Kent W. Peterson

Face Velocity Considerations In Air Handler Selection

BY KENT W. PETERSON, P.E., PRESIDENTIAL MEMBER/FELLOW ASHRAE

Fan energy can account for 30% to 40% of building HVAC system energy. In addition, fan energy use is directly proportional to the pressure drop. Therefore, the more restrictive the supply system, the higher the pressure drop, and the higher the fan energy use. Most air-handling units are still selected at the typical 500 fpm (2.5 m/s) rule-of-thumb, regardless of application. However, energy efficiency proponents say that lower velocity is better for high-performance operation. This month's column evaluates methods to reduce fan energy from internal pressure drop along with the increased initial costs and reduction in annual operating costs.[1]

Air-Handling Unit Applications

Applications for using air-handling units in HVAC systems can range from providing ventilation and controlling temperature and humidity in a typical office building to providing precise temperature and humidity control in 24/7 facilities. To determine the system's air-handling unit requirement, the designer must consider the function and physical characteristics of the space to be conditioned. Specific design parameters must be evaluated to balance initial cost, operating expense, maintenance, and noise.

Various applications can vary significantly in load density, hours of operation and annual load profiles. Constant volume units use significantly more energy than variable volume units. All of these factors impact the life-cycle-cost considerations when selecting air-handling units.

Guiding Principles

The air handler system power consumption can be estimated by the following equation.

$$\text{Fan Power (kW)} = \frac{\text{Airflow(cfm)} \quad \text{Pressure Drop (in.w.g.)}}{6,345 \times \text{Efficiency (\%)}} \times 0.746$$

Note that the efficiency is the product of the fan, motor, belt, and where equipped, variable frequency drive efficiencies.

Cooling Coil Considerations

Most everyone involved in HVAC unit selection is aware of the 500 fpm (2.5 m/s) rule for sizing cooling coils and generally that is sufficient to keep water droplets from leaving the outer edge of the discharge side of the coil (carryover). It is also good practice to use coils with a maximum of 8 to 10 fins per inch (fpi), as higher fpi can have moisture carryover at 500 fpm (2.5 m/s), higher air-side pressure drop and not allow adequate space between fins for coil cleaning.

The required length of the drain pan extending past the leaving edge of a cooling coil at 500 fpm (2.5 m/s) also increases as fin count goes up. A 12 fpi coil typically requires a drain pan that extends 18 in. (457 mm) past the cooling coil while an 8 fpi coil needs only 12 in. (305 mm). Reducing the coil face velocity to 400-fpm (2 m/s)and using an 8 fpi coil can result in the drain pan extending only 6 in. (152 mm) past the coil face and reducing air handler cabinet length.

Taylor provided good guidance on coil selections at 500-fpm (2.5 m/s) for maximizing chilled water ΔT.[2] Lowering cooling coil face velocity allows more resident time in the cooling coil and typically lowers the rows and/or fins per inch resulting in lower coil pressure drop.

Kent W. Peterson, P.E., is chief engineer/COO at P2S Engineering in Long Beach, Calif. He is former chair of Standard 189.1.

Air Filtration Considerations

Effective air filtration provides the primary defense for building occupants and HVAC equipment against particulate pollutants generated within a building as well as pollutants from air drawn into a building from an HVAC system. Since air filters capture particulates, their life is finite and they must be replaced periodically. Their useful life is typically dependent on type and size as well as the installed environment.

Extended surface filters, the most common types of filters used in air handlers, are used where increased capture efficiencies are needed.[3] ASHRAE efficiencies of extended surface filters range from MERV 7 to MERV 16. Some air filter manufacturers provide high efficiency extended surface air filters that exhibit extremely low initial static pressure drops.

TABLE 1 Case 1: Lab VAV air handler.

	UNIT	500 FPM SELECTION	400 FPM SELECTION
Supply Fan	Airflow, cfm	30,600	30,600
	TSP, in. w.c.	4.1	3.7
	ESP, in. w.c.	2.5	2.5
	bhp	26.9	24.4
	rpm	1,374	1,335
Cooling Coil	Rows/fpi	6/8	6/7
	APD, in. w.c.	0.63	0.43
Heating Coil	Rows/fpi	1/9	1/6
	APD, in. w.c.	0.10	0.06
Filter	MERV	13	13
	Clean APD, in. w.c.	0.23	0.14
	Dirty APD, in. w.c.	0.68	0.43
Operating Weight	lbs	11,500	12,000)
Supply Fan Annual Energy	kWh	66,531	60,279
	kW	20.1	18.3
First Cost	US$	$62,500	$68,000
Annual Energy Costs	US$	$10,379	$9,404
Simple Payback	Years		5.6

TABLE 2 Case 2: Administration building VAV air handler.

