate to Zone,hourly; !- HVAC Average [W]
Report Variable,*,FuelCell Heat Loss Energy to Zone,hourly; !- HVAC Sum [J]
Report Variable,*,FuelCell Convection Heat Loss Rate to Zone,hourly; !- HVAC Average [W]
Report Variable,*,FuelCell Radiation Heat Loss Rate to Zone,hourly; !- HVAC Average [W]
```

Generator Electric Power Produced [W]

This report is the net electrical power produced by the generator in watts.

Generator Electric Energy Produced [J]

This report is the net electrical energy produced by the generator in joules. This report variable is also put on the meter for on-site production.

Generator Thermal Power Produced [W]**Generator Thermal Energy Produced [J]**

These are the rate and energy of thermal heat transferred from the engine to the heat recovery fluid in the coolant control volume.

Generator Fuel Consumption HHV Basis [J]

This is the energy used by the cogeneration device in terms of higher heating value in joules. This is the report variable is also put on the meter for natural gas.

Generator Fuel Consumption Rate HHV Basis [W]

This is the rate of fuel energy use by the cogeneration device in terms of higher heating value in watts.

Generator Fuel Consumption LHV Basis [J]

This is the fuel energy used by the cogeneration device in terms of lower heating value in joules.

Generator Fuel Consumption Rate LHV Basis [W]

This is the rate of fuel energy use by the cogeneration device in terms of lower heating value in watts.

FC Heat Loss Rate to Zone [W]

This variable provides the results for the total rate of skin losses from the fuel cell to the surrounding zone.

FC Heat Loss Energy to Zone [J]

This variable provides the results for the total energy in skin losses from the fuel cell to the surrounding zone.

FC Convection Heat Loss Rate to Zone [W]

This variable provides the results for the rate of skin losses in the form of surface convection heat transfer from the fuel cell to the surrounding zone.

FC Radiation Heat Loss Rate to Zone [W]

This variable provides the results for the rate of skin losses in the form of radiation heat transfer from the fuel cell to the surrounding zone.

Using the FC model with DisplayAdvancedReportVariables (see Diagnostics object or use of operating system's environment variables) makes the following output variables available as listed in the RDD file. There are a large number of output variables that provide access to the inner workings of the model and individual subsystems that are not likely to be useful for the average user.

```

HVAC,Average,FC Air Temperature at Inlet [C]
HVAC,Average,FC Air Temperature Entering Power Module [C]
HVAC,Average,FC Air Flow Rate [kmol/s]
HVAC,Average,FC Air Enthalpy Entering Power Module [W]
HVAC,Average,FC Air Blower Electrical Power [W]
HVAC,Sum,FC Air Blower Electrical Energy [J]
HVAC,Average,FC Air Blower Skin Losses [W]
HVAC,Average,FC Fuel Temperature at Inlet [C]
HVAC,Average,FC Fuel Temperature Entering Power Module [C]
HVAC,Average,FC Fuel Flow Rate [kmol/s]
HVAC,Average,FC Fuel Enthalpy Entering Power Module [W]
HVAC,Average,FC Fuel Compressor Electrical Power [W]
HVAC,Sum,FC Fuel Compressor Electrical Energy [J]
HVAC,Average,FC Fuel Compressor Skin Losses [W]
HVAC,Average,FC Reforming Water Temperature at Inlet [C]
HVAC,Average,FC Reforming Water Temperature Entering Power Module [C]
HVAC,Average,FC Reforming Water Flow Rate [kmol/sec]
HVAC,Average,FC Reforming Water Pump Electrical Power [W]
HVAC,Sum,FC Reforming Water Pump Electrical Energy [J]
HVAC,Average,FC Reforming Water Enthalpy Entering Power Module [W]
HVAC,Average,FC Product Gas Temperature [C]
HVAC,Average,FC Product Gas Enthalpy [W]
HVAC,Average,FC Product Gas Flow Rate [kmol/s]
HVAC,Average,FC Product Gas Argon Flow Rate [kmol/s]

```

```

HVAC,Average,FC Product Gas Carbon Dioxide Flow Rate [kmol/s]
HVAC,Average,FC Product Gas Water Vapor Flow Rate [kmol/s]
HVAC,Average,FC Product Gas Nitrogen Flow Rate [kmol/s]
HVAC,Average,FC Product Gas Oxygen Flow Rate [kmol/s]
HVAC,Average,FC Power Conditioning Losses [W]
HVAC,Average,FC DC Power Generated [W]
HVAC,Average,FC DC Power Efficiency [ ]
HVAC,Average,FC Electrical Storage State of Charge [J]
HVAC,Average,FC DC Power Into Storage [W]
HVAC,Sum,FC DC Energy Into Storage [J]
HVAC,Average,FC DC Power From Storage [W]
HVAC,Sum,FC DC Energy From Storage [J]
HVAC,Average,FC AC Ancillaries Power [W]
HVAC,Sum,FC AC Ancillaries Energy [J]
HVAC,Average,FC Heat Loss Rate to Zone [W]
HVAC,Sum,FC Heat Loss Energy to Zone [J]
HVAC,Average,FC Convection Heat Loss Rate to Zone [W]
HVAC,Average,FC Radiation Heat Loss Rate to Zone [W]
HVAC,Sum,FC Model Iterations [ ]
HVAC,Sum,FC Regula Falsi Iterations [ ]

```

FC Air Temperature at Inlet [C]

This variable provides the temperature of air supplied to the FC.

FC Air Temperature Entering Power Module [C]

This variable provides the temperature of the air supplied to the power module after it has gone through the blower and received any heat recovered from other subsystems.

FC Air Flow Rate [kmol/s]

This variable provides the results for \dot{N}_{air} , the flow rate of air into the FC.

FC Air Enthalpy Entering Power Module [W]

This variable provides the results for $\sum_i \left(\dot{N}_i \cdot \left[\hat{h}_i - \Delta_f \hat{h}_i^0 \right] \right)_{air}$, which is the enthalpy flow in the air stream entering the power module relative to 25°C.

FC Air Blower Electrical Power [W]

This variable provides the results for $P_{blower-el}$, which is the electrical power used by the air supply blower.

FC Air Blower Electrical Energy [J]

This variable provides the results for the energy used by the air supply blower. It is also added to the appropriate meters.

FC Air Blower Skin Losses [W]

This variable provides the results for $q_{blower-heat-loss}$, which is the rate of energy “lost” to the surroundings.

FC Fuel Temperature at Inlet [C]

This variable provides the temperature of the fuel supplied to the FC.

FC Fuel Temperature Entering Power Module [C]

This variable provides the temperature of the fuel supplied to the power module after it has gone through the compressor.

FC Fuel Flow Rate [kmol/s]

This variable provides the results for \dot{N}_{fuel} , which is the flow rate of fuel into the FC.

FC Fuel Enthalpy Entering Power Module [W]

This variable provides the results for $\sum_i \left(\dot{N}_i \cdot \left[\hat{h}_i - \Delta_f \hat{h}_i^0 \right] \right)_{fuel}$, which is the enthalpy flow in the fuel stream entering the power module relative to 25°C.

FC Fuel Compressor Electrical Power [W]

This variable provides the results for $P_{comp-el}$, which is the electrical power used by the fuel supply compressor.

FC Fuel Compressor Electrical Energy [J]

This variable provides the results for the energy used by the fuel supply compressor. It is also added to the appropriate meters.

FC Fuel Compressor Skin Losses [W]

This variable provides the results for the rate of energy “lost” to the surroundings.

FC Reforming Water Temperature at Inlet [C]

This variable provides the temperature of the water supplied to the FC for reforming.

FC Reforming Water Temperature Entering Power Module [C]

This variable provides the temperature of the water supplied to the power module after it has gone through the pump.

FC Reforming Water Flow Rate [kmol/sec]

This variable provides the results for \dot{N}_{water} , which the flow rate of reforming water into the FC.

FC Reforming Water Pump Electrical Power [W]

This variable provides the results for $P_{pump-el}$, which is the electrical power used by the water pump.

FC Reforming Water Pump Electrical Energy [J]

This variable provides the results for energy used by the water pump. It is also added to the appropriate meters.

FC Reforming Water Enthalpy Entering Power Module [W]

This variable provides the results for $\dot{H}_{liq-water}$ which is the enthalpy flow of the water stream entering the power module relative to 25°C.

FC Product Gas Temperature [C]

This variable provides the results for the temperature of the product gas stream leaving the fuel cell power module.

FC Product Gas Enthalpy [W]

This variable provides the results for $\sum_i \left(\dot{N}_i \cdot \left[\hat{h}_i - \Delta_f \hat{h}_i^0 \right] \right)_{FCPM-cg}$, which is the enthalpy flow in the product gas stream leaving the power module relative to 25°C.

FC Product Gas Flow Rate [kmol/s]

This variable provides the results for the flow rate of all the product gases leaving the fuel cell power module.

FC Product Gas Argon Flow Rate [kmol/s]

This variable provides the results for the flow rate of the argon gas leaving the fuel cell power module.

FC Product Gas Carbon Dioxide Flow Rate [kmol/s]

This variable provides the results for the flow rate of the carbon dioxide gas leaving the fuel cell power module.

FC Product Gas Water Vapor Flow Rate [kmol/s]

This variable provides the results for the flow rate of the water gas leaving the fuel cell power module.

FC Product Gas Nitrogen Flow Rate [kmol/s]

This variable provides the results for the flow rate of the nitrogen gas leaving the fuel cell power module.

FC Product Gas Oxygen Flow Rate [kmol/s]

This variable provides the results for the flow rate of the oxygen gas leaving the fuel cell power module.

FC Power Conditioning Losses [W]

This variable provides the results for the power losses associated with inefficiencies in the inverter.

FC DC Power Generated [W]

This variable provides the results for P_{el} , which is the net DC electrical power produced by the fuel cell power module.

FC DC Power Efficiency []

This variable provides the results for ε_{el} , which is the electrical efficiency of the fuel cell power module.

FC Electrical Storage State of Charge [J]

This variable provides the results for state of charge of the electrical storage device inside the fuel cell. Although the units are Joules, this is a state variable and is reported as an average rather than a sum.

FC DC Power Into Storage [W]

This variable provides the rate at which power was stored into the fuel cell's electrical storage subsystem.

FC DC Energy Into Storage [J]

This variable provides the energy stored into the fuel cell's electrical storage subsystem.

FC DC Power From Storage [W]

This variable provides the rate at which power was drawn from the fuel cell's electrical storage subsystem.

FC DC Energy From Storage [J]

This variable provides the energy drawn from the fuel cell's electrical storage subsystem.

FC AC Ancillaries Power [W]

This variable provides the results for $P_{el,ancillaries-AC}$, which is the rate at which ancillary devices within the power module use electricity supplied to the fuel cell by an external source.

FC AC Ancillaries Energy [J]

This variable provides the results for the energy used by AC ancillaries. It is also added to the appropriate meters.

FC Model Iterations []

This variable provides information on the numerical method used to calculate the FC model. EnergyPlus uses a sequential substitution iterative algorithm to solve the main heat balance equation for the FC model. This report variable indicates the number of iterations needed to converge.

FC Regula Falsi Iterations []

This variable provides information on the numerical method used to calculate product gas temperature as a function of the product gas's enthalpy. A Regula Falsi numerical method is used to invert the Shomate equation for enthalpy as a function of temperature. This report variable indicates the number of iterations needed for the Regula Falsi method to converge.

Generator:FuelCell:PowerModule

This object is used to describe the core power module subsystem of the FC. This includes the fuel cell stack, fuel reformer, and whatever ancillary devices are included inside. If the model has multiple FC generators that are of the exact same type, then only one of these objects is needed and all the Generator:FuelCell can reference it. The model uses a number of curves to describe operating performance. Input data for specific models of FC are not yet available but will be produced by IEA Annex 42 and should be available in the future.

```

Generator:FuelCell:PowerModule,
A1, \field Name
    \required-field
    \reference FCPMNames
A2, \field Efficiency Curve Mode
    \type choice
    \key Annex42
    \key Normalized
A3, \field Efficiency Curve Name
    \type object-list
    \object-list QuadraticCurves
    \required-field
N1, \field Nominal Efficiency
    \note This field is not used.
N2, \field Nominal Electrical Power
    \note This field is not used
    \units W
N3, \field Number of Stops at Start of Simulation
    \note this is Nstops in SOFC model specification
N4, \field Cycling Performance Degradation Coefficient
    \note this is D in SOFC model specification
N5, \field Number of Run Hours at Beginning of Simulation
    \units hr
N6, \field Accumulated Run Time Degradation Coefficient
    \note this is L in SOFC model specification
N7, \field Run Time Degradation Initiation Time Threshold
    \units hr
N8, \field Power Up Transient Limit
    \units W/s
    \note Maximum rate of change in electrical output [power increasing]
N9, \field Power Down Transient Limit
    \units W/s
    \note Maximum rate of change in electrical output [power decreasing]
    \note Enter positive value for rate of change
N10, \field Start Up Time
    \units s
    \note Time from start up to normal operation
N11, \field Start Up Fuel
    \units kmol
N12, \field Start Up Electricity Consumption
    \units J
N13, \field Start Up Electricity Produced
    \units J
N14, \field Shut Down Time
    \units s
N15, \field Shut Down Fuel
    \units kmol
N16, \field Shut Down Electricity Consumption
    \units J
N17, \field Ancilliary Electricity Constant Term
N18, \field Ancilliary Electricity Linear Term
A4, \field Skin Loss Calculation Mode
    \type choice
    \key ConstantRate
    \key UAForProcessGasTemperature
    \key QuadraticFunctionOfFuelRate
A5, \field Zone Name
    \type object-list
    \object-list ZoneNames
N19, \field Skin Loss Radiative Fraction
    \minimum 0.0
    \maximum 1.0
N20, \field Constant Skin Loss Rate
    \units W
N21, \field Skin Loss U-Factor Times Area Term
    \units W/K
A6, \field Skin Loss Quadratic Curve Name
    \type object-list
    \object-list QuadraticCurves
    \note curve is function of fuel use rate
N22, \field Dilution Air Flow Rate

```

```

\units kmol/s
N23,\field Stack Heat loss to Dilution Air
\units W
A7, \field Dilution Inlet Air Node Name
A8, \field Dilution Outlet Air Node Name
N24, \field Minimum Operating Point
\units W
N25; \field Maximum Operating Point
\units W
    
```

Field: Name

This field contains a unique name for the fuel cell power module subsystem.

Field: Efficiency Curve Mode

This field is used to choose between different modes of inputting the electrical efficiency curve. There are two options available for this field: “Annex42” and “Normalized”. The “Annex42” option indicates that the efficiency curves are not normalized and are used for the single size and type of FC product. The “Normalized” option indicates that the efficiency curves are normalized (as is standard practice in EnergyPlus) relative to a single rating point. In the Annex42 mode, the curves directly represent efficiency as a function of fuel use, but in the Normalized mode, the curves represent an efficiency modification that is applied to the efficiency at the rating point.

Field: Efficiency Curve Name

This field contains the name of a Curve:Quadratic input object described elsewhere in the input file. The curve is a function of the net DC electric power, P_{el} (W), produced by the power module and describes either the electrical efficiency or the how the efficiency is modified depending on the mode selected in the previous field. This quadratic curve is just one part of the entire parametric relation used to describe electrical efficiency ϵ_{el} . For the Annex42 mode the full relation for efficiency is,

$$\epsilon_{el} = \left[\epsilon_0 + \epsilon_1 \cdot P_{el} + \epsilon_2 \cdot P_{el}^2 \right] \cdot \left[1 - N_{stops} \cdot D \right] \cdot \left[1 - (MAX(\int dt - t_{threshold}, 0.0)) \cdot L \right]$$

where the Curve:Quadratic input object named in this field serves to define the quadratic portion in the first set of brackets. For the Normalized mode the full relation for efficiency is,

$$\epsilon_{el} = \left[\epsilon_0 + \epsilon_1 \cdot \frac{P_{el}}{P_{nom}} + \epsilon_2 \cdot \left(\frac{P_{el}}{P_{nom}} \right)^2 \right] \cdot \epsilon_{nom} \cdot \left[1 - N_{stops} \cdot D \right] \cdot \left[1 - (MAX(\int_0 dt - t_{threshold}, 0.0)) \cdot L \right]$$

where ϵ_{nom} is the nominal electrical efficiency at the rating point P_{nom} which are described in the next two fields. The Normalized mode may be more useful for a simulation study that needs to vary the capacity of the FC.

Field: Nominal Efficiency

This field is used for the “Normalized” efficiency curve mode and provides the nominal efficiency ϵ_{nom} (dimensionless) at the rating point. This field can be left blank if using the “Annex42” mode.

Field: Nominal Electrical Power

This field is used for the “Normalized” efficiency curve mode and provides the nominal net DC electrical power produced P_{nom} (W) at the rating point. This field can be left blank if using the “Annex42” mode.

Field: Number of Stops at Start of Simulation

This field is used to describe the number of times the FC has been cycled on and off prior to the start of the simulation. FC products might degrade as a result of starting and stopping the fuel cell stack, so the model includes terms to model the degradation effects of cycling FC units on and off. This is the initial value of the N_{stops} term in the efficiency relation above.

Field: Cycling Performance Degradation Coefficient

This field is used to describe the fixed value representing the fractional performance degradation associated with each start and stop cycle. This is the value of D in the efficiency relations above. If there is no degradation from cycling, then D should be 0.0.

Field: Number of Run Hours at Beginning of Simulation

This field is used to describe the amount of time the FC has been operating prior to the start of the simulation. FC products might degrade over time so the model includes terms to model the degradation effects of FC run time. This is the initial value of the integrated run time term

$$\int_0 dt .$$

Field: Accumulated Run Time Degradation Coefficient

This field is used to describe the fixed value representing the fractional performance degradation associated with the total amount of run time. This is the value of L in the efficiency relations above. If there is no degradation from run time, the L should be 0.0.

Field: Run Time Degradation Initiation Time Threshold

This field is used to describe the time period for which there is no degradation associated with the amount of run time. This provides the ability to model a system that initially operates without degradation for some period time before it starts to degrade. This is the value of $t_{threshold}$ in the efficiency relations above.

Field: Power Up Transient Limit

This field is used to describe the maximum allowable rate at which the fuel cell can increase the level of power it produces (W/s). This is a time derivative of the net DC electrical power used to limit how fast the FC can ramp up.

Field: Power Down Transient Limit

This field is used to describe the maximum allowable rate at which the fuel cell can decrease the level of power it produces (W/s). This is a time derivative of the net DC electrical power used to limit how fast the FC can ramp down.

Field: Start Up Time

This field is used to describe the length of time (seconds) of the start up period when the FC is turned on.

Field: Start Up Fuel

This field is used to describe the amount of fuel (kmol) used during the entire start up period. The fuel is the same type as what is described in the Generator:FuelSupply object elsewhere in the input file.

Field: Start Up Electricity Consumption

This field is used to describe the amount of electricity (Joules) used by ancillary equipment during the entire start up period.

Field: Start Up Electricity Produced

This field is used to describe the amount of electricity (Joules) produced by the power module during the entire start up period.

Field: Shut Down Time

This field is used to describe the length of time (seconds) of the shut down period.

Field: Shut Down Fuel

This field is used to describe the amount of fuel (kmol) used during the entire shut down period. The fuel is the same type as what is described in the Generator:FuelSupply object elsewhere in the input file.

Field: Shut Down Electricity Consumption

This field is used to describe the amount of electricity (J) used by ancillary equipment during the entire shut down period.

Field: Ancillary Electricity Constant Term

This field is used to describe the constant term, anc_0 , in a relation that describes the AC electrical power used by ancillary equipment located inside the power module, $P_{el,ancillaries-AC}$. The model uses this relation,

$$P_{el,ancillaries-AC} = anc_0 + anc_1 \cdot \dot{N}_{fuel}$$

where \dot{N}_{fuel} is the rate of fuel use in the power module (kmol/s).

Field: Ancillary Electricity Linear Term

This field is used to describe the linear term, anc_1 , in the relation shown in the previous field.

Field: Skin Loss Calculation Mode

This field is used to select the mode for how skin losses are modeled. Skin losses are heat energy “lost” from the power module and transferred to the surrounding thermal zone named in the following field. There are three alpha options to choose from: “ConstantRate”, “UAForProcessGasTemperature”, or “QuadraticFunctionOfFuelRate.” Enter ConstantRate in this field to model skin losses using a constant rate, e.g. 100 watts. Enter UAForProcessGasTemperature to model skin losses using a “UA-Delta-T” calculation method with the temperature difference determined by the power module’s product gas temperature and the surrounding zone. Enter QuadraticFunctionOfFuelRate to model skin losses as a function of the rate of fuel use.

Field: Zone Name

This field is used to describe the thermal zone that will receive skin and other heat losses from the FC. This should be the name of a Zone input object declared elsewhere in the input file.

Field: Skin Loss Radiative Fraction

This field is used to describe the portion of skin losses that are in the form of thermal radiation. This controls the radiative/convective split for the energy transferred to the zone by the FC.

Field: Constant Skin Loss Rate

This field is used to describe the constant rate of skin losses (W). This field is used with the ConstantRate mode. It can be left blank for other skin loss modes.

Field: Skin Loss U-Factor Times Area Term

This field is used to describe the “UA” term (W/K). This field is used with the UAForProcessGasTemperature mode. It can be left blank for other skin loss modes. “UA” is the product of the overall heat transfer coefficient “U” and the area “A.”

Field: Skin Loss Quadratic Curve Name

This field is used to refer to the name of a quadratic curve object defined elsewhere in the input file. The quadratic curve should define skin heat loss rate as a function of the fuel use rate (kmol/s) so that,

$$q_{skin-loss} = s_0 + s_1 \cdot \dot{N}_{fuel} + s_2 \cdot \dot{N}_{fuel}^2$$

Field: Dilution Air Flow Rate

This field is used to describe the rate of dilution air (kmol/sec) drawn into, or through, the power module. This air stream may not be present in all FC products. It is used for limiting skin and stack heat losses and for strategies that mitigate potential safety issue were fuel gases to escape the stack.

Field: Stack Heat loss to Dilution Air

This field is used to describe the rate at which the fuel cell stack adds energy to the dilution air stream. It is entered as a constant heat rate (W).

Field: Dilution Inlet Air Node Name

This field is used to describe the air node where the dilution air is drawn from. This would typically be the name of the air node associated with the thermal zone where the FC is located.

Field: Dilution Outlet Air Node Name

This field is used to describe the air node where the dilution air is exhausted to. This could be the inlets to a heat recovery ventilator or an exhaust node.

Field: Minimum Operating Point

This field is used to describe the minimum operating point for the net DC electric power, P_{el} (W).

Field: Maximum Operating Point

This field is used to describe the maximum operating point for the net DC electric power, P_{el} (W).

An example input data file (IDF) entry for this object is provided below:

```

Generator:FuelCell:PowerModule,
  FCT SOFC Power Module,    !- Name
  Annex42,                  !- Efficiency Curve Mode
  FCT Power Curve,         !- Efficiency Curve Name
  0.354,                    !- Nominal Efficiency
  3400,                     !- Nominal Electrical Power {W}
  0,                         !- Number of Stops at Start of Simulation
  0.0,                      !- Cycling Performance Degradation Coefficient
  0,                         !- Number of Run Hours at Beginning of Simulation {hr}
  0.0,                      !- Accumulated Run Time Degradation Coefficient
  10000,                    !- Run Time Degradation Initiation Time Threshold {hr}
  1.4,                      !- Power Up Transient Limit {W/s}
  0.2,                      !- Power Down Transient Limit {W/s}
  0.0,                      !- Start Up Time {s}
  0.2,                      !- Start Up Fuel {kmol}
  ,                          !- Start Up Electricity Consumption {J}
  0.0,                      !- Start Up Electricity Produced {J}
  0.0,                      !- Shut Down Time {s}
  0.2,                      !- Shut Down Fuel {kmol}
  ,                          !- Shut Down Electricity Consumption {J}
  0.0,                      !- Ancilliary Electricity Constant Term
  0.0,                      !- Ancilliary Electricity Linear Term
  ConstantRate,            !- Skin Loss Calculation Mode
  ZN_1_FLR_1_SEC_5,        !- Zone Name
  0.6392,                   !- Skin Loss Radiative Fraction
  729,                      !- Constant Skin Loss Rate {W}
  0.0,                      !- Skin Loss U-Factor Times Area Term {W/K}
  ,                          !- Skin Loss Quadratic Curve Name
  6.156E-3,                 !- Dilution Air Flow Rate {kmol/s}
  2307,                     !- Stack Heat loss to Dilution Air {W}
  SOFC Air HR Inlet,        !- Dilution Inlet Air Node Name
  SOFC Air HR Outlet,       !- Dilution Outlet Air Node Name
  3010,                     !- Minimum Operating Point {W}
  3728;                     !- Maximum Operating Point {W}

```

Generator:FuelCell:StackCooler

This object is optional and is used to define details needed to model the stack cooler on PEMFC.


```

Generator:FuelCell:StackCooler,
  A1, \field Name
      \required-field
      \type alpha
      \reference FCStackCoolerNames
  A2, \field Heat Recovery Water Inlet Node Name
  A3, \field Heat Recovery Water Outlet Node Name
  N1, \field Nominal Stack Temperature
      \units C
  N2, \field Actual Stack Temperature
      \units C
  N3, \field Coefficient r0
  N4, \field Coefficient r1
  N5, \field Coefficient r2
  N6, \field Coefficient r3
  N7, \field Stack Coolant Flow Rate
      \units kg/s
  N8, \field Stack Cooler U-Factor Times Area Value
      \units W/K
  N9, \field Fs-cogen Adjustment Factor
  N10, \field Stack Cogeneration Exchanger Area
      \units m2
  N11, \field Stack Cogeneration Exchanger Nominal Flow Rate
      \units kg/s
  N12, \field Stack Cogeneration Exchanger Nominal Heat Transfer Coefficient
      \units W/m2-K
  N13, \field Stack Cogeneration Exchanger Nominal Heat Transfer Coefficient Exponent
  N14, \field Stack Cooler Pump Power
      \units W
  N15, \field Stack Cooler Pump Heat loss
      \minimum 0.0
      \maximum 1.0
  N16, \field Stack Air Cooler Fan Coefficient f0
  N17, \field Stack Air Cooler Fan Coefficient f1
  N18; \field Stack Air Cooler Fan Coefficient f2

```

Field: Name

This field contains a unique name for the PEM fuel cell stack cooler

Field: Heat Recovery Water Inlet Node Name

This field contains the node name for the water inlet to the stack cooler.

Field: Heat Recovery Water Outlet Node Name

This field contains the node name for the water outlet from the stack cooler.

Field: Nominal Stack Temperature

This field contains the nominal stack operating temperature for the PEMFC, T_{stack}^o . This field and the next five provide values for use in the empirical equation for the rate of heat extracted from the fuel cell power module by the stack cooler using the following relation

$$q_{s-cool} = \left[r_0 + r_1 \left(T_{stack} - T_{stack}^o \right) \right] \cdot \left[1 + r_2 P_{el} + r_3 P_{el}^2 \right]$$

Field: Actual Stack Temperature]

This field contains the actual stack operating temperature for the PEMFC, T_{stack} .

Field: Coefficient r0

This field contains the coefficient r_0 in the equation above.

Field: Coefficient r1

This field contains the coefficient r_1 in the equation above.

Field: Coefficient r2

This field contains the coefficient r_2 in the equation above.

Field: Coefficient r3

This field contains the coefficient r_3 in the equation above.

Field: Stack Coolant Flow Rate

The stack cooler is assumed to have a closed water circulation loop that is used to extract heat from the stack and move it to a cogeneration heat exchanger and/or an air cooler. This field is used to enter the flow rate of coolant in this loop.

Field: Stack Cooler U-Factor Times Area Value

This is the heat transfer coefficient between the stack and the coolant.

Field: Fs-cogen Adjustment Factor

This field provides the value for an adjustment factor, $F_{s-cogen}$, used in the following relation for the cogeneration heat transfer coefficient, $(UA)_{s-cogen}$:

$$(UA)_{s-cogen} = \left[\frac{1}{(hA)_{s-cogen}} + F_{s-cogen} \right]^{-1}$$

Field: Stack Cogeneration Exchanger Area

This field provides the value for the cogeneration heat exchanger area, $A_{s-cogen}$

Field: Stack Cogeneration Exchanger Nominal Flow Rate

This field provides the value for $\dot{N}_{s-cogen}^0$ in the following relation for the cogeneration heat exchanger convection coefficient, $h_{s-cogen}$:

$$h_{s-cogen} = h_{s-cogen}^0 \cdot \left(\frac{\dot{N}_{s-cogen}}{\dot{N}_{s-cogen}^0} \right)^{n_s}$$

Field: Stack Cogeneration Exchanger Nominal Heat Transfer Coefficient

This field provides the value for $h_{s-cogen}^0$ in the relation above for the cogeneration heat exchanger convection coefficient, $h_{s-cogen}$.

Field: Stack Cogeneration Exchanger Nominal Heat Transfer Coefficient Exponent

This field provides the value for n_s is the relation above for the cogeneration heat exchanger convection coefficient, $h_{s-cogen}$.

Field: Stack Cooler Pump Power

This field is the power used by the stack cooler's circulating pump in Watts. It is a constant power draw whenever the stack cooler is active.

Field: Stack Cooler Pump Heat loss

This field is the fraction of the pump power consumption that is lost to the surround zone.

Field: Stack Air Cooler Fan Coefficient f0

This field and the next two are used to define coefficients for the following relation for the power used by the air-cooler's fan to dump excess heat into the surrounding zone:

$$P_{s-air-el} = f_0 + f_1 \cdot q_{s-air} + f_2 \cdot q_{s-air}^2$$

Field: Stack Air Cooler Fan Coefficient f1

This field provides a value for the coefficient f_1 in the relation above.

Field: Stack Air Cooler Fan Coefficient f2

This field provides a value for the coefficient f_2 in the relation above.

Generator:FuelCell:AirSupply

This object is used to define details of the air supply subsystem.

```

Generator:FuelCell:AirSupply,
  \extensible:2 - repeat last two fields, remembering to remove ; from "inner" fields.
A1, \field Name
  \required-field
  \reference FCAirSupNames
A2, \field Air Inlet Node Name
A3, \field Blower Power Curve Name
  \type object-list
  \object-list QubicCurves
N1, \field Blower Heat Loss Factor
  \minimum 0.0
  \maximum 1.0
A4, \field Air Supply Rate Calculation Mode
  \required-field
  \type choice
  \key AirRatiobyStoics
  \key QuadraticFunctionofElectricPower
  \key QuadraticFunctionofFuelRate
N2, \field Stoichiometric Ratio
  \note This is the excess air "stoics"
  \note the value entered is incremented by 1 in the model.
A5, \field Air Rate Function of Electric Power Curve Name
  \type object-list
  \object-list QuadraticCurves
N3, \field Air Rate Air Temperature Coefficient
A6, \field Air Rate Function of Fuel Rate Curve Name
  \type object-list
  \object-list QuadraticCurves
A7, \field Air Intake Heat Recovery Mode
  \required-field
  \type choice
  \key NoRecovery
  \key RecoverBurnerInverterStorage
  \key RecoverAuxiliaryBurner
  \key RecoverInverterandStorage
  \key RecoverInverter
  \key RecoverElectricalStorage
A8, \field Air Supply Constituent Mode
  \required-field
  \type choice
  \key AmbientAir
  \key UserDefinedConstituents
N4, \field Number of UserDefined Constituents
  \maximum 5
A9, \field Constituent 1 Name
  \type choice
  \key CarbonDioxide
  \key Nitrogen
  \key Oxygen
  \key Water
  \key Argon
N5, \field Molar Fraction 1
  \minimum 0.0
  \maximum 1.0
A10, \field Constituent 2 Name
  \type choice
  \key CarbonDioxide
  \key Nitrogen
  \key Oxygen
  \key Water
  \key Argon
N6, \field Molar Fraction 2
  \minimum 0.0
  \maximum 1.0
A11, \field Constituent 3 Name
  \type choice
  \key CarbonDioxide
  \key Nitrogen
  \key Oxygen
  \key Water
  \key Argon

```

```

N7, \field Molar Fraction 3
    \minimum 0.0
    \maximum 1.0
A12, \field Constituent 4 Name
    \type choice
    \key CarbonDioxide
    \key Nitrogen
    \key Oxygen
    \key Water
    \key Argon
N8, \field Molar Fraction 4
    \minimum 0.0
    \maximum 1.0
A13, \field Constituent 5 Name
    \type choice
    \key CarbonDioxide
    \key Nitrogen
    \key Oxygen
    \key Water
    \key Argon
N9, \field Molar Fraction 5
    \minimum 0.0
    \maximum 1.0

```

Field: Name

This field contains a unique name for the fuel cell air supply subsystem.

Field: Air Inlet Node Name

This field is used to define the air node where the inlet air stream is drawn from. If the FC uses outdoor air then the node named here should be designated an outdoor air node. If the FC draws air from its surroundings, then this would be the name of the air node associated with the thermal zone containing the FC.

Field: Blower Power Curve Name

This field contains the name of a Curve:Cubic input object described elsewhere in the input file. The curve provides the power used by the air blower (W) as a cubic function of the rate of air supply (kmol/s).

$$P_{blower-el} = b_0 + b_1 \cdot \dot{N}_{air} + b_2 \cdot \dot{N}_{air}^2 + b_3 \cdot \dot{N}_{air}^3$$

Field: Blower Heat Loss Factor

This field describes the portion of blower electrical power that is “lost” to the surroundings. The rest of the energy is added to the air stream. A heat loss factor of 1.0 indicates that all the heat is lost to the surroundings and no energy is added to the air inlet stream.

Field: Air Supply Rate Calculation Mode

This field describes how the model will calculate the air supply rate. There are three options to choose from: “AirRatiobyStoics”, “QuadraticFunctionofElectricPower”, and “QuadraticFunctionofFuelRate.” The choice will determine how the model calculates the rate of air and will depend on the formulations used to develop model input data. The choices are described in the next four fields.

Field: Stoichiometric Ratio

This field describes the excess air ratio beyond stoichiometric air supply. This field is only used if the air supply rate calculation mode is AirRatiobyStoics. The total air supply ratio will be the value entered here plus 1.0. Thus if 1.0 is entered in this field, the total air flow will be 2.0 times what is needed to exactly match stoichiometry with the fuel supply.

Field: Air Rate Function of Electric Power Curve Name

This field contains the name of a QuadraticCurve input object described elsewhere in the input file. This field is only used if the air supply rate calculation mode is QuadraticFunctionofElectricPower. The quadratic curve named here describes the first part of the relation below used to calculate the rate of inlet air, \dot{N}_{air} (kmol/s). It is a quadratic function of the net DC electrical power, P_{el} (W).

$$\dot{N}_{air} = \left[a_0 + a_1 \cdot P_{el} + a_2 \cdot P_{el}^2 \right] \cdot \left[1 + a_3 \cdot T_{air} \right]$$

Field: Air Rate Air Temperature Coefficient

This field is used to describe the air temperature coefficient, a_3 , used to adjust inlet air flow rate in the relations for inlet air rate.

Field: Air Rate Function of Fuel Rate Curve Name

This field contains the name of a Curve:Quadratic input object described elsewhere in the input file. This field is only used if the air supply rate calculation mode is QuadraticFunctionofFuelRate. The quadratic curve named here describes the first part of the relation used to calculate the rate of inlet air, \dot{N}_{air} (kmol/s). It is a quadratic function of the fuel flow rate, \dot{N}_{fuel} .

$$\dot{N}_{air} = \left[a_0 + a_1 \cdot \dot{N}_{fuel} + a_2 \cdot \dot{N}_{fuel}^2 \right] \cdot \left[1 + a_3 \cdot T_{air} \right]$$

Field: Air Intake Heat Recovery Mode

This field is used to control how heat losses from three other subsystems within the FC may or may not be recovered by the air inlet. There are six possible choices for what to use in this field: “NoRecovery” “RecoverBurnerInverterStorage” “RecoverAuxiliaryBurner” “RecoverInverterandStorage” “RecoverInverter” and “RecoverElectricalStorage”. If heat is recovered then that means that energy “losses” from those subsystems are added to the inlet air and fed back into the FC power module. The following table clarifies the meaning of the six possible choices.

Table 29. Air Intake Heat Recovery Mode Choices

Field Choice	Inverter Heat Losses Recovered?	Electrical Storage Heat Losses Recovered?	Auxiliary Heater Losses Recovered?
NoRecovery”	No	No	No
RecoverBurnerInverterStorage	Yes	Yes	Yes
RecoverAuxiliaryBurner	No	No	Yes
RecoverInverterandStorage	Yes	Yes	No
RecoverInverter	Yes	No	No
RecoverElectricalStorage	No	Yes	No

Field: Air Supply Constituent Mode

This field is used to choose between two different modes for describing the make up of the inlet air stream. There are two possible choices: "AmbientAir" or "UserDefinedConstituents." Choosing the AmbientAir mode will automatically set the composition of air to be usual at: 77.28% nitrogen, 20.73% oxygen, 1.04% water, 0.92% argon, and 0.03% carbon dioxide. Choosing UserDefinedConstituents allows the user to customize the make up the inlet air in the remaining fields.

Field: Number of UserDefined Constituents

This field is used to describe the number of constituents in the inlet air. This field is only used if the air supply constituent mode is set to UserDefinedConstituents. The maximum number is 5.

The remaining fields in this object are repeating pairs of fields with one pair for each constituent and the same number as described in the previous field. The pairs consist of the name of the constituent followed by the molar fraction of that constituent.

Field: Constituent 1-5 Name

These fields describe the air stream constituents by name. The name field for each pair must be filled with one of these choices: "CarbonDioxide", "Nitrogen," "Oxygen," "Water," or "Argon."

Field: Molar Fraction 1-5

These fields describe the molar fraction of the air stream constituents. It is very important that the sum of the molar fractions add up to 1.0.

An example input data file (IDF) entry for this object is provided below:

```
Generator:FuelCell:AirSupply,
FCT SOFC Air Supply,      !- Name
SOFC Air Inlet Node,     !- Air Inlet Node Name
FCT Blower Power Curve,  !- Blower Power Curve Name
1.0,                     !- Blower Heat Loss Factor
QuadraticFunctionofElectricPower, !- Air Supply Rate Calculation Mode
,                         !- Stoichiometric Ratio
FCT Excess Air Ratio Curve, !- Air Rate Function of Electric Power Curve Name
2.83507E-3,              !- Air Rate Air Temperature Coefficient
,                         !- Air Rate Function of Fuel Rate Curve Name
NoRecovery,              !- Air Intake Heat Recovery Mode
UserDefinedConstituents, !- Air Supply Constituent Mode
5,                       !- Number of UserDefined Constituents
Nitrogen,                !- Constituent 1 Name
0.7728,                  !- Molar Fraction 1
Oxygen,                  !- Constituent 2 Name
0.2073,                  !- Molar Fraction 2
Water,                   !- Constituent 3 Name
0.0104,                  !- Molar Fraction 3
Argon,                   !- Constituent 4 Name
0.0092,                  !- Molar Fraction 4
CarbonDioxide,           !- Constituent 5 Name
0.0003;                  !- Molar Fraction 5
```

Generator:FuelCell:WaterSupply

This object is used to provide details of the water supply subsystem. This water is used for steam reforming of the fuel and is not the same as the water used for thermal heat recovery.

```

Generator:FuelCell:WaterSupply,
  A1, \field Name
      \required-field
      \reference FCWaterSupNames
  A2, \field Reformer Water Flow Rate Function of Fuel Rate Curve Name
      \type object-list
      \object-list QuadraticCurves
  A3, \field Reformer Water Pump Power Function of Fuel Rate Curve Name
      \type object-list
      \object-list QubicCurves
  N1, \field Pump Heat Loss Factor
  A4, \field Water Temperature Modeling Mode
      \type choice
      \key TemperatureFromAirNode
      \key TemperatureFromWaterNode
      \key TemperatureFromSchedule
      \key MainsWaterTemperature
  A5, \field Water Temperature Reference Node Name
  A6, \field Water Temperature Schedule Name
      \type object-list
      \object-list ScheduleNames

```

Field: Name

This field contains a unique name for the fuel cell water supply subsystem.

Field: Reformer Water Flow Rate Function of Fuel Rate Curve Name

This field contains the name of a Curve:Quadratic input object described elsewhere in the input file. The curve provides the rate of water flow (kmol/sec) as a function of fuel flow rate (kmol/sec).

$$\dot{N}_{liq-water} = w_0 + w_1 \cdot \dot{N}_{fuel} + w_2 \cdot \dot{N}_{fuel}^2$$

If the unit does not use water for reforming then use a “null” quadratic where all the coefficients are 0.0.

Field: Reformer Water Pump Power Function of Fuel Rate Curve Name

This field contains the name of a Curve:Cubic input object described elsewhere in the input file. The curve provides the power used by the water pump (W) as a cubic function of the rate of water supply (kmol/s).

$$P_{pump-el} = p_0 + p_1 \cdot \dot{N}_{water} + p_2 \cdot \dot{N}_{water}^2 + p_3 \cdot \dot{N}_{water}^3$$

If the unit does not use water for reforming then use a “null” cubic where all the coefficients are 0.0.

Field: Pump Heat Loss Factor

This field describes the portion of pump electrical power that is “lost” to the surroundings. The rest of the energy is added to the water stream. A heat loss factor of 1.0 indicates that all the heat is lost to the surroundings and no energy is added to the water inlet stream.

Field: Water Temperature Modeling Mode

This field describes how the model will determine the inlet temperature of the water stream. There are four options to choose from: “TemperatureFromAirNode,” “TemperatureFromWaterNode,” “TemperatureFromSchedule,” and “MainsWaterTemperature.” For the first two options, the temperature of the water inlet is determined by the temperature at the node named in the next field. For the third option, the temperature is determined by the schedule in the last field. Using the

MainsWaterTemperature option requires also defining a separate "Site:WaterMainsTemperature" input object elsewhere in the input file.

Field: Water Temperature Reference Node Name

This field is used to define the node where the temperature of the inlet water stream is obtained. This can be either an air node or a water node.

Field: Water Temperature Schedule Name

This field is used to define the name of a schedule, defined elsewhere in the input file, that will be used to determine the temperature of the water inlet stream when using the TemperatureFromSchedule mode.

An example input data file (IDF) entry for this object is provided below:

```
Generator:FuelCell:WaterSupply,
  FCT SOFC Water Supply,      !- Name
  Null Quadratic,            !- Reformer Water Flow Rate Function of Fuel Rate Curve Name
  Null Cubic,                 !- Reformer Water Pump Power Function of Fuel Rate Curve Name
  0.0,                        !- Pump Heat Loss Factor
  TemperatureFromAirNode,     !- Water Temperature Modeling Mode
  SOFC Air Inlet Node,        !- Water Temperature Reference Node Name
  ;                            !- Water Temperature Schedule Name

Curve:Quadratic,
  Null Quadratic,            !- Name
  0.0,                       !- Coefficient1 Constant
  0.0,                       !- Coefficient2 x
  0.0,                       !- Coefficient3 x**2
  -1.0E+10,                  !- Minimum Value of x
  1.0E+10;                  !- Maximum Value of x

Curve:Cubic,
  Null Cubic,                !- Name
  0.0,                       !- Coefficient1 Constant
  0.0,                       !- Coefficient2 x
  0.0,                       !- Coefficient3 x**2
  0.0,                       !- Coefficient4 x**3
  -1.0E+10,                  !- Minimum Value of x
  1.0E+10;                  !- Maximum Value of x
```

Generator:FuelCell:AuxiliaryHeater

This object is intended for modeling an auxiliary heater, however this portion of the model is not yet available in EnergyPlus. An auxiliary heater may be present in fuel cell products so that the unit can meet much higher thermal loads than would be possible using only cogeneration. This portion of the model will be added in the future once suitable cogeneration control capabilities are also available. The input fields are described for future reference but may change. The program still requires one of these objects be included even though the data are not yet used (so that internal data structures can be allocated).

```

Generator:FuelCell:AuxiliaryHeater,
  A1, \field Name
      \required-field
      \reference FCAuxHeatNames
  N1, \field Excess Air Ratio
  N2, \field Ancilliary Power Constant Term
  N3, \field Ancilliary Power Linear Term
  N4, \field Skin Loss U-Factor Times Area Value
  A2, \field Skin Loss Destination
      \type choice
      \key SurroundingZone
      \key AirInletForFuelCell
  A3, \field Zone Name to Receive Skin Losses
  A4, \field Heating Capacity Units
      \type choice
      \key Watts
      \key kmol/s
  N5, \field Maximum Heating Capacity in Watts
      \units W
  N6, \field Minimum Heating Capacity in Watts
      \units W
  N7, \field Maximum Heating Capacity in Kmol per Second
      \units kmol/s
  N8; \field Minimum Heating Capacity in Kmol per Second
      \units kmol/s

```

Field: Name

This field contains a unique name for the fuel cell auxiliary heater subsystem.

Field: Excess Air Ratio

This field describes the excess air ratio beyond stoichiometric air supply for the heater. The total air supply ratio will be the value entered here plus 1.0. Thus if 1.0 is entered in this field, the total air flow will be 2.0 times what is needed to exactly match stoichiometry with the fuel supply.

Field: Ancillary Power Constant Term

This field describes the constant term, x_0 , used to model the auxiliary burner's ancillary devices such as fans and ignition controls. The electrical power for ancillaries is calculated using,

$$P_{el,aux-ancillaries} = x_0 + x_1 \cdot \dot{N}_{aux-fuel}$$

Field: Ancillary Power Linear Term

This field describes the linear term, x_1 , used to model the auxiliary burner's ancillary devices.

Field: Skin Loss U-Factor Times Area Value

This field describes the "UA" term (W/K) for calculating skin losses in the auxiliary burner. "UA" is the product of the overall heat transfer coefficient "U" and the area "A." The skin heat losses are calculated using,

$$q_{aux-skin-losses} = (UA)_{aux} \cdot (T_{aux-mix} - T_{room})$$

where, $T_{aux-mix}$ is temperature of product gases leaving the auxiliary burner and includes the mixing of the product gases from the fuel cell power module. Thus, the input for UA should reflect this choice of reference temperature rather than an exterior surface temperature of the auxiliary burner.

Field: Skin Loss Destination

This field describes the user's choice for what happens to the skin losses. There are two options: "SurroundingZone" and "AirInletForFuelCell". Entering SurroundingZone will direct the model to put the "lost" energy into the surrounding thermal Zone named in the next field. Entering AirInletForFuelCell will direct the model to put the "lost" energy into the air inlet stream for the fuel cell to preheat that air.

Field: Zone Name to Receive Skin Losses

This field is used to determine the zone that will receive the skin losses. Enter the name of a Zone declared elsewhere in the input file. This field is only used if the "SurroundingZone" mode is used in the previous field.

Field: Heating Capacity Units

This field describes the user's choice for how the capacity of the auxiliary heater will be defined. There are two options: "Watts" or "kmol/s." Entering Watts will direct the program to use the next two fields to determine the maximum and minimum heating capacity. Entering kmol/s will direct the program to use the last two fields to determine the maximum and minimum heating capacities.

Field: Maximum Heating Capacity in Watts

This field is used to describe the maximum heating capacity of the auxiliary burner (W).

Field: Minimum Heating Capacity in Watts

This field is used to describe the minimum heating capacity of the auxiliary burner (W).

Field: Maximum Heating Capacity in Kmol per Second

This field is used to describe the maximum fuel use rate for the auxiliary burner (kmol/s).

Field: Minimum Heating Capacity in Kmol per Second

This field is used to describe the minimum fuel use rate for the auxiliary burner (kmol/s).

An example input data file (IDF) entry for this object is provided below:

```
Generator:FuelCell:AuxiliaryHeater,
  FCT SOFC Auxiliary Heater,  !- Name
  0.0,                        !- Excess Air Ratio
  0.0,                        !- Ancilliary Power Constant Term
  0.0,                        !- Ancilliary Power Linear Term
  0.5,                        !- Skin Loss U-Factor Times Area Value
  SurroundingZone,           !- Skin Loss Destination
  ZN_1_FLR_1_SEC_5,         !- Zone Name to Receive Skin Losses
  Watts,                     !- Heating Capacity Units
  0.0,                       !- Maximum Heating Capacity in Watts
  0.0,                       !- Minimum Heating Capacity in Watts
  ,                           !- Maximum Heating Capacity in Kmol per Second
  ;                           !- Minimum Heating Capacity in Kmol per Second
```

Generator:FuelCell:ExhaustGasToWaterHeatExchanger

This object is used to describe the exhaust gas heat exchanger subsystem of the FC used to recovery thermal energy.

```

Generator:FuelCell:ExhaustGasToWaterHeatExchanger,
A1, \field Name
    \required-field
    \reference FCExhaustHXNames,
A2, \field Heat Recovery Water Inlet Node Name
A3, \field Heat Recovery Water Outlet Node Name
N1, \field Heat Recovery Water Maximum Flow Rate
    \units m3/s
A4, \field Exhaust Outlet Air Node Name
A5, \field Heat Exchanger Calculation Method
    \type choice
    \key FixedEffectiveness
    \key EmpiricalUAeff
    \key FundamentalUAeff
    \key Condensing
N2, \field Method 1 Heat Exchanger Effectiveness
N3, \field Method 2 Parameter hxs0
N4, \field Method 2 Parameter hxs1
N5, \field Method 2 Parameter hxs2
N6, \field Method 2 Parameter hxs3
N7, \field Method 2 Parameter hxs4
N8, \field Method 3 h0Gas Coefficient
N9, \field Method 3 NdotGasRef Coefficient
N10, \field Method 3 n Coefficient
N11, \field Method 3 Gas Area
N12, \field Method 3 h0 Water Coefficient
N13, \field Method 3 N dot Water ref Coefficient
N14, \field Method 3 m Coefficient
N15, \field Method 3 Area Water Coefficient
N16, \field Method 3 F Adjustment Factor
N17, \field Method 4 hx11 Coefficient
N18, \field Method 4 hx12 Coefficient
N19; \field Method 4 Condensation Threshold
    \units C

```

Field: Name

This field contains a unique name for the fuel cell power module subsystem.

Field: Heat Recovery Water Inlet Node Name

This field contains the name of the node that connects the heat exchanger's inlet to the plant loop. This water is used for heat recovery.

Field: Heat Recovery Water Outlet Node Name

This field contains the name of the node that connects the heat exchanger's outlet to the plant loop.

Field: Heat Recovery Water Maximum Flow Rate

This field describes the design maximum flow rate of the heat recovery water (m³/s). The value should match the design flow rate of the plant loop connected to the FC.

Field: Exhaust Outlet Air Node Name

This field is used to determine which node will receive the exhaust air stream leaving the FC. This node will usually be outside and not be referenced elsewhere. However, if the exhaust stream is used in a heat recovery ventilator (as described in section 11 of the Annex 42 specification) then the node would be reference in the heat recovery ventilator object.

Field: Heat Exchanger Calculation Method

This field is used to direct how EnergyPlus will calculate heat exchanger performance. The Annex 42 model provides for four different methods of modeling the heat exchanger. The choices available for this field are: "FixedEffectiveness" (method 1 in Annex 42 specification), "EmpiricalUAeff" (method 2), "FundamentalUAeff" (method 3), or "Condensing" (method 4).

The remaining fields provide input data for the different methods. The heat exchanger correlations are described below.

Field: Method 1 Heat Exchanger Effectiveness

This field describes constant heat exchanger effectiveness, ε_{HX} . This field is only used with the “FixedEffectiveness” mode, which corresponds to “method 1” in the Annex 42 specification. For this mode, the heat exchange between the exhaust gases and the heat recovery water are calculated using,

$$q_{HX} = \varepsilon_{HX} \cdot (\dot{N}\hat{c}_p)_{\min} \cdot (T_{aux-mix} - T_{water,in})$$

where, $(\dot{N}\hat{c}_p)_{\min}$ is the minimum value of $(\dot{N}\hat{c}_p)_{aux-mix}$ and $(\dot{N}\hat{c}_p)_{water}$.

Field: Method 2 Parameter hxs0

This field describes the value of $hx_{s,0}$ in the relation below for effective UA. This field is used with the “EmpiricalUAeff” mode, which corresponds to “method 2” in the Annex 42 specification and with the “Condensing” mode, which corresponds to “method 4”. This method uses the log mean temperature difference (LMTD) approach to calculate the heat exchange:

$$q_{HX} = (UA)_{eff} \cdot \frac{(T_{aux-mix} - T_{water,out}) - (T_{HX-exh} - T_{water,in})}{\ln\left(\frac{T_{aux-mix} - T_{water,out}}{T_{HX-exh} - T_{water,in}}\right)}$$

The user input in this field, and the next four fields, describe coefficients in an empirical relation for $(UA)_{eff}$:

$$(UA)_{eff} = hx_{s,0} + hx_{s,1} \cdot \dot{N}_{water} + hx_{s,2} \cdot \dot{N}_{water}^2 + hx_{s,3} \cdot \dot{N}_{aux-mix} + hx_{s,4} \cdot \dot{N}_{aux-mix}^2$$

Field: Method 2 Parameter hxs1

This field describes the value of $hx_{s,1}$ in the relation above for effective UA. This field is used with the “EmpiricalUAeff” mode, which corresponds to “method 2” in the Annex 42 specification and with the “Condensing” mode, which corresponds to “method 4”.

Field: Method 2 Parameter hxs2

This field describes the value of $hx_{s,2}$ in the relation above for effective UA. This field is used with the “EmpiricalUAeff” mode, which corresponds to “method 2” in the Annex 42 specification and with the “Condensing” mode, which corresponds to “method 4”.

Field: Method 2 Parameter hxs3

This field describes the value of $hx_{s,3}$ in the relation above for effective UA. This field is used with the “EmpiricalUAeff” mode, which corresponds to “method 2” in the Annex 42 specification and with the “Condensing” mode, which corresponds to “method 4”.

Field: Method 2 Parameter hxs4

This field describes the value of $hx_{s,4}$ in the relation above for effective UA. This field is used with the “EmpiricalUAeff” mode, which corresponds to “method 2” in the Annex 42 specification and with the “Condensing” mode, which corresponds to “method 4”.

Field: Method 3 h0Gas Coefficient

This field describes the value of h_{gas}^0 in the relation below. This field is only used with the “FundamentalUAeff” mode, which corresponds to “method 3” in the Annex 42 specification. For this mode, the heat exchange is calculated using the LMTD method, but the effective UA is determined using:

$$(UA)_{eff} = \left[\frac{1}{(hA)_{gas}} + \frac{1}{(hA)_{water}} + F_{HX} \right]^{-1}$$

where,

F_{HX} is an adjustment factor,

$$h_{gas} = h_{gas}^0 \cdot \left(\frac{\dot{N}_{gas}}{\dot{N}_{gas}^0} \right)^n,$$

$$h_{water} = h_{water}^0 \cdot \left(\frac{\dot{N}_{water}}{\dot{N}_{water}^0} \right)^m$$

Field: Method 3 NdotGasRef Coefficient

This field describes the value of \dot{N}_{gas}^0 in the relation above. This field is only used with the “FundamentalUAeff” mode, which corresponds to “method 3” in the Annex 42 specification.

Field: Method 3 n Coefficient

This field describes the value of n in the relation above. This field is only used with the “FundamentalUAeff” mode, which corresponds to “method 3” in the Annex 42 specification.

Field: Method 3 Gas Area

This field describes the value of A_{gas} in the relation above. This field is only used with the “FundamentalUAeff” mode, which corresponds to “method 3” in the Annex 42 specification.

Field: Method 3 h0 Water Coefficient

This field describes the value of h_{water}^0 in the relation above. This field is only used with the “FundamentalUAeff” mode, which corresponds to “method 3” in the Annex 42 specification.

Field: Method 3 N dot Water ref Coefficient

This field describes the value of \dot{N}_{water}^0 in the relation above. This field is only used with the “FundamentalUAeff” mode, which corresponds to “method 3” in the Annex 42 specification.

Field: Method 3 m Coefficient

This field describes the value of m in the relation above. This field is only used with the “FundamentalUAeff” mode, which corresponds to “method 3” in the Annex 42 specification.

Field: Method 3 Area Water Coefficient

This field describes the value of A_{water} in the relation above. This field is only used with the “FundamentalUAeff” mode, which corresponds to “method 3” in the Annex 42 specification.

Field: Method 3 F Adjustment Factor

This field describes the value of F_{HX} in the relation above. This field is only used with the “FundamentalUAeff” mode, which corresponds to “method 3” in the Annex 42 specification.

Field: Method 4 hxl1 Coefficient

This field describes the value of $hx_{l,1}$ in the relation below for the rate of condensation of water from the gas stream, $\dot{N}_{H_2O-cond}$. This field is only used with the “Condensing” mode, which corresponds to “method 4” in the Annex 42 specification. This method uses a modified version of the LMTD approach to calculate heat exchange:

$$q_{HX} = (UA)_{eff} \cdot \frac{(T_{aux-mix} - T_{water,out}) - (T_{HX-exh} - T_{water,in})}{\ln\left(\frac{T_{aux-mix} - T_{water,out}}{T_{HX-exh} - T_{water,in}}\right)} + \dot{N}_{H_2O-cond} \cdot \hat{h}_{fg}$$

where,

$$\dot{N}_{H_2O-cond} = (T_{cond-threshold} - T_{water,in}) \cdot \left[hx_{l,1} \cdot \left(\frac{\dot{N}_{H_2O}}{\dot{N}_{aux-mix}} \right) + hx_{l,2} \cdot \left(\frac{\dot{N}_{H_2O}}{\dot{N}_{aux-mix}} \right)^2 \right]$$

Field: Method 4 hxl2 Coefficient

This field describes the value of $hx_{l,2}$ in the relation above for the rate of condensation of water from the gas stream, $\dot{N}_{H_2O-cond}$. This field is only used with the “Condensing” mode, which corresponds to “method 4” in the Annex 42 specification.

Field: Method 4 Condensation Threshold

This field describes the value of $T_{cond-threshold}$ in the relation above for the rate of condensation of water from the gas stream, $\dot{N}_{H_2O-cond}$. This field is only used with the “Condensing” mode, which corresponds to “method 4” in the Annex 42 specification.

An example input data file (IDF) entry for this object is provided below:

```

Generator:FuelCell:ExhaustGasToWaterHeatExchanger,
  FCT SOFC Exhaust HX,      !- Name
  Small SOFC Heat Rec Inlet Node,  !- Heat Recovery Water Inlet Node Name
  Small SOFC Heat Rec Outlet Node, !- Heat Recovery Water Outlet Node Name
  0.0004,                   !- Heat Recovery Water Maximum Flow Rate {m3/s}
  SOFC Air Outlet Node,     !- Exhaust Outlet Air Node Name
  CONDENSING,               !- Heat Exchanger Calculation Method
  ,                          !- Method 1 Heat Exchanger Effectiveness
  83.1,                     !- Method 2 Parameter hxs0
  4798,                     !- Method 2 Parameter hxs1
  -138E+3,                  !- Method 2 Parameter hxs2
  -353.8E+3,                !- Method 2 Parameter hxs3
  5.15E+8,                  !- Method 2 Parameter hxs4
  ,                          !- Method 3 h0Gas Coefficient
  ,                          !- Method 3 NdotGasRef Coefficient
  ,                          !- Method 3 n Coefficient
  ,                          !- Method 3 Gas Area
  ,                          !- Method 3 h0 Water Coefficient
  ,                          !- Method 3 N dot Water ref Coefficient
  ,                          !- Method 3 m Coefficient
  ,                          !- Method 3 Area Water Coefficient
  ,                          !- Method 3 F Adjustment Factor
  -1.96E-4,                 !- Method 4 hxl1 Coefficient
  3.1E-3,                   !- Method 4 hxl2 Coefficient
  35.0;                      !- Method 4 Condensation Threshold {C}

```

Generator:FuelCell:ElectricalStorage

This object is used to describe the electrical storage subsystem for the FC. The electrical storage model is a very simple “constrained bucket” model. Future developments made add additional models for battery systems. Note that this electrical storage is embedded within the FC device.

```

Generator:FuelCell:ElectricalStorage,
  A1, \field Name
      \required-field
      \reference FCStorageNames
  A2, \field Choice of Model
      \type choice
      \key SimpleEfficiencyWithConstraints
  N1, \field Nominal Charging Energetic Efficiency
      \maximum 1.0
      \minimum 0.0
  N2, \field Nominal Discharging Energetic Efficiency
      \maximum 1.0
      \minimum 0.0
  N3, \field Simple Maximum Capacity
      \units J
  N4, \field Simple Maximum Power Draw
      \units W
  N5, \field Simple Maximum Power Store
      \units W
  N6; \field Initial Charge State
      \units J

```

Field: Name

This field contains a unique name for the fuel cell electrical storage subsystem.

Field: Choice of Model

This field is used to direct how EnergyPlus will model electrical storage. The only choice currently available is “SimpleEfficiencyWithConstraints,” which should be entered in this field. Future developments may expand the number of models available for electrical storage.

Field: Nominal Charging Energetic Efficiency

This field describes the value of ϵ_{charge} in the relation for the State of Charge, $Q_{battery}^{t+\Delta t}$:

$$Q_{battery}^{t+\Delta t} = Q_{battery}^t + P_{battery-charge} \cdot \epsilon_{charge} \cdot \Delta t$$

This is the energetic efficiency of charging the storage device. A value of 1.0 means that the storage device does not lose any energy when charging. Note that the model can recover the “lost” energy into the air supply intake.

Field: Nominal Discharging Energetic Efficiency

This field describes the value of $\epsilon_{discharge}$ in the relation for the State of Charge, $Q_{battery}^{t+\Delta t}$:

$$Q_{battery}^{t+\Delta t} = Q_{battery}^t + \frac{P_{battery-discharge} \cdot \Delta t}{\epsilon_{discharge}}$$

This is the energetic efficiency of discharging the storage device. A value of 1.0 means that the storage device does not lose any energy when discharging. Note that the model can recover the “lost” energy into the air supply intake.

Field: Simple Maximum Capacity

This field describes the maximum amount of electrical energy that can be stored in the device (J).

Field: Simple Maximum Power Draw

This field describes the maximum rate at which electrical power can be discharged from the storage device (W).

Field: Simple Maximum Power Store

This field describes the maximum rate at which electrical power can charge the storage device (W).

Field: Initial Charge State

This field describes the value for the initial state of charge (J). This allows the storage device to contain some amount of stored electricity at the beginning of the simulation period.

An example input data file (IDF) entry for this object is provided below:

```
Generator:FuelCell:ElectricalStorage,
  FCT SOFC Battery,           !- Name
  SimpleEfficiencyWithConstraints, !- Choice of Model
  1.0,                        !- Nominal Charging Energetic Efficiency
  1.0,                        !- Nominal Discharging Energetic Efficiency
  0,                          !- Simple Maximum Capacity {J}
  0,                          !- Simple Maximum Power Draw {W}
  0,                          !- Simple Maximum Power Store {W}
  0;                          !- Initial Charge State {J}
```

Generator:FuelCell:Inverter

This object is used to describe the power condition unit subsystem of the FC. This object models an inverter system contained within a fuel cell system that converts from direct current (DC) to alternating current (AC).

```

Generator:FuelCell:Inverter,
  A1, \field Name
      \required-field
      \reference FCInverterNames
  A2, \field Inverter Efficiency Calculation Mode
      \type choice
      \key Quadratic
      \key Constant
  N1, \field Inverter Efficiency
      \minimum 0.0
      \maximum 1.0
  A3; \field Efficiency Function of DC Power Curve Name
      \type object-list
      \object-list QuadraticCurves

```

Field: Name

This field contains a unique name for the fuel cell inverter subsystem.

Field: Inverter Efficiency Calculation Mode

This field is used to direct how EnergyPlus will calculate the inverter efficiency. There are two possible choices: “Constant” or “Quadratic”.

Field: Inverter Efficiency

This field describes the value for inverter efficiency when using the **Constant** mode.

Field: Efficiency Function of DC Power Curve Name

This field names a Curve:Quadratic object defined elsewhere in the input file. The curve determines inverter efficiency as a function of the DC power entering the inverter as follows:

$$\eta_{PCU} = u_0 + u_1 \cdot P_{PCU-in} + u_2 \cdot P_{PCU-in}^2$$

An example input data file (IDF) entry for this object is provided below:

```

Generator:FuelCell:Inverter,
  FCT SOFC Inverter,      !- Name
  Quadratic,             !- Inverter Efficiency Calculation Mode
  ,                       !- Inverter Efficiency
  FCT Inverter Quadratic; !- Efficiency Function of DC Power Curve Name

Curve:Quadratic,
  FCT Inverter Quadratic, !- Name
  0.560717,               !- Coefficient1 Constant
  1.24019E-4,             !- Coefficient2 x
  -2.01648E-8,           !- Coefficient3 x**2
  -1.0E+10,               !- Minimum Value of x
  1.0E+10;                !- Maximum Value of x

```

Generator:FuelSupply

This object is used to define details of the fuel supply for certain generators. This object allows the user to describe a wide array of possible fuel mixtures. The program contains data and internal methods to calculate the properties of the various mixtures of gaseous fuels. The program will calculate the Lower Heating Value (LHV), Higher Heating Value (HHV), and molecular weight for the fuel mixture. The fuel properties are then use by both fuel cell and Micro CHP models. Results of the gas phase thermochemistry modeling are also reported in the EIO file.

In addition to gaseous mixtures, the Micro CHP model is able to use generic liquid fuels and this object is used to describe the properties.

Note that the fuel consumption metering is currently handled by the Natural Gas meter. So no matter what fuel mixture is defined in this object, the aggregated reports from EnergyPlus

meters for (natural) Gas will include the fuel used for the generator (with the Joule content based on HHV).

```

Generator:FuelSupply,
  A1, \field Name
      \required-field
      \reference GenFuelSupNames
  A2, \field Fuel Temperature Modeling Mode
      \type choice
      \key TemperatureFromAirNode
      \key Scheduled
  A3, \field Fuel Temperature Reference Node Name
  A4, \field Fuel Temperature Schedule Name
  A5, \field Compressor Power Function of Fuel Rate Curve Name
      \type object-list
      \object-list QubicCurves
  N1, \field Compressor Heat Loss Factor
      \minimum 0.0
      \maximum 1.0
  A6, \field Fuel Type
      \type choice
      \key GaseousConstituents
      \key LiquidGeneric
  N2, \field Liquid Generic Fuel Lower Heating Value
      \units kJ/kg
  N3, \field Liquid Generic Fuel Higher Heating Value
      \units kJ/kg
  N4, \field Liquid Generic Fuel Molecular Weight
      \units g/mol
  N5, \field Liquid Generic Fuel CO2 Emission Factor
  N6, \field Number of Constituents in Gaseous Constituent Fuel Supply
      \minimum 0.0
      \maximum 12.0
  ! sets of input data on each constituent
  A7, \field Constituent 1 Name
      \type choice
      \key CarbonDioxide
      \key Nitrogen
      \key Oxygen
      \key Water
      \key Argon
      \key Hydrogen
      \key Methane
      \key Ethane
      \key Propane
      \key Butane
      \key Pentane
      \key Hexane
      \key Methanol
      \key Ethanol
  N7, \field Constituent 1 Molar Fraction
      \minimum 0.0
      \maximum 1.0
-- reduced for brevity --

```

Field: Name

This field contains a unique name for the fuel cell fuel supply subsystem.

Field: Fuel Temperature Modeling Mode

This field describes how the model will determine the temperature of the fuel. There are two options for this field to choose from: "TemperatureFromAirNode" and "Scheduled." If this field contains TemperatureFromAirNode then the fuel is modeled as having the same temperature as the air node that is named in the next field. If this field contains Scheduled then the fuel is modeled as having the temperature described in a schedule defined elsewhere in the input file.

Field: Fuel Temperature Reference Node Name

This field contains the name of the air node used to obtain the inlet temperature of the fuel. This field is only used if the Fuel Temperature Modeling Mode is set to TemperatureFromAirNode.

Field: Fuel Temperature Schedule Name

This field contains the name of a temperature schedule defined elsewhere in the input file. This field is only used if the Fuel Temperature Modeling Mode is set to Scheduled. The temperature of the fuel inlet will be obtained from the schedule.

Field: Compressor Power Function of Fuel Rate Curve Name

This field contains the name of a Curve:Cubic input object described elsewhere in the input file. The curve provides the electrical power used by the fuel compressor (W) as a cubic function of the rate of fuel supply (kmol/s).

$$P_{comp-el} = c_0 + c_1 \cdot \dot{N}_{fuel} + c_2 \cdot \dot{N}_{fuel}^2 + c_3 \cdot \dot{N}_{fuel}^3$$

Field: Compressor Heat Loss Factor

This field describes the portion of the compressor electrical power that is “lost” to the surroundings. The rest of the energy is added to the fuel stream. A heat loss factor of 1.0 indicates that all the heat is lost to the surroundings and no energy is added to the fuel inlet stream.

Field: Fuel Type

Choose between “GaseousConstituents” or “LiquidGeneric”.

Field: Liquid Generic Fuel Lower Heating Value

For fuel type “LiquidGeneric,” this field is used to enter the lower heating value of the fuel in units of kJ/kg.

Field: Liquid Generic Fuel Higher Heating Value

For fuel type “LiquidGeneric,” this field is used to enter the higher heating value of the fuel in units of kJ/kg.

Field: Liquid Generic Fuel Molecular Weight

For fuel type “LiquidGeneric,” this field is used to enter the molecular weight of the fuel in units of g/mol.

Field: Liquid Generic Fuel CO2 Emission Factor

This field is not used. This part of the Annex 42 model was not implemented in EnergyPlus; see the FuelFactors object.

Field: Number of Constituents in Gaseous Constituent Fuel Supply

This field is used to describe the number of constituents in the inlet fuel supply. The maximum number of different types of constituents is currently set to 12.

The remaining fields in this object are repeating pairs of fields with one pair for each constituent and the same number as described in the previous field. The field set pairs consist of the name of the constituent followed by the molar fraction of that constituent.

Field: Constituent 1-12 Name

These fields describe the fuel stream constituents by name. The name field for each pair must be filled with one of these 14 choices: "CarbonDioxide", "Nitrogen", "Oxygen", "Water", "Argon", "Hydrogen", "Methane", "Ethane", "Propane", "Butane", "Pentane", "Hexane", "Methanol", and "Ethanol". No other fuel constituents can currently be modeled. The properties of the constituents are already contained inside the program as provided in the Annex 42 model specification.

Field: Constituent 1-12 Molar Fraction

These fields describe the molar fraction of the fuel stream constituents. It is very important that the sum of the molar fractions add up to 1.0.

Generator:FuelSupply Outputs

In addition to the following report variables, the resulting fuel heating values are also reported to the eio file.

```
HVAC,Average,FuelCell Fuel Compressor Electrical Power [W]
HVAC,Sum,FuelCell Fuel Compressor Electrical Energy [J]
HVAC,Average,FuelCell Fuel Compressor Skin Losses [W]
```

Generator Fuel Compressor Electrical Power [W]

This is the rate of energy use by the gas compressor, if any, that provides fuel at a higher pressure.

Generator Fuel Compressor Electrical Energy [J]

This is the energy used by the gas compressor, if any, that provides fuel at a higher pressure.

Generator Fuel Compressor Skin Losses [W]

Convective heat gains to zone from gas compressor, if any, that provides fuel at a higher pressure.

Photovoltaic Generators

EnergyPlus offers different options for predicting the electricity produced by solar electric photovoltaic (PV) panels. The three different options are "Simple", "Equivalent One-Diode" and "Sandia" and the choice will determine the mathematical models used to determine energy production. The first allows the user to input an arbitrary efficiency. The other two models use empirical relationships to predict PV operating performance based on many environmental variables such as cell temperature. The PV models can be used with either normal PV modules or as part of a hybrid photovoltaic/thermal (PVT) flat plat collector.

The generator is connected to an Electric Load Center. The PV models refer to surface input objects defined elsewhere in the input file. This object describes an array that is "attached" to a surface object in order to describe its orientation and to access results of the solar insolation calculations. These can be either HeatTransfer or Shading objects (see Surfaces). This will define the orientation of the solar panel for the detailed models and also the area for the simple model. The exposure of that surface to incident solar radiation is calculated using the full set of models in EnergyPlus that are used to account for solar thermal loads arising from building windows and walls. Therefore the incident solar radiation is calculated to include the effects of shading and reflections from other surfaces declared in the input file. In addition to the output variables associated with PV models, there are numerous related output variables available for the surfaces including: 'Surface Ext Sunlit Area', 'Surface Ext Sunlit Fraction', 'Surface Ext Solar Incident', 'Surface Ext Solar Beam Incident', 'Surface Ext Solar Sky Diffuse Incident', 'Surface Ext Solar Ground Diffuse Incident', 'Surface Ext Solar Beam Cosine Of Incidence Angle', 'Surface Ext Solar From Sky Diffuse Refl From Ground', 'Surface Ext Solar From Sky Diffuse Refl From Obstructions', 'Surface Ext Beam Sol From Bm-To-Bm Refl From Obstructions', 'Surface Ext Diff Sol From Bm-To-Diff

Refl From Obstructions', and 'Surface Ext Solar From Bm-To-Diff Refl From Ground.' Note that it is possible to define a PV array area that doesn't conform to the surface area (i.e. model a PV array area that is larger or smaller than what is available on the surface) so it is the users responsibility to not over-specify area when determining how many modules will fit onto a surface. However this type of input is allowed.

EnergyPlus does not include models for ancillary equipment for a PV array including charge controllers or power-point trackers. The operation of the entire electrical system that must go along with a PV array is not currently modeled in EnergyPlus and is therefore assumed to operate in ideal ways. The PV production models do not resolve voltage and current, only power (and energy). Electricity production is metered based on the output of the inverter. Output results are available before and after the inverter. One assumption is that the array is assumed to be always operating at the maximum power point. Energy production is based on the assumption that the quasi-steady power prediction is constant and continuous over the simulation timestep.

For a variety of reasons, actual installations of photovoltaics are often observed to exhibit system-level problems that significantly reduce electricity production. Therefore this modeling should be considered a method of bracketing the upper end of electricity production rather than an accurate prediction of what the panels will produce. Also note that the model predictions are closely related to the solar radiation data (typically of of TMY2 origin) in the EnergyPlus weather file, that the solar data in these is usually from a model rather than direct measurements, and that solar resources encountered by a real installation in a given year are likely to differ from the weather data file.

Generator:Photovoltaic

This object is used to describe an array of PV modules and how they are to be modeled. A series of different PV arrays can be connected to a single electric load center (and inverter) by listing them all in an ElectricLoadCenter:Generator object.

Field: Name

This field is a unique name for the PV array.

Field: Surface Name

This field is the name of a surface that defines the location and geometry of the array.

Field: Photovoltaic Performance Object Type

This field is the type of PV performance model. The choices are the class names for the three modeling options:

```
PhotovoltaicPerformance:Simple
PhotovoltaicPerformance:EquivalentOne-Diode
PhotovoltaicPerformance:Sandia.
```

Field: Module Performance Name

This is the name of the PV performance object define elsewhere (corresponding to the object type listed in the previous field)

Field: Heat Transfer Integration Mode

The PV model allows for different ways of integrating with other EnergyPlus heat transfer surfaces and models and calculating cell temperature. For Building Integrated PV (BIPV), the "Integrated" options allow for the PV modeling to be coupled to the surface heat transfer models elsewhere in EnergyPlus. The user must select one of these options for this field:

- **Decoupled.** The cell temperature of modules in the array is computed based on a energy balance relative to NOCT conditions. The input fields for Module Heat Capacity and Module Heat Loss Coefficient are ignored.

- **DecoupledUllebergDynamic** the cell temperature is calculated based on a dynamic model developed by Ulleberg¹³. The input fields for Module Heat Capacity and Module Heat Loss Coefficient are required.
- **IntegratedSurfaceOutsideFace** The cell temperature is obtained from the outside face of the Surface:Heat Transfer named in the previous field. Energy exported by the module is removed from the heat transfer surface (at the position determined by the associated Construction with Internal Source). The input fields for Module Heat Capacity and Module Heat Loss Coefficient are ignored.
- **IntegratedTranspiredCollector** The cell temperature is obtained from the collector surface temperature in the unglazed transpired collector model. Energy exported by the module is removed from the collector surface. The input fields for Module Heat Capacity and Module Heat Loss Coefficient are ignored.
- **IntegratedExteriorVentedCavity** The cell temperature is obtained from the exterior baffle temperature in the naturally ventilated exterior cavity model. Energy exported by the module is removed from the exterior baffle surface. The input fields for Module Heat Capacity and Module Heat Loss Coefficient are ignored.
- **PhotovoltaicThermalSolarCollector** The cell temperature is obtained from the photovoltaic/thermal solar collector model. If the PV layer is inside the collector, then the incident solar is modified by the photovoltaic/thermal solar collector model.

Field: Number of Modules in Parallel

This field is the number of modules wired in parallel to form the PV array.

Field: Number of Modules in Series

This field is the number of modules wired in series to form the PV array.

¹³ Ulleberg Ø. (1997) Simulation of autonomous PV-H2 systems: analysis of the PHOEBUS plant design, operation and energy management. In *Proceedings of ISES 1997 Solar World Congress*, August 24-30, Taejeon, Korea.

Ulleberg Ø. (1998) *Stand-Alone Power Systems for the Future: Optimal Design, Operation & Control of Solar-Hydrogen Energy Systems*. PhD thesis, Norwegian University of Science and Technology, Trondheim.

```

Generator:Photovoltaic,
  A1 , \field Name
        \required-field
        \reference GeneratorNames
        \reference PVGeneratorNames
  A2 , \field Surface Name
        \required-field
        \type object-list
        \object-list AllShadingAndHTSurfNames
  A3 , \field Photovoltaic Performance Object Type
        \type choice
        \key PhotovoltaicPerformance:Simple
        \key PhotovoltaicPerformance:EquivalentOne-Diode
        \key PhotovoltaicPerformance:Sandia
  A4 , \field Module Performance Name
        \note PV array modeling details
        \type object-list
        \object-list PVModules
  A5 , \field Heat Transfer Integration Mode
        \type choice
        \key Decoupled
        \key DecoupledUllebergDynamic
        \key IntegratedSurfaceOutsideFace
        \key IntegratedTranspiredCollector
        \key IntegratedExteriorVentedCavity
        \key PhotovoltaicThermalSolarCollector
        \default Decoupled
  N1 , \field Number of Modules in Parallel
        \default 1
        \units dimensionless
        \minimum 1
  N2 ; \field Number of Modules in Series
        \default 1
        \units dimensionless
        \minimum 1

```

Generator:Photovoltaic Outputs

Using the Generator:PV:Simple object makes a number of output variables available.

PV Generator DC Power [W]

This output variable is the power of DC electricity delivered.

PV Generator DC Energy [J]

This output variable is the energy in DC electricity.

PV Array Efficiency []

This output variable is the resulting efficiency .

The two more detailed PV models also have the following output variables.

PV Cell Temperature [°C]

This output variable represents the temperature of the solar cell used in the calculation of cell performance.

PV Array Short Circuit Current [A]

This output variable represents the short circuit current of the PV array. This is provided to describe the I-V characteristics.

PV Array Open Circuit Voltage [V]

This output variable represents the open circuit voltage of the PV array. This is provided to describe the I-V characteristics.

PhotovoltaicPerformance:Simple

The PhotovoltaicPerformance:Simple object describes a simple model of photovoltaics that may be useful for early phase design analysis. In this model the user has direct access to the efficiency with which surfaces convert incident solar radiation to electricity and need not specify arrays of specific modules. The full geometric model for solar radiation is used, including shading and reflections, to determine the incident solar resource. This model is intended to be useful for design purposes to quickly get an idea of the levels for annual production and peak power. The model can also accept arbitrary conversion efficiencies and does not require actual production units be tested to obtain performance coefficients.

Field: Name

This field is the name of the PV array. The name is only used as an identifier. Multiple instances need have unique names.

Field: Fraction of Surface Area with Active Solar Cells

This field is the user defined fraction for the area of surface named in the parent PV object that will have active PV cells on it. The area actually covered with solar cells will be the net area of the surface (gross area less any subsurfaces like windows) times the fraction entered here. This fraction includes the difference between PV module area and active cells within it and any losses for how closely packed modules can be arranged on surface. The value should be between 0.0 and 1.0.

Field: Conversion Efficiency Input Mode

This field specifies how the PV array efficiency values are input. There are two choices, **Fixed** and **Scheduled**. If this field is set to 'Fixed' then the PV array always has the efficiency value specified in the next field. If this field is set to 'Scheduled' then the efficiency is determined by a user defined schedule named in the second field to follow.

Field: Value for Cell Efficiency if Fixed

This field specifies the efficiency with which solar incident energy is converted to electricity. Efficiency = (electrical power generated [W])/(power of incident solar[W]). These efficiency values are dimensionless and should be between 0.0 and 1.0.

Field: Efficiency Schedule Name

This field should be set to the name of schedule defined elsewhere in the input file. This schedule should specify dimensionless efficiency values between 0.0 and 1.0. This could be used for example to vary the efficiency to match results computed with more detailed models.

```

PhotovoltaicPerformance:Simple,
  A1 , \field Name
        \reference PVModules
  N1 , \field Fraction of Surface Area with Active Solar Cells
        \required-field
        \type real
        \units dimensionless
        \minimum 0.0
        \maximum 1.0
  A2 , \field Conversion Efficiency Input Mode
        \type choice
        \key Fixed
        \key Scheduled
  N2 , \field Value for Cell Efficiency if Fixed
        \note Efficiency = (power generated [W])/(incident solar[W])
        \type real
        \minimum 0.0
        \maximum 1.0
  A3 ; \field Efficiency Schedule Name
        \type object-list
        \object-list ScheduleNames
    
```

An example idf instance of this object follows:

```

PhotovoltaicPerformance:Simple,
  Simple PV Flat, !- Name
  0.1044 , !- Fraction of Surface area that has active solar cells
  FIXED , !- Conversion efficiency input mode
  0.12 , !- Value for cell efficiency if fixed
  ; !- Name of Schedule that Defines Efficiency
    
```

PhotovoltaicPerformance:EquivalentOne-Diode

This object describes the performance characteristics of Photovoltaic (PV) modules to be modeled using an equivalent one-diode circuit. This model is also known at the 4- or 5-parameter TRNSYS model for photovoltaics.

The following table shows several sample PV array types with their input values.

Table 30. Photovoltaics Array Types with Values

	Short Circuit Current	Open Circuit Voltage	Voltage at Maximum Power	Current at Maximum Power	Temperature Coefficient of Short Circuit Current	Temperature Coefficient of Open Circuit Voltage	Number of Cells in Series per Module	Cell Temperature at NOCT Conditions	Module Area
Units:	[A]	[V]	[V]	[A]	{A/K}	[V/K]	[-]	[K]	[m2]
ASE 300-DFG/50	6.2	60	50.5	5.6	0.001	-0.0038	216	318	2.43
BP solar 275	4.75	21.4	17	4.45	0.00065	-0.08	36	320	0.63
BP solar 3160	4.8	44.2	35.1	4.55	0.00065	-0.16	72	320	1.26
BP solar 380	4.8	22.1	17.6	4.55	0.00065	-0.08	36	320	0.65
BP solar 4160	4.9	44.2	35.4	4.52	0.00065	-0.16	72	320	1.26
BP solar 5170	5	44.2	36	4.72	0.00065	-0.16	72	320	1.26
BP solar 585	5	22.1	18	4.72	0.00065	-0.08	36	320	0.65
Shell SM110-12	6.9	21.7	17.5	6.3	0.0028	-0.076	36	318	0.86856

Shell SM110-24	3.45	43.5	35	3.15	0.0014	-0.152	72	318	0.86856
Shell SP70	4.7	21.4	16.5	4.25	0.002	-0.076	36	318	0.6324
Shell SP75	4.8	21.7	17	4.4	0.002	-0.076	36	318	0.6324
Shell SP140	4.7	42.8	33	4.25	0.002	-0.152	72	318	1.320308
Shell SP150	4.8	43.4	34	4.4	0.002	-0.152	72	318	1.320308
Shell S70	4.5	21.2	17	4	0.002	-0.076	36	317	0.7076
Shell S75	4.7	21.6	17.6	4.2	0.002	-0.076	36	317	0.7076
Shell S105	4.5	31.8	25.5	3.9	0.002	-0.115	54	317	1.037
Shell S115	4.7	32.8	26.8	4.2	0.002	-0.115	54	317	1.037
Shell ST40	2.68	23.3	16.6	2.41	0.00035	-0.1	16	320	0.424104
UniSolar PVL-64	4.8	23.8	16.5	3.88	0.00065	-0.1	40	323	0.65
UniSolar PVL-128	4.8	47.6	33	3.88	0.00065	-0.2	80	323	1.25

Where:

Shunt Resistance: the value of shunt resistance is finite only if the PV Module being modeled is a thin film variety. For all crystalline silicon modules the value is essentially infinite

Shunt Resistance value: 1,000,000 Ω (ohms)

Module Heat Loss Coefficient: this value is dependent more on the array configuration than on the module itself.

Module Heat Loss Coefficient value: 30 W/m²-K

Module Heat Capacity: this is a typical value for a silicon based sandwich construction framed PV panel.

Module Heat Capacity Value: 50,000 J/m²-K

Reference Temperature: 298K (25C)

Insolation at Reference Conditions: 1000 W/m²

Ambient Temperature at NOCT conditions: 293K (20C)

Insolation at NOCT Conditions: 800 W/m²

Average tau-alpha Product: .9

Semiconductor Bandgap: 1.12 eV

Field: Name

This field contains the unique name for the photovoltaic module performance data. The name is only used as an identifier.

Field: Cell Type

This field is used to describe the type of technology used in the PV module. There are two options available, **CrystallineSilicon** and **AmorphousSilicon**. The choice affects the modeling.

Field: Number of Cells in Series

This field is an integer representing the number of individual cells wired in series to make up a single module. The typical number for a 12V crystalline silicon PV module is 36.

Field: Active Area

This field is the active area of the PV module in m².

Field: Transmittance Absorptance Product

This field indicates the transmittance-absorptance product at normal incidence angles for the PV modules. If the $\tau\alpha$ product is positive, that value will be used for all angles of incidence. If the value specified is negative, then the magnitude of the given value will be used for normal incidence and the IAM modifier correlation will be used for all other angles.

Field: Semiconductor Bandgap

This field is the semiconductor bandgap for the PV material. The bandgap for silicon is 1.12 eV (electron volts).

Field: Shunt Resistance

This field is the shunt (parallel) resistance (in Ω) in the single diode electrical model of the PV. The shunt resistance is effectively infinite for crystalline silicon based PV modules and is finite for thin film and exotic metal modules.

Field: Short Circuit Current

This field is the short circuit current (in Amps) for an individual module in the PV array at reference conditions.

Field: Open Circuit Voltage

This field is the open circuit voltage (in Volts) for an individual module in the PV array at reference conditions.

Field: Reference Temperature

This field is the ambient temperature (in Kelvin) at reference conditions. The value is usually 298K

Field: Reference Insolation

This field is the radiation level (in W/m²) at reference conditions. The value is usually 1000 W/m².

Field: Module Current at Maximum Power

This field is module current (in Amps) at the maximum power point and reference conditions.

Field: Module Voltage at Maximum Power

This field is module voltage (in Volts) at the maximum power point and reference conditions.

Field: Temperature Coefficient of Short Circuit Current

This field accounts for the fact that the module short circuit current is temperature dependent. The coefficient is given in Amps/Kelvin.

Field: Temperature Coefficient of Open Circuit Voltage

This field accounts for the fact that the module open circuit voltage is temperature dependent. The coefficient is given in Volts/Kelvin.

Field: Nominal Operating Cell Temperature Test Ambient Temperature

This field is the ambient temperature (in Kelvin) from the Nominal Operating Cell Temperature (NOCT) test. The value is usually 293 K

Field: Nominal Operating Cell Temperature Test Cell Temperature

This field is the cell temperature (in Kelvin) from the Nominal Operating Cell Temperature (NOCT) test.

Field: Nominal Operating Cell Temperature Test Insolation

This field is the insolation level (in W/m^2) from the Nominal Operating Cell Temperature (NOCT) test. The value is usually $800 W/m^2$.

Field: Module Heat Loss Coefficient

This field is the heat loss coefficient (in $W/m^2.K$) for the array. The heat loss coefficient is dependent upon measures taken to actively or passively promote airflow over the array surface. The heat loss coefficient value is used only if the Integration and Cell Temperature Mode is set to "Decoupled Ulleberg Dynamic."

Field: Total Heat Capacity

This field is the heat capacity (in $J/m^2.K$) of the modules in the array. It describes the module's ability to store incident solar radiation internally. Such energy storage is manifested as a temperature increase in the modules that is considered to be undesirable. The total heat capacity value is used only if the Integration and Cell Temperature Mode is set to "Decoupled Ulleberg Dynamic."

PhotovoltaicPerformance:EquivalentOne-Diode,

```

A1 , \field Name
    \reference PVModules
A2 , \field Cell type
    \type choice
    \key CrystallineSilicon
    \key AmorphousSilicon
N1 , \field Number of Cells in Series
    \default 36
    \type integer
    \units dimensionless
    \minimum 0
N2 , \field Active Area
    \note The total power output of the array is determined by the
    \note number of modules (see above). The Active Area is only
    \note used to calculate the PV Array Efficiency report variable.
    \default 0.89
    \type real
    \units m2
    \minimum 0.1
N3 , \field Transmittance Absorptance Product
    \default 0.95
    \type real
    \units dimensionless
    \minimum 0.0
    \maximum 1.0
N4 , \field Semiconductor Bandgap
    \default 1.12
    \type real
    \units eV
    \minimum 0.0
N5 , \field Shunt Resistance
    \default 1000000.0
    \type real
    \units ohms
    \minimum 0.0
N6 , \field Short Circuit Current
    \default 6.5
    \type real
    \units A
    \minimum 0.0
N7, \field Open Circuit Voltage
    \default 21.6
    \type real
    \units V
    \minimum 0.0
N8, \field Reference Temperature
    \default 25
    \type real
    \units C
    \minimum 0.0
N9, \field Reference Insolation
    \default 1000
    \type real
    \units W/m2
    \minimum 0.0
N10, \field Module Current at Maximum Power
    \note Single module current at the maximum power point
    \note and reference conditions. Module Current, Module Voltage,
    \note Number of Modules in Parallel and Number of Modules in Series
    \note determine the maximum power output of the array.
    \default 5.9
    \type real
    \units A
    \minimum 0.0
N11, \field Module Voltage at Maximum Power
    \note Single module voltage at the maximum power point
    \note and reference conditions. Module Current, Module Voltage,
    \note Number of Modules in Parallel and Number of Modules in Series
    \note determine the maximum power output of the array.
    \default 17

```

```

        \type real
        \units V
        \minimum 0.0
N12, \field Temperature Coefficient of Short Circuit Current
        \default -0.079
        \type real
        \units A/K
N13, \field Temperature Coefficient of Open Circuit Voltage
        \default 0.02
        \type real
        \units V/K
N14, \field Nominal Operating Cell Temperature Test Ambient Temperature
        \default 20
        \type real
        \units C
        \minimum 0.0
N15, \field Nominal Operating Cell Temperature Test Cell Temperature
        \default 40
        \type real
        \units C
        \minimum 0.0
N16, \field Nominal Operating Cell Temperature Test Insolation
        \default 800
        \type real
        \units W/m2
        \minimum 0.0
N17, \field Module Heat Loss Coefficient
        \default 30
        \type real
        \units W/m2-K
        \minimum 0.0
N18; \field Total Heat Capacity
        \default 50000
        \type real
        \units J/m2-K
        \minimum 0.0

```

An IDF example:

```

PhotovoltaicPerformance:EquivalentOne-Diode,
Siemens, ! Name
CrystallineSilicon, !cell Type
36,      !cells in series [-]
1.0,    !module area [m2]
0.9,    !tau alpha product at normal incidence [-]
1.12,   !electron bandgap [eV]
1000000, !shunt resistance [ohms]
6.5,    !short circuit current at reference conditions [A/K]
21.6,   !open circuit voltage at reference conditions [V/K]
25,     !temperature at reference conditions [C]
1000,   !radiation at reference conditions [W/m2]
5.9,    !current at max power
17,     !voltage at max power
0.002,  !temperature coefficient of short circuit current
-0.079, !temperature coefficient of open circuit voltage
20,     !ambient temperature at NOCT [C]
45,     !cell temperature at NOCT [C]
800,    !radiation at NOCT [W/m2]
30,     !heat loss coefficient [W/m2.K]
50000;  !total heat capacity (only used in TC mode 1)

```

PhotovoltaicPerformance:Sandia

This 'PhotovoltaicPerformance:Sandia' object describes the performance of a single type of module. The model used with this object for predicting the electricity generated by photovoltaics is referred to as the Sandia model. This model is based on work done at Sandia National Lab, Albuquerque, NM by David King -- with the help of many others.

This object describes performance input data needed for specific makes and models of production PV panels using the empirical coefficients assembled by Sandia National Laboratory. There are a large number of empirical coefficients required to use the Sandia model. These data are obtained after extensive measurements and data reduction. This testing has been performed for some types of production panels and Sandia publishes a database of module and array performance parameters on the web at www.sandia.gov/pv. The entries in the database as of January 15, 2004 were converted to idf segments and are included with the EnergyPlus release in the library file SandiaPVData.imf. There are more than hundred different module types included in the library and identified by the manufacturer's model names listed at the beginning of the file SandiaPVData.imf. This data library file is arranged for use with EpMacro but the user can also copy .idf segments directly from the macro data set.

The Sandia model itself can aggregate multiple PV modules. Therefore, an instance of a 'PhotovoltaicPerformance:Sandia' object could actually represent an array of modules as well as the more usual single module. These can be thought of as simple larger modules and used by Generator:PV:Sandia objects in the usual manner.

The many empirical coefficients for the model are listed below and are described in more detail in the EnergyPlus engineering documentation EngineeringDoc.pdf.

The field descriptions below focus on providing the parameter's variable name as identified in the Sandia database. See the the EngineeringDoc.pdf for details on how the input fields are used in the correlations. The user generally would not need to worry about the details of the fields since he/she is not likely to generate the data on their own.

Field: Name

This field provides a unique name for the PV module. This is often the manufacturer's identifier for a particular model of a PV module.

Field: Active Area

Units m^2 , real number, area of active solar electric cell for the entire module.

Field: Number of Cells in Series

"Series_Cells" in Sandia Database.

Field: Number of Cells in Parallel

"Parallel_Cells" in Sandia Database

Field: Short-Circuit Current

"Isco" in Sandia Database. Short-circuit current is a basic parameter Typically supplied by manufacturers at Standard Report Conditions. (Amps)

Field: Open-Circuit Voltage

"Voco" in Sandia Database, Open-circuit voltage is a basic parameter typically provided by manufacturers at Standard Report Conditions. (Volts)

Field: Current at Maximum Power Point

"Impo" in Sandia Database. Current at maximum powerpoint is a basic parameter provided by manufacturers at Standard Report Conditions. (Amps)

Field: Voltage at Maximum PowerPoint

"Vmpto" in Sandia Database. Voltage at maximum powerpoint is a basic parameter typically provided by manufacturers at Standard Report Conditions. (Volts)

Field: Sandia Database Parameter alsC

"alsc in Sandia Database" (1/degC)

Field: Sandia Database Parameter *almp*

“almp” in Sandia Database (1/degC)

Field: Sandia Database Parameter *c0*

“C0” in Sandia Database, (non-dimensional)

Field: Sandia Database Parameter *c1*

“C1” in Sandia Database (non-dimensional)

Field: Sandia Database Parameter *Bvoc0*

“Bvoco” in Sandia Database (Volts/degC)

Field: Sandia Database Parameter *mBVoc*

“mBVoc” in Sandia Database (Volts/degC)

Field: Sandia Database Parameter *BVmp0*

“Bvmpo” in Sandia Database (Volts/degC)

Field: Sandia Database Parameter *mBVmp*

“mBVmp” in Sandia Database (Volts/degC)

Field: Diode Factor

“n” in Sandia Database (non-dimensional)

Field: Sandia Database Parameter *c2*

“C2” in Sandia Database (non-dimensional)

Field: Sandia Database Parameter *c3*

“C3” in Sandia Database (non-dimensional)

Field: Sandia Database Parameter *a0*

“A0” in Sandia Database (non-dimensional)

Field: Sandia Database Parameter *a1*

“A1” in Sandia Database (non-dimensional)

Field: Sandia Database Parameter *a2*

“A2” in Sandia Database (non-dimensional)

Field: Sandia Database Parameter *a3*

“A3” in Sandia Database (non-dimensional)

Field: Sandia Database Parameter *a4*

“A4” in Sandia Database (non-dimensional)

Field: Sandia Database Parameter *b0*

“B0” in Sandia Database (non-dimensional)

Field: Sandia Database Parameter *b1*

“B1” in Sandia Database (non-dimensional)

Field: Sandia Database Parameter *b2*

“B2” in Sandia Database (non-dimensional)

Field: Sandia Database Parameter b3

"B3" in Sandia Database (non-dimensional)

Field: Sandia Database Parameter b4

"B4" in Sandia Database (non-dimensional)

Field: Sandia Database Parameter b5

"B5" in Sandia Database (non-dimensional)

Field: Sandia Database Parameter Delta(TC)

"d(Tc)" in Sandia Database (deg C)

Field: Sandia Database Parameter fd

"fd" in Sandia Database (non-dimensional)

Field: Sandia Database Parameter a

"a" in Sandia Database (non-dimensional)

Field: Sandia Database Parameter b

"b" in Sandia Database (non-dimensional)

Field: Sandia Database Parameter c4

"C4" in Sandia Database (non-dimensional)

Field: Sandia Database Parameter c5

"C5" in Sandia Database (non-dimensional)

Field: Sandia Database Parameter Ix0

"Ix0" in Sandia Database (Amps)

Field: Sandia Database Parameter Ixx0

"Ixx0" in Sandia Database (Amps)

Field: Sandia Database Parameter c6

"C6" in Sandia Database (non-dimensional)

Field: Sandia Database Parameter c7

"C7" in Sandia Database (non-dimensional)

PhotovoltaicPerformance:Sandia,

```

A1 , \field Name
    \reference PVModules
N1 , \field Active Area
    \note (m2, single module)
    \default 1.0
    \type real
    \units m2
    \minimum 0.0
N2 , \field Number of Cells in Series
    \default 1
    \type integer
    \units dimensionless
    \minimum 1
N3 , \field Number of Cells in Parallel
    \default 1
    \type integer
    \units dimensionless
    \minimum 1
N4 , \field Short Circuit Current
    \note (Amps)
    \type real
    \units A
N5 , \field Open Circuit Voltage
    \note (Volts)
    \type real
    \units V
N6 , \field Current at Maximum Power Point
    \note (Amps)
    \type real
    \units A
N7 , \field Voltage at Maximum Power Point
    \note (Volts)
    \type real
    \units V
N8 , \field Sandia Database Parameter aIsc
    \note (1/degC)
    \type real
    \units 1/K
N9 , \field Sandia Database Parameter aImp
    \note (1/degC)
    \type real
    \units 1/K
N10 , \field Sandia Database Parameter c0
    \note (nondimensional)
    \type real
    \units dimensionless
N11 , \field Sandia Database Parameter c1
    \note (nondimensional)
    \type real
    \units dimensionless
N12 , \field Sandia Database Parameter BVoc0
    \note (Volts/degC)
    \type real
    \units V/K
N13 , \field Sandia Database Parameter mBVoc
    \note (Volts/degC)
    \type real
    \units V/K
N14 , \field Sandia Database Parameter BVmp0
    \note (Volts/degC)
    \type real
    \units V/K
N15 , \field Sandia Database Parameter mBVmp
    \note (Volts/degC)
    \type real
    \units V/K
N16 , \field Diode Factor
    \note (nondimensional)
    \type real
    \units dimensionless

```

```
N17 , \field Sandia Database Parameter c2
      \note (nondimensional)
      \type real
      \units dimensionless
N18 , \field Sandia Database Parameter c3
      \note (nondimensional)
      \type real
      \units dimensionless
N19 , \field Sandia Database Parameter a0
      \note (nondimensional)
      \type real
      \units dimensionless
N20 , \field Sandia Database Parameter a1
      \note (nondimensional)
      \type real
      \units dimensionless
N21 , \field Sandia Database Parameter a2
      \note (nondimensional)
      \type real
      \units dimensionless
N22 , \field Sandia Database Parameter a3
      \note (nondimensional)
      \type real
      \units dimensionless
N23 , \field Sandia Database Parameter a4
      \note (nondimensional)
      \type real
      \units dimensionless
N24 , \field Sandia Database Parameter b0
      \note (nondimensional)
      \type real
      \units dimensionless
N25 , \field Sandia Database Parameter b1
      \note (nondimensional)
      \type real
      \units dimensionless
N26 , \field Sandia Database Parameter b2
      \note (nondimensional)
      \type real
      \units dimensionless
N27 , \field Sandia Database Parameter b3
      \note (nondimensional)
      \type real
      \units dimensionless
N28 , \field Sandia Database Parameter b4
      \note (nondimensional)
      \type real
      \units dimensionless
N29 , \field Sandia Database Parameter b5
      \note (nondimensional)
      \type real
      \units dimensionless
N30 , \field Sandia Database Parameter Delta(Tc)
      \note (deg C)
      \type real
      \units deltaC
N31 , \field Sandia Database Parameter fd
      \note (nondimensional)
      \type real
      \units dimensionless
N32 , \field Sandia Database Parameter a
      \note (nondimensional)
      \type real
      \units dimensionless
N33 , \field Sandia Database Parameter b
      \note (nondimensional)
      \type real
      \units dimensionless
N34 , \field Sandia Database Parameter c4
      \note (nondimensional)
      \type real
```

```

\units dimensionless
N35 , \field Sandia Database Parameter c5
\note (nondimensional)
\type real
\units dimensionless
N36 , \field Sandia Database Parameter Ix0
\note (Amps)
\type real
N37 , \field Sandia Database Parameter Ixx0
\note (Amps)
\type real
N38 , \field Sandia Database Parameter c6
\note (nondimensional)
\type real
N39 ; \field Sandia Database Parameter c7
\note (nondimensional)
\type real

```

An example of an instance of a PV MODULE:SANDIA PARAMETERS object follows:

```

PhotovoltaicPerformance:Sandia,
ASE-50-ATF-17_45, ! Module Name (production Name)
0.43, ! field Active Area Acoll {m2}, single module
36, ! NcellSer {unitless}
1, ! NparSerCells
2.90, ! Isc0 {Amps}
20.70, ! Voc0 {Volts}
2.65, ! Imp0 {Amps}
17.00, ! Vmp0 {Volts}
7.8e-04, ! aIsc {1/degC}
1.0e-04, ! aImp {1/degC}
0.99, ! C0 {unitless}
3.0e-03, ! C1 {unitless}
-0.07, ! BVoc0 {Volts/degC}
0.00, ! mBVoc {Volts/degC}
-0.07, ! BVmp0 {Volts/degC}
0.00, ! mBVmp {Volts/degC}
1.29, ! Diode Factor (n) {Unitless}
0.20, ! C2 {Unitless}
-8.60, ! C3 {Unitless}
0.93, ! A0 {Unitless}
0.05, ! A1 {Unitless}
-7.9402e-03, ! A2 {Unitless}
5.2228e-04, ! A3 {Unitless}
-1.3142e-05, ! A4 {Unitless}
1.00, ! B0 {Unitless}
-2.438e-03, ! B1 {Unitless}
3.103e-04, ! B2 {Unitless}
-1.246e-05, ! B3 {Unitless}
2.112e-07, ! B4 {Unitless}
-1.359e-09, ! B5 {Unitless}
3.00, ! dT0 {degC}
1.00, ! fd {Unitless}
-3.47, ! a {Unitless}
-0.05, ! b {Unitless}
0.98, ! C4 {Unitless}
0.01, ! C5 {Unitless}
2.86, ! Ix0 {Amps}
1.85, ! Ixx0 {Amps}
1.13, ! C6 {Unitless}
-0.13, ! C7 {Unitless}
-1.359e-09, ! B5 {Unitless}
3.00, ! dT0 {degC}
1.00; ! fd {Unitless}

```

When using EpMacro with an typical installation of EnergyPlus, the above entry can be included in an input file by adding the following two lines to an input macro file (*.imf).

