Oregon Non-Residential Building Energy Code

OREGON DEPARTMENT OF ENERGY

Airside Controls

This fact sheet highlights three important control requirements that apply to variable air volume (VAV) HVAC systems: 1) "deadband" control, 2) static pressure reset, and 3) supply air temperature reset. When implemented properly, these measures provide significant savings in fan, cooling, and reheat energy.

Space Temperature Control Deadband

Section 1317.4.2.1 includes an important requirement that must be considered during selection of the control system vendor and communicated to the control system contractor. This section requires a "deadband" of at least 5°F for space temperature control. As stated in the code, "Variable air volume (VAV) terminal units shall be programmed to operate at the minimum airflow setting without addition of reheat when the zone temperature is within the set deadband."

To meet this requirement, the control system must allow separate heating and cooling setpoints that are at least 5°F apart. If, for example, the cooling setpoint is 75°F, then the control system cannot enable the reheat coil until the space temperature drops to 70°F or below.

There are a few cases where this requirement does not apply. First, of course, is cooling-only terminal units (VAV boxes), which do not have reheat and are typically serving interior zones. Second, there is an exception in the code for special occupancies that require tight temperature control.

Dual-duct VAV boxes are a special case. These terminal units do not have reheat coils, instead they have two inlets – cool duct and warm duct – each with its own volume damper. In order to meet the deadband control of section 1317.4.2.1, the warm duct damper must remain closed when space temperature is within the 5°F deadband.

Another special case is parallel fan-powered VAV boxes, which have a small fan that activates in heating mode and draws air from another space such as a return air plenum. To meet the requirements of section 1317.4.2.1, these fans must be programmed to remain off when space temperature is within the deadband.

The minimum airflow setting for VAV boxes is discussed in the fact sheet titled Airside Design.

A good discussion of VAV box control strategies can be found in the Advanced VAV System Design Guide (see page 4).

Continues on **page 2**

Code Language

1317.4.2.1 Control capabilities. Where used to control comfort heating, zone thermostatic controls shall be capable of being set locally or remotely down to 55°F (13°C).

Where used to control comfort cooling, zone thermostatic controls shall be capable of being set locally or remotely up to 85°F (29°C).

Where used to control both comfort heating and cooling, zone thermostatic controls shall be capable of providing a temperature range or dead band of at least 5°F (3°C) within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum. Variable air volume (VAV) terminal units shall be programmed to operate at the minimum airflow setting without addition of reheat when the zone temperature is within the set deadband.

Exceptions:

1. Special occupancy, special usage or code requirements where deadband controls are not appropriate (such as process applications and areas of hospitals normally used by patients).
2. Thermostats that require manual changeover between heating and cooling modes.

1318.2.3 Variable air volume system static pressure reset controls. The system static pressure set point shall be reset to the lowest point possible while still providing the required air flow to the zones with the greatest demand.

Exceptions:

1. Systems that are not controlled by a static pressure sensor.

Code Language continues on **page 2**

Documentation: Each of the requirements described in this fact sheet must be included in the sequence of operations for the control system. The location of this information in the plans and/or specifications must be indicated on the compliance form.

The deadband control requirements are documented on compliance form 4a, line 6.3.

Variable Air Volume System Static Pressure Reset Controls requirement is documented on compliance Form 4b, line 6.

Supply-air Temperature Reset Controls are to be documented on Form 4b, line 8.

Code Language continued from **page 1**

2. Systems without direct digital control of individual zone boxes.

1318.2.5 Supply-air temperature reset controls. Multiple zone HVAC systems must include controls that automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperature. The controls must be capable of resetting the supply air temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

Exceptions:

1. Systems that prevent re-heating, re-cooling, or mixing of heated and cooled supply air.
2. 75 percent of the energy for reheating is from site recovered or site solar energy sources.
3. Zones with peak supply air quantities of 300 cfm or less.

Continued from page 1

Static Pressure Reset

In a typical VAV system, the fan speed is controlled to maintain static pressure at a specific setpoint, often somewhere between 1 in. and 2 in. w.c. of pressure. The code requires that this set point be adjusted automatically to minimize fan energy. The required controls will maintain the pressure in the duct only as high as necessary to meet the airflow requirements for all zones. These static pressure reset controls can provide very significant fan energy savings, because buildings operate at partial-load conditions most of the time. Another common benefit is reduced fan noise.

There are several methods for implementing static pressure reset control. Options will vary based on the capabilities of the control system hardware and software (it is, therefore, important to clearly specify the required capabilities for new control systems). The desired control method is to monitor VAV box damper position for all zones and adjust the static pressure setpoint so that the damper in the most demanding zone is close to 100 percent open. If zone damper position information is not available in the control system, then another control option is to make periodic adjustments to the static pressure setpoint while comparing actual space temperatures to the desired space temperature setpoint. The DDC system can monitor zone temperatures and slowly lower the supply air pressure setpoint as long as all zones are meeting their temperature setpoint. As the duct pressure setpoint is lowered, and one or more zones begins to exceed its temperature setpoint, then it is time to slightly increase the pressure setpoint again. The Advanced VAV System Design Guide listed at the end of this fact sheet is a good source for more information on control methods, and it includes a sample sequence of operations.

The intent of the pressure reset requirements is to avoid situations where the dampers in all VAV boxes are partially closed, which means that the air pressure in the supply duct is greater than necessary at that point and fan energy is being wasted.

The code allows for a few exceptions to the static pressure reset requirement. The most significant exception is for systems without direct digital control of individual zone VAV boxes. The reason for this exception is that the central control system requires information from each zone – such as the space temperature, VAV box air flow, or VAV box damper position – in order to know whether or not the zone loads are being satisfied. Without that information, the central system cannot know whether it is ok at any point in time to reduce the pressure setpoint or whether additional pressure is needed.

