Optimizing Your System

DOAS Configurations and Control Strategies

By John Murphy, Member ASHRAE

A dedicated outdoor air system (DOAS) uses a separate unit to dehumidify all of the outdoor air brought into the building for ventilation and then delivers it directly to each occupied space (*Figure 1*) or to local HVAC units serving those spaces. Meanwhile, the local units (fan coils, water-source heat pumps, small packaged units, chilled ceiling or beams, etc.) in or near each space maintain space temperature by only treating recirculated indoor air.

Although not a new concept, DOAS are increasing in popularity. However, many of the systems designed and installed today are suboptimal. This article discusses ways to optimize the design and control of DOAS to lower installed cost and energy use.

Deliver Conditioned Outdoor Air Cold, Not Neutral

Many DOAS are designed to dehumidify the outdoor air so it is drier than the space[1] and then reheat it to approximately space temperature (neutral). Delivering the conditioned outdoor air at a neutral dry-bulb temperature can simplify local comfort control because it has no impact on space sensible loads.

However, when a chilled water or direct expansion coil dehumidifies the outdoor air, the dry-bulb temperature of the air leaving the coil is colder than the space (*Figure 2*). If the dehumidified outdoor air is reheated to neutral, the sensible cooling performed by the DOAS unit is wasted.

In contrast, if the DOAS unit dehumidifies the outdoor air but then delivers the conditioned air cold (not reheated to neutral) directly to the space (*Figure 1*), the low dry-bulb temperature offsets part of the sensible cooling load in the space. At design load, this means less cooling capacity and less airflow are required from the local HVAC equipment than in a neutral air system.[1,2,3,4]

Compared with a neutral air system, a DOAS that delivers cold air directly to the occupied spaces:

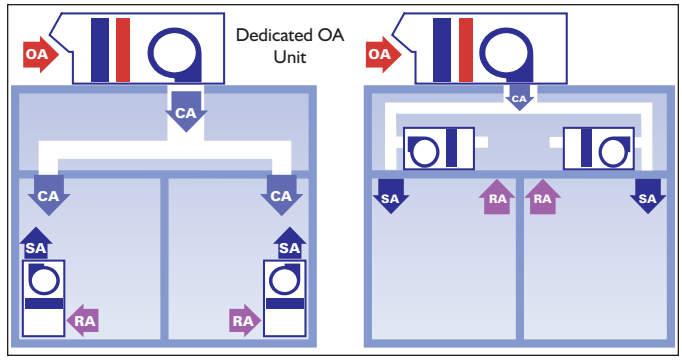


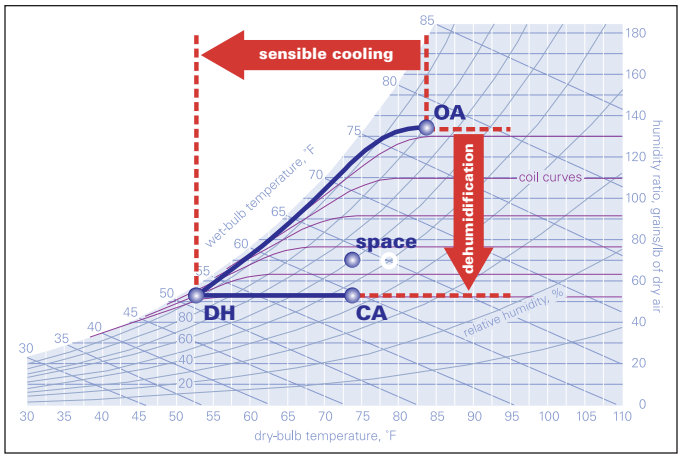
Figure 1: Conditioned outdoor air delivered directly to spaces.

- Requires less overall cooling capacity. The required cooling capacity of each local HVAC unit is less than in a neutral air system, and the required capacity of the DOAS unit is the same for both configurations.
- Requires less overall cooling energy for much of the year. By taking advantage of the sensible cooling already done by the DOAS unit, the cold air system requires less cooling energy at each local HVAC unit. The neutral air system throws away this sensible cooling benefit by reheating the air to approximately space temperature.
- May require less reheat energy. If new (not recovered) energy is used to reheat the dehumidified outdoor air, a cold air system avoids the energy costs of reheating for much of the year.
- Requires less overall fan airflow and, therefore, less overall fan energy. The supply airflow delivered by each local HVAC unit is less than in a neutral air system, and the airflow delivered by the DOAS unit is the same for both configurations.