```

##include C:\EnergyPlus\MacroDataSets\SandiaPVdata.imf
ASE-50-ATF-17_45[]

```

Group – Water Systems

This group of objects is used to describe the water systems in the building. EnergyPlus offers water modeling capabilities that include not only hot water systems but also the overall water systems including cold water uses, on-site water collection (e.g., from rain, condensate, or well), and storage. HVAC components may consume or collect a significant portion of the water making it appropriate to include water modeling in EnergyPlus.

All water systems are collected into an end use category called “Water Systems”. This category includes hot and cold water. Water consumed by an HVAC component will be assigned to the end use category for that component. End use subcategories are available to separate hot water from cold water if desired. Simple hot water systems can be configured as stand-alone or use a PlantLoop. The Water Systems can be connected to PlantLoops for modeling heated water end uses. However PlantLoops are not used to model cold water and the WaterUse:Storages portions of the water system. Cold water systems are connected together using WaterUse:Storage objects. WaterUse:Connections are used at the zone level to connect to both cold and hot water.

In addition to the input objects described in this section below, there are a variety of HVAC components that can be configured to interact with the water systems. These component input objects include optional fields that allow describing how the water systems are connected to them by providing the name of a storage tank. The following table lists EnergyPlus input objects that include provisions for connecting to the water systems but are described elsewhere in this document:

Table 31. Water Systems Objects

Input Object Name	Type of Water Interactions
Site:Precipitation	Describes rainfall for WaterUse:RainCollector
Coil:Cooling:Water	Condensate collection to WaterUse:Storage
Coil:Cooling:Water:DetailedGeometry	Condensate collection to WaterUse:Storage
Coil:Cooling:DX:SingleSpeed	Optional evaporative condenser can be supplied by WaterUse:Storage Condensate collection to WaterUse:Storage
Coil:Cooling:DX:TwoSpeed	Evaporative condenser supplied by WaterUse:Storage Condensate collection to WaterUse:Storage
Coil:Cooling:DX:TwoStageWithHumidityControlMode	Evaporative condenser supplied by WaterUse:Storage Condensate collection to WaterUse:Storage
Coil:Cooling:DX:MultiSpeed	Evaporative condenser supplied by WaterUse:Storage Condensate collection to WaterUse:Storage
Humidifier:Steam:Electric	Water supplied by WaterUse:Storage

Input Object Name	Type of Water Interactions
CoolingTower:SingleSpeed	Water supplied by WaterUse:Storage
CoolingTower:TwoSpeed	Water supplied by WaterUse:Storage
CoolingTower:VariableSpeed	Water supplied by WaterUse:Storage
ZoneCoolTower:Shower	Water supplied by WaterUse:Storage
Refrigeration:CompressorRack	Water supplied by WaterUse:Storage
Refrigeration:Condenser:EvaporativeCooled	Water supplied by WaterUse:Storage
EvaporativeCooler:Direct:CelDekPad	Evaporation water supplied by WaterUse:Storage
EvaporativeCooler:Indirect:CelDekPad	Evaporation water supplied by WaterUse:Storage
EvaporativeCooler:Indirect:WetCoil	Evaporation water supplied by WaterUse:Storage
EvaporativeCooler:Indirect:ResearchSpecial	Evaporation water supplied by WaterUse:Storage

WaterUse:Equipment

The WaterUse:Equipment object is a generalized object for simulating all water end uses. Hot and cold water uses are included, as well as controlled mixing of hot and cold water at the tap. The WaterUse:Equipment object can be used stand-alone, or coupled into a plant loop using the WaterUse:Connections object (see below). The WaterUse:Connections object allows water uses to be linked to WaterUse:Storage objects to store and draw reclaimed water. The WaterUse:Connections object can also simulate drainwater heat recovery.

The WaterUse:Equipment object serves all of the same purposes as the existing objects: Exterior:WaterEquipment, and HotWaterEquipment.

The WaterUse:Equipment object does a better job of modeling domestic hot water by allowing mixing at the tap in order to account for both hot and cold water used at sinks, showers, etc. It also improves on the stand-alone energy modeling of domestic hot water. Because all of the temperatures and flow rates can be solved, the energy usage can be accounted for as "Purchased Heating".

In either stand-alone mode or used with the WaterUse:Connections object, the WaterUse:Equipment object will attempt to meet a scheduled target temperature at the tap by mixing hot and cold water flows. If the hot water flow is not hot enough, or if the flow is limited by plant loop constraints, the result is a cooler mixed water temperature and the target temperature will not be met. In stand-alone mode the hot and cold water temperatures are specified by schedules. However, if the cold water schedule is omitted, the water temperature will be calculated by the Site:WaterMainsTemperature object. If the hot water schedule or target temperature schedule are omitted, all water is delivered as cold water. If only using cold water, the WaterUse:Equipment object is similar to the Exterior:WaterEquipment object.

The WaterUse:Equipment object improves on the internal gains object HotWaterEquipment by associating actual water usage with a sensible and latent gain to a zone. Equipment, such as showers, that generate a significant heat gain can be modeled using the Sensible Fraction Schedule and Latent Fraction Schedule fields. The schedules are used to set the fraction of the maximum possible heat gain (based on inlet water conditions and ambient zone

conditions) that should be added to the zone. The split between sensible and latent will vary depending on the type of equipment that is to be modeled. Typically, both fractions should be small numbers.

IDD specification:

```
WaterUse:Equipment,
  A1 , \field Name
      \required-field
      \type alpha
      \reference WaterUseEquipmentNames
  A2 , \field End-Use Subcategory
      \type alpha
      \retaincase
      \default General
  N1 , \field Peak Flow Rate
      \required-field
      \units m3/s
      \type real
      \minimum 0.0
  A3 , \field Flow Rate Fraction Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Defaults to 1.0 at all times
  A4 , \field Target Temperature Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Defaults to hot water supply temperature
  A5 , \field Hot Water Supply Temperature Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Defaults to cold water supply temperature
  A6 , \field Cold Water Supply Temperature Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Defaults to water temperatures calculated by Site:WaterMainsTemperature object
  A7 , \field Zone Name
      \type alpha
      \object-list ZoneNames
  A8 , \field Sensible Fraction Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Defaults to 0.0 at all times
  A9 ; \field Latent Fraction Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Defaults to 0.0 at all times
```

Field: Name

The unique object name for reference by other objects.

Field: End-Use Subcategory

Allows you to specify a user-defined end-use subcategory, e.g., "Laundry", "Dish Washing", etc. A new meter for reporting is created for each unique subcategory (ref: Report Meter). Subcategories are also reported in the ABUPS table under the "Water Systems" end-use category. If this field is omitted or blank, the water use will be assigned to the "General" end-use subcategory.

Field: Peak Flow Rate

The peak demanded hot water flow rate [m³/s]. This value is multiplied by the Flow Rate Fraction Schedule (below) to determine the actual volumetric flow rate.

Field: Flow Rate Fraction Schedule Name

Reference to the schedule object specifying the flow rate fraction relative to the Peak Flow Rate (above). If blank, the schedule defaults to 1.0 at all times.

Field: Target Temperature Schedule Name

Reference to the schedule object specifying the target water temperature [C]. Hot and cold water are mixed at the tap to attain the target temperature. If insufficient hot water is available to reach the target temperature, the result is cooler water at the tap. If blank, the target temperature defaults to the hot water supply temperature.

Field: Hot Water Supply Temperature Schedule Name

Reference to the schedule object specifying the hot water temperature [C]. The hot water temperature is used to calculate the "Purchased Heating" energy usage in stand-alone mode. If blank in stand-alone mode, the hot water supply temperature defaults to the cold water supply temperature. This field is ignored if the object is used with the WaterUse:Connections object.

Field: Cold Water Supply Temperature Schedule Name

Reference to the Schedule object specifying the cold water temperature [C] from the supply mains that provides the cold water to the tap and makes up for all water lost down the drain. If blank, water temperatures are calculated by the Site:WaterMainsTemperature object. This field is ignored if the object is used with the WaterUse:Connections object.

Field: Zone Name

Reference to the zone name where the water equipment will be considered as latent load to the zone.

Field: Sensible Fraction Schedule Name

Reference to the schedule object specifying the fraction of the maximum possible sensible heat gain (based on inlet water conditions and ambient zone conditions) that is added to the zone. If blank, the schedule defaults to 0 at all times.

Field: Latent Fraction Schedule Name

Reference to the schedule object specifying the fraction of the maximum possible latent heat gain (based on inlet water conditions and ambient zone conditions) that is added to the zone. If blank, the schedule defaults to 0 at all times.

IDF examples:

```

WaterUse:Equipment,
Landscaping,  !- Name
Landscaping,  !- End-Use Subcategory
0.003;        !- Peak Flow Rate {m3/s}

WaterUse:Equipment,
Dishwashing,  !- Name
Domestic Hot Water,  !- End-Use Subcategory
0.001,  !- Peak Flow Rate {m3/s}
Dishwashing Schedule,  !- Flow Rate Fraction Schedule Name
Dishwashing Target Temp,  !- Target Temperature Schedule Name
Hot Water Temp,  !- Hot Water Supply Temperature Schedule Name
Mains Water;  !- Cold Water Supply Temperature Schedule Name

WaterUse:Equipment,
Showers,  !- Name
Domestic Hot Water,  !- End-Use Subcategory
0.0002,  !- Peak Flow Rate {m3/s}
Shower Schedule,  !- Flow Rate Fraction Schedule Name
Shower Target Temp,  !- Target Temperature Schedule Name
Hot Water Temp,  !- Hot Water Supply Temperature Schedule Name
,  !- Cold Water Supply Temperature Schedule Name
Shower Room,  !- Zone Name
Sensible Frac Schedule,  !- Sensible Fraction Schedule Name
Latent Frac Schedule;  !- Latent Fraction Schedule Name

```

WaterUse:Equipment Outputs

The following output variables are reported for the WaterUse:Equipment object:

```

HVAC,Average,Water Use Equipment Hot Water Mass Flow Rate [kg/s]
HVAC,Average,Water Use Equipment Cold Water Mass Flow Rate [kg/s]
HVAC,Average,Water Use Equipment Total Mass Flow Rate [kg/s]
HVAC,Average,Water Use Equipment Hot Water Consumption Rate [m3/s]
HVAC,Average,Water Use Equipment Cold Water Consumption Rate [m3/s]
HVAC,Average,Water Use Equipment Total Consumption Rate [m3/s]
HVAC,Sum,Water Use Equipment Hot Water Consumption [m3]
HVAC,Sum,Water Use Equipment Cold Water Consumption [m3]
HVAC,Sum,Water Use Equipment Total Consumption [m3]
HVAC,Average,Water Use Equipment Hot Water Temperature [C]
HVAC,Average,Water Use Equipment Cold Water Temperature [C]
HVAC,Average,Water Use Equipment Target Water Temperature [C]
HVAC,Average,Water Use Equipment Mixed Water Temperature [C]
HVAC,Average,Water Use Equipment Drain Water Temperature [C]
HVAC,Average,Water Use Equipment Heating Rate [W]
HVAC,Sum,Water Use Equipment Heating Energy [J]
HVAC,Average,Water Use Equipment Sensible Heat Rate To Zone [W]
HVAC,Sum,Water Use Equipment Sensible Heat Gain To Zone [J]
HVAC,Average,Water Use Equipment Latent Heat Rate To Zone [W]
HVAC,Sum,Water Use Equipment Latent Heat Gain To Zone [J]
HVAC,Average,Water Use Equipment Moisture Rate To Zone [kg/s]
HVAC,Sum,Water Use Equipment Moisture Gain To Zone [kg]

```

Water Use Equipment Hot Water Mass Flow Rate [kg/s]

The mass flow rate of hot water supplied to the equipment.

Water Use Equipment Cold Water Mass Flow Rate [kg/s]

The mass flow rate of cold water supplied to the equipment.

Water Use Equipment Total Mass Flow Rate [kg/s]

The total mass flow rate of water (hot + cold) supplied to the equipment.

Water Use Equipment Hot Water Consumption Rate [m3/s]

The volumetric flow rate of hot water supplied to the equipment and consumed down the drain.

Water Use Equipment Cold Water Consumption Rate [m3/s]

The volumetric flow rate of cold water supplied to the equipment and consumed down the drain.

Water Use Equipment Total Consumption Rate [m3/s]

The total volumetric flow rate of water (hot + cold) supplied to the equipment and consumed down the drain.

Water Use Equipment Hot Water Consumption [m3]

The volume of hot water supplied to the equipment and consumed down the drain.

Water Use Equipment Cold Water Consumption [m3]

The volume of cold water supplied to the equipment and consumed down the drain.

Water Use Equipment Total Consumption [m3]

The total volume of water (hot+cold) supplied to the equipment and consumed down the drain.

Water Use Equipment Hot Water Temperature [C]

The temperature of hot water supplied to the equipment.

Water Use Equipment Cold Water Temperature [C]

The temperature of cold water supplied to the equipment.

Water Use Equipment Target Water Temperature [C]

The user-specified target temperature for the mixing of hot and cold supply flows.

Water Use Equipment Mixed Water Temperature [C]

The actual mixed water temperature possible with the available hot and cold temperatures and flow rates.

Water Use Equipment Drain Water Temperature [C]

The water temperature at the drain equal to the mixed water temperature minus any heat loss to the zone.

Water Use Equipment Heating Rate [W]

The heating rate defined by the hot water flow and the temperature difference between the hot water supply and the cold makeup return water.

Water Use Equipment Heating Energy [J]

The heating energy accumulated by the heating rate above.

Water Use Equipment Sensible Heat Rate To Zone [W]

The sensible heat rate to the zone due to the water flow being exposed to zone air.

Water Use Equipment Sensible Heat Gain To Zone [J]

The sensible heat energy accumulated by the latent heat rate above.

Water Use Equipment Latent Heat Rate To Zone [W]

The latent heat rate to the zone due to the water flow being exposed to zone air.

Water Use Equipment Latent Heat Gain To Zone [J]

The latent heat energy accumulated by the latent heat rate above.

Water Use Equipment Moisture Rate To Zone [kg/s]

The moisture rate of evaporation to the zone due to the water flow being exposed to zone air.

Water Use Equipment Moisture Gain To Zone [kg]

The moisture mass accumulated by the moisture rate above.

WaterUse:Connections

The WaterUse:Connections object can be thought of as a subsystem that groups together multiple WaterUse:Equipment components. As its name suggests, the object provides connections that are shared by these components, including:

- Inlet node and outlet node connections to a plant loop
- Connections to WaterUse:Storage objects to store and draw reclaimed water
- Internal connections to simulate drainwater heat recovery.

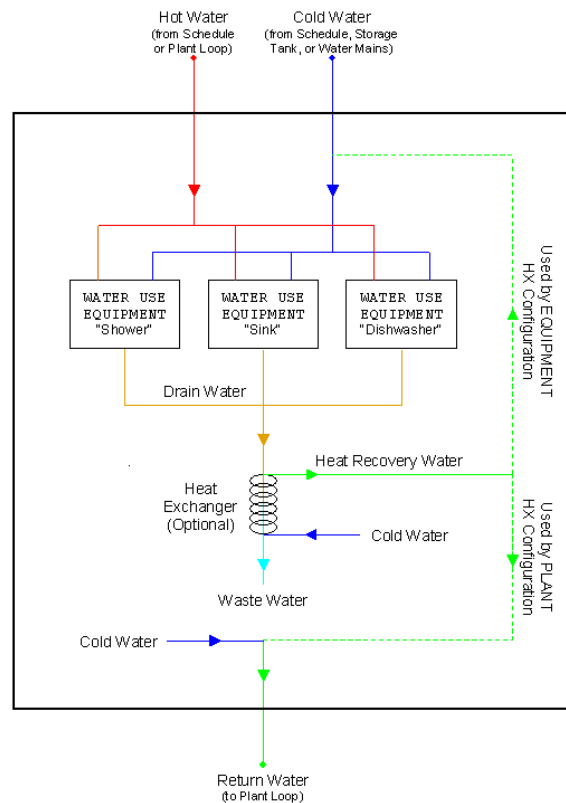


Figure 127. Diagram of internal connections for WaterUse:Connections

The WaterUse:Connections object can be used stand-alone or coupled into a plant loop. In stand-alone mode, the Hot and Cold Water Supply Temperature Schedules override the values for the listed WaterUse:Equipment objects. When coupled to the plant, the Hot Water Supply Temperature Schedule is overridden by the actual plant loop inlet water temperature. When coupled to the plant, the WaterUse:Connections object should be on a Branch object whose control type is set to “Active.”

IDD specification:

```

WaterUse:Connections,
  \extensible:1 - repeat last field
A1 , \field Name
  \required-field
  \type alpha
A2 , \field Inlet Node Name
  \type alpha
A3 , \field Outlet Node Name
  \type alpha
A4 , \field Supply Water Storage Tank Name
  \type object-list
  \object-list WaterStorageTankNames
  \note If blank, or tank is empty, defaults to fresh water from the mains
A5 , \field Reclamation Water Storage Tank Name
  \type object-list
  \object-list WaterStorageTankNames
A6 , \field Hot Water Supply Temperature Schedule Name
  \type object-list
  \object-list ScheduleNames
  \note Defaults to cold water supply temperature
A7 , \field Cold Water Supply Temperature Schedule Name
  \type object-list
  \object-list ScheduleNames
  \note Defaults to water temperatures calculated by Site:WaterMainsTemperature object
A8 , \field Drain Water Heat Exchanger Type
  \type choice
  \key None
  \key Ideal
  \key CounterFlow
  \key CrossFlow
  \default None
A9 , \field Drain Water Heat Exchanger Destination
  \type choice
  \key Plant
  \key Equipment
  \key PlantAndEquipment
  \default Plant
N1 , \field Drain Water Heat Exchanger U-Factor Times Area
  \type real
  \units W/K
  \minimum 0.0
A10, \field Water Use Equipment 1 Name
  \note Enter the name of a WaterUse:Equipment object.
  \required-field
  \type object-list
  \object-list WaterUseEquipmentNames
A11, \field Water Use Equipment 2 Name
  \note Enter the name of a WaterUse:Equipment object.
  \type object-list
  \object-list WaterUseEquipmentNames
<reduced for brevity>

```

Field: Name

The unique object name for reference by other objects.

Field: Inlet Node Name

The hot water inlet node when connected to a plant loop. The hot water supplies all of the WaterUse:Equipment objects that demand hot water. Insufficient supply temperature or flow results in cooler water at the tap.

Field: Outlet Node Name

The cold water outlet node, i.e. the cold water supply mains, when connected to a plant loop. The return node provides make-up water for the hot water lost down the drain.

Field: Supply Water Storage Tank Name

Reference to the WaterUse:Storage object that supplies cold water to the listed WaterUse:Equipment objects. If the field is blank, or the tank is empty, fresh water is supplied from the water mains.

Field: Reclamation Water Storage Tank Name

Reference to the WaterUse:Storage object that stores the resulting graywater from the listed WaterUse:Equipment objects. If the field is blank, the graywater is not reclaimed.

Field: Hot Water Supply Temperature Schedule Name

Reference to the schedule object specifying the hot water temperature [C]. If blank in stand-alone mode, the hot water supply temperature defaults to the cold water supply temperature. This field (even if blank) overrides the Hot Water Supply Temperature Schedule in all of the listed WaterUse:Equipment objects.

Field: Cold Water Supply Temperature Schedule Name

Reference to the schedule object specifying the cold water temperature [C] from the supply mains that provides the cold water to the tap and makes up for all water lost down the drain. If blank, water temperatures are calculated by the Site:WaterMainsTemperature object.

This field (even if blank) overrides the Cold Water Supply Temperature Schedule in all of the listed WaterUse:Equipment objects.

Field: Drain Water Heat Exchanger Type

The heat exchanger type to be used for drainwater heat recovery. None indicates no heat recovery is to be simulated. Ideal sets a heat exchanger effectiveness of 1.0. Effectiveness is calculated dynamically for CounterFlow and CrossFlow options.

One popular type of drainwater heat exchanger is the Gravity-Film Heat Exchanger (GFX). The GFX is most closely approximated with the CounterFlow option, but keep in mind that the UA varies more with flow rate for the GFX than for most traditional heat exchangers.

Field: Drain Water Heat Exchanger Destination

The heat exchanger configuration to be used for drainwater heat recovery. The configuration determines where the heat will be used after it is recovered.

Plant indicates that the all of the recovered heat will be sent to the return flow at the outlet node of the WaterUse:Connections object to preheat the make-up cold water from the water mains.

Equipment indicates that the all of the recovered heat will be used to preheat the cold water flow side of the WaterUse:Equipment objects listed *in this* WaterUse:Connections object

PlantAndEquipment indicates the recovered heat will be divided between the plant and the WaterUse:Equipment objects, as described above. This is the only option where the flow rates are equal in the drain and the heat exchanger.

Field: Drain Water Heat Exchanger U-Factor Times Area

The UA is the heat transfer coefficient [W/K] for the heat exchanger and is the product of U, the overall heat transfer coefficient, and A, the heat exchanger surface area.

Field: Water Use Equipment 1-10 Name

References to WaterUse:Equipment objects.

IDF examples:

```

WaterUse:Connections,
  Domestic Water Uses,  !- Name
  Water Eq Inlet Node,  !- Inlet Node Name
  Water Eq Outlet Node, !- Outlet Node Name
  Rainwater Storage,   !- Supply Water Storage Tank Name
  Graywater Storage,   !- Reclamation Water Storage Tank Name
  ,                    !- Hot Water Supply Temperature Schedule Name
  ,                    !- Cold Water Supply Temperature Schedule Name
  CounterFlow,         !- Drain Water Heat Exchanger Type
  Plant,               !- Drain Water Heat Exchanger Destination
  1500,                !- Drain Water Heat Exchanger U-Factor Times Area {W/K}
  Sinks,               !- Water Use Equipment 1 Name
  Showers,             !- Water Use Equipment 2 Name
  Dishwasher,         !- Water Use Equipment 3 Name
  Clotheswasher;      !- Water Use Equipment 4 Name

```

WaterUse:Connections Outputs

The following output variables are reported for the WaterUse:Connections object:

```

HVAC,Average,Water Use Connections Hot Water Mass Flow Rate [kg/s]
HVAC,Average,Water Use Connections Cold Water Mass Flow Rate [kg/s]
HVAC,Average,Water Use Connections Total Mass Flow Rate [kg/s]
HVAC,Average,Water Use Connections Drain Mass Flow Rate [kg/s]
HVAC,Average,Water Use Connections Heat Recovery Mass Flow Rate [kg/s]
HVAC,Average,Water Use Connections Hot Water Consumption Rate [m3/s]
HVAC,Average,Water Use Connections Cold Water Consumption Rate [m3/s]
HVAC,Average,Water Use Connections Total Consumption Rate [m3/s]
HVAC,Sum,Water Use Connections Hot Water Consumption [m3]
HVAC,Sum,Water Use Connections Cold Water Consumption [m3]
HVAC,Sum,Water Use Connections Total Consumption [m3]
HVAC,Average,Water Use Connections Hot Water Temperature [C]
HVAC,Average,Water Use Connections Cold Water Temperature [C]
HVAC,Average,Water Use Connections Drain Water Temperature [C]
HVAC,Average,Water Use Connections Return Water Temperature [C]
HVAC,Average,Water Use Connections Waste Water Temperature [C]
HVAC,Average,Water Use Connections Heat Recovery Water Temperature [C]
HVAC,Average,Water Use Connections Heat Recovery Effectiveness []
HVAC,Average,Water Use Connections Heat Recovery Rate [W]
HVAC,Sum,Water Use Connections Heat Recovery Energy [J]
HVAC,Sum,Water Use Connections Plant Hot Water Consumption [J]

```

Water Use Connections Hot Water Mass Flow Rate [kg/s]

The mass flow rate of hot water supplied to all equipment.

Water Use Connections Cold Water Mass Flow Rate [kg/s]

The mass flow rate of cold water supplied to all equipment.

Water Use Connections Total Mass Flow Rate [kg/s]

The total mass flow rate of water (hot + cold) supplied to all equipment.

Water Use Connections Drain Mass Flow Rate [kg/s]

The mass flow rate of drainwater from all equipment.

Water Use Connections Heat Recovery Mass Flow Rate [kg/s]

The mass flow rate of make-up water in the heat exchanger.

Water Use Connections Hot Water Consumption Rate [m3/s]

The volumetric flow rate of hot water supplied to all equipment and consumed down the drain.

Water Use Connections Cold Water Consumption Rate [m3/s]

The volumetric flow rate of cold water supplied to all equipment and consumed down the drain.

Water Use Connections Total Consumption Rate [m3/s]

The total volumetric flow rate of water (hot + cold) supplied to all equipment and consumed down the drain.

Water Use Connections Hot Water Consumption [m3]

The volume of hot water supplied to all equipment and consumed down the drain.

Water Use Connections Cold Water Consumption [m3]

The volume of cold water supplied to all equipment and consumed down the drain.

Water Use Connections Total Consumption [m3]

The total volume of water (hot+cold) supplied to all equipment and consumed down the drain.

Water Use Connections Hot Water Temperature [C]

The temperature of hot water supplied to all equipment.

Water Use Connections Cold Water Temperature [C]

The temperature of cold water supplied to all equipment.

Water Use Connections Drain Water Temperature [C]

The water temperature at the drain equal to the mixed water temperature minus any heat losses to the zone.

Water Use Connections Return Water Temperature [C]

The temperature of make-up water returned to the plant loop.

Water Use Connections Waste Water Temperature [C]

The temperature of the water leaving the heat exchanger. If no heat exchanger, the waste water temperature equals the drain water temperature.

Water Use Connections Heat Recovery Water Temperature [C]

The temperature of the water leaving the heat exchanger. If no heat exchanger, the waste water temperature equals the drain water temperature.

Water Use Connections Heat Recovery Effectiveness []

The effectiveness value of the heat exchanger.

Water Use Connections Heat Recovery Rate [W]

The heat recovered by the heat exchanger and used to preheat the cold make-up water.

Water Use Connections Heat Recovery Energy [J]

The energy recovered by the heat exchanger and used to preheat the cold make-up water.

Water Use Connections Plant Hot Water Consumption [J]

The plant loop energy consumed by the hot water used.

WaterUse:Storage

The WaterUse:Storage object is a central component for complex water systems. This object is not needed if the only use of water is directly from the mains, or utility service water. If the building model is to include any on-site collection or wells or storing and reuse of graywater,

then a WaterUse:Storage is needed. Each WaterUse:Storage can serve as a central node and make connections to numerous sources of supply or numerous components with demand. If a maximum capacity is not specified, the tank is assumed to have unlimited capacity. This is useful for sizing.

Storage tanks may handle a lot of water but show no use. This is because water usage is metered at the component level where water is “used up.” The only water a storage tank might use up is overflow water if it is discarded.

IDD specification:

```

WaterUse:Storage,
A1 , \field Name
    \required-field
    \type alpha
    \reference WaterStorageTankNames
A2 , \field Water Quality Subcategory
    \type alpha
N1 , \field Maximum Capacity
    \type real
    \units m3
    \note Defaults to unlimited capacity.
N2 , \field Initial Volume
    \type real
    \units m3
N3 , \field Design In Flow Rate
    \type real
    \units m3/s
    \note Defaults to unlimited flow.
N4 , \field Design Out Flow Rate
    \type real
    \units m3/s
    \note Defaults to unlimited flow.
A3 , \field Overflow Destination
    \type object-list
    \object-list WaterStorageTankNames
    \note If blank, overflow is discarded
A4 , \field Type of Supply Controlled by Float Valve
    \type choice
    \key None
    \key Mains
    \key GroundwaterWell
    \key OtherTank
N5 , \field Float Valve On Capacity
    \type real
    \units m3
    \note Lower range of target storage level e.g. float valve kicks on
N6 , \field Float Valve Off Capacity
    \type real
    \units m3
    \note Upper range of target storage level e.g. float valve kicks off
N7 , \field Backup Mains Capacity
    \type real
    \units m3
    \note Lower range of secondary target storage level
    \note used to keep tanks at a minimum level using
    \note mains water if well can't keep up
A5, \field Other Tank Name
    \type object-list
    \object-list WaterStorageTankNames
A6 , \field Water Thermal Mode
    \type choice
    \key ScheduledTemperature
    \key ThermalModel
A7 , \field Water Temperature Schedule Name
    \required-field
    \type object-list
    \object-list ScheduleNames
A8 , \field Ambient Temperature Indicator
    \type choice
    \key Schedule
    \key Zone
    \key Outdoors
A9 , \field Ambient Temperature Schedule Name
    \type object-list
    \object-list ScheduleNames
A10, \field Zone Name
    \type object-list
    \object-list ZoneNames
N8 , \field Tank Surface Area
    \type real
    \units m2

```

```

N9 , \field Tank U Value
      \type real
      \units W/m2-K
All; \field Tank Outside Surface Material Name
      \type object-list
      \object-list MaterialName

```

Field: Name

The unique object name for reference by other objects.

Field: Water Quality Subcategory

Describes the quality of the water contained in the tank. Used for reporting and to check that the uses and supply match the category of water quality.

Field: Maximum Capacity

The maximum volumetric capacity [m3] of the water tank. If blank, this field defaults to unlimited capacity.

Field: Initial Volume

The volume of water in the storage tank at the beginning of each simulation environmental period [m3]. This provides a starting point for the amount of water in storage.

Field: Design In Flow Rate

The design flow rate [m3/s] of fittings that provide water into the tank from external sources. In a scenario where a heavy rain fall is being harvested, the actual reclamation rate might be limited by pipe size or filtration. If blank, this field defaults to unlimited rate.

Field: Design Out Flow Rate

The design flow rate [m3/s] of fitting that withdraw water from the tank to end uses. Heavy demand (landscaping?) might be limited by pipe size or filtration. If Blank, this field defaults to unlimited rate.

Field: Overflow Destination

Name of a second WaterUse:Storage that would receive overflow. Overflow could occur if the maximum capacity is reached or if the design in flow rate is exceeded. If left blank, then the overflow is discarded and lost from the water system.

Field: Type of Supply Controlled by Float Valve

The storage tank can include the capability of modeling a float valve that will call for water to be added to the tank. This field is used to select the type of system used to respond to fill requests made by a float valve. The available options are 'None', 'Mains', 'GroundwaterWell', or 'OtherTank.' The float valve settings are described in the next two fields.

Field: Float Valve On Capacity

The volumetric capacity [m3] of the water tank when a floating valve would turn on to allow filling the tank.

Field: Float Valve Off Capacity

The volumetric capacity [m3] of the water tank when a floating valve would turn off after having been filling the tank.

Field: Backup Mains Capacity

The volumetric capacity of the tank that indicates where a secondary float valve will maintain the volume by calling for mains water. Used if the well or other tank cannot keep up with the needs of the main float valve. If left blank or equal 0.0, then there is no mains water backup.

If specified, then mains water will be drawn once the storage tank reaches this level and then the mains water will fill all the way to capacity specified in the previous field.

Field: Other Tank Name

This field contains the name of another WaterUse:Storage defined elsewhere in the input file. This field is only used if the Type of Controlled Supply field is set to 'OtherTank' and the current tank is to be configured to be supplied by a second tank in response to a float valve.

Field: Water Thermal Mode

Controls the method of determining the temperature of the water in the storage tank. The only available option at the current time is ScheduledTemperature.

Field: Water Temperature Schedule Name

Reference to the schedule object specifying the temperature [C] of the water in the tank. This takes the place of a full thermal model of the tank.

Field: Ambient Temperature Indicator

Reserved for future use. The field can be Schedule, Zone, or Outdoors.

Field: Ambient Temperature Schedule Name

Reserved for future use. Schedule name for ambient temperature when previous field is Schedule.

Field: Zone Name

Reserved for future use. Name of zone where the tank is located.

Field: Tank Surface Area

Reserved for future zone thermal model.

Field: Tank U Value

Reserved for future zone thermal model.

Field: Tank Outside Surface Material Name

Reserved for future zone thermal model.

IDF examples:

```
WaterUse:Storage,
Tower 2 water tank, !- Name
Tower water make up Holding tank, !- Water Quality Subcategory
30.0 , !- Maximum Capacity {m3}
10.0 , !- Initial Volume {m3}
20.0, !- Design In Flow Rate {m3}
20.0, !- Design Out Flow Rate {m3}
, !- Overflow Destination
Mains, !- Type of Supply Controlled by Float Valve
8.0 , !- Float Valve On Capacity {m3}
10.0, !- Float Valve Off Capacity {m3}
3.0, !- Backup Mains Capacity {m3}
, !- Other Tank Name
ScheduledTemperature , !- Water Thermal Mode
Water Tank Temp Sched , !- Water Temperature Schedule Name
, !- Ambient Temperature Indicator
, !- Ambient Temperature Schedule Name
, !- Zone Name
, !- Tank Surface Area {m2}
, !- Tank U Value {W/m2-K}
; !- Tank Outside Surface Material Name
```

WaterUse:Storage Outputs

The following output variables are available for reporting for each WaterUse:Storage object.

Storage Tank Volume [m3]

This is the volume of water stored in the storage tank

Storage Tank Net Volumetric Flow Rate [m3]

This is the net rate of flows in and out of the storage tank.

Storage Tank Inlet Volumetric Flow Rate [m3/s]

This is the rate of flows into the storage tank

Storage Tank Outlet Volumetric Flow Rate [m3]

This is the rate of flows out of the storage tank

Storage Tank Mains Water [m3/s]

This is the volume of water drawn from the mains in order to fill the tank.

Storage Tank Mains Water Volumetric Rate [m3/s]

This is the rate of water draw from the mains in order to fill the tank.

Tank Water Temperature [C]

This is the temperature of the water in the tank.

Storage Tank Overflow Volumetric Flow Rate [m3/s]

This is the rate of water flows that overflow the tank either because of limits on how fast the tank can fill or because the tank is full and cannot handle the water provided.

Storage Tank Overflow Water [m3]

This is the volume of water overflowing the tank because of limits on how fast the tank can fill or because the tank is full and cannot handle the water provided.

WaterUse:RainCollector

The WaterUse:RainCollector object is used for harvesting rainwater falling on building surfaces. The rainwater is sent to a WaterUse:Storage object. In order to use this object it is necessary to also include a Site:Precipitation object to describe the rates of rainfall.

IDD specification:

```

WaterUse:RainCollector,
  \extensible:1 - repeat last field
A1 , \field Name
  \required-field
  \type alpha
A2 , \field Storage Tank Name
  \required-field
  \type object-list
  \object-list WaterStorageTankNames
A3, \field Loss Factor Mode
  \type choice
  \key Constant
  \key Scheduled
N1 , \field Collection Loss Factor
  \type real
  \note this is the portion of rain
  \note that is lost in the process of collecting it
  \note the rain collected is one minus this factor
A4 , \field Collection Loss Factor Schedule Name
  \type object-list
  \object-list ScheduleNames
N2 , \field Maximum Collection Rate
  \type real
  \units m3/s
  \note Defaults to unlimited flow.
A5 , \field Collection Surface 1 Name
  \required-field
  \type alpha
  \type object-list
  \object-list AllShadingAndHTSurfNames
A6 , \field Collection Surface 2 Name
  \type alpha
  \type object-list
  \object-list AllShadingAndHTSurfNames
<<snipped>>
A14; \field Collection Surface 10 Name
  \type alpha
  \type object-list
  \object-list AllShadingAndHTSurfNames

```

Field: Name

The unique object name for reference by other objects.

Field: Storage Tank Name

A reference to a WaterUse:Storage object where the rainwater will be collected and stored for later use.

Field: Loss Factor Mode

The WaterUse:RainCollector model includes a loss factor that indicates the portion of incident rain that is not successfully collected. Two modes are available: Constant and Scheduled. Enter Constant in this field for the model to use a simple fixed loss factor defined in the next field. For versatility, the loss factor can follow a schedule by entering Scheduled in this field and then the name of a schedule in the second field below.

Field: Collection Loss Factor

Constant loss factor for how much of the incident rainwater is lost and not collected. The factor should be between 0 and 1.

Field: Collection Loss Factor Schedule Name

Name of a schedule that defines a variable collection loss factor if the mode is selected as Scheduled.

Field: Maximum Collection Rate

The maximum flow rate [m³/s] for rainwater collection. In a scenario where a heavy rain fall is being harvested, the actual reclamation rate might be limited by pipe size or the filtration system.

Field: Collection Surface 1-10 Name

A reference to the name of a surface object which will collect the rain. Typically the collection surfaces would correspond to roof surfaces on the building. The effective area for rainwater collection is the horizontal component (area * cosine of the slope, etc.). More detailed modeling of rainwater collection can be added later to account for factors such as wind speed and direction, etc.

IDF examples:

```
WaterUse:RainCollector,
  My Test Rain Collector ,!- Name
  My Test Tank , !- Storage Tank Name
  CONSTANT, !- Loss Factor Mode
  0.9 , !- Collection Loss Factor
  , !- Collection Loss Factor Schedule Name
  1.0 , !- Maximum Collection Rate
  SouthRoof , !- Collection Surface 1 Name
  NorthRoof1, !- Collection Surface 2 Name
  NorthRoof3 , !- Collection Surface 3 Name
  NorthRoof2 ; !- Collection Surface 4 Name
```

WaterUse:RainCollector Outputs**Rainwater Collector Volumetric Rate [m³/s]****Rainwater Collector Water [m³]**

These output variables provide the rate and volume of water collected by the WaterUse:RainCollector.

WaterUse:Well

The WaterUse:Well object is for simulating on-site water supply from a well. Well water is pumped out of the ground and into a WaterUse:Storage. The operation of the ground water well is controlled by the associated WaterUse:Storage which is assumed to be operated as a vented cistern with no pressure tank. The current implementation is very simple and only requires two numeric inputs: the rated pump flow and power. A more elaborate well model may be added and many input fields are reserved for this future expansion.

IDD specification:

```

WaterUse:Well,
  A1 , \field Name
      \required-field
      \type alpha
  A2 , \field Storage Tank Name
      \required-field
      \type object-list
      \object-list WaterStorageTankNames
  N1 , \field Pump Depth
      \type real
      \units m
  N2 , \field Pump Rated Flow Rate
      \type real
      \units m3/s
  N3 , \field Pump Rated Head
      \type real
      \units Pa
  N4 , \field Pump Rated Power Consumption
      \type real
      \units W
  N5 , \field Pump Efficiency
      \type real
  N6 , \field Well Recovery Rate
      \type real
      \units m3/s
  N7 , \field Nominal Well Storage Volume
      \type real
      \units m3
  A3 , \field Water Table Depth Mode
      \type choice
      \key Constant
      \key Scheduled
  N8 , \field Water Table Depth
      \type real
  A4 ; \field Water Table Depth Schedule Name
      \type object-list
      \object-list ScheduleNames

```

Field: Name1

Unique name of this well.

Field: Storage Tank Name

A reference to a WaterUse:Storage object where the rainwater will be collected and stored for later use.

Field: Pump Depth

Reserved for future use. Effective depth of well [m]

Field: Pump Rated Flow Rate

This is the nominal pump flow rate [m3/s]. This field is required.

Field: Pump Rated Head

Reserved for future use [Pa]. Pump head at rated conditions in Pascals.

Field: Pump Rated Power Consumption

This is the pump power at the nominal pump flow rate [W]. This field is required.

Field: Pump Efficiency

Reserved for future use.

Field: Well Recovery Rate

Reserved for future use. Rate at which ground water enters well during a sustained draw, e.g., 2 hour well test [m3/s].

Field: Nominal Well Storage Volume

Reserved for future use. Capacity in well after long period of inactivity and the usual water table depth. [m3]

Field: Water Table Depth Mode

Reserved for future use. Two options available: Constant or Scheduled

Field: Water Table Depth

Reserved for future use. Depth of water table from WaterUse:Storage

Field: Water Table Depth Schedule Name

Reserved for future use.

An example input object:

```
WaterUse:Well,
  My Test Well,  !- Name
  Tower 1 Water Tank,  !- Storage Tank Name
  ,  !- Pump Depth
  0.1,  !- Pump Rated Flow Rate {m3/s}
  ,  !- Pump Rated Head {Pa}
  120,  !- Pump Rated Power Consumption {W}
  ,  !- Pump Efficiency
  ,  !- Well Recovery Rate {m3/s}
  ,  !- Nominal Well Storage Volume {m3}
  ,  !- Water Table Depth Mode
  ,  !- Water Table Depth
  ;  !- Water Table Depth Schedule Name
```

Group – Performance Curves

This group of objects consists of polynomial curves which are used to characterize the performance of HVAC equipment. The curves are input, stored, and evaluated entirely within the CurveManager module. The curves are usually derived from fits or regressions to data covering a limited range. Results for independent variable values outside this range are likely to be invalid, so curve input always contains a range of validity (maximum and minimum permitted values) for each independent variable and can optionally have limits on the curve output. No error or warning message is issued if an independent variable is outside the range. Instead, the curve manager uses the minimum value if an independent variable is less than the minimum, and the maximum if a variable exceeds the maximum. Similarly, no error or warning message is issued if the curve output is outside the range of the optional minimum and maximum curve output limits. Instead, the curve manager uses the minimum and maximum curve limits to cap the output of the performance curve.

Curve:Linear

Input for the linear curve consists of a curve name, the two coefficients, and the maximum and minimum valid independent variable values. Optional inputs for curve minimum and maximum may be used to limit the output of the performance curve (e.g., limit extrapolation). The equation represented by the linear curve is:

$$y = C_1 + C_2 * x$$

Field: Name

A user assigned unique name for an instance of a linear curve. When a curve is used, it is referenced by this name.

Field: Coefficient1 Constant

The constant coefficient (C_1) in the equation.

Field: Coefficient2 x

The linear coefficient (C_2) in the equation.

Field: Minimum Value of x

The minimum allowable value of x. Values of x less than the minimum will be replaced by the minimum.

Field: Maximum Value of x

The maximum allowable value of x. Values of x greater than the maximum will be replaced by the maximum.

Field: Minimum Curve Output

The minimum allowable value of the evaluated curve. Values less than the minimum will be replaced by the minimum.

Field: Maximum Value of x

The maximum allowable value of the evaluated curve. Values greater than the maximum will be replaced by the maximum.

The Input Data Dictionary is shown below:

```
Curve:Linear,
  A1 , \field Name
      \required-field
      \type alpha
      \reference LinearCurves
      \reference AllCurves
      \note curve = C1 + C2*x
  N1 , \field Coefficient1 Constant
      \required-field
      \type real
  N2 , \field Coefficient2 x
      \required-field
      \type real
  N3 , \field Minimum Value of x
      \required-field
      \type real
  N4 , \field Maximum Value of x
      \required-field
      \type real
  N5 , \field Minimum Curve Output
      \type real
      \note Specify the minimum value calculated by this curve object
  N6 ; \field Maximum Curve Output
      \type real
      \note Specify the maximum value calculated by this curve object
```

Following is an example input:

```
Curve:Linear,
  Curve-Linear, ! name
  -1,           ! Coefficient1 Constant
  2,           ! Coefficient2 x
  0.0,         ! min
  1.0;         ! max
```

Curve:Quadratic

Input for a quadratic curve consists of the curve name, the three coefficients, and the maximum and minimum valid independent variable values. Optional inputs for curve minimum and maximum may be used to limit the output of the performance curve (e.g., limit extrapolation). The equation represented by the quadratic curve is:

$$y = C_1 + C_2 * x + C_3 * x^2$$

Field: Name

A user assigned unique name for an instance of a quadratic curve. When a curve is used, it is referenced by this name.

Field: Coefficient1 Constant

The constant coefficient (C_1) in the equation.

Field: Coefficient2 x

The linear coefficient (C_2) in the equation.

Field: Coefficient3 x2**

The quadratic coefficient (C_3) in the equation.

Field: Minimum Value of x

The minimum allowable value of x. Values of x less than the minimum will be replaced by the minimum.

Field: Maximum Value of x

The maximum allowable value of x. Values of x greater than the maximum will be replaced by the maximum.

Field: Minimum Curve Output

The minimum allowable value of the evaluated curve. Values less than the minimum will be replaced by the minimum.

Field: Maximum Value of x

The maximum allowable value of the evaluated curve. Values greater than the maximum will be replaced by the maximum.

The Input Data Dictionary description is shown below.

```

Curve:Quadratic,
  A1 , \field Name
        \required-field
        \type alpha
        \reference QuadraticCurves
        \reference AllCurves
        \reference QuadraticCubicCurves
        \reference BiquadraticQuadraticCubicCurves
        \note curve = C1 + C2*x + C3*x**2
  N1 , \field Coefficient1 Constant
        \required-field
        \type real
  N2 , \field Coefficient2 x
        \required-field
        \type real
  N3 , \field Coefficient3 x**2
        \required-field
        \type real
  N4 , \field Minimum Value of x
        \required-field
        \type real
  N5 , \field Maximum Value of x
        \required-field
        \type real
  N6 , \field Minimum Curve Output
        \type real
        \note Specify the minimum value calculated by this curve object
  N7 ; \field Maximum Curve Output
        \type real
        \note Specify the maximum value calculated by this curve object

```

Following is an example input.

```

Curve:Quadratic,
  WindACCBFFFF, ! name
  -2.277,        ! Coefficient1 Constant
  5.2114,        ! Coefficient2 x
  -1.9344,       ! Coefficient3 x**2
  0.0,          ! Minimum Value of x
  1.0;          ! Maximum Value of x

```

Curve:Cubic

Input for a cubic curve consists of the curve name, the 4 coefficients, and the maximum and minimum valid independent variable values. Optional inputs for curve minimum and maximum may be used to limit the output of the performance curve (e.g., limit extrapolation). The equation represented by the cubic curve is:

$$y = C_1 + C_2 * x + C_3 * x^2 + C_4 * x^3$$

Field: Name

A user assigned unique name for an instance of a cubic curve. When a curve is used, it is referenced by this name.

Field: Coefficient1 Constant

The constant coefficient (C_1) in the equation.

Field: Coefficient2 x

The linear coefficient (C_2) in the equation.

Field: Coefficient3 x2**

The quadratic coefficient (C_3) in the equation.

Field: Coefficient4 x3**

The cubic coefficient (C₄) in the equation.

Field: Minimum Value of x

The minimum allowable value of x. Values of x less than the minimum will be replaced by the minimum.

Field: Maximum Value of x

The maximum allowable value of x. Values of x greater than the maximum will be replaced by the maximum.

Field: Minimum Curve Output

The minimum allowable value of the evaluated curve. Values less than the minimum will be replaced by the minimum.

Field: Maximum Value of x

The maximum allowable value of the evaluated curve. Values greater than the maximum will be replaced by the maximum.

The Input Data Dictionary description is shown below.

```
Curve:Cubic,
  A1 , \field Name
        \required-field
        \type alpha
        \reference CubicCurves
        \reference AllCurves
        \reference QuadraticCubicCurves
        \reference BiquadraticCubicCurves
        \reference BiquadraticQuadraticCubicCurves
        \note curve = C1 + C2*x + C3*x**2 + C4*x**3
  N1 , \field Coefficient1 Constant
        \required-field
        \type real
  N2 , \field Coefficient2 x
        \required-field
        \type real
  N3 , \field Coefficient3 x**2
        \required-field
        \type real
  N4 , \field Coefficient4 x**3
        \required-field
        \type real
  N5 , \field Minimum Value of x
        \required-field
        \type real
  N6 , \field Maximum Value of x
        \required-field
        \type real
  N7 , \field Minimum Curve Output
        \type real
        \note Specify the minimum value calculated by this curve object
  N8 ; \field Maximum Curve Output
        \type real
        \note Specify the maximum value calculated by this curve object
```

Following is an input example.

```

Curve:Cubic,
  WindACEIRFPLF, ! name
  .00000273404, ! Coefficient1 Constant
  1.05259, ! Coefficient2 x
  -.0552087, ! Coefficient3 x**2
  .00262236, ! coeff4
  0.0, ! min
  1.1; ! max

```

Curve:Exponent

Input for an exponent curve consists of the curve name, the 3 coefficients, and the maximum and minimum valid independent variable values. Optional inputs for curve minimum and maximum may be used to limit the output of the performance curve (e.g., limit extrapolation). The equation represented by the exponent curve is:

$$y = C1 + C2 * x^{C3}$$

Field: Name

A user assigned unique name for an instance of an exponent curve. When a curve is used, it is referenced by this name.

Field: Coefficient1 Constant

The constant coefficient (C_1) in the equation.

Field: Coefficient2 Constant

The linear coefficient (C_2) in the equation.

Field: Coefficient3 Constant

The exponent coefficient (C_3) in the equation.

Field: Minimum Value of x

The minimum allowable value of x. Values of x less than the minimum will be replaced by the minimum.

Field: Maximum Value of x

The maximum allowable value of x. Values of x greater than the maximum will be replaced by the maximum.

Field: Minimum Curve Output

The minimum allowable value of the evaluated curve. Values less than the minimum will be replaced by the minimum.

Field: Maximum Value of x

The maximum allowable value of the evaluated curve. Values greater than the maximum will be replaced by the maximum.

The Input Data Dictionary description is shown below.

```

Curve:Exponent,
  \min-fields 6
A1 , \field Name
    \required-field
    \type alpha
    \reference ExponentCurves
    \reference AllCurves
    \note curve = C1 + C2*x**C3
    \note The independent variable x is raised to the C3 power, multiplied by C2, and C1 is added to
the result.
N1 , \field Coefficient1 Constant
    \required-field
    \type real
N2 , \field Coefficient2 Constant
    \required-field
    \type real
N3 , \field Coefficient3 Constant
    \required-field
    \type real
N4 , \field Minimum Value of x
    \required-field
    \type real
    \note Specify the minimum value of the independent variable x allowed
N5 , \field Maximum Value of x
    \required-field
    \type real
    \note Specify the maximum value of the independent variable x allowed
N6 , \field Minimum Curve Output
    \type real
    \note Specify the minimum value calculated by this curve object
N7 ; \field Maximum Curve Output
    \type real
    \note Specify the maximum value calculated by this curve object

```

Following is an input example.

```

Curve:Exponent,
! Curve = C1 + C2*x**C3, x = fan speed ratio
FanPowerExponentCurve, !- Name
0.0, !- Coefficient1 Constant
1.0, !- Coefficient2 Constant
3.0, !- Coefficient3 Constant
0.0, !- Minimum Value of x
1.5, !- Maximum Value of x
0.1, !- Minimum Curve Output
1.5; !- Maximum Curve Output

```

Curve:Bicubic

This curve type is a function of two independent variables. Input consists of the curve name, the ten coefficients, and the minimum and maximum values for each of the independent variables. Optional inputs for curve minimum and maximum may be used to limit the output of the performance curve (e.g., limit extrapolation). The equation represented by the bicubic curve is:

$$z = C_1 + C_2 * x + C_3 * x^2 + C_4 * y + C_5 * y^2 + C_6 * xy + C_7 * x^3 + C_8 * y^3 + C_9 * x^2 y + C_{10} * xy^2$$

Field: Name

A user assigned unique name for an instance of a bicubic curve. When a curve is used by another object, it is referenced by this name.

Field: Coefficient1 Constant

The constant coefficient (C_1) in the equation.

Field: Coefficient2 x

The coefficient C_2 in the equation.

Field: Coefficient3 x2**

The coefficient C_3 in the equation.

Field: Coefficient4 y

The coefficient C_4 in the equation.

Field: Coefficient5 y2**

The coefficient C_5 in the equation.

Field: Coefficient6 x*y

The coefficient C_6 in the equation.

Field: Coefficient7 x3**

The coefficient C_7 in the equation.

Field: Coefficient8 y3**

The coefficient C_8 in the equation.

Field: Coefficient9 x2*y**

The coefficient C_9 in the equation.

Field: Coefficient10 x*y2**

The coefficient C_{10} in the equation.

Field: Minimum Value of x

The minimum allowable value of x. Values of x less than this minimum will be replaced by the minimum.

Field: Maximum Value of x

The maximum allowable value of x. Values of x greater than this maximum will be replaced by the maximum.

Field: Minimum Value of y

The minimum allowable value of y. Values of y less than this minimum will be replaced by the minimum.

Field: Maximum Value of y

The maximum allowable value of y. Values of y greater than this maximum will be replaced by the maximum.

Field: Minimum Curve Output

The minimum allowable value of the evaluated curve. Values less than the minimum will be replaced by the minimum.

Field: Maximum Value of x

The maximum allowable value of the evaluated curve. Values greater than the maximum will be replaced by the maximum.

The Input Data Dictionary definition for this object is shown below.


```

Curve:Bicubic,
A1 , \field Name
    \required-field
    \type alpha
    \reference AllCurves
    \reference BicubicCurves
    \reference BicubicBiquadraticCurves
    \note curve = C1 + C2*x + C3*x**2 + C4*y + C5*y**2 + C6*x*y + C7*x**3 + C8*y**3 + C9*x**2*y
    \note + C10*x*y**2
N1 , \field Coefficient1 Constant
    \required-field
    \type real
N2 , \field Coefficient2 x
    \required-field
    \type real
N3 , \field Coefficient3 x**2
    \required-field
    \type real
N4 , \field Coefficient4 y
    \required-field
    \type real
N5 , \field Coefficient5 y**2
    \required-field
    \type real
N6 , \field Coefficient6 x*y
    \required-field
    \type real
N7 , \field Coefficient7 x**3
    \required-field
    \type real
N8 , \field Coefficient8 y**3
    \required-field
    \type real
N9 , \field Coefficient9 x**2*y
    \required-field
    \type real
N10, \field Coefficient10 x*y**2
    \required-field
    \type real
N11, \field Minimum Value of x
    \required-field
    \type real
N12, \field Maximum Value of x
    \required-field
    \type real
N13, \field Minimum Value of y
    \required-field
    \type real
N14, \field Maximum Value of y
    \required-field
    \type real
N15, \field Minimum Curve Output
    \type real
    \note Specify the minimum value calculated by this curve object
N16; \field Maximum Curve Output
    \type real
    \note Specify the maximum value calculated by this curve object

```

Below is an example input.

```

Curve:Bicubic,
Main Chiller EIRFPLR,      !- Name
7.086284E-02,             !- Coefficient1 Constant
2.787561E-03,             !- Coefficient2 x
-8.917038E-06,            !- Coefficient3 x**2
2.309734E-01,             !- Coefficient4 y
1.250442E+00,             !- Coefficient5 y**2
-2.161029E-03,            !- Coefficient6 x*y
0.000000E+00,             !- Coefficient7 x**3
-5.630094E-01,            !- Coefficient8 y**3
0.000000E+00,             !- Coefficient9 x**2*y
0.000000E+00,             !- Coefficient10 x*y**2
20.33,                    !- Minimum Value of x
35.00,                    !- Maximum Value of x
0.25,                     !- Minimum Value of y
1.01;                     !- Maximum Value of y

```

Curve:Biquadratic

This curve is a function of two independent variables. Input consists of the curve name, the six coefficients, and min and max values for each of the independent variables. Optional inputs for curve minimum and maximum may be used to limit the output of the performance curve (e.g., limit extrapolation). The equation represented by the bicubic curve is:

$$z = C_1 + C_2 * x + C_3 * x^2 + C_4 * y + C_5 * y^2 + C_6 * xy$$

Field: Name

A user assigned unique name for an instance of a biquadratic curve. When a curve is used, it is referenced by this name.

Field: Coefficient1 Constant

The constant coefficient (C_1) in the equation.

Field: Coefficient2 x

The coefficient C_2 in the equation.

Field: Coefficient3 x**2

The coefficient C_3 in the equation.

Field: Coefficient4 y

The coefficient C_4 in the equation.

Field: Coefficient5 y**2

The coefficient C_5 in the equation.

Field: Coefficient6 x*y

The coefficient C_6 in the equation.

Field: Minimum Value of x

The minimum allowable value of x. Values of x less than the minimum will be replaced by the minimum.

Field: Maximum Value of x

The maximum allowable value of x. Values of x greater than the maximum will be replaced by the maximum.

Field: Minimum Value of y

The minimum allowable value of y. Values of y less than the minimum will be replaced by the minimum.

Field: Maximum Value of y

The maximum allowable value of y. Values of y greater than the maximum will be replaced by the maximum.

Field: Minimum Curve Output

The minimum allowable value of the evaluated curve. Values less than the minimum will be replaced by the minimum.

Field: Maximum Value of x

The maximum allowable value of the evaluated curve. Values greater than the maximum will be replaced by the maximum.

The following shows the Input Data Dictionary definition of the object.

```

Curve:Biquadratic,
  A1 , \field Name
      \required-field
      \type alpha
      \reference BiquadraticCurves
      \reference AllCurves
      \reference BiquadraticCubicCurves
      \reference BiquadraticQuadraticCubicCurves
      \reference BicubicBiquadraticCurves
      \note curve = C1 + C2*x + C3*x**2 + C4*y + C5*y**2 + C6*x*y
  N1 , \field Coefficient1 Constant
      \required-field
      \type real
  N2 , \field Coefficient2 x
      \required-field
      \type real
  N3 , \field Coefficient3 x**2
      \required-field
      \type real
  N4 , \field Coefficient4 y
      \required-field
      \type real
  N5 , \field Coefficient5 y**2
      \required-field
      \type real
  N6 , \field Coefficient6 x*y
      \required-field
      \type real
  N7 , \field Minimum Value of x
      \required-field
      \type real
  N8 , \field Maximum Value of x
      \required-field
      \type real
  N9 , \field Minimum Value of y
      \required-field
      \type real
  N10, \field Maximum Value of y
      \required-field
      \type real
  N11, \field Minimum Curve Output
      \type real
      \note Specify the minimum value calculated by this curve object
  N12; \field Maximum Curve Output
      \type real
      \note Specify the maximum value calculated by this curve object

```

Below is an example input.

```

Curve:Biquadratic,
  WindACCoolCapFT, ! name
  0.942587793,      ! Coefficient1 Constant
  0.009543347,     ! Coefficient2 x
  0.000683770,     ! Coefficient3 x**2
  -0.011042676,    ! Coefficient4 y
  0.000005249,     ! Coefficient5 y**2
  -0.000009720,    ! Coefficient6 x*y
  15., 22., ! min and max of first independent variable
  29., 47.; ! min and max of second independent variable

```

Curve:QuadraticLinear

This curve is a function of two independent variables. Input consists of the curve name, the six coefficients, and min and max values for each of the independent variables. Optional inputs for curve minimum and maximum may be used to limit the output of the performance curve (e.g., limit extrapolation). The equation represented by the quadratic linear curve:

$$y = (C_1 + C_2 * x + C_3 * x^2 + C_4 * x^3) + (C_4 + C_5 * x + C_6 * x^2) * y$$

Field: Name

A user assigned unique name for an instance of a quadratic-linear curve. When a curve is used, it is referenced by this name.

Field: Coefficient1 Constant

The constant coefficient (C₁) in the equation.

Field: Coefficient2 x

The coefficient C₂ in the equation.

Field: Coefficient3 x2**

The coefficient C₃ in the equation.

Field: Coefficient4 y

The coefficient C₄ in the equation.

Field: Coefficient5 x*y

The coefficient C₅ in the equation.

Field: Coefficient6 x2*y**

The coefficient C₆ in the equation.

Field: Minimum Value of x

The minimum allowable value of x. Values of x less than the minimum will be replaced by the minimum.

Field: Maximum Value of x

The maximum allowable value of x. Values of x greater than the maximum will be replaced by the maximum.

Field: Minimum Value of y

The minimum allowable value of y. Values of y less than the minimum will be replaced by the minimum.

Field: Maximum Value of y

The maximum allowable value of y. Values of y greater than the maximum will be replaced by the maximum.

Field: Minimum Curve Output

The minimum allowable value of the evaluated curve. Values less than the minimum will be replaced by the minimum.

Field: Maximum Value of x

The maximum allowable value of the evaluated curve. Values greater than the maximum will be replaced by the maximum.

The following shows the Input Data Dictionary definition of the object.

```

Curve:QuadraticLinear,
  A1 , \field Name
      \required-field
      \type alpha
      \reference QuadraticLinearCurves
      \reference AllCurves
      \note curve = (C1 + C2*x + C3*x**2) + (C4 + C5*x + C6*x**2)*y
  N1 , \field Coefficient1 Constant
      \required-field
      \type real
  N2 , \field Coefficient2 x
      \required-field
      \type real
  N3 , \field Coefficient3 x**2
      \required-field
      \type real
  N4 , \field Coefficient4 y
      \required-field
      \type real
  N5 , \field Coefficient5 x*y
      \required-field
      \type real
  N6 , \field Coefficient6 x**2*y
      \required-field
      \type real
  N7 , \field Minimum Value of x
      \required-field
      \type real
  N8 , \field Maximum Value of x
      \required-field
      \type real
  N9 , \field Minimum Value of y
      \required-field
      \type real
  N10, \field Maximum Value of y
      \required-field
      \type real
  N11, \field Minimum Curve Output
      \type real
      \note Specify the minimum value calculated by this curve object
  N12; \field Maximum Curve Output
      \type real
      \note Specify the maximum value calculated by this curve object

```

Below is an example input.

```

Curve:QuadraticLinear,
  DischargeCurve,      !- Curve Name
  0.0,                  !- Coefficient1 Constant
  0.09,                 !- Coefficient2 x
  -0.15,                !- Coefficient3 x**2
  0.612,                !- Coefficient4 y
  -0.324,               !- Coefficient5 x*y
  -0.216,               !- Coefficient6 x**2*y
  0.0,                  !- Minimum Value of x
  1.0,                  !- Maximum Value of x
  0.0,                  !- Minimum Value of y
  9.9;                  !- Maximum Value of y

```

Curve:Triquadratic

This curve is a 2nd order polynomial function of three variable polynomial independent variables. Input consists of the curve name, the twenty seven coefficients, and min and max values for each of the independent variables. Optional inputs for curve minimum and maximum may be used to limit the output of the performance curve (e.g., limit extrapolation). The equation represented by the triquadratic curve:

$$\begin{aligned}
 CurveValue = & A_0 + A_1 * x^2 + A_2 * x + A_3 * y^2 + A_4 * y + A_5 * z^2 + A_6 * z + A_7 * x^2 y^2 + A_8 * xy + \\
 & A_9 * xy^2 + A_{10} * x^2 y + A_{11} * x^2 z^2 + A_{12} * xz + A_{13} * xz^2 + A_{14} * x^2 z + A_{15} * y^2 z^2 + \\
 & A_{16} * yz + A_{17} * yz^2 + A_{18} * y^2 z + A_{19} * x^2 y^2 z^2 + A_{20} * x^2 y^2 z + A_{21} x^2 yz^2 + A_{22} xy^2 z^2 + \\
 & A_{23} x^2 yz + A_{24} xy^2 z + A_{25} xyz^2 + A_{26} xyz
 \end{aligned}$$

Field: Coefficient1 Constant

The constant coefficient (A_0) in the equation.

Field: Coefficient2 x2**

The coefficient (A_1) in the equation.

Field: Coefficient3 x

The coefficient (A_2) in the equation.

Field: Coefficient4 y2**

The coefficient (A_3) in the equation.

Field: Coefficient5 y

The coefficient (A_4) in the equation.

Field: Coefficient6 z2**

The coefficient (A_5) in the equation.

Field: Coefficient7 z

The coefficient (A_6) in the equation.

Field: Coefficient8 x2*y**2**

The coefficient (A_7) in the equation.

Field: Coefficient9 x*y

The coefficient (A_8) in the equation.

Field: Coefficient10 x*y2**

The coefficient (A_9) in the equation.

Field: Coefficient11 x2*y**

The coefficient (A_{10}) in the equation.

Field: Coefficient12 x2*z**2**

The coefficient (A_{11}) in the equation.

Field: Coefficient13 x*z

The coefficient (A_{12}) in the equation.

Field: Coefficient14 x*z2**

The coefficient (A_{13}) in the equation.

Field: Coefficient15 x2*z**

The coefficient (A_{14}) in the equation.

Field: Coefficient16 y2*z**2**

The coefficient (A_{15}) in the equation.

Field: Coefficient17 $y*z$

The coefficient (A_{16}) in the equation.

Field: Coefficient18 $y*z2$**

The coefficient (A_{17}) in the equation.

Field: Coefficient19 $y2*z$**

The coefficient (A_{18}) in the equation.

Field: Coefficient20 $x2*y**2*z**2$**

The coefficient (A_{19}) in the equation.

Field: Coefficient21 $x2*y**2*z$**

The coefficient (A_{20}) in the equation.

Field: Coefficient22 $x2*y*z**2$**

The coefficient (A_{21}) in the equation.

Field: Coefficient23 $x*y2*z**2$**

The coefficient (A_{22}) in the equation.

Field: Coefficient24 $x2*y*z$**

The coefficient (A_{23}) in the equation.

Field: Coefficient25 $x*y2*z$**

The coefficient (A_{24}) in the equation.

Field: Coefficient26 $x*y*z2$**

The coefficient (A_{25}) in the equation.

Field: Coefficient27 $x*y*z$

The coefficient (A_{26}) in the equation.

Field: Minimum Value of x

The minimum allowable value of x. Values of x less than the minimum will be replaced by the minimum.

Field: Maximum Value of x

The maximum allowable value of x. Values of x greater than the maximum will be replaced by the maximum.

Field: Minimum Value of y

The minimum allowable value of y. Values of y less than the minimum will be replaced by the minimum.

Field: Maximum Value of y

The maximum allowable value of y. Values of y greater than the maximum will be replaced by the maximum.

Field: Minimum Value of z

The minimum allowable value of z. Values of z less than the minimum will be replaced by the minimum.

Field: Maximum Value of z

The maximum allowable value of z. Values of z greater than the maximum will be replaced by the maximum.

Field: Minimum Curve Output

The minimum allowable value of the evaluated curve. Values less than the minimum will be replaced by the minimum.

Field: Maximum Value of x

The maximum allowable value of the evaluated curve. Values greater than the maximum will be replaced by the maximum.

The data dictionary definition of the curve object is:

```

Curve:Triquadratic,
A1 , \field Name
    \required-field
    \type alpha
    \reference TriQuadraticCurves
    \reference AllCurves
    \note 2nd order polynomial in three variable polynomial (all terms)
    \note curve = a0 + a1*x**2 + a2*x + a3*y**2 + a4*y
    \note           + a5*z**2 + a6*z + a7*x**2*y**2 + a8*x*y
    \note           + a9*x*y**2 + a10*x**2*y + a11*x**2*z**2
    \note           + a12*x*z + a13*x*z**2 + a14*x**2*z + a15*y**2*z**2
    \note           + a16*y*z + a17*y*z**2 + a18*y**2*z + a19*x**2*y**2*z**2
    \note           + a20*x**2*y**2*z + a21*x**2*y*z**2 + a22*x*y**2*z**2
    \note           + a23*x**2*y*z + a24*x*y**2*z + a25*x*y*z**2 +a26*x*y*z
N1 , \field Coefficient1 Constant
    \type real
N2 , \field Coefficient2 x**2
    \type real
N3 , \field Coefficient3 x
    \type real
N4 , \field Coefficient4 y**2
    \type real
N5 , \field Coefficient5 y
    \type real
N6 , \field Coefficient6 z**2
    \type real
N7 , \field Coefficient7 z
    \type real
N8 , \field Coefficient8 x**2*y**2
    \type real
N9 , \field Coefficient9 x*y
    \type real
N10, \field Coefficient10 x*y**2
    \type real
N11, \field Coefficient11 x**2*y
    \type real
N12, \field Coefficient12 x**2*z**2
    \type real
N13, \field Coefficient13 x*z
    \type real
N14, \field Coefficient14 x*z**2
    \type real
N15, \field Coefficient15 x**2*z
    \type real
N16, \field Coefficient16 y**2*z**2
    \type real
N17, \field Coefficient17 y*z
    \type real
N18, \field Coefficient18 y*z**2
    \type real
N19, \field Coefficient19 y**2*z
    \type real
N20, \field Coefficient20 x**2*y**2*z**2
    \type real
N21, \field Coefficient21 x**2*y**2*z
    \type real
N22, \field Coefficient22 x**2*y*z**2
    \type real
N23, \field Coefficient23 x*y**2*z**2
    \type real
N24, \field Coefficient24 x**2*y*z
    \type real
N25, \field Coefficient25 x*y**2*z
    \type real
N26, \field Coefficient26 x*y*z**2
    \type real
N27, \field Coefficient27 x*y*z
    \type real
N28, \field Minimum Value of x
    \type real
N29, \field Maximum Value of x

```

```

\type real
N30, \field Minimum Value of y
\type real
N31, \field Maximum Value of y
\type real
N32, \field Minimum Value of z
\type real
N33, \field Maximum Value of z
\type real
N34, \field Minimum Curve Output
\type real
\note Specify the minimum value calculated by this curve object
N35; \field Maximum Curve Output
\type real
\note Specify the maximum value calculated by this curve object

```

Group – Fluid Properties

The Fluid Property routines in EnergyPlus have been designed for ease of use and to allow users to add refrigerant and glycol data to the input file without having to make any changes to the program code. Fluid properties are calculated by interpolating the tabulated data in the input file. The main input requirement is that in order to add a new fluid, a user must enter a full set of data. The user may determine the interval between data points according to the desired accuracy and range required. Data for a number of common fluids are available in the required format in a reference dataset so that the user may append this data to their input file. In addition, data for Water, Ethylene Glycol (in various concentrations from 0 to 90%), and Propylene Glycol (in various concentrations from 0 to 90%) are available as default values within EnergyPlus.

Each fluid is categorized as either a 'Refrigerant' or 'Glycol'. Refrigerant data is further categorized as either saturated or superheated. Saturated refrigerant data is indexed, in the input data, according to pressure and temperature i.e. the specific heat, density, enthalpy in the input data are given for a given combination of pressure and temperature. Saturated refrigerant data is indexed according to pressure and quality. In the case of saturated pressure data only a temperature index is used. Glycol data is indexed in the input data according to temperature and concentration. The input data structure for each property is essentially two-dimensional (a matrix). However, since all fluid loops are assumed to be of constant concentration, EnergyPlus internally will interpolate from input data to data for the actual concentration being used in a particular loop. This reduces internally to a one-dimensional array of data for various properties where temperature is the only variable. This saves time since it reduces all interpolations for glycols to a single dimension.

In most cases there will be combinations of index variable (e.g. some combination of pressure and temperature) at which either no data is available, or the property data is invalid/irrelevant. For example, in the superheated refrigerant data, some combinations of temperature and pressure may correspond to a state in the saturated rather than superheated region. Similarly, in the case of glycols there may be some combinations of temperature and concentration that would correspond to the frozen state. In these cases, and where data is just not available, a zero should be present in the data at these points to indicate an invalid condition. EnergyPlus uses the presence of zeros to detect invalid conditions and give warning messages.

FluidProperties:Names

The names of each fluid for which property data is given in the user input have to be specified in a FluidProperties:Names data object. If data is to be included for a given fluid, either a refrigerant or a glycol, then its name must be included in the FluidProperties:Names data.

Field: Fluid <x> Name

Each fluid name is a unique identifier that will be used in conjunction with the data statements described later in this section. The fluid name is either referred to by a component (in the case of a Refrigerant) or by another input line (in the case of a Glycol). This list is simply a list of user defined fluids present in the input data file.

Field: Fluid <x>Type

Each fluid name must be identified by type - either **Refrigerant** or **Glycol**. This designation determines what type of data EnergyPlus expects for the fluid name. If the fluid name is defined as a Refrigerant, the user must supply valid data for pressure, enthalpy, specific heat, and density in the saturated region and enthalpy and density in the superheated region. If the fluid name is defined as a Glycol, the user must supply valid data for specific heat, conductivity, viscosity, and density at various concentrations (percentage of non-water liquid) and temperatures.

```
FluidProperties:Names,
    \unique-object
    \extensible:2 repeat last two fields
    \memo list of potential fluid names/types in the input file, maximum of ten
A1, \field Fluid 1 Name
    \type alpha
A2, \field Fluid 1 Type
    \type choice
    \key Refrigerant
    \key Glycol
... same thing repeated over and over again ...
```

An example of this statement in an input data file is:

```
FluidProperties:Names,
R11, Refrigerant,
R12, Refrigerant,
R22, Refrigerant,
NH3, Refrigerant,
Steam, Refrigerant,
SaltBrine, Glycol,
NewGlycol, Glycol;
```

FluidProperties:GlycolConcentrations

This input syntax is used to specify fluids that will be used with HVAC loops such as plant and condenser loops or that could be used within particular components (if necessary). It allows the user to define a mixture of water and some other substance and the particular concentration being used. The fluid name will be referred to by the loops or components and thus used to identify which value is valid for a particular fluid at a particular temperature. A series of three inputs is required for each fluid concentration definition; this may be repeated for up to 10 fluids. Only one GlycolConcentrations input may be entered in any single EnergyPlus run.

Field: Fluid <x> Name

Each fluid name is a unique identifier that will be used to define a particular combination of water and some other substance (usually another fluid). Other input (such as loop definitions) will refer to this name, linking the other input to the proper fluid definition.

Field: Glycol <x> Name

This field refers to the substance that is being mixed with water to create the glycol. The user may either select from the two default fluids (Ethylene Glycol or Propylene Glycol) or from fluids that have been entered elsewhere in the input file. It should be noted that users must enter a complete definition of new glycols—including values for conductivity, specific heat, density, and viscosity at various concentrations and temperatures—in order for them to be used in conjunction with this statement.

Field: Glycol <x> Concentration

This field allows the user to specify the actual concentration of glycol being used for this particular fluid. A concentration of 0.0 refers to pure water. A concentration of 1.0 would denote 100% of the fluid referenced in the Glycol Name input discussed above. Users should enter this value as a decimal fraction since EnergyPlus will limit the range of valid input values to between 0.0 and 1.0.

```
FluidProperties:GlycolConcentrations,
  \unique-object
  \memo list of glycols and what concentration they are, maximum of ten
A1, \field Fluid 1 Name
  \type alpha
  \reference GlycolConcentrations
A2, \field Glycol 1 Name
  \type choice
  \key EthyleneGlycol
  \key PropyleneGlycol
  \memo or UserDefined Fluid (must show up as a glycol in FluidProperties:Names list)
N1, \field Glycol 1 Concentration
  \type real
  \minimum 0.0
  \maximum 1.0
<repeated up to 10 fluid/glycol pairs>
```

An example of this statement in an input data file is:

```
FluidProperties:GlycolConcentrations,
EthGly25Percent, EthyleneGlycol, 0.25,
ProGly40Percent, PropyleneGlycol, 0.40,
HalfAndHalf, NewBrine, 0.5;
```

FluidProperties:Temperatures

It is assumed that all fluid properties vary with temperature. A common set of temperatures is required for each set of fluid property data. Fluid property data supplied by the user must correspondingly be given at these temperatures. Since in most cases, refrigerant data can be specified at a common set of temperatures, a single set of 'FluidPropertyTemperatures' can be referenced by a number of sets of property data. This provides a more compact input structure and avoids listing the temperatures multiple times. In the case of glycol data the same set of temperatures have to be used for each set of data at a given concentration. Units for the temperatures are degrees Celsius.

Field: Name

This field is simply an unique identifier name that is used to cross reference the list of temperatures with a specific list of fluid property data. A single temperature list can be used for more than one thermal property or fluid. For example, the same temperature list can be used for the superheated enthalpy of a refrigerant and the specific heat of a glycol if appropriate.

Field(s) 1-250: Temperature

These fields (up to 250) are the temperatures at which the data for the thermal properties are to be expected. Temperatures are assumed to be in ascending order in units of Celsius.

```

FluidProperties:Temperatures,
  \memo property values for fluid properties
  \memo list of up to 250 temperatures, note that number of property values must match the number of
properties
  \memo in other words, there must be a one-to-one correspondance between the property values in this
list and
  \memo the actual properties list in other syntax
  \memo degrees C (for all temperature inputs)
  \format FluidProperty
A1, \field Name
  \type alpha
N1, \field Temperature 1
  \type real
  \units C
<repeated up for 250 temperatures>

```

An example of this statement in an input data file is:

```

FluidProperties:Temperatures,
  R11Temperatures,
  -70,-65,-60,-55,-50,-45,-40,-35,-30,-25,-20,-15,-10,-5,0,2,4,6,8,10,12,
  14,16,18,20,22,24,26,28,30,32,34,36,38,40,42,44,46,48,50,55,60,65,70,
  75,80,85,90,95,100,105,110,115,120,125,130,135,140,145,150,155,160,
  165,170,175,180,185,190,198;

```

FluidProperties:Saturated

Refrigerant property data for the saturated region is entered with the following syntax. For each set of property data a unique name, the type of property, phase and the corresponding list of temperatures have to be specified along with the property values.

Field: Name

This name identifies the fluid for which data follows in the remaining syntax. This fluid name must also be given in the fluid names list (ref: FluidProperties:Names object) as a **Refrigerant**.

Field: Fluid Property Type

This field identifies the fluid property for which data is being entered with this statement. The options for the saturated region are **Enthalpy**, **Density**, **SpecificHeat**, and **Pressure**. The units for these properties are J/kg, kg/m³, J/kg-K and Pa, respectively.

Field: Fluid Phase

In the saturated region, each property has two values: one for the saturated liquid state and one for the saturated gaseous state. Accordingly, the phase for which the saturated property data applies is specified as either **Fluid** or **FluidGas**. Data for each phase are required and are interpolated according to quality. However, in the case of saturated pressure data values for only one phase are required (i.e. can be specified with phase specified as either Fluid or FluidGas, as this is irrelevant).

Field: Temperatures Values Name

This name refers to the corresponding list of temperatures (ref: FluidProperties:Temperatures object). Each temperature in the temperature list corresponds to a data item found in the remaining fields of this syntax. The first temperature in the temperature list corresponds to the first fluid property value, the second temperature in the temperature list corresponds to the second fluid property value, etc.

Field(s) 1-250: Property Value

These fields (up to 250) are the values of the thermal property specified in the fluid property type field for the phase specified in the fluid phase field. The temperature list specified in the temperature list name field links the data with the corresponding temperatures.

```

FluidProperties:Saturated,
  \memo fluid properties for the saturated region
  \format FluidProperty
  A1, \field Name
  \reference FluidNames
  A2, \field Fluid Property Type
  \note Enthalpy Units are J/kg
  \note Density Units are kg/m3
  \note SpecificHeat Units are J/kg-K
  \note Pressure Units are Pa
  \type choice
  \key Enthalpy      ! Units are J/kg
  \key Density       ! Units are kg/m3
  \key SpecificHeat ! Units are J/kg-K
  \key Pressure      ! Units are Pa
  A3, \field Fluid Phase
  \note Fluid=saturated fluid
  \note FluidGas=saturated vapor
  \type choice
  \key Fluid         ! saturated fluid
  \key FluidGas      ! saturated vapor
  A4, \field Temperature Values Name
  \note Enter the name of a FluidProperties:Temperatures object.
  \reference FluidPropertyTemperatures
  N1, \field Property Value 1
  \type real
  <repeated up for 250 values>

```

An example of this statement in an input data file is:

```

FluidProperties:Saturated,
  R11,Enthalpy,Fluid,R11Temperatures, ! Enthalpy in J/kg
  153580,154600,156310,158580,161300,164380,167740,171330,175100,179020,183060,
  187190,191400,195680,200000,201740,203490,205240,207000,208770,210530,212310,
  214080,215870,217650,219860,221230,223030,224830,226630,228860,230250,232060,
  233860,235700,237520,239350,241180,243010,246350,249450,254080,258730,263480,
  268110,272860,277000,282410,287240,292120,297030,302000,307090,312080,317210,
  322400,327670,333020,338460,344010,349680,355500,361480,367690,374100,381060,
  388850,397280,426300;

```

FluidProperties:Superheated

The format of the data for the superheated region is similar to that of the saturated region but with the addition of the pressure for which each set of property values applies. A single temperature specification is required for each set of property data at a number of pressures.

Field: Fluid Name

This name identifies the fluid for which data follows in the remaining syntax. This fluid name must show up in the fluid names list (ref: FluidProperties:Names object) as a **Refrigerant**.

Field: Fluid Property Type

This field identifies the fluid property for which data is being entered with this statement. The options for the superheated region are **Enthalpy** and **Density**. The units for these properties are J/kg and kg/m³, respectively.

Field: Temperatures Values Name

This name refers to the corresponding list of temperatures (ref: FluidProperties:Temperatures object). Each temperature in the temperature list corresponds to a given property data item at each pressure. The first temperature in the temperature list corresponds to the first fluid property value, the second temperature in the temperature list corresponds to the second fluid property value, etc.

Field: Pressure

In the superheated region, each fluid property is indexed according to temperature and pressure. Thus, a pressure must be listed for each set of property values. The units for

pressure are Pascals (Pa). Lists of properties are various pressures and temperatures form a two-dimensional table from which EnergyPlus interpolates to find the property value at a specified temperature and pressure.

Field(s) 1-250: Property Value

These fields (up to 250) are the values of the thermal property specified in the fluid property type field for the phase specified in the fluid phase field. The temperature list specified in the temperature list name field links the data with the corresponding temperatures.

```
FluidProperties:Superheated,
  \memo fluid properties for the superheated region
  \format FluidProperty
A1, \field Fluid Name
  \reference FluidNames
A2, \field Fluid Property Type
  \note Enthalpy Units are J/kg
  \note Density Units are kg/m3
  \type choice
  \key Enthalpy      ! Units are J/kg
  \key Density      ! Units are kg/m3
A3, \field Temperature Values Name
  \note Enter the name of a FluidProperties:Temperatures object.
  \reference FluidPropertyTemperatures
N1, \field Pressure
  \note pressure for this list of properties
  \type real
  \units Pa
  \minimum> 0.0
N2, \field Property Value 1
  \type real
<repeated up for 250 values>
```

An example of this statement in an input data file is:

```
FluidProperties:Superheated,
  R11,Density,SuperR11Temperatures, ! Density in kg/m^3
  62000., !Pressure = 62000Pa
  0,0,0,0,0,0,0,0.0139,0.0134,0.0129,0.0124,0.012,0.0116,0.0112,0.0109,0.0105,
  0.0102,0.0099,0.0097,0.0094,0.0092,0.0089,0,0,0,0,0,0,0,0,0,0;
```

Glycol Fluid Type

A full data set for a glycol fluid type in EnergyPlus includes: a temperature list and lists of values for specific heat at a given concentration. Data have to be given for at least two different concentrations. The syntax lines for the property value lists are described below.

FluidProperties:Concentration

The format of the data for the glycols is similar to that of superheated refrigerants except that data at a number of concentrations is given, rather than pressures. The concentration is listed before the rest of the data and is normalized (i.e. in the range 0.0 to 1.0, rather than a percentage). Note that glycol solutions are assumed to exist in liquid form only in EnergyPlus.

Field: Fluid Name

This name identifies the fluid for which data follows in the remaining syntax. This fluid name must show up in the fluid names list (ref: FluidProperties:Names object) as a **Glycol..** Note that users should not use Water, EthyleneGlycol, or PropyleneGlycol as names since these are default fluids.

Field: Fluid Property Type

This field identifies the fluid property for which data is being entered with this statement. The required data for glycols includes **SpecificHeat** with units of J/kg-K, **Density** with units of kg/m³, **Conductivity** with units of W/m-K, and **Viscosity** with units of N-s/m².

Field: Temperatures Values Name

This name refers to the corresponding list of temperatures (ref: FluidProperties:Temperatures object). Each temperature in the temperature list corresponds to a data item found in the remaining fields of this syntax. The first temperature in the temperature list corresponds to the first fluid property value, the second temperature in the temperature list corresponds to the second fluid property value, etc.

Field: Concentration

A concentration must be listed for the values of specific heat that follow. Lists of properties are various concentrations and temperatures form a two-dimensional table from which EnergyPlus interpolates to find the property value at a specified temperature and concentration. Concentrations are specified in a normalized form (i.e. in the range 0.0 to 1.0, rather than a percentage)

Field(s) 1-250: Property Value

These fields (up to 250) are the values of the thermal property specified in the fluid property type field for the phase specified in the fluid phase field. The temperature list specified in the temperature list name field links the data with the corresponding temperatures.

```
FluidProperties:Concentration,
  \memo fluid properties for water/other fluid mixtures
  \format FluidProperty
A1, \field Fluid Name
  \reference FluidNames
  \note should not be any of the defaults (Water, EthyleneGlycol, or PropyleneGlycol)
A2, \field Fluid Property Type
  \note Density Units are kg/m3
  \note SpecificHeat Units are J/kg-K
  \note Conductivity Units are W/m-K
  \note Viscosity Units are N-s/m2
  \type choice
  \key Density      ! Units are kg/m3
  \key SpecificHeat ! Units are J/kg-K
  \key Conductivity ! Units are W/m-K
  \key Viscosity    ! Units are N-s/m2
A3, \field Temperature Values Name
  \note Enter the name of a FluidProperties:Temperatures object.
  \reference FluidPropertyTemperatures
N1, \field Concentration
  \note Glycol concentration for this list of properties entered as a fraction
  \type real
  \units dimensionless
  \minimum 0.0
  \maximum 1.0
<repeated up for 250 values>
```

An example of this statement in an input data file is:

```
FluidPropertyConcentration,
  NewGlycol,SpecificHeat ,GlycolTemperatures, ! Spec. heat in J/kg-K
  0.8, ! Concentration
  2572,2600,2627,2655,2683,2710,2738,2766,2793,2821,2849,2876,2904,2931,2959,
  2987,3014,3042,3070,3097,3125,3153,3180,3208,3236,3263,3291,3319,3346,3374,
  3402,3429,3457;
```

HVAC Template Objects

Group – HVAC Templates

This group of objects allows for the specification of simple zone thermostats and HVAC systems with automatically generated node names. The combinations of HVACTemplate objects are shown below.

For a simple ideal loads system to use for sizing and loads oriented simulations:

HVACTemplate:Thermostat
HVACTemplate:Zone:IdealLoadsAirSystem

For packaged terminal air conditioner (PTAC) systems with optional hot water boiler:

HVACTemplate:Thermostat
HVACTemplate:Zone:PTAC
HVACTemplate:Plant:HotWaterLoop (optional)
HVACTemplate:Plant:Boiler (optional)

For packaged terminal air-to-air heat pump (PTHP) systems:

HVACTemplate:Thermostat
HVACTemplate:Zone:PTHP

For direct-expansion cooling, packaged and split system simulations:

HVACTemplate:Thermostat
HVACTemplate:Zone:Unitary
HVACTemplate:System:Unitary

For direct-expansion heat pump systems:

HVACTemplate:Thermostat
HVACTemplate:Zone:Unitary
HVACTemplate:System:UnitaryHeatPump:AirToAir

For packaged variable air volume systems using direct-expansion cooling:

HVACTemplate:Thermostat
HVACTemplate:Zone:VAV
or HVACTemplate:Zone:VAV:FanPowered
HVACTemplate:System:PackagedVAV
HVACTemplate:Plant:HotWaterLoop
HVACTemplate:Plant:Boiler

For variable air volume systems with boilers and air-cooled chillers:

HVACTemplate:Thermostat
HVACTemplate:Zone:VAV
or HVACTemplate:Zone:VAV:FanPowered
HVACTemplate:System:VAV
HVACTemplate:Plant:ChilledWaterLoop
HVACTemplate:Plant:HotWaterLoop
HVACTemplate:Plant:Chiller
HVACTemplate:Plant:Boiler

For variable air volume systems with boilers and water-cooled chillers, an object related to towers is added:

HVACTemplate:Thermostat
HVACTemplate:Zone:VAV
HVACTemplate:System:VAV
or HVACTemplate:Zone:VAV:FanPowered
HVACTemplate:Plant:ChilledWaterLoop
HVACTemplate:Plant:HotWaterLoop
HVACTemplate:Plant:Chiller
HVACTemplate:Plant:Boiler
HVACTemplate:Plant:Tower

For fan coil systems with boilers and chillers:

HVACTemplate:Thermostat
HVACTemplate:Zone:FanCoil
HVACTemplate:Plant:ChilledWaterLoop
HVACTemplate:Plant:HotWaterLoop
HVACTemplate:Plant:Chiller
HVACTemplate:Plant:Boiler
HVACTemplate:Plant:Tower

The only other objects besides the HVACTemplate objects that need to be specified related to HVAC systems are:

- Schedule:Year or Schedule:Compact
- SizingPeriod objects (one for heating and one for cooling) Note: all SizingPeriod objects can be used but for simplicity in the following descriptions, we will only reference SizingPeriod:DesignDay
- SimulationControl
- Sizing:Parameters

This makes the input requirements much smaller but sacrifices some of the flexibility normally found in EnergyPlus.

HVACTemplate Processing

Unlike other EnergyPlus objects, the HVACTemplate objects are not handled by EnergyPlus directly. Instead, they are preprocessed by a program called ExpandObjects. If you use EP-Launch or RunEPlus.bat, this preprocessor step is performed automatically using the following sequence:

- 1)** The preprocessor program, ExpandObjects, reads your IDF file and converts all of the HVACTemplate objects into other EnergyPlus objects.
- 2)** The ExpandObjects program copies the original idf file with the HVACTemplate objects commented out (i.e., inserts a “!” in front of the object name and its input fields) plus all of the new objects created in Step 1 and writes a new file which is saved with the extension “expidf”. This “expidf” file may be used as a standard EnergyPlus IDF file if the extension is changed to idf; however, for safety’s sake, both filename and extension should be changed.
- 3)** The EnergyPlus simulation proceeds using the expidf file as the input stream.
- 4)** If there are error messages from EnergyPlus, they will refer to the contents of the expidf file. Specific objects referred to in error messages may exist in the original idf, but they may be objects created by ExpandObjects and only exist in the expidf. Remember that the expidf will be overwritten everytime the original idf is run using EP-Launch or RunEPlus.bat.

If you are trying to go beyond the capabilities of the HVACTemplate objects, one strategy you can use is to start your specification using the HVACTemplate objects, run EnergyPlus using EP-Launch and producing an expidf file, rename that file and start making modifications. This approach may help with getting all of the objects needed and the node names set consistently.

Users need to remember that no objects related to HVAC except for HVAC template objects are needed in the IDF file. The existence of other objects (unless specifically described in the following sections) may cause unexpected errors to occur. Sizing:Zone, Sizing:System, and Sizing:Plant objects will be generated by the corresponding HVACTemplate objects; the user does not need to create these elsewhere in the input file.

HVACTemplate:Thermostat

Each type of HVAC template zone object may reference one of these HVAC template thermostat objects. Multiple HVAC template zones can reference the same HVAC template thermostat object. The object allows the setpoints to be specified either as a constant for the entire simulation or as schedules. Referenced schedules must be defined elsewhere in the idf. Thermostat control type is dual setpoint with deadband. This object may be omitted and the user may define zone thermostat controls directly using standard EnergyPlus objects (ZoneControl:Thermostat and related objects).

Field: Name

A name used to reference this object. This name is referenced by HVACTemplate:Zone objects: i.e., HVACTemplate:Zone:IdealLoadsAirSystem, HVACTemplate:Zone:FanCoil, HVACTemplate:Zone:Unitary, HVACTemplate:Zone:VAV or HVACTemplate:Zone:VAV:FanPowered objects.

Field: Heating Setpoint Schedule Name

Enter the name of a heating setpoint schedule that has values that change at different times of the day or year. If a constant set point is needed simply leave this field blank and use the next field. The values in the schedule are in degrees C.

Field: Constant Heating Setpoint

Enter the heating setpoint temperature in degrees C if constant throughout the year. If the previous field is used this field should be left blank and will be ignored.

Field: Cooling Setpoint Schedule Name

Enter the name of a cooling setpoint schedule that has values that change at different times of the day or year. If a constant set point is needed simply leave this field blank and use the next field. The values in the schedule are in degrees C.

Field: Constant Cooling Setpoint

Enter the cooling setpoint temperature in degrees C if constant throughout the year. If the previous field is used this field should be left blank and will be ignored.