In order for the system to take full advantage of the energy savings potential of pressure reset controls, pay special attention during design and construction to avoid creating “rogue” zones. These are zones that require higher duct pressure than all the others and force the whole system to operate at higher static pressure even though all the other zones would receive adequate airflow at a lower duct pressure setpoint. Rogue zones can occur if either the loads in a zone turn out to be greater than expected (i.e. the VAV

Continues on **page 3**

Continued from page 2

box is undersized for the loads) or if there are airflow constraints in the ductwork that result in greater than expected pressure loss. One measure to help avoid rogue zones is to be extra generous in sizing duct and VAV boxes for zones with uncertain loads.

Supply-air Temperature Reset

To prevent unnecessary cooling and reheat energy consumption, the code requires automatic controls that adjust, or "reset", the supply air temperature (Section 1381.2.5). The intent is that the supply air temperature be no cooler than necessary to satisfy space temperature requirements at any point in time. This requirement is especially important in most parts of Oregon, where outdoor temperatures often fall in the range of about 55°F to 65°F. In these areas, a supply air temperature reset scheme significantly increases the number of hours when "free cooling" from an economizer cycle can be used instead of mechanical cooling.

There are several acceptable supply air temperature control methods. The code requires that the controls act in "response to representative building loads, or to outdoor air temperature." Control vendors can typically provide a function in DDC systems that monitors space thermostat cooling demand to determine whether the supply air temperature needs to be adjusted downwards because one or more zones is getting too warm or whether the zone thermostat can be adjusted upwards because all zones are satisfied with less than 100 percent airflow. This type of control is generally preferred over a reset scheme based on outdoor air temperature because it reduces the odds of a zone going unsatisfied.

The code also specifies a minimum range of adjustment capability, stating that "the controls must be capable of resetting the supply air temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature." For a typical system designed for 55°F supply air and 75°F space temperature, the code requires an adjustment capability of at least 5°F – equal to (75-55)*0.25. Therefore, in that case the control system must be able to reset the supply air temperature up to at least 60°F.

The code offers a few exemptions from the reset requirement. The first is for "systems that prevent re-heating, re-cooling, or mixing of heated and cooled supply air." This exemption will apply to cooling-only VAV systems or generally to any single-zone system. The second exemption applies to systems where, "75 percent of the energy for reheating is from site-recovered or site solar energy sources." Sources that would qualify as "site-recovered" include condenser heat (which would otherwise be rejected to outdoors via a cooling tower or air-cooled condenser), heat recovered from an electric generator (i.e. cogeneration), or heat from a process that would otherwise be rejected to outdoors.

There are several important considerations to keep in mind when specifying supply air temperature reset controls. There is usually

Continues on **page 4**

Examples

Q My system has pneumatic actuators on VAV box dampers and reheat coil valves. Which of these requirements apply?

A The only exception for pneumatic controls is for the supply air pressure reset requirements (1318.2.3). VAV systems with pneumatic controls must comply with the deadband requirements in 1317.4.2.1 and the supply air temperature reset requirements of 1318.2.5, unless the system falls under one of the other specific exceptions to those sections.

Q My project is a tenant improvement on one floor of a five story building with a central air handler. All ductwork and VAV boxes on this floor are to be replaced. No changes to the central air handler or other floors are planned. Which of these requirements apply?

A The deadband controls of1317.4.2.1 apply to all new zone controllers, therefore, they are required for the new VAV boxes and their controls on this project. The static pressure reset controls will be required only if the central control system is being replaced and all other existing zones in the building have direct digital control. Similarly, supply air temperature reset control is required only in the case that the central control system is being replaced.

Q How do these requirements apply to a DDC control system retrofit project on an existing building with a VAV system?

A All three requirements will apply: deadband controls, static pressure reset, and supply air temperature reset.

Continued from page 3

a tradeoff between fan energy, cooling energy, and reheat energy. Lower supply air temperatures lead to less fan energy but usually higher cooling and reheat energy. For any point in time there will be an optimal supply air temperature that balances these tradeoffs to minimize energy cost. A good discussion of optimal supply air temperature control can be found in the Advanced VAV System Design Guide (see For More Information below).

Another important design consideration is that for supply air temperature reset to be successful, the air flow to interior zones must be sized based on the fully reset supply air temperature (e.g. 60°F to 65°F) rather than the normal design air temperature (typically around 55°F). Otherwise, those interior zones may require a constant supply of 55°F air and never allow the control system to reset the supply air temperature upwards. As an alternative design strategy, zones with constant or unique loads could be served by a separate system.

Coordination between supply air temperature reset control and static pressure reset control requires some attention. However, in the recommended control method there should not be a problem. In that method (which requires zone-level DDC control), supply air temperature is controlled based on the zone with the highest "thermostat cooling demand" value (typically available from the VAV box controller) and static pressure is controlled based on the zone with the "most open" damper. Therefore, these control loops are based on different inputs, and as long as the temperature reset control loop responds relatively slowly compared to the static pressure reset control loop, then operation should be stable. Where problems might occur is in control schemes where temperature and pressure are being reset based on the same input.

For More Information

See also the fact sheets covering Airside System Design Requirements, Air Transport Energy, Economizers, Ventilation Controls for High Occupancy Areas, and Exhaust Air Heat Recovery.

See the Advanced VAV System Design Guide for detailed recommendations on VAV box minimum airflow settings. Available at http://www.newbuildings.org/mechanical.htm.

See also ASHRAE Standard 62.1-2004 Ventilation for Acceptable Indoor Air Quality and the Standard 62.1-2004 User's Manual for guidance in determining ventilation rates and in performing "critical zone" calculations. Available at www.ashrae.org.

Find Out More

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Non-residential code HVAC fact sheets include:

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