Meeting IAQ Requirements With Unitary Equipment

Dedicated outdoor air systems can offer an effective, economical solution to the inherent inability of unitary equipment to accommodate the large quantities of outside air required in spaces with high occupancy densities.

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Unitary equipment is a popular choice of designers for several reasons, not the least of which is its affordability. This column focuses on providing good IAQ with unitary equipment.

Several articles have been published on IAQ and unitary equipment. One article focused on the effects of oversizing equipment and excessive equipment cycling.[1] Another provides additional considerations related to introducing ventilation air into spaces that use unitary equipment.[2]

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All-Air Systems

With the advent of all-air HVAC systems in the 1940s and 50s, it seemed logical that the ventilation air supply should be an integral part of the system. Typically, systems were designed to draw outdoor air into the return air duct from a wall louver or roof intake, and mix (at least to some degree) with return air from the building before being filtered and conditioned for delivery to the building.

Although developed more than 50 years ago, this technique is used today and, if properly designed and installed using central station equipment, can provide acceptable indoor air quality.

Unitary Equipment Pros and Cons

However, many systems, primarily for economic reasons, are designed around unitary equipment such as packaged rooftop units, split systems, packaged terminal units, etc. Such equipment offers several advantages including:

1. Low construction costs compared to chiller/boiler systems and modular air-handling units,
2. Multiple temperature control zones to be provided economically,
3. Energy-efficient equipment, and
4. Easy maintainence with minimum skill levels and experience.

Such equipment, when applied to high occupancy spaces, especially in smaller sizes (i.e., residential and small commercial units) have inherent limitations with regard to ventilation issues, which introduce challenges to the designer. First, off-the-shelf equipment latent capacities limit the amount of outside air that can be introduced through the equipment. Also, design methodology usually results in equipment selections based on peak space loads.

Since most unitary equipment is constant volume, it has excess capacity during part-load conditions. This results in short equipment runtime, since the thermostat is satisfied long before the coil can condense moisture from the air. Short "run" cycles produce a warmer coil temperature with less latent capacity than needed for the combination of space and outside air latent loads. The result is less humidity control when it may be needed most.

Even a modest oversizing of the equipment can exacerbate the problem and contribute to additional negative impacts, such as "marginal part-load temperature control, degraded humidity control, occupant discomfort/dissatisfaction, higher installed costs, increased potential for mold growth, potential to contribute to asthma and other respiratory conditions, among others."[1]

Unitary equipment control sequences typically call for the thermostat to cycle the blower on and off with the compressor (or heat exchanger). ANSI/ASHRAE Standard 62-2001, *Ventilation for Acceptable Indoor Air Quality,* specifies minimum ventilation rates to achieve acceptable air quality through either the "Ventilation Rate Procedure" or the "Indoor Air Quality Procedure." Section 5.2, as amended by Addendum 62*v*, requires, "The ventilation air distribution system shall be provided with means to adjust the system to achieve at least the minimum ventilation airflow as required by Section 6 under any load condition."

Section 5.2, as amended by Addendum 62*u*, also requires the system to be designed to maintain minimum airflow rates as required by Section 6 under any load condition. Obviously, with a system that combines the ventilation airstream with the conditioned airstream, no ventilation or conditioned airflow to the space exists unless the supply fan is operating.

This was the subject of Interpretation of IC 62-1999-19. The project committee agreed that, while a unit may supply the proper outside airflow rate while the thermostat calls for heating or cooling, the unit will stop supplying the air when the thermostat is satisfied. Since the thermostat may be satisfied for prolonged periods of time (i.e., during part-load conditions) control of indoor air quality through ventilation is lost.

Yet another problem with the introduction and treatment of outside air through unitary equipment occurs when the fans are cycled. Central exhaust systems operate continuously. They rely on ventilation air supplied to the spaces to make up for the air being exhausted. When one or more system fan is off, the resulting negative imbalance in the building draws in more unconditioned outside air into the spaces. Again, this contributes to elevation of space humidity. This can be significant under part-load conditions, when several systems may be off for extended periods of time.

Unsuccessful attempts to solve the problem by operating the fan continuously have resulted in the loss of humidity control. Constant introduction of nonconditioned and moisture-laden outside air into the space, plus the added moisture from the reevaporation of condensate left on the coil and in the drain pan, elevate the space humidity above recommended levels.

Other approaches have introduced cooled and dehumidified ventilation air from a preconditioning unit directly into the return of the equipment. This hasn't proven satisfactory since the resulting ventilation air distribution is ineffective when the unitary equipment fan has cycled off.

Dedicated Outdoor Air Systems

The most successful solution to these problems in hot and humid climates has been the use of dedicated outdoor air systems (DOAS) incorporating heat recovery devices. While there are many types and variations of such heat recovery equipment, the most common type transfers both sensible energy and moisture. Such energy recovery ventilators (ERVs) are used for applications where year-round economical precooling and preheating of outside air is necessary.

With an outside design condition of 95°F (35°C) dry bulb, 78°F (25.6°C) wet bulb, and an ERV with an effectiveness of 80%, the outside air conditions would be reduced to 79°F (26°C) dry bulb, 66.1°F (19°C) wet bulb, resulting in a reduction in required refrigeration capacity of approximately 3.9 tons/1,000 cfm (29 kW per 1000 L/s).

DOAS solved the problems created by intermittent fan operation, equipment oversizing at part-load conditions, and building pressurization by providing a constant supply of ventilation air in the quantities required by each space. Since the system also exhausts air from spaces, a positive pressure always can be easily maintained throughout the building under all conditions.

On the downside, a DOAS requires parallel air paths for outdoor air and exhaust air, which increases the initial cost for ductwork and air-distribution devices. Also, care must be taken to design the air distribution in each space to comply with Paragraph 6.1.3.3 of Standard 62, which requires well-mixed conditions in the occupied zone.

DOAS can offer an effective, economical solution to the inherent inability of unitary equipment to accommodate the large quantities of outside air required in spaces with high occupancy densities. A DOAS can be engineered to ensure compliance with all requirements of Standard 62 and reduce equipment tonnage through energy recovery while allowing the designer to provide systems that are easily operated and maintained.

References

1. Hourahan, G. 2004. "How to properly size unitary equipment." *ASHRAE Journal* 46(2)15–18.

2. Henderson, H. 2003. "Effects of cycling on unitary system performance." *ARI Magazine* Spring.

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