```

HVACTemplate:Thermostat,
  \min-fields 5
  \memo Zone thermostat control. Referenced schedules must be
  \memo defined elsewhere in the idf. Thermostat control type is
  \memo dual setpoint with deadband. It is not necessary to create
  \memo a thermostat object for every zone, only for each unique
  \memo set of setpoint schedules. For example, an office building
  \memo may have two thermostat objects, one for "Office" and one
  \memo for "Storage".
A1, \field Name
  \note This name is referenced by HVACTemplate:Zone:* objects
  \reference CompactHVACThermostats
A2, \field Heating Setpoint Schedule Name
  \note Leave blank if constant setpoint specified below, must enter schedule or constant setpoint
  \type object-list
  \object-list ScheduleNames
N1, \field Constant Heating Setpoint
  \note Ignored if schedule specified above, must enter schedule or constant setpoint
  \units C
A3, \field Cooling Setpoint Schedule Name
  \note Leave blank if constant setpoint specified below, must enter schedule or constant setpoint
  \type object-list
  \object-list ScheduleNames
N2; \field Constant Cooling Setpoint
  \note Ignored if schedule specified above, must enter schedule or constant setpoint
  \units C

```

And, as shown in an IDF:

```

HVACTemplate:Thermostat,
  Office Thermostat,                !- Thermostat Name
  Htg-SetP-Sch,                    !- Heating Setpoint Schedule
  ,                                  !- Constant Heating Setpoint {C}
  Clg-SetP-Sch,                    !- Cooling Setpoint Schedule
  ;                                  !- Constant Cooling Setpoint {C}

```

HVACTemplate:Zone:IdealLoadsAirSystem

This object provides an ideal system to supply conditioned air to the zone that meets all the load requirements and consumes no energy. It is often used for load calculations, an evaluation where the load components of the building are all that is being investigated, or as the first step to a more realistic model of a building.

Field: Zone Name

Enter the name of the zone. The name must match a building zone name used in the ZONE object.

Field: Template Thermostat Name

Enter the name of a HVACTemplate:Thermostat object. Multiple HVACTemplate:Zone:IdealLoadsAirSystem objects can reference the same HVACTemplate:Thermostat object which makes it easier to revise the thermostat controls for portions of a building.

When this field is blank, it has a special meaning. A blank entry means that traditional thermostat objects referencing the same zone name are used instead of HVACTemplate:Thermostat.

```

HVACTemplate:Zone:IdealLoadsAirSystem,
  \min-fields 2
  \memo Zone with ideal air system that meets heating or cooling loads
A1, \field Zone Name
  \note Zone name must match a building zone name
  \type object-list
  \object-list ZoneNames
A2; \field Template Thermostat Name
  \note Enter the name of a HVACTemplate:Thermostat object.
  \note If blank, then it is assumed that standard thermostat objects
  \note have been defined for this zone.
  \type object-list
  \object-list CompactHVACThermostats

```

And, as shown in an IDF:

```

HVACTemplate:Zone:IdealLoadsAirSystem,
RESISTIVE ZONE,           !- Zone Name
All Zones;                !- Thermostat Name

```

HVACTemplate:Zone:FanCoil

This object simulates a 4 pipe fan coil unit with hot water heating coil, chilled water cooling coil, and an outdoor air mixer. The coils are served directly by HVACTemplate:Plant:ChilledWaterLoop and HVACTemplate:Plant:HotWaterLoop objects. No HVACTemplate:System object is required. Reference ZoneHVAC:FourPipeFanCoil for more details about the fan coil model.

Field: Zone Name

Enter the name of the zone. The name must match a building zone name used in the ZONE object.

Field: Template Thermostat Name

Enter the name of a HVACTemplate:Thermostat object. Multiple COMPACT zone objects can reference the same HVACTemplate:Thermostat object which makes it easier to revise the thermostat controls for portions of a building.

When this field is blank, it has a special meaning. A blank entry means that traditional thermostat objects referencing the same zone name are used instead of HVACTemplate:Thermostat.

Field: Supply Air Maximum Flow Rate

By entering Autosize, the maximum supply air flow rate is automatically determined for the zone based on the loads experienced by the zone during the specified heating SizingPeriod:DesignDay and cooling SizingPeriod:DesignDay. Note that the zone must have a thermostat specified in order to autosize the flow rate. If a value is entered it is used as the maximum supply air flow rate into the zone. The units are in m³/s.

Field: Supply Air Sizing Factor

This input is a zone level sizing ratio. The zone design heating and cooling air flow rates and loads will be multiplied by the number input in this field when Zone Supply Air Max Flow Rate is autosized. If this field is left blank, the building level sizing factor from Sizing:Parameters will be used.

Field: Outdoor Air Method

The input must be either *Flow/Zone*, or *Flow/Person*, *Flow/Area*, *Sum*, or *Maximum*. *Flow/Zone* means that the program will use the input of the field *Outdoor Air Flow* as the zone design outdoor air flow rate. *Flow/Person* means the program will use the input from the field *Outdoor Air Flow per Person* and the maximum occupancy to calculate a zone design outdoor air flow rate. *Flow/Area* means the program will use the input from the field *Outdoor Air Flow per Zone Floor Area* to calculate a zone design outdoor air flow rate. *Sum* means

that the flows calculated from the fields *Outdoor Air Flow per Person*, *Outdoor Air Flow per Area* and *Outdoor Air Flow per Zone* will be added to obtain the zone design outdoor air flow rate. *Maximum* means that the maximum flow derived from *Outdoor Air Flow per Person*, *Outdoor Air Flow per Area* and *Outdoor Air Flow per Zone* will be used for the zone design outdoor air flow rate. The default is *Flow/Person*.

If the air handler serves more than one zone, the total outdoor air flow for the system is the sum of the zone outdoor air flows if the system outdoor air flow is autosized. Since the zones share a single outdoor air source, the amount of outdoor air actually delivered to the zone is based on the fraction of supply air delivered to the zone to the total supply air from the system. The amount of outdoor air flow is specified in units of m³/s. The default 0.00944 m³/s is 20 cfm per person

Field: Outdoor Air Flow Rate per Person

The design outdoor air flow rate per person for this zone in cubic meters per second. The default is 0.00944 (20 cfm per person). An outdoor air flow rate is calculated based on the total number of people for all People statements assigned to the zone. Occupancy schedule values are not applied. This input is used if *Outdoor Air Method* is one of *Outdoor Air Flow per Person*, *Sum*, or *Maximum*.

Field: Outdoor Air Flow Rate per Zone Floor Area

The design outdoor air volumetric flow rate per square meter of floor area (units are m³/s-m²). This input is multiplied by the zone area to obtain a flow rate. This input is used if *Outdoor Air Method* is *Flow/Area*, *Sum* or *Maximum*.

Field: Outdoor Air Flow Rate per Zone

The design outdoor air flow rate for this zone in cubic meters per second. This input field is used if *Outdoor Air Method* is *Flow/Zone*, *Sum* or *Maximum*.

Field: System Availability Schedule Name

Leave this field blank if you want the system to be available for the entire year to perform heating or cooling if called for by the thermostat. If a schedule name is specified, those times that the system is available should be specified as 1.0. Those times that the system is not available should have a zero value in the schedule specified. Fan coil systems are modeled with continuous fan operation, so this is also the supply fan operating schedule.

Field: Supply Fan Total Efficiency

Enter the total efficiency of the supply fan. This is the ratio of the power delivered to the air to the electrical input power at maximum flow. This is also the product of the fan motor efficiency and fan (impeller) efficiency. The motor efficiency is the power delivered to the shaft divided by the electrical power input to the motor. The fan efficiency is the power delivered to the air divided by the shaft power. The power delivered to the fluid is the mass flow rate of the air multiplied by the pressure rise divided by the air density. Must be greater than 0 and less than or equal to 1.

Field: Supply Fan Delta Pressure

Enter the pressure rise in Pa at full flow and standard conditions. Standard conditions are considered 20°C at sea level, 101325 Pa.

Field: Supply Fan Motor Efficiency

Enter the shaft power of the supply fan divided by the electrical power consumed. Must be greater than 0 and less than or equal to 1.

Field: Supply Fan Motor in Air Stream Fraction

Enter the fraction of the motor heat that is added to the air stream. A value of 0 means that the motor is completely outside the air stream. A value of 1 means that all of the motor heat will go into the air stream and act to cause a temperature rise. Must be between 0 and 1.

Field: Cooling Coil Type

There are two coil types available:

- ChilledWater
- ChilledWaterDetailedFlatModel

Chilled Water uses the COIL:Cooling:Water object with the DetailedAnalysis option. This is the preferred coil model for most applications. *ChilledWaterDetailedFlatModel* uses the Coil:Cooling:Water:DetailedGeometry object. This option is available for special applications. The default is *ChilledWater*.

Field: Cooling Coil Availability Schedule Name

Usually set to blank, which allows the cooling coil to be available anytime the system is operating. If a schedule name is specified, it defines when the coil is available. This is most often used when cooling is only available seasonally. A schedule value of one indicates that the cooling coil can be on during a given time period. A value of zero denotes that the cooling coil cannot be used during that time period.

Field: Cooling Coil Design Setpoint

This is the design supply air temperature in C used to size the cooling supply air flow and the cooling coil.

Field: Heating Coil Type

Only one possible value may be entered here:

- HotWater

Future versions may have additional heating coil types.

Field: Heating Coil Availability Schedule Name

Usually set to blank, which allows the heating coil to be available anytime the system is operating. If a schedule name is specified, it defines when the coil is available. This is most often used when heating is only available seasonally. The schedule values denote whether the heating coil can run during a given time period. A schedule value of one indicates that the heating coil can be on during a given time period. A value of zero denotes that the heating coil cannot be used during that time period.

Field: Heating Coil Design Setpoint

This is the design supply air temperature in C used to size the heating supply air flow and the heating coil.


```

HVACTemplate:Zone:FanCoil,
  \min-fields 19
  \memo 4 pipe fan coil unit with optional outdoor air.
A1, \field Zone Name
  \note Zone name must match a building zone name
  \type object-list
  \object-list ZoneNames
A2, \field Template Thermostat Name
  \note Enter the name of a HVACTemplate:Thermostat object.
  \note If blank, then it is assumed that standard thermostat objects
  \note have been defined for this zone.
  \type object-list
  \object-list CompactHVACThermostats
N1, \field Supply Air Maximum Flow Rate
  \autosizable
  \default Autosize
  \units m3/s
N2, \field Supply Air Sizing Factor
  \note Applicable when Zone Supply Air Maximum Flow Rate is autosized
  \note If blank, value from Sizing:Parameters will be used.
A3, \field Outdoor Air Method
  \type choice
  \key Flow/Person
  \key Flow/Zone
  \key Flow/Area
  \key Sum
  \key Maximum
  \default Flow/Person
N3, \field Outdoor Air Flow Rate per Person
  \units m3/s
  \note Default 0.00944 is 20 cfm per person
  \note This input is used if the field Outdoor Air Method is
  \note Flow/Person, Sum, or Maximum
  \default 0.00944
N4, \field Outdoor Air Flow Rate per Zone Floor Area
  \units m3/s-m2
  \default 0.0
  \note This input is used if the field Outdoor Air Method is
  \note Flow/Area, Sum, or Maximum
N5, \field Outdoor Air Flow Rate per Zone
  \type real
  \units m3/s
  \default 0.0
  \note This input is used if the field Outdoor Air Method is
  \note Flow/Zone, Sum, or Maximum
A4, \field System Availability Schedule Name
  \note If blank, always on
  \type object-list
  \object-list ScheduleNames
N6, \field Supply Fan Total Efficiency
  \minimum> 0.0
  \maximum 1.0
  \default 0.7
N7, \field Supply Fan Delta Pressure
  \units Pa
  \ip-units inH2O
  \minimum 0
  \default 75
N8, \field Supply Fan Motor Efficiency
  \minimum> 0.0
  \maximum 1.0
  \default 0.9
N9, \field Supply Fan Motor in Air Stream Fraction
  \minimum 0.0
  \maximum 1.0
  \default 1.0

```

```

A5, \field Cooling Coil Type
    \type choice
    \key ChilledWater
    \key ChilledWaterDetailedFlatModel
    \default ChilledWater
A6, \field Cooling Coil Availability Schedule Name
    \note If blank, always on
    \type object-list
    \object-list ScheduleNames
N10, \field Cooling Coil Design Setpoint
    \note Used for sizing.
    \default 14.0
    \units C
A7, \field Heating Coil Type
    \type choice
    \key HotWater
    \default HotWater
A8, \field Heating Coil Availability Schedule Name
    \note If blank, always on
    \type object-list
    \object-list ScheduleNames
N11; \field Heating Coil Design Setpoint
    \note Used for sizing.
    \default 50.0
    \units C

```

And, as shown in an IDF:

```

HVACTemplate:Zone:FanCoil,
SPACE1-1,           !- Zone Name
All Zones,         !- Thermostat Name
autosize,          !- Zone Supply Air Max Flow Rate {m3/s}
1.1,              !- Zone Supply Air Sizing Factor
Flow/Person,      !- Zone Outdoor air MethodFlow Type
0.00944,         !- Zone Outdoor air Flow Rate per Person {m3/s}
0.0               !- Zone Outdoor air Flow per Zone Area {m3/s-m2}
0.0              !- Zone Outdoor air Flow per Zone {m3/s}
FanAvailSched,    !- System Availability Schedule
0.7,             !- Supply Fan Total Efficiency
75,              !- Supply Fan Delta Pressure {Pa}
0.9,            !- Supply Fan Motor Efficiency
1,              !- Supply Fan Motor in Air Stream Fraction
ChilledWater,    !- Cooling Coil Type
,                !- Cooling Coil Availability Schedule
14,             !- Cooling Coil Design Setpoint {C}
HotWater,        !- Heating Coil Type
,               !- Heating Coil Availability Schedule
50;             !- Heating Coil Design Setpoint {C}

```

HVACTemplate:Zone:PTAC

This object simulates a packaged terminal air conditioner (PTAC) with a DX cooling coil, a heating coil (electric, gas, or hot water), and an outdoor air mixer. The optional hot water heating coil is served directly by HVACTemplate:Plant:HotWaterLoop and HVACTemplate:Plant:Boiler objects. No HVACTemplate:System object is required. Reference ZoneHVAC:PackagedTerminalAirConditioner for more details about the PTAC model.

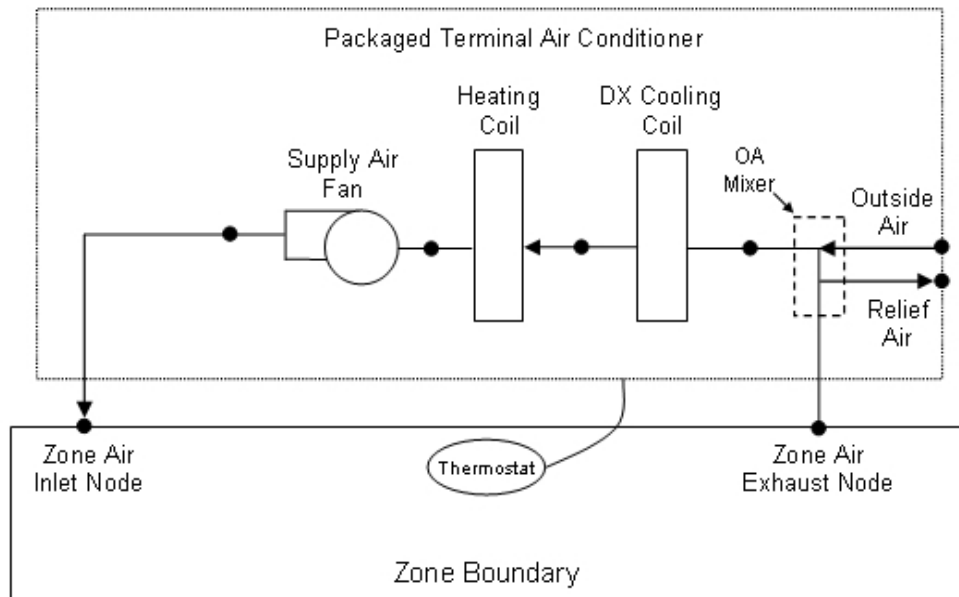


Figure 128. Schematic of a packaged terminal air conditioner with draw through fan placement

Field: Zone Name

Enter the name of the zone. The name must match a building zone name used in the ZONE object.

Field: Template Thermostat Name

Enter the name of a HVACTemplate:Thermostat object. Multiple COMPACT zone objects can reference the same HVACTemplate:Thermostat object which makes it easier to revise the thermostat controls for portions of a building.

When this field is blank, it has a special meaning. A blank entry means that traditional thermostat objects referencing the same zone name are used instead of HVACTemplate:Thermostat.

Field: Cooling Supply Air Flow Rate

This field specifies the supply air flow rate when the DX cooling coil is operating. By entering Autosize, the supply air flow rate is automatically determined based on the loads experienced by the zone during the specified cooling SizingPeriod:DesignDay. The units are in m³/s. The default is autosize.

Field: Heating Supply Air Flow Rate

This field specifies the supply air flow rate when the heating coil is operating. By entering Autosize, the supply air flow rate is automatically determined based on the loads experienced by the zone during the specified heating SizingPeriod:DesignDay. The units are in m³/s. The default is autosize.

Field: No Load Supply Air Flow Rate

This field specifies the supply air flow rate when neither cooling nor heating is required (i.e., DX coil and heater are off but the supply air fan operates). This field is only used when the supply air fan operating mode schedule specifies continuous fan operation. Values must be greater than or equal to zero, or this field is autosizable. If the air conditioner's supply air fan operating mode schedule specifies continuous fan operation and this value is set to zero or this field is left blank, then the model assumes that the supply air flow rate when no cooling/heating is needed is equal to the supply air flow rate when the cooling or heating coil was last operating (for cooling operation or heating operation). This field specifies the supply

air flow rate when the heating coil is operating. By entering Autosize, the supply air flow rate will be sized to match the smaller of the Cooling and Heating flow rates. The units are in m³/s. The default is autosize.

Field: Supply Air Sizing Factor

This input is a zone level sizing ratio. The zone design heating and cooling air flow rates and loads will be multiplied by the number input in this field when Zone Supply Air Max Flow Rate is autosized. If this field is left blank, the building level sizing factor from Sizing:Parameters will be used.

Field: Outdoor Air Method

The input must be either *Flow/Zone*, or *Flow/Person*, *Flow/Area*, *Sum*, or *Maximum*. *Flow/Zone* means that the program will use the input of the field *Outdoor Air Flow* as the zone design outdoor air flow rate. *Flow/Person* means the program will use the input from the field *Outdoor Air Flow per Person* and the maximum occupancy to calculate a zone design outdoor air flow rate. *Flow/Area* means the program will use the input from the field *Outdoor Air Flow per Zone Floor Area* to calculate a zone design outdoor air flow rate. *Sum* means that the flows calculated from the fields *Outdoor Air Flow per Person*, *Outdoor Air Flow per Area* and *Outdoor Air Flow per Zone* will be added to obtain the zone design outdoor air flow rate. *Maximum* means that the maximum flow derived from *Outdoor Air Flow per Person*, *Outdoor Air Flow per Area* and *Outdoor Air Flow per Zone* will be used for the zone design outdoor air flow rate. The default is *Flow/Person*.

If the air handler serves more than one zone, the total outdoor air flow for the system is the sum of the zone outdoor air flows if the system outdoor air flow is autosized. Since the zones share a single outdoor air source, the amount of outdoor air actually delivered to the zone is based on the fraction of supply air delivered to the zone to the total supply air from the system. The amount of outdoor air flow is specified in units of m³/s. The default 0.00944 m³/s is 20 cfm per person

Field: Outdoor Air Flow Rate per Person

The design outdoor air flow rate per person for this zone in cubic meters per second. The default is 0.00944 (20 cfm per person). An outdoor air flow rate is calculated based on the total number of people for all People statements assigned to the zone. Occupancy schedule values are not applied. This input is used if *Outdoor Air Method* is one of *Outdoor Air Flow per Person*, *Sum*, or *Maximum*.

Field: Outdoor Air Flow Rate per Zone Floor Area

The design outdoor air volumetric flow rate per square meter of floor area (units are m³/s-m²). This input is multiplied by the zone area to obtain a flow rate. This input is used if *Outdoor Air Method* is *Flow/Area*, *Sum* or *Maximum*.

Field: Outdoor Air Flow Rate per Zone

The design outdoor air flow rate for this zone in cubic meters per second. This input field is used if *Outdoor Air Method* is *Flow/Zone*, *Sum* or *Maximum*.

Field: System Availability Schedule Name

Leave this field blank if you want the system to be available for the entire year to perform heating or cooling if called for by the thermostat. If a schedule name is specified, those times that the system is available should be specified as 1.0. Those times that the system is not available should have a zero value in the schedule specified. When the fan operating mode schedule indicates continuous fan operation, the fan will operate whenever this schedule is 1.0. If the fan operating schedule indicates cycling fan operation, then fan will only cycle on as needed to meet a load.

Field: Supply Fan Operating Mode Schedule Name

This field specifies the name of the supply air fan operating mode schedule. The supply air fan operating mode may vary during the simulation based on time-of-day or with a change of season. Schedule values of 0 denote that the supply air fan and the heating or cooling coil cycle on and off together to meet the heating or cooling load (a.k.a. AUTO fan). Schedule values other than 0 denote that the supply fan runs continuously while the heating or cooling coil cycles to meet the load. The keywords *Cycling* or *Continuous* may also be used to specify a single mode of operation for the entire simulation. The default is *Cycling*.

Field: Supply Fan Placement

Enter the supply fan placement type. This alpha field has two choices, *DrawThrough* or *BlowThrough*. *DrawThrough* models a system where the supply air fan is after the cooling and heating coils. *BlowThrough* models a system where the supply air fan is before the cooling and heating coils. The default is *DrawThrough*.

Field: Supply Fan Total Efficiency

Enter the total efficiency of the supply fan. This is the ratio of the power delivered to the air to the electrical input power at maximum flow. This is also the product of the fan motor efficiency and fan (impeller) efficiency. The motor efficiency is the power delivered to the shaft divided by the electrical power input to the motor. The fan efficiency is the power delivered to the air divided by the shaft power. The power delivered to the fluid is the mass flow rate of the air multiplied by the pressure rise divided by the air density. Must be greater than 0 and less than or equal to 1. The default is 0.7.

Field: Supply Fan Delta Pressure

Enter the pressure rise in Pa at full flow and standard conditions. Standard conditions are considered 20°C at sea level, 101325 Pa. The default is 75.

Field: Supply Fan Motor Efficiency

Enter the shaft power of the supply fan divided by the electrical power consumed. Must be greater than 0 and less than or equal to 1. The default is 0.9.

Field: Cooling Coil Type

Enter the type of cooling coil. There is currently only one choices for this field, SingleSpeedDX.

Field: Cooling Coil Availability Schedule Name

Usually set to blank, which allows the cooling coil to be available anytime the system is operating. If a schedule name is specified, it defines when the coil is available. This is most often used when cooling is only available seasonally. A schedule value of 1.0 indicates that the cooling coil can be on during a given time period. A value of zero denotes that the cooling coil cannot be used during that time period.

Field: Cooling Coil Rated Capacity

Enter autosize to let the automatic sizing algorithm determine the cooling coil capacity based on the maximum cooling loads during the cooling design day. If a value is entered, it represents the full load cooling capacity, including both sensible and latent capacity, in watts of the DX coil unit at rated conditions. Rated conditions are air entering the cooling coil at the maximum supply air flow rate at 26.7°C drybulb/19.4°C wetbulb with air entering the outdoor condenser coil at 35°C drybulb. Capacity should be the "gross" capacity where the impact of supply air fan heat is NOT included. The units are in W. The default is autosize.

Field: Cooling Coil Rated Sensible Heat Ratio

Enter Autosize to allow the sizing algorithm to determine the sensible heat ratio based on the rated capacity and air flow rate. Otherwise, enter the value of the ratio of the sensible

capacity divided by total cooling capacity of the DX cooling coil at rated conditions. Rated conditions are air entering the cooling coil at the maximum supply air flow rate at 26.7°C drybulb/19.4°C wetbulb with air entering the outdoor condenser coil at 35°C drybulb. Both the sensible and total cooling capacities used to define the Rated Sensible Heat Ratio (SHR) should be “gross” capacity where the impact of supply air fan heat is NOT included. The default is autosize.

Field: Cooling Coil Rated COP

Enter the coefficient of performance defined as the gross cooling coil capacity in watts divided by electrical power input in watts of the DX cooling coil unit at rated conditions. Rated conditions are air entering the cooling coil at the maximum supply air flow rate at 26.7°C drybulb/19.4°C wetbulb with air entering the outdoor condenser coil at 35°C drybulb. The input power includes electric power for the compressor and condenser fan but does not include the power consumption of the supply air fan. The default is 3.0.

Field: Heating Coil Type

Enter the type of heating coil. The choices for this field are

- Electric
- HotWater
- Gas

If HotWater is specified, then a HVACTemplate:Plant:HotWaterLoop and a HVACTemplate:Plant:Boiler must be included in the input file to serve this hot water coil. The default is Electric.

Field: Heating Coil Availability Schedule Name

Usually set to blank, which allows the heating coil to be available anytime the system is operating. If a schedule name is specified, it defines when the coil is available. This is most often used when heating is only available seasonally. The schedule values denote whether the heating coil can run during a given time period. A schedule value of 1.0 indicates that the heating coil can be on during a given time period. A value of zero denotes that the heating coil cannot be used during that time period

Field: Heating Coil Capacity

Enter autosize to allow the sizing algorithm to determine the proper capacity required based on the loads experienced during the heating design day. If a value is specified, it is the maximum amount of heat that the coil can deliver in Watts. The default is autosize.

Field: Gas Heating Coil Efficiency

Enter gas burner efficiency as a decimal, not as a percent. A burner that is 80% efficient would have an entry of 0.8 here, which is the default. This field applies only if the heating coil type is gas.

Field: Gas Heating Coil Parasitic Electric Load

Enter the parasitic electric load associated with the gas heating coil operation, such as a combustion fan. The units are in W. This field applies only if the heating coil type is gas.

```

HVACTemplate:Zone:PTAC,
  \min-fields 26
  \memo Pacakged Terminal Air Conditioner
A1, \field Zone Name
  \note Zone name must match a building zone name
  \type object-list
  \object-list ZoneNames
A2, \field Template Thermostat Name
  \note Enter the name of a HVACTemplate:Thermostat object.
  \note If blank, then it is assumed that standard thermostat objects
  \note have been defined for this zone.
  \type object-list
  \object-list CompactHVACThermostats
N1, \field Cooling Supply Air Flow Rate
  \note Supply air flow rate during heating operation
  \type real
  \minimum> 0.0
  \autosizable
  \default Autosize
  \units m3/s
N2, \field Heating Supply Air Flow Rate
  \note Supply air flow rate during heating operation
  \type real
  \minimum> 0.0
  \autosizable
  \default Autosize
  \units m3/s
N3, \field No Load Supply Air Flow Rate
  \note Supply air flow rate when no cooling or heating is needed
  \note Only used when heat pump fan operating mode is ContinuousFanWithCyclingCompressor. This air
flow rate
  \note is used when no heating or cooling is required and the DX coil compressor is off.
  \note If this field is left blank or zero, the supply air flow rate from the previous on cycle
  \note (either cooling or heating) is used.
  \type real
  \minimum 0
  \autosizable
  \units m3/s
N4, \field Supply Air Sizing Factor
  \note Applicable when supply air flow rates are autosized
  \note If blank, value from Sizing:Parameters will be used.
A3, \field Outdoor Air Method
  \type choice
  \key Flow/Person
  \key Flow/Zone
  \key Flow/Area
  \key Sum
  \key Maximum
  \default Flow/Person
N5, \field Outdoor Air Flow Rate per Person
  \units m3/s
  \note Default 0.00944 is 20 cfm per person
  \note This input is used if the field Outdoor Air Method is
  \note Flow/Person, Sum, or Maximum
  \default 0.00944
N6, \field Outdoor Air Flow Rate per Zone Floor Area
  \units m3/s-m2
  \default 0.0
  \note This input is used if the field Outdoor Air Method is
  \note Flow/Area, Sum, or Maximum
N7, \field Outdoor Air Flow Rate per Zone
  \type real
  \units m3/s
  \default 0.0
  \note This input is used if the field Outdoor Air Method is
  \note Flow/Zone, Sum, or Maximum

```

```
A4, \field System Availability Schedule Name
\note If blank, always on
\type object-list
\object-list ScheduleNames
A5, \field Supply Fan Operating Mode Schedule Name
\note Refers to a schedule to specify unitary supply fan operating mode.
\note Schedule Name values of 0 indicate cycling fan (auto)
\note Schedule values of 1 indicate continuous fan (on)
\note Keywords "Cycling" or "Continuous" may also be used here.
\type object-list
\object-list ScheduleNames
\default Cycling
A6, \field Supply Fan Placement
\type choice
\key BlowThrough
\key DrawThrough
\default DrawThrough
N8, \field Supply Fan Total Efficiency
\minimum> 0.0
\maximum 1.0
\default 0.7
N9, \field Supply Fan Delta Pressure
\units Pa
\ip-units inH2O
\minimum 0
\default 75
N10, \field Supply Fan Motor Efficiency
\minimum> 0.0
\maximum 1.0
\default 0.9
A7, \field Cooling Coil Type
\type choice
\key SingleSpeedDX
\default SingleSpeedDX
A8, \field Cooling Coil Availability Schedule Name
\note If blank, always on
\type object-list
\object-list ScheduleNames
N11, \field Cooling Coil Rated Capacity
\note Gross capacity excluding effect of supply air fan heat
\note Rating point: air entering the cooling coil at 26.7 C dry-bulb/19.4 C wet-bulb, and
\note air entering the outdoor condenser coil at 35 C dry-bulb/23.9 C wet-bulb
\type real
\minimum> 0.0
\autosizable
\default Autosize
\units W
N12, \field Cooling Coil Rated Sensible Heat Ratio
\note Rated sensible heat ratio (gross sensible capacity/gross total capacity)
\note Sensible and total capacities do not include effect of supply fan heat
\type real
\autosizable
\minimum 0.5
\maximum 1.0
\default Autosize
N13, \field Cooling Coil Rated COP
\note Gross cooling capacity divided by power in
\note does not include supply fan heat or supply fan electrical energy input
\type real
\minimum> 0.0
\default 3.0
A9, \field Heating Coil Type
\type choice
\key Electric
\key HotWater
\key Gas
\default Electric
```



```

A10, \field Heating Coil Availability Schedule Name
     \note If blank, always on
     \type object-list
     \object-list ScheduleNames
N14, \field Heating Coil Capacity
     \autosizable
     \default Autosize
     \units W
N15, \field Gas Heating Coil Efficiency
     \note Applies only if Heating Coil Type is Gas
     \maximum 1.0
     \minimum 0.0
     \default 0.8
N16; \field Gas Heating Coil Parasitic Electric Load
     \note Applies only if Heating Coil Type is Gas
     \units W
     \ip-units W
     \minimum 0.0
     \default 0.0

```

And, as shown in an IDF:

```

HVACTemplate:Zone:PTAC,
SPACE1-1,           !- Zone Name
All Zones,         !- Thermostat Name
autosize,          !- Zone Supply Air Cooling Flow Rate {m3/s}
autosize,          !- Zone Supply Air Heating Flow Rate {m3/s}
,                 !- Zone Supply Air No-Load Flow Rate {m3/s}
,                 !- Zone Supply Air Sizing Factor
Flow/Person,      !- Zone Outdoor air Method
0.00944,          !- Zone Outdoor air Flow Rate per Person {m3/s}
,                 !- Zone Outdoor air Flow per Zone Area {m3/s-m2}
,                 !- Zone Outdoor air Flow per Zone {m3/s}
,                 !- System Availability Schedule
Cycling,          !- Supply Fan Operating Mode Schedule Name
DrawThrough,      !- Supply Fan Placement
0.7,              !- Supply Fan Total Efficiency
75,               !- Supply Fan Delta Pressure {Pa}
0.9,              !- Supply Fan Motor Efficiency
SingleSpeedDX,   !- Cooling Coil Type
,                 !- Cooling Coil Availability Schedule
autosize,        !- Cooling Coil Rated Capacity {W}
autosize,        !- Cooling Coil Rated SHR
3,               !- Cooling Coil Rated COP
Electric,        !- Heating Coil Type
,                 !- Heating Coil Availability Schedule
autosize,        !- Heating Coil Capacity {W}
0.8,             !- Gas Heating Coil Efficiency
;                !- Gas Heating Coil Parasitic Electric Load {W}

```

HVACTemplate:Zone:PTHP

This object simulates a packaged terminal air-to-air heat pump (PTHP) with a DX cooling coil, a DX air-to-air heat pump heating coil, a supplemental heating coil (electric or gas), and an outdoor air mixer. No HVACTemplate:System object is required. Reference ZoneHVAC:PackagedTerminalHeatPump for more details about the PTHP model.

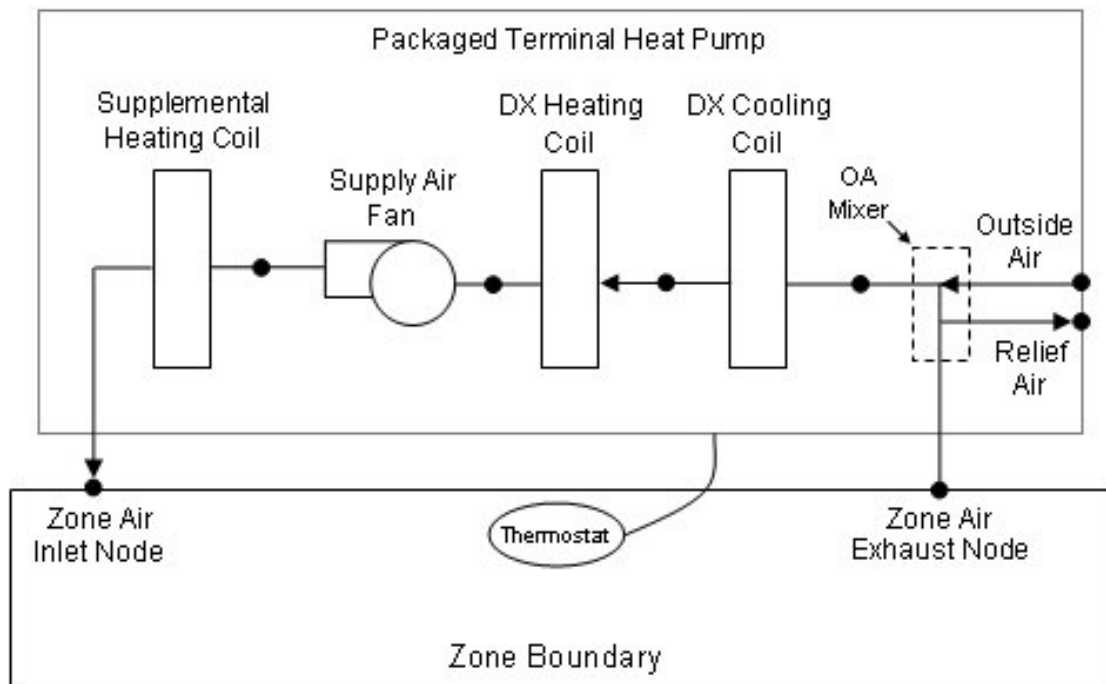


Figure 129. Schematic of a packaged terminal heat pump (draw through fan placement)

Field: Zone Name

Enter the name of the zone. The name must match a building zone name used in the ZONE object.

Field: Template Thermostat Name

Enter the name of a HVACTemplate:Thermostat object. Multiple COMPACT zone objects can reference the same HVACTemplate:Thermostat object which makes it easier to revise the thermostat controls for portions of a building.

When this field is blank, it has a special meaning. A blank entry means that traditional thermostat objects referencing the same zone name are used instead of HVACTemplate:Thermostat.

Field: Cooling Supply Air Flow Rate

This field specifies the supply air flow rate when the DX cooling coil is operating. By entering Autosize, the supply air flow rate is automatically determined based on the loads experienced by the zone during the specified cooling SizingPeriod:DesignDay. The units are in m³/s. The default is autosize.

Field: Heating Supply Air Flow Rate

This field specifies the supply air flow rate when the heating coil is operating. By entering Autosize, the supply air flow rate is automatically determined based on the loads experienced by the zone during the specified heating SizingPeriod:DesignDay. The units are in m³/s. The default is autosize.

Field: No Load Supply Air Flow Rate

This field specifies the supply air flow rate when neither cooling nor heating is required (i.e., DX coil and heater are off but the supply air fan operates). This field is only used when the supply air fan operating mode schedule specifies continuous fan operation. Values must be

greater than or equal to zero, or this field is autosizable. If the air conditioner's supply air fan operating mode schedule specifies continuous fan operation and this value is set to zero or this field is left blank, then the model assumes that the supply air flow rate when no cooling/heating is needed is equal to the supply air flow rate when the cooling or heating coil was last operating (for cooling operation or heating operation). This field specifies the supply air flow rate when the heating coil is operating. By entering Autosize, the supply air flow rate will be sized to match the smaller of the Cooling and Heating flow rates. The units are in m³/s. The default is autosize.

Field: Supply Air Sizing Factor

This input is a zone level sizing ratio. The zone design heating and cooling air flow rates and loads will be multiplied by the number input in this field when Zone Supply Air Max Flow Rate is autosized. If this field is left blank, the building level sizing factor from Sizing:Parameters will be used.

Field: Outdoor Air Method

The input must be either *Flow/Zone*, or *Flow/Person*, *Flow/Area*, *Sum*, or *Maximum*. *Flow/Zone* means that the program will use the input of the field *Outdoor Air Flow* as the zone design outdoor air flow rate. *Flow/Person* means the program will use the input from the field *Outdoor Air Flow per Person* and the maximum occupancy to calculate a zone design outdoor air flow rate. *Flow/Area* means the program will use the input from the field *Outdoor Air Flow per Zone Floor Area* to calculate a zone design outdoor air flow rate. *Sum* means that the flows calculated from the fields *Outdoor Air Flow per Person*, *Outdoor Air Flow per Area* and *Outdoor Air Flow per Zone* will be added to obtain the zone design outdoor air flow rate. *Maximum* means that the maximum flow derived from *Outdoor Air Flow per Person*, *Outdoor Air Flow per Area* and *Outdoor Air Flow per Zone* will be used for the zone design outdoor air flow rate. The default is *Flow/Person*.

If the air handler serves more than one zone, the total outdoor air flow for the system is the sum of the zone outdoor air flows if the system outdoor air flow is autosized. Since the zones share a single outdoor air source, the amount of outdoor air actually delivered to the zone is based on the fraction of supply air delivered to the zone to the total supply air from the system. The amount of outdoor air flow is specified in units of m³/s. The default 0.00944 m³/s is 20 cfm per person

Field: Outdoor Air Flow Rate per Person

The design outdoor air flow rate per person for this zone in cubic meters per second. The default is 0.00944 (20 cfm per person). An outdoor air flow rate is calculated based on the total number of people for all People statements assigned to the zone. Occupancy schedule values are not applied. This input is used if *Outdoor Air Method* is one of *Outdoor Air Flow per Person*, *Sum*, or *Maximum*.

Field: Outdoor Air Flow Rate per Zone Floor Area

The design outdoor air volumetric flow rate per square meter of floor area (units are m³/s-m²). This input is multiplied by the zone area to obtain a flow rate. This input is used if *Outdoor Air Method* is *Flow/Area*, *Sum* or *Maximum*.

Field: Outdoor Air Flow Rate per Zone

The design outdoor air flow rate for this zone in cubic meters per second. This input field is used if *Outdoor Air Method* is *Flow/Zone*, *Sum* or *Maximum*.

Field: System Availability Schedule Name

Leave this field blank if you want the system to be available for the entire year to perform heating or cooling if called for by the thermostat. If a schedule name is specified, those times that the system is available should be specified as 1.0. Those times that the system is not available should have a zero value in the schedule specified. When the fan operating mode

schedule indicates continuous fan operation, the fan will operate whenever this schedule is 1.0. If the fan operating schedule indicates cycling fan operation, then fan will only cycle on as needed to meet a load.

Field: Supply Fan Operating Mode Schedule Name

This field specifies the name of the supply air fan operating mode schedule. The supply air fan operating mode may vary during the simulation based on time-of-day or with a change of season. Schedule values of 0 denote that the supply air fan and the heating or cooling coil cycle on and off together to meet the heating or cooling load (a.k.a. AUTO fan). Schedule values other than 0 denote that the supply fan runs continuously while the heating or cooling coil cycles to meet the load. The keywords *Cycling* or *Continuous* may also be used to specify a single mode of operation for the entire simulation. The default is *Cycling*.

Field: Supply Fan Placement

Enter the supply fan placement type. This alpha field has two choices, *DrawThrough* or *BlowThrough*. *DrawThrough* models a system where the supply air fan is after the cooling and heating coils. *BlowThrough* models a system where the supply air fan is before the cooling and heating coils. The default is *DrawThrough*.

Field: Supply Fan Total Efficiency

Enter the total efficiency of the supply fan. This is the ratio of the power delivered to the air to the electrical input power at maximum flow. This is also the product of the fan motor efficiency and fan (impeller) efficiency. The motor efficiency is the power delivered to the shaft divided by the electrical power input to the motor. The fan efficiency is the power delivered to the air divided by the shaft power. The power delivered to the fluid is the mass flow rate of the air multiplied by the pressure rise divided by the air density. Must be greater than 0 and less than or equal to 1. The default is 0.7.

Field: Supply Fan Delta Pressure

Enter the pressure rise in Pa at full flow and standard conditions. Standard conditions are considered 20° C at sea level, 101325 Pa. The default is 75.

Field: Supply Fan Motor Efficiency

Enter the shaft power of the supply fan divided by the electrical power consumed. Must be greater than 0 and less than or equal to 1. The default is 0.9.

Field: Cooling Coil Type

Enter the type of cooling coil. There is currently only one choices for this field, SingleSpeedDX.

Field: Cooling Coil Availability Schedule Name

Usually set to blank, which allows the cooling coil to be available anytime the system is operating. If a schedule name is specified, it defines when the coil is available. This is most often used when cooling is only available seasonally. A schedule value of 1.0 indicates that the cooling coil can be on during a given time period. A value of zero denotes that the cooling coil cannot be used during that time period.

Field: Cooling Coil Rated Capacity

Enter autosize to let the automatic sizing algorithm determine the cooling coil capacity based on the maximum cooling loads during the cooling design day. If a value is entered, it represents the full load cooling capacity, including both sensible and latent capacity, in watts of the DX coil unit at rated conditions. Rated conditions are air entering the cooling coil at the maximum supply air flow rate at 26.7°C drybulb/19.4°C wetbulb with air entering the outdoor condenser coil at 35°C drybulb. Capacity should be the "gross" capacity where the impact of supply air fan heat is NOT included. The units are in W. The default is autosize.

Field: Cooling Coil Rated Sensible Heat Ratio

Enter Autosize to allow the sizing algorithm to determine the sensible heat ratio based on the rated capacity and air flow rate. Otherwise, enter the value of the ratio of the sensible capacity divided by total cooling capacity of the DX cooling coil at rated conditions. Rated conditions are air entering the cooling coil at the maximum supply air flow rate at 26.7°C drybulb/19.4°C wetbulb with air entering the outdoor condenser coil at 35°C drybulb. Both the sensible and total cooling capacities used to define the Rated Sensible Heat Ratio (SHR) should be “gross” capacity where the impact of supply air fan heat is NOT included. The default is autosize.

Field: Cooling Coil Rated COP

Enter the coefficient of performance defined as the gross cooling coil capacity in watts divided by electrical power input in watts of the DX cooling coil unit at rated conditions. Rated conditions are air entering the cooling coil at the maximum supply air flow rate at 26.7°C drybulb/19.4°C wetbulb with air entering the outdoor condenser coil at 35°C drybulb. The input power includes electric power for the compressor and condenser fan but does not include the power consumption of the supply air fan. The default is 3.0.

Field: Heat Pump Heating Coil Type

Enter the type of heat pump heating coil. There is currently only one choices for this field, SingleSpeedDXHeatPump.

Field: Heat Pump Heating Coil Availability Schedule Name

Usually set to blank, which allows the heat pump heating coil to be available anytime the system is operating. If a schedule name is specified, it defines when the coil is available. This is most often used when heating is only available seasonally. A schedule value of 1.0 indicates that the heat pump heating coil can be on during a given time period. A value of zero denotes that the heat pump heating coil cannot be used during that time period.

Field: Heat Pump Heating Coil Rated Capacity

Enter autosize to let the automatic sizing algorithm determine the heat pump heating coil capacity based on the maximum heating loads during the heating design day. If a value is entered, it represents the full load heating capacity, in watts of the DX heat pump unit at rated conditions. Rated conditions are air entering the heat pump heating coil at the heating supply air flow rate at 21.11°C drybulb/15.55°C wetbulb with air entering the outdoor coil at 8.33°C drybulb/6.11C wetbulb. Capacity should be the “gross” capacity where the impact of supply air fan heat is NOT included. The units are in W. The default is autosize.

Field: Heat Pump Heating Coil Rated COP

Enter the coefficient of performance defined as the gross heating coil capacity in watts divided by electrical power input in watts of the DX heating coil unit at rated conditions. Rated conditions are air entering the heat pump heating coil at the heating supply air flow rate at 21.11°C drybulb/15.55°C wetbulb with air entering the outdoor coil at 8.33°C drybulb/6.11C wetbulb. The input power includes electric power for the compressor and condenser fan but does not include the power consumption of the supply air fan. The default is 2.75.

Field: Heat Pump Heating Minimum Outdoor Dry-Bulb Temperature

This numeric field defines the minimum outdoor dry-bulb temperature in degrees Celsius for PTHP compressor operation. The compressor will not operate (for DX heating or DX cooling) when outdoor dry-bulb temperatures fall below this value. The minimum value must be greater than or equal to -20 °C. The default value is -8°C.

Field: Heat Pump Defrost Maximum Outdoor Dry-Bulb Temperature

This numeric field defines the outdoor air dry-bulb temperature above which outdoor coil defrosting is disabled. The temperature for this input field must be greater than or equal to 0 C and less than or equal to 7.22 C. If this input field is left blank, the default value is 5 C.

Field: Heat Pump Defrost Strategy

This alpha field has two choices: *ReverseCycle* or *Resistive*. If the *ReverseCycle* strategy is selected, the heating cycle is reversed periodically to provide heat to melt frost accumulated on the outdoor coil. If a *Resistive* defrost strategy is selected, the frost is melted using an electric resistance heater. If this input field is left blank, the default defrost strategy is *ReverseCycle*.

Field: Heat Pump Defrost Control

This alpha field has two choices: *Timed* or *OnDemand*. If *Timed* control is selected, the defrost time period is calculated based on a fixed value or compressor runtime whether or not frost has actually accumulated. For *Timed* defrost control, the fractional amount of time the unit is in defrost is entered in the input field "Defrost Time Period Fraction" described below. If *OnDemand* defrost control is selected, the defrost time period is calculated based on outdoor weather (humidity ratio) conditions. Regardless of which defrost control is selected, defrost does not occur above the user specified outdoor temperature entered in the input field "Heat Pump Defrost Maximum Outdoor Dry-Bulb Temperature" described above. If this input field is left blank, the default defrost control is *Timed*.

Field: Heat Pump Defrost Time Period Fraction

This numeric field defines the fraction of compressor runtime when the defrost cycle is active, and only applies to "timed" defrost (see Heat Pump Defrost Control input field above). For example, if the defrost cycle is active for 3.5 minutes for every 60 minutes of compressor runtime, then the user should enter $3.5/60 = 0.058333$. The value for this input field must be greater than or equal to 0. If this input field is left blank, the default value is 0.058333.

Field: Supplemental Heating Coil Type

Enter the type of supplemental heating coil. The choices for this field are

- Electric
- Gas

The default is Electric.

Field: Supplemental Heating Coil Availability Schedule Name

Usually set to blank, which allows the supplemental heating coil to be available anytime the system is operating. If a schedule name is specified, it defines when the coil is available. This is most often used when supplemental heating is only available seasonally. The schedule values denote whether the supplemental heating coil can run during a given time period. A schedule value of 1.0 indicates that the supplemental heating coil can be on during a given time period. A value of zero denotes that the supplemental heating coil cannot be used during that time period

Field: Supplemental Heating Coil Capacity

Enter autosize to allow the sizing algorithm to determine the proper capacity required based on the loads experienced during the heating design day. If a value is specified, it is the maximum amount of heat that the supplemental heating coil can deliver in Watts. The default is autosize.

Field: Supplemental Heating Coil Maximum Outdoor Dry-Bulb Temperature

This numeric field defines the outdoor air dry-bulb temperature above which the supplemental heating coil is disabled. The temperature for this input field must be less than or equal to 21 C. If this input field is left blank, the default value is 21 C.

Field: Supplemental Gas Heating Coil Efficiency

Enter supplemental heating coil gas burner efficiency as a decimal, not as a percent. A burner that is 80% efficient would have an entry of 0.8 here, which is the default. This field applies only if the supplemental heating coil type is gas.

Field: Supplemental Gas Heating Coil Parasitic Electric Load

Enter the parasitic electric load associated with the gas supplemental heating coil operation, such as a combustion fan. The units are in W. The default is 0.0. This field applies only if the supplemental heating coil type is gas.

```

HVACTemplate:Zone:PTHP,
  \min-fields 36
  \memo Packaged Terminal Heat Pump
A1, \field Zone Name
  \note Zone name must match a building zone name
  \type object-list
  \object-list ZoneNames
A2, \field Template Thermostat Name
  \note Enter the name of a HVACTemplate:Thermostat object.
  \note If blank, then it is assumed that standard thermostat objects
  \note have been defined for this zone.
  \type object-list
  \object-list CompactHVACThermostats
N1, \field Cooling Supply Air Flow Rate
  \note Supply air flow rate during heating operation
  \type real
  \minimum> 0.0
  \autosizable
  \default Autosize
  \units m3/s
N2, \field Heating Supply Air Flow Rate
  \note Supply air flow rate during heating operation
  \type real
  \minimum> 0.0
  \autosizable
  \default Autosize
  \units m3/s
N3, \field No Load Supply Air Flow Rate
  \note Supply air flow rate when no cooling or heating is needed
  \note Only used when heat pump fan operating mode is ContinuousFanWithCyclingCompressor. This air
flow rate
  \note is used when no heating or cooling is required and the DX coil compressor is off.
  \note If this field is left blank or zero, the supply air flow rate from the previous on cycle
  \note (either cooling or heating) is used.
  \type real
  \minimum 0
  \autosizable
  \units m3/s
N4, \field Supply Air Sizing Factor
  \note Applicable when supply air flow rates are autosized
  \note If blank, value from Sizing:Parameters will be used.

```

```

A3, \field Outdoor Air Method
\type choice
\key Flow/Person
\key Flow/Zone
\key Flow/Area
\key Sum
\key Maximum
\default Flow/Person
N5, \field Outdoor Air Flow Rate per Person
\units m3/s
\note Default 0.00944 is 20 cfm per person
\note This input is used if the field Outdoor Air Method is
\note Flow/Person, Sum, or Maximum
\default 0.00944
N6, \field Outdoor Air Flow Rate per Zone Floor Area
\units m3/s-m2
\default 0.0
\note This input is used if the field Outdoor Air Method is
\note Flow/Area, Sum, or Maximum
N7, \field Outdoor Air Flow Rate per Zone
\type real
\units m3/s
\default 0.0
\note This input is used if the field Outdoor Air Method is
\note Flow/Zone, Sum, or Maximum
A4, \field System Availability Schedule Name
\note If blank, always on
\type object-list
\object-list ScheduleNames
A5, \field Supply Fan Operating Mode Schedule Name
\note Refers to a schedule to specify unitary supply fan operating mode.
\note Schedule values of 0 indicate cycling fan (auto)
\note Schedule values of 1 indicate continuous fan (on)
\note Keywords "Cycling" or "Continuous" may also be used here.
\type object-list
\object-list ScheduleNames
\default Cycling
A6, \field Supply Fan Placement
\type choice
\key BlowThrough
\key DrawThrough
\default DrawThrough
N8, \field Supply Fan Total Efficiency
\minimum> 0.0
\maximum 1.0
\default 0.7
N9, \field Supply Fan Delta Pressure
\units Pa
\ip-units inH2O
\minimum 0
\default 75
N10, \field Supply Fan Motor Efficiency
\minimum> 0.0
\maximum 1.0
\default 0.9
A7, \field Cooling Coil Type
\type choice
\key SingleSpeedDX
\default SingleSpeedDX
A8, \field Cooling Coil Availability Schedule Name
\note If blank, always on
\type object-list
\object-list ScheduleNames

```



```
N11, \field Cooling Coil Rated Capacity
\note Gross capacity excluding effect of supply air fan heat
\note Rating point: air entering the cooling coil at 26.7 C dry-bulb/19.4 C wet-bulb, and
\note air entering the outdoor condenser coil at 35 C dry-bulb/23.9 C wet-bulb
\type real
\minimum> 0.0
\autosizable
\default Autosize
\units W
N12, \field Cooling Coil Rated Sensible Heat Ratio
\note Rated sensible heat ratio (gross sensible capacity/gross total capacity)
\note Sensible and total capacities do not include effect of supply fan heat
\type real
\autosizable
\minimum 0.5
\maximum 1.0
\default Autosize
N13, \field Cooling Coil Rated COP
\note Gross cooling capacity divided by power in
\note does not include supply fan heat or supply fan electrical energy input
\type real
\minimum> 0.0
\default 3.0
A9, \field Heat Pump Heating Coil Type
\type choice
\key SingleSpeedDXHeatPump
\default SingleSpeedDXHeatPump
A10, \field Heat Pump Heating Coil Availability Schedule Name
\note If blank, always on
\type object-list
\object-list ScheduleNames
N14, \field Heat Pump Heating Coil Rated Capacity
\note Capacity excluding supply air fan heat
\note Rating point outdoor dry-bulb temp 8.33 C, outdoor wet-bulb temp 6.11 C
\note Rating point heating coil entering air dry-bulb 21.11 C, coil entering wet-bulb 15.55 C
\type real
\units W
\minimum> 0.0
\autosizable
\default Autosize
\units W
N15, \field Heat Pump Heating Coil Rated COP
\note Heat Pump Heating Coil Rate Capacity divided by power in
\note Does not include supply air fan heat or supply air fan electrical energy
\note Rating point outdoor dry-bulb temp 8.33 C, outdoor wet-bulb temp 6.11 C
\note Rating point heating coil entering air dry-bulb 21.11 C, coil entering wet-bulb 15.55 C
\minimum> 0.0
\default 2.75
N16, \field Heat Pump Heating Minimum Outdoor Dry-Bulb Temperature
\type real
\minimum -20.0
\default -8.0
\units C
N17, \field Heat Pump Defrost Maximum Outdoor Dry-Bulb Temperature
\type real
\minimum 0.0
\maximum 7.22
\default 5.0
\units C
A11, \field Heat Pump Defrost Strategy
\type choice
\key ReverseCycle
\key Resistive
\default ReverseCycle
```

```
A12, \field Heat Pump Defrost Control
    \type choice
    \key Timed
    \key OnDemand
    \default Timed
N18, \field Heat Pump Defrost Time Period Fraction
    \type real
    \minimum 0.0
    \default 0.058333
    \note Fraction of time in defrost mode
    \note only applicable if Timed defrost control is specified
A13, \field Supplemental Heating Coil Type
    \type choice
    \key Electric
    \key Gas
    \default Electric
A14, \field Supplemental Heating Coil Availability Schedule Name
    \note If blank, always on
    \type object-list
    \object-list ScheduleNames
N19, \field Supplemental Heating Coil Capacity
    \autosizable
    \default Autosize
    \units W
N20, \field Supplemental Heating Coil Maximum Outdoor Dry-Bulb Temperature
    \type real
    \maximum 21.0
    \default 21.0
    \units C
    \note Supplemental heater will not operate when outdoor temperature exceeds this value.
N21, \field Supplemental Gas Heating Coil Efficiency
    \note Applies only if Supplemental Heating Coil Type is Gas
    \maximum 1.0
    \minimum 0.0
    \default 0.8
N22; \field Supplemental Gas Heating Coil Parasitic Electric Load
    \note Applies only if Supplemental Heating Coil Type is Gas
    \units W
    \ip-units W
    \minimum 0.0
    \default 0.0
```

And, as shown in an IDF:

```

HVACTemplate:Zone:PTHP,
SPACE1-1,           !- Zone Name
All Zones,         !- Thermostat Name
autosize,          !- Zone Supply Air Cooling Flow Rate {m3/s}
autosize,          !- Zone Supply Air Heating Flow Rate {m3/s}
,                 !- Zone Supply Air No-Load Flow Rate {m3/s}
,                 !- Zone Supply Air Sizing Factor
Flow/Person,       !- Zone Outdoor air Method
0.00944,          !- Zone Outdoor air Flow Rate per Person {m3/s}
,                 !- Zone Outdoor air Flow per Zone Area {m3/s-m2}
,                 !- Zone Outdoor air Flow per Zone {m3/s}
,                 !- System Availability Schedule
Cycling,           !- Supply Fan Operating Mode
DrawThrough,       !- Supply Fan Placement
0.7,              !- Supply Fan Total Efficiency
75,               !- Supply Fan Delta Pressure {Pa}
0.9,              !- Supply Fan Motor Efficiency
SingleSpeedDX,    !- Cooling Coil Type
,                 !- Cooling Coil Availability Schedule
autosize,          !- Cooling Coil Rated Capacity {W}
autosize,          !- Cooling Coil Rated SHR
3,                !- Cooling Coil Rated COP
SingleSpeedDXHeatPump, !- Heat Pump Heating Coil Type
,                 !- Heat Pump Heating Coil Availability Schedule
autosize,          !- Heat Pump Heating Coil Rated Capacity {W}
2.75,             !- Heat Pump Heating Coil Rated COP
-8,               !- Heat Pump Heating Min Outdoor Dry-Bulb Temperature {C}
5,                !- Heat Pump Defrost Max Outdoor Dry-Bulb Temperature {C}
ReverseCycle,     !- Heat Pump Defrost Strategy
Timed,            !- Heat Pump Defrost Control
0.058333,        !- Heat Pump Defrost Time Period Fraction
Electric,         !- Supplemental Heating Coil Type
,                 !- Supplemental Heating Coil Availability Schedule
autosize,          !- Supplemental Heating Coil Capacity {W}
21,               !- Supplemental Heating Coil Max Outdoor Dry-Bulb Temperature {C}
0.8,              !- Supplemental Gas Heating Coil Efficiency
;                 !- Supplemental Gas Heating Coil Parasitic Electric Load {W}

```

HVACTemplate:Zone:Unitary

This object simulates the zone portion of a constant volume direct-expansion based HVAC configuration with several different heating options. Often a single HVACTemplate:Zone:Unitary object will be used with a single HVACTemplate:System:Unitary object to simulate single zone direct-expansion based air conditioning systems. In addition, multiple HVACTemplate:Zone:Unitary objects may appear that all reference the same HVACTemplate:System:Unitary object in a multiple zone version. For a multizone system, only one zone is specified as the control zone (see HVACTemplate:System:Unitary for more information). Direct expansion includes single packaged rooftop systems commonly seen in commercial applications and split systems commonly seen in residential applications.

Field: Zone Name

Enter the name of the zone. The name must match a building zone name used in the ZONE object.

Field: Template Unitary System Name

Enter the name of the HVACTemplate:System:Unitary object serving this zone.

Field: Template Thermostat Name

Enter the name of a HVACTemplate:Thermostat object. Multiple HVACTemplate zone objects can reference the same HVACTemplate:Thermostat object which makes it easier to revise the thermostat controls for portions of a building.

When this field is blank, it has a special meaning. A blank entry means that traditional thermostat objects referencing the same zone name are used instead of HVACTemplate:Thermostat.

Field: Supply Air Maximum Flow Rate

By entering Autosize, the maximum supply air flow rate is automatically determined for the zone based on the loads experienced by the zone during the specified heating SizingPeriod:DesignDay and cooling SizingPeriod:DesignDay. Note that the zone must have a thermostat specified in order to autosize the flow rate, even if it is not the control zone in a multiple zone unitary system. If a value is entered it is used as the maximum supply air flow rate into the zone. The HVACTemplate:System:Unitary object that is referenced also allows the specification of supply air flow. If the value is specified at the system level it should be consistent with the sum of the zone values. The units are in m³/s.

Field: Supply Air Sizing Factor

This input is a zone level sizing ratio. The zone design heating and cooling air flow rates and loads will be multiplied by the number input in this field when Supply Air Maximum Flow Rate is autosized. If this field is left blank, the building level sizing factor from Sizing:Parameters will be used.

Field: Outdoor Air Method

The input must be either *Flow/Zone*, or *Flow/Person*, *Flow/Area*, *Sum*, or *Maximum*. *Flow/Zone* means that the program will use the input of the field *Outdoor Air Flow* as the zone design outdoor air flow rate. *Flow/Person* means the program will use the input from the field *Outdoor Air Flow per Person* and the maximum occupancy to calculate a zone design outdoor air flow rate. *Flow/Area* means the program will use the input from the field *Outdoor Air Flow per Zone Floor Area* to calculate a zone design outdoor air flow rate. *Sum* means that the flows calculated from the fields *Outdoor Air Flow per Person*, *Outdoor Air Flow per Area* and *Outdoor Air Flow per Zone* will be added to obtain the zone design outdoor air flow rate. *Maximum* means that the maximum flow derived from *Outdoor Air Flow per Person*, *Outdoor Air Flow per Area* and *Outdoor Air Flow per Zone* will be used for the zone design outdoor air flow rate. The default is *Flow/Person*.

If the air handler serves more than one zone, the total outdoor air flow for the system is the sum of the zone outdoor air flows if the system outdoor air flow is autosized. Since the zones share a single outdoor air source, the amount of outdoor air actually delivered to the zone is based on the fraction of supply air delivered to the zone to the total supply air from the system. The amount of outdoor air flow is specified in units of m³/s. The default 0.00944 m³/s is 20 cfm per person

Field: Outdoor Air Flow Rate per Person

The design outdoor air flow rate per person for this zone in cubic meters per second. The default is 0.00944 (20 cfm per person). An outdoor air flow rate is calculated based on the total number of people for all People statements assigned to the zone. Occupancy schedule values are not applied. This input is used if *Outdoor Air Method* is one of *Outdoor Air Flow per Person*, *Sum*, or *Maximum*.

Field: Outdoor Air Flow Rate per Zone Floor Area

The design outdoor air volumetric flow rate per square meter of floor area (units are m³/s-m²). This input is multiplied by the zone area to obtain a flow rate. This input is used if *Outdoor Air Method* is *Flow/Area*, *Sum* or *Maximum*.

Field: Outdoor Air Flow Rate per Zone

The design outdoor air flow rate for this zone in cubic meters per second. This input field is used if *Outdoor Air Method* is *Flow/Zone*, *Sum* or *Maximum*.

Field: Supply Plenum Name

This field allows the user to specify a supply plenum which serves only this zone. The plenum zone is added to the supply air path after the system splitter or system-level supply plenum and before the zone terminal unit. Set to blank if no AirLoopHVAC:SupplyPlenum is to be modeled. If a AirLoopHVAC:SupplyPlenum is modeled, it must be modeled as a zone with surfaces, and the name of the plenum zone should be entered here.

Field: Return Plenum Name

This field allows the user to specify a return plenum which serves only this zone. The plenum zone is added to the return air path immediately after the zone and before the system mixer or system-level return plenum. Set to blank if no zone return plenum is to be modeled. If a zone return plenum is modeled, it must be modeled as a zone with surfaces, and the name of the plenum zone should be entered here.

Field: Baseboard Heating Type

This field specifies the availability of thermostatically controlled baseboard heat in this zone. The choices are:

- HotWater
- Electric
- None

The default choice is None.

Field: Baseboard Heating Availability Schedule Name

Leave this field blank if you want the baseboard heating to be available for the entire year to perform heating if called for by the thermostat. If a schedule name is specified, those times that the baseboard heating is available should be specified as 1.0. Those times that the baseboard heating is not available should have a zero value in the schedule. Please note that this is not a schedule of when the baseboard is providing heat but a schedule of when it can provide heat.

Field: Baseboard Heating Capacity

Enter autosize to allow the sizing algorithm to determine the proper capacity required based on the loads experienced during the heating design day. If a value is specified, it is the maximum amount of heat that the baseboard heating can deliver in Watts. Note that EnergyPlus autosizing will autosize the baseboard heating to meet the full heating load of the zone, regardless of the heating capability of the unitary air handling system. The baseboard heating will be set to heating priority 2, which means it will meet any remaining heating load not met by the unitary system.

```
HVACTemplate:Zone:Unitary,
  \min-fields 14
  \memo Zone terminal unit, constant volume, no controls.
A1, \field Zone Name
  \note Zone name must match a building zone name
  \type object-list
  \object-list ZoneNames
A2, \field Template Unitary System Name
  \note Enter the name of a HVACTemplate:System:Unitary object serving this zone
  \type object-list
  \object-list CompactHVACSystemUnitary
```

```

A3, \field Template Thermostat Name
    \note Enter the name of a HVACTemplate:Thermostat object.
    \note If blank, then it is assumed that standard thermostat objects
    \note have been defined for this zone.
    \type object-list
    \object-list CompactHVACThermostats
N1, \field Supply Air Maximum Flow Rate
    \autosizable
    \default Autosize
    \units m3/s
N2, \field Supply Air Sizing Factor
    \note Applicable when Supply Air Maximum Flow Rate is autosized
    \note If blank, value from SizingParameters will be used.
A4, \field Outdoor Air Method
    \type choice
    \key Flow/Person
    \key Flow/Zone
    \key Flow/Area
    \key Sum
    \key Maximum
    \default Flow/Person
N3, \field Outdoor Air Flow Rate per Person
    \units m3/s
    \note Default 0.00944 is 20 cfm per person
    \note This input is used if the field Outdoor Air Method is
    \note Flow/Person, Sum, or Maximum
    \default 0.00944
N4, \field Outdoor Air Flow Rate per Zone Floor Area
    \units m3/s-m2
    \default 0.0
    \note This input is used if the field Outdoor Air Method is
    \note Flow/Area, Sum, or Maximum
N5, \field Outdoor Air Flow Rate per Zone
    \type real
    \units m3/s
    \default 0.0
    \note This input is used if the field Outdoor Air Method is
    \note Flow/Zone, Sum, or Maximum
A5, \field Supply Plenum Name
    \note Plenum zone name. Supply plenum runs through only this zone.
    \note Blank if none.
    \type object-list
    \object-list ZoneNames
A6, \field Return Plenum Name
    \note Plenum zone name. Return plenum runs through only this zone.
    \note Blank if none.
    \type object-list
    \object-list ZoneNames
A7, \field Baseboard Heating Type
    \type choice
    \key HotWater
    \key Electric
    \key None
    \default None
A8, \field Baseboard Heating Availability Schedule Name
    \note If blank, always on
    \type object-list
    \object-list ScheduleNames
N6; \field Baseboard Heating Capacity
    \autosizable
    \default Autosize
    \units W

```

And, as shown in an IDF:

```

HVACTemplate:Zone:Unitary,
SPACE1-1,           !- Zone Name
Furnace DX 1-1,    !- Air Handling System Name
All Zones,         !- Thermostat Name
autosize,          !- Zone Supply Air Max Flow Rate {m3/s}
1.1,              !- Zone Supply Air Sizing Factor
Flow/Person,       !- Zone Outdoor air MethodFlow Type
0.00944,          !- Zone Outdoor air Flow Rate per Person {m3/s}
0.0               !- Zone Outdoor air Flow per Zone Area {m3/s-m2}
0.0               !- Zone Outdoor air Flow per Zone {m3/s}
,                 !- Zone Supply Plenum Name
,                 !- Zone Return Plenum Name
None,             !- Baseboard Heating Type
,                 !- Baseboard Heating Availability Schedule
0.0;              !- Baseboard Heating Capacity {W}

```

HVACTemplate:Zone:VAV

This object simulates the zone portion of a variable air volume HVAC configuration with several different heating options. Multiple HVACTemplate:Zone:VAV or HVACTemplate:Zone:VAV:FanPowered objects are usually specified for each HVACTemplate:System:VAV object. Reheat is specified at the zone level. Reference SINGLE DUCT:VAV:REHEAT and SINGLE DUCT:VAV:NOREHEAT for more details about VAV terminal units.

Field: Zone Name

Enter the name of the zone. The name must match a building zone name used in the ZONE object.

Field: Template VAV System Name

Enter the name of the HVACTemplate:System:VAV object serving this zone.

Field: Template Thermostat Name

Enter the name of a HVACTemplate:Thermostat object. Multiple COMPACT zone objects can reference the same HVACTemplate:Thermostat object which makes it easier to revise the thermostat controls for portions of a building.

When this field is blank, it has a special meaning. A blank entry means that traditional thermostat objects referencing the same zone name are used instead of HVACTemplate:Thermostat.

Field: Supply Air Maximum Flow Rate

By entering Autosize, the maximum supply air flow rate is automatically determined for the zone based on the loads experienced by the zone during the specified heating SizingPeriod:DesignDay and cooling SizingPeriod:DesignDay. If a value is entered it is used as the maximum supply air flow rate into the zone. The HVACTemplate:System:VAV object that is referenced also allows the specification of supply air flow. If the value is specified at the system level it should be consistent with sum of the zone values. The units are in m3/s.

Field: Supply Air Sizing Factor

This input is a zone level sizing ratio. The zone design heating and cooling air flow rates and loads will be multiplied by the number input in this field when Supply Air Maximum Flow Rate is autosized. If this field is left blank, the building level sizing factor from Sizing:Parameters will be used.

Field: Supply Air Minimum Flow Fraction

Enter the fraction that the VAV box can reduce to based on the supply air maximum flow rate.

Field: Outdoor Air Method

The input must be either *Flow/Zone*, or *Flow/Person*, *Flow/Area*, *Sum*, or *Maximum*. *Flow/Zone* means that the program will use the input of the field *Outdoor Air Flow* as the zone design outdoor air flow rate. *Flow/Person* means the program will use the input from the field *Outdoor Air Flow per Person* and the maximum occupancy to calculate a zone design outdoor air flow rate. *Flow/Area* means the program will use the input from the field *Outdoor Air Flow per Zone Floor Area* to calculate a zone design outdoor air flow rate. *Sum* means that the flows calculated from the fields *Outdoor Air Flow per Person*, *Outdoor Air Flow per Area* and *Outdoor Air Flow per Zone* will be added to obtain the zone design outdoor air flow rate. *Maximum* means that the maximum flow derived from *Outdoor Air Flow per Person*, *Outdoor Air Flow per Area* and *Outdoor Air Flow per Zone* will be used for the zone design outdoor air flow rate. The default is *Flow/Person*.

If the air handler serves more than one zone, the total outdoor air flow for the system is the sum of the zone outdoor air flows if the system outdoor air flow is autosized. Since the zones share a single outdoor air source, the amount of outdoor air actually delivered to the zone is based on the fraction of supply air delivered to the zone to the total supply air from the system. The amount of outdoor air flow is specified in units of m³/s. The default 0.00944 m³/s is 20 cfm per person

Field: Outdoor Air Flow Rate per Person

The design outdoor air flow rate per person for this zone in cubic meters per second. The default is 0.00944 (20 cfm per person). An outdoor air flow rate is calculated based on the total number of people for all People statements assigned to the zone. Occupancy schedule values are not applied. This input is used if *Outdoor Air Method* is one of *Outdoor Air Flow per Person*, *Sum*, or *Maximum*.

Field: Outdoor Air Flow Rate per Zone Floor Area

The design outdoor air volumetric flow rate per square meter of floor area (units are m³/s-m²). This input is multiplied by the zone area to obtain a flow rate. This input is used if *Outdoor Air Method* is *Flow/Area*, *Sum* or *Maximum*.

Field: Outdoor Air Flow Rate per Zone

The design outdoor air flow rate for this zone in cubic meters per second. This input field is used if *Outdoor Air Method* is *Flow/Zone*, *Sum* or *Maximum*.

Field: Reheat Coil Type

A reheat coil may be added to the VAV box with this field. The choices are:

- HotWater
- Electric
- None

The default choice is None.

Field: Reheat Coil Availability Schedule Name

Leave this field blank if you want the reheat coil to be available for the entire year to perform heating if called for by the thermostat. If a schedule name is specified, those times that the coil is available should be specified as 1.0. Those times that the coil is not available should have a zero value in the schedule specified. Please note that this is not a schedule of when the coil is providing heat but a schedule of when it can provide heat.

Field: Damper Heating Action

The VAV box flow rate can be controlled in one of two ways during heating operation:

- Normal
- Reverse

Under “Normal” operation, the supply air flow into the zone is the minimum air flow rate of the VAV system during heating, essentially acting like a constant volume system during heating. Under “Reverse” the air flow rate through the VAV box may increase above the minimum air flow when the heating demand cannot be satisfied unless greater air flow is provided. The default value is Normal.

Field: Supply Plenum Name

This field allows the user to specify a supply plenum which serves only this zone. The plenum zone is added to the supply air path after the system splitter or system-level supply plenum and before the zone terminal unit. Set to blank if no AirLoopHVAC:SupplyPlenum is to be modeled. If a AirLoopHVAC:SupplyPlenum is modeled, it must be modeled as a zone with surfaces, and the name of the plenum zone should be entered here.

Field: Return Plenum Name

This field allows the user to specify a return plenum which serves only this zone. The plenum zone is added to the return air path immediately after the zone and before the system mixer or system-level return plenum. Set to blank if no zone return plenum is to be modeled. If a zone return plenum is modeled, it must be modeled as a zone with surfaces, and the name of the plenum zone should be entered here.

Field: Baseboard Heating Type

This field specifies the availability of thermostatically controlled baseboard heat in this zone. The choices are:

- HotWater
- Electric
- None

The default choice is None.

Field: Baseboard Heating Availability Schedule Name

Leave this field blank if you want the baseboard heating to be available for the entire year to perform heating if called for by the thermostat. If a schedule name is specified, those times that the baseboard heating is available should be specified as 1.0. Those times that the baseboard heating is not available should have a zero value in the schedule. Please note that this is not a schedule of when the baseboard is providing heat but a schedule of when it can provide heat.

Field: Baseboard Heating Capacity

Enter autosize to allow the sizing algorithm to determine the proper capacity required based on the loads experienced during the heating design day. If a value is specified, it is the maximum amount of heat that the baseboard heating can deliver in Watts. Note that EnergyPlus autosizing will autosize the baseboard heating to meet the full heating load of the zone, regardless of the heating capability of the VAV air handling system. The baseboard heating will be set to heating priority 2, which means it will meet any remaining heating load not met by the VAV system.

```

HVACTemplate:Zone:VAV,
  \min-fields 18
  \memo Zone terminal unit, variable volume, reheat optional.
  \memo Referenced schedules must be defined elsewhere in the idf.
A1, \field Zone Name
  \note Zone name must match a building zone name
  \type object-list
  \object-list ZoneNames
A2, \field Template VAV System Name
  \note Name of a HVACTemplate:System:VAV object serving this zone
  \type object-list
  \object-list CompactHVACSystemVAV
A3, \field Template Thermostat Name
  \note Enter the name of a HVACTemplate:Thermostat object.
  \note If blank, then it is assumed that standard thermostat objects
  \note have been defined for this zone.
  \type object-list
  \object-list CompactHVACThermostats
N1, \field Supply Air Maximum Flow Rate
  \autosizable
  \default Autosize
  \units m3/s
N2, \field Supply Air Sizing Factor
  \note Applicable when Supply Air Maximum Flow Rate is autosized
  \note If blank, value from Sizing:Parameters will be used.
N3, \field Supply Air Minimum Flow Fraction
  \minimum 0.0
  \maximum 1.0
A4, \field Outdoor Air Method
  \type choice
  \key Flow/Person
  \key Flow/Zone
  \key Flow/Area
  \key Sum
  \key Maximum
  \default Flow/Person
N4, \field Outdoor Air Flow Rate per Person
  \units m3/s
  \note Default 0.00944 is 20 cfm per person
  \note This input is used if the field Outdoor Air Method is
  \note Flow/Person, Sum, or Maximum
  \default 0.00944
N5, \field Outdoor Air Flow Rate per Zone Floor Area
  \units m3/s-m2
  \default 0.0
  \note This input is used if the field Outdoor Air Method is
  \note Flow/Area, Sum, or Maximum
N6, \field Outdoor Air Flow Rate per Zone
  \type real
  \units m3/s
  \default 0.0
  \note This input is used if the field Outdoor Air Method is
  \note Flow/Zone, Sum, or Maximum
A5, \field Reheat Coil Type
  \type choice
  \key HotWater
  \key Electric
  \key None
  \default None
A6, \field Reheat Coil Availability Schedule Name
  \note If blank, always on
  \type object-list
  \object-list ScheduleNames
A7, \field Heating Damper Action
  \type choice
  \key Normal
  \key Reverse
  \default Normal

```

```

A8, \field Supply Plenum Name
    \note Plenum zone name. Supply plenum runs through only this zone.
    \note Blank if none.
    \type object-list
    \object-list ZoneNames
A9, \field Return Plenum Name
    \note Plenum zone name. Return plenum runs through only this zone.
    \note Blank if none.
    \type object-list
    \object-list ZoneNames
A10, \field Baseboard Heating Type
    \type choice
    \key HotWater
    \key Electric
    \key None
    \default None
A11, \field Baseboard Heating Availability Schedule Name
    \note If blank, always on
    \type object-list
    \object-list ScheduleNames
N7; \field Baseboard Heating Capacity
    \autosizable
    \default Autosize
    \units W

```

And, as shown in an IDF:

```

HVACTemplate:Zone:VAV,
SPACE1-1,           !- Zone Name
VAV Sys 1,          !- Air Handling System Name
All Zones,         !- Thermostat Name
autosize,          !- Zone Supply Air Max Flow Rate {m3/s}
1.1,              !- Zone Supply Air Sizing Factor
0.3,              !- Zone Supply Air Min Flow Fraction
Flow/Person,      !- Zone Outdoor air MethodFlow Type
0.00944,          !- Zone Outdoor air Flow Rate per Person {m3/s}
0.0               !- Zone Outdoor air Flow per Zone Area {m3/s-m2}
0.0               !- Zone Outdoor air Flow per Zone {m3/s}
HotWater,         !- Reheat Coil Type
,                 !- Reheat Coil Availability Schedule
Reverse,          !- Zone Damper Heating Action
,                 !- Zone Supply Plenum Name
,                 !- Zone Return Plenum Name
HotWater,         !- Baseboard Heating Type
,                 !- Baseboard Heating Availability Schedule
autosize;         !- Baseboard Heating Capacity {W}

```

HVACTemplate:Zone:VAV:FanPowered

This object simulates the zone portion of a variable air volume HVAC configuration with a series or parallel fan powered terminal unit (also know as a powered induction unit or PIU) and several different heating options. Multiple HVACTemplate:Zone:VAV or HVACTemplate:Zone:VAV:FanPowered objects are usually specified for each HVACTemplate:System:VAV object. Reheat is specified at the zone level.

The series powered induction unit is an air system terminal unit that mixes varying amounts of secondary (recirculated) air and primary (conditioned supply) air to produce a fixed flow of air to a zone. The unit contains a small fan that acts to induce the secondary air and a heating coil for heating the mixed secondary and primary air. The fan runs at a constant volume flow rate whenever the unit is on. The fan is downstream of the primary and secondary air inlets. The variable mixing is accomplished by a damper in the unit's primary air supply inlet duct. This damper can move from fully open (100% primary air. 0% secondary air) to a minimum stop that is specified in the input description. At full cooling the damper will be fully open. At minimum cooling and for heating the damper will be at the minimum stop and the secondary air flow will be at its maximum. Reference object AirTerminal:SingleDuct:SeriesPIU:Reheat for more details.

The parallel powered induction unit is an air system terminal unit that mixes varying amounts of secondary (recirculated) air and primary (conditioned supply) air to produce a variable total flow of air to a zone. The unit contains a small fan that acts to induce the secondary air and a heating coil for heating the mixed secondary and primary air. The secondary and primary air streams enter the unit in parallel. The fan sits in the secondary air stream and runs only when secondary air is needed. The primary air inlet contains a damper that can move from fully open (maximum primary air) to a minimum stop (minimum primary air). At full cooling load the primary air damper is fully open and the fan is off. The primary air flow is at maximum and there is little or no secondary air flow. As the cooling load decreases, the primary air damper gradually closes and the secondary air flow remains close to zero. At some point, usually when the primary air flow has reached the minimum, the fan switches on and secondary air is induced. The heating coil will switch on as needed to meet any heating demand. Reference object AirTerminal:SingleDuct:ParallelPIU:Reheat for more details.

Field: Zone Name

Enter the name of the zone. The name must match a building zone name used in the ZONE object.

Field: Template VAV System Name

Enter the name of the HVACTemplate:System:VAV object serving this zone.

Field: Template Thermostat Name

Enter the name of a HVACTemplate:Thermostat object. Multiple HVACTemplate zone objects can reference the same HVACTemplate:Thermostat object which makes it easier to revise the thermostat controls for portions of a building.

When this field is blank, it has a special meaning. A blank entry means that traditional thermostat objects referencing the same zone name are used instead of HVACTemplate:Thermostat.

Field: Primary Supply Air Maximum Flow Rate

In a fan powered VAV terminal unit, the primary air flow is the air supplied by the central air handler. By entering Autosize, the maximum primary supply air flow rate is automatically determined for the zone based on the loads experienced by the zone during the specified and cooling SizingPeriod:DesignDay. If a value is entered it is used as the maximum supply air flow rate into the zone. The HVACTemplate:System:VAV object that is referenced also allows the specification of supply air flow. If the value is specified at the system level it should be consistent with sum of the zone values. The units are in m³/s.

Field: Supply Air Sizing Factor

This input is a zone level sizing ratio. The zone design heating and cooling air flow rates and loads will be multiplied by the number input in this field when Supply Air Maximum Flow Rate is autosized. If this field is left blank, the building level sizing factor from Sizing:Parameters will be used.

Field: Primary Supply Air Minimum Flow Fraction

Enter the fraction that the VAV box can reduce to based on the primary supply air maximum flow rate. This field may be sized automatically by entering Autosize.

Field: Secondary Supply Air Minimum Flow Fraction

In a fan powered VAV terminal unit, the secondary air flow is the air taken from the zone by the terminal unit fan. By entering Autosize, the maximum secondary supply air flow rate is automatically determined for the zone based on the loads experienced by the zone during the specified heating SizingPeriod:DesignDay. The units are in m³/s.

Field: Flow Type

This field specifies the type of fan powered unit (PIU). The choices for this field are:

- *Series*
- *Parallel*

See descriptions of these configurations in the general description for this object, above.

Field: Parallel Fan On Flow Fraction

For parallel PIUs, this field specifies the fraction of the primary air flow at which fan turns on. In the parallel PIU the fan operation is intermittent. If the primary air flow is above this fraction of the maximum, the fan is off. Otherwise it is on. This field does not apply to series PIUs.

Field: Outdoor Air Method

The input must be either *Flow/Zone*, or *Flow/Person*, *Flow/Area*, *Sum*, or *Maximum*. *Flow/Zone* means that the program will use the input of the field *Outdoor Air Flow* as the zone design outdoor air flow rate. *Flow/Person* means the program will use the input from the field *Outdoor Air Flow per Person* and the maximum occupancy to calculate a zone design outdoor air flow rate. *Flow/Area* means the program will use the input from the field *Outdoor Air Flow per Zone Floor Area* to calculate a zone design outdoor air flow rate. *Sum* means that the flows calculated from the fields *Outdoor Air Flow per Person*, *Outdoor Air Flow per Area* and *Outdoor Air Flow per Zone* will be added to obtain the zone design outdoor air flow rate. *Maximum* means that the maximum flow derived from *Outdoor Air Flow per Person*, *Outdoor Air Flow per Area* and *Outdoor Air Flow per Zone* will be used for the zone design outdoor air flow rate. The default is *Flow/Person*.

If the air handler serves more than one zone, the total outdoor air flow for the system is the sum of the zone outdoor air flows if the system outdoor air flow is autosized. Since the zones share a single outdoor air source, the amount of outdoor air actually delivered to the zone is based on the fraction of supply air delivered to the zone to the total supply air from the system. The amount of outdoor air flow is specified in units of m³/s. The default 0.00944 m³/s is 20 cfm per person

Field: Outdoor Air Flow Rate per Person

The design outdoor air flow rate per person for this zone in cubic meters per second. The default is 0.00944 (20 cfm per person). An outdoor air flow rate is calculated based on the total number of people for all People statements assigned to the zone. Occupancy schedule values are not applied. This input is used if *Outdoor Air Method* is one of *Outdoor Air Flow per Person*, *Sum*, or *Maximum*.

Field: Outdoor Air Flow Rate per Zone Floor Area

The design outdoor air volumetric flow rate per square meter of floor area (units are m³/s-m²). This input is multiplied by the zone area to obtain a flow rate. This input is used if *Outdoor Air Method* is *Flow/Area*, *Sum* or *Maximum*.

Field: Outdoor Air Flow Rate per Zone

The design outdoor air flow rate for this zone in cubic meters per second. This input field is used if *Outdoor Air Method* is *Flow/Zone*, *Sum* or *Maximum*.

Field: Reheat Coil Type

A reheat coil may be added to the VAV box with this field. The choices are:

- *HotWater*
- *Electric*

The default choice is *Electric*.

Field: Reheat Coil Availability Schedule Name

Leave this field blank if you want the reheat coil to be available for the entire year to perform heating if called for by the thermostat. If a schedule name is specified, those times that the coil is available should be specified as 1.0. Those times that the coil is not available should have a zero value in the schedule specified. Please note that this is not a schedule of when the coil is providing heat but a schedule of when it can provide heat.

Field: Fan Total Efficiency

Enter the total efficiency of the zone induction fan. This is the ratio of the power delivered to the air to the electrical input power at maximum flow. This is also the product of the fan motor efficiency and fan (impeller) efficiency. The motor efficiency is the power delivered to the shaft divided by the electrical power input to the motor. The fan efficiency is the power delivered to the air divided by the shaft power. The power delivered to the fluid is the mass flow rate of the air multiplied by the pressure rise divided by the air density. Must be greater than 0 and less than or equal to 1.

Field: Fan Delta Pressure

Enter the pressure rise of the zone induction fan in Pa at full flow and standard conditions. Standard conditions are considered 20° C at sea level, 101325 Pa.

Field: Fan Motor Efficiency

Enter the shaft power of the zone induction fan divided by the electrical power consumed. Must be greater than 0 and less than or equal to 1. Note that the zone fan motor is assumed to be 100% in the air stream.

Field: Supply Plenum Name

This field allows the user to specify a supply plenum which serves only this zone. The plenum zone is added to the supply air path after the system splitter or system-level supply plenum and before the zone terminal unit. Set to blank if no AirLoopHVAC:SupplyPlenum is to be modeled. If a AirLoopHVAC:SupplyPlenum is modeled, it must be modeled as a zone with surfaces, and the name of the plenum zone should be entered here.

Field: Return Plenum Name

This field allows the user to specify a return plenum which serves only this zone. The plenum zone is added to the return air path immediately after the zone and before the system mixer or system-level return plenum. Set to blank if no zone return plenum is to be modeled. If a zone return plenum is modeled, it must be modeled as a zone with surfaces, and the name of the plenum zone should be entered here.

Field: Baseboard Heating Type

This field specifies the availability of thermostatically controlled baseboard heat in this zone. The choices are:

- HotWater
- Electric
- None

The default choice is None.

Field: Baseboard Heating Availability Schedule Name

Leave this field blank if you want the baseboard heating to be available for the entire year to perform heating if called for by the thermostat. If a schedule name is specified, those times that the baseboard heating is available should be specified as 1.0. Those times that the baseboard heating is not available should have a zero value in the schedule. Please note that

this is not a schedule of when the baseboard is providing heat but a schedule of when it can provide heat.

Field: Baseboard Heating Capacity

Enter autosize to allow the sizing algorithm to determine the proper capacity required based on the loads experienced during the heating design day. If a value is specified, it is the maximum amount of heat that the baseboard heating can deliver in Watts. Note that EnergyPlus autosizing will autosize the baseboard heating to meet the full heating load of the zone, regardless of the heating capability of the VAV air handling system. The baseboard heating will be set to heating priority 2, which means it will meet any remaining heating load not met by the VAV system.

