Oregon Non-Residential Building Energy Code

OREGON DEPARTMENT OF ENERGY

Exhaust Air Heat Recovery

This fact sheet describes Oregon Energy Code requirements for heat recovery for large volume fan systems and indoor pool facilities.

Exhaust Air Heat Recovery

Heat recovery is an essential means of reducing both the heating and cooling energy required to condition outside air. Some types of heat recovery systems can also both add and remove moisture (latent heat) from the incoming air. Heat recovery is important for systems that bring in large percentages of outside air. The code requires heat recovery for systems with a design supply air capacity of 10,000 cfm or greater and a minimum outside air supply of 70 percent or greater.

The Code requires that the heat recovery system raise the outside air supply temperature by 20°F for Climate Zone 1 and by 30°F by Climate Zone 2. This corresponds to a heat recovery effectiveness of approximately 50 percent.

Heat recovery effectiveness, in terms of energy delivered to the supply air, is defined as:

$$\eta_{HR} = \frac{h_{OA,entering} - h_{OA,leaving}}{h_{OA,entering} - h_{RA}}$$

where the terms are the enthalpy of the entering and leaving outside air and enthalpy of the return air, respectively. For systems that provide only sensible heat recovery, the heat recovery effectiveness is given by:

$$\eta_{HR} = \frac{T_{OA,entering} - T_{OA,leaving}}{T_{OA,entering} - T_{RA}}$$

The Code expresses heat recovery requirement in terms of temperature gain at design heating conditions. For example, for a building in Climate Zone 1 with a 30°F winter design dry-bulb temperature, and a return air temperature of 70°F, the required heat recovery effectiveness is $\eta_{HR} = (30 - 50) / (30 - 70) = 0.50$ Note that the effectiveness of many types of heat recovery devices decreases as the entering air temperature decreases. The device must meet the effectiveness requirement at design heating conditions.

Types of heat recovery systems that may meet this requirement include run-around coils, fixed plate heat exchangers, heat pipes or enthalpy wheels. A run-around coil is a common method of heat

Continues on **page 2**

Code Language

Documentation: Exhaust air heat recovery is documented on Form 4a, line 14. Heat recovery for swimming pools is documented on Form 4a, line 18.

1318.3 Exhaust air-heat recovery. An exhaust air heat recovery system shall be installed for each HVAC fan system that has all of the following:

1. A design supply air capacity of 10,000 cfm (4,720 L/s) or greater,
2. A minimum outside air supply of 70% or greater,
3. At least one exhaust fan rated at 75% of the minimum outside air supply.

The heat recovery system shall be capable of increasing the outside air supply temperature at design heating conditions by 20°F in Climate Zone 1 and 30°F in Climate Zone 2. A provision shall be made to bypass or control the heat recovery system to permit air economizer operation as required by Section 1317.3.

Exceptions:

1. HVAC systems with ventilation controls for high occupancy areas per Section 1317.2.2.
2. Laboratory systems meeting Section 1317.2.1.
3. Systems serving spaces which are not cooled and which are heated to less than 55°F.
4. Systems exhausting toxic, flammable, paint exhaust, corrosive fumes, or dust.
5. Type 1 kitchen hoods.
6. Where more than 60% of the heating energy is provided from site-recovered or solar energy.
7. Systems that provide only cooling.

1315.5.3 Heat recovery. Heated indoor swimming pools and Spas or Hot tubs over 200 square feet in size shall provide for energy conservation by at least one of the following methods:

1. The ventilating system shall provide a heat recovery of 70% at winter design conditions;
2. Heat recovered through dehumidification shall be used to heat pool, spa or hot tub room supply air.

Exception: Pools heated by renewable energy or waste heat recovery sources capable of providing at least 70% of the heating energy required over an operating season.

Code Language continues on **page 2**

Code Language continued from **page 1**

1317.2.1 Fume Hoods. Buildings with fume hood systems having a total exhaust rate greater than 15,000 cfm (7 m^3/s) shall include at least one of the following features:

1. Variable air volume hood exhaust and room supply systems capable of reducing exhaust and makeup air volume to 50 percent or less of design values; or
2. Direct makeup (auxiliary) air supply equal to at least 75 percent of the exhaust rate, heated no warmer than 2°F below room setpoint, cooled to no cooler than 3°F above room setpoint, no humidification added, and no simultaneous heating and cooling used for dehumidification control; or
3. Heat recovery systems to precondition makeup air from fume hood exhaust in accordance with Section 1318.3.

