Oregon Non-Residential Building Energy Code

OREGON DEPARTMENT OF ENERGY

Large Volume Fan Systems

The Oregon Energy Code has special fan speed control requirements for large-volume fan systems. The requirement applies to single-zone systems with a supply airflow of 15,000 cfm or greater. These are common in large interior spaces such as gymnasiums and cafeterias.

The Code requires that these systems include either a two-speed fan or a variable-speed drive for reducing airflow to a maximum of 60 percent of peak airflow or to the minimum ventilation requirement. The minimum ventilation requirement, defined in Chapter 4 of the Oregon Mechanical Specialty Code, specifies minimum outside air requirements for a given space type. In most cases, the code minimum requirement for ventilation will be less than 60 percent of design airflow. Variable-speed drives offer an excellent opportunity for energy savings. Fan power varies with the cube of airflow; the greater the turndown ability for the fan system, the greater the energy savings will be. VAV control will also allow for improved humidity control at part-load conditions, by maintaining the desired supply air temperature.

Exceptions

Exceptions are provided for systems that provide specific humidity control or that supply air required for an exhaust system. A dehumidification heat pump system serving a natatorium would be an example of the humidty control exemption. This system needs to dehumidify large quantities of natatorium air to control humidity levels. A kitchen make-up unit would be an example of a system fitting the exception of supplying an exhaust system. For these applications, a constant volume system is allowed.

Typical direct-expansion (DX) systems provide dehumidification only indirectly. The systems primarily address sensible loads by controlling the space temperature to the thermostat setting. By cooling the supply air to below its dewpoint temperature, dehumidification also occurs. Some systems provide an additional humidity control option, with a RH sensor and a control algorithm to turn on compressor cooling under low load conditions if the relative humidity exceeds the setpoint. These type of systems, that treat occupant and ventilation air latent loads, do not qualify for the exception.

Controlling Cooling Supply Air Temperature

The Code requirement for large volume fan systems applies to units with either direct-expansion (DX) air handlers or with chilled water coils, as well as heating only systems. An HVAC unit with a design airflow capacity of 15,000 cfm or greater corresponds to a design cooling capacity of 35 to 40 tons or greater. To

Continues on **page 2**

Code Language

1318.4.2.4 Large volume fan systems. Fan systems over 15,000 (7 m^3/s) cfm that serve single zone areas including but not limited to gymnasiums, cafeterias, auditoriums or warehouses, are required to reduce airflow based on space thermostat heating and cooling demand. A two-speed motor or variable frequency drive shall reduce airflow to a maximum 60 percent of peak airflow or minimum ventilation air requirement as required by Chapter 4 of the Oregon Mechanical Specialty Code, whichever is greater.

Exception: Systems where the function of the supply air is for purposes other than temperature control, such as maintaining specific humidity levels or supplying an exhaust system.

Documentation: Large Volume Fan System fan speed control is documented on Form 4A, line 15. Note that single-zone packaged DX units that would otherwise be classified as simple systems by the Oregon Code become complex if an automatic fan speed control is required.

Examples

Q A 10,000 ft^2 cafeteria at a high school is conditioned by a heating/ventilation unit. The unit includes two stages of heating and specifies a 20,000 cfm design airflow. What controls are required for this system?

A Since the design airflow is greater than 15,000 cfm, the system requires fan speed controls. The minimum ventilation requirement is determined from Chapter 4 of the Oregon Mechanical Specialty Code. If the peak occupancy is 500 persons, the outdoor air requirement is 500 person x 20 cfm/person = 10,000 cfm of outdoor air. This is less than 60% of the design airflow, so the airflow must be reduced to a minimum of 12,000 cfm (60% of 20,000 cfm) or lower. The occupant load factor from Table 1004.12 of the Oregon Structural Specialty Code is 15 ft^2/person. Since the occupant load factor is less than 20, Ventilation Controls for High Occupancy Areas (Section 1317.2.2) must also be provided. (A heat recovery system with an effectiveness of 50% or greater may be specified, as an alternative to ventilation controls, as specified in Section 1317.2.2.)

Continued from page 1

maintain a steady supply air temperature (SAT) as supply air flow is reduced, the cooling capacity will need to be staged. DX systems of this size typically have multiple compressors to reduce capacity at part-load conditions. The cooling capacity can typically be reduced to as low as 25 percent of peak capacity. To maintain a steady supply air temperature (SAT), the air volume can be staged in discrete steps with the cooling capacity.

Chilled water systems consist of a water coil and control valve to provide space cooling. With a chilled water system, air volume can be varied continuously while still maintaining tight control of the supply air temperature. This is achieved by modulating the flow through a chilled water coil. A PID control sequence will allow for the closest control of supply air temperature and minimize temperature fluctuations. It is important to verify control operation and tune the loops as necessary.

Controlling Heating Suppy Air Temperature

Some large volume fan systems will provide heating or ventilation only, to spaces such as gymnasiums. These systems also require fan speed control. Units with gas-fired heaters are typically capable of reducing airflow by 50 percent or greater when operating in a heating mode. A reduction in airflow will lead to an increased temperature rise of the supply air. Multiple heating stages or modulating burner controls with up to 10:1 turndown are recommended with such systems, to maintain acceptable supply air temperature control. These systems often provide very warm supply air (90-105°F) from outlets high in the space. High supply air temperatures, combined with a ceiling supply and return, can lead to poor ventilation effectiveness. Some of the supply air can short-circuit to the return before it has a chance to condition the space under these conditions. To help achieve a more fully mixed airspace, it is preferable to design the system with low return grilles to counterbalance the natural buoyancy of warm air. If supply and returns must be located high in the space, moderating the supply air temperature in heating can increase ventilation effectiveness.

Maintaining Minimum Ventilation Air

When specifying VAV control, it is important to verify that the outside air damper minimum position varies as the fan speed setting moves between the maximum and minimum flow. When CO_2 based control of outside air (see Ventilation Controls fact sheet) is combined with a variable air volume single zone system, supply airflow can be greatly reduced during periods of low occupancy and reduced thermal load.

Related Code Sections

Variable air volume (VAV) systems must also meet maximum fan power limitations of Section 1318.4.2.2. Systems that are used with high occupancy spaces, such as theaters or cafeterias, may require ventilation controls as specified in Section 1317.2.2. A heating-only system may have a relatively low design airflow per occupant. Such a system may require exhaust air heat recovery, as specified in Section 1318.3. Large volume fan systems must also include optimum start controls (1317.4.3.2) and shutoff damper controls (1317.4.3.3.1), which close outdoor air supply and exhaust dampers when the systems are providing conditioning during unoccupied periods.

Examples

Q A large open exhibit hall in a museum uses a 35-ton packaged DX unit to provide heating and cooling, and to provide close humidity control to 50% or lower, to maintain the integrity of the historic documents and artifacts. Is a fan speed control required for this system?

A No. Since the process entails specific dehumidification requirements, a constant volume system is acceptable.

Q A 40-ton packaged DX unit that provides 16,000 cfm of supply air at design conditions is specified with a two-speed fan. The high fan speed is used in cooling mode only. The low fan speed setting is used in ventilation mode and in heating mode. Does this unit comply with the fan speed control requirement?

A Yes, this is an acceptable design. This system should be designed with the first stage of cooling using the economizer at low fan speed (if outside air conditions allow economizer operation). If load is not met with this operation, the fan should be increased to full speed.

Find Out More

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Non-residential code HVAC fact sheets include:

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