```

HVACTemplate:Zone:VAV:FanPowered,
  \min-fields 23
  \memo Zone terminal unit, fan powered variable volume, reheat optional.
  \memo Referenced schedules must be defined elsewhere in the idf.
A1, \field Zone Name
  \note Zone Name must match a building zone name
  \type object-list
  \object-list ZoneNames
A2, \field Template VAV System Name
  \note Enter then name of a HVACTemplate:System:VAV object serving this zone.
  \type object-list
  \object-list CompactHVACSystemVAV
A3, \field Template Thermostat Name
  \note Enter the name of a HVACTemplate:Thermostat object.
  \note If blank, then it is assumed that standard thermostat objects
  \note have been defined for this zone.
  \type object-list
  \object-list CompactHVACThermostats
N1, \field Primary Supply Air Maximum Flow Rate
  \autosizable
  \default Autosize
  \units m3/s
N2, \field Supply Air Sizing Factor
  \note Applicable when Primary Supply Air Maximum Flow Rate is autosized
  \note If blank, value from Sizing:Parameters will be used.
N3, \field Primary Supply Air Minimum Flow Fraction
  \autosizable
  \default Autosize
  \minimum 0.0
  \maximum 1.0
N4, \field Secondary Supply Air Maximum Flow Rate
  \autosizable
  \default Autosize
  \units m3/s
A4, \field Flow Type
  \type choice
  \key Parallel
  \key Series
  \default Parallel
N5, \field Parallel Fan On Flow Fraction
  \note The fraction of the primary air flow at which fan turns on
  \note Applicable only to Parallel Flow Type
  \autosizable
  \default Autosize

```

```

A5, \field Outdoor Air Method
\type choice
\key Flow/Person
\key Flow/Zone
\key Flow/Area
\key Sum
\key Maximum
\default Flow/Person
N6, \field Outdoor Air Flow Rate per Person
\units m3/s
\note Default 0.00944 is 20 cfm per person
\note This input is used if the field Outdoor Air Method is
\note Flow/Person, Sum, or Maximum
\default 0.00944
N7, \field Outdoor Air Flow Rate per Zone Floor Area
\units m3/s-m2
\default 0.0
\note This input is used if the field Outdoor Air Method is
\note Flow/area, Sum, or Maximum
N8, \field Outdoor Air Flow Rate per Zone
\type real
\units m3/s
\default 0.0
\note This input is used if the field Outdoor Air Method is
\note Flow/Zone, Sum, or Maximum
A6, \field Reheat Coil Type
\type choice
\key HotWater
\key Electric
\default Electric
A7, \field Reheat Coil Availability Schedule Name
\note If blank, always on
\type object-list
\object-list ScheduleNames
N9, \field Fan Total Efficiency
\minimum> 0.0
\maximum 1.0
\default 0.7
N10, \field Fan Delta Pressure
\units Pa
\ip-units inH2O
\minimum 0
\default 1000
N11, \field Fan Motor Efficiency
\minimum> 0.0
\maximum 1.0
\default 0.9
A8, \field Supply Plenum Name
\note Plenum zone name. Supply plenum runs through only this zone.
\note Blank if none.
\type object-list
\object-list ZoneNames
A9, \field Return Plenum Name
\note Plenum zone name. Return plenum runs through only this zone.
\note Blank if none.
\type object-list
\object-list ZoneNames
A10, \field Baseboard Heating Type
\type choice
\key HotWater
\key Electric
\key None
\default None
A11, \field Baseboard Heating Availability Schedule Name
\note If blank, always on
\type object-list
\object-list ScheduleNames
N12; \field Baseboard Heating Capacity
\autosizable
\default Autosize
\units W

```


And, as shown in an IDF:

```

HVACTemplate:Zone:VAV:FanPowered,
SPACE1-1,           !- Zone Name
VAV Sys 1,         !- Air Handling System Name
All Zones,         !- Thermostat Name
autosize,          !- Primary Supply Air Max Flow Rate {m3/s}
1.1,              !- Zone Supply Air Sizing Factor
autosize,          !- Primary Supply Air Min Flow Fraction
autosize,          !- Secondary Supply Air Max Flow Rate {m3/s}
Series,           !- Flow Type
autosize,          !- Parallel Fan On Flow Fraction
Flow/Person,      !- Zone Outdoor air MethodFlow Type
0.00944,          !- Zone Outdoor air Flow Rate per Person {m3/s}
0.0               !- Zone Outdoor air Flow per Zone Area {m3/s-m2}
0.0               !- Zone Outdoor air Flow per Zone {m3/s}
HotWater,         !- Reheat Coil Type
,                !- Reheat Coil Availability Schedule
0.7,             !- Zone Fan Total Efficiency
1000,            !- Zone Fan Delta Pressure {Pa}
0.9,            !- Zone Fan Motor Efficiency
,               !- Zone Supply Plenum Name
,;              !- Zone Return Plenum Name
HotWater,        !- Baseboard Heating Type
,               !- Baseboard Heating Availability Schedule
autosize;        !- Baseboard Heating Capacity {W}

```

HVACTemplate:System:Unitary

This object simulates the system portion of a constant volume direct-expansion based HVAC configuration with several different heating options. Often a single HVACTemplate:Zone:Unitary object will be used with a single HVACTemplate:System:Unitary object to simulate single zone direct-expansion based air conditioning systems. In addition, multiple HVACTemplate:Zone:Unitary objects may appear that all reference the same HVACTemplate:System:Unitary object in a multiple zone version. For a multizone system, only one zone is specified as the control zone. Direct expansion includes single packaged rooftop systems commonly seen in commercial buildings and split systems commonly seen in residential buildings.

Field: Name

Enter a name for the HVACTemplate:System:Unitary object. This name is used in the HVACTemplate:Zone:Unitary object to reference this system.

Field: System Availability Schedule Name

Leave this field blank if you want the system to be available for the entire year to perform heating or cooling if called for by the thermostat. If a schedule name is specified, those times that the system is available should be specified as 1.0. Those times that the system is not available should have a zero value in the schedule specified. If the "Supply Fan Operating Mode" (see below) is set to Cycling, then this is the supply fan operating schedule. If the fan mode is Cycling this is not a schedule of when the system is providing heating, cooling or air flow but a schedule of when it can provide either heating, cooling, or air flow.

Field: Control Zone or Thermostat Location Name

Enter the name of the HVACTemplate:Zone:Unitary object that contains the thermostat. While multiple HVACTemplate:Zone:Unitary objects can be part of a HVACTemplate:System:Unitary system, only one of the zones contains a thermostat that controls heating and cooling operation. For a single zone system, this field should contain the name of that zone.

Field: Supply Fan Maximum Flow Rate

Enter Autosize to set the system maximum air-flow rate to the sum of the zone air flow rates. If a value is entered here for the maximum air-flow rate, it is the upper limit on system flow, even if the zone level air flow inputs sum to a greater value. The units are m³/s.

Field: Supply Fan Operating Mode Schedule Name

This field specifies the name of the supply air fan operating mode schedule. The supply air fan operating mode may vary during the simulation based on time-of-day or with a change of season. Schedule values of 0 denote that the supply air fan and the heating or cooling coil cycle on and off together to meet the heating or cooling load (a.k.a. AUTO fan). Schedule values other than 0 denote that the supply fan runs continuously while the heating or cooling coil cycles to meet the load. The keywords *Cycling* or *Continuous* may also be used to, specify a single mode of operation for the entire simulation. The default is *Cycling*.

Field: Supply Fan Total Efficiency

Enter the total efficiency of the supply fan. This is the ratio of the power delivered to the air to the electrical input power at maximum flow. This is also the product of the fan motor efficiency and fan (impeller) efficiency. The motor efficiency is the power delivered to the shaft divided by the electrical power input to the motor. The fan efficiency is the power delivered to the air divided by the shaft power. The power delivered to the fluid is the mass flow rate of the air multiplied by the pressure rise divided by the air density. Must be greater than 0 and less than or equal to 1.

Field: Supply Fan Delta Pressure

Enter the pressure rise in Pa at full flow and standard conditions. Standard conditions are considered 20°C at sea level, 101325 Pa.

Field: Supply Fan Motor Efficiency

Enter the shaft power of the supply fan divided by the electrical power consumed. Must be greater than 0 and less than or equal to 1.

Field: Supply Fan Motor in Air Stream Fraction

Enter the fraction of the motor heat that is added to the air stream. A value of 0 means that the motor is completely outside the air stream. A value of 1 means that all of the motor heat will go into the air stream and act to cause a temperature rise. Must be between 0 and 1.

Field: Cooling Coil Type

Enter the type of cooling coil. The choices for this field are:

- None
- SingleSpeedDX

Set this value to "SingleSpeedDX" if you want to simulate a system that provides cooling. You may set this value to "None" if no cooling is desired. The default value is SingleSpeedDX. Future versions may have additional cooling coil types.

Field: Cooling Coil Availability Schedule Name

Usually set to blank, which allows the cooling coil to be available anytime the system is operating. If a schedule name is specified, it defines when the coil is available. This is most often used when cooling is only available seasonally. A schedule value of 1.0 indicates that the cooling coil can be on during a given time period. A value of zero denotes that the cooling coil cannot be used during that time period.

Field: Cooling Coil Capacity

Enter autosize to let the automatic sizing algorithm determine the cooling coil capacity based on the maximum cooling loads during the cooling design day. If a value is entered, it

represents the full load cooling capacity, including both sensible and latent capacity, in watts of the DX coil unit at rated conditions. Rated conditions are air entering the cooling coil at the maximum supply air flow rate at 26.7°C drybulb/19.4°C wetbulb with air entering the outdoor condenser coil at 35°C drybulb. Capacity should be the “gross” capacity where the impact of supply air fan heat is NOT included. The units are in W.

Field: Cooling Coil Rated Sensible Heat Ratio

Enter Autosize to allow the sizing algorithm to determine the sensible heat ratio based on the rated capacity and air flow rate. Otherwise, enter the value of the ratio of the sensible capacity divided by total cooling capacity of the DX cooling coil at rated conditions. Rated conditions are air entering the cooling coil at the maximum supply air flow rate at 26.7°C drybulb/19.4°C wetbulb with air entering the outdoor condenser coil at 35°C drybulb. Both the sensible and total cooling capacities used to define the Rated Sensible Heat Ratio (SHR) should be “gross” capacity where the impact of supply air fan heat is NOT included.

Field: Cooling Coil Rated COP

Enter the coefficient of performance defined as the gross cooling coil capacity in watts divided by electrical power input in watts of the DX cooling coil unit at rated conditions. Rated conditions are air entering the cooling coil at the maximum supply air flow rate at 26.7°C drybulb/19.4°C wetbulb with air entering the outdoor condenser coil at 35°C drybulb. The input power includes electric power for the compressor and condenser fan but does not include the power consumption of the supply air fan.

Field: Heating Coil Type

Enter the type of heating used in the unitary system. The choices for this field are

- Electric
- Gas

Field: Heating Coil Availability Schedule Name

Usually set to blank, which allows the heating coil to be available anytime the system is operating. If a schedule name is specified, it defines when the coil is available. This is most often used when heating is only available seasonally. The schedule values denote whether the heating coil can run during a given time period. A schedule value of 1.0 indicates that the heating coil can be on during a given time period. A value of zero denotes that the heating coil cannot be used during that time period

Field: Heating Coil Capacity

Enter autosize to allow the sizing algorithm to determine the proper capacity required based on the loads experienced during the heating design day. If a value is specified, it is the maximum amount of heat that the coil can deliver in Watts.

Field: Gas Heating Coil Efficiency

Enter gas burner efficiency as a decimal, not as a percent. A burner that is 80% efficient would have an entry of 0.8 here, which is the default

Field: Gas Heating Coil Parasitic Electric Load

Enter the parasitic electric load associated with the gas heating coil operation, such as a combustion fan. The units are in W.

Field: Maximum Outdoor Air Flow Rate

Enter autosize or a value for the maximum amount of outdoor air flow into the unit when the economizer is operating. Autosize means that 100% of the full supply flow may be taken from outdoor air. If a value is entered, it is used instead of the autosize value. The units are in m³/s. That is, the entered value is used to define the Maximum Outside Air Flow Rate for the Controller:OutdoorAir object that will be generated by this template.

Field: Minimum Outdoor Air Flow Rate

Enter autosize or the value for the minimum amount of outdoor air that can enter the unit and be distributed to the zones. Usually this is set to autosize and the value is calculated by the outdoor air requirements of each zone. If a value is entered it overrides the outdoor air specification from the zone level. The units are in m³/s. Note if heat recovery is specified (see Heat Recovery Type below), then a value must be entered in this field, because heat recovery equipment is not yet autosizable. That is, the entered value is used to define the Minimum Outside Air Flow Rate for the Controller:OutdoorAir object that will be generated by this template.

Field: Minimum Outdoor Air Schedule Name

Leave this field blank if you want the minimum outdoor air to be the same for all hours in the entire year. If a schedule name is specified, values are decimal fractions (0.0 – 1.0) that multiply the minimum outdoor air flow rate. This schedule is useful for reducing the outdoor air flow rate to zero during unoccupied or start up hours.

Field: Economizer Type

The options for this field are

- 'FixedDryBulb'
- 'DifferentialDryBulb'
- 'FixedEnthalpy'
- 'DifferentialEnthalpy'
- 'ElectronicEnthalpy' (i.e., humidity ratio curve strategy)
- 'FixedDewPointAndDryBulb'
- 'DifferentialDryBulbAndEnthalpy'
- 'NoEconomizer'

Choosing **NoEconomizer** means the economizer will not operate and the outdoor airflow rate will be at the minimum for the entire simulation.

Choosing **FixedDryBulb** means the economizer will set the outdoor airflow rate at minimum if the outdoor air temperature is higher than a specified dry-bulb temperature limit.

Choosing **DifferentialDryBulb** will trigger the outdoor airflow to minimum when the dry-bulb temperature of outdoor air is higher than the dry-bulb temperature of the return air.

FixedEnthalpy checks the upper limit of the enthalpy given as a field input against the enthalpy content of outdoor air and will set the outdoor airflow rate to minimum if the latter is greater than the former.

DifferentialEnthalpy does the same thing but compares the return air enthalpy with the enthalpy of outdoor air. When the enthalpy of outdoor air is greater than the enthalpy of the return air, the outdoor air flow rate is set to minimum.

Choosing **ElectronicEnthalpy** enables the simulation to calculate the humidity ratio limit of outdoor air based on the dry-bulb temperature of outdoor air and a quadratic/cubic curve, and compare it to the actual outdoor air humidity ratio. If the actual outdoor humidity ratio is greater than the calculated humidity ratio limit, then the outdoor airflow rate is set to minimum.

Choosing **FixedDewPointAndDryBulb** compares both the outdoor dewpoint temperature and the outdoor dry-bulb temperature to their specified high limit values. If either outdoor temperature exceeds the high limit value, the outdoor airflow rate is set to minimum.

Another option **DifferentialDryBulbAndEnthalpy** enables the control strategy to be based on both the **DifferentialDryBulb** and **DifferentialEnthalpy** economizer control strategies.

In addition to all economizer control types listed above, each control type checks for user-entered values for the upper limit of dry-bulb temperature, enthalpy limit, humidity ratio limit

and dewpoint limit. The outdoor air flow rate is set to minimum if any of these entered limits are exceeded.

The default for this field is **NoEconomizer**.

Field: Economizer Lockout

Enter one of the following choices for this field:

- NoLockout
- LockoutWithHeating
- LockoutWithCompressor

The default value is **NoLockout**. The **LockoutWithHeating** means that if the packaged unit is in heating mode, the economizer is locked out – i.e., the economizer dampers are closed and there is minimum outdoor air flow. **LockoutWithCompressor** means that in addition to locking out the economizer when the unit is in heating mode the economizer is locked out when the DX unit compressor is on. In other words, when the DX coil is off, the economizer must meet the entire cooling load – it isn't allowed to operate in conjunction with the DX cooling coil. Similarly, when the DX coil is operating, the economizer is not allowed to operate. The **LockoutWithCompressor** option is sometimes called a “nonintegrated” economizer.

Field: Economizer Upper Temperature Limit

Enter the outdoor air temperature high limit (°C) for economizer operation. If the outdoor air temperature is above this limit, the outdoor air flow rate will be set to the minimum and heat recovery will be enabled if available. No input or zero in this field means that there is no outdoor air temperature high limit control.

Field: Economizer Lower Temperature Limit

Enter the outdoor air temperature low limit (°C) for economizer operation. If the outdoor air temperature is below this limit, the outdoor air flow rate will be set to the minimum and heat recovery will be enabled if available. No input or zero in this field means that there is no outdoor air temperature low limit control.

Field: Economizer Upper Enthalpy Limit

Enter the outdoor air upper enthalpy limit (in J/kg) for economizer operation. If the outdoor air enthalpy is above this value, the outdoor air flow rate will be set to the minimum and heat recovery will be enabled if available. No input or zero in this field means that there is no outdoor air enthalpy limit control.

Field: Supply Plenum Name

Set to blank if no supply plenum is to be modeled. If a supply plenum is modeled, it must be modeled as a zone with surfaces, and the name of the plenum zone should be entered here. This supply plenum serves all zones on this system. If any AirLoopHVAC:SupplyPlenums have been specified, the outlet from the system supply plenum will flow through the AirLoopHVAC:SupplyPlenum to the zone terminal unit.

Field: Return Plenum Name

Set to blank if no return plenum is to be modeled. If a return plenum is modeled, it must be modeled as a zone with surfaces, and the name of the plenum zone should be entered here. This return plenum serves all zones on this system. If any zone return plenums have been specified, the return air from the zone will flow through the zone return plenum and then into the system return plenum.

Field: Supply Fan Placement

Enter the supply fan placement type. This alpha field has two choices, *DrawThrough* or *BlowThrough*. *DrawThrough* models a system where the supply air fan is after the cooling

and heating coils. *BlowThrough* models a system where the supply air fan is before the cooling and heating coils. The default is *BlowThrough*.

Field: Night Cycle Control

Enter the system behavior during times when the System Availability Schedule is zero (off). The possible inputs are *StayOff*, *CycleOnAny*, or *CycleOnControlZone*. *StayOff* means the system will remain off, no matter how hot or cold the zones may be. *CycleOnAny* means that if any zone served by this system has an air temperature outside the cooling or heating set points the central fan will turn on even though the System Availability Schedule indicates the fan is off. *CycleOnControlZone* means the same thing except the availability manager looks at the temperature in only the zone specified in Night Cycle Control Zone Name. The default is *StayOff*.

Field: Night Cycle Control Zone Name

For the Night Cycle Control option *CycleOnControlZone* enter the name of the control zone. For other Night Cycle Control options, this field is ignored.

Field: Heat Recovery Type

Enter the type of air-to-air heat recovery which is available between the relief air stream and the outdoor air inlet stream. The choices are:

- *None*
- *Sensible*
- *Enthalpy*

The default is **None**. If heat recovery is specified (i.e., **Sensible** or **Enthalpy**), then a value must be entered in the Minimum Outdoor Air Flow Rate field, because heat recovery equipment is not yet autosizable. The entered Minimum Outdoor Air Flow Rate is used to define the Nominal Supply Air Flow Rate for the HeatExchanger:AirToAir:SensibleAndLatent object generated by this template.

Field: Sensible Heat Recovery Effectiveness

Enter the sensible heat recovery effectiveness. This is applied as a constant effectiveness at all conditions. The valid range is from 0.0 to 1.0, and the default is 0.70.

Field: Latent Heat Recovery Effectiveness

Enter the latent heat recovery effectiveness if Heat Recovery Type is *Enthalpy*. This is applied as a constant effectiveness at all conditions. The valid range is from 0.0 to 1.0, and the default is 0.65.

Field: Dehumidification Control Type

There are three dehumidification control type options available:

- *None*
- *CoolReheatHeatingCoil*
- *CoolReheatDesuperheater*

The *CoolReheatHeatingCoil* option cools beyond the dry-bulb setpoint as required to meet the humidity setpoint if the system is capable of doing so. Reheat is provided as required by the heating coil. In the simulation, two instances of the heating coil are modeled, one for heating, and one for reheat. The two coil objects represent the same physical coil and never operate simultaneously.

The *CoolReheatDesuperheater* option cools beyond the dry-bulb setpoint as required to meet the humidity setpoint if the system is capable of doing so. Reheat is provided by a desuperheater coil (see object Coil:WaterHeating:Desuperheater).

The default is *None* which meets the sensible cooling load only.

Field: Dehumidification Control Zone Name

This field specifies the zone name where the humidistat is located for controlling dehumidification.

Field: Dehumidification Setpoint

This field specifies the zone humidistat setpoint for dehumidification in percent (0 to 100). The default is 60%.

Field: Humidifier Type

There are two humidifier type options available:

- None
- ElectricSteam

The *ElectricSteam* humidifier option uses the Humidifier:Steam:Electric object. The default is *None*.

Field: Humidifier Availability Schedule Name

If left blank, the humidifier will be available anytime the system is operating. If a schedule name is specified, it defines when the humidifier is available. The schedule values denote whether the humidifier can run during a given time period. A schedule value of 1.0 indicates that the humidifier can be on during a given time period. A value of zero denotes that the humidifier cannot be used during that time period

Field: Humidifier Rated Capacity

Enter the rated moisture output rate in m3/s. The humidifier does not currently autosize, so the default is very large to allow for adequate capacity. The default is 0.000001 m3/s.

Field: Humidifier Rated Electric Power

Enter the electric power input at the rated capacity moisture output. The humidifier does not currently autosize, so the default power input is consistent with the default capacity input (2690 W per 0.000001 m3/s output) Power consumption is proportional to moisture output with no part-load penalty.

Field: Humidifier Control Zone Name

This field specifies the zone name where the humidistat is located for controlling humidification.

Field: Humidifier Setpoint

This field specifies the zone humidistat setpoint for humidification in percent (0 to 100). The default is 30%.

```

HVACTemplate: System: Unitary,
  \min-fields 44
  \memo Unitary furnace with air conditioner
  \memo Referenced schedules must be defined elsewhere in the idf.
A1, \field Name
  \reference CompactHVACSystemUnitary
A2, \field System Availability Schedule Name
  \note If blank, always on; Unitary System always on. Schedule is used in availability manager
  \note and fan scheduling.
  \note Also see "Night Cycle Control" field.
  \type object-list
  \object-list ScheduleNames

```

```

A3, \field Control Zone or Thermostat Location Name
    \type object-list
    \object-list ZoneNames
N1, \field Supply Fan Maximum Flow Rate
    \autosizable
    \default Autosize
    \units m3/s
    \minimum> 0.0
A4, \field Supply Fan Operating Mode Schedule Name
    \note Refers to a schedule to specify unitary supply fan operating mode.
    \note Schedule values of 0 indicate cycling fan (auto)
    \note Schedule values of 1 indicate continuous fan (on)
    \note Keywords "Cycling" or "Continuous" may also be used here.
    \type object-list
    \object-list ScheduleNames
    \default Cycling
N2, \field Supply Fan Total Efficiency
    \minimum> 0.0
    \maximum 1.0
    \default 0.7
N3, \field Supply Fan Delta Pressure
    \units Pa
    \ip-units inH2O
    \minimum 0
    \default 600
N4, \field Supply Fan Motor Efficiency
    \minimum> 0.0
    \maximum 1.0
    \default 0.9
N5, \field Supply Fan Motor in Air Stream Fraction
    \minimum 0.0
    \maximum 1.0
    \default 1.0
A5, \field Cooling Coil Type
    \type choice
    \key SingleSpeedDX
    \key None
    \default SingleSpeedDX
A6, \field Cooling Coil Availability Schedule Name
    \note If blank, always on
    \type object-list
    \object-list ScheduleNames
N6, \field Cooling Coil Capacity
    \note Gross cooling capacity (net capacity plus fan heat)
    \autosizable
    \default Autosize
    \units W
N7, \field Cooling Coil Rated Sensible Heat Ratio
    \note Gross SHR
    \autosizable
    \minimum 0.5
    \maximum 1.0
    \default Autosize
N8, \field Cooling Coil Rated COP
    \note Gross cooling capacity divided by power in
    \minimum> 0.0
    \default 3.0
A7, \field Heating Coil Type
    \type choice
    \key Electric
    \key Gas
A8, \field Heating Coil Availability Schedule Name
    \note If blank, always on
    \type object-list
    \object-list ScheduleNames
N9, \field Heating Coil Capacity
    \autosizable
    \default Autosize
    \units W

```



```

N10, \field Gas Heating Coil Efficiency
    \maximum 1.0
    \minimum 0.0
    \default 0.8
N11, \field Gas Heating Coil Parasitic Electric Load
    \units W
    \ip-units W
    \minimum 0.0
    \default 0.0
N12, \field Maximum Outdoor Air Flow Rate
    \autosizable
    \default Autosize
    \units m3/s
    \minimum 0.0
N13, \field Minimum Outdoor Air Flow Rate
    \autosizable
    \default Autosize
    \units m3/s
    \minimum 0.0
A9, \field Minimum Outdoor Air Schedule Name
    \note Schedule values multiply the minimum outdoor air flow rate
    \note If blank, always one
    \type object-list
    \object-list ScheduleNames
A10, \field Economizer Type
    \type choice
    \key FixedDryBulb
    \key FixedEnthalpy
    \key DifferentialDryBulb
    \key DifferentialEnthalpy
    \key FixedDewPointAndDryBulb
    \key ElectronicEnthalpy
    \key DifferentialDryBulbAndEnthalpy
    \key NoEconomizer
    \default NoEconomizer
A11, \field Economizer Lockout
    \type choice
    \key NoLockout
    \key LockoutWithHeating
    \key LockoutWithCompressor
    \default NoLockout
N14, \field Economizer Upper Temperature Limit
    \note Outdoor temperature above which economizer is disabled and
    \note heat recovery is enabled (if available).
    \note Blank means no limit.
    \units C
N15, \field Economizer Lower Temperature Limit
    \note Outdoor temperature below which economizer is disabled and
    \note heat recovery is enabled (if available).
    \note Blank means no limit.
    \units C
N16, \field Economizer Upper Enthalpy Limit
    \note Outdoor enthalpy above which economizer is disabled and
    \note heat recovery is enabled (if available).
    \note Blank means no limit.
    \units J/kg
A12, \field Supply Plenum Name
    \note Plenum zone name. Supply plenum serves all zones on this system.
    \note Blank if none.
    \type object-list
    \object-list ZoneNames
A13, \field Return Plenum Name
    \note Plenum zone name. Return plenum serves all zones on this system.
    \note Blank if none.
    \type object-list
    \object-list ZoneNames
A14, \field Supply Fan Placement
    \type choice
    \key BlowThrough
    \key DrawThrough
    \default BlowThrough

```

```

A15, \field Night Cycle Control
\type choice
\key StayOff
\key CycleOnAny
\key CycleOnControlZone
\default StayOff
A16, \field Night Cycle Control Zone Name
\note Applicable only if Night Cycle Control is Cycle On Control Zone.
\type object-list
\object-list ZoneNames
A17, \field Heat Recovery Type
\note If heat recovery is specified, then a value must be entered in
\note the Minimum Outdoor Air Flow Rate field, because heat recovery
\note equipment is not yet autosizable.
\type choice
\key None
\key Sensible
\key Enthalpy
\default None
N17, \field Sensible Heat Recovery Effectiveness
\minimum 0.0
\maximum 1.0
\default 0.70
N18, \field Latent Heat Recovery Effectiveness
\note Applicable only if Heat Recovery Type is Enthalpy.
\minimum 0.0
\maximum 1.0
\default 0.65
A18, \field Dehumidification Control Type
\note None = meet sensible cooling load only
\note CoolReheatHeatingCoil = cool beyond the dry-bulb setpoint
\note as required to meet the humidity setpoint, reheat with main heating coil.
\note CoolReheatDesuperheater = cool beyond the dry-bulb setpoint
\note as required to meet the humidity setpoint, reheat with desuperheater coil.
\type choice
\key None
\key CoolReheatHeatingCoil
\key CoolReheatDesuperheater
\default None
A19, \field Dehumidification Control Zone Name
\note Zone name where humidistat is located
\type object-list
\object-list ZoneNames
N19, \field Dehumidification Setpoint
\note Zone relative humidity setpoint in percent (0 to 100)
\type real
\minimum 0.0
\maximum 100.0
\default 60.0
\units percent
A20, \field Humidifier Type
\type choice
\key None
\key ElectricSteam
\default None
A21, \field Humidifier Availability Schedule Name
\note If blank, always available
\type object-list
\object-list ScheduleNames
N20, \field Humidifier Rated Capacity
\note Moisture output rate at full rated power input.
\note The humidifier does not currently autosize, so the default is very large
\note to allow for adequate capacity.
\type real
\units m3/s
\minimum 0.0
\default 0.000001
\ip-units gal/min

```

```

N21, \field Humidifier Rated Electric Power
    \note Electric power input at rated capacity moisture output.
    \note The humidifier does not currently autosize, so the default power input is
    \note consistent with the default capacity input (2690 W per 0.000001 m3/s output)
    \note Power consumption is proportional to moisture output with no part-load penalty.
    \type real
    \units W
    \minimum 0.0
    \default 2690.0
    \ip-units W
A22, \field Humidifier Control Zone Name
    \note Zone name where humidistat is located
    \type object-list
    \object-list ZoneNames
N22; \field Humidifier Setpoint
    \note Zone relative humidity setpoint in percent (0 to 100)
    \type real
    \minimum 0.0
    \maximum 100.0
    \default 30.0
    \units percent

```

And, as shown in an IDF:

```

HVACTemplate:System:Unitary,
  AHU 1,                !- Air Handling System Name
  FanAndCoilAvailSched, !- System Availability Schedule
  EAST_ZONE,           !- Control Zone Name or Thermostat Location
  autosize,            !- Supply Fan Max Flow Rate {m3/s}
  Fan Mode Schedule,   !- Supply Fan Operating Mode Schedule
  .7,                  !- Supply Fan Total Efficiency
  600,                 !- Supply Fan Delta Pressure {Pa}
  .9,                  !- Supply Fan Motor Efficiency
  1,                   !- Supply Fan Motor in Air Stream Fraction
  SingleSspeedDX,     !- Cooling Coil Type
  FanAndCoilAvailSched, !- Cooling Coil Availability Schedule
  autosize,            !- Cooling Coil Capacity {W}
  autosize,            !- Cooling Coil Rated SHR
  3,                   !- Cooling Coil Rated COP
  Gas,                 !- Heating Coil Type
  FanAndCoilAvailSched, !- Heating Coil Availability Schedule
  autosize,            !- Heating Coil Capacity {W}
  .8,                  !- Gas Heating Coil Efficiency
  0,                   !- Gas Heating Coil Parasitic Electric Load {W}
  autosize,            !- Maximum Outdoor air Flow Rate {m3/s}
  autosize,            !- Minimum Outdoor air Flow Rate {m3/s}
  ,                    !- Minimum Outdoor air Schedule Name
  NoEconomizer,       !- Economizer Type
  NoLockout,          !- Economizer Lockout
  ,                    !- Economizer Upper Temperature Limit {C}
  ,                    !- Economizer Lower Temperature Limit {C}
  ,                    !- Economizer Upper Enthalpy Limit {J/kg}
  ,                    !- Supply Plenum Name
  ,                    !- Return Plenum Name

```

```

BlowThrough,      !- Supply Fan Placement
CycleOnAny,      !- Night Cycle Control
,                !- Night Cycle Control Zone Name
None,            !- Heat Recovery Type
,                !- Sensible Heat Recovery Effectiveness
,                !- Latent Heat Recovery Effectiveness
None,            !- Dehumidification Control Type
,                !- Dehumidification Control Zone Name
60,              !- Dehumidification Setpoint {percent}
ElectricSteam,   !- Humidifier Type
,                !- Humidifier Availability Schedule
0.000001,        !- Humidifier Rated Capacity {m3/s}
2690,            !- Humidifier Rated Electric Power {W}
EAST_ZONE,       !- Humidifier Control Zone Name
30;              !- Humidifier Setpoint {percent}

```

HVACTemplate:System:UnitaryHeatPump:AirToAir

This object simulates the system portion of an air to air direct-expansion unitary heat pump. Often a single HVACTemplate:Zone:Unitary object will be used with a single HVACTemplate:System:UnitaryHeatPump:AirToAir object to simulate single zone direct-expansion based heat pump systems. In addition, multiple HVACTemplate:Zone:Unitary objects may appear that all reference the same HVACTemplate:System:UnitaryHeatPump:AirToAir object in a multiple zone version. For a multizone system, only one zone is specified as the control zone. The model can simulate heat pumps seen in commercial buildings and split systems commonly seen in residential buildings.

Field: Name

Enter a name for the HVACTemplate:System:UnitaryHeatPump:AirToAir object. This name is used in the HVACTemplate:Zone:Unitary object to reference this system.

Field: System Availability Schedule Name

Leave this field blank if you want the system to be available for the entire year to perform heating or cooling if called for by the thermostat. If a schedule name is specified, those times that the system is available should be specified as 1.0. Those times that the system is not available should have a zero value in the schedule specified. During times when the system is available, the supply fan operating mode controls fan operation. (See "Supply Fan Operating Mode Schedule Name" below)

Field: Control Zone or Thermostat Location Name

Enter the name of the HVACTemplate:Zone:Unitary object that contains the thermostat. While multiple HVACTemplate:Zone:Unitary objects can be part of a HVACTemplate:System:UnitaryHeatPump:AirToAir system, only one of the zones contains a thermostat that controls heating and cooling operation. For a single zone system, this field should contain the name of that zone.

Field: Cooling Supply Air Flow Rate

This field specifies the supply air flow rate when the DX cooling coil is operating. By entering Autosize, the supply air flow rate is automatically determined based on the loads experienced by the zone during the specified cooling SizingPeriod:DesignDay. The units are in m3/s. The default is Autosize.

Field: Heating Supply Air Flow Rate

This field specifies the supply air flow rate when the heating coil is operating. By entering Autosize, the supply air flow rate is automatically determined based on the loads experienced by the zone during the specified heating SizingPeriod:DesignDay. The units are in m3/s. The default is Autosize.

Field: No Load Supply Air Flow Rate

This field specifies the supply air flow rate when neither cooling nor heating is required (i.e., DX coil and heater are off but the supply air fan operates). This field is only used when the supply air fan operating mode schedule specifies continuous fan operation. Values must be greater than or equal to zero, or this field is autosizable. If the air conditioner's supply air fan operating mode schedule specifies continuous fan operation and this value is set to zero or this field is left blank, then the model assumes that the supply air flow rate when no cooling/heating is needed is equal to the supply air flow rate when the cooling or heating coil was last operating (for cooling operation or heating operation). By entering Autosize, the supply air flow rate will be sized to match the smaller of the Cooling and Heating flow rates. The units are in m³/s. The default is Autosize.

Field: Supply Fan Operating Mode Schedule Name

This field specifies the name of the supply air fan operating mode schedule. The supply air fan operating mode may vary during the simulation based on time-of-day or with a change of season. Schedule values of 0 denote that the supply air fan and the heating or cooling coil cycle on and off together to meet the heating or cooling load (a.k.a. AUTO fan). Schedule values other than 0 denote that the supply fan runs continuously while the heating or cooling coil cycles to meet the load. The keywords Cycling or Continuous may also be used to, specify a single mode of operation for the entire simulation. The default is Cycling.

Field: Supply Fan Placement

Enter the supply fan placement type. This alpha field has two choices, *DrawThrough* or *BlowThrough*. *DrawThrough* models a system where the supply air fan is after the dx cooling/heating coil and before the supplemental heating coil. *BlowThrough* models a system where the supply air fan is before the dx cooling/heating coil and the supplemental heating coil. The default is *BlowThrough*.

Field: Supply Fan Total Efficiency

Enter the total efficiency of the supply fan. This is the ratio of the power delivered to the air to the electrical input power at maximum flow. This is also the product of the fan motor efficiency and fan (impeller) efficiency. The motor efficiency is the power delivered to the shaft divided by the electrical power input to the motor. The fan efficiency is the power delivered to the air divided by the shaft power. The power delivered to the fluid is the mass flow rate of the air multiplied by the pressure rise divided by the air density. Must be greater than 0 and less than or equal to 1. The default is 0.7.

Field: Supply Fan Delta Pressure

Enter the pressure rise in Pa at full flow and standard conditions. Standard conditions are considered 20 C at sea level, 101325 Pa. The default is 600 Pa.

Field: Supply Fan Motor Efficiency

Enter the shaft power of the supply fan divided by the electrical power consumed. Must be greater or equal to the Supply Fan Total Efficiency and less than or equal to 1. The default is 0.9.

Field: Supply Fan Motor in Air Stream Fraction

Enter the fraction of the motor heat that is added to the air stream. A value of 0 means that the motor is completely outside the air stream. A value of 1 means that all of the motor heat will go into the air stream and act to cause a temperature rise. Must be between 0 and 1. The default is 1.0.

Field: Cooling Coil Type

Enter the type of cooling coil. There is currently only one choices for this field, SingleSpeedDX. Future versions may have additional cooling coil types.

Field: Cooling Coil Availability Schedule Name

Usually set to blank, which allows the cooling coil to be available anytime the system is operating. If a schedule name is specified, it defines when the coil is available. This is most often used when cooling is only available seasonally. A schedule value of 1.0 indicates that the cooling coil can be on during a given time period. A value of zero denotes that the cooling coil cannot be used during that time period.

Field: Cooling Coil Capacity

Enter Autosize to let the automatic sizing algorithm determine the cooling coil capacity based on the maximum cooling loads during the cooling design day. If a value is entered, it represents the full load cooling capacity, including both sensible and latent capacity, in watts of the DX coil unit at rated conditions. Rated conditions are air entering the cooling coil at the maximum supply air flow rate at 26.7°C drybulb/19.4°C wetbulb with air entering the outdoor condenser coil at 35°C drybulb. Capacity should be the “gross” capacity where the impact of supply air fan heat is NOT included. The units are in W. The default is Autosize.

Field: Cooling Coil Rated Sensible Heat Ratio

Enter Autosize to allow the sizing algorithm to determine the sensible heat ratio based on the rated capacity and air flow rate. Otherwise, enter the value of the ratio of the sensible capacity divided by total cooling capacity of the DX cooling coil at rated conditions. Rated conditions are air entering the cooling coil at the maximum supply air flow rate at 26.7°C drybulb/19.4°C wetbulb with air entering the outdoor condenser coil at 35°C drybulb. Both the sensible and total cooling capacities used to define the Rated Sensible Heat Ratio (SHR) should be “gross” capacity where the impact of supply air fan heat is NOT included. The default is Autosize.

Field: Cooling Coil Rated COP

Enter the coefficient of performance defined as the gross cooling coil capacity in watts divided by electrical power input in watts of the DX cooling coil unit at rated conditions. Rated conditions are air entering the cooling coil at the maximum supply air flow rate at 26.7°C drybulb/19.4°C wetbulb with air entering the outdoor condenser coil at 35°C drybulb. The input power includes electric power for the compressor and condenser fan but does not include the power consumption of the supply air fan. The default is 3.0.

Field: Heat Pump Heating Coil Type

Enter the type of heat pump heating coil. There is currently only one choice for this field, SingleSpeedDXHeatPump.

Field: Heat Pump Heating Coil Availability Schedule Name

Usually set to blank, which allows the heat pump heating coil to be available anytime the system is operating. If a schedule name is specified, it defines when the coil is available. This is most often used when heating is only available seasonally. A schedule value of 1.0 indicates that the heat pump heating coil can be on during a given time period. A value of zero denotes that the heat pump heating coil cannot be used during that time period.

Field: Heat Pump Heating Coil Rated Capacity

Enter Autosize to let the automatic sizing algorithm determine the heat pump heating coil capacity based on the maximum heating loads during the heating design day. If a value is entered, it represents the full load heating capacity, in watts of the DX heat pump unit at rated conditions. Rated conditions are air entering the heat pump heating coil at the heating supply air flow rate at 21.11°C drybulb/15.55°C wetbulb with air entering the outdoor coil at 8.33°C drybulb/6.11C wetbulb. Capacity should be the “gross” capacity where the impact of supply air fan heat is NOT included. The units are in W. The default is Autosize.

Field: Heat Pump Heating Coil Rated COP

Enter the coefficient of performance defined as the gross heating coil capacity in watts divided by electrical power input in watts of the DX heating coil unit at rated conditions. Rated conditions are air entering the heat pump heating coil at the heating supply air flow rate at 21.11°C drybulb/15.55°C wetbulb with air entering the outdoor coil at 8.33°C drybulb/6.11C wetbulb. The input power includes electric power for the compressor and condenser fan but does not include the power consumption of the supply air fan. The default is 2.75.

Field: Heat Pump Heating Minimum Outdoor Dry-Bulb Temperature

This numeric field defines the minimum outdoor dry-bulb temperature in degrees Celsius for compressor operation. The compressor will not operate (for DX heating or DX cooling) when outdoor dry-bulb temperatures fall below this value. The minimum value must be greater than or equal to -20 °C. The default value is -8°C.

Field: Heat Pump Defrost Maximum Outdoor Dry-Bulb Temperature

This numeric field defines the outdoor air dry-bulb temperature above which outdoor coil defrosting is disabled. The temperature for this input field must be greater than or equal to 0 C and less than or equal to 7.22 C. If this input field is left blank, the default value is 5 C.

Field: Heat Pump Defrost Strategy

This alpha field has two choices: *ReverseCycle* or *Resistive*. If the *ReverseCycle* strategy is selected, the heating cycle is reversed periodically to provide heat to melt frost accumulated on the outdoor coil. If a *Resistive* defrost strategy is selected, the frost is melted using an electric resistance heater. If this input field is left blank, the default defrost strategy is *ReverseCycle*.

Field: Heat Pump Defrost Control

This alpha field has two choices: *Timed* or *OnDemand*. If *Timed* control is selected, the defrost time period is calculated based on a fixed value or compressor runtime whether or not frost has actually accumulated. For *Timed* defrost control, the fractional amount of time the unit is in defrost is entered in the input field "Defrost Time Period Fraction" described below. If *OnDemand* defrost control is selected, the defrost time period is calculated based on outdoor weather (humidity ratio) conditions. Regardless of which defrost control is selected, defrost does not occur above the user specified outdoor temperature entered in the input field "Heat Pump Defrost Maximum Outdoor Dry-Bulb Temperature" described above. If this input field is left blank, the default defrost control is *Timed*.

Field: Heat Pump Defrost Time Period Fraction

This numeric field defines the fraction of compressor runtime when the defrost cycle is active, and only applies to "timed" defrost (see Heat Pump Defrost Control input field above). For example, if the defrost cycle is active for 3.5 minutes for every 60 minutes of compressor runtime, then the user should enter $3.5/60 = 0.058333$. The value for this input field must be greater than or equal to 0. If this input field is left blank, the default value is 0.058333.

Field: Supplemental Heating Coil Type

Enter the type of supplemental heating coil. The choices for this field are

- Electric
- Gas

The default is Electric.

Field: Supplemental Heating Coil Availability Schedule Name

Usually set to blank, which allows the supplemental heating coil to be available anytime the system is operating. If a schedule name is specified, it defines when the coil is available. This is most often used when supplemental heating is only available seasonally. The schedule

values denote whether the supplemental heating coil can run during a given time period. A schedule value of 1.0 indicates that the supplemental heating coil can be on during a given time period. A value of zero denotes that the supplemental heating coil cannot be used during that time period

Field: Supplemental Heating Coil Capacity

Enter Autosize to allow the sizing algorithm to determine the proper capacity required based on the loads experienced during the heating design day. If a value is specified, it is the maximum amount of heat that the supplemental heating coil can deliver in Watts. The default is Autosize.

Field: Supplemental Heating Coil Maximum Outdoor Dry-Bulb Temperature

This numeric field defines the outdoor air dry-bulb temperature above which the supplemental heating coil is disabled. The temperature for this input field must be less than or equal to 21 C. If this input field is left blank, the default value is 21 C.

Field: Supplemental Gas Heating Coil Efficiency

Enter supplemental heating coil gas burner efficiency as a decimal, not as a percent. A burner that is 80% efficient would have an entry of 0.8 here, which is the default. This field applies only if the supplemental heating coil type is gas.

Field: Supplemental Gas Heating Coil Parasitic Electric Load

Enter the parasitic electric load associated with the gas supplemental heating coil operation, such as a combustion fan. The units are in W. The default is 0.0. This field applies only if the supplemental heating coil type is gas.

Field: Maximum Outdoor Air Flow Rate

Enter Autosize or a value for the maximum amount of outdoor air flow into the unit when the economizer is operating. Autosize means that 100% of the full supply flow may be taken from outdoor air. The units are in m3/s. That is, the entered value is used to define the Maximum Outside Air Flow Rate for the Controller:OutdoorAir object that will be generated by this template.

Field: Minimum Outdoor Air Flow Rate

Enter Autosize or the value for the minimum amount of outdoor air that can enter the unit and be distributed to the zones. Usually this is set to autosize and the value is calculated by the outdoor air requirements of each zone. If a value is entered it overrides the outdoor air specification from the zone level. The units are in m3/s. The default is Autosize. Note if heat recovery is specified (see Heat Recovery Type below), then a value must be entered in this field, because heat recovery equipment is not yet autosizable. That is, the entered value is used to define the Minimum Outside Air Flow Rate for the Controller:OutdoorAir object that will be generated by this template.

Field: Minimum Outdoor Air Schedule Name

Leave this field blank if you want the minimum outdoor air to be the same for all hours in the entire year. If a schedule name is specified, values are decimal fractions (0.0 – 1.0) that multiply the minimum outdoor air flow rate. This schedule is useful for reducing the outdoor air flow rate during unoccupied or start up hours.

Field: Economizer Type

The options for this field are

- 'FixedDryBulb'
- 'DifferentialDryBulb'
- 'FixedEnthalpy'

- 'DifferentialEnthalpy'
- 'ElectronicEnthalpy' (i.e., humidity ratio curve strategy)
- 'FixedDewPointAndDryBulb'
- 'DifferentialDryBulbAndEnthalpy'
- 'NoEconomizer'

Choosing **NoEconomizer** means the economizer will not operate and the outdoor airflow rate will be at the minimum for the entire simulation.

Choosing **FixedDryBulb** means the economizer will set the outdoor airflow rate at minimum if the outdoor air temperature is higher than a specified dry-bulb temperature limit.

Choosing **DifferentialDryBulb** will trigger the outdoor airflow to minimum when the dry-bulb temperature of outdoor air is higher than the dry-bulb temperature of the return air.

FixedEnthalpy checks the upper limit of the enthalpy given as a field input against the enthalpy content of outdoor air and will set the outdoor airflow rate to minimum if the latter is greater than the former.

DifferentialEnthalpy does the same thing but compares the return air enthalpy with the enthalpy of outdoor air. When the enthalpy of outdoor air is greater than the enthalpy of the return air, the outdoor air flow rate is set to minimum.

Choosing **ElectronicEnthalpy** enables the simulation to calculate the humidity ratio limit of outdoor air based on the dry-bulb temperature of outdoor air and a quadratic/cubic curve, and compare it to the actual outdoor air humidity ratio. If the actual outdoor humidity ratio is greater than the calculated humidity ratio limit, then the outdoor airflow rate is set to minimum.

Choosing **FixedDewPointAndDryBulb** compares both the outdoor dewpoint temperature and the outdoor dry-bulb temperature to their specified high limit values. If either outdoor temperature exceeds the high limit value, the outdoor airflow rate is set to minimum.

Another option **DifferentialDryBulbAndEnthalpy** enables the control strategy to be based on both the **DifferentialDryBulb** and **DifferentialEnthalpy** economizer control strategies.

In addition to all economizer control types listed above, each control type checks for user-entered values for the upper limit of dry-bulb temperature, enthalpy limit, humidity ratio limit and dewpoint limit. The outdoor air flow rate is set to minimum if any of these entered limits are exceeded.

The default for this field is **NoEconomizer**

Field: Economizer Lockout

Enter one of the following choices for this field:

- NoLockout
- LockoutWithHeating
- LockoutWithCompressor

The default value is **NoLockout**. The **LockoutWithHeating** means that if the packaged unit is in heating mode, the economizer is locked out – i.e., the economizer dampers are closed and there is minimum outdoor air flow. **LockoutWithCompressor** means that in addition to locking out the economizer when the unit is in heating mode the economizer is locked out when the DX unit compressor is on. In other words, when the DX coil is off, the economizer must meet the entire cooling load – it isn't allowed to operate in conjunction with the DX cooling coil. Similarly, when the DX coil is operating, the economizer is not allowed to operate. The **LockoutWithCompressor** option is sometimes called a "nonintegrated" economizer.

Field: Economizer Maximum Limit Dry-Bulb Temperature

Input for this field is the outdoor air temperature high limit (°C) for economizer operation. If the outdoor air temperature is above this limit, the outdoor airflow rate will be set to the minimum.

This field is required if Economizer Control Type 'FixedDryBulb' or 'FixedDewPointAndDryBulb' has been specified. No input (blank) in this field means that there is no outdoor air temperature high limit control.

Field: Economizer Maximum Limit Enthalpy

Enter the outdoor air upper enthalpy limit (in J/kg) for economizer operation. If the outdoor air enthalpy is above this value, the outdoor air flow rate will be set to the minimum and heat recovery will be enabled if available. No input or zero in this field means that there is no outdoor air enthalpy limit control.

Field: Economizer Maximum Limit Dewpoint Temperature

Input for this field is the outdoor air dewpoint limit (°C) for economizer operation. If the outdoor air dewpoint temperature is above this value, the outdoor airflow rate will be set to the minimum. This field is required if the Economizer Control Type 'FixedDewPointAndDryBulb' has been specified. No input (blank) in this field means that there is no outdoor air dewpoint limit control.

Field: Economizer Minimum Limit Dry-Bulb Temperature

Enter the outdoor air temperature low limit (C) for economizer operation. If the outdoor air temperature is below this limit, the outdoor air flow rate will be set to the minimum and heat recovery will be enabled if available. No input or zero in this field means that there is no outdoor air temperature low limit control.

Field: Supply Plenum Name

Set to blank if no supply plenum is to be modeled. If a supply plenum is modeled, it must be modeled as a zone with surfaces, and the name of the plenum zone should be entered here. This supply plenum serves all zones on this system. If any zone supply plenums have been specified, the outlet from the system supply plenum will flow through the zone supply plenum to the zone terminal unit.

Field: Return Plenum Name

Set to blank if no return plenum is to be modeled. If a return plenum is modeled, it must be modeled as a zone with surfaces, and the name of the plenum zone should be entered here. This return plenum serves all zones on this system. If any zone return plenums have been specified, the return air from the zone will flow through the zone return plenum and then into the system return plenum.

Field: Night Cycle Control

Enter the system behavior during times when the System Availability Schedule is zero (off). The possible inputs are *StayOff*, *CycleOnAny*, or *CycleOnControlZone*. *StayOff* means the system will remain off, no matter how hot or cold the zones may be. *CycleOnAny* means that if any zone served by this system has an air temperature outside the cooling or heating set points the central fan will turn on even though the System Availability Schedule indicates the fan is off. *CycleOnControlZone* means the same thing except the availability manager looks at the temperature in only the zone specified in Night Cycle Control Zone Name. The default is *StayOff*.

Field: Night Cycle Control Zone Name

For the Night Cycle Control option *CycleOnControlZone* enter the name of the control zone. For other Night Cycle Control options, this field is ignored.

Field: Heat Recovery Type

Enter the type of air-to-air heat recovery which is available between the relief air stream and the outdoor air inlet stream. The choices are:

- *None*

- *Sensible*
- *Enthalpy*

The default is **None**. If heat recovery is specified (i.e., **Sensible** or **Enthalpy**), then a value must be entered in the Minimum Outdoor Air Flow Rate field, because heat recovery equipment is not yet autosizable. The entered Minimum Outdoor Air Flow Rate is used to define the Nominal Supply Air Flow Rate for the HeatExchanger:AirToAir:SensibleAndLatent object generated by this template.

Field: Sensible Heat Recovery Effectiveness

Enter the sensible heat recovery effectiveness. This is applied as a constant effectiveness at all conditions. The valid range is from 0.0 to 1.0, and the default is 0.70.

Field: Latent Heat Recovery Effectiveness

Enter the latent heat recovery effectiveness if Heat Recovery Type is *Enthalpy*. This is applied as a constant effectiveness at all conditions. The valid range is from 0.0 to 1.0, and the default is 0.65.

Field: Humidifier Type

There are two humidifier type options available:

- None
- ElectricSteam

The *ElectricSteam* humidifier option uses the Humidifier:Steam:Electric object. The default is *None*.

Field: Humidifier Availability Schedule Name

If left blank, the humidifier will be available anytime the system is operating. If a schedule name is specified, it defines when the humidifier is available. The schedule values denote whether the humidifier can run during a given time period. A schedule value of 1.0 indicates that the humidifier can be on during a given time period. A value of zero denotes that the humidifier cannot be used during that time period

Field: Humidifier Rated Capacity

Enter the rated moisture output rate in m³/s. The humidifier does not currently autosize, so the default is very large to allow for adequate capacity. The default is 0.000001 m³/s.

Field: Humidifier Rated Electric Power

Enter the electric power input at the rated capacity moisture output. The humidifier does not currently autosize, so the default power input is consistent with the default capacity input (2690 W per 0.000001 m³/s output) Power consumption is proportional to moisture output with no part-load penalty.

Field: Humidifier Control Zone Name

This field specifies the zone name where the humidistat is located for controlling humidification.

Field: Humidifier Setpoint

This field specifies the zone humidistat setpoint for humidification in percent (0 to 100). The default is 30%.

```

HVACTemplate:System:UnitaryHeatPump:AirToAir,
  \min-fields 54
  \memo Unitary furnace with electric air-to-air heat pump
  \memo Referenced schedules must be defined elsewhere in the idf.
A1, \field Name
  \reference CompactHVACSystemUnitary
A2, \field System Availability Schedule Name
  \note If blank, always on; Unitary System always on. Schedule is used in availability manager
  \note and fan scheduling.
  \note Also see "Night Cycle Control" field.
  \type object-list
  \object-list ScheduleNames
A3, \field Control Zone or Thermostat Location Name
  \type object-list
  \object-list ZoneNames
N1, \field Cooling Supply Air Flow Rate
  \note Supply air flow rate during heating operation
  \type real
  \minimum> 0.0
  \autosizable
  \default Autosize
  \units m3/s
N2, \field Heating Supply Air Flow Rate
  \note Supply air flow rate during heating operation
  \type real
  \minimum> 0.0
  \autosizable
  \default Autosize
  \units m3/s
N3, \field No Load Supply Air Flow Rate
  \note Supply air flow rate when no cooling or heating is needed
  \note Only used when heat pump fan operating mode is Continuous. This air flow rate
  \note is used when no heating or cooling is required and the DX coil compressor is off.
  \note If this field is left blank or zero, the supply air flow rate from the previous on cycle
  \note (either cooling or heating) is used.
  \type real
  \minimum 0
  \default Autosize
  \autosizable
  \units m3/s
A4, \field Supply Fan Operating Mode Schedule Name
  \note Refers to a schedule to specify unitary supply fan operating mode.
  \note Schedule values of 0 indicate cycling fan (auto)
  \note Schedule values of 1 indicate continuous fan (on)
  \note Keywords "Cycling" or "Continuous" may also be used here.
  \type object-list
  \object-list ScheduleNames
  \default Cycling
A5, \field Supply Fan Placement
  \type choice
  \key BlowThrough
  \key DrawThrough
  \default BlowThrough
N4, \field Supply Fan Total Efficiency
  \minimum> 0.0
  \maximum 1.0
  \default 0.7
N5, \field Supply Fan Delta Pressure
  \units Pa
  \ip-units inH2O
  \minimum 0
  \default 600
N6, \field Supply Fan Motor Efficiency
  \minimum> 0.0
  \maximum 1.0
  \default 0.9

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```

N7, \field Supply Fan Motor in Air Stream Fraction
  \minimum 0.0
  \maximum 1.0
  \default 1.0
A6, \field Cooling Coil Type
  \type choice
  \key SingleSpeedDX
  \default SingleSpeedDX
A7, \field Cooling Coil Availability Schedule Name
  \note If blank, always on
  \type object-list
  \object-list ScheduleNames
N8, \field Cooling Coil Capacity
  \note Gross capacity excluding effect of supply air fan heat
  \note Rating point: air entering the cooling coil at 26.7 C dry-bulb/19.4 C wet-bulb, and
  \note air entering the outdoor condenser coil at 35 C dry-bulb/23.9 C wet-bulb
  \autosizable
  \default Autosize
  \units W
N9, \field Cooling Coil Rated Sensible Heat Ratio
  \note Rated sensible heat ratio (gross sensible capacity/gross total capacity)
  \note Sensible and total capacities do not include effect of supply fan heat
  \autosizable
  \minimum 0.5
  \maximum 1.0
  \default Autosize
N10, \field Cooling Coil Rated COP
  \note Gross cooling capacity divided by power in
  \minimum > 0.0
  \default 3.0
A8, \field Heat Pump Heating Coil Type
  \type choice
  \key SingleSpeedDXHeatPump
  \default SingleSpeedDXHeatPump
A9, \field Heat Pump Heating Coil Availability Schedule Name
  \note If blank, always on
  \type object-list
  \object-list ScheduleNames
N11, \field Heat Pump Heating Coil Rated Capacity
  \note Capacity excluding supply air fan heat
  \note Rating point outdoor dry-bulb temp 8.33 C, outdoor wet-bulb temp 6.11 C
  \note Rating point heating coil entering air dry-bulb 21.11 C, coil entering wet-bulb 15.55 C
  \type real
  \units W
  \minimum > 0.0
  \autosizable
  \default Autosize
  \units W
N12, \field Heat Pump Heating Coil Rated COP
  \note Heat Pump Heating Coil Rate Capacity divided by power in
  \note Does not include supply air fan heat or supply air fan electrical energy
  \note Rating point outdoor dry-bulb temp 8.33 C, outdoor wet-bulb temp 6.11 C
  \note Rating point heating coil entering air dry-bulb 21.11 C, coil entering wet-bulb 15.55 C
  \minimum > 0.0
  \default 2.75
N13, \field Heat Pump Heating Minimum Outdoor Dry-Bulb Temperature
  \type real
  \minimum -20.0
  \default -8.0
  \units C
N14, \field Heat Pump Defrost Maximum Outdoor Dry-Bulb Temperature
  \type real
  \minimum 0.0
  \maximum 7.22
  \default 5.0
  \units C
A10, \field Heat Pump Defrost Strategy
  \type choice
  \key ReverseCycle
  \key Resistive
  \default ReverseCycle

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```

A11, \field Heat Pump Defrost Control
\type choice
\key Timed
\key OnDemand
\default Timed
N15, \field Heat Pump Defrost Time Period Fraction
\type real
\minimum 0.0
\default 0.058333
\note Fraction of time in defrost mode
\note only applicable if Timed defrost control is specified
A12, \field Supplemental Heating Coil Type
\type choice
\key Electric
\key Gas
\default Electric
A13, \field Supplemental Heating Coil Availability Schedule Name
\note If blank, always on
\type object-list
\object-list ScheduleNames
N16, \field Supplemental Heating Coil Capacity
\autosizable
\default Autosize
\units W
N17, \field Supplemental Heating Coil Maximum Outdoor Dry-Bulb Temperature
\type real
\maximum 21.0
\default 21.0
\units C
\note Supplemental heater will not operate when outdoor temperature exceeds this value.
N18, \field Supplemental Gas Heating Coil Efficiency
\note Applies only if Supplemental Heating Coil Type is Gas
\maximum 1.0
\minimum 0.0
\default 0.8
N19, \field Supplemental Gas Heating Coil Parasitic Electric Load
\note Applies only if Supplemental Heating Coil Type is Gas
\units W
\ip-units W
\minimum 0.0
\default 0.0
N20, \field Maximum Outdoor Air Flow Rate
\autosizable
\default Autosize
\units m3/s
\minimum 0.0
N21, \field Minimum Outdoor Air Flow Rate
\autosizable
\default Autosize
\units m3/s
\minimum 0.0
A14, \field Minimum Outdoor Air Schedule Name
\note Schedule values multiply the minimum outdoor air flow rate
\note If blank, always one
\type object-list
\object-list ScheduleNames
A15, \field Economizer Type
\type choice
\key FixedDryBulb
\key FixedEnthalpy
\key DifferentialDryBulb
\key DifferentialEnthalpy
\key FixedDewPointAndDryBulb
\key ElectronicEnthalpy
\key DifferentialDryBulbAndEnthalpy
\key NoEconomizer
\default NoEconomizer

```

```
A16, \field Economizer Lockout
\type choice
\key NoLockout
\key LockoutWithHeating
\key LockoutWithCompressor
\default NoLockout
N22, \field Economizer Maximum Limit Dry-Bulb Temperature
\type real
\units C
\note Enter the maximum outdoor dry-bulb temperature limit for FixedDryBulb
\note economizer control type. No input or blank input means this limit is
\note not operative. Limit is applied regardless of economizer control type.
N23, \field Economizer Maximum Limit Enthalpy
\type real
\units J/kg
\note Enter the maximum outdoor enthalpy limit for FixedEnthalpy economizer control type.
\note No input or blank input means this limit is not operative
\note Limit is applied regardless of economizer control type.
N24, \field Economizer Maximum Limit Dewpoint Temperature
\type real
\units C
\note Enter the maximum outdoor dewpoint temperature limit for FixedDewPointAndDryBulb
\note economizer control type. No input or blank input means this limit is not operative.
\note Limit is applied regardless of economizer control type.
N25, \field Economizer Minimum Limit Dry-Bulb Temperature
\type real
\units C
\note Enter the minimum outdoor dry-bulb temperature limit for economizer control.
\note No input or blank input means this limit is not operative
\note Limit is applied regardless of economizer control type.
A17, \field Supply Plenum Name
\note Plenum zone name. Supply plenum serves all zones on this system.
\note Blank if none.
\type object-list
\object-list ZoneNames
A18, \field Return Plenum Name
\note Plenum zone name. Return plenum serves all zones on this system.
\note Blank if none.
\type object-list
\object-list ZoneNames
A19, \field Night Cycle Control
\type choice
\key StayOff
\key CycleOnAny
\key CycleOnControlZone
\default StayOff
A20, \field Night Cycle Control Zone Name
\note Applicable only if Night Cycle Control is Cycle On Control Zone.
\type object-list
\object-list ZoneNames
A21, \field Heat Recovery Type
\note If heat recovery is specified, then a value must be entered in
\note the Minimum Outdoor Air Flow Rate field, because heat recovery
\note equipment is not yet autosizable.
\type choice
\key None
\key Sensible
\key Enthalpy
\default None
N26, \field Sensible Heat Recovery Effectiveness
\minimum 0.0
\maximum 1.0
\default 0.70
N27, \field Latent Heat Recovery Effectiveness
\note Applicable only if Heat Recovery Type is Enthalpy.
\minimum 0.0
\maximum 1.0
\default 0.65
```

```

A22, \field Humidifier Type
      \type choice
      \key None
      \key ElectricSteam
      \default None
A23, \field Humidifier Availability Schedule Name
      \note If blank, always available
      \type object-list
      \object-list ScheduleNames
N28, \field Humidifier Rated Capacity
      \note Moisture output rate at full rated power input.
      \note The humidifier does not currently autosize, so the default is very large
      \note to allow for adequate capacity.
      \type real
      \units m3/s
      \minimum 0.0
      \default 0.000001
      \ip-units gal/min
N29, \field Humidifier Rated Electric Power
      \note Electric power input at rated capacity moisture output.
      \note The humidifier does not currently autosize, so the default power input is
      \note consistent with the default capacity input (2690 W per 0.000001 m3/s output)
      \note Power consumption is proportional to moisture output with no part-load penalty.
      \type real
      \units W
      \minimum 0.0
      \default 2690.0
      \ip-units W
A24, \field Humidifier Control Zone Name
      \note Zone name where humidistat is located
      \type object-list
      \object-list ZoneNames
N30; \field Humidifier Setpoint
      \note Zone relative humidity setpoint in percent (0 to 100)
      \type real
      \minimum 0.0
      \maximum 100.0
      \default 30.0
      \units percent

```

And, as shown in an IDF:

```

HVACTemplate:System:UnitaryHeatPump:AirToAir,
Heat Pump 1,           !- Name
FanAvailsSched,      !- System Availability Schedule Name
SPACE1-1,            !- Control Zone or Thermostat Location Name
autosize,             !- Cooling Supply Air Flow Rate {m3/s}
autosize,             !- Heating Supply Air Flow Rate {m3/s}
autosize,             !- No Load Supply Air Flow Rate {m3/s}
Cycling,              !- Supply Fan Operating Mode Schedule Name
BlowThrough,         !- Supply Fan Placement
0.7,                  !- Supply Fan Total Efficiency
600,                  !- Supply Fan Delta Pressure {Pa}
0.9,                  !- Supply Fan Motor Efficiency
1,                    !- Supply Fan Motor in Air Stream Fraction
SingleSpeedDX,       !- Cooling Coil Type
,                     !- Cooling Coil Availability Schedule Name
autosize,             !- Cooling Coil Capacity {W}
autosize,             !- Cooling Coil Rated Sensible Heat Ratio
3,                    !- Cooling Coil Rated COP
SingleSpeedDXHeatPump, !- Heat Pump Heating Coil Type
,                     !- Heat Pump Heating Coil Availability Schedule Name
autosize,             !- Heat Pump Heating Coil Rated Capacity {W}
2.75,                !- Heat Pump Heating Coil Rated COP
-8,                   !- Heat Pump Heating Minimum Outdoor Dry-Bulb Temperature {C}

```



```

5,                !- Heat Pump Defrost Maximum Outdoor Dry-Bulb Temperature {C}
ReverseCycle,    !- Heat Pump Defrost Strategy
Timed,           !- Heat Pump Defrost Control
0.058333,       !- Heat Pump Defrost Time Period Fraction
Electric,        !- Supplemental Heating Coil Type
,               !- Supplemental Heating Coil Availability Schedule Name
autosize,        !- Supplemental Heating Coil Capacity {W}
21,             !- Supplemental Heating Coil Maximum Outdoor Dry-Bulb Temperature {C}
0.8,            !- Supplemental Gas Heating Coil Efficiency
,               !- Supplemental Gas Heating Coil Parasitic Electric Load {W}
autosize,        !- Maximum Outdoor Air Flow Rate {m3/s}
autosize,        !- Minimum Outdoor Air Flow Rate {m3/s}
Min OA Sched,   !- Minimum Outdoor Air Schedule Name
DifferentialDryBulb, !- Economizer Type
NoLockout,      !- Economizer Lockout
19,             !- Economizer Maximum Limit Dry-Bulb Temperature {C}
,               !- Economizer Maximum Limit Enthalpy {J/kg}
,               !- Economizer Maximum Limit Dewpoint Temperature {C}
4,              !- Economizer Minimum Limit Dry-Bulb Temperature {C}
,               !- Supply Plenum Name
,               !- Return Plenum Name
CycleOnAny,     !- Night Cycle Control
,               !- Night Cycle Control Zone Name
None,           !- Heat Recovery Type
0.7,            !- Sensible Heat Recovery Effectiveness
0.65,           !- Latent Heat Recovery Effectiveness
None,           !- Humidifier Type
,               !- Humidifier Availability Schedule Name
0.000001,      !- Humidifier Rated Capacity {m3/s}
2690,          !- Humidifier Rated Electric Power {W}
,               !- Humidifier Control Zone Name
30;            !- Humidifier Setpoint {percent}

```

HVACTemplate:System:VAV

This object simulates the system portion of a variable air volume HVAC configuration with several different heating options. Multiple HVACTemplate:Zone:VAV objects are usually specified for each HVACTemplate:System:VAV object.

Field: Name

Enter a name for the HVACTemplate:System:VAV object. This name is used in the HVACTemplate:Zone:VAV object to reference this system.

Field: System Availability Schedule Name

Leave this field blank if you want the system to be available for the entire year to perform heating or cooling if called for by the thermostat. If a schedule name is specified, those times that the system is available should be specified as 1.0. Those times that the system is not available should have a zero value in the schedule specified. Please note that for this system type, this is a schedule of when the system is providing air flow.

Field: Supply Fan Maximum Flow Rate

Enter Autosize to set the system maximum air-flow rate to the sum of the zone air flow rates. If a value is entered here for the maximum air-flow rate, it is the upper limit on system flow, even if the zone level air flow inputs sum to a greater value. The units are m³/s.

Field: Supply Fan Minimum Flow Rate

Enter the minimum supply air volume that may be provided. This field may be set to autosize and then the supply fan minimum is determined by the zone minimum air flow requirements. The units are in m³/s.

Field: Supply Fan Total Efficiency

Enter the total efficiency of the supply fan. This is the ratio of the power delivered to the air to the electrical input power at maximum flow. This is also the product of the fan motor

efficiency and fan (impeller) efficiency. The motor efficiency is the power delivered to the shaft divided by the electrical power input to the motor. The fan efficiency is the power delivered to the air divided by the shaft power. The power delivered to the fluid is the mass flow rate of the air multiplied by the pressure rise divided by the air density. Must be greater than 0 and less than or equal to 1.

Field: Supply Fan Delta Pressure

Enter the pressure rise in Pa at full flow and standard conditions. Standard conditions are considered 20°C at sea level, 101325 Pa.

Field: Supply Fan Motor efficiency

Enter the shaft power of the supply fan divided by the electrical power consumed. Must be greater than 0 and less than or equal to 1.

Field: Supply Fan Motor in Air Stream Fraction

Enter the fraction of the motor heat that is added to the air stream. A value of 0 means that the motor is completely outside the air stream. A value of 1 means that all of the motor heat will go into the air stream and act to cause a temperature rise. Must be between 0 and 1.

Field: Cooling Coil Type

There are two coil types available:

- ChilledWater
- ChilledWaterDetailedFlatModel

ChilledWater uses the COIL:Cooling:Water object with the DetailedAnalysis option. This is the preferred coil model for most applications. *ChilledWaterDetailedFlatModel* uses the Coil:Cooling:Water:DetailedGeometry object. This option is available for special applications. The default is *ChilledWater*.

Field: Cooling Coil Availability Schedule Name

Usually set to blank, which allows the cooling coil to be available anytime the system is operating. If a schedule name is specified, it defines when the coil is available. This is most often used when cooling is only available seasonally. A schedule value of one indicates that the cooling coil can be on during a given time period. A value of zero denotes that the cooling coil cannot be used during that time period.

Field: Cooling Coil Setpoint Schedule Name

If a constant setpoint for the cooling coil is to be specified, leave this field blank, and the Cooling Coil Design Setpoint value will be used at all times. If a set point schedule is to be used for the cooling coil specify the schedule name here. The schedule should control the supply air temperature delivered to the zones. For Blow Through fan placement, this is the leaving air temperature from the cooling coil. For Draw Through fan placement, this is the leaving air temperature after the supply fan. The values in the schedule are in degrees C. This field is ignored if the Cooling Coil Setpoint Reset Type is something other than None (see below).

Field: Cooling Coil Design Setpoint

Enter the cooling supply air temperature in C to be used for sizing the cooling coil and zone supply air flow rates. The default is 12.8C. If no Cooling Coil Setpoint Schedule or Cooling Coil Setpoint Reset Type is specified, this value is used as a constant cooling supply air setpoint temperature.

Field: Heating Coil Type

The heating coil is located in the supply air stream, upstream of the cooling coil and after the outdoor air mixing box. If no central heating coil is used in the VAV system, then the option

“none” should be specified here. Otherwise this indicates the type of heating coil. It is unlikely that both a heating coil and a preheat coil would be used at the same time. The choices for this field are

- HotWater
- Electric
- Gas
- None

The default value is None. Note that the configuration of HVACTemplate:System:VAV assumes that there will be reheat coils or baseboard heating to provide heating control at the zone level. If a heating coil is specified, the heating and cooling coil setpoint controls and availability schedules must coordinate to prevent the coils from opposing each other.

Field: Heating Coil Availability Schedule Name

Usually set to blank, which allows the heating coil to be available anytime the system is operating. If a schedule name is specified, it defines when the coil is available. This is most often used when heating is only available seasonally. The schedule values denote whether the heating coil can run during a given time period. A schedule value of one indicates that the heating coil can be on during a given time period. A value of zero denotes that the heating coil cannot be used during that time period

Field: Heating Coil Setpoint Schedule Name

If a constant setpoint for the heating coil is to be specified, leave this field blank, and the Heating Coil Design Setpoint value will be used at all times. If a set point schedule is to be used for the heating coil specify the schedule name here. The schedule should control the supply air temperature delivered to the zones. For Blow Through fan placement, this is the leaving air temperature from the heating coil. For Draw Through fan placement, this is the leaving air temperature after the supply fan. The values in the schedule are in degrees C. This field is ignored if the Heating Coil Setpoint Reset Type is something other than None (see below).

Field: Heating Coil Design Setpoint

Enter the heating supply air temperature in C to be used for sizing the heating coil and zone supply air flow rates. If no Heating Coil Setpoint Schedule or Heating Coil Setpoint Reset Type is specified, this value is used as a constant heating supply air setpoint temperature. The default is 10.0C.

Field: Gas Heating Coil Efficiency

Enter gas burner efficiency as a decimal, not as a percent. A burner that is 80% efficient would have an entry of 0.8 here, which is the default

Field: Gas Heating Coil Parasitic Electric Load

Enter the parasitic electric load associated with the gas heating operation, such as a combustion fan. The units are in W.

Field: Preheat Coil Type

The preheat coil is located in the outdoor air stream, upstream of the outdoor air mixing box and tempers the outdoor air. If no preheat coil is used in the VAV system, then the option “none” should be specified here. Otherwise this indicates the type of preheat coil. It is unlikely that both a heating coil and a preheat coil would be used at the same time. The choices for this field are

- Electric
- Gas
- None

The default value is None. If a preheat coil is specified, the preheat and cooling coil setpoint controls and availability schedules must coordinate to prevent the coils from opposing each other.

Field: Preheat Coil Availability Schedule Name

Usually set to blank, which allows the preheat coil to be available anytime the system is operating. If a schedule name is specified, it defines when the preheat coil is available. This is most often used when preheat is only available seasonally. The schedule values denote whether the preheat coil can run during a given time period. A schedule value of 1.0 indicates that the preheat coil can be on during a given time period. A value of zero denotes that the preheat coil cannot be used during that time period

Field: Preheat Coil Setpoint Schedule Name

If a constant setpoint for the preheat coil is to be specified, leave this field blank, and the Preheat Coil Design Setpoint value will be used at all times. If a set point schedule is to be used for the preheat coil specify the schedule name here. The schedule should control the leaving air temperature from the preheat coil. The values in the schedule are in degrees C.

Field: Preheat Coil Design Setpoint

Enter the preheat supply air temperature in C to be used for sizing the preheat coil. If no Preheat Coil Setpoint Schedule is specified, this value is used as a constant preheat supply air setpoint temperature. The default is 7.2C.

Field: Gas Preheat Coil Efficiency

Enter gas burner efficiency as a decimal, not as a percent. A burner that is 80% efficient would have an entry of 0.8 here, which is the default

Field: Gas Preheat Coil Parasitic Electric Load

Enter the parasitic electric load associated with the gas heating operation, such as an combustion fan. The units are in W.

Field: Maximum Outdoor Air Flow Rate

Enter autosize or a value for the maximum amount of outdoor air flow into the unit when the economizer is operating. Autosize means that 100% of the full supply flow may be taken from outdoor air. If a value is entered, it is used instead of the autosize value. The units are in m³/s. That is, the entered value is used to define the Maximum Outside Air Flow Rate for the Controller:OutdoorAir object that will be generated by this template.

Field: Minimum Outdoor Air Flow Rate

Enter autosize or the value for the minimum amount of outdoor air that can enter the unit and be distributed to the zones. Usually this is set to autosize and the value is calculated by the outdoor air requirements of each zone. If a value is entered it overrides the outdoor air specification from the zone level. The units are in m³/s. Note if heat recovery is specified (see Heat Recovery Type below), then a value must be entered in this field, because heat recovery equipment is not yet autosizable. That is, the entered value is used to define the Minimum Outside Air Flow Rate for the Controller:OutdoorAir object that will be generated by this template.

Field: Minimum Outdoor Air Control Type

Choices for this field are **FixedMinimum** or **ProportionalMinimum**. FixedMinimum means that the minimum outdoor air flow rate is fixed no matter what the actual system flow rate is. ProportionalMinimum means the minimum outdoor air flow rate varies in proportion to the total system air flow rate. The default is ProportionalMinimum.

Field: Minimum Outdoor Air Schedule Name Name

Leave this field blank if you want the minimum outdoor air to be the same for all hours in the entire year. If a schedule name is specified, values are decimal fractions (0.0 – 1.0) that multiply the minimum outdoor air flow rate. This schedule is useful for reducing the outdoor air flow rate to zero during unoccupied or start up hours.

Field: Economizer Type

The options for this field are

- 'FixedDryBulb'
- 'DifferentialDryBulb'
- 'FixedEnthalpy'
- 'DifferentialEnthalpy'
- 'ElectronicEnthalpy' (i.e., humidity ratio curve strategy)
- 'FixedDewPointAndDryBulb'
- 'DifferentialDryBulbAndEnthalpy'
- 'NoEconomizer'

Choosing **NoEconomizer** means the economizer will not operate and the outdoor airflow rate will be at the minimum for the entire simulation.

Choosing **FixedDryBulb** means the economizer will set the outdoor airflow rate at minimum if the outdoor air temperature is higher than a specified dry-bulb temperature limit.

Choosing **DifferentialDryBulb** will trigger the outdoor airflow to minimum when the dry-bulb temperature of outdoor air is higher than the dry-bulb temperature of the return air.

FixedEnthalpy checks the upper limit of the enthalpy given as a field input against the enthalpy content of outdoor air and will set the outdoor airflow rate to minimum if the latter is greater than the former.

DifferentialEnthalpy does the same thing but compares the return air enthalpy with the enthalpy of outdoor air. When the enthalpy of outdoor air is greater than the enthalpy of the return air, the outdoor air flow rate is set to minimum.

Choosing **ElectronicEnthalpy** enables the simulation to calculate the humidity ratio limit of outdoor air based on the dry-bulb temperature of outdoor air and a quadratic/cubic curve, and compare it to the actual outdoor air humidity ratio. If the actual outdoor humidity ratio is greater than the calculated humidity ratio limit, then the outdoor airflow rate is set to minimum.

Choosing **FixedDewPointAndDryBulb** compares both the outdoor dewpoint temperature and the outdoor dry-bulb temperature to their specified high limit values. If either outdoor temperature exceeds the high limit value, the outdoor airflow rate is set to minimum.

Another option **DifferentialDryBulbAndEnthalpy** enables the control strategy to be based on both the **DifferentialDryBulb** and **DifferentialEnthalpy** economizer control strategies.

In addition to all economizer control types listed above, each control type checks for user-entered values for the upper limit of dry-bulb temperature, enthalpy limit, humidity ratio limit and dewpoint limit. The outdoor air flow rate is set to minimum if any of these entered limits are exceeded.

The default for this field is **NoEconomizer**.

Field: Economizer Lockout

The only choice for this field is

- NoLockout

The default value is NoLockout. Future versions may have additional options.

Field: Economizer Upper Temperature Limit

Enter the outdoor air temperature high limit (°C) for economizer operation. If the outdoor air temperature is above this limit, the outdoor air flow rate will be set to the minimum and heat recovery will be enabled if available. No input or zero in this field means that there is no outdoor air temperature high limit control.

Field: Economizer Lower Temperature Limit

Enter the outdoor air temperature low limit (°C) for economizer operation. If the outdoor air temperature is below this limit, the outdoor air flow rate will be set to the minimum and heat recovery will be enabled if available. No input or zero in this field means that there is no outdoor air temperature low limit control.

Field: Economizer Upper Enthalpy Limit

Enter the outdoor air upper enthalpy limit (in J/kg) for economizer operation. If the outdoor air enthalpy is above this value, the outdoor air flow rate will be set to the minimum and heat recovery will be enabled if available. No input or zero in this field means that there is no outdoor air enthalpy limit control.

Field: Supply Plenum Name

Set to blank if no supply plenum is to be modeled. If a supply plenum is modeled, it must be modeled as a zone with surfaces, and the name of the plenum zone should be entered here. This supply plenum serves all zones on this system. If any AirLoopHVAC:SupplyPlenums have been specified, the outlet from the system supply plenum will flow through the AirLoopHVAC:SupplyPlenum to the zone terminal unit.

Field: Return Plenum Name

Set to blank if no return plenum is to be modeled. If a return plenum is modeled, it must be modeled as a zone with surfaces, and the name of the plenum zone should be entered here. This return plenum serves all zones on this system. If any zone return plenums have been specified, the return air from the zone will flow through the zone return plenum and then into the system return plenum.

Field: Supply Fan Placement

Enter the supply fan placement type. This alpha field has two choices, *DrawThrough* or *BlowThrough*. *DrawThrough* models a system where the supply air fan is after the cooling and heating coils. *BlowThrough* models a system where the supply air fan is before the cooling and heating coils. The default is *Draw Through*.

Field: Supply Fan Part-Load Power Coefficients

Select the set of generic pre-defined coefficients to use for the supply fan part-load power consumption. This alpha field has the following choices:

- *InletVaneDampers*
- *OutletDampers*
- *VariableSpeedMotor*
- *ASHRAE90.1-2004Appendix G*

The default is *InletVaneDampers*. The resulting power curves are shown in Figure 130 below. The ASHRAE 90.1-2004 Appendix G coefficients are from TABLE G3.1.3.15, Method 2. The other sets of coefficients are from the EnergyPlus Input Output Reference, Fan Coefficient Values table.

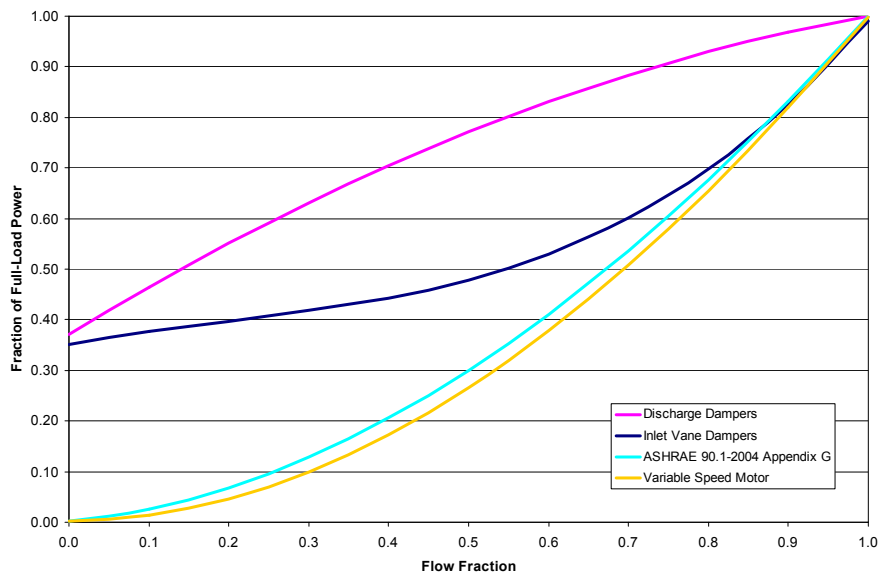


Figure 130. VAV Supply Fan Part-Load Power Coefficient Options

Field: Night Cycle Control

Enter the system behavior during times when the System Availability Schedule is zero (off). The possible inputs are *StayOff*, *CycleOnAny*, *CycleOnControl Zone* or *CycleOnAnyZoneFansOnly*. *StayOff* means the system will remain off, no matter how hot or cold the zones may be. *CycleOnAny* means that if any zone served by this system has an air temperature outside the cooling or heating set points the central fan will turn on even though the System Availability Schedule indicates the fan is off. *CycleOnControlZone* means the same thing except the availability manager looks at the temperature in only the zone specified in Night Cycle Control Zone Name. *CycleOnAnyZoneFansOnly* is the same as *CycleOnAny* except that only the zone fans are cycled on and the central air handler fan is left off (applicable only if using HVACTemplate:Zone:VAV:FanPowered in one or more zones). The default is *StayOff*.

Field: Night Cycle Control Zone Name

For the Night Cycle Control option *Cycle On Control Zone* enter the name of the control zone. For other Night Cycle Control options, this field is ignored.

Field: Heat Recovery Type

Enter the type of air-to-air heat recovery which is available between the relief air stream and the outdoor air inlet stream. The choices are:

- *None*
- *Sensible*
- *Enthalpy*

The default is **None**. If heat recovery is specified (i.e., **Sensible** or **Enthalpy**), then a value must be entered in the Minimum Outdoor Air Flow Rate field, because heat recovery equipment is not yet autosizable. The entered Minimum Outdoor Air Flow Rate is used to define the Nominal Supply Air Flow Rate for the HeatExchanger:AirToAir:SensibleAndLatent object generated by this template.

Field: Sensible Heat Recovery Effectiveness

Enter the sensible heat recovery effectiveness. This is applied as a constant effectiveness at all conditions. The valid range is from 0.0 to 1.0, and the default is 0.70.

Field: Latent Heat Recovery Effectiveness

Enter the latent heat recovery effectiveness if Heat Recovery Type is *Enthalpy*. This is applied as a constant effectiveness at all conditions. The valid range is from 0.0 to 1.0, and the default is 0.65.

Field: Cooling Coil Setpoint Reset Type

Select the type of automatic reset control for the cooling supply air temperature. The choices are:

- *None* – no reset, use the Cooling Coil Setpoint Schedule or Cooling Coil Design Setpoint.
- *Warmest* – reset the cooling supply air temperature to the highest supply air temperature that will meet the cooling requirements of all the zones. The minimum setpoint allowed is the Cooling Coil Design Setpoint. The maximum setpoint allowed is defaulted to 18C. (Reference SetpointManager:Warmest)
- *OutdoorAirTemperatureReset* – reset the cooling supply air temperature based on the following default rules. When the outdoor dry-bulb temperature (ODB) is at or below 15.6C the setpoint is 18.0C. When the ODB is at or above 26.7C the setpoint is the Cooling Coil Design Setpoint. In between, the setpoint is varied linearly. (Reference SetpointManager:OutdoorAirReset)

The default is *None*.

Field: Heating Coil Setpoint Reset Type

Select the type of automatic reset control for the central heating supply air temperature. The choices are:

- *None* – no reset, use the Heating Coil Setpoint Schedule or Heating Coil Design Setpoint.
- *OutdoorAirTemperatureReset* – reset the heating supply air temperature based on the following default rules. When the outdoor dry-bulb temperature (ODB) is at or below -6.7C the setpoint is the Heating Coil Design Setpoint. When the ODB is at or above 10.0C the setpoint is 20.0C. In between, the setpoint is varied linearly. (Reference SetpointManager:OutdoorAirReset).

The default is *None*.

Field: Dehumidification Control Type

There are two dehumidification control type options available:

- *None*
- *CoolReheat*

The *CoolReheat* option cools beyond the dry-bulb setpoint as required to meet the humidity setpoint if the system is capable of doing so. Reheat is provided as required by the terminal unit reheat coils if available.

The default is *None* which meets the sensible cooling setpoint only..

Field: Dehumidification Control Zone Name

This field specifies the zone name where the humidistat is located for controlling dehumidification.

Field: Dehumidification Setpoint

This field specifies the zone humidistat setpoint for dehumidification in percent (0 to 100). The default is 60%.

Field: Humidifier Type

There are two humidifier type options available:

- None
- ElectricSteam

The *ElectricSteam* humidifier option uses the Humidifier:Steam:Electric object. The default is *None*.

Field: Humidifier Availability Schedule Name

If left blank, the humidifier will be available anytime the system is operating. If a schedule name is specified, it defines when the humidifier is available. The schedule values denote whether the humidifier can run during a given time period. A schedule value of 1.0 indicates that the humidifier can be on during a given time period. A value of zero denotes that the humidifier cannot be used during that time period

Field: Humidifier Rated Capacity

Enter the rated moisture output rate in m3/s. The humidifier does not currently autosize, so the default is very large to allow for adequate capacity. The default is 0.000001 m3/s.

Field: Humidifier Rated Electric Power

Enter the electric power input at the rated capacity moisture output. The humidifier does not currently autosize, so the default power input is consistent with the default capacity input (2690 W per 0.000001 m3/s output) Power consumption is proportional to moisture output with no part-load penalty.

Field: Humidifier Control Zone Name

This field specifies the zone name where the humidistat is located for controlling humidification.

Field: Humidifier Setpoint

This field specifies the zone humidistat setpoint for humidification in percent (0 to 100). The default is 30%.