Continued from page 1

recovery, where heat rejected from the exhaust air stream is recovered and sent to the supply airstream using a heat transferring fluid such as a water and glycol solution. A distinct advantage of this type of system is that the supply and exhaust air streams can be separated. Glycol, added to the water for freeze protection, can significantly lower the heat recovery effectiveness. Other methods of heat recovery require the supply and exhaust air streams to be adjacent. The recovery effectiveness of these other devices are generally better than run-around coils. Fixed plate heat exchangers have low pressure drops and a typical sensible recovery effectiveness of 50-80%. Heat pipes provide energy transfer through evaporation and condensation of a working fluid (refrigerant). They are compact in design and typically have an effectiveness of 45-65%. Rotary enthalpy wheels (heat wheels) use a desiccant to transfer both heat and moisture. Enthalpy wheels are compact and have relatively low pressure drops.

The heat recovery effectiveness of all of these devices is largely driven by the heat transfer surface area. Larger devices can have higher efficiencies, but cost more to purchase and require more space dedicated to mechanical equipment.

When selecting the heat transfer device it is also important to consider the air pressure drop across the heat exchanger. A lower pressure drop reduces the fan energy penalty needed to move air through the heat exchanger. Heat recovery in cold climates, Climate Zone 2, should also incorporate some form of frost control so the warm moist air stream doesn't ice up on the heat recovery device, restricting coil area and limiting airflow capacity.

Heat recovery will reduce heating and cooling requirements, so HVAC equipment should be selected based on the reduced design loads that account for the effect of heat recovery. The heat recovery design must also allow for a means to bypass heat recovery during economizer operation, to avoid unneeded heat gain and the pressure drop across the heat exchanger.

Exceptions

- Densely occupied spaces, with an average occupant load factor of 20ft^2/person or less (50 or more occupants/1,000ft^2) with 1,500 cfm (or more) of outdoor ventilation air, may allow either ventilation controls or a heat recovery system with an energy recovery effectiveness of 50% or greater. These requirements are mutually exclusive – either a heat recovery system or demand controlled ventilation system must be installed. Refer to the Ventilation Controls fact sheet for more information. Ventilation controls are more commonly used for spaces with variable occupancy, such as a lecture hall, gymnasium, restaurant, or theater.

- Buildings such as laboratories that use fume hood systems with a total exhaust air flow rate exceeding 15,000 cfm require heat recovery to precondition makeup air. Exceptions are provided for systems that use variable air volume control that is capable of reducing the airflow to 50% of the

Continues on **page 3**

Continued from page 2

peak design airflow. A VAV system will reduce fan energy and also reduce the energy required to precondition makeup air. The code also allows an exception for direct makeup systems that heat the air to no warmer than 2°F below room setpoint and cool the air to no cooler than 3°F above the setpoint. The auxiliary system must not add humidity to the incoming air. Direct makeup systems have difficulty in maintaining tight humidity control, and are less effective than variable air volume systems.

- A building, such as storage facility, that is not cooled and only heated to less than 55°F qualifies as an exception.
- Type 1 kitchen exhaust hoods are also exempted from the heat recovery requirement.
- Another exception is provided when more than 60% of the heating energy requirement is met by site-recovered energy or solar energy. Site-recovered energy could be in the form of co-generation, where the exhaust heat is recovered for hot water heating. Cogeneration is especially effective in applications that have a large and continuous heating load, such as pool heating. Solar water heating is commonly used in low-temperature applications such as pool heating and service water heating.

Heat Recovery for Indoor Swimming Pools

The Code requires heat recovery for indoor swimming pools, spas and hot tubs over 200 ft² in size. The Code requires either heat recovery from the ventilation system, with a recovery effectiveness of 70% at winter design conditions, or heat recovery from dehumidification. Indoor pool facilities require dehumidification to offset evaporation from the pool to the indoor air. Indoor temperature is typically controlled to 2 degrees above the pool water temperature. Lowering the air temperature below the pool water temperature raises the pool evaporation rate significantly and increases the energy required to heat the pool water. Indoor humidity is typically controlled between 50% and 60% RH. Higher humidity levels can create conditions where the interior building walls, structural columns and roof surface temperature reach the dew-point, causing condensation that allows mold growth and can lead to problems with the structure of the building. Lower humidity levels increases both dehumidification energy and pool heating energy, through an increase in evaporation rate. Evaporation, the major source of indoor pool heat loss, can be greatly reduced by the use of a pool cover.

