Oregon Non-Residential Building Energy Code

OREGON DEPARTMENT OF ENERGY

Air Transport Energy

The energy code places an upper limit on fan power for HVAC systems, with the intent of encouraging energy efficient air distribution design.

The fan power limit in Section 1318.4.2 applies to systems with a total motor nameplate horsepower of 7.5 hp or greater. This total horsepower threshold applies to the sum of all fan motors in the system, including the supply, return, and exhaust fans as well as motors in fan-powered terminal units (with a few exceptions as noted later).

For the purpose of this requirement, a "fan system" is essentially a central air handler and all other fans that serve the same zones. A single building often has more than one fan system, and it is possible that some of those systems fall under the scope of the fan power limit, meaning they total more than 7.5 hp, while others do not.

Fan Power Savings Opportunities

Fan energy is a significant component of energy use in commercial buildings. Designers are encouraged to consider the many opportunities for reducing fan power far below the limits in the energy code.

- Efficient fan selection.
- Selection of "housed" fans rather than "plenum" or "plug" type fans where practical.
- Increased coil and filter face area for reduced pressure loss.
- Generous duct sizing.
- Selection of low-loss duct transitions.
- Minimizing the number of duct turns.
- Use of a return air plenum rather than ducted return air where practical.
- Selection of VAV boxes for low pressure loss.
- Generous return air shaft sizing.
- Use of low pressure drop air filters.
- Minimal use of sound traps.

Calculating the Fan Power Allowance

The code specifies a formula for calculating the maximum

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Code Language

Documentation:

Air transport energy for complex systems is documented in line 2 of Form 4B. Worksheet 4L must be completed for each fan system where total motor nameplate horsepower is 7.5 hp or greater.

1318.4.2 Air transport energy. The energy demand of each HVAC fan system shall be limited as specified in Section 1318.4.1 and 1318.4.2. For the purposes of determining allowable fan motor horsepower, maximum combined fan motor horsepower is the sum of the motor brake horsepower of all fans operating at design conditions, including supply fans, return/exhaust fan and fan-powered terminal units.

Exceptions:

1. Individual HVAC fan systems with total nameplate fan system motor horsepower of 7.5 or less.
2. Individual exhaust fans with nameplate fan horsepower of 1 hp or less.
3. Induction/dilution exhaust fans used in hospitals and laboratories.
4. Fan-powered, parallel airflow terminal units where the fan does not operate in cooling mode.

1318.4.2.1 Constant volume fan systems. For fan systems which provide a constant air volume whenever the fans are operating, the power required by the motors for combined fan system at design conditions shall not exceed Formula CV-1 shown below. This requirement includes 2-speed motors.

Formula CV-1

$$BHP = \frac{\text{Design Airflow (CFM)} * 4.3}{4131}$$

Fan systems with filtration systems that have a pressure drop at design air flow in excess of 1" w.c. when the filters are clean, heat recovery or direct evaporative humidifier/cooler may use Formula CV-2:

Formula CV-2

$$BHP = \frac{\text{Design Airflow (CFM)} * (PD + 4.3)}{4131}$$

1318.4.2.2 Variable air volume (VAV) fan systems. For fan systems which are able to vary air volume automatically as a function of load, the power required by the motors for the combined fan system shall not exceed Formula VAV-1 shown below.

Formula VAV-1

$$BHP = \frac{\text{Design Airflow (CFM)} * 6.0}{4131}$$

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Fan systems with filtration systems that have a pressure drop at design air flow in excess of 1" w.c. when the filters are clean, heat recovery or direct evaporative humidifier/cooler may use Formula CV-2:

Formula VAV-2

$$BHP = \frac{\text{Design Airflow (CFM)} * (PD + 6.0)}{4131}$$

(Refer to the Oregon code for variable definitions and additional information.)

1318.4.2.3 Selecting and sizing nameplate motor horsepower: Selected fan motor shall be no larger than the first available motor size greater than the brake horsepower.

EXCEPTIONS:

1. Constant Volume Fans: Where the first available motor larger than the brake horsepower has a nameplate rating within 22% of the brake horsepower, the next larger nameplate motor size may be selected.
2. Fans with Variable Speed: Where the motor is controlled by a variable speed drive and where the first available motor larger than the brake horsepower has a nameplate rating within 50% of the brake horsepower, the next larger nameplate motor size may be selected.

Examples

Q My building includes a rooftop air conditioner with a 7.5 hp supply fan and 2 hp powered exhaust. The exhaust fan is controlled to maintain building static pressure at a fixed setpoint by cycling on and off. It mainly comes on when the system is in economizer mode. Does the air transport energy section of the code apply to this system?

A Yes, the code applies in this case. The exhaust fan must be included in the total fan horsepower calculation because the fan may come on even when the system is not in economizer mode. Therefore, the total fan system nameplate horsepower is 9.5 hp, which exceeds the 7.5 hp threshold. If the exhaust fan was not controlled based on building pressure, but instead was interlocked with the economizer operation, then the exhaust fan could be excluded, and Section 1318.4.2 of the code would not apply.