```

HVACTemplate: System: VAV,
  \min-fields 53
  \memo Variable Air Volume (VAV) air loop with optional heating coil
  \memo and optional preheat.
  \memo Referenced Schedules must be defined elsewhere in the idf.
A1, \field Name
  \reference CompactHVACSystemVAV
A2, \field System Availability Schedule Name
  \note If blank, always on; VAV System always on. Schedule is used in availability manager
  \note and fan scheduling.
  \note Also see "Night Cycle Control" field.
  \type object-list
  \object-list ScheduleNames
N1, \field Supply Fan Maximum Flow Rate
  \autosizable
  \default Autosize
  \units m3/s
  \minimum> 0.0

```

```

N2, \field Supply Fan Minimum Flow Rate
    \autosizable
    \default Autosize
    \units m3/s
    \minimum 0.0
N3, \field Supply Fan Total Efficiency
    \minimum> 0.0
    \maximum 1.0
    \default 0.7
N4, \field Supply Fan Delta Pressure
    \units Pa
    \ip-units inH2O
    \minimum 0
    \default 1000
N5, \field Supply Fan Motor Efficiency
    \minimum> 0.0
    \maximum 1.0
    \default 0.9
N6, \field Supply Fan Motor in Air Stream Fraction
    \minimum 0.0
    \maximum 1.0
    \default 1.0
A3, \field Cooling Coil Type
    \type choice
    \key ChilledWater
    \key ChilledWaterDetailedFlatModel
    \default ChilledWater
A4, \field Cooling Coil Availability Schedule Name
    \note If blank, always on
    \type object-list
    \object-list ScheduleNames
A5, \field Cooling Coil Setpoint Schedule Name
    \note Leave blank if constant setpoint
    \type object-list
    \object-list ScheduleNames
N7, \field Cooling Coil Design Setpoint
    \note Used for sizing and as constant setpoint if no Cooling Coil Setpoint Schedule Name is
specified.
    \default 12.8
    \units C
A6, \field Heating Coil Type
    \type choice
    \key HotWater
    \key Electric
    \key Gas
    \key None
    \default None
A7, \field Heating Coil Availability Schedule Name
    \note If blank, always on
    \type object-list
    \object-list ScheduleNames
A8, \field Heating Coil Setpoint Schedule Name
    \note Leave blank if constant setpoint
    \type object-list
    \object-list ScheduleNames
N8, \field Heating Coil Design Setpoint
    \note Used for sizing and as constant setpoint if no Heating Coil Setpoint Schedule Name is
specified.
    \default 10.0
    \units C
N9, \field Gas Heating Coil Efficiency
    \maximum 1.0
    \minimum 0.0
    \default 0.8
N10, \field Gas Heating Coil Parasitic Electric Load
    \units W
    \ip-units W
    \minimum 0.0
    \default 0.0

```

```

A9, \field Preheat Coil Type
  \type choice
  \key Electric
  \key Gas
  \key None
  \default None
A10, \field Preheat Coil Availability Schedule Name
  \note If blank, always on
  \type object-list
  \object-list ScheduleNames
A11, \field Preheat Coil Setpoint Schedule Name
  \note Leave blank if constant setpoint
  \type object-list
  \object-list ScheduleNames
N11, \field Preheat Coil Design Setpoint
  \note Used for sizing and as constant setpoint if no Preheat Coil Setpoint Schedule Name
  specified.
  \units C
  \default 7.2
N12, \field Gas Preheat Coil Efficiency
  \maximum 1.0
  \minimum 0.0
  \default 0.8
N13, \field Gas Preheat Coil Parasitic Electric Load
  \units W
  \ip-units W
  \minimum 0.0
  \default 0.0
N14, \field Maximum Outdoor Air Flow Rate
  \autosizable
  \default Autosize
  \units m3/s
  \minimum 0.0
N15, \field Minimum Outdoor Air Flow Rate
  \autosizable
  \default Autosize
  \units m3/s
  \minimum 0.0
A12, \field Minimum Outdoor Air Control Type
  \type choice
  \key FixedMinimum
  \key ProportionalMinimum
  \default ProportionalMinimum
A13, \field Minimum Outdoor Air Schedule Name
  \note Schedule values multiply the Minimum Outdoor Air Flow Rate
  \note If blank, always one
  \type object-list
  \object-list ScheduleNames
A14, \field Economizer Type
  \type choice
  \key FixedDryBulb
  \key FixedEnthalpy
  \key DifferentialDryBulb
  \key DifferentialEnthalpy
  \key FixedDewPointAndDryBulb
  \key ElectronicEnthalpy
  \key DifferentialDryBulbAndEnthalpy
  \key NoEconomizer
  \default NoEconomizer
A15, \field Economizer Lockout
  \type choice
  \key NoLockout
  \default NoLockout
N16, \field Economizer Upper Temperature Limit
  \note Outdoor temperature above which economizer is disabled and
  \note heat recovery is enabled (if available).
  \note Blank means no limit.
  \units C

```

```

N17, \field Economizer Lower Temperature Limit
\note Outdoor temperature below which economizer is disabled and
\note heat recovery is enabled (if available).
\note Blank means no limit.
\units C
N18, \field Economizer Upper Enthalpy Limit
\note Outdoor enthalpy above which economizer is disabled and
\note heat recovery is enabled (if available).
\note Blank means no limit.
\units J/kg
A16, \field Supply Plenum Name
\note Plenum zone name. Supply plenum serves all zones on this system.
\note Blank if none.
\type object-list
\object-list ZoneNames
A17, \field Return Plenum Name
\note Plenum zone name. Supply plenum serves all zones on this system.
\note Blank if none.
\type object-list
\object-list ZoneNames
A18, \field Supply Fan Placement
\type choice
\key DrawThrough
\key BlowThrough
\default DrawThrough
A19, \field Supply Fan Part-Load Power Coefficients
\note This field selects a predefined set of fan power coefficients.
\note The ASHRAE 90.1-2004 Appendix G coefficients are from TABLE G3.1.3.15, Method 2.
\note The other sets of coefficients are from the EnergyPlus Input
\note Output Reference, Fan Coefficient Values table.
\type choice
\key InletVaneDampers
\key OutletDampers
\key VariableSpeedMotor
\key ASHRAE90.1-2004AppendixG
\default InletVaneDampers
A20, \field Night Cycle Control
\type choice
\key StayOff
\key CycleOnAny
\key CycleOnControlZone
\key CycleOnAnyZoneFansOnly
\default StayOff
A21, \field Night Cycle Control Zone Name
\note Applicable only if Night Cycle Control is Cycle On Control Zone.
\type object-list
\object-list ZoneNames
A22, \field Heat Recovery Type
\note If heat recovery is specified, then a value must be entered in
\note the Minimum Outdoor Air Flow Rate field, because heat recovery
\note equipment is not yet autosizable.
\type choice
\key None
\key Sensible
\key Enthalpy
\default None
N19, \field Sensible Heat Recovery Effectiveness
\minimum 0.0
\maximum 1.0
\default 0.70
N20, \field Latent Heat Recovery Effectiveness
\minimum 0.0
\maximum 1.0
\default 0.65

```

```

A23, \field Cooling Coil Setpoint Reset Type
\note Overrides Cooling Coil Setpoint Schedule Name
\note Warmest = as warm as possible yet meet all zone cooling loads
\type choice
\key None
\key Warmest
\key OutdoorAirTemperatureReset
\default None
A24, \field Heating Coil Setpoint Reset Type
\note Overrides Heating Coil Setpoint Schedule Name
\type choice
\key None
\key OutdoorAirTemperatureReset
\default None
A25, \field Dehumidification Control Type
\note None = meet sensible load only
\note CoolReheat = cool beyond the dry-bulb setpoint
\note as required to meet the humidity setpoint.
\type choice
\key None
\key CoolReheat
\default None
A26, \field Dehumidification Control Zone Name
\note Zone name where humidistat is located
\type object-list
\object-list ZoneNames
N21, \field Dehumidification Setpoint
\note Zone relative humidity setpoint in percent (0 to 100)
\type real
\minimum 0.0
\maximum 100.0
\default 60.0
\units percent
A27, \field Humidifier Type
\type choice
\key None
\key ElectricSteam
\default None
A28, \field Humidifier Availability Schedule Name
\note If blank, always available
\type object-list
\object-list ScheduleNames
N22, \field Humidifier Rated Capacity
\note Moisture output rate at full rated power input.
\note The humidifier does not currently autosize, so the default is very large
\note to allow for adequate capacity.
\type real
\units m3/s
\minimum 0.0
\default 0.000001
\ip-units gal/min
N23, \field Humidifier Rated Electric Power
\note Electric power input at rated capacity moisture output.
\note The humidifier does not currently autosize, so the default power input is
\note consistent with the default capacity input (2690 W per 0.000001 m3/s output)
\note Power consumption is proportional to moisture output with no part-load penalty.
\type real
\units W
\minimum 0.0
\default 2690.0
\ip-units W
A29, \field Humidifier Control Zone Name
\note Zone name where humidistat is located
\type object-list
\object-list ZoneNames

```

```

N24; \field Humidifier Setpoint
      \note Zone relative humidity setpoint in percent (0 to 100)
      \type real
      \minimum 0.0
      \maximum 100.0
      \default 30.0
      \units percent

```

And, as shown in an IDF:

```

HVACTemplate:System:VAV,
VAV Sys 1,           !- Name
FanAvailSched,      !- System Availability Schedule Name
autosize,           !- Supply Fan Maximum Flow Rate {m3/s}
autosize,           !- Supply Fan Minimum Flow Rate {m3/s}
0.7,                !- Supply Fan Total Efficiency
600,                !- Supply Fan Delta Pressure {Pa}
0.9,                !- Supply Fan Motor Efficiency
1,                  !- Supply Fan Motor in Air Stream Fraction
ChilledWater,       !- Cooling Coil Type
,                   !- Cooling Coil Availability Schedule Name
,                   !- Cooling Coil Setpoint Schedule Name
12.8,               !- Cooling Coil Design Setpoint {C}
HotWater,           !- Heating Coil Type
,                   !- Heating Coil Availability Schedule Name
,                   !- Heating Coil Setpoint Schedule Name
10.0,               !- Heating Coil Design Setpoint {C}
0.8,                !- Gas Heating Coil Efficiency
0.0,                !- Gas Heating Coil Parasitic Electric Load {W}
None,               !- Preheat Coil Type
,                   !- Preheat Coil Availability Schedule Name
,                   !- Preheat Coil Setpoint Schedule Name
,                   !- Preheat Coil Design Setpoint {C}
0.8,                !- Gas Preheat Coil Efficiency
0.0,                !- Gas Preheat Coil Parasitic Electric Load {W}
autosize,           !- Maximum Outdoor Air Flow Rate {m3/s}
autosize,           !- Minimum Outdoor Air Flow Rate {m3/s}
FixedMinimum,       !- Minimum Outdoor Air Control Type
Min OA Sched,       !- Minimum Outdoor Air Schedule Name
DifferentialDryBulb, !- Economizer Type
NoLockout,          !- Economizer Lockout
19,                 !- Economizer Upper Temperature Limit {C}
4,                  !- Economizer Lower Temperature Limit {C}
,                   !- Economizer Upper Enthalpy Limit {J/kg}
,                   !- Supply Plenum Name
PLENUM-1,           !- Return Plenum Name
DrawThrough,        !- Supply Fan Placement
InletVaneDampers,   !- Supply Fan Part-Load Power Coefficients
CycleOnAnyZoneFansOnly, !- Night Cycle Control
,                   !- Night Cycle Control Zone Name
None,               !- Heat Recovery Type
0.70,               !- Sensible Heat Recovery Effectiveness
0.65,               !- Latent Heat Recovery Effectiveness
None,               !- Cooling Coil Setpoint Reset Type
None,               !- Heating Coil Setpoint Reset Type

```

None,	!- Dehumidification Control Type
,	!- Dehumidification Control Zone Name
60.0,	!- Dehumidification Setpoint {percent}
None,	!- Humidifier Type
,	!- Humidifier Availability Schedule Name
0.000001,	!- Humidifier Rated Capacity {m3/s}
2690.0,	!- Humidifier Rated Electric Power {W}
,	!- Humidifier Control Zone Name
30.0;	!- Humidifier Setpoint {percent}

HVACTemplate:System:PackagedVAV

This object simulates the system portion of a packaged direct-expansion based variable air volume HVAC configuration with several different heating options. Multiple HVACTemplate:Zone:VAV objects are usually specified for each HVACTemplate:System:PackagedVAV object.

Field: Name

Enter a name for the HVACTemplate:System:PackagedVAV object. This name is used in the HVACTemplate:Zone:VAV object to reference this system.

Field: System Availability Schedule Name

Leave this field blank if you want the system to be available for the entire year to perform heating or cooling if called for by the thermostat. If a schedule name is specified, those times that the system is available should be specified as 1.0. Those times that the system is not available should have a zero value in the schedule specified. Please note that for this system type, this is a schedule of when the system is providing air flow.

Field: Supply Fan Maximum Flow Rate

Enter Autosize to set the system maximum air-flow rate to the sum of the zone air flow rates. If a value is entered here for the maximum air-flow rate, it is the upper limit on system flow, even if the zone level air flow inputs sum to a greater value. The units are m³/s. The default is Autosize.

Field: Supply Fan Minimum Flow Rate

Enter the minimum supply air volume that may be provided. This field may be set to Autosize and then the supply fan minimum is determined by the zone minimum air flow requirements. The units are in m³/s. The default is Autosize.

Field: Supply Fan Placement

Enter the supply fan placement type. This alpha field has two choices, *DrawThrough* or *BlowThrough*. *DrawThrough* models a system where the supply air fan is after the cooling and heating coils. *BlowThrough* models a system where the supply air fan is before the cooling and heating coils. The default is *DrawThrough*.

Field: Supply Fan Total Efficiency

Enter the total efficiency of the supply fan. This is the ratio of the power delivered to the air to the electrical input power at maximum flow. This is also the product of the fan motor efficiency and fan (impeller) efficiency. The motor efficiency is the power delivered to the shaft divided by the electrical power input to the motor. The fan efficiency is the power delivered to the air divided by the shaft power. The power delivered to the fluid is the mass flow rate of the air multiplied by the pressure rise divided by the air density. Must be greater than 0 and less than or equal to 1. The default is 0.7.

Field: Supply Fan Delta Pressure

Enter the pressure rise in Pa at full flow and standard conditions. Standard conditions are considered 20° C at sea level, 101325 Pa. The default is 1000 Pa.

Field: Supply Fan Motor Efficiency

Enter the shaft power of the supply fan divided by the electrical power consumed. Must be greater or equal to the Supply Fan Total Efficiency and less than or equal to 1. The default is 0.9.

Field: Supply Fan Motor in Air Stream Fraction

Enter the fraction of the motor heat that is added to the air stream. A value of 0 means that the motor is completely outside the air stream. A value of 1 means that all of the motor heat will go into the air stream and act to cause a temperature rise. Must be between 0 and 1. The default is 1.0.

Field: Cooling Coil Type

The coil types available:

- TwoSpeedDX
- TwoSpeedHumidControlDX

TwoSpeedDX uses the Coil:Cooling:DX:TwoSpeed object. This is the preferred coil model for most applications. The *TwoSpeedHumidControlDX* option uses the Coil:Cooling:DX:TwoStageWithHumidityControlMode object.

Field: Cooling Coil Availability Schedule Name

Usually set to blank, which allows the cooling coil to be available anytime the system is operating. If a schedule name is specified, it defines when the coil is available. This is most often used when cooling is only available seasonally. A schedule value of one indicates that the cooling coil can be on during a given time period. A value of zero denotes that the cooling coil cannot be used during that time period.

Field: Cooling Coil Setpoint Schedule Name

If a constant setpoint for the cooling coil is to be specified, leave this field blank, and the Cooling Coil Design Setpoint value will be used at all times. If a set point schedule is to be used for the cooling coil specify the schedule name here. The schedule should control the supply air temperature delivered to the zones. For Blow Through fan placement, this is the leaving air temperature from the cooling coil. For Draw Through fan placement, this is the leaving air temperature after the supply fan. The values in the schedule are in degrees C. This field is ignored if the Cooling Coil Setpoint Reset Type is something other than None (see below). The default is None.

Field: Cooling Coil Design Setpoint

Enter the cooling supply air temperature in degrees C to be used for sizing the cooling coil and zone supply air flow rates. The default is 12.8C. If no Cooling Coil Setpoint Schedule or Cooling Coil Setpoint Reset Type is specified, this value is used as a constant cooling supply air setpoint temperature.

Field: Cooling Coil Capacity

Enter Autosize to let the automatic sizing algorithm determine the cooling coil capacity based on the maximum cooling loads during the cooling design day. If a value is entered, it represents the full load cooling capacity, including both sensible and latent capacity, in watts of the DX coil unit at rated conditions. Rated conditions are air entering the cooling coil at the maximum supply air flow rate at 26.7°C drybulb/19.4°C wetbulb with air entering the outdoor condenser coil at 35°C drybulb. Capacity should be the "gross" capacity where the impact of supply air fan heat is NOT included. The units are in W. The default is Autosize.

Field: Cooling Coil Rated Sensible Heat Ratio

Enter Autosize to allow the sizing algorithm to determine the sensible heat ratio based on the rated capacity and air flow rate. Otherwise, enter the value of the ratio of the sensible capacity divided by total cooling capacity of the DX cooling coil at rated conditions. Rated conditions are air entering the cooling coil at the maximum supply air flow rate at 26.7°C drybulb/19.4°C wetbulb with air entering the outdoor condenser coil at 35°C drybulb. Both the sensible and total cooling capacities used to define the Rated Sensible Heat Ratio (SHR) should be “gross” capacity where the impact of supply air fan heat is NOT included. The default is Autosize.

Field: Cooling Coil Rated COP

Enter the coefficient of performance defined as the gross cooling coil capacity in watts divided by electrical power input in watts of the DX cooling coil unit at rated conditions. Rated conditions are air entering the cooling coil at the maximum supply air flow rate at 26.7°C drybulb/19.4°C wetbulb with air entering the outdoor condenser coil at 35°C drybulb. The input power includes electric power for the compressor and condenser fan but does not include the power consumption of the supply air fan. The default is 3.0.

Field: Heating Coil Type

Enter the type of heating used in the unitary system. The choices for this field are

- Electric
- Gas
- HotWater

Field: Heating Coil Availability Schedule Name

Usually set to blank, which allows the heating coil to be available anytime the system is operating. If a schedule name is specified, it defines when the coil is available. This is most often used when heating is only available seasonally. The schedule values denote whether the heating coil can run during a given time period. A schedule value of 1.0 indicates that the heating coil can be on during a given time period. A value of zero denotes that the heating coil cannot be used during that time period

Field: Heating Coil Setpoint Schedule Name

If a constant setpoint for the heating coil is to be specified, leave this field blank, and the Heating Coil Design Setpoint value will be used at all times. If a set point schedule is to be used for the heating coil specify the schedule name here. The schedule should control the supply air temperature delivered to the zones. For Blow Through fan placement, this is the leaving air temperature from the heating coil. For Draw Through fan placement, this is the leaving air temperature after the supply fan. The values in the schedule are in degrees C. This field is ignored if the Heating Coil Setpoint Reset Type is something other than None (see below).

Field: Heating Coil Design Setpoint

Enter the heating supply air temperature in degrees C to be used for sizing the heating coil and zone supply air flow rates. If no Heating Coil Setpoint Schedule or Heating Coil Setpoint Reset Type is specified, this value is used as a constant heating supply air setpoint temperature. The default is 10.0C.

Field: Heating Coil Capacity

Enter Autosize to allow the sizing algorithm to determine the proper capacity required based on the loads experienced during the heating design day. If a value is specified, it is the maximum amount of heat that the coil can deliver in Watts.

Field: Gas Heating Coil Efficiency

Enter gas burner efficiency as a decimal, not as a percent. A burner that is 80% efficient would have an entry of 0.8 here, which is the default

Field: Gas Heating Coil Parasitic Electric Load

Enter the parasitic electric load associated with the gas heating coil operation, such as a combustion fan. The units are in W. The default is 0.0 W.

Field: Maximum Outdoor Air Flow Rate

Enter Autosize or a value for the maximum amount of outdoor air flow into the unit when the economizer is operating. Autosize means that 100% of the full supply flow may be taken from outdoor air. If a value is entered, it is used instead of the autosize value. The units are in m³/s. That is, the entered value is used to define the Maximum Outside Air Flow Rate for the Controller:OutdoorAir object that will be generated by this template. The default is Autosize.

Field: Minimum Outdoor Air Flow Rate

Enter Autosize or the value for the minimum amount of outdoor air that can enter the unit and be distributed to the zones. Usually this is set to autosize and the value is calculated by the outdoor air requirements of each zone. If a value is entered it overrides the outdoor air specification from the zone level. The units are in m³/s. The default is Autosize. Note if heat recovery is specified (see Heat Recovery Type below), then a value must be entered in this field, because heat recovery equipment is not yet autosizable. That is, the entered value is used to define the Minimum Outside Air Flow Rate for the Controller:OutdoorAir object that will be generated by this template.

Field: Minimum Outdoor Air Control Type

Choices for this field are **FixedMinimum** or **ProportionalMinimum**. FixedMinimum means that the minimum outdoor air flow rate is fixed no matter what the actual system flow rate is. ProportionalMinimum means the minimum outdoor air flow rate varies in proportion to the total system air flow rate. The default is ProportionalMinimum.

Field: Minimum Outdoor Air Schedule Name

Leave this field blank if you want the minimum outdoor air to be the same for all hours in the entire year. If a schedule name is specified, values are decimal fractions (0.0 – 1.0) that multiply the minimum outdoor air flow rate. This schedule is useful for reducing the outdoor air flow rate to zero during unoccupied or start up hours.

Field: Economizer Type

The options for this field are

- 'FixedDryBulb'
- 'DifferentialDryBulb'
- 'FixedEnthalpy'
- 'DifferentialEnthalpy'
- 'ElectronicEnthalpy' (i.e., humidity ratio curve strategy)
- 'FixedDewPointAndDryBulb'
- 'DifferentialDryBulbAndEnthalpy'
- 'NoEconomizer'

Choosing **NoEconomizer** means the economizer will not operate and the outdoor airflow rate will be at the minimum for the entire simulation.

Choosing **FixedDryBulb** means the economizer will set the outdoor airflow rate at minimum if the outdoor air temperature is higher than a specified dry-bulb temperature limit.

Choosing **DifferentialDryBulb** will trigger the outdoor airflow to minimum when the dry-bulb temperature of outdoor air is higher than the dry-bulb temperature of the return air.

FixedEnthalpy checks the upper limit of the enthalpy given as a field input against the enthalpy content of outdoor air and will set the outdoor airflow rate to minimum if the latter is greater than the former.

DifferentialEnthalpy does the same thing but compares the return air enthalpy with the enthalpy of outdoor air. When the enthalpy of outdoor air is greater than the enthalpy of the return air, the outdoor air flow rate is set to minimum.

Choosing **ElectronicEnthalpy** enables the simulation to calculate the humidity ratio limit of outdoor air based on the dry-bulb temperature of outdoor air and a quadratic/cubic curve, and compare it to the actual outdoor air humidity ratio. If the actual outdoor humidity ratio is greater than the calculated humidity ratio limit, then the outdoor airflow rate is set to minimum.

Choosing **FixedDewPointAndDryBulb** compares both the outdoor dewpoint temperature and the outdoor dry-bulb temperature to their specified high limit values. If either outdoor temperature exceeds the high limit value, the outdoor airflow rate is set to minimum.

Another option **DifferentialDryBulbAndEnthalpy** enables the control strategy to be based on both the **DifferentialDryBulb** and **DifferentialEnthalpy** economizer control strategies.

In addition to all economizer control types listed above, each control type checks for user-entered values for the upper limit of dry-bulb temperature, enthalpy limit, humidity ratio limit and dewpoint limit. The outdoor air flow rate is set to minimum if any of these entered limits are exceeded.

The default for this field is **NoEconomizer**.

Field: Economizer Lockout

Enter one of the following choices for this field:

- NoLockout
- LockoutWithHeating
- LockoutWithCompressor

The default value is **NoLockout**. The **LockoutWithHeating** means that if the packaged unit is in heating mode, the economizer is locked out – i.e., the economizer dampers are closed and there is minimum outdoor air flow. **LockoutWithCompressor** means that in addition to locking out the economizer when the unit is in heating mode the economizer is locked out when the DX unit compressor is on. In other words, when the DX coil is off, the economizer must meet the entire cooling load – it isn't allowed to operate in conjunction with the DX cooling coil. Similarly, when the DX coil is operating, the economizer is not allowed to operate. The **LockoutWithCompressor** option is sometimes called a “nonintegrated” economizer.

Field: Economizer Maximum Limit Dry-Bulb Temperature

Input for this field is the outdoor air temperature high limit (°C) for economizer operation. If the outdoor air temperature is above this limit, the outdoor airflow rate will be set to the minimum. This field is required if Economizer Control Type 'FixedDryBulb' or 'FixedDewPointAndDryBulb' has been specified. No input (blank) in this field means that there is no outdoor air temperature high limit control.

Field: Economizer Maximum Limit Enthalpy

Enter the outdoor air upper enthalpy limit (in J/kg) for economizer operation. If the outdoor air enthalpy is above this value, the outdoor air flow rate will be set to the minimum and heat recovery will be enabled if available. No input or zero in this field means that there is no outdoor air enthalpy limit control.

Field: Economizer Maximum Limit Dewpoint Temperature

Input for this field is the outdoor air dewpoint limit (°C) for economizer operation. If the outdoor air dewpoint temperature is above this value, the outdoor airflow rate will be set to the minimum. This field is required if the Economizer Control Type 'FixedDewPointAndDryBulb' has been specified. No input (blank) in this field means that there is no outdoor air dewpoint limit control.

Field: Economizer Minimum Limit Dry-Bulb Temperature

Enter the outdoor air temperature low limit (C) for economizer operation. If the outdoor air temperature is below this limit, the outdoor air flow rate will be set to the minimum and heat recovery will be enabled if available. No input or zero in this field means that there is no outdoor air temperature low limit control.

Field: Supply Plenum Name

Set to blank if no supply plenum is to be modeled. If a supply plenum is modeled, it must be modeled as a zone with surfaces, and the name of the plenum zone should be entered here. This supply plenum serves all zones on this system. If any zone supply plenums have been specified, the outlet from the system supply plenum will flow through the zone supply plenum to the zone terminal unit.

Field: Return Plenum Name

Set to blank if no return plenum is to be modeled. If a return plenum is modeled, it must be modeled as a zone with surfaces, and the name of the plenum zone should be entered here. This return plenum serves all zones on this system. If any zone return plenums have been specified, the return air from the zone will flow through the zone return plenum and then into the system return plenum.

Field: Supply Fan Part-Load Power Coefficients

Select the set of generic pre-defined coefficients to use for the supply fan part-load power consumption. This alpha field has the following choices:

- *InletVaneDampers*
- *OutletDampers*
- *VariableSpeedMotor*
- *ASHRAE90.1-2004Appendix G*

The default is *InletVaneDampers*. The resulting power curves are shown in Figure 130 below. The ASHRAE 90.1-2004 Appendix G coefficients are from TABLE G3.1.3.15, Method 2. The other sets of coefficients are from the EnergyPlus Input Output Reference, Fan Coefficient Values table.

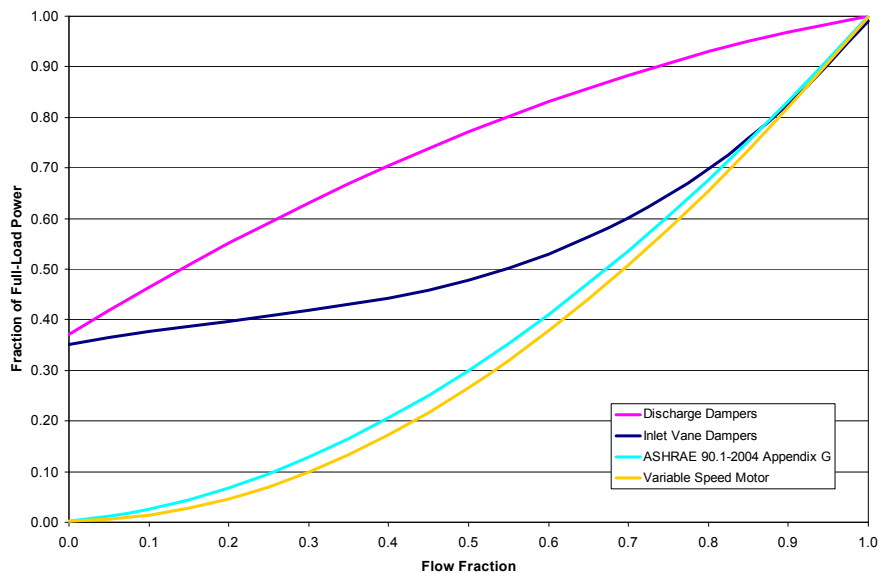


Figure 131. VAV Supply Fan Part-Load Power Coefficient Options

Field: Night Cycle Control

Enter the system behavior during times when the System Availability Schedule is zero (off). The possible inputs are *StayOff*, *CycleOnAny*, *CycleOnControl Zone* or *CycleOnAnyZoneFansOnly*. *StayOff* means the system will remain off, no matter how hot or cold the zones may be. *CycleOnAny* means that if any zone served by this system has an air temperature outside the cooling or heating set points the central fan will turn on even though the System Availability Schedule indicates the fan is off. *CycleOnControlZone* means the same thing except the availability manager looks at the temperature in only the zone specified in Night Cycle Control Zone Name. *CycleOnAnyZoneFansOnly* is the same as *CycleOnAny* except that only the zone fans are cycled on and the central air handler fan is left off (applicable only if using HVACTemplate:Zone:VAV:FanPowered in one or more zones). The default is *StayOff*.

Field: Night Cycle Control Zone Name

For the Night Cycle Control option *Cycle On Control Zone* enter the name of the control zone. For other Night Cycle Control options, this field is ignored.

Field: Heat Recovery Type

Enter the type of air-to-air heat recovery which is available between the relief air stream and the outdoor air inlet stream. The choices are:

- *None*
- *Sensible*
- *Enthalpy*

The default is **None**. If heat recovery is specified (i.e., **Sensible** or **Enthalpy**), then a value must be entered in the Minimum Outdoor Air Flow Rate field, because heat recovery equipment is not yet autosizable. The entered Minimum Outdoor Air Flow Rate is used to define the Nominal Supply Air Flow Rate for the HeatExchanger:AirToAir:SensibleAndLatent object generated by this template.

Field: Sensible Heat Recovery Effectiveness

Enter the sensible heat recovery effectiveness. This is applied as a constant effectiveness at all conditions. The valid range is from 0.0 to 1.0, and the default is 0.70.

Field: Latent Heat Recovery Effectiveness

Enter the latent heat recovery effectiveness if Heat Recovery Type is *Enthalpy*. This is applied as a constant effectiveness at all conditions. The valid range is from 0.0 to 1.0, and the default is 0.65.

Field: Cooling Coil Setpoint Reset Type

Select the type of automatic reset control for the cooling supply air temperature. The choices are:

- *None* – no reset, use the Cooling Coil Setpoint Schedule or Cooling Coil Design Setpoint.
- *Warmest* – reset the cooling supply air temperature to the highest supply air temperature that will meet the cooling requirements of all the zones. The minimum setpoint allowed is the Cooling Coil Design Setpoint. The maximum setpoint allowed is defaulted to 18C. (Reference SetpointManager:Warmest)
- *OutdoorAirTemperatureReset* – reset the cooling supply air temperature based on the following default rules. When the outdoor dry-bulb temperature (ODB) is at or below 15.6C the setpoint is 18.0C. When the ODB is at or above 26.7C the setpoint is the Cooling Coil Design Setpoint. In between, the setpoint is varied linearly. (Reference SetpointManager:OutdoorAirReset)

The default is *None*.

Field: Heating Coil Setpoint Reset Type

Select the type of automatic reset control for the central heating supply air temperature. The choices are:

- *None* – no reset, use the Heating Coil Setpoint Schedule or Heating Coil Design Setpoint.
- *OutdoorAirTemperatureReset* – reset the heating supply air temperature based on the following default rules. When the outdoor dry-bulb temperature (ODB) is at or below -6.7C the setpoint is the Heating Coil Design Setpoint. When the ODB is at or above 10.0C the setpoint is 20.0C. In between, the setpoint is varied linearly. (Reference SetpointManager:OutdoorAirReset).

The default is *None*.

Field: Dehumidification Control Type

There are two dehumidification control type options available:

- *None*
- *CoolReheat*

The *CoolReheat* option cools beyond the dry-bulb setpoint as required to meet the humidity setpoint if the system is capable of doing so. Reheat is provided as required by the terminal unit reheat coils if available.

The default is *None* which meets the sensible cooling setpoint only.

Field: Dehumidification Control Zone Name

This field specifies the zone name where the humidistat is located for controlling dehumidification.

Field: Dehumidification Setpoint

This field specifies the zone humidistat setpoint for dehumidification in percent (0 to 100). The default is 60%.

Field: Humidifier Type

There are two humidifier type options available:

- None
- ElectricSteam

The *ElectricSteam* humidifier option uses the Humidifier:Steam:Electric object. The default is *None*.

Field: Humidifier Availability Schedule Name

If left blank, the humidifier will be available anytime the system is operating. If a schedule name is specified, it defines when the humidifier is available. The schedule values denote whether the humidifier can run during a given time period. A schedule value of 1.0 indicates that the humidifier can be on during a given time period. A value of zero denotes that the humidifier cannot be used during that time period

Field: Humidifier Rated Capacity

Enter the rated moisture output rate in m3/s. The humidifier does not currently autosize, so the default is very large to allow for adequate capacity. The default is 0.000001 m3/s.

Field: Humidifier Rated Electric Power

Enter the electric power input at the rated capacity moisture output. The humidifier does not currently autosize, so the default power input is consistent with the default capacity input (2690 W per 0.000001 m3/s output) Power consumption is proportional to moisture output with no part-load penalty.

Field: Humidifier Control Zone Name

This field specifies the zone name where the humidistat is located for controlling humidification.

Field: Humidifier Setpoint

This field specifies the zone humidistat setpoint for humidification in percent (0 to 100). The default is 30%.

```

HVACTemplate: System: PackagedVAV,
  \min-fields 50
  \memo Packaged Variable Air Volume (PVAV) air loop with optional heating coil
  \memo and optional preheat.
  \memo Referenced Schedules must be defined elsewhere in the idf.
A1, \field Name
  \reference CompactHVACSystemVAV
A2, \field System Availability Schedule Name
  \note If blank, always on; PVAV System always on. Schedule is used in availability manager
  \note and fan scheduling.
  \note Also see "Night Cycle Control" field.
  \type object-list
  \object-list ScheduleNames
N1, \field Supply Fan Maximum Flow Rate
  \autosizable
  \default Autosize
  \units m3/s
  \minimum> 0.0

```

```

N2, \field Supply Fan Minimum Flow Rate
    \autosizable
    \default Autosize
    \units m3/s
    \minimum 0.0
A3, \field Supply Fan Placement
    \type choice
    \key DrawThrough
    \key BlowThrough
    \default DrawThrough
N3, \field Supply Fan Total Efficiency
    \minimum> 0.0
    \maximum 1.0
    \default 0.7
N4, \field Supply Fan Delta Pressure
    \units Pa
    \ip-units inH2O
    \minimum 0
    \default 1000
N5, \field Supply Fan Motor Efficiency
    \minimum> 0.0
    \maximum 1.0
    \default 0.9
N6, \field Supply Fan Motor in Air Stream Fraction
    \minimum 0.0
    \maximum 1.0
    \default 1.0
A4, \field Cooling Coil Type
    \type choice
    \key TwoSpeedDX
    \key TwoSpeedHumidControlDX
    \default TwoSpeedDX
A5, \field Cooling Coil Availability Schedule Name
    \note If blank, always on
    \type object-list
    \object-list ScheduleNames
A6, \field Cooling Coil Setpoint Schedule Name
    \note Leave blank if constant setpoint
    \type object-list
    \object-list ScheduleNames
N7, \field Cooling Coil Design Setpoint
    \note Used for sizing and as constant setpoint if no Cooling Coil Setpoint Schedule Name is
specified.
    \default 12.8
    \units C
N8, \field Cooling Coil Capacity
    \note Gross cooling capacity (net capacity plus fan heat)
    \autosizable
    \default Autosize
    \units W
N9, \field Cooling Coil Rated Sensible Heat Ratio
    \note Gross SHR
    \autosizable
    \minimum 0.5
    \maximum 1.0
    \default Autosize
N10, \field Cooling Coil Rated COP
    \note Gross cooling capacity divided by power in
    \minimum> 0.0
    \default 3.0
A7, \field Heating Coil Type
    \type choice
    \key HotWater
    \key Electric
    \key Gas
    \key None
    \default None

```



```

A8, \field Heating Coil Availability Schedule Name
    \note If blank, always on
    \type object-list
    \object-list ScheduleNames
A9, \field Heating Coil Setpoint Schedule Name
    \note Leave blank if constant setpoint
    \type object-list
    \object-list ScheduleNames
N11, \field Heating Coil Design Setpoint
    \note Used for sizing and as constant setpoint if no Heating Coil Setpoint Schedule Name is
specified.
    \default 10.0
    \units C
N12, \field Heating Coil Capacity
    \autosizable
    \default Autosize
    \units W
N13, \field Gas Heating Coil Efficiency
    \maximum 1.0
    \minimum 0.0
    \default 0.8
N14, \field Gas Heating Coil Parasitic Electric Load
    \units W
    \ip-units W
    \minimum 0.0
    \default 0.0
N15, \field Maximum Outdoor Air Flow Rate
    \autosizable
    \default Autosize
    \units m3/s
    \minimum 0.0
N16, \field Minimum Outdoor Air Flow Rate
    \autosizable
    \default Autosize
    \units m3/s
    \minimum 0.0
A10, \field Minimum Outdoor Air Control Type
    \type choice
    \key FixedMinimum
    \key ProportionalMinimum
    \default ProportionalMinimum
A11, \field Minimum Outdoor Air Schedule Name
    \note Schedule values multiply the Minimum Outdoor Air Flow Rate
    \note If blank, always one
    \type object-list
    \object-list ScheduleNames
A12, \field Economizer Type
    \type choice
    \key FixedDryBulb
    \key FixedEnthalpy
    \key DifferentialDryBulb
    \key DifferentialEnthalpy
    \key FixedDewPointAndDryBulb
    \key ElectronicEnthalpy
    \key DifferentialDryBulbAndEnthalpy
    \key NoEconomizer
    \default NoEconomizer
A13, \field Economizer Lockout
    \type choice
    \key NoLockout
    \key LockoutWithHeating
    \key LockoutWithCompressor
    \default NoLockout
N17, \field Economizer Maximum Limit Dry-Bulb Temperature
    \type real
    \units C
    \note Enter the maximum outdoor dry-bulb temperature limit for FixedDryBulb
    \note economizer control type. No input or blank input means this limit is
    \note not operative. Limit is applied regardless of economizer control type.

```

```

N18, \field Economizer Maximum Limit Enthalpy
\type real
\units J/kg
\note Enter the maximum outdoor enthalpy limit for FixedEnthalpy economizer control type.
\note No input or blank input means this limit is not operative
\note Limit is applied regardless of economizer control type.
N19, \field Economizer Maximum Limit Dewpoint Temperature
\type real
\units C
\note Enter the maximum outdoor dewpoint temperature limit for FixedDewPointAndDryBulb
\note economizer control type. No input or blank input means this limit is not operative.
\note Limit is applied regardless of economizer control type.
N20, \field Economizer Minimum Limit Dry-Bulb Temperature
\type real
\units C
\note Enter the minimum outdoor dry-bulb temperature limit for economizer control.
\note No input or blank input means this limit is not operative
\note Limit is applied regardless of economizer control type.
A14, \field Supply Plenum Name
\note Plenum zone name. Supply plenum serves all zones on this system.
\note Blank if none.
\type object-list
\object-list ZoneNames
A15, \field Return Plenum Name
\note Plenum zone name. Supply plenum serves all zones on this system.
\note Blank if none.
\type object-list
\object-list ZoneNames
A16, \field Supply Fan Part-Load Power Coefficients
\note This field selects a predefined set of fan power coefficients.
\note The ASHRAE 90.1-2004 Appendix G coefficients are from TABLE G3.1.3.15, Method 2.
\note The other sets of coefficients are from the EnergyPlus Input
\note Output Reference, Fan Coefficient Values table.
\type choice
\key InletVaneDampers
\key OutletDampers
\key VariableSpeedMotor
\key ASHRAE90.1-2004AppendixG
\default InletVaneDampers
A17, \field Night Cycle Control
\type choice
\key StayOff
\key CycleOnAny
\key CycleOnControlZone
\key CycleOnAnyZoneFansOnly
\default StayOff
A18, \field Night Cycle Control Zone Name
\note Applicable only if Night Cycle Control is Cycle On Control Zone.
\type object-list
\object-list ZoneNames
A19, \field Heat Recovery Type
\note If heat recovery is specified, then a value must be entered in
\note the Minimum Outdoor Air Flow Rate field, because heat recovery
\note equipment is not yet autosizable.
\type choice
\key None
\key Sensible
\key Enthalpy
\default None
N21, \field Sensible Heat Recovery Effectiveness
\minimum 0.0
\maximum 1.0
\default 0.70
N22, \field Latent Heat Recovery Effectiveness
\minimum 0.0
\maximum 1.0
\default 0.65

```

```

A20, \field Cooling Coil Setpoint Reset Type
\note Overrides Cooling Coil Setpoint Schedule Name
\note Warmest = as warm as possible yet meet all zone cooling loads
\type choice
\key None
\key Warmest
\key OutdoorAirTemperatureReset
\default None
A21, \field Heating Coil Setpoint Reset Type
\note Overrides Heating Coil Setpoint Schedule Name
\type choice
\key None
\key OutdoorAirTemperatureReset
\default None
A22, \field Dehumidification Control Type
\note None = meet sensible load only
\note CoolReheat = cool beyond the dry-bulb setpoint
\note as required to meet the humidity setpoint.
\type choice
\key None
\key CoolReheat
\default None
A23, \field Dehumidification Control Zone Name
\note Zone name where humidistat is located
\type object-list
\object-list ZoneNames
N23, \field Dehumidification Setpoint
\note Zone relative humidity setpoint in percent (0 to 100)
\type real
\minimum 0.0
\maximum 100.0
\default 60.0
\units percent
A24, \field Humidifier Type
\type choice
\key None
\key ElectricSteam
\default None
A25, \field Humidifier Availability Schedule Name
\note If blank, always available
\type object-list
\object-list ScheduleNames
N24, \field Humidifier Rated Capacity
\note Moisture output rate at full rated power input.
\note The humidifier does not currently autosize, so the default is very large
\note to allow for adequate capacity.
\type real
\units m3/s
\minimum 0.0
\default 0.000001
\ip-units gal/min
N25, \field Humidifier Rated Electric Power
\note Electric power input at rated capacity moisture output.
\note The humidifier does not currently autosize, so the default power input is
\note consistent with the default capacity input (2690 W per 0.000001 m3/s output)
\note Power consumption is proportional to moisture output with no part-load penalty.
\type real
\units W
\minimum 0.0
\default 2690.0
\ip-units W
A26, \field Humidifier Control Zone Name
\note Zone name where humidistat is located
\type object-list
\object-list ZoneNames

```

```

N26; \field Humidifier Setpoint
      \note Zone relative humidity setpoint in percent (0 to 100)
      \type real
      \minimum 0.0
      \maximum 100.0
      \default 30.0
      \units percent

```

And, as shown in an IDF:

```

HVACTemplate:System:PackagedVAV,
DXVAV Sys 1,           !- Name
FanAvailSched,        !- System Availability Schedule Name
autosize,              !- Supply Fan Maximum Flow Rate {m3/s}
autosize,              !- Supply Fan Minimum Flow Rate {m3/s}
DrawThrough,          !- Supply Fan Placement
0.7,                  !- Supply Fan Total Efficiency
1000,                 !- Supply Fan Delta Pressure {Pa}
0.9,                  !- Supply Fan Motor Efficiency
1,                    !- Supply Fan Motor in Air Stream Fraction
TwoSpeedDX,           !- Cooling Coil Type
,                     !- Cooling Coil Availability Schedule Name
,                     !- Cooling Coil Setpoint Schedule Name
12.8,                 !- Cooling Coil Design Setpoint {C}
autosize,              !- Cooling Coil Capacity {W}
autosize,              !- Cooling Coil Rated Sensible Heat Ratio
3,                    !- Cooling Coil Rated COP
Gas,                  !- Heating Coil Type
,                     !- Heating Coil Availability Schedule Name
,                     !- Heating Coil Setpoint Schedule Name
10,                   !- Heating Coil Design Setpoint {C}
autosize,              !- Heating Coil Capacity {W}
0.8,                  !- Gas Heating Coil Efficiency
,                     !- Gas Heating Coil Parasitic Electric Load {W}
autosize,              !- Maximum Outdoor Air Flow Rate {m3/s}
autosize,              !- Minimum Outdoor Air Flow Rate {m3/s}
ProportionalMinimum, !- Minimum Outdoor Air Control Type
Min OA Sched,         !- Minimum Outdoor Air Schedule Name
DifferentialDryBulb,  !- Economizer Type
NoLockout,           !- Economizer Lockout
19,                   !- Economizer Maximum Limit Dry-Bulb Temperature {C}
,                     !- Economizer Maximum Limit Enthalpy {J/kg}
,                     !- Economizer Maximum Limit Dewpoint Temperature {C}
4,                    !- Economizer Minimum Limit Dry-Bulb Temperature {C}
,                     !- Supply Plenum Name
PLENUM-1,             !- Return Plenum Name
InletVaneDampers,    !- Supply Fan Part-Load Power Coefficients
CycleOnAny,          !- Night Cycle Control
,                     !- Night Cycle Control Zone Name
None,                 !- Heat Recovery Type
0.7,                  !- Sensible Heat Recovery Effectiveness
0.65,                 !- Latent Heat Recovery Effectiveness
None,                 !- Cooling Coil Setpoint Reset Type
None,                 !- Heating Coil Setpoint Reset Type
None,                 !- Dehumidification Control Type
,                     !- Dehumidification Control Zone Name
60,                   !- Dehumidification Setpoint {percent}
None,                 !- Humidifier Type
,                     !- Humidifier Availability Schedule Name
0.000001,            !- Humidifier Rated Capacity {m3/s}
2690,                 !- Humidifier Rated Electric Power {W}
,                     !- Humidifier Control Zone Name
30;                   !- Humidifier Setpoint {percent}

```

HVACTemplate:Plant:ChilledWaterLoop

The piping systems that connect the chilled water coils in the HVAC template objects with the chillers and the cooling towers (if present) are described with this object. The piping systems

are called loops and this object describes the controls and pumps on the loops. Only one of these objects may be defined in an input file and all chilled water coils from HVAC template objects are served with this object.

Field: Name

The name used to designate the HVACTemplate:Plant:ChilledWaterLoop.

Field: Pump Schedule Name

Leave this field blank if the chilled water and condenser water pumps are always available. If a schedule name is specified, those times that the pumps are available should be specified as 1.0. Those times that the pumps are not available should have a zero value in the schedule specified. Please note that this is not a schedule of when the system is providing chilled water to the coils but a schedule of when it can provide chilled water to the coils.

Field: Pump Control Type

Applies to both chilled water and condenser loop pumps. The choices for this field are:

- Intermittent
- Continuous

The default value is Intermittent.

If the pump control type is **Continuous**, the pump will run according to the Pump Schedule (see above) regardless of whether or not there is a load. If the pump control type is **Intermittent**, the pump will run if a load is sensed and will shut off if there is no load on the loop.

Field: Chiller Plant Operation Scheme Type

The choices for this field are:

- Default
- UserDefined

Default operation type makes all equipment available at all times operating in order of Priority specified in HVACTemplate:Plant:Chiller objects. If a different scheme is to be used to sequence the chillers, then this entry should be set to User Defined. If the User Defined option is chosen, then additional EnergyPlus objects must be included and completely defined in the IDF file such as shown below depending on the type of plant operation control scheme chosen:

- PlantEquipmentOperationSchemes
- PlantEquipmentOperation:CoolingLoad
- PlantEquipmentList (refer to HVACTemplate:Plant:Chiller object description for chiller key name required in this object).

The default value is Default.

Field: Chiller Plant Equipment Operation Schemes Name

This field should contain the name of a PlantEquipmentOperationSchemes object only when the previous field is set to UserDefined. It is ignored if Chiller Plant Operation Scheme Type is Default.

Field: Chilled Water Setpoint Schedule Name

Enter the name of a chilled water setpoint schedule that has values that change at different times of the year. If a constant set point is needed simply leave this field blank and the value in the next field will be used at all times. The values in the schedule are in degrees C. This field is ignored if the Chilled Water Setpoint Reset Type is something other than None.

Field: Chilled Water Design Setpoint

Enter the chilled water setpoint temperature to be used for sizing the chilled water loop and associated equipment in degrees C. If the Chilled Water Setpoint Schedule is blank and the Chilled Water Setpoint Reset Type is *None*, then this value will be used as the setpoint at all times.

Field: Chilled Water Pump Configuration

The choices for this field are

- VariablePrimaryNoSecondary – variable flow to chillers and coils
- ConstantPrimaryNoSecondary – constant flow to chillers and coils with bypass
- ConstantPrimaryVariableSecondary – constant flow to chillers with bypass, variable flow to coils
- VariablePrimaryConstantSecondary – variable flow to chillers, constant flow to coils with bypass

The default value is ConstantPrimaryNoSecondary.

The operation of a constant speed pump is fairly straightforward. If the user designates a constant speed pump that is operating continuously, the pump will run regardless of whether or not there is a load. This may have the net effect of adding heat to the loop if no equipment is turned on. If the pump is constant speed and operates intermittently, the pump will run at its capacity if a load is sensed and will shut off if there is no load on the loop.

A variable speed pump is defined with maximum and minimum flow rates that are the physical limits of the device. If there is no load on the loop and the pump is operating intermittently, then the pump can shutdown. For any other condition such as the loop having a load and the pump is operating intermittently or the pump is continuously operating (regardless of the loading condition), the pump will operate and select a flow somewhere between the minimum and maximum limits. In these cases where the pump is running, it will try to meet the flow request made by demand side components.

Field: Primary Chilled Water Pump Rated Head

The rated head of the primary chilled water pump in Pa. The default value is 179352 Pa which is equivalent to 60 feet H₂O.

Field: Secondary Chilled Water Pump Rated Head

The rated head of the secondary chilled water pump in Pa. The default value is 179352 Pa which is equivalent to 60 feet H₂O. This field is applicable only if the “Chilled Water Pump Configuration” is *Constant Primary Variable Secondary* or *Variable Primary Constant Secondary*.

Field: Condenser Plant Operation Scheme Type

The choices for this field are:

- Default
- UserDefined

Default operation type makes all equipment available at all times operating in order of Priority specified in HVACTemplate:Plant:Tower objects. If a different scheme is to be used to sequence the towers, then this entry should be set to User Defined. May be left blank if not serving any water cooled chillers.

If User Defined option is chosen, then additional EnergyPlus objects must be included and completely defined in the IDF file such as shown below depending on the type of condenser operation control scheme chosen:

- CondenserEquipmentOperationSchemes
- PlantEquipmentOperation:CoolingLoad

- PlantEquipmentList (refer to the HVACTemplate:Plant:Tower object description for key name required for this object).

The default value is Default.

Field: Condenser Equipment Operation Schemes Name

This field should contain the name of a CondenserEquipmentOperationSchemes object only when the previous field is set to UserDefined. It is ignored if Condenser Plant Operation Scheme Type is Default. May be left blank if not serving any water cooled chillers.

Field: Condenser Water Temperature Control Type

If water cooled chillers are present the condenser water temperature control can be one of the following options:

- OutdoorWetBulbTemperature
- SpecifiedSetpoint

If a specified set point is used then the towers are operated to deliver that condenser water set point. If outdoor wet-bulb is used then the condenser water temperature decreases with decreasing outdoor wet-bulb temperature. May be left blank if not serving any water cooled chillers.

Field: Condenser Water Setpoint Schedule Name

Used when Condenser Water Temperature Control Type is set to Specified Setpoint. Ignored if Condenser Water Temperature Control Type is set to Outdoor Wet-bulb. The field may be left blank if constant setpoint temperature is used for the condenser water temperature. If may also be left blank if not serving any water cooled chillers. If specified, the schedule should contain the set point temperatures in degrees C for the condenser water loop.

Field: Condenser Water Design Setpoint

Enter the condenser water temperature to be used for sizing the condenser loop and associated equipment. If a constant setpoint control is used for the condenser water, this value will be used as the setpoint at all times. May be left blank if not serving any water cooled chillers. Used when Condenser Water Temperature Control Type is set to Specified Setpoint. Ignored if Condenser Water Temperature Control Type is set to Outdoor Wet Bulb. The units are in C.

Field: Condenser Water Pump Rated Head

The rated head of the condenser water pumps in Pa. May be left blank if not serving any water cooled chillers. The default value is 179352 Pa which is equivalent to 60 feet H₂O.

Field: Chilled Water Setpoint Reset Type

Select the type of automatic reset control for the chilled water supply temperature. The choices are:

- *None* – no reset, use the Chilled Water Setpoint Schedule or Chilled Water Design Setpoint.
- *OutdoorAirTemperatureReset* – reset the chilled water supply temperature based on the following default rules. The temperature limits and setpoints are specified using the fields below. If the default values are used, when the outdoor dry-bulb temperature (ODB) is at or below 15.6C the setpoint is 12.2C. When the ODB is at or above 26.7C the setpoint is 6.7C. In between, the setpoint is varied linearly. (Reference SetpointManager:OutdoorAirReset)

The default is *None*.

Field: Chilled Water Setpoint at Outdoor Dry-Bulb Low

The chilled water setpoint temperature in C when the outdoor dry-bulb is at or below the low limit (Chilled Water Reset Outdoor Dry Bulb Low). The default is 12.2C.

Field: Chilled Water Reset Outdoor Dry-Bulb Low

The low limit of outdoor dry-bulb temperature in C for outdoor air reset control. When the outdoor dry-bulb is at or below this temperature, the setpoint is the value of Chilled Water Setpoint at Outdoor Dry Bulb Low. The default is 15.6C.

Field: Chilled Water Setpoint at Outdoor Dry-Bulb High

The chilled water setpoint temperature in C when the outdoor dry-bulb is at or above the high limit (Chilled Water Reset Outdoor Dry Bulb Low). The default is 6.7C.

Field: Chilled Water Reset Outdoor Dry-Bulb High

The high limit of outdoor dry-bulb temperature in C for outdoor air reset control. When the outdoor dry-bulb is at or above this temperature, the setpoint is the value of Chilled Water Setpoint at Outdoor Dry Bulb High. The default is 26.7C.

```

HVACTemplate:Plant:ChilledWaterLoop,
  \min-fields 21
  \memo Plant and condenser loops to serve all HVACTemplate
  \memo chilled water coils, chillers, and towers.
  \unique-object
A1, \field Name
A2, \field Pump Schedule Name
  \note If blank, always available
  \note Applies to both chilled water and condenser loop pumps
  \type object-list
  \object-list ScheduleNames
A3, \field Pump Control Type
  \note Applies to both chilled water and condenser loop pumps
  \type choice
  \key Intermittent
  \key Continuous
  \default Intermittent
A4, \field Chiller Plant Operation Scheme Type
  \note Default operation type makes all equipment available
  \note at all times operating in order of Priority specified
  \note in HVACTemplate:Plant:Chiller objects.
  \type choice
  \key Default
  \key UserDefined
  \default Default
A5, \field Chiller Plant Equipment Operation Schemes Name
  \type object-list
  \object-list PlantOperationSchemes
  \note Name of a PlantEquipmentOperationSchemes object
  \note Ignored if Chiller Plant Operation Scheme Type = Default
A6, \field Chilled Water Setpoint Schedule Name
  \note Leave blank if constant setpoint
  \type object-list
  \object-list ScheduleNames
N1, \field Chilled Water Design Setpoint
  \note Used for sizing and as constant setpoint if no Chilled Water Setpoint Schedule Name is
  specified.
  \default 7.22
  \units C

```



```

A7, \field Chilled Water Pump Configuration
  \note VariablePrimaryNoSecondary - variable flow to chillers and coils
  \note ConstantPrimaryNoSecondary - constant flow to chillers and coils, excess bypassed
  \note ConstantPrimaryVariableSecondary - constant flow to chillers, variable flow to coils
  \note VariablePrimaryConstantSecondary - variable flow to chillers, constant flow to coils
  \type choice
  \key ConstantPrimaryNoSecondary
  \key VariablePrimaryNoSecondary
  \key ConstantPrimaryVariableSecondary
  \key VariablePrimaryConstantSecondary
  \default ConstantPrimaryNoSecondary
N2, \field Primary Chilled Water Pump Rated Head
  \units Pa
  \minimum 0.0
  \default 179352
  \note default head is 60 feet H2O
  \ip-units ftH2O
N3, \field Secondary Chilled Water Pump Rated Head
  \units Pa
  \minimum 0.0
  \default 179352
  \note default head is 60 feet H2O
  \ip-units ftH2O
A8, \field Condenser Plant Operation Scheme Type
  \note Default operation type makes all equipment available
  \note at all times operating in order of Priority specified
  \note in HVACTemplate:Plant:Tower objects.
  \type choice
  \key Default
  \key UserDefined
  \default Default
  \note May be left blank if not serving any water cooled chillers
A9, \field Condenser Equipment Operation Schemes Name
  \type object-list
  \object-list CondenserOperationSchemes
  \note Name of a CondenserEquipmentOperationSchemes object
  \note Ignored if Condenser Plant Operation Scheme Type = Default
  \note May be left blank if not serving any water cooled chillers
A10, \field Condenser Water Temperature Control Type
  \note May be left blank if not serving any water cooled chillers
  \type choice
  \key OutdoorWetBulbTemperature
  \key SpecifiedSetpoint
A11, \field Condenser Water Setpoint Schedule Name
  \note Leave blank if constant setpoint
  \note May be left blank if not serving any water cooled chillers
  \type object-list
  \object-list ScheduleNames
N4, \field Condenser Water Design Setpoint
  \note Used for sizing and as constant setpoint if no Condenser Water Setpoint Schedule Name is
specified.
  \note May be left blank if not serving any water cooled chillers
  \default 29.4
  \units C
N5, \field Condenser Water Pump Rated Head
  \note May be left blank if not serving any water cooled chillers
  \units Pa
  \minimum 0.0
  \default 179352
  \note default head is 60 feet H2O
  \ip-units ftH2O
A12, \field Chilled Water Setpoint Reset Type
  \note Overrides Chilled Water Setpoint Schedule Name
  \type choice
  \key None
  \key OutdoorAirTemperatureReset
  \default None

```

```

N6, \field Chilled Water Setpoint at Outdoor Dry-Bulb Low
    \note Applicable only for OutdoorAirTemperatureReset control.
    \units C
    \default 12.2
N7, \field Chilled Water Reset Outdoor Dry-Bulb Low
    \note Applicable only for OutdoorAirTemperatureReset control.
    \units C
    \default 15.6
N8, \field Chilled Water Setpoint at Outdoor Dry-Bulb High
    \note Applicable only for OutdoorAirTemperatureReset control.
    \units C
    \default 6.7
N9; \field Chilled Water Reset Outdoor Dry-Bulb High
    \note Applicable only for OutdoorAirTemperatureReset control.
    \units C
    \default 26.7

```

And, as shown in an IDF:

```

HVACTemplate:Plant:ChilledWaterLoop,
  Chilled Water Loop,          !- Plant Loop Name
  CoolingPumpAvailSched,      !- Pump Schedule
  Intermittent,               !- Pump Control Type
  Default,                    !- Chiller Plant Operation Scheme Type
  ,                            !- Chiller Plant Operation Scheme Name
  CW Loop Temp Schedule,      !- Chilled Water Setpoint Schedule
  7.22,                       !- Chilled Water Design Setpoint {C}
  VariableFlowNoSecondary,    !- Chilled Water Pump Configuration
  179352,                     !- Primary Chilled Water Pump Rated Head {Pa}
  179352,                     !- Secondary Chilled Water Pump Rated Head {Pa}
  Default,                    !- Condenser Plant Operation Scheme Type
  ,                            !- Condenser Plant Operation Scheme List Name
  OutdoorWetBulbTemperature,  !- Condenser Water Temperature Control Type
  ,                            !- Condenser Water Setpoint Schedule
  29.4,                       !- Condenser Water Design Setpoint {C}
  179352,                     !- Condenser Water Pump Rated Head {Pa}
  None,                       !- Chilled Water Setpoint Reset Type
  12.2,                       !- Chilled Water Setpoint at Outdoor Dry Bulb Low {C}
  15.6,                       !- Chilled Water Reset Outdoor Dry Bulb Low {C}
  6.7,                        !- Chilled Water Setpoint at Outdoor Dry Bulb High {C}
  26.7;                       !- Chilled Water Reset Outdoor Dry Bulb High {C}

```

HVACTemplate:Plant:Chiller

A chiller or purchased cooling source is described with this object. To define multiple chillers, use multiple HVACTemplate:Plant:Chiller objects. If multiple chillers are autosized, each chiller will be sized to meet the full design cooling load. Run the simulation once and locate the autosized capacity for one chiller in the eio output file. This value represents the total required chiller capacity. Copy the expidf output to a new idf file name. Edit this input file, and enter values for the capacity and flow rates of each chiller object to apportion this total capacity between the multiple chillers.

Field: Name

The name used to reference the HVACTemplate:Plant:Chiller object.

Field: Chiller Type

While EnergyPlus has a variety of chiller options, the only choices currently for this field are:

- DistrictChilledWater
- ElectricCentrifugalChiller
- ElectricReciprocatingChiller

The EnergyPlus equipment object types which are used are DistrictCooling or Chiller:Electric:EIR. These equipment type keys must be used if setting up a user-defined chiller plant operation scheme.

Field: Capacity

This field may be set to autosize, which means that the capacity is based on the peak loads during the design days. This numeric field contains the design cooling capacity of the chiller. This capacity should be at the design temperatures and water flow rates. The units are in W.

Field: Nominal COP

This numeric field contains the chiller's coefficient of performance. This value should **not** include energy use due to pumps, evap-cooled or air-cooled condenser fans, or cooling tower fans. This Nominal COP should be at the design temperatures and water flow rates. Not applicable if Chiller Type is DistrictChilledWater.

Field: Condenser Type

The choices for this field are

- AirCooled
- WaterCooled
- EvaporativelyCooled

The default value is WaterCooled. If WaterCooled, then at least one HVACTemplate:Plant:Tower object should be defined. Not applicable if Chiller Type is Purchased Chilled Water.

Field: Priority

Enter the priority number of the chiller where 1 is the highest priority, 2 is just lower, 3 is lower than 2, etc. This is used if Chiller Plant Operation Scheme Type is set to Default in HVACTemplate:Plant:ChilledWaterLoop. Equipment is operated in order of the priority number. This allows multiple chillers to be sequenced.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. For this component the chiller object inputs that would be altered by the sizing factor are: Reference Capacity, Reference Chilled Water Flow Rate and Reference Condenser Water Flow Rate. Sizing Factor allows the user to size a component to meet part of the design load while continuing to use the autosizing feature.

```

HVACTemplate:Plant:Chiller,
  \min-fields 6
A1, \field Name
A2, \field Chiller Type
  \type choice
  \key DistrictChilledWater
  \key ElectricCentrifugalChiller
  \key ElectricReciprocatingChiller
N1, \field Capacity
  \autosizable
  \default Autosize
  \units W
  \minimum> 0.0

```

```

N2, \field Nominal COP
    \note Not applicable if Chiller Type is DistrictChilledWater
    \note Electric Reciprocating Chiller
    \units W/W
    \minimum> 0.0
A3, \field Condenser Type
    \note Not applicable if Chiller Type is DistrictChilledWater
    \type choice
    \key AirCooled
    \key WaterCooled
    \key EvaporativelyCooled
    \default WaterCooled
A4, \field Priority
    \note If Chiller Plant Operation Scheme Type=Default
    \note in HVACTemplate:Plant:ChilledWaterLoop, then equipment
    \note operates in Priority order, 1, 2, 3, etc.
N3; \field Sizing Factor
    \note Multiplies the autosized capacity and flow rates
    \type real
    \minimum> 0.0
    \default 1.0

```

And, as shown in an IDF:

```

HVACTemplate:Plant:Chiller,
    District Cooling,          !- Chiller Name
    ElectricCentrifugalChiller, !- Chiller Type
    autosize,                  !- Capacity {W}
    3.2,                        !- COP
    WaterCooled,               !- Condenser Type
    1,                          !- Priority
    1.0;                        !- Sizing Factor

```

HVACTemplate:Plant:Tower

A cooling tower is described with this object. To define multiple cooling towers, use multiple HVACTemplate:Plant:Tower objects. If multiple towers are autosized, each tower will be sized to meet the full design heat rejection load. Run the simulation once and locate the autosized capacities for one tower in the eio output file. These values represent the total required tower capacity. Copy the expidf output to a new idf file name. Edit this input file and enter values for the capacity and flow rates of each tower object to apportion this total capacity between the multiple towers.

Field: Name

The name used to reference the HVACTemplate:Plant:Tower object.

Field: Tower Type

The choices for this field are

- SingleSpeed
- TwoSpeed

The EnergyPlus equipment object types which are used are CoolingTower:SingleSpeed or CoolingTower:TwoSpeed. These equipment type keys must be used if setting up a user-defined condenser plant operation scheme.

Field: High-Speed Nominal Capacity

Applicable for Tower Type Single Speed and Two Speed. This field may be set to autosize. If this field is set to autosize, then the Low-Speed Nominal Capacity and the Free Convection Capacity must also be autosized. The units are W. This numeric input field contains the “nominal” heat rejection capacity of the cooling tower in watts under high-speed fan operation, with entering water at 35C (95F), leaving water at 29.4C (85F), entering air at 25.6C (78F) wetbulb and 35C (95F) drybulb temperatures. The design water flow rate is assumed to be 5.382E-8 m³/s per watt of high-speed nominal capacity (3 gpm/ton). 125% of this nominal tower capacity gives the actual tower heat rejection at these operating conditions

(based on historical assumption that the tower must dissipate 0.25W of compressor heat for every watt of heat removed by the evaporator).

Field: High-Speed Fan Power

The tower fan electric consumption when at high speed. Applicable for Tower Type Single Speed and Two Speed. This field may be set to autosize. The units are W.

Field: Low-Speed Nominal Capacity

Applicable only for Tower Type Two Speed. This field may be set to autosize. If this field is set to autosize, then the High-Speed Nominal Capacity and the Free Convection Capacity must also be autosized. The units are W. This numeric input field contains the “nominal” heat rejection capacity of the cooling tower in watts under low-speed fan operation, with entering water at 35C (95F), leaving water at 29.4C (85F), entering air at 25.6C (78F) wetbulb and 35C (95F) drybulb temperatures. The design water flow rate is assumed to be $5.382E-8 \text{ m}^3/\text{s}$ per watt of high-speed nominal tower capacity (input field above). 125% of this nominal tower capacity gives the actual tower heat rejection at these operating conditions (based on historical assumption that the tower must dissipate 0.25W of compressor heat for every watt of heat removed by the evaporator). The value specified for this field must be greater than zero but less than the value specified for the field “Tower High-Speed Nominal Capacity”.

Field: Low-Speed Fan Power

The tower fan electric consumption when at low speed. Applicable only for Tower Type Two Speed. This field may be set to autosize. The units are W.

Field: Free Convection Capacity

Applicable for Tower Type Single Speed and Two Speed. This field may be set to autosize. If this field is set to autosize, then the High-Speed Nominal Capacity and the Low-Speed Nominal Capacity must also be autosized. The units are W. This numeric input field contains the “nominal” heat rejection capacity of the cooling tower in watts when the tower is in the “free convection” regime (water flow exists but tower fan is turned off), with entering water at 35C (95F), leaving water at 29.4C (85F), entering air at 25.6C (78F) wetbulb and 35C (95F) drybulb temperatures. The design water flow rate is assumed to be $5.382E-8 \text{ m}^3/\text{s}$ per watt of high-speed nominal tower capacity (input field above). 125% of this free convection tower capacity gives the actual tower heat rejection at these operating conditions (based on historical assumption that the tower must dissipate 0.25W of compressor heat for every watt of heat removed by the evaporator). If the user does not wish to model “free convection”, then this field should be set to 0.0.

Field: Priority

Enter the priority number of the tower where 1 is the highest priority, 2 is just lower, 3 is lower than 2, etc. This is used if Condenser Plant Operation Scheme Type is set to Default in HVACTemplate:Plant:ChilledWaterLoop. Equipment is operated in order of the priority number. This allows multiple towers to be sequenced.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. Sizing factor allows the user to size a component to meet part of the design load while continuing to use the autosizing feature. For this component the tower object inputs that would be altered by the sizing factor are:

1. Design Water Flow Rate;
2. Air Flow Rate at High Fan Speed;
3. Fan Power at High Fan Speed;
4. U-Factor Times Area Value at High Fan Speed;

5. Air Flow Rate at Low Fan Speed (for two-speed tower);
6. Fan Power at Low Fan Speed (for two-speed tower);
7. U-Factor Times Area Value at Low Fan Speed (for two-speed tower);
8. Air Flow Rate in Free Convection Regime;
9. U-Factor Times Area Value at Free Convection Air Flow Rate.

Note that the U-Factor Times Area Value at High Fan Speed is not *multiplied* by the Sizing Factor. Instead the design tower load is multiplied by the sizing factor and the design UA then calculated as usual. The U-Factor Times Area Value at Low Fan Speed is set to 60% of the full load design UA. The U-Factor Times Area Value at Free Convection Air Flow Rate is set to 10% of the design Tower UA.

```

HVACTemplate:Plant:Tower,
  \min-fields 8
A1, \field Name
A2, \field Tower Type
  \type choice
  \key SingleSpeed
  \key TwoSpeed
N1, \field High Speed Nominal Capacity
  \note Applicable for tower type SingleSpeed and TwoSpeed
  \note Nominal tower capacity with entering water at 35C (95F), leaving water at
  \note 29.44C (85F), entering air at 25.56C (78F) wet-bulb temperature and 35C (95F)
  \note dry-bulb temperature, with the tower fan operating at high speed. Design water
  \note flow rate assumed to be 5.382E-8 m3/s per watt(3 gpm/ton). Nominal tower capacity
  \note times (1.25) gives the actual tower heat rejection at these operating conditions.
  \autosizable
  \default Autosize
  \units W
  \minimum> 0.0
N2, \field High Speed Fan Power
  \note Applicable for tower type SingleSpeed and TwoSpeed
  \autosizable
  \default Autosize
  \units W
  \ip-units W
  \minimum> 0.0
N3, \field Low Speed Nominal Capacity
  \note Applicable only for Tower Type TwoSpeed
  \note Nominal tower capacity with entering water at 35C (95F), leaving water at
  \note 29.44C (85F), entering air at 25.56C (78F) wet-bulb temperature and 35C (95F)
  \note dry-bulb temperature, with the tower fan operating at low speed. Design water flow
  \note rate assumed to be 5.382E-8 m3/s per watt of tower high-speed nominal capacity
  \note (3 gpm/ton). Nominal tower capacity times (1.25) gives the actual tower heat
  \note rejection at these operating conditions.
  \autosizable
  \default Autosize
  \units W
  \minimum> 0.0
N4, \field Low Speed Fan Power
  \note Applicable only for Tower Type TwoSpeed
  \autosizable
  \default Autosize
  \units W
  \ip-units W
  \minimum> 0.0

```

```

N5, \field Free Convection Capacity
\note Applicable for Tower Type SingleSpeed and TwoSpeed
\note Tower capacity in free convection regime with entering water at 35C (95F),
\note leaving water at 29.44C (85F), entering air at 25.56C (78F) wet-bulb temperature
\note and 35C (95F) dry-bulb temperature. Design water flow rate assumed to be
\note 5.382E-8 m3/s per watt of tower high-speed nominal capacity (3 gpm/ton). Tower
\note free convection capacity times (1.25) gives the actual tower heat rejection at
\note these operating conditions.
\autosizable
\default Autosize
\units W
\minimum 0.0
A3, \field Priority
\note Applicable for all Tower Types
\note If Condenser Plant Operation Scheme Type=Default
\note in HVACTemplate:Plant:ChilledWaterLoop, then equipment
\note operates in Priority order, 1, 2, 3, etc.
N6; \field Sizing Factor
\note Multiplies the autosized capacity and flow rates
\type real
\minimum> 0.0
\default 1.0

```

And, as shown in an IDF:

```

HVACTemplate:Plant:Tower,
Tower 1,           !- Tower Name
SingleSpeed,      !- Tower Type
autosize,         !- High-Speed Nominal Capacity {W}
autosize,         !- High-Speed Fan Power {W}
,                !- Low-Speed Nominal Capacity {W}
,                !- Low-Speed Fan Power {W}
autosize,        !- Free Convection Capacity {W}
1,               !- Priority
1.0;            !- Sizing Factor

```

HVACTemplate:Plant:HotWaterLoop

The piping systems that connect the hot water coils in the HVAC template objects with the boilers are described with this object. The piping systems are called loops and this object describes the controls and pumps on the loops. Only one of these objects should be defined in an input file and all hot water coils from HVAC template objects are served with this object.

Field: Name

The name used to designate the HVACTemplate:Plant:HotWaterLoop.

Field: Pump Schedule Name

Leave this field blank if the hot water pump is always available. If a schedule name is specified, those times that the pump is available should be specified as 1.0. Those times that the pump is not available should have a zero value in the schedule specified. Please note that this is not a schedule of when the system is providing hot water to the coils but a schedule of when it can provide hot water to the coils.

Field: Pump Control Type

The choices for this field are

- Intermittent
- Continuous

The default value is Intermittent.

If the pump control type is **Continuous**, the pump will run according to the Pump Schedule (see above) regardless of whether or not there is a load. If the pump control type is **Intermittent**, the pump will run if a load is sensed and will shut off if there is no load on the loop.

Field: Hot Water Plant Operation Scheme Type

The choices for this field are:

- Default
- UserDefined

Default operation type makes all equipment available at all times operating in order of Priority specified in HVACTemplate:Plant:Boiler objects. If a different scheme is to be used to sequence the boilers, then this entry should be set to User Defined.

If User Defined option is chosen, then additional EnergyPlus objects must be defined in the IDF file such as shown below depending on the type of plant operation control scheme chosen:

- PlantEquipmentOperationSchemes
- PlantEquipmentOperation:HeatingLoad
- PlantEquipmentList (refer to HVACTemplate:Plant:Boiler object description for key name required in this object)

The default value is Default.

Field: Hot Water Plant Equipment Operation Schemes Name

This field should contain the name of a PlantEquipmentOperationSchemes object only when the previous field is set to User Defined. It is ignored if Hot Water Plant Operation Scheme Type is Default.

Field: Hot Water Setpoint Schedule Name

Enter the name of a hot water setpoint schedule that has values that change at different times of the year. If a constant set point is needed simply leave this field blank and the value in the next field will be used at all times. The values in the schedule are in degrees C. This field is ignored if the Hot Water Setpoint Reset Type is something other than None.

Field: Hot Water Design Setpoint

Enter the hot water setpoint temperature to be used for sizing the hot water loop and associated equipment in degrees C. If the Hot Water Setpoint Schedule is blank and the Hot Water Setpoint Reset Type is *None*, then this value will be used as the setpoint at all times.

Field: Hot Water Pump Configuration

The choices for this field are

- VariableFlow
- ConstantFlow

The default value is ConstantFlow. The variable flow option simulates a pump with variable flow to boilers and coils, excess bypassed. The constant flow option simulates constant flow to boilers and coils, excess bypassed.

The operation of a constant speed pump is fairly straightforward. If the user designates a constant speed pump that is operating continuously, the pump will run regardless of whether or not there is a load. This may have the net effect of adding heat to the loop if no equipment is turned on. If the pump is constant speed and operates intermittently, the pump will run at its capacity if a load is sensed and will shut off if there is no load on the loop.

A variable speed pump is defined with maximum and minimum flow rates that are the physical limits of the device. If there is no load on the loop and the pump is operating intermittently, then the pump can shutdown. For any other condition such as the loop having a load and the pump is operating intermittently or the pump is continuously operating (regardless of the loading condition), the pump will operate and select a flow somewhere between the minimum and maximum limits. In these cases where the pump is running, it will try to meet the flow request made by demand side components.

Field: Hot Water Pump Rated Head

The rated head of the hot water pump in Pa. The default value is 179352 Pa which is equivalent to 60 feet H2O.

Field: Hot Water Setpoint Reset Type

Select the type of automatic reset control for the Hot Water supply temperature. The choices are:

- *None* – no reset, use the Hot Water Setpoint Schedule or Hot Water Design Setpoint.
- *OutdoorAirTemperatureReset* – reset the Hot Water supply temperature based on the following default rules. The temperature limits and setpoints are specified using the fields below. If the default values are used, when the outdoor dry-bulb temperature (ODB) is at or below –6.7C the setpoint is 82.2C. When the ODB is at or above 10.0C the setpoint is 65.6C. In between, the setpoint is varied linearly. (Reference SetpointManager:OutdoorAirReset)

The default is *None*.

Field: Hot Water Setpoint at Outdoor Dry Bulb Low

The Hot Water setpoint temperature in C when the outdoor dry-bulb is at or below the low limit (Hot Water Reset Outdoor Dry Bulb Low). The default is –6.7C.

Field: Hot Water Reset Outdoor Dry Bulb Low

The low limit of outdoor dry-bulb temperature in C for outdoor air reset control. When the outdoor dry-bulb is at or below this temperature, the setpoint is the value of Hot Water Setpoint at Outdoor Dry Bulb Low. The default is 82.2C.

Field: Hot Water Setpoint at Outdoor Dry Bulb High

The Hot Water setpoint temperature in C when the outdoor dry-bulb is at or above the high limit (Hot Water Reset Outdoor Dry Bulb Low). The default is 10.0C.

Field: Hot Water Reset Outdoor Dry Bulb High

The high limit of outdoor dry-bulb temperature in C for outdoor air reset control. When the outdoor dry-bulb is at or above this temperature, the setpoint is the value of Hot Water Setpoint at Outdoor Dry Bulb High. The default is 65.6C.

```

HVACTemplate:Plant:HotWaterLoop,
  \min-fields 14
  \unique-object
  \memo Plant loop to serve all HVACTemplate
  \memo hot water coils and boilers.
A1, \field Name
A2, \field Pump Schedule Name
  \note If blank, always available
  \type object-list
  \object-list ScheduleNames
A3, \field Pump Control Type
  \type choice
  \key Intermittent
  \key Continuous
  \default Intermittent
A4, \field Hot Water Plant Operation Scheme Type
  \note Default operation type makes all equipment available
  \note at all times operating in order of Priority specified
  \note in HVACTemplate:Plant:Boiler objects.
  \type choice
  \key Default
  \key UserDefined
  \default Default

```

```

A5, \field Hot Water Plant Equipment Operation Schemes Name
    \type object-list
    \object-list PlantOperationSchemes
    \note Name of a PlantEquipmentOperationSchemes object
    \note Ignored if Plant Operation Scheme Type = Default
A6, \field Hot Water Setpoint Schedule Name
    \note Leave blank if constant setpoint
    \type object-list
    \object-list ScheduleNames
N1, \field Hot Water Design Setpoint
    \note Used for sizing and as constant setpoint if no Setpoint Schedule Name is specified.
    \default 82.0
    \units C
A7, \field Hot Water Pump Configuration
    \note VariableFlow - variable flow to boilers and coils, excess bypassed
    \note ConstantFlow - constant flow to boilers and coils, excess bypassed
    \type choice
    \key VariableFlow
    \key ConstantFlow
    \default ConstantFlow
N2, \field Hot Water Pump Rated Head
    \units Pa
    \minimum 0.0
    \default 179352
    \note Default head is 60 feet H2O
    \ip-units ftH2O
A8, \field Hot Water Setpoint Reset Type
    \note Overrides Hot Water Setpoint Schedule Name
    \type choice
    \key None
    \key OutdoorAirTemperatureReset
    \default None
N3, \field Hot Water Setpoint at Outdoor Dry-Bulb Low
    \note Applicable only for OutdoorAirTemperatureReset control.
    \units C
    \default 82.2
N4, \field Hot Water Reset Outdoor Dry-Bulb Low
    \note Applicable only for OutdoorAirTemperatureReset control.
    \units C
    \default -6.7
N5, \field Hot Water Setpoint at Outdoor Dry-Bulb High
    \note Applicable only for OutdoorAirTemperatureReset control.
    \units C
    \default 65.6
N6, \field Hot Water Reset Outdoor Dry-Bulb High
    \note Applicable only for OutdoorAirTemperatureReset control.
    \units C
    \default 10.0

```

And, as shown in an IDF:

```

HVACTemplate:Plant:HotWaterLoop,
  Hot Water Loop,          !- Plant Loop Name
  ,                        !- Pump Schedule
  Intermittent,           !- Pump Control Type
  Default,                !- Hot Water Plant Operation Scheme Type
  ,                        !- Hot Water Plant Operation Scheme List Name
  HW Loop Temp Schedule,  !- Hot Water Setpoint Schedule
  82,                      !- Hot Water Design Setpoint {C}
  VariableFlow,           !- Hot Water Pump Configuration
  179352,                  !- Hot Water Pump Rated Head {Pa}
  None,                   !- Hot Water Setpoint Reset Type
  82.2,                   !- Hot Water Setpoint at Outdoor Dry Bulb Low {C}
  -6.7,                   !- Hot Water Reset Outdoor Dry Bulb Low {C}
  65.6,                   !- Hot Water Setpoint at Outdoor Dry Bulb High {C}
  10;                     !- Hot Water Reset Outdoor Dry Bulb High {C}

```

HVACTemplate:Plant:Boiler

A boiler or purchased heating source is described with this object. To define multiple boilers, use multiple HVACTemplate:Plant:Boiler objects. If multiple boilers are autosized, each boiler

will be sized to meet the full design heating load. Run the simulation once and locate the autosized capacity for one boiler in the eio output file. This value represents the total required boiler capacity. Copy the expidf output to a new idf file name. Edit this input file and enter values for the capacity and flow rates of each boiler object to apportion this total capacity between the multiple boilers.

Field: Name

The name used to reference the HVACTemplate:Plant:Boiler object.

Field: Boiler Type

While EnergyPlus has a variety of boiler options, the only choices currently for this field are:

- DistrictHotWater
- HotWaterBoiler

The EnergyPlus equipment object types which are used are DistrictHeating or Boiler:HotWater. These equipment type keys must be used if setting up a user-defined chiller plant operation scheme.

Field: Capacity

This field may be set to autosize, which means that the capacity is based on the peak loads during the design days. This numeric field contains the design heating capacity of the boiler. This capacity should be at the design water flow rates. The units are in W.

Field: Efficiency

This numeric field contains the heating efficiency (as a fraction between 0 and 1) of the boiler's burner. Not applicable if Boiler Type is DistrictHotWater.

Field: Fuel Type

The choices for this field are

- Electricity
- NaturalGas
- PropaneGas
- FuelOil#1
- FuelOil#2
- Coal
- Diesel
- Gasoline

Not applicable if Boiler Type is DistrictHotWater

Field: Priority

Enter the priority number of the boiler where 1 is the highest priority, 2 is just lower, 3 is lower than 2, etc. This is used if Boiler Plant Operation Scheme Type is set to Default in HVACTemplate:Plant:HotWaterLoop. Equipment is operated in order of the priority number. This allows multiple boilers to be sequenced.

Field: Sizing Factor

This optional numeric field allows the user to specify a sizing factor for this component. The sizing factor is used when the component design inputs are autosized: the autosizing calculations are performed as usual and the results are multiplied by the sizing factor. For this component the boiler object inputs that would be altered by the sizing factor are: Nominal Capacity and Design Water Flow Rate. Sizing factor allows the user to size a component to meet part of the design load while continuing to use the autosizing feature.

```

HVACTemplate:Plant:Boiler,
  \min-fields 6
A1, \field Name
A2, \field Boiler Type
  \type choice
  \key DistrictHotWater
  \key HotWaterBoiler
N1, \field Capacity
  \autosizable
  \default Autosize
  \units W
  \minimum> 0.0
N2, \field Efficiency
  \note Not applicable if Boiler Type is DistrictHotWater
  \minimum 0.0
  \maximum 1.0
  \default 0.8
A3, \field Fuel Type
  \note Not applicable if Boiler Type is DistrictHotWater
  \type choice
  \key Electricity
  \key NaturalGas
  \key PropaneGas
  \key FuelOil#1
  \key FuelOil#2
  \key Coal
  \key Diesel
  \key Gasoline
A4, \field Priority
  \note If Hot Water Plant Operation Scheme Type=Default
  \note in HVACTemplate:Plant:HotWaterLoop, then equipment
  \note operates in priority order, 1, 2, 3, etc.
N3, \field Sizing Factor
  \note Multiplies the autosized capacity and flow rates
  \type real
  \minimum> 0.0
  \default 1.0

```

And, as shown in an IDF:

```

HVACTemplate:Plant:Boiler,
  District Heating,      !- Boiler Name
  HotWaterBoiler,      !- Boiler Type
  autosize,             !- Capacity {W}
  0.8,                  !- Efficiency
  NaturalGas,           !- Fuel Type
  1,                    !- Priority
  1.0;                  !- Sizing Factor

```

EnergyPlus Economics

Group – Economics

EnergyPlus contains a number of objects to model construction cost and utility bill calculations.

The objects used by EnergyPlus for construction cost calculations are as follows:

ComponentCost:Adjustments

ComponentCost:Reference

ComponentCost:LineItem

The objects used by EnergyPlus for utility bill calculations are as follows:

UtilityCost:Tariff

UtilityCost:Qualify

UtilityCost:Charge:Simple

UtilityCost:Charge:Block

UtilityCost:Ratchet

UtilityCost:Variable

UtilityCost:Computation

The object used for specifying the currency symbol of the monetary unit used is:

CurrencyType

Introduction to Economics

While it is true that monthly utility bills are often directly related to monthly energy consumption and monthly peak demand, due to the elaborate regulatory environment and the changing value of the energy based on load factor, the calculations involved are often complicated. The EnergyPlus approach is to allow you to model the individual component charges that make up the utility bill and report the results on a monthly basis.

To show you how simple the specification of a rate can be here is a simple example for a flat charge of 8 cents for every kWh sold.

```
UtilityCost:Tariff,
  TariffExample1,      ! Name
  Electricity:Facility, ! Output Meter Name
  kWh,                 ! Conversion Factor Choice

UtilityCost:Charge:Simple,
  ChargeExample1,     ! Charge Variable Name
  TariffExample1,     ! Tariff Name
  totalEnergy,        ! Source Variable
  Annual,              ! Season
  EnergyCharges,      ! Category Variable Name
  0.08;                ! Cost Per Unit Value or Variable Name
```

Overall, the goals of the economics section of EnergyPlus are to make simple tariffs easy to model and complex tariffs possible to model.

The cost implications of alternative, energy-related design options may be important in determining the whether or not a particular design is viable. Although the main purpose of EnergyPlus is to determine the energy performance of a building, component cost modeling is provided to allow estimating initial construction costs associated with the building and

HVAC system being modeled. This is provided in order to ensure that cost estimates are consistent with the EnergyPlus model and it allows using results calculated during a simulation such as equipment sizes and surface areas. The cost estimating capabilities are not comprehensive and are not intended to duplicate all the types of analyses included in cost estimating software. Economics modeling is being implemented in stages. Future versions of EnergyPlus will add other investment related analyses such as life-cycle cost. The objects used by EnergyPlus for calculating first costs for construction projects are as follows:

- ComponentCost:Adjustments
- ComponentCost:Reference
- ComponentCost:LineItem

The results of the cost estimate are reported in a Construction Cost Estimate Summary table provided that the user requests the results using the object Output:Table:SummaryReports object with the Component Cost Economics Summary option selected. The style of this predefined report can be controlled using the OutputControl:Table:Style object. If the Annual Building Performance Report Summary is also requested, then cost estimate results will follow that data in the same output file.

The rest of this Economics section is organized to first present reference material on tariff calculations followed by construction cost estimating.

Conceptual Framework – Variables and Hierarchy

To understand how to use the utility bill calculation portion of EnergyPlus you first need to understand some important concepts of variables and hierarchy. A variable, for the purposes of this section, is simply a named holder of a series of numbers. In most cases, the variable will be a named holder of 12 numbers, one number for each monthly utility bill. Here is a visualization of a variable called Electric Energy Use:

Table 32. Example Electric Energy Use (for Economics Calculation)

Month	Electric Energy Use
January	12143
February	13454
March	14178
April	14876
May	15343
June	16172
July	16105
August	15762
September	14543
October	13987
November	13287
December	12403

If you have ever done any computer programming, you can think of a variable as an array. Many of the names used in the utility bill calculation portion of EnergyPlus are names of variables. In the case of the UtilityCost:Charge objects, the name of the object is also used as a name of a variable.

In many of today's utility rates, the charges for energy or demand are broken into distribution and supply charges. To allow for this, more than one charge may to be defined for a particular category. The variables assigned to the same category are added together.

The categories are combined in following hierarchy:

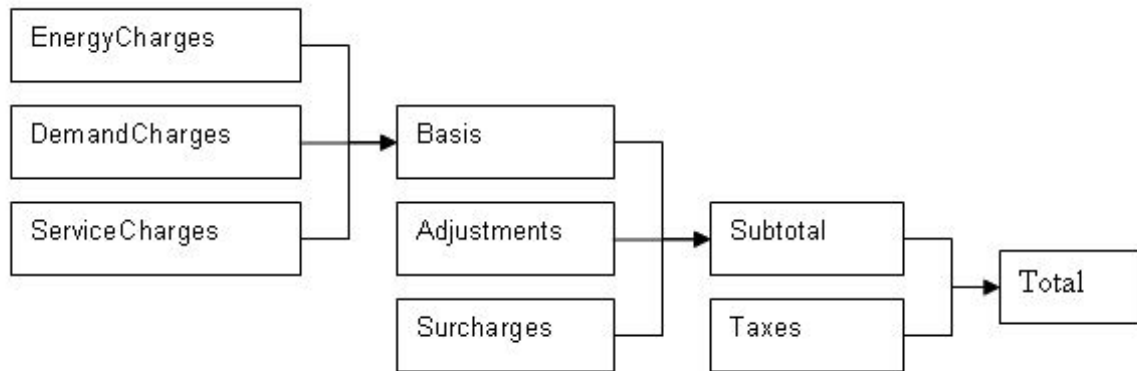


Figure 132. Hierarchy for Economics Charges

Any charges included in the EnergyCharges category are added together. The EnergyCharges, DemandCharges and ServiceCharges are added together to form the Basis. The Basis, Adjustments and Surcharges are added together to form the Subtotal. The Subtotal and Taxes are added together to be the Total. The total represents the total monthly charges on that tariff for the energy source used. The combining of categories together is performed automatically unless the user specifies the UtilityCost:Computation. In addition, each category, which is also a variable, may be used as a source. For example, a tax that is 5% of the subtotal would be shown as:

```

UtilityCost:Charge:Simple,
TaxOfFivePercent,      ! Charge Variable Name
TariffExample1,        ! Tariff Name
Subtotal,              ! Source Variable
Annual,                ! Season
Taxes,                 ! Category Variable Name
0.05;                  ! Cost Per Unit Value or Variable Name
  
```

As you can see, the UtilityCost:Charge:Simple and UtilityCost:Charge:Block objects do most of the “work” of computing the annual energy cost. The benefit of using this categorization is that totals of each category are shown in the output reports and it organizes the charges in the monthly calculations in a logical way that fits almost all tariffs. If no categorization is desired, theoretically, all charges could be assigned to the Total category. The categories themselves are simply variable names. Charges may also be assigned to the “NotIncluded” category if the result of the charge is used as an intermediate calculation and should not be included in the Total.

The rest of this section is divided into a reference of the objects and the fields, a set of examples, discussion of the reporting, and a description of Complex Tariff Modeling. For most tariffs, simply using a variety of UtilityCost:Charge:Simple’s and UtilityCost:Charge:Block’s will result in a good model but for some more complex tariffs, especially ones with complex block sizes, variables may be computed using a very simple programming language that may appear in the UtilityCost:Computation object. This will be described more in the Complex Tariff Modeling section.

UtilityCost:Tariff

Defines the name of the tariff, the type of tariff, and other details about the overall tariff. Each other object that is part of the tariff model references the tariff name including the

UtilityCost:Charge:Simple, UtilityCost:Charge:Block, UtilityCost:Ratchet, UtilityCost:Qualify, UtilityCost:Variable and UtilityCost:Computation objects.

Multiple UtilityCost:Tariff objects can appear in the same IDF file. It is common that electric and gas utilities have more than one rate that may be used. Only one UtilityCost:Tariff for each Report Meter and Group Name is shown in the Economics Summary Report. The one that is shown in that report is chosen by first eliminating UtilityCost:Tariff objects that are not qualified due to their UtilityCost:Qualify objects. If more than one UtilityCost:Tariff object remains, the one that has the lowest cost for a combination of Report Meter and Group Name will be selected. If the Group Name field is not used, then the lowest cost UtilityCost:Tariff is chosen for each Report Meter.

Part of the tariff description is used to transform the annual energy use of any fuel under any meter into a group of named variables containing the values for each of the periods that the bills are calculated (usually monthly). The schedules create a variable for energy use and for demand. If specified it also creates a variable for energy and a variable for demand for the “on-peak”, “off-peak”, and “shoulder” periods for use in time-of-use tariffs. It performs this allocation prior to other calculations for the tariff. The variables that are always created are:

- totalEnergy
- totalDemand

Field: Name

The name of the tariff. Tariffs are sometimes called rates. The name is used in identifying the output results and in associating all of the charges and other objects that make up a tariff.

Field: Output Meter Name

The name of any meter defined but usually set to either Electricity:Facility or Gas:Facility.

Field: Conversion Factor Choice

A choice that allows several different predefined conversion factors to be used; otherwise, user defined conversion factors are used as defined in the next two fields.

- UserDefined
- kWh
- Therm
- MMBtu
- MJ
- KBtu
- MCF
- CCF

Field: Energy Conversion Factor

Is a multiplier used to convert energy into the units specified by the utility in their tariff. If left blank, it defaults to 1 (no conversion). This field will be used only if Conversion Factor Choice is set to UserDefined. Within EnergyPlus energy always has units of J (joules). For conversion from J to kWh use the value of 0.0000002778. This is also used for all objects that reference the UtilityCost:Tariff.

Field: Demand Conversion Factor

Is a multiplier used to convert demand into the units specified by the utility in their tariff. If left blank, it defaults to 1 (no conversion). This field will be used only if Conversion Factor Choice is set to UserDefined. Within EnergyPlus demand always has units of J/s (joules/sec) which equivalent to W (watts). For conversion from W to kW use the value of 0.001. This is also used for all objects that reference the UtilityCost:Tariff.

Field: Time of Use Period Schedule Name

The name of the schedule that defines the time-of-use periods that occur each day. The period schedule is used to determine which variables are defined. The values for the different variables are:

- 1 is Peak
- 2 is Shoulder
- 3 is OffPeak
- 4 is MidPeak

The following variables are created automatically if these different periods are used in the schedule and include:

- peakEnergy
- peakDemand
- shoulderEnergy
- shoulderDemand
- offPeakEnergy
- offPeakDemand
- midPeakEnergy
- midPeakDemand

Some special variables are created that include only demand from one period that exceeds the demand from another period. For other months that do not exceed, the values are zero. These variables are seldom used but are available for the occasional rate that includes a clause looking at demands during one period that exceed another period.

- PeakExceedsOffPeak
- OffPeakExceedsPeak
- PeakExceedsMidPeak
- MidPeakExceedsPeak
- PeakExceedsShoulder
- ShoulderExceedsPeak

If no Period Schedule is specified then no peak, offPeak, midPeak or shoulder variables are defined.

Field: Season Schedule Name

The name of a schedule that defines the seasons. The seasons are

- 1 is Winter
- 2 is Spring
- 3 is Summer
- 4 is Autumn

The change in the season schedule must occur at the same time as the change in the Monthly Schedule. In other words, a season must end at the same time as a billing month. Variables are automatically created if a season schedule is used. These variables are set to 1 within the season and 0 for the months that are not in the season. The variables are:

- isWinter
- isNotWinter
- isSpring
- isNotSpring
- isSummer
- isNotSummer

- isAutumn
- isNotAutumn

Field: Month Schedule Name

The name of the schedule that defines the billing periods of the year. Normally this entry is allowed to default and a schedule will be internally used that has the breaks between billing periods occurring at the same time as the breaks between months, i.e., at midnight prior to the first day of the month. If other billing periods are used such as two month cycles or a single bill for an entire season, such as some natural gas companies do in the summer, then the month schedule may be used to redefine it. Make sure that the month schedule and season schedule are consistent, otherwise an error will be issued.

- 1 is the first month, usually January
- 2 is the second month, usually February
- 3 is the third month, usually March
- 4 is the fourth month, usually April
- 5 is the fifth month, usually May
- 6 is the sixth month, usually June
- 7 is the seventh month, usually July
- 8 is the eighth month, usually August
- 9 is the ninth month, usually September
- 10 is the tenth month, usually October
- 11 is the eleventh month, usually November
- 12 is the twelfth month, usually December

Thus, the schedule that represents this would look like the following. If no schedule is specified the following Month Schedule is used which defines the months of the year as the normal calendar months.

```
Schedule:Compact, defaultMonths, number,
Through: 1/31, For: AllDays, Until: 24:00, 1,
Through: 2/28, For: AllDays, Until: 24:00, 2,
Through: 3/31, For: AllDays, Until: 24:00, 3,
Through: 4/30, For: AllDays, Until: 24:00, 4,
Through: 5/31, For: AllDays, Until: 24:00, 5,
Through: 6/30, For: AllDays, Until: 24:00, 6,
Through: 7/31, For: AllDays, Until: 24:00, 7,
Through: 8/31, For: AllDays, Until: 24:00, 8,
Through: 9/30, For: AllDays, Until: 24:00, 9,
Through: 10/31, For: AllDays, Until: 24:00, 10,
Through: 11/30, For: AllDays, Until: 24:00, 11,
Through: 12/31, For: AllDays, Until: 24:00, 12;
```

Field: Demand Window Length

The determination of demand can vary by utility. Some utilities use the peak instantaneous demand measured but most use a fifteen minute average demand or a one hour average demand. Some gas utilities measure demand as the use during the peak day or peak week. The choices for demand window are:

- QuarterHour
- HalfHour
- FullHour
- Day
- Week

If no value is entered, QuarterHour is assumed. The choice may be overridden based on the value of Timestep so that they are consistent. If the Timestep is 6, i.e. 10 minute timesteps, then QuarterHour is not used and instead HalfHour is used instead. If Timestep is 3, i.e. 20 minute timesteps, then QuarterHour and HalfHour are not used and instead FullHour is used instead. Day and Week are primarily used by fuel utilities.

Field: Monthly Charge or Variable Name

The fixed monthly service charge that many utilities have. The entry may be numeric and gets added to the ServiceCharges variable or if a variable name is entered here, its values for each month are used.

Field: Minimum Monthly Charge or Variable Name

The minimum total charge for the tariff or if a variable name is entered here, its values for each month are used. The sum of the subtotal and taxes usually equals the total unless you have specified the minimum monthly charge. If the minimum monthly charge does not apply to the entire bill, a UtilityCost:Computation object can be specified using a Minimum function for the appropriate variables.

Field: Real Time Pricing Charge Schedule Name

Used with real time pricing rates. The name of a schedule that contains the cost of energy for that particular time period of the year. Real time rates can be modeled using a charge schedule with the actual real time prices entered in the schedule. The charges should be consistent with the conversion factor specified in the tariff.

Field: Customer Baseline Load Schedule Name

Used with real time pricing rates and often described as the CBL or customer baseline load. The name of a schedule that contains the baseline energy use for the customer. Many real time rates apply the charges as a credit or debit only to the difference between the baseline use and the actual use. The baseline use is established between the customer and the utility using a contract. If this field is used the baseline use schedule will be used for establishing the totalEnergy and totalDemand instead of the metered value and the real time rate charge is added or subtracted to the rate calculation using the real time charge schedule. If this field is not used, the real time charge schedule applies to all energy from the meter and totalEnergy and totalDemand is based on metered value as usual.

Field: Group Name

The group name of the tariff such as distribution, transmission, supplier, etc. If more than one tariff with the same group name is present and qualifies, only the lowest cost tariff is used. Usually the group name field is left blank which results in all tariffs using the same meter variable being compared and the lowest cost one being selected.

Field: Buy Or Sell

Sets whether the tariff is used for buying, selling or both to the utility. This should be allowed to default to BuyFromUtility unless a power generation system is included in the building that may generate more power than the building needs during the year. The choices are:

- BuyFromUtility – The values from the metered variable are used and are shown as being purchases from the utility.
- SellToUtility – The values from the metered variable are used for a “sell back” rate to the utility. The charges in the rate should be expressed as negative values.
- NetMetering – Negative values are used to reduce any positive values during the specific period on the tariff when negative values occur.

A warning will be issued if the selection of this field does not match the type of report meter.

UtilityCost:Qualify

Many utilities provide a large number of tariffs and separate their customers by the amount of energy use they have or by the amount of demand. The qualify object allows only certain tariffs that are modeled to be used. If the results of the simulation fall outside of the range of qualifications, that tariff is still calculated but the “Qualified” entry will say “No” and the UtilityCost:Qualify that caused its exclusion is shown. When multiple tariffs from the same utility are modeled and only one of them should be used, make sure that the qualifiers are consistent especially within the same GroupName (see UtilityCost:Tariff). Multiple UtilityCost:Qualify objects can appear for a specific rate and they can be based on any variable.

The energy used and demands for each month vary. Since it is possible that they vary across the minimum and maximum values defined by this object, a choice in how to treat the thresholds is necessary. Say that a utility has two tariffs, a small tariff that has a maximum demand requirement of 50kW and a large tariff that has a minimum demand requirement of 50kW. If the use for a building goes above the 50kW threshold during some summer months and the rest of the time is below 50kW, then how does the utility choose which rate would qualify. The utility probably has very specific requirements about which months or consecutive months can be above or below a threshold to qualify for the rate.

Field: Name

The name used for the UtilityCost:Qualify and displayed if the tariff does not qualify. It is also treated as a variable and contains:

- 1 for each month that does qualify,
- 0 for months that do not qualify, and
- -1 for months that are not part of the season selected.

Field: Tariff Name

The name of the UtilityCost:Tariff object that is associated with this UtilityCost:Qualify object.

Field: Variable Name

The name of the variable used. For energy and demand, the automatically created variables, totalEnergy and totalDemand should be used, respectively.

Field: Qualify Type

Enter either “Minimum” or “Maximum”.

Field: Threshold Value or Variable Name

The minimum or maximum value for the qualify. If the variable has values that are less than this value when the qualify type is minimum then the tariff may be disqualified. If the variable has values that are greater than this value when the qualify type is maximum then the tariff may be disqualified. For demand, it is still the minimum of the demands set each month even though the demands are, by definition, the peak value for the month. Depending on the threshold test entry (see below) this minimum applies to all months, some of the months, or just a single month.

Field: Season

If the UtilityCost:Qualify only applies to a season, enter the season name from the following list:

- Annual
- Winter
- Spring
- Summer

- Fall

If this field is left blank, it defaults to Annual.

Field: Threshold Test

Enter either “Count” or “Consecutive”. Uses the number in Number of Months in one of two different ways depending on the Threshold Test. If the Threshold Test is set to “Count” then the qualification is based on the count of the total number of months per year. If the Threshold Test is set to “Consecutive” then the qualification is based on a consecutive number of months. If left blank this field defaults to count and it should be allowed to default for most cases.

Field: Number of Months

A number from 1 to 12. If no value entered, 12 is assumed when the qualify type is minimum and 1 when the qualify type is maximum. This is the number of months that the threshold test applies to determine if the rate qualifies or not. If the season is less than 12 months (if it is not annual) then the value is automatically reduced to the number of months of the season.

UtilityCost:Charge:Simple

The UtilityCost:Charge:Simple is one of the most often used objects for tariff calculation. It is used to compute energy and demand charges that are very simple. It may also be used for taxes, surcharges and any other charges that occur on a utility bill. As many UtilityCost:Charge:Simple objects as needed may be defined for a single tariff and they will be added together.

Field: Charge Variable Name

This is the name associated with the UtilityCost:Charge:Simple object and will appear in the report. In addition, the results of the UtilityCost:Charge:Simple calculation are stored in a variable with the same name. That way, the results may be used for further calculation. Spaces are not significant in Charge Variable Names. They are removed during the utility bill calculation process.

Field: Tariff Name

The name of the tariff that this UtilityCost:Charge:Simple is associated with.

Field: Source Variable

The name of the source used by the UtilityCost:Charge:Simple. This is usually the name of the variable holding the energy or demand but may also be the name of any variable including the subtotal or basis if other charges are based on those.

Field: Season

This is the name (or number) of a season for which the UtilityCost:Charge:Simple is calculated. If this is set to Annual, the calculations are performed for the UtilityCost:Charge:Simple for the entire year (all months) otherwise it is calculated only for those months in the season defined. The season is defined by the Season Schedule in the UtilityCost:Tariff object. The choices for seasons are the following names or numbers may be used:

- Annual
- Winter
- Spring
- Summer
- Fall

Field: Category Variable Name

All charges get added somewhere in the hierarchy described in the introduction to EnergyPlus economics above. This field shows where the charge should be added. The reason to enter this field appropriately is so that the charge gets reported in a reasonable category. The charge automatically gets added to the variable that is the category. The choices for this field are limited to:

- EnergyCharges
- DemandCharges
- ServiceCharges
- Basis
- Adjustment
- Surcharge
- Subtotal
- Taxes
- Total
- NotIncluded

Field: Cost per Unit Value or Variable Name

This field contains either a single number or the name of a variable. The number is multiplied with all of the energy or demand or other source that is specified in the source field. If a variable is used, then the monthly values of the variable are multiplied against the variable specified in the source field. This field makes it easy to include a simple charge without specifying block sizes. It is added to any of the block calculations (see later fields) but is most often used by itself. If no value or variable is entered, a zero is assumed. This is a good way to include a tax or cost adjustment. For SellToUtility tariffs, the values in this field are usually expressed as negative numbers.

UtilityCost:Charge:Block

The UtilityCost:Charge:Block objects is also used extensively for tariff calculation. It is used to compute energy and demand charges that are structured in blocks of charges. It may also be used for taxes, surcharges and any other charges that occur on a utility bill but those are more commonly simple flat charges so UtilityCost:Charge:Simple is more commonly used for those functions. As many UtilityCost:Charge:Block objects as needed may be defined for a single tariff and they will be added together. Blocks are a structure used by almost all utilities for calculating energy and demand charges and they allow the utility to charge more or less per unit of energy or demand if more units are used.

Field: Charge Variable Name

This is the name associated with the UtilityCost:Charge:Block object and will appear in the report. In addition, the results of the UtilityCost:Charge:Block are stored in a variable with the same name. That way, the results may be used for further calculation.

Field: Tariff Name

The name of the tariff that this UtilityCost:Charge:Block is associated with.

Field: Source Variable

The name of the source used by the UtilityCost:Charge:Block. This is usually the name of the variable holding the energy or demand but may also be the name of any variable including the subtotal or basis if other charges are based on those.

Field: Season

This is the name (or number) of a season for which the UtilityCost:Charge:Block is calculated. If this is set to annual, the calculations are performed for the UtilityCost:Charge:Block for the entire year (all months) otherwise it is calculated only for those months in the season defined. The season is defined by the Season Schedule in the UtilityCost:Tariff object. The choices for seasons are the following names or numbers may be used:

- Annual
- Summer
- Winter
- Spring
- Fall

Field: Category Variable Name

All charges get added somewhere in the hierarchy described in the introduction to EnergyPlus economics above. This field shows where the charge should be added. The reason to enter this field appropriately is so that the charge gets reported in a reasonable category. The charge automatically gets added to the variable that is the category. The choices for this field are limited to:

- EnergyCharges
- DemandCharges
- ServiceCharges
- Basis
- Adjustment
- Surcharge
- Subtotal
- Taxes
- Total
- NotIncluded

Field: Remaining Into Variable

If the blocks do not use all of the energy or demand from the source, some energy and demand remains, then the remaining amount should be assigned to a variable. If no variable is assigned and some amount of energy or demand is not used in the block structure a warning will be issued.

Field: Block Size Multiplier Value or Variable Name

The sizes of the blocks are usually used directly but if a value or a variable is entered here, the block sizes entered in the rest of the charge are first multiplied by the entered value prior to being used. This is common for rates that are kWh/kW rates and in that case the variable that holds the monthly total electric demand would be entered. If no value is entered, a default value of one is assumed so that the block sizes remain exactly as entered. This field is unusual for the EnergyPlus syntax because it can be either a number or a name of a variable.

Field: Block Size 1 Value or Variable Name

The size of the first block of the charges is entered here. For most rates that use multiple blocks, this will be the value for the first block size. Additional block sizes are entered with every other field. A default variable named "remaining" contains a large value and this may be used when the remaining amount should be included in that block. This field and the next

field may be repeated in groups of two for as many blocks as are defined. This field is unusual for the EnergyPlus syntax because it can be either a number or a name of a variable.

Field: Block 1 Cost per Unit Value or Variable Name

The cost of the first block. This value is also repeated for every other field in the charge. As many blocks may be entered as are needed. This field and the previous field may be repeated in groups of two for as many blocks as are defined. This field is unusual for the EnergyPlus syntax because it can be either a number or a name of a variable. For SellToUtility tariffs, the values in this field are usually expressed as negative numbers.

These last two fields may be repeated fifteen times. If more blocks are defined by the utility, the computation can be continued using another UtilityCost:Charge:Block and using the variable from Remaining Into Variable as the source variable.

UtilityCost:Ratchet

The UtilityCost:Ratchet command allows the modeling of tariffs that include some type of seasonal ratcheting. Ratchets are most common when used with electric demand charges. A ratchet is when a utility requires that the demand charge for a month with a low demand may be increased to be more consistent with a month that set a higher demand charge.

While the details of the UtilityCost:Ratchet command are described further in this section, an example is probably the easiest way to learn the basic functions.

Ratchet Example: A utility has a single ratchet that says that the billing demand for each month of the year is the higher value of the actual demand or 60% of the peak summer demand

```
UtilityCost:Ratchet,
BillingDemand1,    ! Ratchet Variable Name
ExampleTariff1,   ! Tariff Name
TotalDemand,      ! Baseline Source Variable
TotalDemand,      ! Adjustment Source Variable
Summer,           ! Season From
Annual,           ! Season To
0.60,             ! Multiplier Value or Variable Name
0;                ! Offset Value or Variable Name
```

The Ratchet Variable Name (the first field) should be used wherever the ratchet should be applied and is often the source variable for UtilityCost:Charge:Simple or UtilityCost:Charge:Block.

The detailed steps taken for the ratchet are the following:

- AdjSeasonal contains either:
 - When SeasonFrom is not set to Monthly, the maximum for all months in Season From in the Adjustment Source Variable. This is a single value.
 - When SeasonFrom is set to Monthly, the monthly values of the Adjustment Source Variable.
- $AdjPeak = (AdjSeasonal + Offset) * Multiplier$
- $MaxAdjBase = \text{maximum value of either } AdjPeak \text{ or Baseline Source Variable}$
- The resulting Ratchet Variable contains:
 - For months not in SeasonTo, the values of Baseline Source Variable
 - For months in SeasonTo, the values of MaxAdjBase

If multiple ratchets occur in the same tariff, multiple UtilityCost:Ratchet commands should be “chained” together with the Baseline Source Variable subsequent ratchets referencing the Ratchet Variable Name of the previous UtilityCost:Ratchet.

Since the ratchet command can add together two variables, multiply two variables, or take the maximum value between two variables, it may be used for other difficult to model tariffs without needing to use UtilityCost:Computation. Clever use of UtilityCost:Ratchet should be well documented with comments.

Field: Ratchet Variable Name

The name of the ratchet and the name of the result of this single ratchet.

Field: Tariff Name

The name of the tariff that this UtilityCost:Ratchet is associated with.

Field: Baseline Source Variable

The name of the variable used as the baseline value. When the ratcheted value exceeds the baseline value for a month the ratcheted value is used but when the baseline value is greater then the ratcheted value the baseline value is used. Usually the electric demand charge is used. The baseline source variable can be the results of another ratchet object. This allows utility tariffs that have multiple ratchets to be modeled.

Field: Adjustment Source Variable

The variable that the ratchet is calculated from. It is often but not always the same as the baseline source variable. The ratcheting calculations using offset and multiplier are using the values from the adjustment source variable. If left blank, the adjustment source variable is the same as the baseline source variable.

Field: Season From

The name of the season that is being examined. The maximum value for all of the months in the named season is what is used with the multiplier and offset. This is most commonly Summer or Annual. When Monthly is used, the adjustment source variable is used directly for all months.

- Annual
- Winter
- Spring
- Summer
- Fall
- Monthly

Field: Season To

The name of the season when the ratchet would be calculated. This is most commonly Winter. The ratchet only is applied to the months in the named season. The resulting variable for months not in the Season To selection will contain the values as appear in the baseline source variable.

- Annual
- Winter
- Spring
- Summer
- Fall

Field: Multiplier Value or Variable Name

Often the ratchet has a clause such as “the current month demand or 90% of the summer month demand”. For this case a value of 0.9 would be entered here as the multiplier. This value may be left blank if no multiplier is needed and a value of one will be used as a default.

Field: Offset Value or Variable Name

A less common strategy is to say that the ratchet must be all demand greater than a value, in this case an offset that is added to the demand may be entered here. If entered, it is common for the offset value to be negative representing that the demand be reduced. If no value is entered it is assumed to be zero and not affect the ratchet.

UtilityCost:Variable

The UtilityCost:Variable object allows for the direct entry of monthly values into a variable.

Field: Name

The name of the variable.

Field: Tariff Name

The name of the tariff that is using the variable.

Field: January through December Values

An entry (up to 24 are available) of the monthly values of the variable. Normally 12 months are used for most utility rates and so 12 values should be entered. If any values are not entered, the value of the previous entry is used. This allows a variable that is constant for an entire year to be entered using only the first value.

UtilityCost:Computation

The UtilityCost:Computation object lists a series of computations that are used to perform the bill calculation. The object is only used for complex tariffs that cannot be modeled any other way. For 95% of the utility tariffs, using UtilityCost:Computation is unnecessary and should be avoided. If the UtilityCost:Computation object is used, it must contain references to all objects involved in the rate in the order that they should be computed.

Field: Name

The name of the UtilityCost:Computation.

Field: Tariff Name

The name of the tariff that this UtilityCost:Charge:Simple is associated with.

Field: Compute Step N

The Compute Step fields contain a simple language that describes the steps used in the computation process similar to a programming language. If no entry is made to any Compute Step fields (as usually the case) a default method of computing the rates shall be used. Compute Step is described later in this section under Complex Tariff Modeling.

Remember, this object should be omitted for almost all tariffs.

UtilityCost:Tariff Examples

One of the best ways to learn the details of EnergyPlus Economics is to see some example tariffs and how they translate into objects. To do this, several different rates of increasing complexity are shown in the following examples.

Another source of examples is the large set of tariff input objects provided with EnergyPlus in the macro data set file called "UtilityTariffObjects.imf" located in the "MacroDataSets" folder where EnergyPlus is installed. This file contains sets of objects that fully define tariffs for commercial customers from a collection of U.S. utility companies.

Example A – Flat Energy Charge

As an example of the simplest type of tariff.

Customer Charge: \$2.51 per month

Energy Charge: 5.5342 cents/kWh

This tariff would use a single UtilityCost:Charge:Simple object. The monthly charge is part of the UtilityCost:Tariff object.