There are two means of controlling the building humidity level: either by using large amounts of outside air to flush out the humid air or by using a refrigerant based dehumidification system that mechanically pulls moisture from the humid air. Heat recovery is required for either system. Pool dehumidification systems allow

Continues on **page 4**

Examples

Q A theatre whose HVAC system has a design air capacity of 20,000 cfm and requires 15,000 cfm of outside air plans to use a run-around coil for heat recovery. The coil requires glycol for freeze and burst protection. The resulting recovery efficiency is only 40 percent (less than the 50 percent code minimum requirement). How can this building comply with code?

A The run-around coil can be redesigned to add coil rows or reduce the concentration of glycol to increase effectiveness. For example, in Climate Zone 1, a 25 percent concentration level might be more appropriate than a 40 percent concentration level. The heat transfer effectiveness is increased by 15 percent with the 25 percent glycol solution. Selecting the coils based on burst temperature allows for lower glycol levels and greater heat transfer effectiveness. The table below demonstrates the difference in freeze point, burst point temperatures, and heat transfer rate for 25 percent and 40 percent glycol solutions.

Additional alternatives to increase efficiency include the use of other heat recovery methods such as air-to-air heat exchange, or, if the space has a high occupant density, the use of demand controlled ventilation can override the requirement for heat recovery.

Propylene Glycol % vol	Freeze Temperature	Burst Temperature	Heat Transfer Rate
40 percent	-10°F	-40°F	0.904 Btu / h- °F
25 percent	10°F	-5°F	0.957 Btu / h-°F

Q An indoor pool facility uses a packaged cogeneration system to provide electricity for the pool circulation pumps and other loads, and uses the waste heat to pre-heat pool water. Does this qualify as an acceptable method of heat recovery?

A Yes, if the system supplies 70% of the heating energy requirement over an operating season. The system should be designed to follow the thermal load. (In some cases this may result in excess electricity generation, which may be sold back to the local electric utility.)

Examples

Q An indoor pool facility uses a dehumidification system to maintain the indoor temperature and humidity levels. Heat rejected from the refrigeration cycle is recovered and used to pre-heat the pool water. Does this system qualify as heat recovery under Section 1315.5.3 of the Code?

A No. Although the system uses heat recovery, the Code requires that the heat recovery system be able to first heat the supply air during the heating season. After the air heating load is met, excess heat can be used to pre-heat pool water.

Continued from page 3

exhaust air heat to be captured and be used for air heating and/or water heating as a standard option. The Code requires that heat recovered from the dehumidification system be used for heating the indoor air first and pool water secondly.

An exception to the heat recovery requirement is given for pools heated by renewable energy sources, such as solar collectors, or waste heat recovery sources (i.e., cogeneration). The renewable or site-generated source must be able to provide 70% of the annual pool heating requirement. If this exception is taken, calculations showing annual pool heating requirements must be provided to, and approved by, the building official.

Find Out More

Copies of Code:
Oregon Building Officials Association
phone: 503-873-1157 fax: 503-373-9389

Technical Support:
Oregon Department of Energy
625 Marion Street NE
Salem, OR 97301-3737
www.oregon.gov/energy
phone: 503-378-4040
toll free: 800-221-8035
fax: 503-373-7806

This fact sheet was developed with funding from the Northwest Energy Efficiency Alliance and the US Department of Energy under contract DE-FG51-02R021378.

Northwest Energy Efficiency Alliance
www.nwalliance.org

Photo on page 1 c/o Warren Gretz, DOE/NREL

12/05 ODOE CF-125/Fact Sheet 11

Non-residential code HVAC fact sheets include:

- Ventilation Controls System
- Exhaust Air Heat Recovery
- Hydronic Design and Controls
- Large Volume Fan Systems
- Simple vs. Complex HVAC Systems
- Economizers
- Airside Design Requirements
- Airside Controls
- Air Transport Energy