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allowed brake horsepower (BHP) as a function of design airflow in cubic feet per minute (cfm). For constant volume systems and for systems with two-speed fans, the following formula applies:

$$\text{Constant Volume BHP} = \frac{\text{Design Airflow (CFM)} * 4.3}{4131}$$

For variable air volume (VAV) systems, the fan power allowance is somewhat higher due to extra air pressure loss through the VAV boxes. This formula also applies to fan systems in hospitals and laboratories that are nominally constant volume systems yet have flow control devices within the air distribution system to maintain precise space pressure control and avoid cross contamination.

$$\text{Variable Air Volume BHP} = \frac{\text{Design Airflow (CFM)} * 6.0}{4131}$$

Additional Fan Power Allowances

There are several cases where an additional fan power allowance applies. In these cases, an excess pressure drop (PD) term is added to the brake horsepower formula. The formulas to be used when one or more of these special allowances apply are the following:

$$\text{Constant Volume BHP} = \frac{\text{Design Airflow (CFM)} * (PD + 4.3)}{4131}$$

$$\text{Variable Air Volume BHP} = \frac{\text{Design Airflow (CFM)} * (PD + 6.0)}{4131}$$

The PD values are determined as follows:

- If air filter pressure drop is greater than 1 in. w.c., then PD is equal to the excess beyond 1 in. For example, if filter pressure drop is 1.6 in. w.c., then PD is equal to 0.6. The pressure drop value used for the calculation must be for clean filters selected at the design airflow. It is important to note that the calculated pressure drop is for all the filters in the system.
- Heat recovery component pressure drop may be added to the PD value. Examples include the pressure drop due to run-around coils, air-to-air heat exchangers, enthalpy wheels, or heat pipes.
- The pressure drop due to direct evaporative sections used for humidification and/or cooling may also be added to PD.

For hospitals and laboratories only, the following extra pressure drop allowances may apply:

- Systems with fully ducted return and/or exhaust air systems are allowed an additional 0.5 in. w.c. PD.
- Systems with return and/or exhaust air flow control devices are allowed an additional 0.5 in. w.c. PD.
- Filter systems of individual filter efficiency greater than 85 percent are also allowed an additional 0.5 in. w.c. PD. For example a lab or hospital HEPA filter would qualify for this pressure drop credit in addition to the previous credit for filtration with

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PDs greater than one inch. This additional credit is allowed to account for the fact that the system must be designed to overcome the pressure drop of filters as they become loaded.

Determining Compliance

The fan system complies with the requirements of Section 1318.4.2 if the total fan motor brake horsepower is no greater than the allowance described above. Note that the limit is expressed in terms of brake horsepower, not motor nameplate horsepower.

For each fan system, sum the total brake horsepower of all fan motors that operate at design conditions. This includes supply, return, and exhaust fans as well as fans in series fan-powered VAV boxes.

There are a few fans that may be left out of the calculations:

- Individual exhaust fans that have motors with nameplate horsepower of 1 hp or less.
- Induction/dilution fans used in hospitals and laboratories. These specialized fans are used to increase discharge velocity or dilute toxic exhaust air using additional outside air.
- Fans in parallel fan-powered boxes where the fan does not operate in cooling mode.

Sizing Fan Motors

Section 1318.4.2.3 of the energy code sets an upper limit on the nameplate horsepower rating of individual fan motors. In general, the motor shall be no larger than the first available motor size greater than the brake horsepower required by the fan. However, the code allows the next larger fan motor size to be selected under the following circumstances:

- For constant volume fans, if a nameplate rating is within 22 percent of the calculated brake horsepower, the next larger fan size may be selected.
- For variable air volume fans, if a nameplate rating is within 50 percent of the calculated brake horsepower, the next larger fan size may be selected.

For More Information

See the Advanced VAV System Design Guide for recommendations on duct design, fan selection, and coil selection for low pressure loss, available at www.newbuildings.org/mechanical.htm or www.energydesignresources.com.

Another good resource is the Design Brief titled Design Details, available at www.energydesignresources.com.

Examples

Q A contant-volume air handler serving a hospital wing has a design supply airflow of 10,000 cfm, a 20 hp supply fan motor with brake horsepower of 15.5 hp and a 5 hp return fan motor with brake horsepower of 3.5. The filter pressure drop is 1.9 in. w.c., and return air is fully ducted. The system uses 100 percent outside air and has a run-around heat recovery system with a coils in the supply and exhaust air streams, each with 0.4 in. w.c. pressure drop at design airflow. Does the fan system comply?

A The maximum allowable fan brake horsepower is calculated by formula VAV-2. The pressure drop in excess of 1 in. w.c. is 0.9 in. w.c. An additional 0.5 in. w.c. credit is allowed due to the fully ducted return air path. The pressure drop due to the heat recovery system coils can also be added to the equation. The allowed brake horsepower is:

BHP = 10000 * [(0.9+0.5+0.4) + 6.0] / 4131 = **19.8 hp**

The total installed fan brake horsepower is 19.0 hp, which is lower than the allowed power. Therefore, this system complies with Section 1318.4.2.2 of the code.
Both the supply and return fan motors are the next available size greater than the calculated fan brake horsepower, therefore, they comply with the sizing criteria of Section 1318.4.2.3.

Find Out More

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Northwest Energy Efficiency Alliance
www.nwalliance.org

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Non-residential code HVAC fact sheets include:

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