```
UtilityCost:Tariff,
ExampleA,                ! Name
Electricity:Facility,    ! Output Meter Name
kWh,                    ! Conversion Factor Choice
,                        ! Energy Conversion Factor
,                        ! Demand Conversion Factor
,                        ! Time of Use Period Schedule Name
,                        ! Season Schedule Name
,                        ! Month Schedule Name
,                        ! Demand Window Length
2.51;                   ! Monthly Charge or Variable Name

UtilityCost:Charge:Simple,
FlatEnergyCharge,       ! Charge Variable Name
ExampleA,               ! Tariff Name
totalEnergy,           ! Source Variable
Annual,                ! Season
EnergyCharges,         ! Category Variable Name
0.055342;              ! Cost Per Unit Value or Variable Name
```

Example B – Block Energy Charge

Another simple type of tariff is one where the energy charges vary by the amount of energy consumed each month.

Customer Charge: \$5.75 per month

Energy Charge: 7.231 cents/kWh for first 200 kWh

6.656 cents/kWh for next 1000 kWh

5.876 cents/kWh for over 1200 kWh

This tariff would use a single UtilityCost:Charge:Block object. The monthly charge is part of the UtilityCost:Tariff object. Note that the block sizes are every other field at the bottom of the object and the that final block size references a built in variable called “remaining” that contains a very large number.

```

UtilityCost:Tariff,
  ExampleB,                ! Name
  Electricity:Facility,    ! Output Meter Name
  kWh,                    ! Conversion Factor Choice
  ,                       ! Energy Conversion Factor
  ,                       ! Demand Conversion Factor
  ,                       ! Time of Use Period Schedule Name
  ,                       ! Season Schedule Name
  ,                       ! Month Schedule Name
  ,                       ! Demand Window Length
  5.75;                   ! Monthly Charge or Variable Name

UtilityCost:Charge:Block,
  BlockEnergyCharge,      ! Charge Variable Name
  ExampleB,              ! Tariff Name
  totalEnergy,           ! Source Variable
  Annual,                ! Season
  EnergyCharges,        ! Category Variable Name
  ,                      ! Remaining Into Variable
  ,                      ! Block Size Multiplier Value or Variable Name
  200,                   ! Block Size 1 Value or Variable Name
  0.07231,               ! Block 1 Cost per Unit Value or Variable Name
  1000,                  ! Block Size 2 Value or Variable Name
  0.06656,               ! Block 2 Cost per Unit Value or Variable Name
  remaining,             ! Block Size 3 Value or Variable Name
  0.05876;               ! Block 3 Cost per Unit Value or Variable Name

```

Example C – Block Energy and Demand Charges

This example contains both a block for energy and a block for demand and is very similar to the previous example except it now includes demand charges as well. The energy and demand charges vary by the amount of energy and demand consumed each month.

Energy Charge:	4.74 cents/kWh for first 20,000 kWh
	4.24 cents/kWh for next 180,000 kWh
	3.83 cents/kWh for additional kWh
Demand Charge:	5.38 dollars per kW for first 20 kW
	4.23 dollars per kW for next 80 kW
	3.60 dollars per kW for additional kW

This tariff would use two UtilityCost:Charge:Block objects. No monthly charge is shown so the UtilityCost:Tariff object can include just the first four fields. Note that the block sizes are every other field at the bottom of the object and the that final block size references a built in variable called “remaining” that contains a very large number.

```

UtilityCost:Tariff,
  ExampleC,                ! Name
  Electricity:Facility,    ! Output Meter Name
  KWh;                     ! Conversion Factor Choice

UtilityCost:Charge:Block,
  BlockEnergyCharge,      ! Charge Variable Name
  ExampleC,               ! Tariff Name
  totalEnergy,            ! Source Variable
  Annual,                 ! Season
  EnergyCharges,         ! Category Variable Name
  ,                       ! Remaining Into Variable
  ,                       ! Block Size Multiplier Value or Variable Name
  20000,                  ! Block Size 1 Value or Variable Name
  0.0474,                 ! Block 1 Cost per Unit Value or Variable Name
  180000,                 ! Block Size 2 Value or Variable Name
  0.0424,                 ! Block 2 Cost per Unit Value or Variable Name
  remaining,              ! Block Size 3 Value or Variable Name
  0.0383;                 ! Block 3 Cost per Unit Value or Variable Name

UtilityCost:Charge:Block,
  BlockDemandCharge,     ! Charge Variable Name
  ExampleC,               ! Tariff Name
  totalDemand,           ! Source Variable
  Annual,                 ! Season
  DemandCharges,        ! Category Variable Name
  ,                       ! Remaining Into Variable
  ,                       ! Block Size Multiplier Value or Variable Name
  20,                    ! Block Size 1 Value or Variable Name
  5.38,                  ! Block 1 Cost per Unit Value or Variable Name
  80,                    ! Block Size 2 Value or Variable Name
  4.23,                  ! Block 2 Cost per Unit Value or Variable Name
  remaining,              ! Block Size 3 Value or Variable Name
  3.60;                  ! Block 3 Cost per Unit Value or Variable Name

```

Example D - Seasonal Energy Charges with Minimum Charge

Another type of tariff is one where the energy charges vary by the amount of energy consumed each month and are different for the summer and winter. In addition, this example demonstrates the minimum charge field.

Minimum Charge: \$7.00 per month

Winter – October through May

Energy Charge: 4.385 cents/kWh for first 650 kWh
 3.763 cents/kWh for next 350 kWh
 3.704 cents/kWh for over 1000 kWh

Summer – June through September

Energy Charge: 8.385 cents/kWh for first 650 kWh
 7.588 cents/kWh for next 350 kWh
 7.103 cents/kWh for over 1000 kWh

This tariff would use two UtilityCost:Charge:Block objects. The monthly charge is part of the UtilityCost:Tariff object. Note that the block sizes are every other field at the bottom of the

object and the that final block size references a built in variable called "remaining" that contains a very large number.

```

UtilityCost:Tariff,
  ExampleD,                ! Name
  Electricity:Facility,    ! Output Meter Name
  KWh,                    ! Conversion Factor Choice
  ,                       ! Energy Conversion Factor
  ,                       ! Demand Conversion Factor
  ,                       ! Time of Use Period Schedule Name
  TwoSeasonSchedule,     ! Season Schedule Name
  ,                       ! Month Schedule Name
  ,                       ! Demand Window Length
  ,                       ! Monthly Charge or Variable Name
  7.00;                  ! Minimum Monthly Charge or Variable Name

UtilityCost:Charge:Block,
  WinterEnergyCost,      ! Charge Variable Name
  ExampleD,              ! Tariff Name
  totalEnergy,          ! Source Variable
  Winter,                ! Season
  EnergyCharges,        ! Category Variable Name
  ,                     ! Remaining Into Variable
  ,                     ! Block Size Multiplier Value or Variable Name
  650,                  ! Block Size 1 Value or Variable Name
  0.04385,              ! Block 1 Cost per Unit Value or Variable Name
  350,                  ! Block Size 2 Value or Variable Name
  0.03763,              ! Block 2 Cost per Unit Value or Variable Name
  remaining,            ! Block Size 3 Value or Variable Name
  0.03704;              ! Block 3 Cost per Unit Value or Variable Name

UtilityCost:Charge:Block,
  SummerEnergyCost,     ! Charge Variable Name
  ExampleD,              ! Tariff Name
  totalEnergy,          ! Source Variable
  Summer,               ! Season
  EnergyCharges,        ! Category Variable Name
  ,                     ! Remaining Into Variable
  ,                     ! Block Size Multiplier Value or Variable Name
  650,                  ! Block Size 1 Value or Variable Name
  0.08385,              ! Block 1 Cost per Unit Value or Variable Name
  350,                  ! Block Size 2 Value or Variable Name
  0.07588,              ! Block 2 Cost per Unit Value or Variable Name
  remaining,            ! Block Size 3 Value or Variable Name
  0.07103;              ! Block 3 Cost per Unit Value or Variable Name

Schedule:Compact, TwoSeasonSchedule, number,
Through: 5/31, For: AllDays, Until: 24:00, 1,
Through: 9/30, For: AllDays, Until: 24:00, 3,
Through: 12/31, For: AllDays, Until: 24:00, 1;

```

Example E – kWh/kW Energy Charges

A more advanced rate varies the size of the blocks based on amount of demand for the month. This creates an effective demand charge if the blocks have declining values.

Customer Charge: \$14.00 per month

Energy Charge: 8.756 cents/kWh for all consumption not greater than 200 hours times the demand

6.812 cents/kWh for all consumption in excess of 200 hours and not greater than 400 hours times the demand

5.029 cents/kWh for all consumption in excess of 400 hours times the demand.

This tariff would use a single `UtilityCost:Charge:Block` object. The monthly charge is part of the `UtilityCost:Tariff` object. In this case the `Block Size Multiplier Value` (or `Variable`) is set to the `totalDemand` variable.

```
UtilityCost:Tariff,
  ExampleE,           ! Name
  Electricity:Facility, ! Output Meter Name
  KWh,               ! Conversion Factor Choice
  ,                 ! Energy Conversion Factor
  ,                 ! Demand Conversion Factor
  ,                 ! Time of Use Period Schedule Name
  ,                 ! Season Schedule Name
  ,                 ! Month Schedule Name
  ,                 ! Demand Window Length
  14;                ! Monthly Charge or Variable Name

UtilityCost:Charge:Block,
  BlockEnergyCharge, ! Charge Variable Name
  ExampleE,          ! Tariff Name
  totalEnergy,       ! Source Variable
  Annual,            ! Season
  EnergyCharges,     ! Category Variable Name
  ,                 ! Remaining Into Variable
  totalDemand,       ! Block Size Multiplier Value or Variable Name
  200,               ! Block Size 1 Value or Variable Name
  0.08756,           ! Block 1 Cost per Unit Value or Variable Name
  200,               ! Block Size 2 Value or Variable Name
  0.06812,           ! Block 2 Cost per Unit Value or Variable Name
  remaining,         ! Block Size 3 Value or Variable Name
  0.05029;           ! Block 3 Cost per Unit Value or Variable Name
```

Example F – Seasonal Time of Use Energy

Tariffs sometimes have higher costs for energy consumed during the daytime than at night. This example includes energy charges that vary by the time of day and by the season.

Monthly Charge: \$37.75 per month

Winter – October through May

On Peak: 8.315 cents/kWh

Off-Peak: 2.420 cents/kWh

Summer – June through September

On Peak: 14.009 cents/kWh

Off-Peak: 6.312 cents/kWh

The on-peak period is defined as the hours starting at 10am and ending at 7pm, Monday through Friday for June through September and 3pm to 10pm Monday through Friday for October through May. All other hours are considered off-peak.

The tariff is only applicable for customers that use 50KW for at least one month of the year.

This tariff uses four different `UtilityCost:Charge:Simple` objects to capture the variation with time of the energy cost. The monthly charge is part of the `UtilityCost:Tariff` object.

```

UtilityCost:Tariff,
  ExampleF,           ! Name
  Electricity:Facility, ! Output Meter Name
  kWh,               ! Conversion Factor Choice
  ,                 ! Energy Conversion Factor
  ,                 ! Demand Conversion Factor
  TimeOfDaySchedule, ! Time of Use Period Schedule Name
  TwoSeasonSchedule, ! Season Schedule Name
  ,                 ! Month Schedule Name
  ,                 ! Demand Window Length
  37.75;            ! Monthly Charge or Variable Name

UtilityCost:Charge:Simple,
  SummerOnPeak,      ! Charge Variable Name
  ExampleF,          ! Tariff Name
  peakEnergy,        ! Source Variable
  Summer,            ! Season
  EnergyCharges,     ! Category Variable Name
  0.14009;           ! Cost per Unit Value or Variable Name

UtilityCost:Charge:Simple,
  SummerOffPeak,     ! Charge Variable Name
  ExampleF,          ! Tariff Name
  offPeakEnergy,     ! Source Variable
  Summer,            ! Season
  EnergyCharges,     ! Category Variable Name
  0.06312;           ! Cost per Unit Value or Variable Name

UtilityCost:Charge:Simple,
  WinterOnPeak,      ! Charge Variable Name
  ExampleF,          ! Tariff Name
  peakEnergy,        ! Source Variable
  Winter,            ! Season
  EnergyCharges,     ! Category Variable Name
  0.08315;           ! Cost per Unit Value or Variable Name

UtilityCost:Charge:Simple,
  WinterOffPeak,     ! Charge Variable Name
  ExampleF,          ! Tariff Name
  offPeakEnergy,     ! Source Variable
  Winter,            ! Season
  EnergyCharges,     ! Category Variable Name
  0.02420;           ! Cost per Unit Value or Variable Name

UtilityCost:Qualify,
  MinDemand,         ! Name
  ExampleF,          ! Tariff Name
  TotalDemand,       ! Variable Name
  Minimum,           ! Qualify Type
  50,                ! Threshold Value or Variable Name
  Annual,            ! Season
  Count,             ! Threshold Test
  1;                 ! Number of Months

Schedule:Compact, TwoSeasonSchedule, number,
Through: 5/31, For: AllDays, Until: 24:00, 1,
Through: 9/30, For: AllDays, Until: 24:00, 3,
Through: 12/31, For: AllDays, Until: 24:00, 1;

Schedule:Compact, TimeOfDaySchedule, number,
Through: 5/31, For: AllDays, Until: 15:00, 3,
                          Until: 22:00, 1,
                          Until: 24:00, 3,
Through: 9/30, For: AllDays, Until: 10:00, 3,
                          Until: 19:00, 1,
                          Until: 24:00, 3,
Through: 12/31, For: AllDays, Until: 15:00, 3,
                          Until: 22:00, 1,
                          Until: 24:00, 3;

```


Example G – Blocks within Blocks

Utilities have come up with many different ways to encourage certain load factors and discourage other load factors. One method that has been used is blocks defined within other blocks. In the following example standard kWh blocks exist within the energy allocated for the first of several kWh/kW blocks.

Monthly Charge: \$35 per month

Energy Charge: For all consumption not greater than 200 hours times the demand use

10.32 cents/kWh for the first 1000 kWh

7.43 cents/kWh for the next 4000 kWh

6.23 cents/kWh for the next 5000 kWh

4.27 cents/kWh for the remaining kWh less than 200 hours times the demand

6.82 cents/kWh for all consumption in excess of 200 hours and not greater than 400 hours times the demand

5.03 cents/kWh for all consumption in excess of 400 hours times the demand.

To set up this “block within a block” a UtilityCost:Charge:Block is first used to separate out the first 200 kWh/kW. The “EnergyFirst200kWhPerkW” charge performs this. It uses demand to multiply the first block size by 200 and the “cost” for the block is simply 1 since it passes through the energy to the variable “EnergyFirst200kWhPerkW”. The remaining energy goes into the “restOfEnergy” variable as specified as the “Remaining Into Variable” field. After this is evaluated we have two new variables that hold energy. Each of these variables are then separately used in UtilityCost:Charge:Block objects to evaluate the different parts of the example tariff. By using the “Remaining Into Variable” along with the concept of variables, many very complex tariffs may be modeled.

```

UtilityCost:Tariff,
  ExampleG,           !- Name
  ElectricityPurchased:Facility, !- Output Meter Name
  KWh,               !- Conversion Factor Choice
  ,                 !- Energy Conversion Factor
  ,                 !- Demand Conversion Factor
  ,                 !- Time of Use Period Schedule Name
  ,                 !- Season Schedule Name
  ,                 !- Month Schedule Name
  ,                 !- Demand Window Length
  35;                !- Monthly Charge or Variable Name

UtilityCost:Charge:Block,
  EnergyFirst200kWhPerkW, !- Charge Variable Name
  ExampleG,               !- Tariff Name
  totalEnergy,           !- Source Variable
  Annual,                 !- Season
  NotIncluded,           !- Category Variable Name
  restOfEnergy,          !- Remaining Into Variable
  totalDemand,           !- Block Size Multiplier Value or Variable Name
  200,                   !- Block Size 1 Value or Variable Name
  1;                     !- Block 1 Cost Per Unit Value or Variable Name

UtilityCost:Charge:Block,
  CostOfFirst200kWhPerkW, !- Charge Variable Name
  ExampleG,               !- Tariff Name
  EnergyFirst200kWhPerkW, !- Source Variable
  Annual,                 !- Season
  EnergyCharges,         !- Category Variable Name
  ,                       !- Remaining Into Variable
  ,                       !- Block Size Multiplier Value or Variable Name
  1000,                  !- Block Size 1 Value or Variable Name
  0.1032,                !- Block 1 Cost Per Unit Value or Variable Name
  4000,                  !- Block Size 2 Value or Variable Name
  0.0743,                !- Block 2 Cost Per Unit Value or Variable Name
  5000,                  !- Block Size 3 Value or Variable Name
  0.0623,                !- Block 3 Cost Per Unit Value or Variable Name
  remaining,             !- Block Size 4 Value or Variable Name
  0.0427;                !- Block 4 Cost Per Unit Value or Variable Name

UtilityCost:Charge:Block,
  CostOfRestOfEnergy,    !- Charge Variable Name
  ExampleG,               !- Tariff Name
  restOfEnergy,          !- Source Variable
  Annual,                 !- Season
  EnergyCharges,         !- Category Variable Name
  ,                       !- Remaining Into Variable
  totalDemand,           !- Block Size Multiplier Value or Variable Name
  200,                   !- Block Size 1 Value or Variable Name
  0.0682,                !- Block 1 Cost Per Unit Value or Variable Name
  remaining,             !- Block Size 2 Value or Variable Name
  0.0503;                !- Block 2 Cost Per Unit Value or Variable Name

```

Example H – Real Time Pricing

Some utilities have tariffs that can have different prices every hour of the year called Real Time Pricing tariffs. Often the utility will inform the customer of the prices for each hour of the day just one day in advance. To model this type of utility rate a normal schedule is used that contains the prices on an hourly basis. The “Charge Schedule” field is where the Schedule object containing the prices is referenced. In addition, the “Baseline Use Schedule” field is used to set the schedule for the customer baseline load. Not all utilities use a customer baseline load so the field can be left blank if none is needed. The Period, Season and Month Schedules are not needed for these tariffs unless UtilityCost:Charge’s are used. The Schedule:File object can be especially useful to input a complex schedule that changes throughout the year.

Example H, shown below, is an example of how to use the UtilityCost:Tariff object with a schedule to calculate a utility tariff using real time prices. The example real time pricing schedule results in the same energy cost as Example F – Seasonal Time of Use Energy. This is only an example and usually for real time pricing the schedule values would vary throughout the year.

```
! EXAMPLE H - Real Time Pricing (RTP)

UtilityCost:Tariff,
  ExampleH,                !- Name
  ElectricityPurchased:Facility, !- Output Meter Name
  kWh,                    !- Conversion Factor Choice
  ,                        !- Energy Conversion Factor
  ,                        !- Demand Conversion Factor
  ,                        !- Time of Use Period Schedule Name
  ,                        !- Season Schedule Name
  ,                        !- Month Schedule Name
  ,                        !- Demand Window Length
  37.75,                  !- Monthly Charge or Variable Name
  ,                        !- Minimum Monthly Charge or Variable Name
  RTPpriceSchedule-H,    !- Real Time Pricing Charge Schedule Name
  ,                        !- Customer Baseline Load Schedule Name
  ,                        !- Group Name
  buyFromUtility;        !- Buy Or Sell

Schedule:Compact,
  RTPpriceSchedule-H,    !- Name
  Any Number,            !- Schedule Type Limits Name
  Through: 5/31,         !- Field 1
  For: AllDays,          !- Field 2
  Until: 15:00,          !- Field 3
  0.02420,               !- Field 4
  Until: 22:00,          !- Field 5
  0.08315,               !- Field 6
  Until: 24:00,          !- Field 7
  0.02420,               !- Field 8
  Through: 9/30,         !- Field 9
  For: AllDays,          !- Field 10
  Until: 10:00,          !- Field 11
  0.06312,               !- Field 12
  Until: 19:00,          !- Field 13
  0.14009,               !- Field 14
  Until: 24:00,          !- Field 15
  0.06312,               !- Field 16
  Through: 12/31,       !- Field 17
  For: AllDays,          !- Field 18
  Until: 15:00,          !- Field 19
  0.02420,               !- Field 20
  Until: 22:00,          !- Field 21
  0.08315,               !- Field 22
  Until: 24:00,          !- Field 23
  0.02420;               !- Field 24
```

Example I – Selling and Net-Metering

When the building contains a generator, photovoltaics, or other sources of electrical power, there is an opportunity for the building generator to produce more power than the building uses. The excess power can either be sold to the utility or offset the energy purchased.

When the excess power is sold, two utility rates need to be defined. The first can be defined just as in any of the previous examples. Since the “Buy or Sell” field of the UtilityCost:Tariff object defaults to “buyFromUtility” it does not even need to be specified. The meter specified in the “Report Meter” is usually set to “ElectricityPurchased:Facility.”

The second tariff needs to be defined with the “Buy or Sell” field set to “sellToUtility.” The “Report Meter” is usually set to “ElectricitySurplusSold:Facility.” It is important to set the

appropriate meters that correspond with the “Buy or Sell” field. The example below shows an tariff that sells the excess electricity back to utility. The UtilityCost:Charge:Simple object contains a “Cost Per Value” with a negative number. A negative number is critical if a credit for selling this electricity is expected.

```
! EXAMPLE I - Selling

UtilityCost:Charge:Simple,
  GeneratedElectricSold,  !- Charge Variable Name
  ExampleI-Sell,         !- Tariff Name
  totalEnergy,          !- Source Variable
  Annual,               !- Season
  EnergyCharges,        !- Category Variable Name
  -0.02;                !- Cost Per Unit Value (or Variable)

UtilityCost:Tariff,
  ExampleI-Sell,        !- Name
  ElectricitySurplusSold:Facility, !- Output Meter Name
  kWh,                 !- Conversion Factor Choice
  ,                    !- Energy Conversion Factor
  ,                    !- Demand Conversion Factor
  ,                    !- Time of Use Period Schedule Name
  ,                    !- Season Schedule Name
  ,                    !- Month Schedule Name
  ,                    !- Demand Window Length
  ,                    !- Monthly Charge or Variable Name
  ,                    !- Minimum Monthly Charge or Variable Name
  ,                    !- Real Time Pricing Charge Schedule Name
  ,                    !- Customer Baseline Load Schedule Name
  ,                    !- Group Name
  sellToUtility;       !- Buy Or Sell

UtilityCost:Charge:Simple,
  GeneratedElectricSold,  !- Charge Variable Name
  ExampleI-Sell,         !- Tariff Name
  totalEnergy,          !- Source Variable
  Annual,               !- Season
  EnergyCharges,        !- Category Variable Name
  -0.02;                !- Cost Per Unit Value or Variable Name
```

The next part of this example is a rate that uses net-metering. With net metering the meter conceptually turns backwards when the energy is being sold to the utility directly reducing the energy consumption being charged. Effectively, the rate charge for purchased electricity is the same as the rate credited for electricity sold to the utility. In this the “Buy or Sell” field should be set to “netMetering.” It is also important the “Report Meter” is set to a meter that represents net metering such as “ElectricityNet:Facility.” The following example shows a simple example tariff using net metering with a single UtilityCost:Charge:Simple:

```

! EXAMPLE I - Net Metering

UtilityCost:Tariff,
  ExampleI-NetMeter,      !- Name
  ElectricityNet:Facility, !- Output Meter Name
  kWh,                   !- Conversion Factor Choice
  ,                      !- Energy Conversion Factor
  ,                      !- Demand Conversion Factor
  ,                      !- Time of Use Period Schedule Name
  ,                      !- Season Schedule Name
  ,                      !- Month Schedule Name
  ,                      !- Demand Window Length
  30.00,                 !- Monthly Charge or Variable Name
  ,                      !- Minimum Monthly Charge or Variable Name
  ,                      !- Real Time Pricing Charge Schedule Name
  ,                      !- Customer Baseline Load Schedule Name
  ,                      !- Group Name
  netMetering;          !- Buy Or Sell

UtilityCost:Charge:Simple,
  NetMeteredCharge,      !- Charge Variable Name
  ExampleI-NetMeter,      !- Tariff Name
  totalEnergy,           !- Source Variable
  Annual,                !- Season
  EnergyCharges,         !- Category Variable Name
  0.065;                 !- Cost Per Unit Value or Variable Name

```

UtilityCost:Tariff Reporting

A standardized tabular output report is created which shows all components of all categories in the calculation sequence on a variable basis (usually 12 numbers, one for each month). The economics report is automatically created if any UtilityCost:Tariff objects are present. The values reported are in the units specified in the UtilityCost:Tariff object. The report includes:

Economic Results Summary Report

- Annual Cost – Shows the annual cost for qualified and selected electric and gas tariffs and the total cost
- Tariff Summary – For each tariff included shows if that tariff was selected, if it was qualified, what meter it was connected to, what group it was part of, and the annual cost. The qualified tariff with the lowest annual cost for each of the meters is indicated as “selected” and shown in the Annual Cost section of the report. If multiple groups are defined, a tariff is selected from each group.

Tariff Summary

- Summary table – Shows the if that tariff was selected, if it was qualified, which qualifier disqualified the tariff, what meter it was connected to, what group it was part of, if the computation was based on a user defined computation or was automatic.
- Categories – Shows the monthly results of all the category variables.
- Charges – Shows the monthly results for all of the simple and block charges.
- Ratchets – Shows the monthly results for all ratchets.
- Qualifies – Shows the monthly results for all qualifies.
- Native Variables – Shows the monthly values for the native variables such as TotalEnergy and TotalDemand.
- Other Variables – Shows the monthly values for any other variables not appearing in the other tables.
- Computation – Shows the computational steps used including those generated automatically.

The report is part of the tabular report and is created using the same style as specified for the tabular reports.

Complex Tariff Modeling

Much can be accomplished with the `UtilityCost:Charge:Simple` and `UtilityCost:Charge:Block` objects. In almost all cases, these structures are flexible enough to model the tariff. At times the built in approach is not sufficient to model a particular rate. In those cases, the rate may be modeled by using the `UtilityCost:Computation` object. For most rates this object can be omitted but for difficult to model rates, they may be used to modify the normal way the rate computation is performed.

Each `ComputeStep` is performed in order and can be either a variable followed by an expression or simply a variable.

- `demandMod SUM demand1 demand2`
- `chargeSummer1`

The normal calculations associated with the `UtilityCost:Qualify`, `UtilityCost:Charge:Simple`, `UtilityCost:Charge:Block`, or `UtilityCost:Ratchet` are performed the first time that object is called. Subsequent times are not recomputed but use the value stored in the appropriate variable. The result of the computation for those objects is available in the expression for further computation. The expressions allow the manipulation of variables directly using simple mathematical functions. Only variable names may be entered along with operators. Numbers may not be entered and should be entered with `UtilityCost:Variable`. Multiple operators are allowed per step. Variables names do not include spaces. If spaces are found in a variable name then an error is shown. Unused variables are flagged with a warning. All expressions are in the form:

- `assignedToVariable OPERATOR variable1 variable2`

Each step is performed for each of the months before the next step is taken. The same operation is performed for each step as specified.

The actual evaluation of the expression is performed from the end of the line to the beginning using stack based operations. Some operators pull all values from the stack (`SUM`, `MAXIMUM`, `MINIMUM`) while most use just one or two values from the stack. All operations return a single value to the stack. This stack based approach to expressions is sometimes called Polish Notation. While multiple operators are allowed per line, it reduces confusion if each line has only a single operator.

When the `UtilityCost:Computation` object is used, it must contain references to all objects involved in the rate in the order that they should be computed. No checking is performed for objects that should or should not be included; instead, the computational process is driven completely by the input of this object.

A typical rate will have a simple series of steps. For example F the following steps would be created automatically by the software:

```
UtilityCost:Computation,
SpecialStepsForF,          !- Name
ExampleF,                  !- Tariff Name
EnergyCharges SUM SummerOnPeak SummerOffPeak WinterOnPeak WinterOffPeak, Compute Step 1
Basis SUM EnergyCharges DemandCharges ServiceCharges, Compute Step 2
SubTotal SUM Basis Adjustments Surcharges, Compute Step 3
Total SUM SubTotal Taxes, Compute Step 4
MinDemand; Compute Step 5
```

This example does not have any dependency of different charges that are summed on the same line but if it did the charges could appear by themselves on lines and this would indicate the order that they should be computed. Here is the same example again showing that form.

```

UtilityCost:Computation,
SpecialStepsForF,          !- Name
ExampleF,                  !- Tariff Name
SummerOnPeak,              !- Compute Step 1
SummerOffPeak,             !- Compute Step 2
WinterOnPeak,              !- Compute Step 3
WinterOffPeak,            !- Compute Step 4
EnergyCharges SUM SummerOnPeak SummerOffPeak WinterOnPeak WinterOffPeak, !- Compute Step 5
Basis SUM EnergyCharges DemandCharges ServiceCharges, !- Compute Step 6
SubTotal SUM Basis Adjustments Surcharges, !- Compute Step 7
Total SUM SubTotal Taxes, !- Compute Step 8
MinDemand;                 !- Compute Step 9

```

This second expanded format is generated automatically when no UtilityCost:Computation object is provided.

The functions built in are (number of arguments in parentheses):

Operator: SUM (unlimited)

Adds together all of the variable values for each month for as many variables that are used.

Operator: ADD (2)

Adds together the first variable value with the second variable value.

Operator: MULTIPLY (2)

Multiplies the first variable value with the second variable value. MULT may also be used.

Operator: SUBTRACT (2)

Subtracts the second variable value from the first variable value. SUBT may also be used.

Operator: DIVIDE (2)

Divides the first variable value by the second variable value. DIV may also be used.

Operator: ABSOLUTE (1)

Takes the absolute value of the variable value. This turns negative values into positive ones. ABS may also be used.

Operator: INTEGER (1)

Removes non-integer portions of the variable values. INT may also be used.

Operator: SIGN (1)

Returns a 1 for positive values, -1 for negative values and 0 for zero values.

Operator: MAXIMUM (unlimited)

Selects the maximum value across variables for each of the months. Two or more variables may be used. MAX may also be used.

Operator: MINIMUM (unlimited)

Selects the minimum value across variables for each of the months. Two or more variables may be used. MIN may also be used.

Operator: EXCEEDS (2)

Returns the difference between the first and second variable if the first variable is greater than the second. If the second variable is greater or equal to the first variable returns a zero.

Operator: ANNUALMINIMUM (1)

Returns the minimum value of the twelve months in the variable. Zero values are ignored (see also ANNUALMINZERO). If all values are zero then zero is returned. ANMIN may also be used.

Operator: ANNUALMAXIMUM (1)

Returns the maximum value of the twelve months in the variable. Zero values are ignored (see also ANNUALMAXZERO). If all values are zero then zero is returned. ANMAX may also be used.

Operator: ANNUALSUM (1)

Returns the sum of the twelve months in the variable. ANSUM may also be used.

Operator: ANNUALAVERAGE (1)

Returns the sum of the twelve monthly values divided by the number of non-zero monthly values. If all values are zero then zero is returned. If an average is desired that includes zero valued elements the SUM() function should be used divided by 12. ANAVG may also be used.

Operator: ANNUALOR (1)

Returns 1 for all monthly values if any of the monthly values are non-zero. ANOR may also be used.

Operator: ANNUALAND (1)

Returns 1 for all monthly values if all of the monthly values are non-zero. ANAND may also be used.

Operator: ANNUALMAXIMUMZERO (1)

Returns the maximum value of the twelve monthly values in x. Zeros are counted so if a zero is the largest value (the rest would be negative) a zero may be returned. ANMAXZ may also be used.

Operator: ANNUALMINIMUMZERO (1)

Returns the minimum value of the twelve monthly values in x. Zeros are counted. ANMINZ may also be used.

Operator: IF (3)

Returns the value of the second variable if the first variable is non-zero otherwise returns the value of the third variable. Usually used with GT, GE, LT, LE, EQ, NE operators.

Operator: GREATERTHAN (2)

1 if the first variable value is greater than the second variable value otherwise 0. GT may also be used.

Operator: GREATEREQUAL (2)

1 if the first variable value is greater than or equal to the second variable value otherwise 0. GE may also be used.

Operator: LESSTHAN (2)

1 if the first variable value is less than the second variable value otherwise 0. LT may also be used.

Operator: LESSEQUAL (2)

1 if the first variable value is less than or equal to the second variable value otherwise 0. LE may also be used.

Operator: EQUAL (2)

1 if the first variable value is equal to the second variable value otherwise 0. EQ may also be used.

Operator: NOTEQUAL (2)

1 if the first variable value is not equal to the second variable value otherwise 0. NE may also be used.

Operator: AND (2)

1 if the first variable value and second variable values are both not zero otherwise 0.

Operator: OR (2)

1 if the first variable value and second variable values are either not zero, otherwise 0 if both the first and second variable value are both zero.

Operator: NOT (2)

1 if the first variable value and only variable value is zero otherwise 0 if the first variable value is not zero.

Operator: FROM (Unlimited)

Indicates what variables a variable is dependant on (or derived from). No computation is performed. The algorithm that creates the automatic sequence of equations uses these to indicate when variables are dependant on other variables so that they can be sorted into the correct order.

Cost Estimating

In order to understand how to include cost estimates, it may be helpful to first define some terminology and provide an overview of the process used in EnergyPlus. There are three broad steps involved. The first involves determining *construction* costs by summing individual "line items." The second involves determining *project* costs by adjusting construction costs to account for things like profit and design fees. The third involves comparing the current simulation to a reference case so that marginal increases can be calculated. Each of these steps involves using one of the three 'ComponentCost' objects described below.

ComponentCost:LineItem

Each instance of this object creates a cost line item and will contribute to the total for a cost estimate. Each line item is reported in table form in the tabular report file. The user must request that this report be generated by including a Output:Table:SummaryReports object with the Component Cost Economics Summary option selected. The style of a tabular report can be controlled using the OutputControl:Table:Style object.

Cost estimates are not currently general in that they cannot be performed for every type of component that could be included in an EnergyPlus model. Although a "General" option is available where all information needed for the cost line item is input by the user, the usefulness of cost modeling within EnergyPlus is expected to be enhanced when quantities are obtained from elsewhere in the input file or computed during a simulation. The cost computations are programmed in selected ways for selected objects. The objects available and the type of cost modeling that may be performed are discussed in detail in the discussion of Reference Object Type field. A particular instance of this object will always have many blank fields. Entering values in too many fields may cause an error because the program may determine how a particular cost is to be calculated based on the presence of non-zero values in particular fields. The input object includes fields that are reserved for future use in expanded cost estimate and investment analyses planned for future versions of EnergyPlus. If you would like to request additional objects or different methods of modeling component costs, feel free to describe your needs and submit a request via email to energyplus-support@gard.com.

Field: Name

This field is a user-selected name that will appear in the line item description of the cost report. It is not used in the calculation but allows identifying a line item in the subsequent report.

Field: Type

This field is not yet used and may be left blank.

Field: Line Item Type

The cost estimate line item calculation will be controlled by the name entered in this field. The requirements for the remaining input, and the cost calculations performed, will vary depending on the object referenced here. Only selected objects can be entered here. The objects available for cost estimating are listed in the following table showing the active fields and options available for each.

Object Types available (choice keys)	Cost per each	Cost per m ²	Cost per kW	Cost per kW *CO P	Cost per m ³	Cost per m ³ /s	Cost per W/K	Qty	Wildcar d for Name
General	X							X	
Construction		X							
Coil:DX Coil:Cooling:DX:SingleSpe ed	X		X	X					X
Chiller:Electric	X		X	X					
Coil:Heating:Gas	X		X	X					X
Daylighting:Controls	X								X
Shading:Zone:Detailed		X							
Lights	X		X						
Generator:Photovoltaic			X						

General

This choice of object is used to calculate costs in a general way. No quantities from internal calculations are used. All information needed for the cost line item is input by the user. The Cost per Each and the Quantity fields that follow need to have values.

Construction

This choice of object type is used to calculate the costs associated with surfaces based on the type of Construction used for the surface. Costs are entered on a per-square-meter basis. The program finds all the surfaces that have the type of Construction named in the Reference

Object Name field that follows and determines the total area. If the model includes duplicate surfaces, as for interior partitions or floors, these will be detected and not double-counted. The cost per area should include all the material layers defined in the Construction.

Coil:DX or Coil:Cooling:DX:SingleSpeed

This choice of object type is used to calculate the cost of direct expansion cooling equipment. Cost can be entered in three different ways, (1) per each, (2) per kW total cooling capacity, or (3) per kW total cooling capacity per COP (coefficient of performance). The program will determine which method to use by examining which input fields have non-zero values. It is an error to specify costs in more than one way. The per-each approach is most useful for discrete packages. The per-kW approach is useful for autosizing DX coils with the same COP. The per-kW-per-COP approach is convenient for modeling autosized DX coils with differing COPs as long as a linear relationship is sufficient.

The wildcard character "*" may be used in the object name field that follows to allow a single line item to include all of the DX coils in the model.

Chiller:Electric

This choice of object type is used to calculate the cost of a central chiller. The object name entered in following field must correspond to a Chiller:Electric object name defined elsewhere in the input file. Cost can be entered in three different ways, (1) per each, (2) per kW total cooling capacity or (3) per kW total cooling capacity per COP (coefficient of performance). The program will determine which method to use by examining which input fields have non-zero values. It is an error to specify costs in more than one way. The per-each approach is most useful for discrete chillers. The per-kW approach is useful for autosizing chillers with the same COP. The per-kW-per-COP approach is convenient for modeling autosized chillers with differing COPs as long as a linear relationship is sufficient.

Coil:Heating:Gas

This choice of object type is used to calculate the cost of gas-fired heating equipment. Cost can be entered in three different ways, (1) per each, (2) per kW of heating capacity, or (3) per kW total cooling capacity per nominal efficiency (actually uses the per kW per COP field). The program will determine which method to use by examining which input fields have non-zero values. It is an error to specify costs in more than one way. The per-each approach is most useful for discrete packages. The per-kW approach is useful for autosizing heating coils with the same efficiency. The per-kW-per-Eff approach is convenient for modeling autosized heating coils with differing efficiencies as long as a linear relationship is sufficient.

The wildcard character "*" may be used in the object name field that follows to allow a single line item to include all of the gas heating coils in the model.

Daylighting:Controls

These choices of object type are used to include the cost of controllers needed to control electric lighting in response to daylight. The only option for entering costs is "per each". The wildcard character "*" may be used in the following object name field to allow a single line item to include all of the simple and detailed daylighting controls in the cost model.

Shading:Zone:Detailed

This choice of object type is used to calculate the costs associated with attached shading surfaces. Costs are entered on a per-square-meter basis. The cost calculations are similar to those for heat transfer surfaces but are handled separately because "Construction" is not defined for a shading surface. The object name entered in the following field must correspond to a Shading:Zone:Detailed object name defined elsewhere in the input file.

Lights

This choice of object is used to calculate the costs associated with electric lighting. Costs are entered on either a cost-per-each basis or as a cost-per-kilowatt-of-design-level. (This design level is an input in the Lights object.). The object name entered into the following field must match the name of a Zone object defined elsewhere in the input file.

Generator:Photovoltaic

This choice of object is used to calculate the costs associated with a photovoltaic system. Costs are entered on a cost-per-kilowatt-of-rated-capacity. The rated capacity of a photovoltaic generator is calculated for cost modeling by exposing the surface to a 1000 W/m² incident radiation using the area fraction and nominal fixed efficiency input by the user (from the Generator:Photovoltaic object). The object name entered into the following field must match the name of a Generator:Photovoltaic object defined elsewhere in the input file.

Field: Item Name

This field is used to refer to a specific instance of an object. The wildcard character "*" is acceptable for some objects as described above for the previous field.

Field: Object End Use Key

This field is not yet used and may be left blank.

Field: Cost per Each

This field is used to enter cost information on a per-each basis. The units are dollars (\$).

Field: Cost per Area

This field is used to enter cost information on a per-area basis. The units are dollars per square meter (\$/m²).

Field: Cost per Unit of Output Capacity

This field is used to enter cost information on a per-kilowatt basis. The units are dollars per kilowatt (\$/kW).

Field: Cost per Unit of Output Capacity per COP

This field is used to enter cost information on a per-kilowatt-per-COP basis. The units are dollars per kilowatt per non-dimensional COP (\$/kW-COP). Note that this field can be used for Coil:Heating:Gas cost modeling in which case the better terminology would be per-kilowatt-per-non-dimensional-efficiency.

Field: Cost per Volume

This field is not yet used but will be used to enter cost information on a per-cubic-meter basis. The units are dollars per cubic meter (\$/m³).

Field: Cost per Volume Rate

This field is not yet used but will be used to enter cost information on a per-cubic-meter-per-second basis. The units are dollars per cubic meter (\$/(m³/s)).

Field: Cost per Energy per Temperature Difference

This field is not yet used but will be used to enter cost information on a per-watt-per-Kelvin basis. These units will be used to represent a UA description of coils and the like. The units are dollars per watt per delta K (\$/(W/K)).

Field: Quantity

This field is used to directly enter the line item quantity. The units should correspond to what is used in the Per Each field.

Field: Annual Operation, Maintenance and Repair Cost

This field is not yet used but will be used to enter annually recurring costs as fraction of the line item cost. This field is defined for future use with life-cycle cost analysis.

Field: Recurring Minor Maintenance or Repair Cost

This field is not yet used but will be used to enter recurring minor maintenance and repair costs as fraction of the line item cost. This field is defined for future use with life-cycle cost analysis.

Field: Recurring Minor Maintenance or Repair Time Interval

This field is not yet used but will be used to enter an interval for recurring minor maintenance and repair costs in years. This field is defined for future use with life-cycle cost analysis.

Field: Recurring Major Maintenance or Repair Cost

This field is not yet used but will be used to enter recurring major maintenance and repair costs as fraction of the line item cost. This field is defined for future use with life-cycle cost analysis.

Field: Recurring Major Maintenance or Repair Time Interval

This field is not yet used but will be used to enter an interval for recurring major maintenance and repair costs in years. This field is defined for future use with life-cycle cost analysis.

Field: Expected Life

This field is not yet used but will be used to enter the expected life of the line item component in years. This field is defined for future use with life-cycle cost analysis.

Field: Residual Value at Replacement

This field is not yet used but will be used to enter the remaining value of the item at the end of its expected life. This field is defined for future use with life-cycle cost analysis.

The IDD specification:

```

ComponentCost:LineItem,
  A1 ,\field Name
      \type alpha
  A2 ,\field Type
      \type alpha
  A3 ,\field Line Item Type
      \required-field
      \type choice
      \key General
      \key Construction
      \key Coil:DX
      \key Coil:Cooling:DX:SingleSpeed
      \key Coil:Heating:Gas
      \key Chiller:Electric
      \key Daylighting:Controls
      \key Shading:Zone:Detailed
      \key Lights
      \key Generator:Photovoltaic
      \note extend choice-keys as Cases are added to code
  A4 ,\field Item Name
      \required-field
      \note wildcard "*" is acceptable for some components
  A5 ,\field Object End Use Key
      \type alpha
      \note not yet used
  N1 ,\field Cost per Each
      \type real
      \units $
  N2 ,\field Cost per Area
      \type real
      \units $/m2
  N3 ,\field Cost per Unit of Output Capacity
      \type real
      \units $/kW
  N4 ,\field Cost per Unit of Output Capacity per COP
      \type real
      \units $/kW
      \note The value is per change in COP.
  N5 ,\field Cost per Volume
      \type real
      \units $/m3
  N6 ,\field Cost per Volume Rate
      \type real
      \units $/(m3/s)
  N7 ,\field Cost per Energy per Temperature Difference
      \type real
      \units $/(W/K)
      \note as in for use with UA sizing of Coils
  N8 ,\field Quantity
      \type real
      \units dimensionless
      \note optional for use with Cost per Each and "General" object Type
  N9 ,\field Annual Operation, Maintenance and Repair Cost
      \type real
      \units $
      \note for future LCC
  N10 ,\field Recurring Minor Maintenance or Repair Cost
      \type real
      \units $
      \note for future LCC
  N11,\field Recurring Minor Maintenance or Repair Time Interval
      \type integer
      \units years
      \note for future LCC
  N12,\field Recurring Major Maintenance or Repair Cost
      \type real
      \units $
      \note for future LCC
  N13,\field Recurring Major Maintenance or Repair Time Interval
      \type integer
      \units years

```

```

\note for future LCC
N14,\field Expected Life
\type integer
\units years
\note for future LCC
N15 ;\field Residual Value at Replacement
\type real
\units $
\note for future LCC

```

Some examples of this object in an IDF:

```

ComponentCost:LineItem,
PSZ Equipment from scaling , !- Name
, !- Type
Coil:DX, !- Line Item Type
ACDXCoil ZN1 , !- Item Name
, !- Object End Use Key
, !- Cost per Each {$}
, !- Cost per Area {$/m2}
, !- Cost per Unit of Output Capacity {$/kW}
82.5, !- Cost per Unit of Output Capacity per COP {$/kW}
,,,,,,,,; !reserved for future
ComponentCost:LineItem,
Lighting Equip: ZN2_E_Space_1, ,
Lights,!- Line Item Type
ZN2_E_Space_1, ,
,!- Cost per Each {$}
,!- Cost per Area {$/m2}
3300.000,!- Cost per Unit of Output Capacity {$/kW}
,,,,,,,,; !- reserved for future

ComponentCost:LineItem, DL controls: ZN4_W_Space_1, ,
Daylighting:Detailed, !- Line Item Type
ZN4_W_Space_1, ,!- Item Name
125.000, !- Cost per Each {$}
,!- Cost per Area {$/m2}
,!- Cost per Unit of Output Capacity {$/kW}
,,,,,,,,; !- reserved for future

```

ComponentCost:Adjustments

This object can be used to perform various modifications to the construction costs to arrive at an estimate for total project costs. This object allows extending the line item model so that the overall costs of the project will reflect various profit and fees. Only one object of this type can be included in the input file. The results are included in the Construction Cost Estimate Summary table by request using the Output:Table:SummaryReports object with the Component Cost Economics Summary option selected.

Field: Miscellaneous Cost per Conditioned Area

This optional field can be used to enter a cost model for miscellaneous project costs that are not included in the line item modeling. Miscellaneous costs are entered in dollars per square meter of conditioned floor area. This field allows including the costs of project elements that go beyond what can be modeled using “ComponentCost:LineItem” input objects including such things as structural components, site preparation, finishes, etc. The value input in this field will be multiplied by the conditioned floor area and listed in the Construction Cost Estimate Summary table. The miscellaneous project costs are added to the line item model total to determine the “modeled and miscellaneous Construction costs” that will be multiplied by the fractions in the following five fields.

Field: Design and Engineering Fees

This optional field can be used to enter a fraction of modeled and miscellaneous construction costs that should be added to account for design and engineering fees. Note that is not the same as a fraction of the total cost estimate.

Field: Contractor Fee

This optional field can be used to enter a fraction of modeled and miscellaneous construction costs that should be added to account for Contractor fees. Note that is not the same as a fraction of the total cost estimate.

Field: Contingency

This optional field can be used to enter a fraction of modeled and miscellaneous construction costs that should be added for contingency. Note that is not the same as a fraction of the total cost estimate.

Field: Permits, Bonding and Insurance

This optional field can be used to enter a fraction of modeled and miscellaneous construction costs that should be added to account for permitting, bonding, and insurance costs to the project. Note that is not the same as a fraction of the total cost estimate.

Field: Commissioning Fee

This optional field can be used to enter a fraction of modeled and miscellaneous construction costs that should be added to account for commissioning services. Note that is not the same as a fraction of the total cost estimate.

Field: Regional Adjustment Factor

This optional field can be used to enter an adjustment factor to account for regional differences in construction costs. The factor will be applied to the modeled and miscellaneous construction costs to determine an amount that should be added, or subtracted, to account for local variations in construction costs. The default factor is 1.0. The additive adjustment is calculated by subtracting 1.0 from the value entered in this field. This field is useful for using national average data in the line item and miscellaneous construction cost models and then altering the results based on regional differences.

The IDD specification:


```

ComponentCost:Adjustments,
  N1 ,\field Miscellaneous Cost per Conditioned Area
      \type real
      \note based on conditioned floor area
      \note for cost not accounted for in current line item cost model
      \units $/m2
  N2 ,\field Design and Engineering Fees
      \type real
      \units dimensionless
  N3 ,\field Contractor Fee
      \type real
      \units dimensionless
  N4 ,\field Contingency
      \type real
      \units dimensionless
  N5 ,\field Permits, Bonding and Insurance
      \type real
      \units dimensionless
  N6 ,\field Commissioning Fee
      \type real
      \units dimensionless
  N7 ;\field Regional Adjustment Factor
      \type real
      \units dimensionless
      \note for use with average data in line item and Misc cost models

```

An example of this object in an IDF is:

```

ComponentCost:Adjustments,
  467, !- Miscellaneous Cost per Conditioned Area
  0.07, !- Design and Engineering Fees
  0.07, !- Contractor Fee
  0.10, !- Contingency
  0.04, !- Permits, Bonding and Insurance
  0.015, !- Commissioning Fee
  1.136; !- Regional Adjustment Factor

```

ComponentCost:Reference

This object can be used to allow comparing the current cost estimate to the results of a previous estimate for a reference building. This object parallels the ComponentCost:Reference object but adds a field for entering the cost line item model result for the reference building. All the various adjustments to the project cost estimate are available here to allow using factors that differ between the current and the reference building models. The factors entered in the field associated with this object are applied to the reference building while the factors listed in the ComponentCost:Reference object are applied to the current building model cost estimate. Only one object of this type can be included in the input file. The results are included in the Construction Cost Estimate Summary table by request using the Output:Table:SummaryReports object with the Component Cost Economics Summary option selected.

Field: Reference Building Line Item Costs

This field is used to enter a dollar amount representing the total for the reference building that the user would like to compare to the line item cost model for the current building model. A typical source of data for this would be the "Line Item Subtotal" from a previous EnergyPlus simulation.

Field: Reference Building Miscellaneous Cost per Conditioned Area

This optional field can be used to enter a cost model for miscellaneous project costs that are not included in the line item modeling. Miscellaneous costs are entered in dollars per square meter of conditioned floor area. This field allows including the costs of project elements that

go beyond what can be modeled using “ComponentCost:LineItem” input objects including such things as structural components, site preparation, finishes, etc. The value input in this field will be multiplied by the conditioned floor area and listed in the Construction Cost Estimate Summary table. The miscellaneous project costs are added to the reference building line item subtotal to determine the “modeled and miscellaneous construction costs” that will be multiplied by the fractions in the following five fields.

Field: Reference Building Design and Engineering Fees

This optional field can be used to enter a fraction of modeled and miscellaneous construction costs that should be added to account for design and engineering fees. Note that is not the same as a fraction of the total cost estimate.

Field: Reference Building Contractor Fee

This optional field can be used to enter a fraction of modeled and miscellaneous construction costs that should be added to account for Contractor fees. Note that is not the same as a fraction of the total cost estimate.

Field: Reference Building Contingency

This optional field can be used to enter a fraction of modeled and miscellaneous construction costs that should be added for contingency. Note that is not the same as a fraction of the total cost estimate.

Field: Reference Building Permits, Bonding and Insurance

This optional field can be used to enter a fraction of modeled and miscellaneous construction costs that should be added to account for permitting, bonding, and insurance costs to the project. Note that is not the same as a fraction of the total cost estimate.

Field: Reference Building Commissioning Fee

This optional field can be used to enter a fraction of modeled and miscellaneous construction costs that should be added to account for commissioning services. Note that is not the same as a fraction of the total cost estimate.

Field: Reference Building Regional Adjustment Factor

This optional field can be used to enter an adjustment factor to account for regional differences in construction costs. The factor will be applied to the modeled and miscellaneous construction costs to determine an amount that should be added, or subtracted, to account for local variations in construction costs. The default factor is 1.0. The additive adjustment is calculated by subtracting 1.0 from the value entered in this field. This field is useful for using national average data in the line item and miscellaneous construction cost models and then altering the results based on regional differences.

The IDD specification:

```

ComponentCost:Reference,
  N1 ,\field Reference Building Line Item Costs
      \type real
      \units $
      \note should be comparable to the components in current line item cost model
  N2 ,\field Reference Building Miscellaneous Cost per Conditioned Area
      \type real
      \units $/m2
      \note based on conditioned floor area
      \note for cost not accounted for in reference line item costs
  N3 ,\field Reference Building Design and Engineering Fees
      \type real
      \units dimensionless
  N4 ,\field Reference Building Contractor Fee
      \type real
      \units dimensionless
  N5 ,\field Reference Building Contingency
      \type real
  N6 ,\field Reference Building Permits, Bonding and Insurance
      \type real
      \units dimensionless
  N7 ,\field Reference Building Commissioning Fee
      \type real
      \units dimensionless
  N8 ;\field Reference Building Regional Adjustment Factor
      \type real
      \units dimensionless
      \note for use with average data in line item and Misc cost models

```

An example of this object in an IDF is:

```

ComponentCost:Reference,
  683060.000, !- Reference Building Line Item Costs {$}
  467.0, !- Reference Building Miscellaneous Cost per Conditioned Area {$/m2}
  0.060, !- Reference Building Design and Engineering Fees {dimensionless}
  0.070, !- Reference Building Contractor Fee {dimensionless}
  0.100, !- Reference Building Contingency
  0.04, !- Reference Building Permits, Bonding and Insurance {dimensionless}
  0.0075, !- Reference Building Commissioning Fee {dimensionless}
  1.136; !- Reference Building Regional Adjustment Factor {dimensionless}

```

Economics Cost Estimate Reporting

Cost estimate results are only output to tabular reports; they are not available in the standard output file (.eso). The results are included in the Construction Cost Estimate Summary table by request using the object Output:Table:SummaryReports object with the Component Cost Economics Summary option selected. The figure below shows an example of summary output using html style for tabular reporting. A second table is produced that provides the line item details with one line for every line item object. Per-area cost modeling and cost normalization are based on total conditioned floor area which is also provided in the tabular report.

Construction Cost Estimate Summary

	Reference Bldg.	Current Bldg. Model	Difference
Line Item SubTotal (\$)	665082.04	718282.97	53200.93
Misc. Costs (\$)	928979.09	928979.09	0.00
Regional Adjustment (\$)	216792.31	224027.64	7235.33
Design Fee (\$)	95643.67	131780.97	36137.30
Contractor Fee (\$)	111584.28	115308.34	3724.07
Contingency (\$)	159406.11	164726.21	5320.09
Permits, Bonds, Insurance (\$)	0.00	0.00	0.00
Commissioning (\$)	7970.31	16472.62	8502.31
Cost Estimate Total (\$)	2185457.81	2299577.84	114120.03
Cost Per Conditioned Building Area (\$/m ²)	1176.27	1237.69	61.42

Difference = Current value - Reference Value

Reference Case information input by user (typ. from previous model)

Current information calculated for model

Sub total of line items

Construction Cost = sum of three terms

Adjustment fractions applied to Construction Cost

Project Cost = sum of eight terms

Normalized Project Cost = Project Cost divided by conditioned floor area

Figure 133. Economics Cost Modeling

“Line Item Subtotal” is the sum of items explicitly modeled in the cost estimate. For the reference building, this value is input by the user. For the current building, this value is the sum of line items which are detailed in Cost Line Item Details table that follows.

“Misc. Cost” is the product of the user-defined Miscellaneous Cost Model (per Square Meter) and the conditioned floor area.

“Regional Adjustment” is the produce of the user-defined Regional Adjustment Factor and the conditioned floor area.

“Design Fee” is the product of the user-defined Design and Engineering Fee Fraction and the subtotal for construction costs (which includes the Line Item Subtotal, Misc. Cost, and Regional Adjustment).

“Contractor Fee” is the product of the user-defined Contractor Fee Fraction and the subtotal for construction costs (which includes the Line Item Subtotal, Misc. Cost, and Regional Adjustment).

“Contingency” is the product of the user-defined Contingency Fraction and the subtotal for construction costs (which includes the Line Item Subtotal, Misc. Cost, and Regional Adjustment).

“Permits, Bonds, and Insurance” is the product of the Permits, Bonding, Insurance Fraction and the subtotal for construction costs (which includes the Line Item Subtotal, Misc. Cost, and Regional Adjustment).

“Commissioning” is the product of the user-defined Commissioning Fee Fraction and the subtotal for construction costs (which includes the Line Item Subtotal, Misc. Cost, and Regional Adjustment).

“Cost Estimate Total” is the sum of eight items above and represents the total project cost estimate.

“Cost per Conditioned Building Area” is the Cost Estimate Total divided by the total conditioned floor area. This represents a normalized cost intensity.

CurrencyType

By default, the predefined reports related to economics use the \$ symbol. If a different symbol should be shown in the predefined reports to represent the local currency this object can be used. If the object is not used, the \$ sign is used in the reports. Only one CurrencyType object is allowed in the input file.

Field: Monetary Unit

The commonly used three letter currency code for the units of money for the country or region. Based on ISO 4217 currency codes. Common currency codes are USD for the U.S. Dollar represented with ‘\$’ and EUR for Euros represented with ‘€’. The three letter currency codes can be seen at the following web sites (as of 2008):

http://www.iso.org/iso/support/faqs/faqs_widely_used_standards/widely_used_standards_other/currency_codes/currency_codes_list-1.htm

<http://www.xe.com/symbols.php>

When a three letter currency code is specified, the HTML file will use either an ASCII character if available or one or more UNICODE characters. Since not all browsers and all fonts used by browsers completely support UNICODE, not all currency symbols may be rendered correctly. If a box or a box with four small letters appears, this indicates that the browser and its fonts do not support a specific UNICODE character.

For text reports, an ASCII representation of the currency code will be used. Since ASCII is much more limited than UNICODE, many times the three letter currency code will be shown in the reports.

Since forms of currency change, please contact EnergyPlus support if a new currency code and symbol are needed.

The IDD:

```
CurrencyType,
  \memo If CurrencyType is not specified, it will default to USD and produce $ in the reports.
  \unique-object
Al;  \field Monetary Unit
     \required-field
     \note The commonly used three letter currency code for the units of money for the country or
region.
     \note Based on ISO 4217 currency codes.  Common currency codes are USD for $ and EUR for Euros.
     \type choice
     \key USD
     \key AFN
     \key ALL
     \key ANG
     \key ARS
     \key AUD
     \key AWG
     \key AZN
     \key BAM
     \key BBD
     \key BGN
     \key BMD
     \key BND
     \key BOB
     \key BRL
     \key BSD
     \key BWP
     \key BYR
     \key BZD
     \key CAD
     \key CHF
     \key CLP
     \key CNY
     \key COP
     \key CRC
     \key CUP
     \key CZK
     \key DKK
     \key DOP
     \key EEK
     \key EGP
     \key EUR
     \key FJD
     \key GBP
     \key GHC
     \key GIP
     \key GTQ
     \key GYD
     \key HKD
     \key HNL
     \key HRK
     \key HUF
     \key IDR
     \key ILS
     \key IMP
     \key INR
     \key IRR
     \key ISK
     \key JEP
     \key JMD
     \key JPY
     \key KGS
     \key KHR
     \key KPW
     \key KRW
     \key KYD
     \key KZT
     \key LAK
     \key LBP
     \key LKR
     \key LRD
     \key LTL
```

```
\key LVL  
\key MKD  
\key MNT  
\key MUR  
\key MXN  
\key MYR  
\key MZN  
\key NAD  
\key NGN  
\key NIO  
\key NOK  
\key NPR  
\key NZD  
\key OMR  
\key PAB  
\key PEN  
\key PHP  
\key PKR  
\key PLN  
\key PYG  
\key QAR  
\key RON  
\key RSD  
\key RUB  
\key SAR  
\key SBD  
\key SCR  
\key SEK  
\key SGD  
\key SHP  
\key SOS  
\key SRD  
\key SVC  
\key SYP  
\key THB  
\key TRL  
\key TRY  
\key TTD  
\key TVD  
\key TWD  
\key UAH  
\key UYU  
\key UZS  
\key VEF  
\key VND  
\key XCD  
\key YER  
\key ZAR  
\key ZWD
```

Input for Output

Several items are used to specify what will appear in the output file(s). The output is described in the next section of this document.

Group – Reports

Variable Dictionary Reports

One of the most important outputs for EnergyPlus is the Variable Dictionary reports – these contain the key variable names for each simulation. This single input object is used to produce two important reports that are used to identify the specific report variables and meters available for a specific EnergyPlus model. Two output files are produced (**eplusout.rdd** & **eplusout.mdd**) that list the names of the report variables and meters for that simulation. You may need to run your simulation once and produce these files before you ask for specific output variables (**rdd**) or meters (**mdd**) (see Output:Variable and Output:Meter). Variables available, to some extent, depend on the simulation input. Variables are “set up” during the initial “get input” processing done within the modules. Therefore, an item that is specific to a certain type of coil would not be available if that coil were not used during the simulation. This command will produce a list of variables available for reporting.

In addition to the variable names, the reports provide information on the frequency and nature of the variables. “**Zone**” variables are calculated and can be reported after each Zone/Heat Balance timestep (ref: Timesteps input object). “**HVAC**” variables are calculated and can be reported with each variable HVAC timestep. “Average” variables will be averaged over the time interval being reported whereas “Sum” variables are summed over that time interval. The units of the variable are given in “[].”

In addition, the reports can be produced as IDF excerpts and also sorted by name.

An example input object for this report follows.

```
Output:VariableDictionary, regular;
```

An example of the results:


```

Program Version,EnergyPlus <version number>, <date of run>,IDD_Version <IDD Version>
Var Type (reported timestep),Var Report Type,Variable Name [Units]
Zone,Average,Outdoor Dry Bulb [C]
Zone,Average,Outdoor Dew Point [C]
Zone,Average,Outdoor Wet Bulb [C]
Zone,Average,Outdoor Humidity Ratio [kgWater/kgAir]
Zone,Average,Outdoor Relative Humidity [%]
Zone,Average,Outdoor Barometric Pressure [Pa]
Zone,Average,Wind Speed [m/s]
Zone,Average,Wind Direction [deg]
Zone,Average,Sky Temperature [C]
Zone,Average,Diffuse Solar [W/m2]
Zone,Average,Direct Solar [W/m2]
Zone,Average,Ground Reflected Solar [W/m2]
Zone,Average,Ground Temperature [C]
Zone,Average,Surface Ground Temperature [C]
Zone,Average,Deep Ground Temperature [C]
Zone,Average,Outdoor Enthalpy [J/kg]
Zone,Average,Outdoor Air Density [kg/m3]
Zone,Average,Solar Azimuth Angle [deg]
Zone,Average,Solar Altitude Angle [deg]
Zone,Average,Solar Hour Angle [deg]
Zone,Average,Fraction of Time Raining[]
Zone,Average,Fraction of Time Snow On Ground[]
Zone,Average,Exterior Horizontal Illuminance From Sky [lux]
Zone,Average,Exterior Horizontal Beam Illuminance [lux]
Zone,Average,Exterior Beam Normal Illuminance [lux]
<reduced>

```

```

Zone,Average,Window Transmitted Solar[W]
Zone,Average,Window Transmitted Beam Solar[W]
Zone,Average,Window Transmitted Diffuse Solar[W]
Zone,Average,Window Heat Gain[W]
Zone,Average,Window Heat Loss[W]
Zone,Average,Window Gap Convective Heat Flow[W]
Zone,Average,Window Solar Absorbed:Shading Device[W]
<reduced>

```

```

HVAC,Average,System Node Temp[C]
HVAC,Average,System Node MassFlowRate[kg/s]
HVAC,Average,System Node Humidity Ratio[]
HVAC,Average,System Node Setpoint Temp[C]
HVAC,Average,System Node Setpoint Temp Hi[C]
HVAC,Average,System Node Setpoint Temp Lo[C]
HVAC,Average,System Node Setpoint Humidity Ratio[]
HVAC,Average,System Node Humidity Ratio Min[]
HVAC,Average,System Node Humidity Ratio Max[]
HVAC,Average,System Node VolFlowRate[m3/s]
HVAC,Average,System Node Enthalpy[J/kg]
HVAC,Average,System Node Wetbulb Temp[C]
<reduced>

```

```

HVAC,Sum,Zone Mechanical Ventilation No Load Heat Removal [J]
HVAC,Sum,Zone Mechanical Ventilation Cooling Load Increase [J]
HVAC,Sum,Zone Mech Ventilation Cooling Load Increase: OverHeating [J]
HVAC,Sum,Zone Mechanical Ventilation Cooling Load Decrease [J]
HVAC,Sum,Zone Mechanical Ventilation No Load Heat Addition [J]
HVAC,Sum,Zone Mechanical Ventilation Heating Load Increase [J]
HVAC,Sum,Zone Mech Ventilation Heating Load Increase: OverCooling[J]
HVAC,Sum,Zone Mechanical Ventilation Heating Load Decrease [J]
HVAC,Average,Zone Mechanical Ventilation Mass Flow Rate [kg/s]
HVAC,Average,Zone Mechanical Ventilation Volume Flow Rate [m3/s]
HVAC,Sum,Zone Mechanical Ventilation Total Volume of Outside Air [m3]
HVAC,Sum,Zone Mechanical Ventilation Total Mass of Outside Air [kg]
HVAC,Average,Zone Mechanical Ventilation Air Change Rate [ach]

```

The eplusout.mdd file has a similar format for meters:

```
Program Version,EnergyPlus <version>, <date time of run>,IDD_Version <IDD Version>
Var Type (reported timestep),Var Report Type,Variable Name [Units]
Zone,Meter,Electricity:Facility [J]
Zone,Meter,Electricity:Building [J]
Zone,Meter,Electricity:Zone:SOUTHZONE_1STFLOOR [J]
Zone,Meter,InteriorLights:Electricity [J]
Zone,Meter,InteriorLights:Electricity:Zone:SOUTHZONE_1STFLOOR [J]
Zone,Meter,GeneralLights:InteriorLights:Electricity [J]
<reduced>
```

Variable Dictionary Report in IDF Format

The common workflow process of examining Variable Dictionary Reports and then adding reporting requests to an IDF file can be facilitated by using the following alternate form (Report Name = IDF) of the input object that requests the reports.

```
Output:VariableDictionary, IDF;
```

This report produces the variable names in a form that are ready to be merged into an input file. By design, hourly reporting is selected – replace this with your desired frequency. An example of the results, first the eplusout.rdd:

```
! Program Version,EnergyPlus <version>, <date time of run>,IDD_Version <IDD Version>
! Report Variable Objects (applicable to this run)
Report Variable,*,Outdoor Dry Bulb,hourly; !- Zone Average [C]
Report Variable,*,Outdoor Dew Point,hourly; !- Zone Average [C]
Report Variable,*,Outdoor Wet Bulb,hourly; !- Zone Average [C]
Report Variable,*,Outdoor Humidity Ratio,hourly; !- Zone Average [kgWater/kgAir]
Report Variable,*,Outdoor Relative Humidity,hourly; !- Zone Average [%]
Report Variable,*,Outdoor Barometric Pressure,hourly; !- Zone Average [Pa]
Report Variable,*,Wind Speed,hourly; !- Zone Average [m/s]
<reduced>
```

Then, eplusout.mdd (includes reporting for cumulative meters as well as normal reporting):

```
! Program Version,EnergyPlus <version>, <date time of run>,IDD_Version <IDD Version>
! Report Meter Objects (applicable to this run)
Report Meter,Electricity:Facility,hourly; !- [J]
Report Cumulative Meter,Electricity:Facility,hourly; !- [J]
Report Meter,Electricity:Building,hourly; !- [J]
Report Cumulative Meter,Electricity:Building,hourly; !- [J]
Report Meter,Electricity:Zone:SOUTHZONE_1STFLOOR,hourly; !- [J]
Report Cumulative Meter,Electricity:Zone:SOUTHZONE_1STFLOOR,hourly; !- [J]
Report Meter,InteriorLights:Electricity,hourly; !- [J]
Report Cumulative Meter,InteriorLights:Electricity,hourly; !- [J]
<reduced>
```

A sorted list would appear similarly:

```
Program Version,EnergyPlus <version number>, <date of run>,IDD_Version <IDD Version>
Var Type (reported timestep),Var Report Type,Variable Name [Units]
Zone,Average,Deep Ground Temperature [C]
Zone,Average,Diffuse Solar [W/m2]
Zone,Average,Direct Solar [W/m2]
Zone,Average,Exterior Beam Normal Illuminance [lux]
Zone,Average,Exterior Horizontal Beam Illuminance [lux]
Zone,Average,Exterior Horizontal Illuminance From Sky [lux]
Zone,Average,Fraction of Time Raining[]
Zone,Average,Fraction of Time Snow On Ground[]
Zone,Average,Ground Reflected Solar [W/m2]
Zone,Average,Ground Temperature [C]
```

```

Zone,Average,Outdoor Air Density [kg/m3]
Zone,Average,Outdoor Barometric Pressure [Pa]
Zone,Average,Outdoor Dew Point [C]
Zone,Average,Outdoor Dry Bulb [C]
Zone,Average,Outdoor Enthalpy [J/kg]
Zone,Average,Outdoor Humidity Ratio [kgWater/kgAir]
Zone,Average,Outdoor Relative Humidity [%]
Zone,Average,Outdoor Wet Bulb [C]
Zone,Average,Skylight Temperature [C]
Zone,Average,Solar Altitude Angle [deg]
Zone,Average,Solar Azimuth Angle [deg]
Zone,Average,Solar Hour Angle [deg]
Zone,Average,Surface Ground Temperature [C]
Zone,Average,Wind Direction [deg]
Zone,Average,Wind Speed [m/s]

```

The IDD for the object:

```

Output:VariableDictionary,
  A1, \field Key Field
  \required-field
  \type choice
  \key IDF
  \key regular
  A2; \field Sort Option
  \type choice
  \key Name
  \key Unsorted

```

Surface Reports

There are two specific objects for surfaces: Output:Surfaces:List and Output:Surfaces:Drawing – as the names imply, the list reports are simple text reports that are contained in one of the output files whereas the drawing reports will create files that are used in other graphic tools.

Information on surfaces in the EnergyPlus model can be reported in several ways:

Output:Surfaces:List

Lines Data Report

An example input object for this report follows.

```
Output:Surfaces:List, Lines;
```

The above IDF line will produce a simple file of line segments that constitute the surfaces in the IDF file. More specifics on this report can be found in the Output Details and Examples document.

The following shows an excerpt of “lines” report (**eplusout.sln**) for a single surface. It gives the coordinates in the “standard” EnergyPlus fashion (that is, UpperLeftCorner first and proceeding around, in this case, the four vertices in the surface).

```

0.00, 0.00, 4.57, 0.00, 0.00, 0.00
0.00, 0.00, 0.00, 15.24, 0.00, 0.00
15.24, 0.00, 0.00, 15.24, 0.00, 4.57
15.24, 0.00, 4.57, 0.00, 0.00, 4.57

```

Field: Report Specifications

An extra option of entering “IDF” in this field directs the Lines report to produce coordinates transformed into Surface Geometry (Lower Left Corner, CounterClockwise, WorldCoordinates). An example of this follows.

```
Output:Surfaces:List, Lines, IDF;
```

The result is put on the **eplusout.sln** file and is nearly ready for putting into a IDF:

```

Building North Axis = 0
GlobalGeometryRules,UpperLeftCorner,CounterClockwise,WorldCoordinates;
Surface=SHADING, Name=ROOMSOUTH SURF6-VFIN1-6
  4, !- Number of (X,Y,Z) groups in this surface
    -23.34,   -14.85,    2.41,  !- X,Y,Z ==> Vertex 1
    -23.34,   -14.76,    2.49,  !- X,Y,Z ==> Vertex 2
    -18.13,   -14.76,    2.49,  !- X,Y,Z ==> Vertex 3
    -18.13,   -14.85,    2.41;  !- X,Y,Z ==> Vertex 4
Surface=WALL, Name=ROOMNORTH SURF3-1
  4, !- Number of (X,Y,Z) groups in this surface
    -15.94,   -5.34,    3.00,  !- X,Y,Z ==> Vertex 1
    -15.94,   -5.34,    0.00,  !- X,Y,Z ==> Vertex 2
    -18.91,   -5.34,    0.00,  !- X,Y,Z ==> Vertex 3
    -18.91,   -5.34,    3.00;  !- X,Y,Z ==> Vertex 4
Surface=WALL, Name=ROOMNORTH SURF4-1
  4, !- Number of (X,Y,Z) groups in this surface
    -18.91,   -5.34,    3.00,  !- X,Y,Z ==> Vertex 1
    -18.91,   -5.34,    0.00,  !- X,Y,Z ==> Vertex 2
    -22.65,   -5.34,    0.00,  !- X,Y,Z ==> Vertex 3
    -22.65,   -5.34,    3.00;  !- X,Y,Z ==> Vertex 4
Surface=WINDOW, Name=ROOMNORTH SURF5-1-NOSHADE
  4, !- Number of (X,Y,Z) groups in this surface
    -19.02,   -5.34,    2.59,  !- X,Y,Z ==> Vertex 1
    -19.02,   -5.34,    0.41,  !- X,Y,Z ==> Vertex 2
    -22.54,   -5.34,    0.41,  !- X,Y,Z ==> Vertex 3
    -22.54,   -5.34,    2.59;  !- X,Y,Z ==> Vertex 4

```

Detailed Surface Data Report

An example input object for this report follows.

```
Output:Surfaces:List, Details;
```

This report (in **eplusout.eio**) contains details about each surface – including surface name, associated zone, area, approximate height and width, tilt, outward facing angle. Specific details on this report can be found in the Output Details and Examples document.

Vertices Data Report

An example input object for this report follows.

```
Output:Surfaces:List, Vertices;
```

This report (in **eplusout.eio**) contains the vertices of each surface along with surface name and other information. Specific details on this report can be found in the Output Details and Examples document.

Detailed Surface Data With Vertices Report

An example input object for this report follows.

```
Output:Surfaces:List, DetailsWithVertices;
```

This report (in **eplusout.eio**) is the combination of the two preceding reports (Details and Vertices). Specific details on this report can be found in the Output Details and Examples document.

View Factor Information Report

An example input object for this report follows.

```
Output:Surfaces:List, ViewFactorInfo;
```

This report (in **eplusout.eio**) provides details about the thermal radiation exchange view factors and interchange factors. Specific details on this report can be found in the Output Details and Examples document.

These data reports are illustrated by the following IDD reference:

```

Output:Surfaces:List,
  A1, \field Report Type
  \required-field
  \type choice
  \key Details
  \key Vertices
  \key DetailsWithVertices
  \key ViewFactorInfo
  \key Lines
A2; Report Specifications
  \note (IDF, only for Surfaces, Lines report -- will print transformed coordinates in IDF style)
  \type choice
  \key IDF

```

Output:Surfaces:Drawing

DXF Surface Report

Examples input objects follow.

```

Output:Surfaces:Drawing, DXF;
Output:Surfaces:Drawing, DXF, RegularPolyline;
Output:Surfaces:Drawing, DXF, Triangulate3DFace, mycolorscheme;

```

The above IDF specification will produce a DXF file (**eplusout.dxf**) of the surfaces in the IDF file. Only one DXF report can be produced. More specifics on this report can be found in the Output Details and Examples document.

Field: Report Specifications 1

As indicated in the example and in the IDD excerpt, you can select among three different ways that surfaces with more than four sides will appear in the DXF file. These are:

- ThickPolyline – surface with >4 sides will be represented as a “thick” line in the appropriate surface color. It will look like a hole in the drawing with a thicker edge.
- RegularPolyline – surface with >4 sides will be represented as a regular line in the appropriate surface color. It will look like a hole in the drawing.
- Triangulate3DFace– surface with >4 sides will be “triangulated” internally within EnergyPlus. This is only for drawing purposes and does not affect the calculations in any way. In a line version of the DXF, it will appear that the surface is split into triangles. In a solid view, the surface will appear similar to surfaces with <=4 sides. The triangulation algorithm is not perfect and warnings do result when the software cannot triangulate the surface.

Field: Report Specifications 2

This field can be used to control the color scheme in the DXF file by entering the name of an OutputControl:SurfaceColorScheme object. Using OutputControl:SurfaceColorScheme, you can define color schemes for surface representation. This feature will let you align the colors with the software of your choice (colors don’t seem to be standard across DXF viewers).

Several software programs can render this file into something viewable. For example:

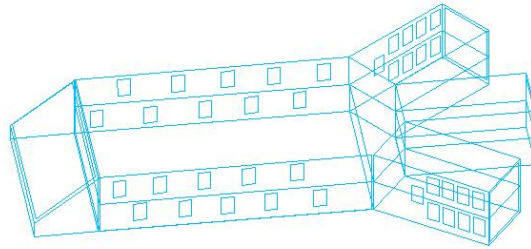


Figure 134. Example building from DXF report.

DXF Wire Frame Report

An example input object for this report follows.

```
Output:Surfaces:Drawing, DXF:WireFrame;
```

The above IDF specification will produce a DXF (Drawing Exchange Format) file (**eplusout.dxf**) of the surfaces in the IDF file using the DXF “Lines” command – producing only a wire frame capable file. More specifics on this report can be found in the Output Details and Examples document. Only one DXF report can be produced.

VRML Report

Examples input objects for this report follow.

```
Output:Surfaces:Drawing, VRML;
Output:Surfaces:Drawing, VRML, Triangulate3DFace;
```

The above IDF specification produces a VRML (Virtual Reality Modeling Language) file (**eplusout.wrl**) of the surfaces in the IDF file. Only one VRML report can be produced. VRML files can be viewed in many web browsers after adding a “plug-in” and there are some stand-alone viewers as well. More specifics on this report can be found in the Output Details and Examples document.

Field: Report Specifications 1

As indicated in the example and in the IDD excerpt, you can select several figure types (for >4 sided surfaces) in the DXF report. These are:

- ThickPolyline – surface with >4 sides will be represented as a “thick” line in the appropriate surface color. It will look like a hole in the drawing with a thicker edge.
- RegularPolyline – surface with >4 sides will be represented as a regular line in the appropriate surface color. It will look like a hole in the drawing.
- Triangulate3DFace – surface with >4 sides will be “triangulated” internally within EnergyPlus. This is only for drawing purposes and does not affect the calculations in any way. In a line version of the VRML, it will appear that the surface is split into triangles. In a solid view, the surface will appear similar to surfaces with <=4 sides. The triangulation algorithm is not perfect and warnings do result when the software cannot triangulate the surface.

Field: Report Specifications 2

Color schemes are not applicable for VRML reports.

The drawing reports are illustrated by the following IDD reference:

```

Output:Surfaces:Drawing,
  A1, \field Report Type
  \required-field
  \type choice
  \key DXF
  \key DXF:WireFrame
  \key VRML
  A2, \field Report Specifications 1
  \type choice
  \key Triangulate3DFace
  \key ThickPolyline
  \key RegularPolyline
  \key Lines
  \key Polylines
  A3 ; \field Report Specifications 2
      \note Use ColorScheme Name for DXF reports
      \object-list ColorSchemes

```

Output:Schedules

This is a condensed reporting that illustrates the full range of schedule values – in the style of input: DaySchedule, WeekSchedule, and Annual Schedule.

Field: Key Field

This field should contain the word **Hourly** or **TimeStep** to obtain the respective reports.

```

Output:Schedules, Hourly; ! values on hourly increments (day schedule resolution)
Output:Schedules, TimeStep; ! will give them at the timestep of the simulation

```

This report is placed on the eplusout.eio file. Details of this reporting are shown in the Output Details and Examples document. Schedule values over time can also be obtained in the EnergyPlus Standard Output (in eplusout.eso) using Output:Variable objects.

The IDD for the object is:

```

Output:Schedules,
  A1; \field Key Field
  \required-field
  \type choice
  \key Hourly
  \key Timestep

```

Output:Constructions

Constructions Report

This report content is added to the “eplusout.eio” file. It shows the calculated results related to conduction transfer functions for each construction. It also includes similar details about the windows. Specific details on this report can be found in the Output Details and Examples document. The following input object is used to obtain the Construction report.

```

Output:Constructions,Construction;

```

Field: Details Type 1, Details Type 2

Either field can contain the word “**Constructions**” to get the constructions report.

Or either field can contain the word “**Materials**” to obtain the Materials report.

Materials Report

This report content is added to the “eplusout.eio” file. It provides a summary of the thermal properties and thickness of the construction and window materials in the model. Specific details on this report can be found in the Output Details and Examples document. The following input object is used to obtain the Materials report.

```

Output:Reports,Materials;

```

The IDD for the object:

```

Output:Constructions,
  A1, \field Details Type 1
      \type choice
      \key Constructions
      \key Materials
  A2; \field Details Type 2
      \type choice
      \key Constructions
      \key Materials

```

OutputControl:SurfaceColorScheme

This object provides control over the colors that appear in the DXF report, by surface. In addition, the Datasets folder contains example objects, including the “original” color scheme (prior to the 2.1 release).

```

OutputControl:SurfaceColorScheme,
  \memo This object is used to set colors for reporting on various building elements particularly for the
  \memo DXF reports. We know the user can enter 0 to 255 and the color map is available in DXF output
  \memo as well as Google Sketchup. Therefore, we are limiting the colors in that range. You can
  \memo extend by editing the IDD but you do so on your own. Colors not changed in any scheme will
  \memo remain as the default scheme uses.
  A1, \field Name
      \required-field
      \note choose a name or use one of the DataSets
      \reference ColorSchemes
  A2, \field Drawing Element 1 Type
      \type choice
      \key Text
      \key Walls
      \key Windows
      \key GlassDoors
      \key Doors
      \key Roofs
      \key Floors
      \key DetachedBuildingShades
      \key DetachedFixedShades
      \key AttachedBuildingShades
      \key Photovoltaics
      \key TubularDaylightDomes
      \key TubularDaylightDiffusers
      \key DaylightReferencePoint1
      \key DaylightReferencePoint2
  N1, \field Color for Drawing Element 1
      \note use color number for output assignment (e.g. DXF)
      \type integer
      \minimum 0
      \maximum 255

  N15; \field Color for Drawing Element 15
      \note use color number for output assignment (e.g. DXF)
      \type integer
      \minimum 0
      \maximum 255

```

Field: Name

This assigns a unique name to this colorscheme data set. This name is used in the DXF output objects.

Field Set: Drawing Element Type and Color

This set of fields can range from none (accepting the default colors) up to 15 sets with individual types of building elements assigned a color number. (drawing element types not assigned a color number will use the default color numbers)

Field: Drawing Element <#> Type

This field uses a choice of the drawing types (Text, Walls, Windows, GlassDoors, Doors, Roofs, Floors, DetachedBuildingShades, DetachedFixedShades, AttachedBuildingShades, Photovoltaics, TubularDaylightDomes, TubularDaylightDiffusers, DaylightReferencePoint1, DaylightReferencePoint2) for the color number assignment in the following field.

Field: Color for Drawing Element <#>

This is a color “number” from 0 to 255. DXF display software is not standardized – you may need to play around with these numbers if you don’t like the supplied default color scheme.

Output:Variable

This input object is used request results reporting. As shown above in the Variable Dictionary Report section, there are many different output variables available for reporting results from EnergyPlus. The Output:Variable object is primarily used for reporting time series data at various frequencys.

```
Output:Variable,
  \memo each Report Variable command picks variables to be put onto the standard output file (.eso)
  \memo some variables may not be reported for every simulation
  \format singleLine
A1 , \field Key Value
  \default *
  \note use '*' (without quotes) to apply this variable to all keys
A2 , \field Variable Name
  \required-field
  \type object-list
  \object-list autoRDDvariable
A3 , \field Reporting Frequency
  \type choice
  \key Detailed
  \note Detailed lists every instance (i.e. HVAC variable timesteps)
  \key Timestep
  \note Timestep refers to the zone Timestep/Timestep in hour value
  \note RunPeriod, Environment, and Annual are the same
  \key Hourly
  \key Daily
  \key Monthly
  \key RunPeriod
  \key Environment
  \key Annual
  \note RunPeriod, Environment, and Annual are synonymous
A4 ; \field Schedule Name
  \type object-list
  \object-list ScheduleNames
```

Each Output:Variable object causes a specific number assignment for outputs. For example, you could request separate reporting for the outside temperature:

```
Output:Variable,*,outdoor dry bulb,timestep;
Output:Variable,*,outdoor dry bulb,hourly;
Output:Variable,*,outdoor dry bulb,monthly;
```

And the following would appear in the standard output file:

```
6,2,Environment,Outdoor Dry Bulb [C] !TimeStep
7,2,Environment,Outdoor Dry Bulb [C] !Hourly
8,2,Environment,Outdoor Dry Bulb [C] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
```

Item # 6 will be listed following the TimeStep timestamp for each timestep. Item #7 will be listed following an hourly timestamp. And item #8 will be listed following a monthly timestamp and has additional fields (because it is an “average” variable) that show the minimum and maximum values with identifying times for those minimum and maximum. An excerpt will illustrate:

```
2, 1, 7,21, 0, 1, 0.00,15.00,Monday - timestep timestamp
6,17.08889
```

```

48,21.39851
49,0.0000000E+00
53,0.0000000E+00
60,21.87214
    2, 1, 7,21, 0, 1, 0.00,60.00,Monday - hourly timestamp
7,16.75555
    4, 1, 7 - monthly timestamp
8,22.77037,15.00000,21, 4,60,32.77778,21,14,60

```

To interpret, the first value (#6) is 17.09 C, #7 is 16.76 C (average for the hour), and #8 is 22.77 C, the average for the month with the low (minimum) of 15 C occurring on 7/21 4:60 (or 5:00) and the high (maximum) occurring on 7/21 14:60 (or 15:00).

Field: Key Value

This alpha field can be used to make a specific reference for reporting. In addition to the generic variable names listed in the Variable Dictionary Report for the input file, variables will also have a key designator (such as Zone name or Surface name). You can reference the standard output file (**eplusout.eso**) to see just how these look.

```

41,2,ZN001:WALL004,Surface Inside Temperature[C]
42,2,ZN001:WALL004,Surface Outside Temperature[C]
43,2,ZN001:WALL004,Surface Int Convection Coeff[W/m2-K]
44,2,ZN001:WALL004,Surface Ext Convection Coeff[W/m2-K]
46,2,ZONE ONE,Mean Radiant Temperature[C]
47,2,ZONE ONE,Zone-Total Latent Gain[J]
51,2,ZONE ONE,Zone-Total Electric Consumption[J]
58,2,ZONE ONE,Zone/Sys Air Temp[C]

```

For example, in the previous block, the key for the surface variables is **ZN001:WALL004** whereas the key for the zone variables is **ZONE ONE** (note that the space is required and significant for this key).

You can have all keys listed in the standard output file by putting a “*” in this field or you can have specific items listed by putting in a key value.

Field: Variable Name

This alpha field is the variable name (you don’t have to put on the units) that is shown in the Variable Dictionary Report file (eplusout.rdd).

Field: Reporting Frequency

This field specifies how often the variable will be listed in the output file. “**Detailed**” will list the value each calculation step (i.e. Zone or HVAC). “**Timestep**” will be the same as “Detailed” for Zone valued variables and will be aggregated to the Zone timestep (i.e. Timestep in Hour value) for HVAC variables. “**Hourly**” will aggregate the value to the hour. “**Daily**” will aggregate to the day (i.e. one value per day). “**Monthly**” will aggregate to the month (i.e. one value per month). “**RunPeriod**” will aggregate to the runperiod specified (each Design Day is a runperiod as is each runperiod object).

Field: Schedule Name

The final field is a schedule name. This can be used to limit the number of lines that appear in your output file. For example, a schedule such as “ON PEAK” or “OFF PEAK” could provide a slice of values. Or, a seasonal schedule could be devised. The report variable will be active during any hour in which the schedule value is >0. For daily, monthly, and environment reporting frequencies, the aggregate value will be only for active schedule hours. Summed variables will report the sum for the active hours only. Averaged variables will report the average during the active hours only. If Schedule_Name is omitted, the report variable will be active for all hours.

Other IDF examples:

```
Output:Variable, * , Mean Air Temperature, hourly;
Output:Variable, * , Mean Radiant Temperature, timestep;
Output:Variable, * , Zone/Sys Sensible Heating Energy, hourly;
Output:Variable, * , Zone/Sys Sensible Cooling Energy, hourly;
Output:Variable, * , Zone/Sys Air Temp, hourly;
```

Output:Meter and Output:Meter:MeterFileOnly

Appropriate variables are grouped onto “meters” for reporting purposes. (The meters available are listed in the eplusout.mdd file, see Variable Dictionary Report section.) If the “Output:Meter” input object is used, these results written out to both the **eplusout.eso** and **eplusout.mtr** files. This allows easy graphing and comparison with “normal” values (such as Zone Temperature or Outdoor Temperature). If the “Output:Meter:MeterFileOnly” input object is used, then the values results written out to only the **eplusout.mtr** file. The **eplusout.mtr** file has the same structure as the **eplusout.eso** file. A companion file, the **eplusout.mtd** file, contains a detailed list and explanation of all meters for a given run and the component values that are accumulated on each meter.

Field: Name

Meter names applicable for the simulation are shown on the Variable Dictionary Report contained in the eplusout.mdd file described above. A snippet from that file will illustrate:

```
Zone,Meter,Electricity:Facility [J]
Zone,Meter,Electricity:Building [J]
Zone,Meter,Electricity:Zone:RESISTIVE ZONE [J]
Zone,Meter,Electricity:Zone:EAST ZONE [J]
Zone,Meter,Electricity:Zone:NORTH ZONE [J]
Zone,Meter,InteriorLights:Electricity [J]
Zone,Meter,InteriorLights:Electricity:Zone:RESISTIVE ZONE [J]
Zone,Meter,InteriorLights:Electricity:Zone:EAST ZONE [J]
Zone,Meter,InteriorLights:Electricity:Zone:NORTH ZONE [J]
```

Meter names are of three forms:

<ResourceType>:<name>

Or

<EndUseType>:<ResourceType>:<name>

Or

<EndUseSubcategory>:<EndUseType>:<ResourceType>:<name>.

The user requests reporting by either specifying the full name above (without Units) or a “wildcard” representation of that name (to obtain all meters of a type). For example, entering “Electricity:*” for the meter name will report on all the Electricity: meters (Electricity:Facility, Electricity:Building, Electricity:Zone:Resistive Zone, Electricity:Zone:East Zone, Electricity:North Zone in the example above). Both the resource types and end-use types are set within the program by the developers. End-use subcategories are user-defined and are an input field for certain objects. Current resource types are shown in the table below:

Table 33. Table of Metered Resource Types

Utility/Fuel Types
Electricity
Gas
Gasoline
Diesel
Coal
FuelOil#1
FuelOil#2
Propane
Water

Steam
DistrictCooling
DistrictHeating

Other Resource Types
EnergyTransfer

The end use types are shown in the following table (note that certain end use types apply only to the EnergyTransfer resource):

Table 34. End Use Category Types

Utility/Fuel End Use Types
InteriorLights
ExteriorLights
InteriorEquipment
ExteriorEquipment
Fans
Pumps
Heating
Cooling
HeatRejection
Humidifier
HeatRecovery
DHW
Cogeneration
Refrigeration
Miscellaneous

Additional End Use Types Only Used for EnergyTransfer
HeatingCoils
CoolingCoils
Chillers
Boilers
Baseboard
HeatRecoveryForCooling
HeatRecoveryForHeating

Specific meter types are then used for grouping the fuel type meters:

Table 35. Overall Meter Types

Meters
Facility
Building
Zone
System
Plant

Facility meters contain all the energy of a fuel type. Building meters contain the sum of each zone's energy. System meters contain the energy from the system components. Plant meters contain the energy from the plant equipments.

Thus, the following relationships should be observed:

$$Facility = \sum (Building + System + Plant + Exterior)$$

$$Building = \sum_1^{NumberOfZones} Zone$$

Further descriptions of Metering is contained in the "Getting Started" document.

Field: Reporting Frequency

Similar to the report variables, meters can be reported at different frequencies. Their resolution is the Zone Timestep interval (Number of Timesteps input). For this frequency, the elemental value of the meter will be reported. For more inclusive frequencies, the summed value along with the maximum and minimum values for the time interval will be reported.

The IDD definition for the Output:Meter object follows.