	UNIT	500 FPM SELECTION	400 FPM SELECTION
Supply Fan	Airflow, cfm	29,700	29,700
	TSP, in. w.c.	3.0	2.6
	ESP, in. w.c.	1.5	1.5
	bhp	19.0	16.9
	rpm	1,237	1,196
Cooling Coil	Rows/fpi	6/7	6/6
	APD, in. w.c.	0.51	0.31
Heating Coil	Rows/fpi	1/9	1/7
	APD, in. w.c.	0.10	0.06
Filter	MERV	13	13
	Clean APD, in. w.c.	0.22	0.18
	Dirty APD, in. w.c.	0.65	0.53
Operating Weight	lbs (kg)	19,000	19,500
Supply Fan Annual Energy	kWh	21,787	19,309
	kW	14.2	12.6
First Cost	US$	$93,000	$98,500
Annual Energy Costs	US$	$3,399	$3,012
Simple Payback	Years		14.2

Maintenance costs associated with the purchase, installation and disposal of filters for a filter type and dust loading capacity are relatively fixed. MERV rating, particulate loading and face velocity affect the operating cost associated with pressure drop and fan energy. Air filter fan energy typically accounts for 70% of the total life-cycle cost (LCC) of the air filtration system. Approximately 30% of annual filter costs are expended on filter costs, labor for filter changes and filter disposal.

Many of the air filtration manufacturers offer LCC software that factor-in four cost components: filter cost, filter change-outs, HVAC-related energy, and filter disposal. In the author's experience, in many instances pre-filters do not provide beneficial LCC when used with extended surface area MERV 11 to 13 final filters. Prefilters have no impact on overall filtration efficiency, which is determined by the final filter, and they increase maintenance costs and energy costs but seldom increase the life of the final filter in most applications. Filter options and LCC should be evaluated on a project-by-project basis.

Comparing Different Selections

Two different air handler applications have been selected to illustrate the potential energy savings and initial cost impacts for sizing the air handlers less than 500 fpm (2.5 m/s). Operating costs were estimated using energy simulation software based on actual anticipated occupancy and operating schedules. Initial air handler costs were determined by actual selections with manufacturers on the projects. Final filter pressure drops were assumed at three-times initial filter pressure drop. Static pressure setpoint reset was used in the energy simulations.

The local time-of-use electrical rate table was used in the model to calculate the electrical energy savings. The average electrical rate was $0.156/kWh for these two applications.

Case 1 is a 100% outdoor air VAV air handler serving an educational lab building in Riverside, California. This air handler is required to operate 24/7 for life safety purposes but the building is occupied on weekdays from 6 am to 8 pm. The lab spaces were required to maintain a minimum 6 air changes per hour (ach) during occupied mode and 4 ach during unoccupied mode.

Table 1 shows the differences between 400 fpm (2 m/s) and 500 fpm (2.5 m/s) air handler selections.

The Case 1 energy cost savings resulted in a 5.6 year simple payback based on the 24/7 operation, load profiles and high cost of electricity in California. With a $0.10/kWh average cost of electricity, the simple payback would change to 8.8 years. The costs assume no added costs for the additional space required and additional weight of the larger air handler. Increasing the height and/or width of the unit could lower the air handler face velocity.

Case 2 *(Table 2)* is a VAV air handler with a return/relief fan serving an educational administration building on the same college campus. This air handler only operates on weekdays from 6 a.m. to 6 p.m.

The energy cost savings provided a much longer payback than Case 1 due to the relative lower hours of operation and lower annual load profile. Both Case 1 and Case 2 show little difference in weight. The increase in unit casing weight is offset by the reduced coil and motor weight.

In the author's experience, it is best to work with several air handler manufacturers to evaluate selections and ways to reduce energy costs while minimizing first cost premiums. Projects that tend to have higher annual hours of operation and/or high internal loads tend to show favorable results for selecting air handlers with lower face velocities.

Concluding Remarks

Low pressure drop air handlers can be beneficial in reducing energy consumption in high-performance building design. Other benefits of low pressure drop systems are less noise, more effective dehumidification, and better filter effectiveness.

Energy cost savings is dependent on the air handler application, load profiles and operating hours. Simulation tools help provide a better understanding of part-load performance and operating costs to determine the optimum face velocity considerations.

References

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