```
Output:Meter,
  \memo Meters requested here show up on eplusout.eso and eplusout.mtr
  \format singleLine
A1 , \field Name
  \required-field
  \type object-list
  \object-list autoRDDmeter
  \note Form is EnergyUseType:..., e.g. Electricity:* for all Electricity meters
  \note or EndUse:..., e.g. GeneralLights:* for all General Lights
  \note Report Meter puts results on both the eplusout.mtr and eplusout.eso files
A2 ; \field Reporting Frequency
  \type choice
  \key Timestep
  \note Timestep refers to the zone Timestep/Timestep in hour value
  \note RunPeriod, Environment, and Annual are the same
  \key Hourly
  \key Daily
  \key Monthly
  \key RunPeriod
  \key Environment
  \key Annual
  \note RunPeriod, Environment, and Annual are synonymous
```

Examples of specifying the object in the IDF follow.

```
Output:Meter,Electricity:*,RunPeriod;
Output:Meter,ExteriorEquipment*,RunPeriod;
```

The IDD definition for the Output:Meter:MeterFileOnly object follows.

```
Output:Meter:MeterFileOnly,
  \memo same reporting as Report Meter -- goes to eplusout.mtr only
  \format singleLine
A1, \field Name
  \required-field
  \type object-list
  \object-list autoRDDmeter
  \note Form is EnergyUseType:..., e.g. Electricity:* for all Electricity meters
  \note or EndUse:..., e.g. GeneralLights:* for all General Lights
  \note Report MeterFileOnly puts results on the eplusout.mtr file only
A2 ; \field Reporting Frequency
  \type choice
  \key Timestep
  \note Timestep refers to the zone Timestep/Timestep in hour value
  \note RunPeriod, Environment, and Annual are the same
  \key Hourly
  \key Daily
  \key Monthly
  \key RunPeriod
  \key Environment
  \key Annual
  \note RunPeriod, Environment, and Annual are synonymous
```

Meter Details File (eplusout.mtd)

The meter details file consists of two parts:

- For report variables that are on meters, it shows all the meters that the report variable is on. In the following example, “Meters for “ <report variable #>, <report variable name> is shown and then the meters that accumulate the value of that variable as a “meter”.

```
Meters for 1240,SPACE1-1:Lights-Electric Consumption[J]
OnMeter=Electricity:Facility [J]
OnMeter=Electricity:Building [J]
OnMeter=Electricity:Zone:SPACE1-1 [J]
OnMeter=InteriorLights:Electricity [J]
OnMeter=InteriorLights:Electricity:Zone:SPACE1-1 [J]
```

```
Meters for 1460,SPACE1-1:Zone/Sys Sensible Heating Energy[J]
OnMeter=EnergyTransfer:Facility [J]
OnMeter=EnergyTransfer:Building [J]
OnMeter=EnergyTransfer:Zone:SPACE1-1 [J]
OnMeter=Heating:EnergyTransfer [J]
```

```
Meters for 1557,SPACE1-1 ZONE COIL:Total Water Heating Coil Energy[J]
OnMeter=EnergyTransfer:Facility [J]
OnMeter=EnergyTransfer:HVAC [J]
OnMeter=HeatingCoils:EnergyTransfer [J]
```

- For each meter, the report variables that make up that meter are shown. In the following example, “For Meter=” <name of meter>, “contents are:” and then each variable that occurs on that “meter” are shown.

```
For Meter=Electricity:Facility [J], contents are:
SPACE1-1 LIGHTS:Lights Electric Consumption
SPACE2-1 LIGHTS:Lights Electric Consumption
SPACE3-1 LIGHTS:Lights Electric Consumption
SPACE4-1 LIGHTS:Lights Electric Consumption
SPACE5-1 LIGHTS:Lights Electric Consumption
SPACE1-1 ELECEQ:Electric Equipment Electric Consumption
SPACE2-1 ELECEQ:Electric Equipment Electric Consumption
SPACE3-1 ELECEQ:Electric Equipment Electric Consumption
SPACE4-1 ELECEQ:Electric Equipment Electric Consumption
SPACE5-1 ELECEQ:Electric Equipment Electric Consumption
SUPPLY FAN 1:Fan Electric Consumption
CENTRAL CHILLER:Chiller Electric Consumption
HW CIRC PUMP:Pump Electric Consumption
CW CIRC PUMP:Pump Electric Consumption
```

```
For Meter=Electricity:Building [J], contents are:
SPACE1-1 LIGHTS:Lights Electric Consumption
SPACE2-1 LIGHTS:Lights Electric Consumption
SPACE3-1 LIGHTS:Lights Electric Consumption
SPACE4-1 LIGHTS:Lights Electric Consumption
SPACE5-1 LIGHTS:Lights Electric Consumption
SPACE1-1 ELECEQ:Electric Equipment Electric Consumption
SPACE2-1 ELECEQ:Electric Equipment Electric Consumption
SPACE3-1 ELECEQ:Electric Equipment Electric Consumption
SPACE4-1 ELECEQ:Electric Equipment Electric Consumption
SPACE5-1 ELECEQ:Electric Equipment Electric Consumption
```

```
For Meter=Electricity:Zone:SPACE1-1 [J], contents are:
SPACE1-1 LIGHTS:Lights Electric Consumption
SPACE1-1 ELECEQ:Electric Equipment Electric Consumption
```

```
For Meter=InteriorLights:Electricity [J], contents are:
SPACE1-1 LIGHTS:Lights Electric Consumption
SPACE2-1 LIGHTS:Lights Electric Consumption
SPACE3-1 LIGHTS:Lights Electric Consumption
SPACE4-1 LIGHTS:Lights Electric Consumption
SPACE5-1 LIGHTS:Lights Electric Consumption
```

For Meter=Gas:Facility [J], contents are:
CENTRAL BOILER:Boiler Gas Consumption

For Meter=Gas:Plant [J], contents are:
CENTRAL BOILER:Boiler Gas Consumption

For Meter=Heating:Gas [J], contents are:
CENTRAL BOILER:Boiler Gas Consumption

For Meter=Electricity:Plant [J], contents are:
CENTRAL CHILLER:Chiller Electric Consumption
HW CIRC PUMP:Pump Electric Consumption
CW CIRC PUMP:Pump Electric Consumption

For Meter=Cooling:Electricity [J], contents are:
CENTRAL CHILLER:Chiller Electric Consumption

For Meter=Cooling:EnergyTransfer [J], contents are:
PLENUM-1:Zone/Sys Sensible Cooling Energy
SPACE1-1:Zone/Sys Sensible Cooling Energy
SPACE2-1:Zone/Sys Sensible Cooling Energy
SPACE3-1:Zone/Sys Sensible Cooling Energy
SPACE4-1:Zone/Sys Sensible Cooling Energy
SPACE5-1:Zone/Sys Sensible Cooling Energy

Outdoor Air Ventilation Report Variables

This section provides more detailed information on the reporting available for outdoor air ventilation. Sixteen cooling and heating load variables and eight energy summary variables are available that report the impact of system outdoor air on zone loads, system demand and total energy use. The representative air system shown in the diagram below shows outdoor air (OA), return air (RA), supply air (SA) and mixed air (MA).

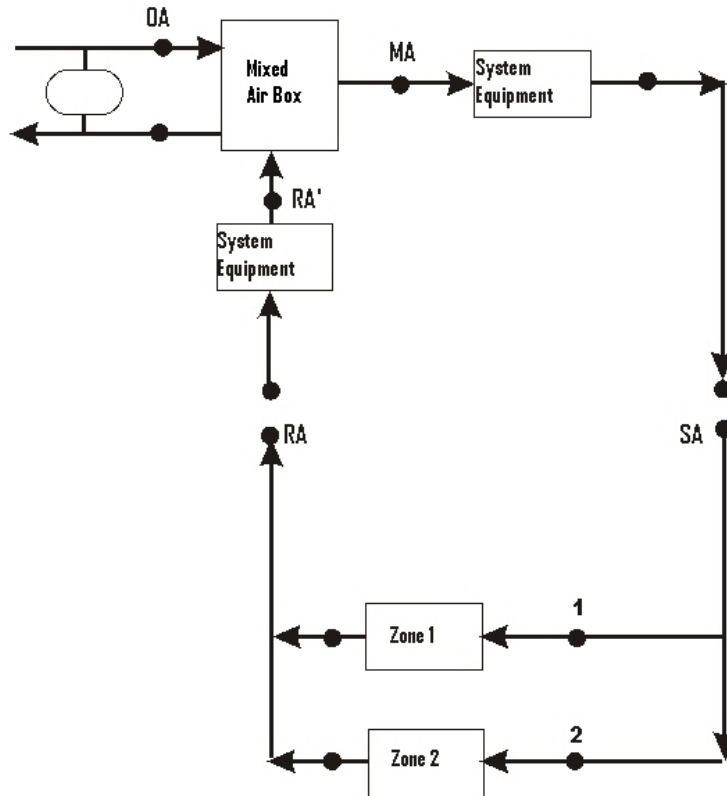


Figure 135. Example System for Ventilation Loads Report

The overall effect of outdoor air on the system shown above can be summarized by considering the mixing box. In this system, part or all of the return air is replaced by outdoor air. The presence of any heat recovery will already be taken into account and thus will automatically be accounted for by using the outdoor air inlet conditions to the mixing box (point OA in the diagram) rather than actual outdoor air conditions. Thus, the overall energy impact of outdoor air (ventilation) on a particular system can be evaluated by multiplying the outdoor air mass flow rate by the enthalpy difference between the outdoor air entering the mixing box (OA) and the return air entering the mixing box (RA') as shown in the following equation.

$$\dot{q}_{OA} = \dot{m}_{OA} (h_{OA} - h_{RA'}) = \dot{m}_{sys} (h_{MA} - h_{RA'})$$

Ventilation Flow Report Variables

The fresh air flow into each zones are reported using the ventilation flow report variables. The total outdoor air flow in a primary air system is divided to each zone based on the fraction of flow each zone is supplied. There are six variables which deals with the mechanical ventilation flow reporting. Those six variables are:

Zone Mechanical Ventilation Mass Flow Rate [kg/s]

Reports the average outdoor air mass flow rate to any zone over the reporting interval.

Zone Mechanical Ventilation Volume Flow Rate [m3/s]

Reports the average outdoor air volume flow rate to any zone over the reporting interval.

Zone Mechanical Ventilation Total Mass of Outside Air [kg]

Reports the total outdoor air mass that has been supplied to any zone over the reporting interval.

Zone Mechanical Ventilation Total Volume of Outside Air [m3]

Reports the total outdoor air volume that has been supplied to any zone over the reporting interval.

Zone Mechanical Ventilation Air Change Rate [ach]

Reports the air changes per hour in the zone due to the outside fresh air supplied by mechanical ventilation system.

The example syntax below shows the basic ventilation flow variables reported on an hourly basis.

```

Output:Variable,
*,                               !- Key Value
Zone Mechanical Ventilation Mass Flow Rate, !- Variable Name
Hourly;                          !- Reporting Frequency

Output:Variable,
*,                               !- Key Value
Zone Mechanical Ventilation Volume Flow Rate, !- Variable Name
Hourly;                          !- Reporting Frequency

Output:Variable,
*,                               !- Key Value
Zone Mechanical Ventilation Total Mass of Outside Air, !- Variable Name
Hourly;                          !- Reporting Frequency

Output:Variable,
*,                               !- Key Value
Zone Mechanical Ventilation Total Volume of Outside Air, !- Variable Name
Hourly;                          !- Reporting Frequency

Output:Variable,
*,                               !- Key Value
Zone Mechanical Ventilation Air Change Rate, !- Variable Name
Hourly;                          !- Reporting Frequency

```

Ventilation Load Reports

The impact of system outdoor air on a particular zone may be calculated by summing the mass flow weighted \dot{q}_{OA} over the supply air paths (both cooling and heating) serving the zone as follows:

$$\dot{q}_{OA,Zone1} = \sum_{n=1}^{AirPathNum} \dot{q}_{OA} \frac{\dot{m}_n}{\dot{m}_{sys}}$$

Four report variables each for cooling and heating report the impact of the ventilation air on the zone load in the absence of ventilation air system interactions. The ventilation load report variables are:

Zone Mechanical Ventilation Cooling Load Increase: OverHeating[J]**Zone Mechanical Ventilation Heating Load Increase: OverHeating[J]**

The cooling/heating load that would occur once ventilation air met the zone cooling/heating load and continued to overcool/overheat the zone. No system effects are accounted for.

Zone Mechanical Ventilation Cooling Load Decrease[J]**Zone Mechanical Ventilation Heating Load Decrease[J]**

The decrease in zone cooling/heating load that would occur as a result of ventilation air introduced directly into the zone. No system effects are accounted for.

Zone Mechanical Ventilation No Load Heat Removal[J]**Zone Mechanical Ventilation No Load Heat Addition[J]**

The addition or removal of heat to a zone with no load. The heat addition or removal is due to mechanical ventilation while the zone thermostat is in the deadband.

To summarize:

Cooling:**1. Zone Mechanical Ventilation No Load Heat Removal [J]**

Cooling that would be provided directly to zone by ventilation air. Ventilation occurred with no zone load.

2. Zone Mechanical Ventilation Cooling Load Increase [J]

The increase in zone cooling load that would occur as a result of ventilation air introduced directly into the zone. No system effects are accounted for.

3. Zone Mech Ventilation Cooling Load Increase: OverHeating [J]

The cooling load that would occur once ventilation air met the zone heating load and continued to overheat the zone. No system effects are accounted for.

4. Zone Mechanical Ventilation Cooling Load Decrease [J]

The decrease in zone cooling load that would occur as a result of ventilation air introduced directly into the zone. No system effects are accounted for.

Heating:**1. Zone Mechanical Ventilation No Load Heat Addition [J]**

Heating that would be provided directly to zone by ventilation air. Ventilation occurred with no zone load.

2. Zone Mechanical Ventilation Heating Load Increase [J]

The increase in zone heating load that would occur as a result of ventilation air introduced directly into the zone. No system effects are accounted for.

3. Zone Mech Ventilation Heating Load Increase: OverCooling[J]

The heating load that would occur once ventilation air met the zone cooling load and continued to overcool the zone. No system effects are accounted for.

4. Zone Mechanical Ventilation Heating Load Decrease [J]

The decrease in zone heating load that would occur as a result of ventilation air introduced directly into the zone. No system effects are accounted for.

The report variables are calculated by comparing the zone ventilation load with the zone cooling or heating load. 'Ventilation cooling' decreases the zone cooling load until the cooling load has been eliminated. The remaining 'ventilation cooling' is reported as 'overcooling'. 'Overheating' is calculated in the same manner. The actual system operation, which determines whether or not an 'overcooling' or 'overheating' load actually results in increased energy consumption, is not considered in the calculation of these report variables.

The ventilation zone load report variables are shown in Table 36. The variables report the maximum potential “cost” or “benefit” of ventilation air introduced directly into the zone.

Table 36. Ventilation Load Report Variables

	No Zone Load	Zone Cooling Load	Zone Heating Load
Ventilation Cooling	Zone Mechanical Ventilation No Load Heat Removal	Zone Mechanical Ventilation Cooling Load Decrease	Zone Mechanical Ventilation Heating Load Increase
		Zone Mech Ventilation Heating Load Increase: OverCooling	
Ventilation Heating	Zone Mechanical Ventilation No Load Heat Addition	Zone Mechanical Ventilation Cooling Load Increase	Zone Mechanical Ventilation Heating Load Decrease
			Zone Mech Ventilation Cooling Load Increase: OverHeating

The example syntax below shows the basic ventilation load variables reported on a monthly basis.

```

Output:Variable,
*,                               !- Key Value
Zone Mechanical Ventilation No Load Heat Removal, !- Variable Name
monthly;                          !- Reporting Frequency

Output:Variable,
*,                               !- Key Value
Zone Mech Ventilation Cooling Load Increase: OverHeating, !- Variable Name
monthly;                          !- Reporting Frequency

Output:Variable,
*,                               !- Key Value
Zone Mechanical Ventilation Cooling Load Decrease, !- Variable Name
monthly;                          !- Reporting Frequency

Output:Variable,
*,                               !- Key Value
Zone Mechanical Ventilation Cooling Load Increase, !- Variable Name
monthly;                          !- Reporting Frequency

Output:Variable,
*,                               !- Key Value
Zone Mechanical Ventilation No Load Heat Addition, !- Variable Name
monthly;                          !- Reporting Frequency

Output:Variable,
*,                               !- Key Value
Zone Mech Ventilation Heating Load Increase: OverCooling, !- Variable Name
monthly;                          !- Reporting Frequency

Output:Variable,
*,                               !- Key Value
Zone Mechanical Ventilation Heating Load Decrease, !- Variable Name
monthly;                          !- Reporting Frequency

Output:Variable,
*,                               !- Key Value
Zone Mechanical Ventilation Heating Load Increase, !- Variable Name
monthly;                          !- Reporting Frequency

```

Reporting on a timestep or monthly level would produce a detailed report with variables intermingled with the other report variables that might be requested in the input file.

Another method will more easily encapsulate the report:

```

OutputControl:Table:Style,
HTML;                               !- ColumnSeparator

Output:Table:Monthly,
Ventilation Loads,             !- Name
,                                   !- DigitsAfterDecimal
Zone Mechanical Ventilation No Load Heat Removal,      SumOrAverage,
Zone Mech Ventilation Cooling Load Increase: OverHeating, SumOrAverage,
Zone Mechanical Ventilation Cooling Load Decrease,      SumOrAverage,
Zone Mechanical Ventilation Cooling Load Increase,      SumOrAverage,
Zone Mechanical Ventilation No Load Heat Addition,      SumOrAverage,
Zone Mech Ventilation Heating Load Increase: OverCooling, SumOrAverage,
Zone Mechanical Ventilation Heating Load Decrease,      SumOrAverage,
Zone Mechanical Ventilation Heating Load Increase,      SumOrAverage,

```

This combination will report the ventilation loads on a monthly basis in a HTML style report that can be easily read in a web browser. Review the Output:Table:Monthly object for other methods of display or further options on this report item.

Systems Level Reporting

Most report variables are a single entity reporting. Meters are a combination of like variables – specifically for Energy Consumption. This section introduces a slightly different concept – where report variables described herein are a combination of several similar items –

specifically targeted at HVAC/System level reporting. This reporting is coupled with an Air Loop (ref: AirLoopHVAC)

All items shown in this section are typical “report variables” and can be reported with the Output:Variable object.

Or, as is shown by example here, perhaps a more readable form is to generate them in Tabular Form with the “Report Table Monthly” object.

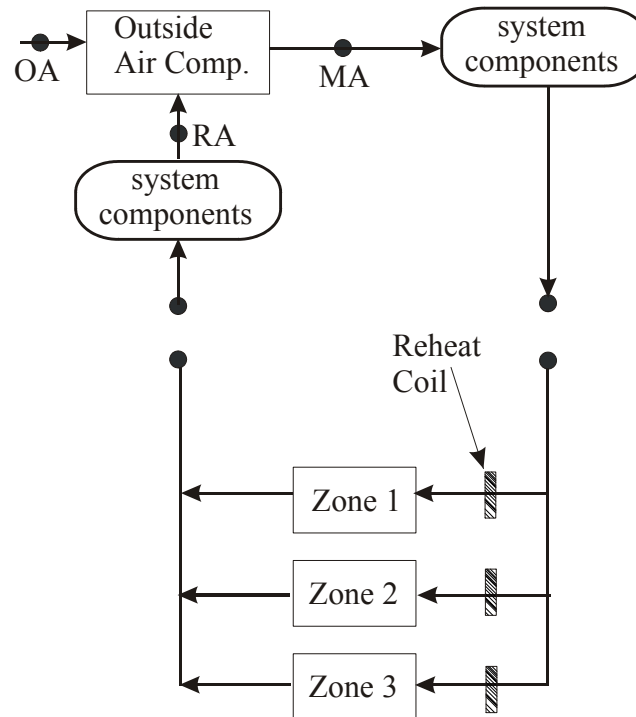


Figure 136. View of System Level Reporting

System Loads Outputs

In this category, the total system load is reported. Two aspects are reported here: Heating and Cooling. The following two variables report the heat energy that system components (including packaged equipment, fans, main coils, reheat coils, humidifiers, desiccant dehumidifiers, evaporative coolers and heat exchangers) add or remove from the air loop. Each variable within these grouping will

Air Loop Total Heating Energy

Heat Addition to the Air Loop (Sum of all components) in Joules

Air Loop Total Cooling Energy

Heat Removal from the Air Loop (Sum of all components) in Joules

In 'Output:Table:Monthly' format shown below.

```
OutputControl:Table:Style ,
  HTML;                               !- ColumnSeparator

Output:Table:Monthly,
  System Loads,                    !- Name
  ,                                     !- DigitsAfterDecimal
```

Air Loop Total Heating Energy,	SumOrAverage,
Air Loop Total Cooling Energy,	SumOrAverage;

System Energy Use Outputs

System Energy Use consists of six output variables that report the total energy (in Joules) and water consumption (in m3) for all system components and including packaged equipment, fans, main coils, reheat coils, humidifiers, desiccant dehumidifiers, and evaporative coolers. The output variables shown below show hot and cold water, steam, electric and gas energy. Hot and cold water energy includes all 'district cooling' and 'district heating' energy.

Air Loop Hot Water Consumption

Hot Water Consumption for the system (Joules).

Air Loop Steam Consumption

Steam Consumption for the system (Joules).

Air Loop Chilled Water Consumption

Chilled Water Consumption for the system (Joules).

Air Loop Electric Consumption

Electric Consumption for the system (Joules).

Air Loop Gas Consumption

Gas (Natural Gas and Propane) Consumption for the system (Joules).

Air Loop Water Consumption

Water Consumption for the system (humidifiers and evaporative coolers) (m3).

The Standard reports file includes these variables reporting in the Tabular report form as "Air Loop System Energy and Water Use".

```

OutputControl:Table:Style,
    HTML;                               !- ColumnSeparator

Output:Table:Monthly,
    Air Loop System Energy and Water Use,      !- Name
    ,                                           !- DigitsAfterDecimal
    Air Loop Hot Water Consumption ,          SumOrAverage,
    Air Loop Steam Consumption ,             SumOrAverage,
    Air Loop Chilled Water Consumption,      SumOrAverage,
    Air Loop Electric Consumption,          SumOrAverage,
    Air Loop Gas Consumption,              SumOrAverage,
    Air Loop Water Consumption,            SumOrAverage;

```

System Component Loads Outputs

Reporting System Component Loads shows the energy transferred to or extracted from the air loop by system component type. Fans, Cooling Coils, Heating Coils, Heat exchangers, humidifiers, evaporative coolers, and desiccant dehumidifiers show heat transfer rates in Joules. The components may be located in outdoor air systems bundled with packaged equipment or specified as stand-alone components. The reporting accounts for both main branch and reheat coils.

The Standard reports file includes these variables reporting in the Tabular report form as "Air Loop System Component Loads".

```

OutputControl:Table:Style,
    HTML;                               !- ColumnSeparator

Output:Table:Monthly,
    Air Loop System Component Loads,      !- Name
    ,                                       !- DigitsAfterDecimal
    Air Loop Fan Heating Energy,      SumOrAverage,
    Air Loop Total Cooling Coil Energy, SumOrAverage,
    Air Loop Total Heating Coil Energy, SumOrAverage,
    Air Loop Total Heat Exchanger Heating Energy, SumOrAverage,
    Air Loop Total Heat Exchanger Cooling Energy, SumOrAverage,
    Air Loop Total Humidifier Heating Energy, SumOrAverage,
    Air Loop Total Evap Cooler Cooling Energy, SumOrAverage,
    Air Loop Total Desiccant Dehumidifier Cooling Energy, SumOrAverage;

```

Air Loop Fan Heating Energy

Energy consumption for Fans (Joules)

Air Loop Total Cooling Coil Energy

Energy consumption for Cooling Coils (Joules)

Air Loop Total Heating Coil Energy

Energy consumption for Heating Coil(s) (Joules)

Air Loop Total Heat Exchanger Heating Energy

Heating energy consumption for heat exchangers (Joules)

Air Loop Total Heat Exchanger Cooling Energy

Heating energy consumption for heat exchangers (Joules)

Air Loop Total Humidifier Heating Energy

Heating energy consumption for humidifiers (Joules)

Air Loop Total Evap Cooler Cooling Energy

Energy consumption for evaporative coolers (Joules)

Air Loop Total Desiccant Dehumidifier Cooling Energy

Energy consumption for desiccant dehumidifiers (Joules)

System Component Energy Use Outputs

Reporting System Component Energy Use consists of eleven output variables that report the total energy consumption (in Joules) of system components by energy type and coil type. Electric energy consumption is reported for fans, heating and cooling coils in packaged (DX) systems, electric resistance heating coils, humidifiers, evaporative coolers and desiccant dehumidifiers.

Air Loop Fan Electric Consumption

Electric consumption for fans. (Joules)

Air Loop Heating Coil Hot Water Consumption

Consumption for heating coil hot water (both purchased and plant supplied) (Joules)

Air Loop Cooling Coil Chilled Water Consumption

Consumption for cooling coil chilled water (both purchased and plant supplied) (Joules)

Air Loop DX Heating Coil Electric Consumption

Compressor plus condenser fan electricity use. (Joules)

Air Loop DX Cooling Coil Electric Consumption

Compressor plus condenser fan electricity use. (Joules)

Air Loop Heating Coil Electric Consumption

Electricity consumption for the heating coil. (Joules)

Air Loop Heating Coil Gas Consumption

Gas (Propane and Natural Gas) consumption for the heating coil. (Joules)

Air Loop Heating Coil Steam Consumption

Steam consumption for the heating coil (steam coils). (Joules)

Air Loop Humidifier Electric Consumption

Electricity consumption for the humidifiers. (Joules)

Air Loop Evap Cooler Electric Consumption

Electricity consumption for the evaporative coolers. (Joules)

Air Loop Desiccant Dehumidifier Electric Consumption

Electricity consumption for the desiccant dehumidifiers. (Joules)

The Standard reports file includes these variables reporting in the Tabular report form as “Air Loop System Component Energy Use”.

```

OutputControl:Table:Style,
    HTML;                                !- ColumnSeparator

Output:Table:Monthly,
    Air Loop System Component Energy Use,      !- Name
    ,                                           !- DigitsAfterDecimal
    Air Loop Fan Electric Consumption,      SumOrAverage,
    Air Loop Heating Coil Hot Water Consumption, SumOrAverage,
    Air Loop Cooling Coil Chilled Water Consumption, SumOrAverage,
    Air Loop DX Heating Coil Electric Consumption, SumOrAverage,
    Air Loop DX Cooling Coil Electric Consumption, SumOrAverage,
    Air Loop Heating Coil Electric Consumption, SumOrAverage,
    Air Loop Heating Coil Gas Consumption, SumOrAverage,
    Air Loop Heating Coil Steam Consumption, SumOrAverage,
    Air Loop Humidifier Electric Consumption, SumOrAverage,
    Air Loop Evap Cooler Electric Consumption, SumOrAverage,
    Air Loop Desiccant Dehumidifier Electric Consumption, SumOrAverage;

```

Output:EnvironmentalImpactFactors

The Output:EnvironmentalImpactFactors object triggers the necessary Facility meters to be reported and the Pollutants resulting from these on and off-site energy consumptions. These values are put into the eplusout.mtr file. Facility meters contain all the energy of a fuel type. Thus, the following relationships should be observed:

$$Facility = \sum (Building + System + Plant + Exterior)$$

Information regarding how the coefficients are derived and applied can be found in the Engineering Document.

To turn on the reporting and the calculations for the environmental factors the user enters 3 objects:

Output:EnvironmentalImpactFactors: (with associated reporting frequency, more than one frequency can be requested)

EnvironmentalImpactFactors: (contains additional information necessary for the calculations not included in the Fuel Factors)

FuelFactors: (required for every fuel that is simulated and converted in this simulation input file)

Users will enter environmental impact factors for each Fuel Type or FuelFactor. This is the same for each Fuel Type: Natural Gas, Residual Oil, Distillate Oil, Coal, Off-Site Electricity, Gasoline, and Propane. For District Heating, District Cooling, and Steam there are additional fields in the EnvironmentalImpactFactors object that help in the conversion of their energy to Natural Gas and Electricity.

The energy is obtained internally from the following facility meters:

Electricity:Facility	Diesel:Facility
DistrictCooling:Facility	DistrictHeating:Facility
Gas:Facility	GASOLINE:Facility
COAL:Facility	FuelOil#1:Facility
FuelOil#2:Facility	Propane:Facility
ElectricityProduced:Facility	Steam:Facility

For the pollutant calculation only the total off-site or purchased electric energy is calculated using Electricity Factors. Off-Site Electricity = Electricity:Facility - ElectricityProduced:Facility, pollutants for the fuel type used by the on-site generator will be calculated, for example Diesel, in these cases.

Field: Reporting Frequency

Similar to the report variables and meters the environmental impact calculations can be reported at different frequencies. Their resolution is the Zone Timestep interval (Number of Timesteps input). For this frequency, the elemental value of the Environmental Impact Factors Calculation will be reported. For more inclusive frequencies, the summed value along with the maximum and minimum values for the time interval will be reported.

The IDD definition for the Report Environmental Impact Factors object is:

```
Output:EnvironmentalImpactFactors,
  \memo This is used to Automatically report the facility meters and turn on the Environmental Impact
Report calculations
  \memo for all of the Environmental Factors.
A1 ; \field Reporting Frequency
  \type choice
  \key Timestep
  \key Hourly
  \key Daily
  \key Monthly
  \key RunPeriod
```

An example of specifying in the IDF:

```
Output:EnvironmentalImpactFactors,
  Monthly; !- Reporting_Frequency
```

EnvironmentalImpactFactors

The EnvironmentalImpactFactors object contains additional information that is not individually specified in the FuelFactors object and is the second object needed to complete the calculation. Source to Site conversion factors for District Heating, District Cooling and Steam are entered in this object.

Field: District Heating Efficiency

The District Heating Efficiency value is used to convert the district (purchased) heating energy to Natural Gas for the environmental impact calculation. The efficiency is a number between 0 and 1 and divided into the district heating energy and the default is 0.3.

Field: District Cooling COP

The District Cooling COP value is used to convert the district (purchased) cooling energy to electricity for the environmental impact calculation. The Coefficient of Performance (COP) is a number greater than 0 and divided into the purchased cooling energy with a default of 3.0.

Field: Steam Conversion Efficiency

The Steam Conversion Efficiency is used to convert the Steam usage to Natural Gas for the environmental impact calculation. The efficiency is a number between 0 and 1 and divided into the purchased heating energy and the default is 0.25.

Field: Total Carbon Equivalent Emission Factor From NO_x

The Intergovernmental Panel on Climate Change has studied the effects on the relative radiative forcing effects of various greenhouse gases. This effect, called Global Warming Potential (GWP), is described in terms of the Carbon Equivalent of a particular greenhouse gas. NO_x (nitrogen oxides) can be produced by all Fuel Types and has a default of carbon equivalent emission factor of 80.7272 kg C/kg NO_z.

Field: Total Carbon Equivalent Emission Factor From CH₄

The Intergovernmental Panel on Climate Change has studied the effects on the relative radiative forcing effects of various greenhouse gases. This effect, called Global Warming Potential (GWP), is described in terms of the Carbon Equivalent of a particular greenhouse gas. CH₄ (methane) can be produced by all Fuel Types and has a default carbon equivalent emission factor of 6.2727 kg C/kg CH₄.

Field: Total Carbon Equivalent Emission Factor From CO₂

The Intergovernmental Panel on Climate Change has studied the effects on the relative radiative forcing effects of various greenhouse gases. This effect, called Global Warming Potential (GWP), is described in terms of the Carbon Equivalent of a particular greenhouse gas. CO₂ (carbon dioxide) can be produced by all Fuel Types and has a default carbon equivalent emission factor of 0.2727 kg C/kg CO₂.

The IDD definition for the Environmental Impact Factors object is:

```

EnvironmentalImpactFactors,
  \memo Used to help convert district and ideal energy use to a fuel type and provide total carbon
equivalent with coefficients
  N1, \field District Heating Efficiency
      \note District heating efficiency used when converted to natural gas
      \minimum> 0.0
      \maximum 1.0
      \default 0.3
  N2, \field District Cooling COP
      \note District cooling COP used when converted to electricity
      \minimum> 0.0
      \default 3.0
  N3, \field Steam Conversion Efficiency
      \note Steam conversion efficiency used to convert steam usage to natural gas
      \minimum> 0.0
      \maximum 1.0
      \default 0.25
  N4, \field Total Carbon Equivalent Emission Factor From NOx
      \units kg/kg
  N5, \field Total Carbon Equivalent Emission Factor From CH4
      \units kg/kg
  N6, \field Total Carbon Equivalent Emission Factor From CO2
      \units kg/kg

```

An example of specifying in the IDF:

```

EnvironmentalImpactFactors,
  0.3,      !- District Heating Efficiency
  3.0,      !- District Cooling COP
  0.25,     !- Steam Conversion Efficiency
  80.7272,  !- Total Carbon Equivalent Emission Factor From NOx
  6.2727,   !- Total Carbon Equivalent Emission Factor From CH4
  0.2727;   !- Total Carbon Equivalent Emission Factor From CO2

```

FuelFactors

Field: Existing Fuel Resource Name

This is the name of the Fuel that is being described with this object. Source to Site conversion factors for each tool are entered with these objects. Allowable Fuel Types are: Electricity, Natural Gas, FuelOil#1, FuelOil#2, Coal, Gasoline, Propane, Diesel.

Field: Units of Measure

Units in mass with kg or by volume in m3.

Field: Energy per Unit Factor

The higher heating value of the fuel type.

Field: Source Energy Factor

Multiplied by the fuel consumption to compute the source energy contribution for the fuel. If a schedule is also specified in the next field, the value specified here, the schedule value, and the fuel consumption are multiplied together for each timestep to determine the source energy contribution for the fuel. If the multipliers in the schedule specified in the next field fully represent the source energy conversion factor, the value in this field should be set to one. If the TDV files (described in next field) are used the value should be 0.293 for electricity and 0.01 for natural gas to account for the units used in the files. Units of J/J.

Field: Source Energy Schedule Name

This field contains the name of a schedule containing values that are multiplied by the fuel consumption to determine the source energy. The values in the schedule are multiplied by the Source Energy Factor field and by the fuel consumption to determine the source energy

consumption for the fuel. If the multipliers in the schedule fully represent the source energy conversion factor, the value in the previous field, Source Energy Factor should be set to one.

The use of this field is required for evaluations using source energy factors that change throughout the year such as Time Dependent Valuation (TDV), the method used to show compliance with to California's Title 24 under the ACM (Alternative Compliance Method). Data files containing TDV factors are in the DataSets\TDV\ directory. An example file for use with TDV file is in the ExampleFiles directory and is named 5zoneTDV.IDF. When using these TDV files with EnergyPlus it is important that a consistent weather file be used. It is also important that the day of the week for January 1 is set to Tuesday since all the TDV and related weather files use 1991 as the year of reference. Also note that the values in the TDV datasets files are in non SI units of measure. The source energy factor field should contain the value of 0.293 for electricity and 0.01 for natural gas to account for the non-standard units used in the files. To learn more about TDV see:

<http://www.energy.ca.gov/title24/2005standards/archive/rulemaking/documents/tdv/index.html>

<http://www.h-m-g.com/TDV/index.htm>

WARNING

THE TDV CALCULATIONS SHOULD ONLY BE PERFORMED ON SIMULATIONS THAT USE THE CALIFORNIA THERMAL ZONE (CTZ REV2) WEATHER FILES. One must match the correct TDV file to its corresponding CTZ weather file. There are 16 TDV files, one for each of the 16 CTZ weather files. The Time Dependent Valuation of TDV files provides a relative cost estimate of the various fuel sources and their relative costs by time of day, month of year and outside temperature. Outside temperature is important as demand for electricity and thus cost of electricity is influenced by temperature. These TDV files are applicable only to the hourly weather data contained in the California Thermal Zone (CTZ rev2) weather files as the time dependent cost information is partially derived from the timing of temperatures in the weather file. Thus using the TDV files with other weather data would provide meaningless results.

Field: CO2 Emission Factor

The environmental impact coefficient for the Fuel for calculating the mass of carbon dioxide (CO₂) released into the atmosphere. The units are grams per MegaJoule. Carbon dioxide gas is naturally produced by animals during respiration and through decay of biomass, and used by plants during photosynthesis. Although it only constitutes 0.04 percent of the atmosphere, it is one of the most important greenhouse gases. The combustion of fossil fuels is increasing carbon dioxide concentrations in the atmosphere, which is believed to be contributing to global warming.

Field: CO2 Emission Factor Schedule Name

This schedule field is not currently implemented.

Field: CO Emission Factor

The environmental impact coefficient for the Fuel for calculating the mass of carbon monoxide (CO) released into the atmosphere. The units are grams per MegaJoule. Carbon monoxide is a colorless, odorless and poisonous gas produced by incomplete fossil fuel combustion. Carbon monoxide combines with the haemoglobin of human beings, reducing its oxygen carrying capacity, with effects harmful to human beings.

Field: CO Emission Factor Schedule Name

This schedule field is not currently implemented.

Field: CH4 Emission Factor

The environmental impact coefficient for the Fuel for calculating the mass of methane (CH₄) released into the atmosphere. The units are grams per MegaJoule. Methane is a colorless, nonpoisonous, flammable gas created by anaerobic decomposition of organic compounds

and is one of the more potent greenhouse gases. A major component of natural gas used in the home.

Field: CH4 Emission Factor Schedule Name

This schedule field is not currently implemented.

Field: NOx Emission Factor

The environmental impact coefficient for the Fuel for calculating the mass of nitrogen oxides (NO_x) released into the atmosphere. The units are grams per MegaJoule. Nitrogen oxides refers to nitric oxide gas (NO) and nitrogen dioxide gas (NO₂) and many other gaseous oxides containing nitrogen. The main source of these gases in urban areas are motor vehicle exhaust and indoor gas stoves and kerosene heaters. The brown haze sometimes seen over cities is mainly nitrogen oxides. These gases are also partly responsible for the generation of ozone, which is produced when nitrogen oxides react with other chemicals in the presence of sunlight. Exposure to high levels of nitrogen dioxide can interfere with the ability of blood to carry oxygen, leading to dizziness and shortness of breath. Prolonged exposure can lead to respiratory failure.

Field: NOx Emission Factor Schedule Name

This schedule field is not currently implemented.

Field: N2O Emission Factor

The environmental impact coefficient for the Fuel for calculating the mass of nitrous oxide (N₂O) released into the atmosphere. The units are grams per MegaJoule. Relatively inert oxide of nitrogen produced as a result of microbial action in the soil, use of fertilizers containing nitrogen, burning of timber and coal, chemical industry, and so forth. This nitrogen compound may contribute to greenhouse and ozone-depleting effects.

Field: N2O Emission Factor Schedule Name

This schedule field is not currently implemented.

Field: SO2 Emission Factor

The environmental impact coefficient for the Fuel for calculating the mass of sulfur dioxide (SO₂) released into the atmosphere. The units are in grams per MegaJoule. Sulfur dioxide gas is formed when fuel containing sulfur, such as coal and oil, is burned, and when gasoline is extracted from oil, or metals are extracted from ore. Sulfur dioxide reacts with other chemicals in the air to form tiny sulfate particles, associated with increased respiratory symptoms and disease, difficulty in breathing, and premature death. Sulfur dioxide and nitrogen oxides react with other substances in the air to form acids, which fall to earth as rain, fog, snow, or dry particles. Acid rain damages forests and crops, changes the makeup of soil, and makes lakes and streams acidic and unsuitable for fish. Sulfur dioxide accelerates the decay of building materials and paints.

Field: SO2 Emission Factor Schedule Name

This schedule field is not currently implemented.

Field: PM Emission Factor

The environmental impact coefficient for the Fuel for calculating the mass of particulate matter (PM) released into the atmosphere. The units are grams per MegaJoule. PM is the sum of all particular matter emitted, including PM10 and PM2.5. Particulate matter, or PM, are particles found in the air, including dust, dirt, soot, smoke, and liquid droplets, which can be suspended in the air for long periods of time. Some particles are large or dark enough to be seen as soot or smoke. Others are so small that individually they can only be detected with an electron microscope. Breathing particulate matter is linked to significant respiratory health problems.

Field: PM Emission Factor Schedule Name

This schedule field is not currently implemented.

Field: PM10 Emission Factor

The environmental impact coefficient for the Fuel for calculating the mass of particulate matter 10 (PM₁₀) released into the atmosphere. The units are grams per MegaJoule. PM₁₀, includes particles with an aerodynamic diameter of less than 10 microns. These smaller particles are most likely responsible for the adverse health effects on humans because particles so small can reach the thoracic or lower regions of the respiratory tract.

Field: PM10 Emission Factor Schedule Name

This schedule field is not currently implemented.

Field: PM2.5 Emission Factor

The environmental impact coefficient for the Fuel for calculating the mass of particulate matter 2.5 (PM_{2.5}) released into the atmosphere. The units are grams per MegaJoule. EPA's national air quality standards for fine particles, also known as "PM_{2.5} standards," are levels allowed in the outdoor air for particulate matter 2.5 microns in diameter or smaller. EPA issued the PM_{2.5} standards in 1997 to protect human health and the environment. Studies have linked increased exposure to PM_{2.5} to increases in premature death as well as a range of serious respiratory and cardiovascular effects.

Field: PM2.5 Emission Factor Schedule Name

This schedule field is not currently implemented.

Field: NH3 Emission Factor

The Environmental impact coefficient for the Fuel for calculating the mass of ammonia (NH₃) released into the atmosphere. The units are grams per MegaJoule. Ammonia reacts with nitrogen and sulfur compounds in the atmosphere, mainly nitric and sulfuric acids, to form particulate matter.

Field: NH3 Emission Factor Schedule Name

This schedule field is not currently implemented.

Field: NMVOC Emission Factor

The Environmental impact coefficient for the Fuel for calculating the mass of non-methane volatile organic compounds (NMVOC) released into the atmosphere. The units are grams per MegaJoule. Non-methane volatile organic compounds (NMVOC), which include propane, butane, and ethane, are emitted primarily from transportation, industrial processes, and non-industrial consumption of organic solvents. Volatile organic compounds react with nitrogen oxides in the atmosphere to form ozone.

Field: NMVOC Emission Factor Schedule Name

This schedule field is not currently implemented.

Field: Hg Emission Factor

The Environmental impact coefficient for the Fuel for calculating the mass of mercury (Hg) released into the atmosphere. The units are grams per MegaJoule. This heavy metal can accumulate in the environment and is highly toxic if breathed or swallowed. In the U.S., primary sources of mercury air emissions are coal-fired power plants.

Field: Hg Emission Factor Schedule Name

This schedule field is not currently implemented.

Field: Pb Emission Factor

The Environmental impact coefficient for the Fuel for calculating the mass of lead (Pb) released into the atmosphere. The units are grams per MegaJoule. A heavy metal that is hazardous to health if breathed or swallowed. Its use in gasoline, paints, and plumbing compounds has been sharply restricted or eliminated by federal laws and regulations.

Field: Pb Emission Factor Schedule Name

This schedule field is not currently implemented.

Field: Waster Emission Factor

The environmental impact coefficient for the Fuel for calculating the volume of water (H₂O) consumed or evaporated in the generation of electricity. The units are liters per MegaJoule or a volume measurement. This is the water consumed in the production of the energy, ie. electricity off-site evaporated in cooling towers or scrubbers, or in the production or processing of the fuel itself, i.e., refinery for gasoline or diesel.

Field: Water Emission Factor Schedule Name

This schedule field is not currently implemented.

Field: Nuclear High Level Emission Factor

The environmental impact coefficient for the Fuel for calculating the mass of high-level nuclear waste, removed as spent nuclear fuel from a nuclear reactor once it no longer is efficient at powering the reactor.. The units are grams per MegaJoule. Once a year, approximately one-third of nuclear fuel is replaced with new fuel. This used fuel is called spent nuclear fuel and is highly radioactive; containing plutonium and other radionuclides. Although there is little information on quantities of high-level nuclear waste, a few utilities are beginning to publish this information.

Field: Nuclear High Level Emission Factor Schedule Name

This schedule field is not currently implemented.

Field: Nuclear Low Level Emission factor

The environmental impact coefficient for the Fuel for calculating the volume of low-level nuclear waste, removed from a nuclear reactor after radiation contamination. The units are cubic meters per MegaJoule or a volume measurement. Low-level waste can come from nuclear reactors or other users of radioactive material, like hospitals or research institutes. Low-level waste is less hazardous than high-level waste.

Field: Nuclear Low Level Emission Factor Schedule Name

This schedule field is not currently implemented.

The IDD definition for the FuelFactors object is:


```

FuelFactors,
  A1,  \field Existing Fuel Resource Name
        \type choice
        \key Electricity
        \key NaturalGas
        \key FuelOil#1
        \key FuelOil#2
        \key Coal
        \key Gasoline
        \key Propane
        \key Diesel
  A2,  \field Units of Measure
  N1,  \field Energy per Unit Factor
  N2,  \field Source Energy Factor
        \units J/J
  A3,  \field Source Energy Schedule Name
        \type object-list
        \object-list ScheduleNames
  N3,  \field CO2 Emission Factor
        \units g/MJ
  A4,  \field CO2 Emission Factor Schedule Name
        \type object-list
        \object-list ScheduleNames
  N4,  \field CO Emission Factor
        \units g/MJ
  A5,  \field CO Emission Factor Schedule Name
        \type object-list
        \object-list ScheduleNames
  N5,  \field CH4 Emission Factor
        \units g/MJ
  A6,  \field CH4 Emission Factor Schedule Name
        \type object-list
        \object-list ScheduleNames
  N6,  \field NOx Emission Factor
        \units g/MJ
  A7,  \field NOx Emission Factor Schedule Name
        \type object-list
        \object-list ScheduleNames
  N7,  \field N2O Emission Factor
        \units g/MJ
  A8,  \field N2O Emission Factor Schedule Name
        \type object-list
        \object-list ScheduleNames
  N8,  \field SO2 Emission Factor
        \units g/MJ
  A9,  \field SO2 Emission Factor Schedule Name
        \type object-list
        \object-list ScheduleNames
  N9,  \field PM Emission Factor
        \units g/MJ
  A10, \field PM Emission Factor Schedule Name
        \type object-list
        \object-list ScheduleNames
  N10, \field PM10 Emission Factor
        \units g/MJ
  A11, \field PM10 Emission Factor Schedule Name
        \type object-list
        \object-list ScheduleNames
  N11, \field PM2.5 Emission Factor
        \units g/MJ
  A12, \field PM2.5 Emission Factor Schedule Name
        \type object-list
        \object-list ScheduleNames
  N12, \field NH3 Emission Factor
        \units g/MJ
  A13, \field NH3 Emission Factor Schedule Name
        \type object-list
        \object-list ScheduleNames
  N13, \field NMVOC Emission Factor
        \units g/MJ
  A14, \field NMVOC Emission Factor Schedule Name

```

```

\type object-list
\object-list ScheduleNames
N14, \field Hg Emission Factor
\units g/MJ
A15, \field Hg Emission Factor Schedule Name
\type object-list
\object-list ScheduleNames
N15, \field Pb Emission Factor
\units g/MJ
A16, \field Pb Emission Factor Schedule Name
\type object-list
\object-list ScheduleNames
N16, \field Water Emission Factor
\units L/MJ
A17, \field Water Emission Factor Schedule Name
\type object-list
\object-list ScheduleNames
N17, \field Nuclear High Level Emission Factor
\units g/MJ
A18, \field Nuclear High Level Emission Factor Schedule Name
\type object-list
\object-list ScheduleNames
N18, \field Nuclear Low Level Emission Factor
\units m3/MJ
A19; \field Nuclear Low Level Emission Factor Schedule Name
\type object-list
\object-list ScheduleNames

```

An example of specifying in the IDF:

```

FuelFactors,          ! USA national average based on eGRID, EIA 1605
Electricity,         !- Existing Fuel Resource Name
kg,                  !- Units of Measure (kg or m3)
,                    !- Energy per Unit Factor
2.253,               !- Source Energy Factor {J/J}
,                    !- Source Energy Schedule Name
168.33317,           !- CO2 Emission Factor {g/MJ}
,                    !- CO2 Emission Factor Schedule Name
4.20616E-02,         !- CO Emission Factor {g/MJ}
,                    !- CO Emission Factor Schedule Name
1.39858E-03,         !- CH4 Emission Factor {g/MJ}
,                    !- CH4 Emission Factor Schedule Name
4.10753E-01,         !- NOx Emission Factor {g/MJ}
,                    !- NOx Emission Factor Schedule Name
2.41916E-03,         !- N2O Emission Factor {g/MJ}
,                    !- N2O Emission Factor Schedule Name
8.65731E-01,         !- SO2 Emission Factor {g/MJ}
,                    !- SO2 Emission Factor Schedule Name
2.95827E-02,         !- PM Emission Factor {g/MJ}
,                    !- PM Emission Factor Schedule Name
1.80450E-02,         !- PM10 Emission Factor {g/MJ}
,                    !- PM10 Emission Factor Schedule Name
1.15377E-02,         !- PM2.5 Emission Factor {g/MJ}
,                    !- PM2.5 Emission Factor Schedule Name
1.10837E-03,         !- NH3 Emission Factor {g/MJ}
,                    !- NH3 Emission Factor Schedule Name
3.72332E-03,         !- NMVOC Emission Factor {g/MJ}
,                    !- NMVOC Emission Factor Schedule Name
3.36414E-06,         !- Hg Emission Factor {g/MJ}
,                    !- Hg Emission Factor Schedule Name
0,                   !- Pb Emission Factor {g/MJ}
,                    !- Pb Emission Factor Schedule Name
2.10074,             !- Water Emission Factor {L/MJ}
,                    !- Water Emission Factor Schedule Name
0,                   !- Nuclear High Level Emission Factor {g/MJ}
,                    !- Nuclear High Level Emission Factor Schedule Name
0;                   !- Nuclear Low Level Emission Factor {m3/MJ}

```

And the following would appear in the standard meter output file:

```

378,1,Electricity:Facility [J] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
622,1,Diesel:Facility [J] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
766,1,Gas:Facility [J] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
971,1,CO2:Facility [kg] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
982,1,CO:Facility [kg] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
993,1,CH4:Facility [kg] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
1004,1,NOx:Facility [kg] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
1015,1,N2O:Facility [kg] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
1026,1,SO2:Facility [kg] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
1037,1,PM:Facility [kg] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
1048,1,PM10:Facility [kg] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
1059,1,PM2.5:Facility [kg] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
1070,1,NH3:Facility [kg] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
1081,1,NMVO:Facility [kg] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
1092,1,Hg:Facility [kg] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
1103,1,Pb:Facility [kg] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
1114,1,Water:Facility [L] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
1125,1,Nuclear High:Facility [kg] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
1136,1,Nuclear Low:Facility [m3] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]
1339,1,Carbon Equivalent:Facility [kg] !Monthly [Value,Min,Day,Hour,Minute,Max,Day,Hour,Minute]

```

What shows up in the output are the Energy Meters that were utilized in this particular input file, the pollutants, and the Total Carbon Equivalent. They show up in the meter output file and can be processed with a post processing program such as ReadVarsEso.exe to create a *.csv file or it is done automatically with EP Launch or the batch file.

Output:SQLite

Output from EnergyPlus can be written to SQLite files for manipulation outside some of the standard (such as spreadsheet) tools.

Currently, there are limited capabilities for specifying SQLite generation. The description for SQLite outputs is described in the Output Details document.

The IDD entry for this object follows.

```

Output:SQLite,
  \unique-object
A1 ; \field Option
  \type choice
  \key Simple
  \default Simple

```

And one includes it in the IDF using the following.

```
Output:SQLite, Simple;
```

Output

EnergyPlus produces several output files as shown in the section on “Running EnergyPlus”. This section will discuss the data contained in the “standard” output files (**eplusout.eso**, **eplusout.mtr**). They, too, have data dictionaries but unlike the input files, the output data dictionary is contained within the output file. Thus, the basic structure of the standard output file is:

```
Data Dictionary Information
End of Data Dictionary
Data
...
Data
End of Data
```

As with the IDF structure, there are rules associated with the interpretation of the standard output data dictionary. These rules are summarized as follows:

- The first item on each line is an integer which represents the “report code”. This “report code” will be listed in the data section where it will also be the first item on each line, identifying the data. Only 2 lines in the output file will not have an integer as the first item (“End of Data Dictionary” and “End of Data” lines).
- The second item on each line is also an integer. This integer corresponds to the number of items left on the dictionary line. Each string consists of a variable name and units in square brackets. Square brackets are required for all strings. If there are no units associated with a particular variable, then there are no characters between the brackets.

Six standard items appear at the start of every EnergyPlus Standard Output File Data Dictionary:

```
Program Version,EnergyPlus <version number indicated>
 1,5,Environment Title[],Latitude[degrees],Longitude[degrees],Time Zone[],Elevation[m]
 2,6,Day of Simulation[],Month[],Day of Month[],DST Indicator[1=yes 0=no],Hour[],StartMinute[],EndMinute[],DayType
 3,3,Cumulative Day of Simulation[],Month[],Day of Month[],DST Indicator[1=yes 0=no],DayType ! When Daily Report
Variables Requested
 4,2,Cumulative Days of Simulation[],Month[] ! When Monthly Report Variables Requested
 5,1,Cumulative Days of Simulation[] ! When Run Period Report Variables Requested
```

Item 0 is the program version statement.

Item 1 is produced at the beginning of each new “environment” (design day, run period).

Item 2 is produced prior to any variable reported at the timestep or hourly intervals. Hourly intervals will be shown with a start minute of 0.0 and an end minute of 60.0. Timestep intervals will show the appropriate start and end minutes.

Item 3 is produced prior to any variable reported at the daily interval.

Item 4 is produced prior to any variable reported at the monthly interval.

Item 5 is produced prior to any variable reported at the end of the “environment”.

Following these five standard lines will be the variables requested for reporting from the input file (ref. Report Variable). For example:

```
6,2,Environment,Outdoor Dry Bulb [C] !Hourly
21,2,ZONE ONE,Mean Air Temperature[C] !Hourly
22,2,ZONE ONE,Zone-Total Latent Gain[J] !Hourly
26,2,ZONE ONE,Zone-Total Electric Consumption[J] !Hourly
```

This example illustrates the non-consecutive nature of the “report codes”. Internally, EnergyPlus counts each variable that *could* be reported. This is the assigned “report code”. However, the user may not request each possible variable for reporting. Note that, currently, the requested reporting frequency is shown as a comment (!) line in the standard output file.

The data is produced when the actual simulation is performed (after the warmup days). Data output is simpler in format than the data dictionary lines. From the dictionary above:

```

1,DENVER COLORADO WINTER, 39.75,-104.87, -7.00,1610.26
2, 1, 1,21, 0, 1, 0.00,60.00,Monday
6,-17.22222
21,-17.22219
22,0.0000000E+00
26,0.0000000E+00
2, 1, 1,21, 0, 2, 0.00,60.00,Monday
6,-17.22222
21,-17.22219
22,0.0000000E+00
26,0.0000000E+00
2, 1, 1,21, 0, 3, 0.00,60.00,Monday
6,-17.22222
21,-17.22219
22,0.0000000E+00
26,0.0000000E+00
...
```

This output file can be easily turned into a form that is read into commonly used spreadsheet programs where it can be further analyzed, graphed, etc.

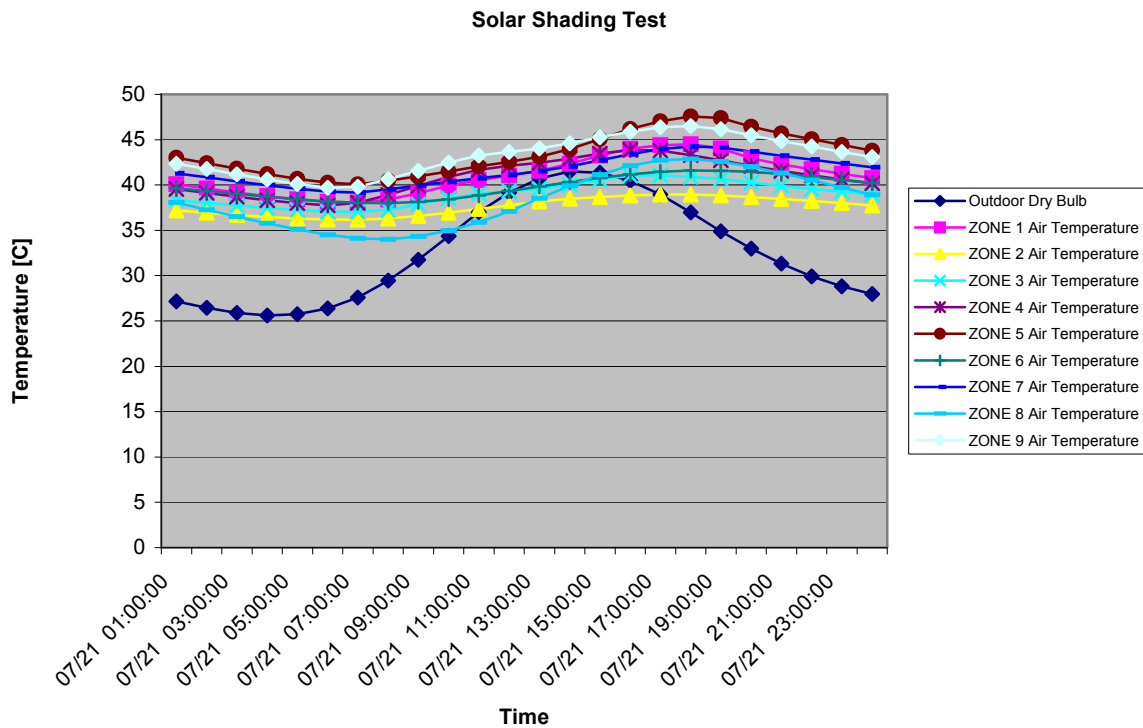


Figure 137. Example Chart from Standard Output File

Using "ReadVarsESO" (Creating Charts, etc. from Output Files)

The ReadVarsESO program is distributed with EnergyPlus as a simple approach to converting the standard output files (**eplusout.eso**, **eplusout.mtr**) into files that can be put directly into a spreadsheet program and then used to create graphs or do other statistical operations. ReadVarsESO can read the complex output files and sort the data into time-based form, it is a very quick application but does not have a lot of features. Note that all the **Output:Meter** objects are included on the **eplusout.eso** file as well as the **eplusout.mtr** file. You can choose the **Output:Meter:MeterFileOnly** object if you do not want a particular meter to show up on the **eplusout.eso** file. If you wish to see only the metered outputs, the **eplusout.mtr** file will typically be a lot smaller than the **eplusout.eso** file.

The ReadVarsESO program has a very simple set of inputs. By default, you will get all the variables listed in the Output:Variable (**eplusout.eso**) or Output:Meter (**eplusout.mtr**) objects into the appropriate output files. The outputs from ReadVarsESO are limited to 255 variables (Microsoft Excel™ limit). You can tailor how many variables to list by specifying variables for the ReadVarsESO runs.

You can override the 255 variable limit by specifying an argument on the command line (**EP-Launch** has a special option for this). You use "unlimited" or "nolimit" on the command line to get as many variables into your output file as desired. Again, this will be limited either by the number of variables in the **eplusout.eso** or **eplusout.mtr** files or the contents of the "rvi" file. If you want to use this option, you must include two arguments to the command line of the ReadVars program – 1) the "rvi" file and 2) the "unlimited" argument.

Table 37. ReadVarsESO Command Line Options

Option	Description
<filename>	To use any of these options, you must include a file name ("rvi" file) as the first argument.
Unlimited (or Nolimit)	Variables of any number will be produced on the output file.
Timestep	Only variables with reported frequency "timestep" (or detailed) will be produced on the output file.
Hourly	Only variables with reported frequency "hourly" will be produced on the output file.
Daily	Only variables with reported frequency "daily" will be produced on the output file.
Monthly	Only variables with reported frequency "monthly" will be produced on the output file.
Annual (or RunPeriod)	Only variables with reported frequency "runperiod" will be produced on the output file.

In addition, another argument can be used so that the output file is only one time frequency. (By default, all variables – hourly, monthly, annual, etc. are mixed together in the output file). By using "Timestep" as an argument, you would get only the TimeStep reported variables. Using "Monthly", only the monthly variables. This is not automated in either **EP-Launch** or the **RunEPlus** batch file but can easily be accomplished.

The program is run automatically from the **EP-Launch** program or the **RunEPlus** batch file (both these methods for executing EnergyPlus are described in the GettingStarted document). These programs use <filename>.rvi for input to the ReadVarsESO program executed first after the EnergyPlus execution and <filename>.mvi for the second execution. Ostensibly, the .rvi file would apply to the eplusout.eso file and the .mvi would apply to the eplusout.mtr file, BUT the contents of the files actually specify the "input" reporting file and the "output" reorganized file. Typical contents of an .rvi file are:

Table 38. "RVI" file contents

.rvi line description	Actual .rvi File Contents
Input File	eplusout.eso
Output File	eplusout.csv
Variable Name	Outdoor Dry Bulb
Variable Name	Zone/Sys Air Temp
Variable Name	Zone Air Humidity Ratio
Variable Name	Zone/Sys Sensible Cooling Rate

Variable Name	Zone/Sys Sensible Heating Rate
Variable Name	Zone-Total Latent Gain
Specific Variable Name	COOLING COIL AIR OUTLET NODE, System Node Temp
Specific Variable Name	AIR LOOP OUTLET NODE, System Node Temp
Specific Variable Name	AIR LOOP OUTLET NODE, System Node Humidity Ratio
Specific Variable Name	Mixed Air Node, System Node MassFlowRate
Specific Variable Name	Outdoor air Inlet Node, System Node MassFlowRate
Variable Name	Humidifier Water Consumption Rate
Variable Name	Humidifier Electric Power
Variable Name	Zone Air Relative Humidity
Variable Name	Zone/Sys Moisture Load Rate Predicted
Termination Line (optional)	0

Note that the first two lines of the file are "input file" (where to read the report variable values from) and "output file" (where to put the reorganized data). If you have only those two lines in an "rvi" file, the program will use all the available variables on indicated input file to produce the output.

ReadVarsESO takes the input stream but recognizes the date/time information and appropriately places the required data onto the "output file". Following these lines are a list of variables to be culled from the "input file" and placed onto the output file. "Variable Name" will take all variables matching that description whereas "Specific Variable Name" will only match the full description of the variable. So, in the above example, "Zone/Sys Air Temp" will report air temperatures for all the zones (but available at the HVAC timestep if you choose the "detailed" reporting frequency in your input file) but "AIR LOOP OUTLET NODE" and "COOLING COIL AIR OUTLET NODE" will be the only values reported for the "System Node Temp" variable (the node temperature is available for all nodes used in the simulation). The termination line (0) is included to terminate the input to the ReadVarsESO program and begin the scanning.

The output from ReadVarsESO is in the form commonly called "comma de-limited" or "comma separated variable". This format can be read easily in spreadsheet programs, such as Excel™.

Note as described in the "Input for Output" above, only variables as listed on the **eplusout.rdd** file are available for reporting. If you request others, they will become "Warning" messages in the **eplusout.err** file.

```
** Warning ** The following Report Variables were requested but not generated
**   ~~~   ** because IDF did not contain these elements or misspelled variable name -- check .rdd file
***** Key=*, VarName=SYSTEM SENSIBLE COOLING RATE
```

The above message was generated from an IDF that requested reporting of the "SYSTEM SENSIBLE COOLING RATE" but that variable was not available from the components in the execution.

Table 39. Example ReadVarsESO command lines and results

Command Line	Description/Result
ReadVarsESO	Take eplusout.eso and produce an eplusout.csv file with all variables (up to 255) on it

ReadVarsESO my.rvi	Use the contents of "my.rvi" to produce the appropriate output file (limited to 255 variables)
ReadVarsESO my.rvi unlimited	Use the contents of "my.rvi" to produce the appropriate output file (no longer limited to 255 variables)
ReadVarsESO my.rvi Monthly	Use the contents of "my.rvi" to produce the appropriate output file and only produce those variables reported for "monthly" frequency (up to 255 variables)
ReadVarsESO my.rvi Daily unlimited	Use the contents of "my.rvi" to produce the appropriate output file and only produce those variables reported for "daily" frequency (no longer limited to 255 variables)

Standard Output Reports

The following objects allow standard reports to be defined and utilized in EnergyPlus:

- Output:Table:TimeBins
- Output:Table:Monthly
- Output:Table:SummaryReports
- OutputControl:Table:Style

No Output:Meter or Output:Variable objects need to be specified to use the standard reports. A good set of example reports are available in the StandardReports.idf file in the DataSets directory of EnergyPlus.

Output:Table:TimeBins

The Output:Table:TimeBins report shows the amount of time in hours that occurs in different bins for the single specific variable or meter specified. Two different types of binning occur: by month and by hour of the day.

The IntervalStart, IntervalSize and IntervalCount determine the size of the bins for many of the types of reports that can be generated. The IntervalStart value is the lowest value of the first bin. The first bin is for all values greater or equal to IntervalStart and less than IntervalStart+IntervalSize. This gets repeated IntervalCount times. A bin for below the first interval and above the last interval is automatically created. Each table also has totals for the column and the rows. The report produced by Report:Table:TimeBins also indicates the total time simulated (for an annual simulation this would be 8760 hours).

NOTE: For summed variables, such as meters, the values are divided by the length of the timestep in seconds before binning. For example, the bins for a variable in Joules are reported in Joules per second (Watts). The interval values must then be entered accordingly.

Field: Key Value

The Key Value field indicates which instance of a variable is reported. An asterisk indicates that a table would be produced for every key.

Field: Variable Name

The variable name to be reported. Reference the eplusout.rdd file for names that are specific to your simulation input file. You do not need to include the units [] field in your names here.

Field: Interval Start

The lower value of the first bin. The first bin is for all values greater or equal to the IntervalStart and less than IntervalStart + IntervalSize. See note above regarding summed variables.

Field: Interval Size

The amount by which each bin range is to increase, i.e. the difference between the upper and lower limits of each bin. See note above regarding summed variables.

Field: Interval Count

The number of bins desired.

Field: Schedule Name

Optional schedule name. If left blank, binning is performed for all hours simulated. If a schedule is specified, binning is performed for non-zero hours in the schedule.

The IDD entry for this object follows.

```

Output:Table:TimeBins,
  \min-fields 5
  A1, \field Key Value
      \default *
      \note use '*' (without quotes) to apply this variable to all keys
  A2, \field Variable Name
      \required-field
      \type object-list
      \object-list autoRDDvariableMeter
  N1, \field Interval Start
      \type real
      \note The lowest value for the intervals being binned into.
  N2, \field Interval Size
      \type real
      \note The size of the bins starting with Interval start.
  N3, \field Interval Count
      \type integer
      \minimum 1
      \maximum 20
      \note The number of bins used. The number of hours below the start of the Lowest bin and above the
value of the last bin
      \note are also shown.
  A3; \field Schedule Name
      \type object-list
      \object-list ScheduleNames
      \note Optional schedule name. Binning is performed for non-zero hours. Binning always performed if
left blank.

```

An example of a time bins input object follows.

```

Output:Table:TimeBins,
*, ! Key Value
Electricity:HVAC, ! Variable Name
4000000, ! Interval Start
500000, ! Interval Size
20; ! Interval Count

```

Output:Table:Monthly

The Output:Table:Monthly object provides a generic method of setting up tables of monthly results. These tables are good for creating reports that broadly summarize the building performance. At the bottom of the tables, three rows are added for the sum or average depending on the type of variable, the maximum and the minimum of each column. The report produced has multiple columns that are each defined using a repeated group of fields. The fields for the variable name and the aggregation type can be repeated for any number of columns. A single Output:Table:Monthly object often produces multiple tables in the output. A table is produced for every “key” for a particular output variable. A single table of results shows values only for a specific “key”. The exception to this are environment variables, such as outdoor air temperature, that are included in each table, no matter what the key.

Field: Name

The Name field allows the user to give the output table a label that is shown in the output file.

Field: Digits After Decimal

The Digits After Decimal field is a numeric value that indicates how many digits after the decimal point should be shown on the table of values.

Field Set: Variable or Meter and Aggregation Type

The VariableOrMeterName field and the AggregationType field may be repeated for each column desired in the monthly report. These two fields define each column of the report. The IDD object has been set up to allow up to 25 columns. This object is extensible, so the number of columns may be increased by editing the IDD file and adding the desired number of fields at the end of the object.

Field: Variable or Meter <#> Name

The remainder of this input object consists of pairs of fields that can be repeated. Variable Or Meter Name fields contain the name of a variable (see Output:Variable and eplusout.rdd), meter (see Output:Meter and eplusout.mdd), or schedule. This value is shown on a monthly basis using the aggregation method specified. If the selected name is used for both a variable or a meter and a schedule name, the variable or meter will be used.

Field: Aggregation Type for Variable or Meter <#>

The aggregation type determines how the variable is aggregated in the table. The choices for aggregation type are described below:

Simple Aggregation Types

SumOrAverage – For “sum” type variables adds up the values for each timestep and reports the sum of the value monthly. For “average” type variables, the value shown will be the average for the month. SumOrAverage is probably the most common choice for aggregation type.

Maximum – Reports the maximum value and the time that the maximum value occurred. When the maximum option is used with a summed variable the value is divided by the length of the timestep in seconds. For example, the maximum for a variable in Joules is reported in Watts.

Minimum – Reports the minimum value and the time that the minimum value occurred. When the minimum option is used with a summed variable the value is divided by the length of the timestep in seconds. For example, the minimum for a variable in Joules is reported in Watts.

HoursNonZero – The HoursNonZero option adds up the elapsed time during the month that this variable is non-zero and would be appropriate to determine the number of hour that a fan operates.

HoursZero – The HoursZero option adds up the elapsed time during the month that this variable has a zero value and would be appropriate to determine the number of hour that a fan does not operate.

HoursPositive – The HoursPositive option adds up the elapsed time during the month that this variable has a positive value. Hours with a zero value are not included.

HoursNonPositive – The HoursNonPositive option adds up the elapsed time during the month that this variable has non-positive value. Hours with a negative value and hours with a zero value are all included.

HoursNegative – The HoursNegative option adds up the elapsed time during the month that this variable has a negative value. Hours with a zero value are not included.

HoursNonNegative – The HoursNonNegative option adds up the elapsed time during the month that this variable has non-negative value. Hours with a positive value and hours with a zero value are all included.

Advanced Aggregation Types

The advanced aggregation types are described below. These aggregation types rely on doing an operation on the current variable but only during the time or times defined by a previously defined field. The ValueWhenMaxOrMin displays the value of one variable at the same time as the maximum or minimum is set on a previous field that is defined as either a maximum or minimum. The “Hours—“ aggregation types display then number of hours that a variable meets a condition. The “—DuringHoursShown” aggregation types perform those aggregations but instead of for all the hours in the month, only for the hours that the previous “Hours—“ entry applies. Multiple “—DuringHoursShown” after an “Hours—“ will all be based on that single “Hours—“ entry, in fact the “—DuringHoursShown” is based on the next column to the left that contains an “Hours—“ entry even if other types of aggregations are used in intermediate columns. Order of the variables in the report is important when using the advanced aggregation types since they often depend on a previous entry.

ValueWhenMaximumOrMinimum – The ValueWhenMaximumOrMinimum option looks at the previous variable in the report that sets a maximum or minimum and displays the value of the current variable at that same timestep. Order of the variables in the report is important when using ValueWhenMaxMin. This can be used, for example, when an outdoor temperature should be reported for the time of the maximum cooling load.

SumOrAverageDuringHoursShown – Provides the sum or average of the named variable when during the hours that the previous variable displayed with any of the aggregation types starting with “Hours”. For “sum” type variables adds up the values for each timestep and reports the sum of the value monthly during the hours reported on the previous variable. For “average” type variables, the value shown will be the average for the month during the hours reported on the previous variable. Order of the variables in the report is important when using this aggregation type.

MaximumDuringHoursShown – Reports the maximum value and the time that the maximum value occurred but only during the hours reported with the previous “hours-“ aggregation type. When the maximum option is used with a summed variable the value is divided by the length of the timestep in seconds. For example, the maximum for a variable in Joules is reported in Watts. Order of the variables in the report is important when using this aggregation type.

MinimumDuringHoursShown - Reports the minimum value and the time that the minimum value occurred but only during the hours reported with the previous “hours-“ aggregation type. When the minimum option is used with a summed variable the value is divided by the length of the timestep in seconds. For example, the minimum for a variable in Joules is reported in Watts. Order of the variables in the report is important when using this aggregation type.

The IDD entry for this object follows.

```

Output:Table:Monthly,
  \extensible:2
  A1, \field Name
    \required-field
    \type alpha
    \reference StandardReportNames
  N1, \field Digits After Decimal
    \type integer
    \default 2
    \minimum 0
    \maximum 10
! The next two fields are repeated for each column
  A2, \field Variable or Meter 1 Name
    \type object-list
    \object-list autoRDDvariableMeter
    \note The name of a report variable or a meter that is available in the RDD file.
  A3, \field Aggregation Type for Variable or Meter 1
    \type choice
    \key SumOrAverage
    \key Maximum
    \key Minimum
    \key ValueWhenMaximumOrMinimum
    \key HoursNonZero
    \key HoursZero
    \key HoursPositive
    \key HoursNonPositive
    \key HoursNegative
    \key HoursNonNegative
    \key SumOrAverageDuringHoursShown
    \key MaximumDuringHoursShown
    \key MinimumDuringHoursShown
    \note The method of aggregation for the selected variable or meter.
    \note SumOrAverage adds up the values for every timestep in the month if the variable is a sum
variable. If the
    \note variable is an average variable it reports the average value. This is probably the most
common
    \note Aggregation Type option to choose.
    \note Maximum and Minimum find the maximum and minimum value for the month and report it along with
the
    \note time that it first occurred. When Maximum or Minimum are selected a column is
automatically shown
    \note in the output report for the time that it occurred. When Maximum or Minimum are used with
an average
    \note variable the value is divided by the length of the timestep.
    \note ValueWhenMaxMin looks at the previous variable in the report that sets a maximum or minimum
and
    \note displays the value of the current variable at that same timestep. Order of the variables
in the
    \note report is important when using ValueWhenMaxMin. This can be used when an outdoor
temperature
    \note should be reported for the time of the maximum cooling load.
    \note HoursNonZero adds up the elapsed time during the month that this variable is non-zero and
would
    \note be appropriate to determine the number of hour that a fan operates.
    \note HoursZero - The HoursZero option adds up the elapsed time during the month that this variable
has a zero
    \note value and would be appropriate to determine the number of hour that a fan does not operate.
    \note HoursPositive - The HoursPositive option adds up the elapsed time during the month that this
variable
    \note has a positive value. Hours with a zero value are not included.
    \note HoursNonPositive - The HoursNonPositive option adds up the elapsed time during the month
that this
    \note variable has non-positive value. Hours with a negative value and hours with a zero value
are all included.
    \note HoursNegative - The HoursNegative option adds up the elapsed time during the month that this
variable
    \note has a negative value. Hours with a zero value are not included.
    \note HoursNonNegative - The HoursNonNegative option adds up the elapsed time during the month
that this
    \note variable has non-negative value. Hours with a positive value and hours with a zero value
are all included.

```

```

    \note SumOrAverageDuringHoursShown - Provides the sum or average of the named variable when during
the hours
    \note that the previous variable displayed with any of the Aggregation Types starting with
"Hours". For "sum"
    \note type variables adds up the values for each timestep and reports the sum of the value
monthly during the
    \note hours reported on the previous variable. For "average" type variables, the value shown
will be the
    \note average for the month during the hours reported on the previous variable. Order of the
variables in the
    \note report is important when using this Aggregation Type.
    \note MaximumDuringHoursShown - Reports the maximum value and the time that the maximum value
occurred but only
    \note during the hours reported with the previous "hours-" Aggregation Type. When the Maximum
option is used
    \note with an average variable the value is divided by the length of the timestep. Order of the
variables in
    \note the report is important when using this Aggregation Type.
    \note MinimumDuringHoursShown - Reports the minimum value and the time that the minimum value
occurred but only
    \note during the hours reported with the previous "hours-" Aggregation Type. When the Minimum
option is used
    \note with an average variable the value is divided by the length of the timestep. Order of the
variables in
    \note the report is important when using this Aggregation Type.
<repeats>

```

An example of this object follows.

```

Output:Table:Monthly,
Building Monthly Cooling Load Report,          ! Name
3,                                              ! Digits After Decimal
Zone/Sys Sensible Cooling Energy,             ! Variable or Meter 1 Name
SumOrAverage,                                 ! Aggregation Type for Variable or Meter 1
Zone/Sys Sensible Cooling Energy,             ! Variable or Meter 2 Name
Maximum,                                       ! Aggregation Type for Variable or Meter 2
Outdoor Dry Bulb,                             ! Variable or Meter 3 Name
ValueWhenMaxMin;                              ! Aggregation Type for Variable or Meter 3

```

Output:Table:SummaryReports

The Output:Table:SummaryReports object controls which predefined tabular reports are produced. The easiest option is to specify "AllSummary" which will produce all of the summary reports described in this section. In addition, "AllMonthly" will produce all of the monthly reports described. If all predefined reports are needed. "AllSummaryAndMonthly" shows all of the summary and monthly predefined reports.

Field: Report <#> Name

All of the fields in the Output:Table:SummaryReports are the same. A long list of predefined summary reports is available by entering one of the available key choices described below. Each one indicates the name of the predefined reports that should be output. The input AllSummary will cause all the reports described below to be created. The Report <#> Name field can be repeated.

Predefined Annual Summary Reports

Annual Building Utility Performance Summary (or ABUPS)

The AnnualBuildingUtilityPerformanceSummary key produces a report that is an overall summary of the utility consumption of the building. It contains a number of subtables that are each described below.

- Site and Source Energy – Indicates the total site and source energy use. For electricity the net electricity from the utility is used for the electric contribution. The site to source conversion factors are based on those entered by the user. These are entered in the EnvironmentalImpactFactors object and FuelFactors objects.

- **Building Area** – Shows the total floorspace of the building and the conditioned floorspace.
- **End Uses** – This shows the total use of electricity, natural gas, other fuels, purchased cooling, purchased heating and water for each major end-use category. The end-use categories are Heating, Cooling, Interior Lighting, Exterior Lighting, Interior Equipment, Exterior Equipment, Fans, Pumps, Heat Rejection, Humidification, Heat Recovery, Hot Water, Refrigeration, and Generators. Not all fuels have corresponding end uses. The values in this sub-table are from report meters. The source of the resource does not affect this table – the amount of electricity used for lights does not change if the electricity is from the utility or from an on-site generator. The Other Fuel column includes fuel oil#1, fuel oil#2, gasoline, coal, propane and diesel. The district heating column also includes steam.
- **End Uses By Subcategory** – Shows a breakdown of the major end uses by user-defined category. If an end-use subcategory was not input for an object, it is automatically added to the General subcategory for that major end-use category.
- **Utility Use Per Floor Area** – These two sub-tables show the results from the end-uses table divided by the total floor area defined for the building and for the total conditioned floor area. Only three categories for end-uses are used for these sub-tables, lighting, HVAC and other. HVAC includes fans, pumps, heating, cooling, heat rejection, humidification, and domestic hot water heating. The Other Fuel column includes fuel oil#1, fuel oil#2, gasoline, coal, propane and diesel. The district heating column also includes steam.
- **Electric Loads Satisfied** – Shows the different methods that electric loads are satisfied in the building. The values shown for on site power generation are: Fuel-Fired Power Generation, High Temperature Geothermal, Photovoltaic Power, and Wind Power. The flows to and from the electric utility are shown next and finally the total electricity used at the site is compared to the total generated on site plus the net amount from the electric utility. The percentages shown are based on the total electricity used by the end-uses. Note that High Temperature Geothermal and Wind Power are not yet implemented in EnergyPlus.
- **On-Site Thermal Sources** – Shows the on-site thermal sources of energy such as Water-Side Heat Recovery, Air to Air Heat Recovery for Cooling, Air to Air Heat Recovery for Heating, High-Temperature Geothermal, Solar Water Thermal, Solar Air Thermal. Note that High-Temperature Geothermal Solar Water Thermal, and Solar Air Thermal are not yet implemented in EnergyPlus.
- **Water Loads Summary** – Shows the different methods the water loads were satisfied. This table shows all zeros because water use is not yet implemented in EnergyPlus.

Input Verification and Results Summary (or IVRS)

The InputVerificationandResultsSummary key produces a report with several tables including:

- **General** which includes general information like the Program Version and Build, Weather, Latitude, Longitude, Elevation, Time Zone, North Axis Angle, and Hours Simulated.
- **Window-Wall Ratio** table for envelope which includes the wall area, the window area and the ratio of the two. These are computed for all walls and for walls that are oriented generally north, south, east and west. All walls are categorized into one of these four cardinal directions. This is computed for walls that have a tilt of 60 degrees or more.
- **Skylight-Roof Ratio** table for envelope which includes the roof area and the skylight area and the ratio of the two. This includes all surfaces with a tilt of less than 60 degrees.

- Zone Summary includes internal load summary for each zone including area, if conditioned, volume, multipliers, gross wall area, window area, design lighting, design people, design plug and process.

Climate Summary

The ClimaticDataSummary key produces a report that includes some of the details on each of the design days including: maximum dry-bulb, daily temperature range, humidity value, humidity type, wind speed, and wind direction.

Envelope Summary

The EnvelopeSummary key produces a report that includes the following tables:

- Opaque which includes all opaque surfaces and includes the name of the construction, reflectance, U-Factor, gross area, azimuth, tilt, cardinal direction.
- Fenestration which includes all non-opaque surfaces and includes the name of the construction, area, U-Factor, SHGC – the sensible heat gain coefficient based on summer conditions, presence of an overhang, projection factor, overhang multiplier, adjusted SHGC, the name of the parent surface. Not all of these fields are currently functional.

Surface Shadowing Summary

The SurfaceShadowingSummary key produces a report that includes two tables. Note that surfaces starting with "Mir-" are automatically generated by EnergyPlus and are the mirror images of user entered surfaces.

- Surfaces (Walls, Roofs, etc) that may be Shadowed by Other Surfaces and includes the name of the surface and a list of surfaces that may possibly cast shadows on that named surface. The list of possible shadow casters does not necessarily mean that they do cast shadows during the simulation, only that their relative position makes it possible that shadows from a surface in the list may fall on the named surface.
- Subsurfaces (Windows and Doors) that may be Shadowed by Surfaces, includes the name of the subsurface such as a window or a door and a corresponding list of surfaces that may be casting shadows on the windows and doors.

Shading Summary

The ShadingSummary key produces a report that includes the following tables:

- Sunlit Fraction which shows a list of windows and the fraction of the window that is sunlit for nine specific times of the year. The nine specific times include 9am, noon and 3pm on March 21, June 21, and December 21. These nine times were chosen to represent the range of sun angles. The simulation must include those times for the value to be included in the report.
- Window control includes the names of all windows that have a window shading control (see WindowProperty:ShadingControl) and includes the name of the control, the type of shading, the shaded construction, the kind of control, and if glare control is used.

Lighting Summary

The LightingSummary key produces a report that includes the following tables:

- Interior Lighting which includes the name of the lights object, the zone that it is used in, the lighting power density, zone area, total power, end use subcategory, schedule name, average hours per week, return air fraction, and whether the zone is conditioned.
- Daylighting which includes the names of the daylighting objects, the zone they are used in, the type of daylighting being used, the control type, the fraction of the

lighting controlled, the total power of the lighting installed in the zone and the lighting power that is controlled by the daylighting object.

- Exterior Lighting which includes the name of the ExteriorLights object, the total watts described by the object, if the ExteriorLights uses an astronomical clock or just a schedule, the name of the schedule used, and the average hours per week for the named schedule for the year. The effect of the astronomical clock does not get included in the averaged hours per week shown.

Equipment Summary

The EquipmentSummary key produces a report that includes some details on the major HVAC equipment present. The report has four parts.

- Central Plant includes details on chillers, boilers, and cooling towers including the capacity and efficiency.
- DX Coils includes the capacity and efficiency for each DX coil.
- Fan includes the type of fan, the total efficiency, delta pressure, max flow rate, motor heat in air fraction, and end use.
- Service Water Heating includes the type of water heater, the storage volume, input, thermal efficiency, recovery efficiency, and energy factor.

HVAC Sizing Summary

The HVAC SizingSummary key produces a report that includes the following tables:

- Zone Cooling which includes the following columns for each zone: the design load, the calculated design air flow, the user specified design air flow, the name of the design day, the time of the peak load during the design day, the temperature at the time of the peak load during the design day, and the humidity ratio at the time of the peak load during the design day.
- Zone Heating which includes the following columns for each zone: the design load, the calculated design air flow, the user specified design air flow, the name of the design day, the time of the peak load during the design day, the temperature at the time of the peak load during the design day, and the humidity ratio at the time of the peak load during the design day.
- System Design Air Flow Rates which includes the following columns for each air loop: the calculated cooling air flow rate, the user specified air flow rate for cooling, the calculated heating air flow rate, the user specified air flow rate for heating.

Component Sizing Summary

The ComponentSizingSummary key produces a report that includes different tables depending on the kinds of HVAC components that exist in the input file. A table is shown for each type of HVAC component that is sized. The table lists the objects of that type of component that appear in the input file and one or more parameters related to that component. For example, the AirTerminal:SingleDuct:VAV:Reheat component creates a table showing the maximum air flow rate from the sizing calculations and the maximum reheat water flow rate. Another example is the Fan:VariableVolume object which shows a table with both the maximum and minimum flow rates for each fan based on the results from the sizing calculations.

Outdoor Air Summary

The OutdoorAirSummary key produces a report that includes the following tables:

- Average Outside Air During Occupied Hours table shows for each zone the average and nominal number of occupants, the zone volume, the average air change rate based on mechanical ventilation, infiltration and simple ventilation during occupied hours.

- Minimum Outside Air During Occupied Hours table shows for each zone the average and nominal number of occupants, the zone volume, the minimum air change rate based on mechanical ventilation, infiltration and simple ventilation during occupied hours.

System Summary

The SystemSummary key produces a report that includes the following tables:

- Economizer which includes the following columns for each Controller:OutdoorAir object: the high limit shutoff control, the minimum outdoor air flow, the maximum outdoor air flow, if the return air temperature has a control limit, if the return air has an enthalpy limit, the outdoor air temperature limit, and the outdoor air enthalpy limit.
- Demand Controlled Ventilation table is for each Controller:MechanicalVentilation object and shows the name, the nominal outdoor air per person and the nominal outdoor air per zone area.
- Time Not Comfortable Based on Simple ASHRAE 55-2004 table shows how many hours that the space is not comfortable for each zone under the criteria of assuming winter clothes, summer clothes or both summer and winter clothes. See the People object for more information about this thermal comfort calculation.
- Time Setpoint is Not Met table shows how many hours the space is more than 0.2C from the setpoint during heating and during cooling. The last two columns indicate those hours that the setpoint is not met while the space is occupied.

Predefined Monthly Summary Reports

The predefined monthly report options are shown below. The key name of the predefined monthly report is all that is needed to have that report appear in the tabular output file. After each report name below are the report variables and aggregation types used. These cannot be modified when using the predefined reports but if changes are desired, a Output:Table:Monthly can be used instead. The StandardReports.idf file in the DataSets directory includes a Output:Table:Monthly that exactly corresponds to the predefined monthly reports shown below. They can be copied into an IDF file and extended if additional variables are desired. A listing of each available key for predefined monthly summary reports follows with a description of the variables included.

ZoneCoolingSummaryMonthly

- Zone/Sys Sensible Cooling Energy (SumOrAverage)
- Zone/Sys Sensible Cooling Rate (Maximum)
- Outdoor Dry Bulb (ValueWhenMaxMin)
- Outdoor Wet Bulb (ValueWhenMaxMin)
- Zone Total Internal Latent Gain (SumOrAverage)
- Zone Total Internal Latent Gain (Maximum)
- Outdoor Dry Bulb (ValueWhenMaxMin)
- Outdoor Wet Bulb (ValueWhenMaxMin)

ZoneHeatingSummaryMonthly

- Zone/Sys Sensible Heating Energy (SumOrAverage)
- Zone/Sys Sensible Heating Rate (Maximum)
- Outdoor Dry Bulb (ValueWhenMaxMin)

ZoneElectricSummaryMonthly

- Zone Lights Electric Consumption (SumOrAverage)

- Zone Lights Electric Consumption (Maximum)
- Zone Electric Equipment Electric Consumption (SumOrAverage)
- Zone Electric Equipment Electric Consumption (Maximum)

SpaceGainsMonthly

- Zone People Total Heat Gain (SumOrAverage)
- Zone Lights Total Heat Gain (SumOrAverage)
- Zone Electric Equipment Total Heat Gain (SumOrAverage)
- Zone Gas Equipment Total Heat Gain (SumOrAverage)
- Zone Hot Water Equipment Total Heat Gain (SumOrAverage)
- Zone Steam Equipment Total Heat Gain (SumOrAverage)
- Zone Other Equipment Total Heat Gain (SumOrAverage)
- Zone Infiltration Sensible Heat Gain (SumOrAverage)
- Zone Infiltration Sensible Heat Loss (SumOrAverage)

PeakSpaceGainsMonthly

- Zone People Total Heat Gain (Maximum)
- Zone Lights Total Heat Gain (Maximum)
- Zone Electric Equipment Total Heat Gain (Maximum)
- Zone Gas Equipment Total Heat Gain (Maximum)
- Zone Hot Water Equipment Total Heat Gain (Maximum)
- Zone Steam Equipment Total Heat Gain (Maximum)
- Zone Other Equipment Total Heat Gain (Maximum)
- Zone Infiltration Sensible Heat Gain (Maximum)
- Zone Infiltration Sensible Heat Loss (Maximum)

SpaceGainComponentsAtCoolingPeakMonthly

- Zone/Sys Sensible Cooling Rate (Maximum)
- Zone People Total Heat Gain (ValueWhenMaxMin)
- Zone Lights Total Heat Gain (ValueWhenMaxMin)
- Zone Electric Equipment Total Heat Gain (ValueWhenMaxMin)
- Zone Gas Equipment Total Heat Gain (ValueWhenMaxMin)
- Zone Hot Water Equipment Total Heat Gain (ValueWhenMaxMin)
- Zone Steam Equipment Total Heat Gain (ValueWhenMaxMin)
- Zone Other Equipment Total Heat Gain (ValueWhenMaxMin)
- Zone Infiltration Sensible Heat Gain (ValueWhenMaxMin)
- Zone Infiltration Sensible Heat Loss (ValueWhenMaxMin)

EnergyConsumptionElectricityNaturalGasMonthly

- Electricity:Facility (SumOrAverage)
- Electricity:Facility (Maximum)
- Gas:Facility (SumOrAverage)
- Gas:Facility (Maximum)

EnergyConsumptionElectricityGeneratedPropaneMonthly

- ElectricityProduced:Facility (SumOrAverage)
- ElectricityProduced:Facility (Maximum)

- Propane:Facility (SumOrAverage)
- Propane:Facility (Maximum)

EnergyConsumptionDieselFuel OilMonthly

- Diesel:Facility (SumOrAverage)
- Diesel:Facility (Maximum)
- FuelOil#1:Facility (SumOrAverage)
- FuelOil#1:Facility (Maximum)
- FuelOil#2:Facility (SumOrAverage)
- FuelOil#2:Facility (Maximum)

EnergyConsumptionDisctrictHeating & Cooling Monthly

- DistrictCooling:Facility (SumOrAverage)
- DistrictCooling:Facility (Maximum)
- DistrictHeating:Facility (SumOrAverage)
- DistrictHeating:Facility (Maximum)

EnergyConsumptionCoalGasoline Monthly

- COAL:Facility (SumOrAverage)
- COAL:Facility (Maximum)
- GASOLINE:Facility (SumOrAverage)
- GASOLINE:Facility (Maximum)

EndUseEnergyConsumptionElectricityMonthly

- InteriorLights:Electricity (SumOrAverage)
- ExteriorLights:Electricity (SumOrAverage)
- InteriorEquipment:Electricity (SumOrAverage)
- ExteriorEquipment:Electricity (SumOrAverage)
- Fans:Electricity (SumOrAverage)
- Pumps:Electricity (SumOrAverage)
- Heating:Electricity (SumOrAverage)
- Cooling:Electricity (SumOrAverage)
- HeatRejection:Electricity (SumOrAverage)
- Humidifier:Electricity (SumOrAverage)
- HeatRecovery:Electricity (SumOrAverage)
- WaterSystems:Electricity (SumOrAverage)
- Cogeneration:Electricity (SumOrAverage)

EndUseEnergyConsumptionNaturalGasMonthly

- InteriorEquipment:Gas (SumOrAverage)
- ExteriorEquipment:Gas (SumOrAverage)
- Heating:Gas (SumOrAverage)
- Cooling:Gas (SumOrAverage)
- WaterSystems:Gas (SumOrAverage)
- Cogeneration:Gas (SumOrAverage)

EndUseEnergyConsumptionDieselMonthly

- ExteriorEquipment:Diesel (SumOrAverage)

- Cooling:Diesel (SumOrAverage)
- Heating:Diesel (SumOrAverage)
- WaterSystems:Diesel (SumOrAverage)
- Cogeneration:Diesel (SumOrAverage)

EndUseEnergyConsumptionFuelOilMonthly

- ExteriorEquipment:FuelOil#1 (SumOrAverage)
- Cooling:FuelOil#1 (SumOrAverage)
- Heating:FuelOil#1 (SumOrAverage)
- WaterSystems:FuelOil#1 (SumOrAverage)
- Cogeneration:FuelOil#1 (SumOrAverage)
- ExteriorEquipment:FuelOil#2 (SumOrAverage)
- Cooling:FuelOil#2 (SumOrAverage)
- Heating:FuelOil#2 (SumOrAverage)
- WaterSystems:FuelOil#2 (SumOrAverage)
- Cogeneration:FuelOil#2 (SumOrAverage)

EndUseEnergyConsumptionCoalMonthly

- ExteriorEquipment:Coal (SumOrAverage)
- Heating:Coal (SumOrAverage)
- WaterSystems:Coal (SumOrAverage)

EndUseEnergyConsumptionPropaneMonthly

- ExteriorEquipment:Propane (SumOrAverage)
- Cooling:Propane (SumOrAverage)
- Heating:Propane (SumOrAverage)
- WaterSystems:Propane (SumOrAverage)
- Cogeneration:Propane (SumOrAverage)

EndUseEnergyConsumptionGasolineMonthly

- ExteriorEquipment:Gasoline (SumOrAverage)
- Cooling:Gasoline (SumOrAverage)
- Heating:Gasoline (SumOrAverage)
- WaterSystems:Gasoline (SumOrAverage)
- Cogeneration:Gasoline (SumOrAverage)

PeakEnergyEndUseElectricityPart1Monthly

- InteriorLights:Electricity (Maximum)
- ExteriorLights:Electricity (Maximum)
- InteriorEquipment:Electricity (Maximum)
- ExteriorEquipment:Electricity (Maximum)
- Fans:Electricity (Maximum)
- Pumps:Electricity (Maximum)
- Heating:Electricity (Maximum)

PeakEnergyEndUseElectricityPart2Monthly

- Cooling:Electricity (Maximum)
- HeatRejection:Electricity (Maximum)

- Humidifier:Electricity (Maximum)
- HeatRecovery:Electricity (Maximum)
- WaterSystems:Electricity (Maximum)
- Cogeneration:Electricity (Maximum)

ElectricComponentsOfPeakDemandMonthly

- Electricity:Facility (Maximum)
- InteriorLights:Electricity (ValueWhenMaxMin)
- InteriorEquipment:Electricity (ValueWhenMaxMin)
- ExteriorLights:Electricity (ValueWhenMaxMin)
- ExteriorEquipment:Electricity (ValueWhenMaxMin)
- Fans:Electricity (ValueWhenMaxMin)
- Pumps:Electricity (ValueWhenMaxMin)
- Heating:Electricity (ValueWhenMaxMin)
- Cooling:Electricity (ValueWhenMaxMin)
- HeatRejection:Electricity (ValueWhenMaxMin)

PeakEnergyEndUseNaturalGasMonthly

- InteriorEquipment:Gas (Maximum)
- ExteriorEquipment:Gas (Maximum)
- Heating:Gas (Maximum)
- Cooling:Gas (Maximum)
- WaterSystems:Gas (Maximum)
- Cogeneration:Gas (Maximum)

PeakEnergyEndUseDieselMonthly

- ExteriorEquipment:Diesel (Maximum)
- Cooling:Diesel (Maximum)
- Heating:Diesel (Maximum)
- WaterSystems:Diesel (Maximum)
- Cogeneration:Diesel (Maximum)

PeakEnergyEndUseFuelOilMonthly

- ExteriorEquipment:FuelOil#1 (Maximum)
- Cooling:FuelOil#1 (Maximum)
- Heating:FuelOil#1 (Maximum)
- WaterSystems:FuelOil#1 (Maximum)
- Cogeneration:FuelOil#1 (Maximum)
- ExteriorEquipment:FuelOil#2 (Maximum)
- Cooling:FuelOil#2 (Maximum)
- Heating:FuelOil#2 (Maximum)
- WaterSystems:FuelOil#2 (Maximum)
- Cogeneration:FuelOil#2 (Maximum)

PeakEnergyEndUseCoalMonthly

- ExteriorEquipment:Coal (Maximum)
- Heating:Coal (Maximum)

- WaterSystems:Coal (Maximum)

PeakEnergyEndUsePropaneMonthly

- ExteriorEquipment:Propane (Maximum)
- Cooling:Propane (Maximum)
- Heating:Propane (Maximum)
- WaterSystems:Propane (Maximum)
- Cogeneration:Propane (Maximum)

PeakEnergyEndUseGasolineMonthly

- ExteriorEquipment:Gasoline (Maximum)
- Cooling:Gasoline (Maximum)
- Heating:Gasoline (Maximum)
- WaterSystems:Gasoline (Maximum)
- Cogeneration:Gasoline (Maximum)

SetpointsNotMetWithTemperaturesMonthly

- Time Heating Setpoint Not Met (HoursNonZero)
- Zone Mean Air Temperature (SumOrAverageDuringHoursShown)
- Time Heating Setpoint Not Met While Occupied (HoursNonZero)
- Zone Mean Air Temperature (SumOrAverageDuringHoursShown)
- Time Cooling Setpoint Not Met (HoursNonZero)
- Zone Mean Air Temperature (SumOrAverageDuringHoursShown)
- Time Cooling Setpoint Not Met While Occupied (HoursNonZero)
- Zone Mean Air Temperature (SumOrAverageDuringHoursShown)

ComfortReportSimple55Monthly

- Time Not Comfortable Summer Clothes (HoursNonZero)
- Zone Mean Air Temperature (SumOrAverageDuringHoursShown)
- Time Not Comfortable Winter Clothes (HoursNonZero)
- Zone Mean Air Temperature (SumOrAverageDuringHoursShown)
- Time Not Comfortable Summer Or Winter Clothes (HoursNonZero)
- Zone Mean Air Temperature (SumOrAverageDuringHoursShown)

UnglazedTranspiredSolarCollectorSummaryMonthly

- UTSC Overall Efficiency (HoursNonZero)
- UTSC Overall Efficiency (SumOrAverageDuringHoursShown)
- UTSC Average Suction Face Velocity (SumOrAverageDuringHoursShown)
- UTSC Sensible Heating Rate (SumOrAverageDuringHoursShown)

OccupantComfortDataSummaryMonthly

- Zone People Number Of Occupants (HoursNonZero)
- Zone/Sys Air Temperature (SumOrAverageDuringHoursShown)
- Zone Air Relative Humidity (SumOrAverageDuringHoursShown)
- FANGERPMV (SumOrAverageDuringHoursShown)

Chille ReportMonthly

- Chiller Electric Consumption (SumOrAverage)

- Chiller Electric Power (Maximum)
- Chiller Electric Consumption (HoursNonZero)
- Chiller Evap Heat Trans (SumOrAverage)
- Chiller Cond Heat Trans (SumOrAverage)
- Chiller COP (SumOrAverage)
- Chiller COP (Maximum)

TowerReportMonthly

- Tower Fan Electric Consumption (SumOrAverage)
- Tower Fan Electric Consumption (HoursNonZero)
- Tower Fan Electric Power (Maximum)
- Tower Heat Transfer (Maximum)
- Tower Water Inlet Temp (SumOrAverage)
- Tower Water Outlet Temp (SumOrAverage)
- Tower Water Mass Flow Rate (SumOrAverage)

BoilerReportMonthly

- Boiler Heating Output Energy (SumOrAverage)
- Boiler Gas Consumption (SumOrAverage)
- Boiler Heating Output Energy (HoursNonZero)
- Boiler Heating Output Rate (Maximum)
- Boiler Gas Consumption Rate (Maximum)
- Boiler Water Inlet Temp (SumOrAverage)
- Boiler Water Outlet Temp (SumOrAverage)
- Boiler Water Mass Flow Rate (SumOrAverage)
- Boiler Parasitic Electric Consumption Rate (SumOrAverage)

DXReportMonthly

- DX Coil Total Cooling Energy (SumOrAverage)
- DX Cooling Coil Electric Consumption (SumOrAverage)
- DX Coil Total Cooling Energy (HoursNonZero)
- DX Coil Sensible Cooling Energy (SumOrAverage)
- DX Coil Latent Cooling Energy (SumOrAverage)
- DX Cooling Coil Crankcase Heater Consumption (SumOrAverage)
- DX Cooling Coil Runtime Fraction (Maximum)
- DX Cooling Coil Runtime Fraction (Minimum)
- DX Coil Total Cooling Rate (Maximum)
- DX Coil Sensible Cooling Rate (Maximum)
- DX Coil Latent Cooling Rate (Maximum)
- DX Cooling Coil Electric Power (Maximum)
- DX Cooling Coil Crankcase Heater Power (Maximum)

WindowReportMonthly

- Window Transmitted Solar (SumOrAverage)
- Window Transmitted Beam Solar (SumOrAverage)
- Window Transmitted Diffuse Solar (SumOrAverage)
- Window Heat Gain (SumOrAverage)

- Window Heat Loss (SumOrAverage)
- Inside Glass Condensation Flag (HoursNonZero)
- Fraction of Time Shading Device Is On (HoursNonZero)
- Storm Window On/Off Flag (HoursNonZero)

WindowEnergyReportMonthly

- Window Transmitted Solar Energy (SumOrAverage)
- Window Transmitted Beam Solar Energy (SumOrAverage)
- Window Transmitted Diffuse Solar Energy (SumOrAverage)
- Window Heat Gain Energy (SumOrAverage)
- Window Heat Loss Energy (SumOrAverage)

WindowZoneSummaryMonthly

- Zone Window Heat Gain (SumOrAverage)
- Zone Window Heat Loss (SumOrAverage)
- Zone Transmitted Solar (SumOrAverage)
- Zone Beam Solar from Exterior Windows (SumOrAverage)
- Zone Diff Solar from Exterior Windows (SumOrAverage)
- Zone Diff Solar from Interior Windows (SumOrAverage)
- Zone Beam Solar from Interior Windows (SumOrAverage)

WindowEnergyZoneSummaryMonthly

- Zone Window Heat Gain Energy (SumOrAverage)
- Zone Window Heat Loss Energy (SumOrAverage)
- Zone Transmitted Solar Energy (SumOrAverage)
- Zone Beam Solar from Exterior Windows Energy (SumOrAverage)
- Zone Diff Solar from Exterior Windows Energy (SumOrAverage)
- Zone Diff Solar from Interior Windows Energy (SumOrAverage)
- Zone Beam Solar from Interior Windows Energy (SumOrAverage)

AverageOutdoorConditionsMonthly

- Outdoor Dry Bulb (SumOrAverage)
- Outdoor Wet Bulb (SumOrAverage)
- Outdoor Dew Point (SumOrAverage)
- Wind Speed (SumOrAverage)
- Sky Temperature (SumOrAverage)
- Diffuse Solar (SumOrAverage)
- Direct Solar (SumOrAverage)
- Raining (SumOrAverage)

OutdoorConditionsMaximumDryBulbMonthly

- Outdoor Dry Bulb (Maximum)
- Outdoor Wet Bulb (ValueWhenMaxMin)
- Outdoor Dew Point (ValueWhenMaxMin)
- Wind Speed (ValueWhenMaxMin)
- Sky Temperature (ValueWhenMaxMin)
- Diffuse Solar (ValueWhenMaxMin)

- Direct Solar (ValueWhenMaxMin)

Outdoor Conditions Minimum Dry Bulb Monthly

- Outdoor Wet Bulb (ValueWhenMaxMin)
- Outdoor Dew Point (ValueWhenMaxMin)
- Wind Speed (ValueWhenMaxMin)
- Sky Temperature (ValueWhenMaxMin)
- Diffuse Solar (ValueWhenMaxMin)
- Direct Solar (ValueWhenMaxMin)

Outdoor Conditions Maximum Wet Bulb Monthly

- Outdoor Wet Bulb (Maximum)
- Outdoor Dry Bulb (ValueWhenMaxMin)
- Outdoor Dew Point (ValueWhenMaxMin)
- Wind Speed (ValueWhenMaxMin)
- Sky Temperature (ValueWhenMaxMin)
- Diffuse Solar (ValueWhenMaxMin)
- Direct Solar (ValueWhenMaxMin)

Outdoor Conditions Maximum Dew Point Monthly

- Outdoor Dew Point (Maximum)
- Outdoor Dry Bulb (ValueWhenMaxMin)
- Outdoor Wet Bulb (ValueWhenMaxMin)
- Wind Speed (ValueWhenMaxMin)
- Sky Temperature (ValueWhenMaxMin)
- Diffuse Solar (ValueWhenMaxMin)
- Direct Solar (ValueWhenMaxMin)

Outdoor Ground Conditions Monthly

- Ground Temperature (SumOrAverage)
- Surface Ground Temperature (SumOrAverage)
- Deep Ground Temperature (SumOrAverage)
- Water Mains Temperature (SumOrAverage)
- Ground Reflected Solar (SumOrAverage)
- Snow On Ground (SumOrAverage)

Window AC Report Monthly

- Window AC Total Zone Cooling Energy (SumOrAverage)
- Window AC Electric Consumption (SumOrAverage)
- Window AC Total Zone Cooling Energy (HoursNonZero)
- Window AC Sensible Zone Cooling Energy (SumOrAverage)
- Window AC Latent Zone Cooling Energy (SumOrAverage)
- Window AC Total Zone Cooling Rate (Maximum)
- Window AC Sensible Zone Cooling Rate (ValueWhenMaxMin)
- Window AC Latent Zone Cooling Rate (ValueWhenMaxMin)
- Window AC Electric Power (ValueWhenMaxMin)

WaterHeaterReportMonthly

- Water Heater Total Demand Energy (SumOrAverage)
- Water Heater Use Energy (SumOrAverage)
- Water Heater Burner Heating Energy (SumOrAverage)
- Water Heater Gas Consumption (SumOrAverage)
- Water Heater Total Demand Energy (HoursNonZero)
- Water Heater Loss Demand Energy (SumOrAverage)
- Water Heater Loss Energy (SumOrAverage)
- Water Heater Tank Temperature (SumOrAverage)
- Water Heater Heat Recovery Supply Energy (SumOrAverage)
- Water Heater Source Energy (SumOrAverage)

GeneratorReportMonthly

- Generator Electric Energy Produced (SumOrAverage)
- Generator Diesel Consumption (SumOrAverage)
- Generator Gas Consumption (SumOrAverage)
- Generator Electric Energy Produced (HoursNonZero)
- Generator Total Heat Recovery (SumOrAverage)
- Generator Jacket Heat Recovery (SumOrAverage)
- Generator Lube Heat Recovery (SumOrAverage)
- Generator Exhaust Heat Recovery (SumOrAverage)
- Generator Exhaust Stack Temp (SumOrAverage)

DaylightingReportMonthly

- Exterior Beam Normal Illuminance (HoursNonZero)
- Ltg Power Multiplier from Daylighting (SumOrAverageDuringHoursShown)
- Ltg Power Multiplier from Daylighting (MinimumDuringHoursShown)
- Daylight Illum at Ref Point 1 (SumOrAverageDuringHoursShown)
- Glare Index at Ref Point 1 (SumOrAverageDuringHoursShown)
- Daylight Illum at Ref Point 2 (SumOrAverageDuringHoursShown)
- Glare Index at Ref Point 2 (SumOrAverageDuringHoursShown)

CoilReportMonthly

- Total Water Heating Coil Energy (SumOrAverage)
- Total Water Heating Coil Rate (Maximum)
- Total Water Cooling Coil Energy (SumOrAverage)
- Sensible Water Cooling Coil Energy (SumOrAverage)
- Total Water Cooling Coil Rate (Maximum)
- Sensible Water Cooling Coil Rate (ValueWhenMaxMin)
- Cooling Coil Area Wet Fraction (SumOrAverage)

PlantLoopDemandReportMonthly

- Plant Loop Cooling Demand (SumOrAverage)
- Plant Loop Cooling Demand (Maximum)
- Plant Loop Heating Demand (SumOrAverage)
- Plant Loop Heating Demand (Maximum)

FanReportMonthly

- Fan Electric Consumption (SumOrAverage)
- Fan Delta Temp (SumOrAverage)
- Fan Electric Power (Maximum)
- Fan Delta Temp (ValueWhenMaxMin)

PumpReportMonthly

- Pump Electric Consumption (SumOrAverage)
- Pump Heat To Fluid Energy (SumOrAverage)
- Pump Electric Power (Maximum)
- Pump Shaft Power (ValueWhenMaxMin)
- Pump Heat To Fluid (ValueWhenMaxMin)
- Pump Outlet Temp (ValueWhenMaxMin)
- Pump Mass Flow Rate (ValueWhenMaxMin)

CondLoopDemandReportMonthly

- Cond Loop Cooling Demand (SumOrAverage)
- Cond Loop Cooling Demand (Maximum)
- Cond Loop Inlet Temp (ValueWhenMaxMin)
- Cond Loop Outlet Temp (ValueWhenMaxMin)
- Cond Loop Heating Demand (SumOrAverage)
- Cond Loop Heating Demand (Maximum)

ZoneTemperatureOscillationReportMonthly

- Time Zone Temperature Oscillating (HoursNonZero)
- Zone People Number Of Occupants (SumOrAverageDuringHoursShown)

AirLoopSystemEnergyAndWaterUseMonthly

- Air Loop Hot Water Consumption (SumOrAverage)
- Air Loop Steam Consumption (SumOrAverage)
- Air Loop Chilled Water Consumption (SumOrAverage)
- Air Loop Electric Consumption (SumOrAverage)
- Air Loop Gas Consumption (SumOrAverage)
- Air Loop Water Consumption (SumOrAverage)

AirLoopSystemComponentLoadsMonthly

- Air Loop Fan Heating Energy (SumOrAverage)
- Air Loop Total Cooling Coil Energy (SumOrAverage)
- Air Loop Total Heating Coil Energy (SumOrAverage)
- Air Loop Total Heat Exchanger Heating Energy (SumOrAverage)
- Air Loop Total Heat Exchanger Cooling Energy (SumOrAverage)
- Air Loop Total Humidifier Heating Energy (SumOrAverage)
- Air Loop Total Evap Cooler Cooling Energy (SumOrAverage)
- Air Loop Total Desiccant Dehumidifier Cooling Energy (SumOrAverage)

AirLoopSystemComponentEnergyUseMonthly

- Air Loop Fan Electric Consumption (SumOrAverage)

- Air Loop Heating Coil Hot Water Consumption (SumOrAverage)
- Air Loop Cooling Coil Chilled Water Consumption (SumOrAverage)
- Air Loop DX Heating Coil Electric Consumption (SumOrAverage)
- Air Loop DX Cooling Coil Electric Consumption (SumOrAverage)
- Air Loop Heating Coil Electric Consumption (SumOrAverage)
- Air Loop Heating Coil Gas Consumption (SumOrAverage)
- Air Loop Heating Coil Steam Consumption (SumOrAverage)
- Air Loop Humidifier Electric Consumption (SumOrAverage)
- Air Loop Evap Cooler Electric Consumption (SumOrAverage)
- Air Loop Desiccant Dehumidifier Electric Consumption (SumOrAverage)

Mechanical Ventilation Loads Monthly

- Zone Mechanical Ventilation No Load Heat Removal (SumOrAverage)
- Zone Mechanical Ventilation Cooling Load Increase (SumOrAverage)
- Zone Mech Ventilation Cooling Load Increase: OverHeating (SumOrAverage)
- Zone Mechanical Ventilation Cooling Load Decrease (SumOrAverage)
- Zone Mechanical Ventilation No Load Heat Addition (SumOrAverage)
- Zone Mechanical Ventilation Heating Load Increase (SumOrAverage)
- Zone Mech Ventilation Heating Load Increase: OverCooling (SumOrAverage)
- Zone Mechanical Ventilation Heating Load Decrease (SumOrAverage)
- Zone Mechanical Ventilation Air Change Rate (SumOrAverage)

```

Output:Table:SummaryReports,
  \extensible:1
  \memo This object allows the user to call report types that are predefined and will appear with the
  \memo other tabular reports. These predefined reports are sensitive to the
OutputControl:Table:Style object
  \memo and appear in the same files as the tabular reports. The entries for this object is a list
  \memo of the predefined reports that should appear in the tabular report output file.
  \unique-object
A1, \field Report 1 Name
  \type choice
  \key AllSummary
  \key AllMonthly
  \key AllSummaryAndMonthly
  \key AnnualBuildingUtilityPerformanceSummary
  \key InputVerificationandResultsSummary
  \key ClimaticDataSummary
  \key EquipmentSummary
  \key EnvelopeSummary
  \key SurfaceShadowingSummary
  \key ShadingSummary
  \key LightingSummary
  \key HVACSizingSummary
  \key SystemSummary
  \key ComponentSizingSummary
  \key OutdoorAirSummary
  \key ObjectCountSummary
  \key ComponentCostEconomicsSummary
  \key ZoneCoolingSummaryMonthly
  \key ZoneHeatingSummaryMonthly
  \key ZoneElectricSummaryMonthly
  \key SpaceGainsMonthly
  \key PeakSpaceGainsMonthly
  \key SpaceGainComponentsAtCoolingPeakMonthly
  \key EnergyConsumptionElectricityNaturalGasMonthly
  \key EnergyConsumptionElectricityGeneratedPropaneMonthly
  \key EnergyConsumptionDieselFuelOilMonthly
  \key EnergyConsumptionDistrictHeatingCoolingMonthly
  \key EnergyConsumptionCoalGasolineMonthly
  \key EndUseEnergyConsumptionElectricityMonthly
  \key EndUseEnergyConsumptionNaturalGasMonthly
  \key EndUseEnergyConsumptionDieselMonthly
  \key EndUseEnergyConsumptionFuelOilMonthly
  \key EndUseEnergyConsumptionCoalMonthly
  \key EndUseEnergyConsumptionPropaneMonthly
  \key EndUseEnergyConsumptionGasolineMonthly
  \key PeakEnergyEndUseElectricityPart1Monthly
  \key PeakEnergyEndUseElectricityPart2Monthly
  \key ElectricComponentsOfPeakDemandMonthly
  \key PeakEnergyEndUseNaturalGasMonthly
  \key PeakEnergyEndUseDieselMonthly
  \key PeakEnergyEndUseFuelOilMonthly
  \key PeakEnergyEndUseCoalMonthly
  \key PeakEnergyEndUsePropaneMonthly
  \key PeakEnergyEndUseGasolineMonthly
  \key SetpointsNotMetWithTemperaturesMonthly
  \key ComfortReportSimple55Monthly
  \key UnglazedTranspiredSolarCollectorSummaryMonthly
  \key OccupantComfortDataSummaryMonthly
  \key ChillerReportMonthly
  \key TowerReportMonthly
  \key BoilerReportMonthly
  \key DXReportMonthly
  \key WindowReportMonthly
  \key WindowEnergyReportMonthly
  \key WindowZoneSummaryMonthly
  \key WindowEnergyZoneSummaryMonthly
  \key AverageOutdoorConditionsMonthly
  \key OutdoorConditionsMaximumDryBulbMonthly
  \key OutdoorConditionsMinimumDryBulbMonthly
  \key OutdoorConditionsMaximumWetBulbMonthly
  \key OutdoorConditionsMaximumDewPointMonthly

```

```

\key OutdoorGroundConditionsMonthly
\key WindowACReportMonthly
\key WaterHeaterReportMonthly
\key GeneratorReportMonthly
\key DaylightingReportMonthly
\key CoilReportMonthly
\key PlantLoopDemandReportMonthly
\key FanReportMonthly
\key PumpReportMonthly
\key CondLoopDemandReportMonthly
\key ZoneTemperatureOscillationReportMonthly
\key AirLoopSystemEnergyAndWaterUseMonthly
\key AirLoopSystemComponentLoadsMonthly
\key AirLoopSystemComponentEnergyUseMonthly
\key MechanicalVentilationLoadsMonthly
<reduced for brevity>

```

Sample IDF Input – Report:Table:Predefined

```

Output:Table:SummaryReports,
    All Summary; !- Report 1 Name

```

OutputControl:Table:Style

The OutputControl:Table:Style object controls how all standardized reports are produced.

Field: Column Separator

You have seven different options:

- Comma
- Tab
- Fixed
- HTML
- CommaAndHTML
- TabAndHTML
- All

The Comma style produces a text file (eplustbl.csv) with the values of the table separated by commas. This is a good format for importing the results into a spreadsheet. If you do open the file with a spreadsheet, make sure you close the file prior to rerunning EnergyPlus otherwise the file will not be updated.

The Tab style produces a text file (eplustbl.tab) with the values separated by tabs. It is also a good format for using with a spreadsheet program but has the advantage of being more readable in a text editor.

The Fixed style produces a text file (eplustbl.txt) with the values at specific columns. It is the easiest to view using a text editor.

The HTML style produces a file (eplustbl.htm) that can be opened with an internet browser program. The values are shown in a tabular format that is easy to view. One advantage of the HTML style is that the results can be viewed in an internet browser program and EnergyPlus can be rerun and the “refresh” button pressed in the internet browser program to see the new results. . When the HTML style is specified, a Table of Contents for the file is generated and placed near the top of the file after the ABUPS report. The Table of Contents includes the names of each report and links for each table in the file.

The last three options combine the previous styles and allow multiple reports with different styles to be produced during a single simulation.

Field: Unit Conversion

This field is optional and if not specified defaults to no unit conversions. Four different input options are available:

- None – no conversions performed
- JtoKWH – Joules converted into kWh (1 / 3,600,000)
- JtoMJ – Joules converted into Megajoules (1 / 1,000,000)
- JtoGJ – Joules converted into Gigajoules (1 / 1,000,000,000)
- InchPound – convert all annual, monthly, economics and timebins tabular values to common Inch-Pound equivalent

The current options are limited to just how the energy is being reported. The default is to report energy in the form of Joules but since the magnitude of those numbers for many buildings is very large, these other conversion factors are available.

The JtoKWH, JtoMJ and JtoGJ unit conversion input option applies only to the Output:Table:Monthly reports and partially to the ABUPS report. For ABUPS, the JtoKWH option changes the report but the JtoMJ and JtoGJ options do not change the report since they it is already in MJ/m² and GJ.. The InchPound unit conversion input option applies to all annual, monthly, timebins and economic reports that appear in the tabular output file. In addition, this option does not effect the standard eplusout.eso file. The eplusout.eso file may be converted by using the ConvertESOMTR utility.

The IDD entry for this object follows.

```
OutputControl:Table:Style,
  \memo default style for the OutputControl:Table:Style is comma -- this works well for
  \memo importing into spreadsheet programs such as Excel(tm) but not so well for word
  \memo processing programs -- there tab may be a better choice.  fixed puts spaces between
  \memo the "columns".  HTML produces tables in HTML.
  \unique-object
A1, \field Column Separator
  \type choice
  \key Comma
  \key Tab
  \key Fixed
  \key HTML
  \key CommaAndHTML
  \key TabAndHTML
  \key All
A2; \field Unit Conversion
  \type choice
  \key None
  \key JtoKWH
  \key JtoMJ
  \key JtoGJ
  \key InchPound
```

An example IDF input object follows.

```
OutputControl:Table:Style,
  Comma,          ! Column Separator
  InchPound;     ! Unit Conversion
```

An example of the comma style OutputControl:Table:Style report is shown below:

Program Version:,EnergyPlus, Version 1.2.3
 Tabular Output Report in Format: ,Comma

Building:,PLANT LOAD PROFILE EXAMPLE
 Environment:,CHICAGO IL USA TMY2-94846 WMO#=725300

 REPORT:,ELECTRICITY:PLANT J per second

FOR:,Meter

Values in table are in hours.

```

,,1,2,3,,
,Interval Start,less than,0.<=,450.<=,900.<=,equal to or more than,Row
,Interval End,0.,450.>,900.>,1350.>,1350.,Total
,January,0.00,31.00,0.00,713.00,0.00,744.00
,February,0.00,28.00,0.00,644.00,0.00,672.00
,March,0.00,31.00,0.00,713.00,0.00,744.00
,April,0.00,30.00,0.00,690.00,0.00,720.00
,May,0.00,31.00,0.00,713.00,0.00,744.00
,June,0.00,30.00,0.00,690.00,0.00,720.00
,July,0.00,31.00,0.00,713.00,0.00,744.00
,August,0.00,31.00,0.00,713.00,0.00,744.00
,September,0.00,30.00,0.00,690.00,0.00,720.00
,October,0.00,31.00,0.00,713.00,0.00,744.00
,November,0.00,30.00,0.00,690.00,0.00,720.00
,December,0.00,31.00,0.00,713.00,0.00,744.00
,12:01 to 1:00 am,0.00,0.00,0.00,365.00,0.00,365.00
, 1:01 to 2:00 am,0.00,0.00,0.00,365.00,0.00,365.00
, 2:01 to 3:00 am,0.00,0.00,0.00,365.00,0.00,365.00
, 3:01 to 4:00 am,0.00,0.00,0.00,365.00,0.00,365.00
, 4:01 to 5:00 am,0.00,0.00,0.00,365.00,0.00,365.00
, 5:01 to 6:00 am,0.00,0.00,0.00,365.00,0.00,365.00
, 6:01 to 7:00 am,0.00,0.00,0.00,365.00,0.00,365.00
, 7:01 to 8:00 am,0.00,0.00,0.00,365.00,0.00,365.00
, 8:01 to 9:00 am,0.00,365.00,0.00,0.00,0.00,365.00
, 9:01 to 10:00 am,0.00,0.00,0.00,365.00,0.00,365.00
,10:01 to 11:00 am,0.00,0.00,0.00,365.00,0.00,365.00
,11:01 to 12:00 pm,0.00,0.00,0.00,365.00,0.00,365.00
,12:01 to 1:00 pm,0.00,0.00,0.00,365.00,0.00,365.00
, 1:01 to 2:00 pm,0.00,0.00,0.00,365.00,0.00,365.00
, 2:01 to 3:00 pm,0.00,0.00,0.00,365.00,0.00,365.00
, 3:01 to 4:00 pm,0.00,0.00,0.00,365.00,0.00,365.00
, 4:01 to 5:00 pm,0.00,0.00,0.00,365.00,0.00,365.00
, 5:01 to 6:00 pm,0.00,0.00,0.00,365.00,0.00,365.00
, 6:01 to 7:00 pm,0.00,0.00,0.00,365.00,0.00,365.00
, 7:01 to 8:00 pm,0.00,0.00,0.00,365.00,0.00,365.00
, 8:01 to 9:00 pm,0.00,0.00,0.00,365.00,0.00,365.00
, 9:01 to 10:00 pm,0.00,0.00,0.00,365.00,0.00,365.00
,10:01 to 11:00 pm,0.00,0.00,0.00,365.00,0.00,365.00
,11:01 to 12:00 am,0.00,0.00,0.00,365.00,0.00,365.00
,Total,0.00,365.00,0.00,8395.00,0.00,8760.00

```

Statistics

```

,,Statistic
,Minimum,0.00
,Mean minus two standard deviations,502.81
,Mean,862.50
,Mean plus two standard deviations,1222.19
,Maximum,900.00
,Standard deviation,179.85

```

Weather Data

The description of the weather data format (a simple text-based format) is well described in the Auxiliary Programs document and won't be repeated here. Descriptions here will be pertinent to running the EnergyPlus program but you may wish to peruse the other descriptions as the statistics reports from the weather files may be useful during design and simulation.

Missing Weather File Data

The weather description of data contains "missing" descriptors, a new concept not introduced previously in our IDD conventions. In this case, it will be processed as though those values are "missing" in the weather conversions and/or EnergyPlus weather processing. This may not always be desirable though EnergyPlus will fill in "missing" value with something "appropriate". Eventually, these missing values will be available through the IDD and users will be able to supply their own values or EnergyPlus will calculate those values (such as radiation and illuminance) that are not a simple value replacement. Until then, the following are used:

Table 40. Missing weather replacement values

Data item	Supplied Value	Units
Dry-bulb Temperature	6	C
Dewpoint Temperature	3	C
Relative Humidity	50	%
Atmospheric Pressure	Standard** Barometric Pressure (altitude based)	Pa
Wind Speed	2.5	m/s
Wind Direction	180	Deg
Total Sky Cover	5	(tenths)
Opaque Sky Cover	5	(tenths)
Visibility	777.7	Km
Ceiling Height	77777	m
Precipitable Water	0	Mm
Aerosol Optical Depth	0	Broadband turbidity
Snow Depth	0	Cm
Days Since Last Snow	88	Days
Radiation Values (Direct/Diffuse)	0.0	Wh/m2
Illuminance Values	0.0	lux (or CD/m2)

**Standard Barometric pressure based on location elevation is taken from ASHRAE 2001 Handbook of Fundamentals, Page 6.1 & 2.

Weather Data Hourly Interpolation

Much of the existing weather data is produced in hourly format (refer to the discussion of data formats and weather conversion processing in the Auxiliary Programs Document). In order to match the hourly data in a continuous manner for EnergyPlus (where the timesteps might be less than hourly), simple interpolation between “last hour’s” values and “this hour’s” values is performed; we will refer to this as “Last Hour Interpolation”.

Note that in versions prior to V1.0.3, the interpolation was done between “this hour” and “next hour”. If required, we will refer to this as “Next Hour Interpolation”.

Remember that hour 1 for EnergyPlus is the time interval 00:00:01AM to 1:00:00AM. Hour 2 is 1:00:01AM to 2:00:00AM (hh:mm:ss). With the interpolation scheme (Last Hour Interpolation) and reporting weather data values at timestep resolution, the “hour” values reported should match with the hourly weather data values. (Note that reporting “hourly” resolution will not do this unless your “Number of Timesteps per Hour” is 1).

Note that this interpolation applies to outdoor data only – schedule values are not interpolated in this manner.

The weighting scheme / interpolation is simply:

$$Value_{TimeStep} = LastHourValue \cdot Weight_{LastHour} + ThisHourValue \cdot Weight_{ThisHour}$$

where

$$Weight_{ThisHour} = \frac{CurrentTimeStep}{Number\ of\ TimeSteps\ in\ Hour}$$

$$Weight_{LastHour} = 1.0 - Weight_{ThisHour}$$

To explain further, the weighting for four (4) timesteps in hour is:

Table 41. Illustration of Data Interpolation for 15 minute timesteps

TimeStep	Time (mm:ss)	Weight _{LastHour}	Weight _{ThisHour}
1	00:01 to 15:00	.75	.25
2	15:01 to 30:00	.5	.5
3	30:01 to 45:00	.25	.75
4	45:01 to 60:00	0	1.0

And similarly for six (6) timesteps in hour:

Table 42. Illustration of Data Interpolation for 10 minute timesteps

TimeStep	Time (mm:ss)	Weight _{LastHour}	Weight _{ThisHour}
1	00:01 to 10:00	0.8333333333333333	0.1666666666666667

2	10:01 to 20:00	0.6666666666666667	0.3333333333333333
3	20:01 to 30:00	.5	.5
4	30:01 to 40:00	0.3333333333333333	0.6666666666666667
5	40:01 to 50:00	0.1666666666666667	0.8333333333333333
6	50:01 to 60:00	0	1.0

This interpolation gives a smooth, continuous look to the outdoor data. For day boundaries (i.e. from hour 24 to hour 1), the values from the previous day's last hour (23:00:01 to 24:00:00). For the a design day, this is the values for hour 24. For the first day of a weather simulation, it is likewise values for hour 24 of that day. For subsequent weather days, it will be the last hour of the previous day.

Weather File Data Reporting (errors) during Simulation

Missing data on the weather file used will be summarized on the **eplusout.err** file. In EnergyPlus, "missing data" is shown only for fields that EnergyPlus will use. For the "WeatherCodes", an invalid field count (where the number of items in the field does not = 9) will be shown. The number of items count refers to the number of records on the weather file that are in error or missing – for an hourly weather file, this is the number of hours. Likewise out of range values (see specific fields in the previous definition) will be counted for each occurrence and summarized. Note that the out of range values will not be changed by EnergyPlus and could affect your simulation results.

For example:

```

** Warning ** Missing Data Found on Weather Data File
***** Missing Atmospheric Pressure, Number of items= 48
***** Missing Dry Bulb Temperatures, Number of items= 4
** Warning ** Out of Range Data Found on Weather Data File
***** Out of Range Dry Bulb Temperature [>-70,<70], Number of items= 1

```

Running EnergyPlus

EnergyPlus is written in language conforming to Fortran Standard 90/95/F2003. It runs as a 32 bit console (non-Windows) application on Intel compatible computers (Windows NT, Windows 95/98). Linux and Macintosh version are also available. Details on running EnergyPlus are available in a separate document (Running EnergyPlus in Getting Started). The following files are needed to run EnergyPlus:

```
EnergyPlus.exe (the executable file)
Energy+.ini (described below)
Energy+.idd (the input data dictionary file)
In.idf (the input file)
In.epw - optional (weather data file)
```

The input data dictionary and input data file have been discussed in the previous sections of this document.

For weather simulations, EnergyPlus accepts EnergyPlus weather files. The actual file name is **in.epw**.

The usual release for Windows platform also includes bindings that require these files.

```
DElight2.dll
```

Energy+.ini

The Energy+.ini file is read by the EnergyPlus.exe program and is *very important* to the simulation run. In specific, this file contains a pointer to where the Energy+.idd file will be found. More description of the Energy+.ini contents is contained in the Auxiliary Programs document.

For the advanced user, there is also the "EPMacro" program, described in the Auxiliary programs document. You run it as a separate program before EnergyPlus (the batch file included in the install and shown in the GettingStarted document contains the commands). It is automatically run if you use the EP-Launch program.

EnergyPlus may create several output files. Whether some files are produced depends on the actual simulation (for example, the .rdd file is only produced when you request a Variable Dictionary using the Output:Report object). Similarly, the .dxf file is only produced when a DXF surface report is requested. Common output files are shown in the following table. A complete, up to date list is shown in the "Output Details and Examples Document".

Table 43. EnergyPlus Output Files

FileName	Description
Eplusout.audit	Echo of input
Eplusout.err	Error file
Eplusout.eso	Standard Output File (contains results from both Report Variable and Report Meter objects).
Eplusout.eio	One time output file
Eplusout.rdd	Report Variable Data Dictionary
Eplusout.dxf	DXF (from Output:Report,Surfaces,DXF;)
Eplusout.mtr	Similar to .eso but only has Meter outputs.

Eplusout.mtd	Meter details report – what variables are on what meters and vice versa.
Eplusout.end	A one line summary of success or failure (useful for Interface programs)
Eplusout.dbg	From Debug Output object – may be useful to support to help track down problems
Eplusout.<ext>	Not directly from EnergyPlus – produced by utility programs that read the .eso file and produce output files for spreadsheet programs
Eplusout.sln	Similar to DXF output but less “formatted”. Results of Report Surface, Lines object.
Epluszsz.<ext>	Results from the Zone Sizing object with extension noted by the Sizing Style object. This file is “spreadsheet” ready.
Eplusssz.<ext>	Results from the System Sizing object with extension noted by the Sizing Style object. This file is “spreadsheet” ready.
Eplusout.bnd	This file contains details about the nodes and branches. Useful in determining if all your nodes are connected correctly.
Eplustbl.<ext>	Results from various “Report Table” and a few other reporting commands. The extension is from the “style” command and this file is “spreadsheet” ready.

Errors

The **eplusout.err** file may contain three levels of errors (Information, Warning, Severe, Fatal) as well as the possibility of just message lines, see Table 44. EnergyPlus Errors and Required Actions. These errors may be duplicated in other files (such as the standard output file). These errors are described more completely in the Output Details and Examples document. An example .err file from the 1ZoneUncontrolled example input file:

```

Program Version,EnergyPlus 3.0.0.025, 11/4/2008 5:03 PM,IDD_Version 3.0.0.025
** Warning ** GetPollutionFactorInput: Requested reporting for Carbon Equivalent Pollution, but
insufficient information is entered.
**   ~~~   ** Both "FuelFactors" and "EnvironmentalImpactFactors" must be entered or the displayed
carbon pollution will all be zero.
*****
***** Testing Individual Branch Integrity
***** All Branches passed integrity testing
***** Testing Individual Supply Air Path Integrity
***** All Supply Air Paths passed integrity testing
***** Testing Individual Return Air Path Integrity
***** All Return Air Paths passed integrity testing
***** No node connection errors were found.
***** EnergyPlus Completed Successfully-- 1 Warning; 0 Severe Errors; Elapsed Time=00hr 00min
6.34sec

```

Table 44. EnergyPlus Errors and Required Actions

Error Level	Action
Information, shown as *****	Informative, usually a follow-on to one of the others. No action required.
** ~~~ **	This is a continuation of a previous message. String all the words/sentences together to form the complete message.
Warning	Take note. Fix as applicable.
Severe	Should Fix
Fatal	Program will abort, Must Fix

EnergyPlus produces several messages as it is executing, as a guide to its progress. These message illustrate the sequence of execution as well as provides checkpoints should the simulation fail.

For example, the run of the 1ZoneUncontrolled example input file produces the log:

```

Running d:\eppgm\intcheck\energyplus.exe
Running d:\eppgm\intcheck\energyplus.exe
Input File : d:\devtests\inputfiles\checkin\1ZoneUncontrolled.idf
Output Files: d:\devtests\inputfiles\outputs\
Weather File: USA_CO_Denver-Stapleton_TMY.epw
ExpandObjects Started.
No expanded file generated.
ExpandObjects Finished. Time: 0.000
ET Start: Tue 11/04/2008 - 17:03:12.56
EnergyPlus Starting
EnergyPlus 3.0.0.025, 11/4/2008 5:03 PM
Processing Data Dictionary
Processing Input File
Initializing Response Factors
Calculating CTFs for "FLOOR", Construction #2
Initializing Window Optical Properties
Initializing Solar Calculations
Allocate Solar Module Arrays
Initializing Zone Report Variables
Initializing Surface Report Variables
Computing Interior Solar Absorption Factors
Determining Shadowing Combinations
Computing Window Shade Absorption Factors
Proceeding with Initializing Solar Calculations
Initializing Surfaces
Initializing Outdoor environment for Surfaces
Initializing Temperature and Flux Histories
Initializing Window Shading
Computing Interior Absorption Factors
Computing Interior Diffuse Solar Absorption Factors
Computing Interior Diffuse Solar Exchange through Interzone Windows
Initializing Solar Heat Gains
Initializing Internal Heat Gains
Initializing Interior Solar Distribution
Initializing Interior Convection Coefficients

```

```
Gathering Information for Predefined Reporting
Completed Initializing Surface Heat Balance
Calculate Outside Surface Heat Balance
Calculate Inside Surface Heat Balance
Calculate Air Heat Balance
Initializing HVAC
Reporting Surfaces
Initializing New Environment Parameters
Warming up {1}
Warming up {2}
Warming up {3}
Starting Simulation at 12/21 for DENVER_STAPLETON ANN HTG 99% CONDNS DB
Initializing New Environment Parameters
Warming up {1}
Warming up {2}
Warming up {3}
Warming up {4}
Starting Simulation at 07/21 for DENVER_STAPLETON ANN CLG 1% CONDNS DB=>MWB
Initializing New Environment Parameters
Warming up {1}
Warming up {2}
Starting Simulation at 01/01 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=01/21
Continuing Simulation at 01/21 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=02/10
Continuing Simulation at 02/10 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=03/02
Continuing Simulation at 03/02 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=03/22
Continuing Simulation at 03/22 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=04/11
Continuing Simulation at 04/11 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=05/01
Continuing Simulation at 05/01 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=05/21
Continuing Simulation at 05/21 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=06/10
Continuing Simulation at 06/10 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=06/30
Continuing Simulation at 06/30 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=07/20
Continuing Simulation at 07/20 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=08/09
Continuing Simulation at 08/09 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=08/29
Continuing Simulation at 08/29 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=09/18
Continuing Simulation at 09/18 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=10/08
Continuing Simulation at 10/08 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=10/28
Continuing Simulation at 10/28 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=11/17
Continuing Simulation at 11/17 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=12/07
Continuing Simulation at 12/07 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Updating Shadowing Calculations, Start Date=12/27
Continuing Simulation at 12/27 for Denver-Stapleton CO USA TMY--23062 WMO#=724690
Writing tabular output file results using HTML format.
EnergyPlus Run Time=00hr 00min 6.34sec
ET End: Tue 11/04/2008 - 17:03:19.39
ReadVarsESO program starting.
ReadVars Run Time=00hr 00min 0.03sec
ReadVarsESO program completed successfully.
ReadVarsESO program starting.
ReadVars Run Time=00hr 00min 0.02sec
ReadVarsESO program completed successfully.
Started HVAC Diagram
Complete
```


In the example, the inclusion of the “ReadVars” program is also shown. It is run twice – once for the **eplusout.eso** file and once for the **eplusout.mtr** file.

Speed of Execution

Extensive timing studies and fine-tuning of EnergyPlus are NOT complete. Remember that hourly simulations can not be directly compared to EnergyPlus with it's less than hourly timesteps.

Appendix A. Units and Abbreviations

Standard EnergyPlus Conditions

Standard Temperature and Pressure

Several objects specify inputs at “standard temperature and pressure”. Standard Temperature is dry air at 20° C drybulb. The program uses local barometric pressure to account for altitude using the equation for "standard atmospheric" pressure on p 6.1 of the ASHRAE 1997 HOF (SI edition) to initialize the air systems being simulated.

$$Stdpressure = 101325 \cdot (1.0 - Z \cdot 2.25577^{-5})^{5.2559}$$

where

StdPressure = pressure {Pa}

Z = altitude/elevation {m}

Standard EnergyPlus Units

EnergyPlus expects information in a single unit system (SI). This requires interface developers to convert user inputs from those preferred by architects and engineers into the standard metric units of EnergyPlus. EnergyPlus will not perform any units conversions and will not have any unit conversion routines.

ASCII with no spaces is used for abbreviations. Note that exponents appear without any indication of exponentiation: i.e., kg/m3 not kg/m^3 or kg/m**3. Also note the use of dashes. We have W/m2-K not W/m2*K or W/(m2*K).

At the end we note the “problem” variables – the inputs that have non-standard units. Inputs using these units will have to be changed and the code checked to see how the quantities are used internally.

Table 45. Standard EnergyPlus Units

Quantity	unit	abbreviation
angular degrees	degree	deg
Length	meter	m
Area	square meter	m2
Volume	cubic meter	m3
Time	seconds	s
Frequency	Hertz	Hz
Temperature	Celsius	C
absolute temperature	Kelvin	K
temperature difference	Kelvin	deltaC
speed	meters per second	m/s
energy (or work)	Joules	J
power	Watts	W
mass	kilograms	kg
force	Newton	N

Quantity	unit	abbreviation
mass flow	kilograms per second	kg/s
volume flow	cubic meters per second	m ³ /s
pressure	Pascals	Pa
pressure difference	Pascals	Pa
specific enthalpy	Joules per kilogram	J/kg
density	kilograms per cubic meter	kg/m ³
heat flux	watts per square meter	W/m ²
specific heat	-----	J/kg-K
conductivity	-----	W/m-K
diffusivity	-----	m ² /s
heat transfer coefficient	-----	W/m ² -K
R-value	-----	m ² -K/W
heating or cooling capacity	Watts	W
electric potential	volts	V
electric current	Amperes	A
illuminance	lux	lx
luminous flux	lumen	lm
luminous intensity	candelas	cd
luminance	candelas per square meter	cd/m ²
vapor diffusivity	meters squared per second	m ² /s
viscosity	-----	kg/m-s
dynamic Viscosity	-----	N-s/m ²
thermal gradient coeff for moisture capacity	-----	kg/kg-K
isothermal moisture capacity	-----	m ³ /kg

Appendix B. Version 3.0 Renamed Objects

In EnergyPlus V3.0 release, the objects, fields and key word values were scrutinized and subjected to a stricter naming convention. No spaces are allowed in objects or key words. Fields, on the other hand, are encouraged to have spaces and read more like full phrases. This section will be removed following the April 2009 (V3.1) release. The following table lists “old” and “new” object types.

Old Object Type	New V3.0 Object Type
AIR CONDITIONER:WINDOW:CYCLING	ZoneHVAC:WindowAirConditioner
AIR DISTRIBUTION UNIT	ZoneHVAC:AirDistributionUnit
AIR LOOP EQUIPMENT LIST	AirLoopHVAC:OutdoorAirSystem:EquipmentList
AIR PRIMARY LOOP	AirLoopHVAC
AIRFLOWNETWORK SIMULATION	AirflowNetwork:SimulationControl
AIRFLOWNETWORK:DISTRIBUTION:COMPONENT COIL	AirflowNetwork:Distribution:Component:Coil
AIRFLOWNETWORK:DISTRIBUTION:COMPONENT CONSTANT PRESSURE DROP	AirflowNetwork:Distribution:Component:ConstantPressureDrop
AIRFLOWNETWORK:DISTRIBUTION:COMPONENT CONSTANT VOLUME FAN	AirflowNetwork:Distribution:Component:ConstantVolumeFan
AIRFLOWNETWORK:DISTRIBUTION:COMPONENT DUCT	AirflowNetwork:Distribution:Component:Duct
AIRFLOWNETWORK:DISTRIBUTION:COMPONENT LEAK	AirflowNetwork:Distribution:Component:Leak
AIRFLOWNETWORK:DISTRIBUTION:COMPONENT LEAKAGE RATIO	AirflowNetwork:Distribution:Component:LeakageRatio
AIRFLOWNETWORK:DISTRIBUTION:COMPONENT TERMINAL UNIT	AirflowNetwork:Distribution:Component:TerminalUnit
AIRFLOWNETWORK:DISTRIBUTION:LINKAGE	AirflowNetwork:Distribution:Linkage
AIRFLOWNETWORK:DISTRIBUTION:NODE	AirflowNetwork:Distribution:Node
AIRFLOWNETWORK:MULTIZONE:COMPONENT DETAILED OPENING	AirflowNetwork:MultiZone:Component:DetailedOpening
AIRFLOWNETWORK:MULTIZONE:COMPONENT SIMPLE OPENING	AirflowNetwork:MultiZone:Component:SimpleOpening
AIRFLOWNETWORK:MULTIZONE:COMPONENT ZONE EXHAUST FAN	AirflowNetwork:MultiZone:Component:ZoneExhaustFan
AIRFLOWNETWORK:MULTIZONE:EXTERNAL NODE	AirflowNetwork:MultiZone:ExternalNode
AIRFLOWNETWORK:MULTIZONE:REFERENCE CRACK CONDITIONS	AirflowNetwork:MultiZone:ReferenceCrackConditions
AIRFLOWNETWORK:MULTIZONE:SITE WIND CONDITIONS	AirflowNetwork:MultiZone:SiteWindConditions
AIRFLOWNETWORK:MULTIZONE:SURFACE	AirflowNetwork:MultiZone:Surface
AIRFLOWNETWORK:MULTIZONE:SURFACE CRACK DATA	AirflowNetwork:MultiZone:Surface:Crack

Old Object Type	New V3.0 Object Type
AIRFLOWNETWORK:MULTIZONE:SURFACE EFFECTIVE LEAKAGE AREA	AirflowNetwork:MultiZone:Surface:EffectiveLeakageArea
AIRFLOWNETWORK:MULTIZONE:WIND PRESSURE COEFFICIENT ARRAY	AirflowNetwork:MultiZone:WindPressureCoefficientArray
AIRFLOWNETWORK:MULTIZONE:WIND PRESSURE COEFFICIENT VALUES	AirflowNetwork:MultiZone:WindPressureCoefficientValues
AIRFLOWNETWORK:MULTIZONE:ZONE	AirflowNetwork:MultiZone:Zone
AngleFactorList	ComfortViewFactorAngles
BASEBOARD HEAT	ZoneBaseboard:OutdoorTemperatureControlled
BASEBOARD HEATER:ELECTRIC:Convective	ZoneHVAC:Baseboard:Convective:Electric
BASEBOARD HEATER:WATER	ZoneHVAC:Baseboard:RadiantConvective:Water
BASEBOARD HEATER:Water:Convective	ZoneHVAC:Baseboard:Convective:Water
BOILER:SIMPLE	Boiler:HotWater
BOILER:SPARK:SBOILER	Boiler:HotWater:SPARK (now obsolete)
BOILER:STEAM	Boiler:Steam
BRANCH	Branch
BRANCH LIST	BranchList
BUILDING	Building
CASE:REFRIGERATED	Refrigeration:Case
CHILLER:ABSORPTION	Chiller:Absorption
CHILLER:COMBUSTION TURBINE	Chiller:CombustionTurbine
CHILLER:CONST COP	Chiller:ConstantCOP
CHILLER:DIRECT FIRED ABSORPTION	ChillerHeater:Absorption:DirectFired
CHILLER:ELECTRIC	Chiller:Electric
CHILLER:ELECTRIC:EIR	Chiller:Electric:EIR
CHILLER:ELECTRIC:REFORMULATEDEIR	Chiller:Electric:ReformulatedEIR
CHILLER:ENGINEDRIVEN	Chiller:EngineDriven
CHILLER:INDIRECTABSORPTION	Chiller:Absorption:Indirect
CHILLER:SPARK:ECHILLER	Chiller:Electric:SPARK (now obsolete)
COIL:Desuperheater:Heating	Coil:Heating:Desuperheater
COIL:DX:CoolingBypassFactorEmpirical	Coil:Cooling:DX:SingleSpeed
COIL:DX:CoolingHeatExchangerAssisted	CoilSystem:Cooling:DX:HeatExchangerAssisted
COIL:DX:HeatingEmpirical	Coil:Heating:DX:SingleSpeed
COIL:DX:HEATPUMPWATERHEATER	Coil:WaterHeating:AirToWaterHeatPump
COIL:DX:MultiMode:CoolingEmpirical	Coil:Cooling:DX:TwoStageWithHumidityControlMode
Coil:DX:MultiSpeed:Cooling	Coil:Cooling:DX:MultiSpeed
COIL:DX:MultiSpeed:CoolingEmpirical	Coil:Cooling:DX:TwoSpeed
COIL:DX:MULTISPEED:HEATING	Coil:Heating:DX:MultiSpeed
COIL:Electric:Heating	Coil:Heating:Electric
COIL:Gas:Heating	Coil:Heating:Gas
COIL:Steam:AirHeating	Coil:Heating:Steam
COIL:Water:Cooling	Coil:Cooling:Water

Old Object Type	New V3.0 Object Type
COIL:Water:CoolingHeatExchangerAssisted	CoilSystem:Cooling:Water:HeatExchangerAssisted
COIL:Water:DesuperheaterHeating	Coil:WaterHeating:Desuperheater
COIL:Water:DetailedFlatCooling	Coil:Cooling:Water:DetailedGeometry
COIL:Water:SimpleHeating	Coil:Heating:Water
COIL:WaterToAirHP:EquationFit:Cooling	Coil:Cooling:WaterToAirHeatPump:EquationFit
COIL:WaterToAirHP:EquationFit:Heating	Coil:Heating:WaterToAirHeatPump:EquationFit
COIL:WaterToAirHP:ParameterEstimation:Cooling	Coil:Cooling:WaterToAirHeatPump:ParameterEstimation
COIL:WaterToAirHP:ParameterEstimation:Heating	Coil:Heating:WaterToAirHeatPump:ParameterEstimation
CoilPerformance:DX:CoolingBypassFactorEmpirical	CoilPerformance:DX:Cooling
COMPACT HVAC:PLANT:BOILER	HVACTemplate:Plant:Boiler
COMPACT HVAC:PLANT:CHILLED WATER LOOP	HVACTemplate:Plant:ChilledWaterLoop
COMPACT HVAC:PLANT:CHILLER	HVACTemplate:Plant:Chiller
COMPACT HVAC:PLANT:HOT WATER LOOP	HVACTemplate:Plant:HotWaterLoop
COMPACT HVAC:PLANT:TOWER	HVACTemplate:Plant:Tower
COMPACT HVAC:SYSTEM:UNITARY	HVACTemplate:System:Unitary
COMPACT HVAC:SYSTEM:VAV	HVACTemplate:System:VAV
COMPACT HVAC:THERMOSTAT	HVACTemplate:Thermostat
COMPACT HVAC:ZONE:FAN COIL	HVACTemplate:Zone:FanCoil
COMPACT HVAC:ZONE:PTAC	HVACTemplate:Zone:PTAC
COMPACT HVAC:ZONE:PTHP	HVACTemplate:Zone:PTHP
COMPACT HVAC:ZONE:PURCHASED AIR	HVACTemplate:Zone:IdealLoadsAirSystem
COMPACT HVAC:ZONE:UNITARY	HVACTemplate:Zone:Unitary
COMPACT HVAC:ZONE:VAV	HVACTemplate:Zone:VAV
COMPACT HVAC:ZONE:VAV:FAN POWERED	HVACTemplate:Zone:VAV:FanPowered
COMPONENT SETPOINT BASED OPERATION	PlantEquipmentOperation:ComponentSetpoint
COMPRESSOR RACK:REFRIGERATED CASE	Refrigeration:CompressorRack
CONDENSER EQUIPMENT LIST	CondenserEquipmentList
CONDENSER LOOP	CondenserLoop
CONDENSER OPERATION SCHEMES	CondenserEquipmentOperationSchemes
CONNECTION COMPONENT:PLANTLOOP	PlantLoopConnection
CONNECTION COMPONENT:PLANTLOOP:CONTROLLED	PlantLoopConnection:Controlled
CONNECTOR LIST	ConnectorList
CONSTRUCTION	Construction
CONSTRUCTION FROM WINDOW5 DATA FILE	Construction:WindowDataFile
CONSTRUCTION WITH INTERNAL SOURCE	Construction:InternalSource

Old Object Type	New V3.0 Object Type
CONTROLLED ZONE EQUIP CONFIGURATION	ZoneHVAC:EquipmentConnections
CONTROLLER LIST	AirLoopHVAC:ControllerList
CONTROLLER:OUTSIDE AIR	Controller:OutdoorAir
CONTROLLER:SIMPLE	Controller:WaterCoil
CONTROLLER:STAND ALONE ERV	ZoneHVAC:EnergyRecoveryVentilator:Controller
ConvectionCoefficients	SurfaceProperty:ConvectionCoefficients
ConvectionCoefficients:MultipleSurface	SurfaceProperty:ConvectionCoefficients:MultipleSurface
COOLING LOAD RANGE BASED OPERATION	PlantEquipmentOperation:CoolingLoad
COOLING TOWER:SINGLE SPEED	CoolingTower:SingleSpeed
COOLING TOWER:TWO SPEED	CoolingTower:TwoSpeed
COOLING TOWER:VARIABLE SPEED	CoolingTower:VariableSpeed
COOLING TOWER:VARIABLE SPEED:COOLTOOLS MODEL COEFFICIENTS	CoolingTowerPerformance:CoolTools
COOLING TOWER:VARIABLE SPEED:YORKCALC MODEL COEFFICIENTS	CoolingTowerPerformance:YorkCalc
COOLTOWER:SHOWER	ZoneCoolTower:Shower
CROSS MIXING	ZoneCrossMixing
CURVE:BICUBIC	Curve:Bicubic
CURVE:BIQUADRATIC	Curve:Biquadratic
CURVE:CUBIC	Curve:Cubic
CURVE:LINEAR	Curve:Linear
CURVE:QUADRATIC	Curve:Quadratic
CURVE:QUADRATICLINEAR	Curve:QuadraticLinear
CURVE:TRIQUADRATIC	Curve:Triquadratic
CUSTOM METER	Meter:Custom
CUSTOM METER:DECREMENT	Meter:CustomDecrement
Daylighting Device:Shelf	DaylightingDevice:Shelf
Daylighting Device:Tubular	DaylightingDevice:Tubular
DAYLIGHTING:DELIGHT	Daylighting:DELIGHT:Controls
DAYLIGHTING:DELIGHT:Complex Fenestration	Daylighting:DELIGHT:ComplexFenestration
DAYLIGHTING:DELIGHT:Reference Point	Daylighting:DELIGHT:ReferencePoint
DAYLIGHTING:DETAILED	Daylighting:Controls
Daylighting:Illuminance Map	Output:IlluminanceMap
Daylighting:Illuminance Map:Style	OutputControl:IlluminanceMap:Style
DaylightSavingPeriod	RunPeriodControl:DaylightSavingTime
DAYSCHEDULE	Schedule:Day:Hourly
DAYSCHEDULE:INTERVAL	Schedule:Day:Interval
DAYSCHEDULE:LIST	Schedule:Day:List
DEBUG OUTPUT	Output:DebuggingData

Old Object Type	New V3.0 Object Type
DEMAND MANAGER LIST	DemandManagerAssignmentList
DEMAND MANAGER:ELECTRIC EQUIPMENT	DemandManager:ElectricEquipment
DEMAND MANAGER:EXTERIOR LIGHTS	DemandManager:ExteriorLights
DEMAND MANAGER:LIGHTS	DemandManager:Lights
DEMAND MANAGER:THERMOSTATS	DemandManager:Thermostats
DESICCANT DEHUMIDIFIER	Dehumidifier:Desiccant:System
DESICCANT DEHUMIDIFIER:SOLID	Dehumidifier:Desiccant:NoFans
DesignDay	SizingPeriod:DesignDay
DIAGNOSTICS	Output:Diagnosics
DIRECT AIR	AirTerminal:SingleDuct:Uncontrolled
DUAL DUCT:CONST VOLUME	AirTerminal:DualDuct:ConstantVolume
DUAL DUCT:VAV	AirTerminal:DualDuct:VAV
DUAL SETPOINT WITH DEADBAND	ThermostatSetpoint:DualSetpoint
DUAL THERMAL COMFORT SETPOINT WITH DEADBAND:FANGER	ThermostatSetpoint:ThermalComfort:Fanger:DualSetpoint
DUCT	Duct
DXSystem:AirLoop	AirLoopHVAC:UnitaryCoolOnly
EARTH TUBE	ZoneEarthtube
Economics:Charge:Block	UtilityCost:Charge:Block
Economics:Charge:Simple	UtilityCost:Charge:Simple
Economics:Component Cost:Adjustments	ComponentCost:Adjustments
Economics:Component Cost:Line Item	ComponentCost:LineItem
Economics:Component Cost:Reference	ComponentCost:Reference
Economics:Computation	UtilityCost:Computation
Economics:CurrencyType	CurrencyType
Economics:Qualify	UtilityCost:Qualify
Economics:Ratchet	UtilityCost:Ratchet
Economics:Tariff	UtilityCost:Tariff
Economics:Variable	UtilityCost:Variable
ELECTRIC EQUIPMENT	ElectricEquipment
ELECTRIC LOAD CENTER:DISTRIBUTION	ElectricLoadCenter:Distribution
ELECTRIC LOAD CENTER:GENERATORS	ElectricLoadCenter:Generators
ElectricLoadCenter:Inverter:FunctionOfPower	ElectricLoadCenter:Inverter:FunctionOfPower
ElectricLoadCenter:Inverter:LookUpTable	ElectricLoadCenter:Inverter:LookUpTable
ElectricLoadCenter:Inverter:Simple	ElectricLoadCenter:Inverter:Simple
ElectricLoadCenter:Storage:Simple	ElectricLoadCenter:Storage:Simple
ENERGY RECOVERY VENTILATOR:STAND ALONE	ZoneHVAC:EnergyRecoveryVentilator
Environmental Impact Factors	EnvironmentalImpactFactors
EvapCooler:Direct:CelDekPad	EvaporativeCooler:Direct:CelDekPad
EvapCooler:InDirect:CelDekPad	EvaporativeCooler:Indirect:CelDekPad

Old Object Type	New V3.0 Object Type
EvapCooler:InDirect:RDDSpecial	EvaporativeCooler:Indirect:ResearchSpecial
EvapCooler:InDirect:WetCoil	EvaporativeCooler:Indirect:WetCoil
ExteriorFuelEquipment	Exterior:FuelEquipment
ExteriorLights	Exterior:Lights
ExteriorWaterEquipment	Exterior:WaterEquipment
FAN COIL UNIT:4 PIPE	ZoneHVAC:FourPipeFanCoil
FAN:NIGHT VENT PERFORMANCE	FanPerformance:NightVentilation
FAN:SIMPLE:ConstVolume	Fan:ConstantVolume
FAN:SIMPLE:ONOFF	Fan:OnOff
FAN:SIMPLE:VariableVolume	Fan:VariableVolume
FLUID COOLER:SINGLE SPEED	FluidCooler:SingleSpeed
FLUID COOLER:TWO SPEED	FluidCooler:TwoSpeed
FluidNames	FluidProperties:Names
FluidPropertyConcentration	FluidProperties:Concentration
FluidPropertySaturated	FluidProperties:Saturated
FluidPropertySuperheated	FluidProperties:Superheated
FluidPropertyTemperatures	FluidProperties:Temperatures
Fuel Factors	FuelFactors
FURNACE:HEATCOOL	AirLoopHVAC:Unitary:Furnace:HeatCool
FURNACE:HEATONLY	AirLoopHVAC:Unitary:Furnace:HeatOnly
GAS EQUIPMENT	GasEquipment
GENERATOR:COMBUSTION TURBINE	Generator:CombustionTurbine
GENERATOR:FUEL CELL	Generator:FuelCell
GENERATOR:FUEL CELL:AIR SUPPLY	Generator:FuelCell:AirSupply
GENERATOR:FUEL CELL:AUXILIARY HEATER	Generator:FuelCell:AuxiliaryHeater
GENERATOR:FUEL CELL:ELECTRICAL STORAGE	Generator:FuelCell:ElectricalStorage
GENERATOR:FUEL CELL:EXHAUST GAS TO WATER HEAT EXCHANGER	Generator:FuelCell:ExhaustGasToWaterHeatExchanger
GENERATOR:FUEL CELL:INVERTER	Generator:FuelCell:Inverter
GENERATOR:FUEL CELL:POWER MODULE	Generator:FuelCell:PowerModule
GENERATOR:FUEL CELL:STACK COOLER	Generator:FuelCell:StackCooler
GENERATOR:FUEL CELL:WATER SUPPLY	Generator:FuelCell:WaterSupply
GENERATOR:FUEL SUPPLY	Generator:FuelSupply
GENERATOR:IC ENGINE	Generator:InternalCombustionEngine
GENERATOR:MICRO CHP	Generator:MicroCHP
GENERATOR:MICRO CHP:NON NORMALIZED PARAMETERS	Generator:MicroCHP:NonNormalizedParameters
GENERATOR:MICROTURBINE	Generator:MicroTurbine
GENERATOR:PV:EQUIVALENT ONE-DIODE	Generator:Photovoltaic
GENERATOR:PV:SANDIA	Generator:Photovoltaic

Old Object Type	New V3.0 Object Type
GENERATOR:PV:SIMPLE	Generator:Photovoltaic
GeometryTransform	GeometryTransform
GlycolConcentrations	FluidProperties:GlycolConcentrations
GROUND HEAT EXCHANGER:POND	GroundHeatExchanger:Pond
GROUND HEAT EXCHANGER:SURFACE	GroundHeatExchanger:Surface
GROUND HEAT EXCHANGER:VERTICAL	GroundHeatExchanger:Vertical
GroundReflectances	Site:GroundReflectance
GroundTemperatures	Site:GroundTemperature:BuildingSurface
GroundTemperatures:Deep	Site:GroundTemperature:Deep
GroundTemperatures:Surface	Site:GroundTemperature:Shallow
GROUNDWATER WELL	WaterUse:Well
HEADERED PUMPS:SIMPLE:CONSTANT SPEED	HeaderedPumps:ConstantSpeed
HEADERED PUMPS:SIMPLE:VARIABLE SPEED	HeaderedPumps:VariableSpeed
HEAT EXCHANGER:AIR TO AIR:FLAT PLATE	HeatExchanger:AirToAir:FlatPlate
HEAT EXCHANGER:AIR TO AIR:GENERIC	HeatExchanger:AirToAir:SensibleAndLatent
HEAT EXCHANGER:DESICCANT:BALANCEDFLOW	HeatExchanger:Desiccant:BalancedFlow
HEAT EXCHANGER:DESICCANT:BALANCEDFLOW :PERFORMANCE DATA TYPE 1	HeatExchanger:Desiccant:BalancedFlow:PerformanceDataType1
HEAT EXCHANGER:HYDRONIC:FREE COOLING	HeatExchanger:Hydronic
HEAT EXCHANGER:PLATE:FREE COOLING	HeatExchanger:Plate
HEAT EXCHANGER:WATERSIDE ECONOMIZER	HeatExchanger:WatersideEconomizer
HEAT PUMP:WATER HEATER	WaterHeater:HeatPump
HEATING LOAD RANGE BASED OPERATION	PlantEquipmentOperation:HeatingLoad
HeatPump:WaterToWater:EquationFit:Cooling	HeatPump:WaterToWater:EquationFit:Cooling
HeatPump:WaterToWater:EquationFit:Heating	HeatPump:WaterToWater:EquationFit:Heating
HeatPump:WaterToWater:ParameterEstimation:Cooling	HeatPump:WaterToWater:ParameterEstimation:Cooling
HeatPump:WaterToWater:ParameterEstimation:Heating	HeatPump:WaterToWater:ParameterEstimation:Heating
HIGH TEMP RADIANT SYSTEM	ZoneHVAC:HighTemperatureRadiant
HOT WATER EQUIPMENT	HotWaterEquipment
HUMIDIFIER:STEAM:ELECTRICAL	Humidifier:Steam:Electric
INFILTRATION	ZoneInfiltration
INSIDE CONVECTION ALGORITHM	SurfaceConvectionAlgorithm:Inside
Light Well	DaylightingDevice:LightWell
LIGHTS	Lights
List:Refrigeration:Cases	Refrigeration:CaseList

Old Object Type	New V3.0 Object Type
List:Refrigeration:Compressors	Refrigeration:CompressorList
Location	Site:Location
LOW TEMP RADIANT SYSTEM:CONSTANT FLOW	ZoneHVAC:LowTemperatureRadiant:ConstantFlow
LOW TEMP RADIANT SYSTEM:ELECTRIC	ZoneHVAC:LowTemperatureRadiant:Electric
LOW TEMP RADIANT SYSTEM:HYDRONIC	ZoneHVAC:LowTemperatureRadiant:VariableFlow
MATERIAL:AIR	Material:AirGap
MATERIAL:ECOROOF	Material:RoofVegetation
MATERIAL:IRT	Material:InfraredTransparent
MATERIAL:REGULAR	Material
MATERIAL:REGULAR-R	Material:NoMass
MATERIAL:WINDOWBLIND	WindowMaterial:Blind
MATERIAL:WINDOWGAS	WindowMaterial:Gas
MATERIAL:WINDOWGASMIXTURE	WindowMaterial:GasMixture
MATERIAL:WINDOWGLASS	WindowMaterial:Glazing
MATERIAL:WINDOWGLASS:AltInput	WindowMaterial:Glazing:RefractionExtinctionMethod
MATERIAL:WINDOWSCREEN	WindowMaterial:Screen
MATERIAL:WINDOWSHADE	WindowMaterial:Shade
MATERIALPROPERTY:MOISTURE:EMPD	MaterialProperty:MoisturePenetrationDepth:Settings
MATERIALPROPERTY:MOISTURE:HAMT-ISOTHERM	MaterialProperty:HeatAndMoistureTransfer:SorptionIsotherm
MATERIALPROPERTY:MOISTURE:HAMT-MU	MaterialProperty:HeatAndMoistureTransfer:Diffusion
MATERIALPROPERTY:MOISTURE:HAMT-PROPERTIES	MaterialProperty:HeatAndMoistureTransfer:Settings
MATERIALPROPERTY:MOISTURE:HAMT-REDISTRIBUTION	MaterialProperty:HeatAndMoistureTransfer:Redistribution
MATERIALPROPERTY:MOISTURE:HAMT-SUCTION	MaterialProperty:HeatAndMoistureTransfer:Suction
MATERIALPROPERTY:MOISTURE:HAMT-THERMAL	MaterialProperty:HeatAndMoistureTransfer:ThermalConductivity
MATERIALPROPERTY:TEMPERATUREDEP:CondFD	MaterialProperty:PhaseChange
MIXER	Connector:Mixer
MIXING	ZoneMixing
MovableInsulation	SurfaceControl:MovableInsulation
MUNDT MODEL CONTROLS	RoomAirSettings:OneNodeDisplacementVentilation
NODE LIST	NodeList
OTHER EQUIPMENT	OtherEquipment
OtherSideCoefficients	SurfaceProperty:OtherSideCoefficients
OtherSideConditionsModel	SurfaceProperty:OtherSideConditionsModel
OUTDOOR DEWPOINT RANGE BASED OPERATION	PlantEquipmentOperation:OutdoorDewpoint
OUTDOOR DEWPOINT TEMPERATURE DIFFERENCE BASED OPERATION	PlantEquipmentOperation:OutdoorDewpointDifference

Old Object Type	New V3.0 Object Type
OUTDOOR DRYBULB RANGE BASED OPERATION	PlantEquipmentOperation:OutdoorDryBulb
OUTDOOR DRYBULB TEMPERATURE DIFFERENCE BASED OPERATION	PlantEquipmentOperation:OutdoorDryBulbDifference
OUTDOOR RHPERCENT RANGE BASED OPERATION	PlantEquipmentOperation:OutdoorRelativeHumidity
OUTDOOR WETBULB RANGE BASED OPERATION	PlantEquipmentOperation:OutdoorWetBulb
OUTDOOR WETBULB TEMPERATURE DIFFERENCE BASED OPERATION	PlantEquipmentOperation:OutdoorWetBulbDifference
Output:SQLite	Output:SQLite
OUTSIDE AIR INLET NODE LIST	OutdoorAir:NodeList
OUTSIDE AIR MIXER	OutdoorAir:Mixer
OUTSIDE AIR NODE	OutdoorAir:Node
OUTSIDE AIR SYSTEM	AirLoopHVAC:OutdoorAirSystem
OUTSIDE CONVECTION ALGORITHM	SurfaceConvectionAlgorithm:Outside
PACKAGEDTERMINAL:AIRCONDITIONER	ZoneHVAC:PackagedTerminalAirConditioner
PACKAGEDTERMINAL:HEATPUMP:AIRTOAIR	ZoneHVAC:PackagedTerminalHeatPump
PEOPLE	People
PhotovoltaicPerformance:EquivalentOne-Diode	PhotovoltaicPerformance:EquivalentOne-Diode
PhotovoltaicPerformance:Sandia	PhotovoltaicPerformance:Sandia
PhotovoltaicPerformance:Simple	PhotovoltaicPerformance:Simple
PIPE	Pipe:Adiabatic
PIPE:EXTERIOR	Pipe:Outdoor
PIPE:INTERIOR	Pipe:Indoor
PIPE:STEAM	Pipe:Adiabatic:Steam
PIPE:UNDERGROUND	Pipe:Underground
PLANT EQUIPMENT LIST	PlantEquipmentList
PLANT LOAD PROFILE	LoadProfile:Plant
PLANT LOOP	PlantLoop
PLANT OPERATION SCHEMES	PlantEquipmentOperationSchemes
PLANT SIZING	Sizing:Plant
Preprocessor Message	Output:PreprocessorMessage
PUMP:CONDENSATE	Pump:VariableSpeed:Condensate
PUMP:CONSTANT SPEED	Pump:ConstantSpeed
PUMP:VARIABLE SPEED	Pump:VariableSpeed
PURCHASED AIR	ZoneHVAC:IdealLoadsAirSystem
PURCHASED:CHILLED WATER	DistrictCooling
PURCHASED:HOT WATER	DistrictHeating
PV MODULE:SANDIA PARAMETERS	PhotovoltaicPerformance:Sandia
RADIANT SYSTEM SURFACE GROUP	ZoneHVAC:LowTemperatureRadiant:SurfaceGroup
RAINWATER COLLECTOR	WaterUse:RainCollector

Old Object Type	New V3.0 Object Type
Refrigeration:Compressor	Refrigeration:Compressor
Refrigeration:Condenser:AirCooled	Refrigeration:Condenser:AirCooled
Refrigeration:Condenser:EvaporativeCooled	Refrigeration:Condenser:EvaporativeCooled
Refrigeration:Condenser:WaterCooled	Refrigeration:Condenser:WaterCooled
Refrigeration:Subcooler	Refrigeration:Subcooler
Refrigeration:System	Refrigeration:System
Report	Output:Reports
Report Cumulative Meter	Output:Meter:Cumulative
Report Cumulative MeterFileOnly	Output:Meter:Cumulative:MeterFileOnly
Report Environmental Impact Factors	Output:EnvironmentalImpactFactors
Report Meter	Output:Meter
Report MeterFileOnly	Output:Meter:MeterFileOnly
Report Variable	Output:Variable
Report:SurfaceColorScheme	OutputControl:SurfaceColorScheme
Report:Table:Monthly	Output:Table:Monthly
Report:Table:Predefined	Output:Table:SummaryReports
Report:Table:Style	OutputControl:Table:Style
Report:Table:TimeBins	Output:Table:TimeBins
ROOF IRRIGATION	RoofIrrigation
ROOMAIR MODEL	RoomAirModelType
ROOMAIR NODE	RoomAir:Node
ROOMAIR TEMPERATURE PATTERN:CONSTANT GRADIENT	RoomAir:TemperaturePattern:ConstantGradient
ROOMAIR TEMPERATURE PATTERN:NON-DIMENSIONAL HEIGHT	RoomAir:TemperaturePattern:NondimensionalHeight
ROOMAIR TEMPERATURE PATTERN:SURFACE MAPPING	RoomAir:TemperaturePattern:SurfaceMapping
ROOMAIR TEMPERATURE PATTERN:TWO GRADIENT INTERPOLATION	RoomAir:TemperaturePattern:TwoGradient
RUN CONTROL	SimulationControl
RunPeriod	RunPeriod
RunPeriod:Design	SizingPeriod:WeatherFileDays
RunPeriod:DesignSelectionFromWeatherFile	SizingPeriod:WeatherFileConditionType
SCHEDULE	Schedule:Year
SCHEDULE:COMPACT	Schedule:Compact
SCHEDULE:FILE:COMMA	Schedule:File
ScheduleType	ScheduleTypeLimits
SET POINT MANAGER:COLDEST	SetpointManager:Coldest
SET POINT MANAGER:MIXED AIR	SetpointManager:MixedAir
SET POINT MANAGER:OUTSIDE AIR	SetpointManager:OutdoorAirReset
SET POINT MANAGER:OUTSIDE AIR PRETREAT	SetpointManager:OutdoorAirPretreat

Old Object Type	New V3.0 Object Type
SET POINT MANAGER:RETURN AIR BYPASS FLOW	SetpointManager:ReturnAirBypassFlow
SET POINT MANAGER:SCHEDULED	SetpointManager:Scheduled
SET POINT MANAGER:SCHEDULED:DUALSETPOINT	SetpointManager:Scheduled:DualSetpoint
SET POINT MANAGER:SINGLE ZONE COOLING	SetpointManager:SingleZone:Cooling
SET POINT MANAGER:SINGLE ZONE HEATING	SetpointManager:SingleZone:Heating
SET POINT MANAGER:SINGLE ZONE MAX HUM	SetpointManager:SingleZone:Humidity:Maximum
SET POINT MANAGER:SINGLE ZONE MIN HUM	SetpointManager:SingleZone:Humidity:Minimum
SET POINT MANAGER:SINGLE ZONE REHEAT	SetpointManager:SingleZone:Reheat
SET POINT MANAGER:WARMEST	SetpointManager:Warmest
SET POINT MANAGER:WARMEST TEMP FLOW	SetpointManager:WarmestTemperatureFlow
Shading Surface Reflectance	ShadingProperty:Reflectance
SHADOWING CALCULATIONS	ShadowCalculation
SINGLE COOLING SETPOINT	ThermostatSetpoint:SingleCooling
SINGLE DUCT:CONST VOLUME:4 PIPE INDUC	AirTerminal:SingleDuct:ConstantVolume:FourPipeInduction
SINGLE DUCT:CONST VOLUME:REHEAT	AirTerminal:SingleDuct:ConstantVolume:Reheat
SINGLE DUCT:PARALLEL PIU:REHEAT	AirTerminal:SingleDuct:ParallelPIU:Reheat
SINGLE DUCT:SERIES PIU:REHEAT	AirTerminal:SingleDuct:SeriesPIU:Reheat
SINGLE DUCT:VAV:NOREHEAT	AirTerminal:SingleDuct:VAV:NoReheat
SINGLE DUCT:VAV:REHEAT	AirTerminal:SingleDuct:VAV:Reheat
SINGLE DUCT:VAV:REHEAT:VS FAN	AirTerminal:SingleDuct:VAV:Reheat:VariableSpeedFan
SINGLE DUCT:VAVHEATANDCOOL:NOREHEAT	AirTerminal:SingleDuct:VAV:HeatAndCool:NoReheat
SINGLE DUCT:VAVHEATANDCOOL:REHEAT	AirTerminal:SingleDuct:VAV:HeatAndCool:Reheat
SINGLE HEATING COOLING SETPOINT	ThermostatSetpoint:SingleHeatingOrCooling
SINGLE HEATING SETPOINT	ThermostatSetpoint:SingleHeating
SINGLE THERMAL COMFORT COOLING SETPOINT:FANGER	ThermostatSetpoint:ThermalComfort:Fanger:SingleCooling
SINGLE THERMAL COMFORT HEATING COOLING SETPOINT:FANGER	ThermostatSetpoint:ThermalComfort:Fanger:SingleHeatingOrCooling
SINGLE THERMAL COMFORT HEATING SETPOINT:FANGER	ThermostatSetpoint:ThermalComfort:Fanger:SingleHeating
SITE ATMOSPHERIC VARIATION	Site:HeightVariation
SITE PRECIPITATION	Site:Precipitation
SIZING PARAMETERS	Sizing:Parameters
Sizing:Output:Style	OutputControl:Sizing:Style

Old Object Type	New V3.0 Object Type
Snow Ground Reflectance Modifiers	Site:GroundReflectance:SnowModifier
SOLAR COLLECTOR PARAMETERS:FLAT PLATE	SolarCollectorPerformance:FlatPlate
SOLAR COLLECTOR:FLAT PLATE	SolarCollector:FlatPlate:Water
SOLAR COLLECTOR:UNGLAZED TRANSPIRED	SolarCollector:UnglazedTranspired
SOLAR COLLECTOR:UNGLAZED TRANSPIRED:MULTISYSTEM	SolarCollector:UnglazedTranspired:Multisystem
SolarCollector:FlatPlate:PhotovoltaicThermal	SolarCollector:FlatPlate:PhotovoltaicThermal
SolarCollectorPerformance:PhotovoltaicThermal:Simple	SolarCollectorPerformance:PhotovoltaicThermal:Simple
SOLUTION ALGORITHM	HeatBalanceAlgorithm
SpecialDayPeriod	RunPeriodControl:SpecialDays
SPLITTER	Connector:Splitter
STEAM EQUIPMENT	SteamEquipment
StormWindow	WindowProperty:StormWindow
Surface:HeatTransfer	BuildingSurface:Detailed
Surface:HeatTransfer:ExteriorNaturalVentedCavity	SurfaceProperty:ExteriorNaturalVentedCavity
Surface:HeatTransfer:InternalMass	InternalMass
Surface:HeatTransfer:Sub	FenestrationSurface:Detailed
Surface:Shading:Attached	Shading:Zone:Detailed
Surface:Shading:Detached:Building	Shading:Building:Detailed
Surface:Shading:Detached:Fixed	Shading:Site:Detailed
SurfaceGeometry	GlobalGeometryRules
SYSTEM AVAILABILITY MANAGER LIST	AvailabilityManagerAssignmentList
SYSTEM AVAILABILITY MANAGER:DIFFERENTIAL THERMOSTAT	AvailabilityManager:DifferentialThermostat
SYSTEM AVAILABILITY MANAGER:HIGH TEMPERATURE TURN OFF	AvailabilityManager:HighTemperatureTurnOff
SYSTEM AVAILABILITY MANAGER:HIGH TEMPERATURE TURN ON	AvailabilityManager:HighTemperatureTurnOn
SYSTEM AVAILABILITY MANAGER:HYBRID VENTILATION CONTROL	AvailabilityManager:HybridVentilation
SYSTEM AVAILABILITY MANAGER:LOW TEMPERATURE TURN OFF	AvailabilityManager:LowTemperatureTurnOff
SYSTEM AVAILABILITY MANAGER:LOW TEMPERATURE TURN ON	AvailabilityManager:LowTemperatureTurnOn
SYSTEM AVAILABILITY MANAGER:NIGHT CYCLE	AvailabilityManager:NightCycle
SYSTEM AVAILABILITY MANAGER:NIGHT VENTILATION	AvailabilityManager:NightVentilation
SYSTEM AVAILABILITY MANAGER:SCHEDULED	AvailabilityManager:Scheduled

Old Object Type	New V3.0 Object Type
SYSTEM AVAILABILITY MANAGER:SCHEDULED OFF	AvailabilityManager:ScheduledOff
SYSTEM AVAILABILITY MANAGER:SCHEDULED ON	AvailabilityManager:ScheduledOn
System Convergence Limits	ConvergenceLimits
SYSTEM SIZING	Sizing:System
THERMAL STORAGE:ICE:DETAILED	ThermalStorage:Ice:Detailed
THERMAL STORAGE:ICE:SIMPLE	ThermalStorage:Ice:Simple
THERMALCHIMNEY	ZoneThermalChimney
ThermalStorage:ChilledWater:Mixed	ThermalStorage:ChilledWater:Mixed
ThermalStorage:ChilledWater:Stratified	ThermalStorage:ChilledWater:Stratified
TIMESTEP IN HOUR	Timestep
UCSD CROSS VENTILATION MODEL CONTROLS	RoomAirSettings:CrossVentilation
UCSD DISPLACEMENT VENTILATION MODEL CONTROLS	RoomAirSettings:ThreeNodeDisplacementVentilation
UCSD UFAD EXTERIOR MODEL CONTROLS	RoomAirSettings:UnderFloorAirDistributionExterior
UCSD UFAD INTERIOR MODEL CONTROLS	RoomAirSettings:UnderFloorAirDistributionInterior
UNCONTROLLED LOOP OPERATION	PlantEquipmentOperation:Uncontrolled
UNIT HEATER	ZoneHVAC:UnitHeater
UNIT VENTILATOR	ZoneHVAC:UnitVentilator
UNITARYSYSTEM:HEATCOOL	AirLoopHVAC:UnitaryHeatCool
UNITARYSYSTEM:HEATONLY	AirLoopHVAC:UnitaryHeatOnly
UNITARYSYSTEM:HEATPUMP:AIRTOAIR	AirLoopHVAC:UnitaryHeatPump:AirToAir
UnitarySystem:HeatPump:WaterToAir	AirLoopHVAC:UnitaryHeatPump:WaterToAir
UNITARYSYSTEM:MULTISPEEDHEATPUMP: AIRTOAIR	AirLoopHVAC:UnitaryHeatPump:AirToAir:MultiSpeed
UNITARYSYSTEM:VAV:CHANGEOVERBYPA SS	AirLoopHVAC:UnitaryHeatCool:VAVChangeoverBypa ss
USER DEFINED ROOMAIR TEMPERATURES	RoomAir:TemperaturePattern:UserDefined
UserViewFactors	ZoneProperty:UserViewFactors
VALVE:TEMPERING	TemperingValve
VaporCoefficients	SurfaceProperties:VaporCoefficients
VENTILATED SLAB	ZoneHVAC:VentilatedSlab
VENTILATION	ZoneVentilation
VENTILATION:MECHANICAL	Controller:MechanicalVentilation
VERSION	Version
WATER HEATER:MIXED	WaterHeater:Mixed
WATER HEATER:SIZING	WaterHeater:Sizing
WATER HEATER:STRATIFIED	WaterHeater:Stratified
WATER MAINS TEMPERATURES	Site:WaterMainsTemperature
WATER STORAGE TANK	WaterUse:Storage
WATER USE CONNECTIONS	WaterUse:Connections

Old Object Type	New V3.0 Object Type
WATER USE EQUIPMENT	WaterUse:Equipment
WEATHER STATION	Site:WeatherStation
WEEKSCHEDULE	Schedule:Week:Daily
WEEKSCHEDULE:COMPACT	Schedule:Week:Compact
WindowFrameAndDivider	WindowProperty:FrameAndDivider
WindowGapAirflowControl	WindowProperty:AirflowControl
WindowGlassSpectralData	MaterialProperty:GlazingSpectralData
WindowShadingControl	WindowProperty:ShadingControl
ZONE	Zone
ZONE CONTROL:HUMIDISTAT	ZoneControl:Humidistat
ZONE CONTROL:THERMAL COMFORT	ZoneControl:Thermostat:ThermalComfort
ZONE CONTROL:THERMOSTATIC	ZoneControl:Thermostat
ZONE CONTROL:THERMOSTATIC:OPERATIVE TEMPERATURE	ZoneControl:Thermostat:OperativeTemperature
ZONE EQUIPMENT LIST	ZoneHVAC:EquipmentList
ZONE EXHAUST FAN	Fan:ZoneExhaust
ZONE GROUP	ZoneGroup
ZONE LIST	ZoneList
ZONE MIXER	AirLoopHVAC:ZoneMixer
ZONE RETURN AIR PATH	AirLoopHVAC:ReturnPath
ZONE RETURN PLENUM	AirLoopHVAC:ReturnPlenum
ZONE SIZING	Sizing:Zone
ZONE SPLITTER	AirLoopHVAC:ZoneSplitter
ZONE SUPPLY AIR PATH	AirLoopHVAC:SupplyPath
ZONE SUPPLY PLENUM	AirLoopHVAC:SupplyPlenum
ZONE VOLUME CAPACITANCE MULTIPLIER	ZoneCapacitanceMultiplier

Appendix C. Notices and Acknowledgments

Copyright Notice

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Portions of the EnergyPlus™ software package have been developed and copyrighted by other individuals, companies and institutions. These portions have been incorporated into the EnergyPlus software package under license.

In addition to the primary authorship of the LBNL Simulation Research Group (<http://simulationresearch.lbl.gov/>) and the UIUC Building Systems Laboratory, the following have contributed to EnergyPlus Version 1 (includes all minor revisions):

Portions of the EnergyPlus weather processor were developed by US Department of Energy, Office of Building Technologies, www.energyplus.gov

Portions of the input processing, output processing, weather processor, BLAST Translator were developed by US Army Corps of Engineers, Construction Engineering Research Laboratories, 2902 Newmark Drive, Champaign IL 61821. www.cecer.army.mil

Portions of this software package were developed for Ernest Orlando Lawrence Berkeley National Laboratory by Linda Lawrie of DHL Consulting.

Portions of this software package were developed for Ernest Orlando Lawrence Berkeley National Laboratory by C.O. Pedersen Associates.

Portions of the EnergyPlus utility software (EP-Launch, IDFEditor, DOE2Translator, HVAC-Diagram, ExpandObjects, CSVProc, System Templates, and convertESOMTR) were developed by GARD Analytics, Inc. 1028 Busse Highway, Park Ridge, Illinois 60068-1802, USA (847) 698-5690, www.gard.com. GARD Analytics performed independent verification and validation testing of the software after developing the testing strategy and plan. GARD Analytics was also responsible for gas absorption chiller, desiccant dehumidifier, ice storage (simple), table reports and economics.

Portions of flow resolver, chiller models (absorption, electric, const cop, engine-driven, gas-turbine), generator models (diesel electric, gas turbine), furnace models, heat recovery loop, plant loop, plant condenser loop, air-change dependent inside film coefficients were

developed by Oklahoma State University, 110 Engineering North, Stillwater, OK 74078.

Portions of EnergyPlus related to the models for EMPD moisture calculations, DX coils, furnace/unitary systems, air-to-air heat pumps, changeover-bypass VAV systems, packaged terminal heat pumps, cooling towers, AirflowNetwork, refrigerated cases, reformulated and electric EIR chillers, desuperheater air and water heating coils, heat pump water heaters, desiccant and generic air-to-air heat exchangers, window screens, and thermal comfort controls were developed by University of Central Florida, Florida Solar Energy Center (FSEC), 1679 Clearlake Road, Cocoa, FL 32922, www.fsec.ucf.edu/.

Portions of the refrigeration model were developed by Oak Ridge National Laboratory, Bethel Valley Road, Oak Ridge, Tennessee 37831.

Portions of EnergyPlus were developed by the National Renewable Energy Laboratory (NREL), 1617 Cole Blvd, Golden, CO 80401.

EnergyPlus v1.0.1, v1.0.2, v1.0.3, v1.1, v1.1.1 (Wintel platform) includes a link to TRNSYS (The Transient Energy System Simulation Tool) for photovoltaic calculations developed by Thermal Energy System Specialists, 2916 Marketplace Drive, Suite 104, Madison, WI 53719; Tel: (608) 274-2577. EnergyPlus v1.2 and later includes Photovoltaic calculations implemented in EnergyPlus by Thermal Energy System Specialists. This model was originally developed by Oystein Ulleberg, Institute for Energy Technology, Norway -- based on the Duffie and Beckman equivalent one-diode model.

Portions of this software package that convert certain stand-alone heat transfer models for slab-on-grade and basement foundations were developed by William Bahnfleth, Cynthia Cogil, and Edward Clements, Department of Architectural Engineering, Pennsylvania State University, 224 Engineering Unit A, University Park, Pennsylvania 16802-1416, (814) 863-2076.

The concept and initial implementation for the EnergyPlus COM/DLL version (Wintel platform) was made possible through cooperation with DesignBuilder Software, Ltd, Andy Tindale – an EnergyPlus collaborative developer.

The thickness, conductivity, density and specific heat values of the material layers for the constructions in the Composite Wall Construction reference data set have been taken from the ASHRAE report “Modeling Two- and Three-Dimensional Heat Transfer through Composite Wall and Roof Assemblies in Hourly Energy Simulation Programs (1145-TRP),” by Enermodal Engineering Limited, Oak Ridge National Laboratory, and the Polish Academy of Sciences, January 2001.

EnergyPlus v1.2 and later versions contains DELight2, a simulation engine for daylighting and electric lighting system analysis developed at Ernest Orlando Lawrence Berkeley National Laboratory.

Portions of the EnergyPlus AirflowNetwork model were written by George Walton of the National Institute for Standards and Technology (NIST), 100 Bureau Drive, Gaithersburg, MD 20899. The EnergyPlus AirflowNetwork model also includes portions of an early version of COMIS (Conjunction Of Multizone Infiltration Specialists) developed by a multinational, multi-institutional effort under the auspices of the International Energy Agency's Buildings and Community Systems Agreement working group focusing on multizone air flow modeling (Annex 23) and now administered by the Swiss Federal Laboratories for Materials Testing and Research (EMPA), Division 175, Überlandstrasse 129, CH-8600 Dübendorf, Switzerland.

The EnergyPlus v1.2 model for displacement ventilation and cross-ventilation was developed by Guilherme Carrilho da Graça (Department of Mechanical and Aerospace Engineering, University of California, San Diego and NaturalWorks) and Paul Linden (Department of Mechanical and Aerospace Engineering, University of California, San Diego).

The EnergyPlus models for UFAD served zones were developed by Anna Liu and Paul Linden at the Department of Mechanical and Aerospace Engineering, University of California, San Diego.

ASHRAE research project 1254-RP supported the development of the following features first added in EnergyPlus v1.2.2: DXSystem:AirLoop enhancements (valid as OA system equipment, new humidity control options); New set point managers: SET POINT MANAGER:SINGLE ZONE HEATING, SET POINT MANAGER:SINGLE ZONE COOLING, and SET POINT MANAGER:OUTSIDE AIR PRETREAT; New 2-stage DX coil with enhanced dehumidification option (COIL:DX:MultiMode:CoolingEmpirical); Additional DESICCANT DEHUMIDIFIER:SOLID setpoint control option; American Society of Heating Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329. www.ashrae.org/. Work performed by GARD Analytics, Inc., 1028 Busse Highway, Park Ridge, Illinois 60068-1802, USA. www.gard.com/, November 2004.

EnergyPlus v1.2.2 and later versions contains links to SPARK, a simulation engine for detailed system modeling developed at Ernest Orlando Lawrence Berkeley National Laboratory in conjunction with Ayres Sowell Associates, Inc.

The Ecoroof (Green Roof) model, first introduced in EnergyPlus v2.0, was developed at Portland State University, by David Sailor and his students. It is based on the FASST vegetation models developed by Frankenstein and Koenig for the US Army Corps of Engineers.

The HAMT (Heat And Moisture Transfer) model, first introduced in EnergyPlus v3.0.0 was developed by Phillip Biddulph, Complex Built Environment Systems, The Bartlett School of Graduate Studies, University College London, Gower Street, London WC1E 6BT, United Kingdom. <http://www.cbes.ucl.ac.uk/>.

The SQLite output module, first introduced in EnergyPlus v3.0.0, was developed by Gregory B. Stark, P.E., Building Synergies, LLC, 1860 Washington Street, Suite 208, Denver, Colorado 80203, United States. <http://www.buildingsynergies.com/>

Refrigeration compressor performance data and refrigeration practices were provided by CDH Energy, Cazenovia, NY 12035.

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