Less supply airflow and less cooling capacity mean smaller local HVAC equipment, which can lower the initial cost and increase usable floor space, *or* provide an acoustical benefit by keeping the same sized cabinet and operating the fan at a lower speed.

When to Reheat the Conditioned Outdoor Air?

While the conditioned outdoor air should be delivered cold whenever possible, there are times when the DOAS unit should reheat the dehumidified outdoor air.[5] As the space sensible cooling load decreases due to changes in outdoor conditions and internal loads, it is possible that the cold, conditioned



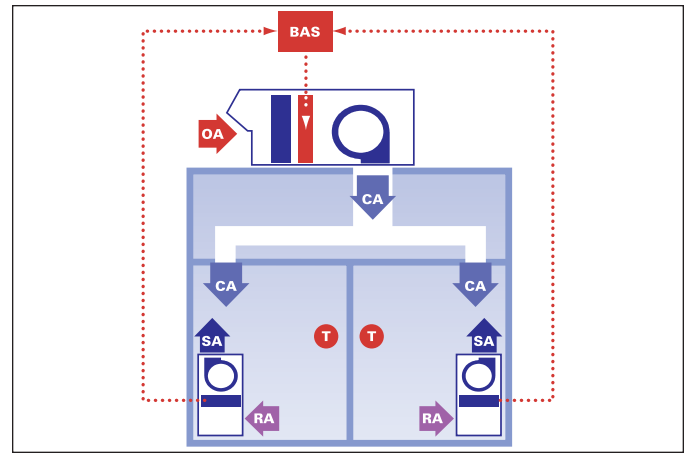


Figure 2 (left): Sensible cooling is a by-product of cold coil dehumidification. Figure 3 (right): Resetting neutral dry bulb based on critical space.

outdoor air may provide more sensible cooling than the space requires.

To avoid overcooling, the local HVAC unit could add heat to the space if a source of heat is available (i.e., if the boiler is not shut off for the season). If this occurs in only a few spaces, the sensible cooling energy benefit to the remaining spaces may offset the heating energy needed for these few spaces. However, if the source of reheat energy in the DOAS is recovered from another part of the system (for example, hot gas reheat, or an air-to-air heat exchanger), it may be more economical to reheat the conditioned outdoor air to avoid overcooling any of the spaces.

In hotel guest rooms or dormitories, where the sensible cooling loads are often drastically different in the various spaces, there may be many hours when overcooling occurs in at least one space. For these applications, it may be simpler to deliver the conditioned outdoor air at a neutral temperature because the benefit of delivering the air cold occurs less frequently. However, space sensible cooling loads are relatively high during daytime hours in classrooms and offices. In fact, for some climates, classrooms may never reach the point where overcooling occurs during occupied hours. These applications are well-suited for delivering the conditioned outdoor air cold.

Communicating Controls to Optimize System Performance

Many DOAS are designed to deliver conditioned outdoor air at a constant dry-bulb temperature (often neutral) and at a dew point that does not exceed a setpoint. This control approach is simple because it allows the DOAS unit to operate independently of the local HVAC units.

Why reheat the dehumidified air to neutral on the hottest day of the summer when all spaces need cooling? Instead, deliver the air cold to offset some of the space sensible cooling loads. As mentioned earlier, this can allow the local HVAC units to be downsized, which helps offset some of the added cost of the DOAS. Reset the dry-bulb temperature delivered by the DOAS so it uses reheat only when needed to avoid overcooling any of the spaces.[2,5]

A simple approach would be to activate the reheat coil, reheating the dehumidified outdoor air to neutral, when the ambient temperature drops to the point at which the sensible load in some spaces is expected to be low enough to result in overcooling.

A more effective way to implement this strategy is to use a building automation system (BAS) to monitor all of the local HVAC units and identify the critical space (the space with the lowest sensible cooling load) most at risk of overcooling (*Figure 3*). If the local units are equipped with communicating controllers, the BAS could monitor the space temperatures. The critical space has a temperature closest to its heating setpoint.

Based on a signal from the BAS, the DOAS unit increases its reheat capacity, resetting the leaving-air dry-bulb temperature up just enough to prevent the critical space from overcooling. The dew point of the conditioned air is controlled independently to meet the humidity control requirements of the spaces.

The system-level control strategy provides conditioned outdoor air that offsets as much of the sensible cooling loads in the spaces as possible without overcooling any space and avoiding the need for any local units to activate their heating coils.

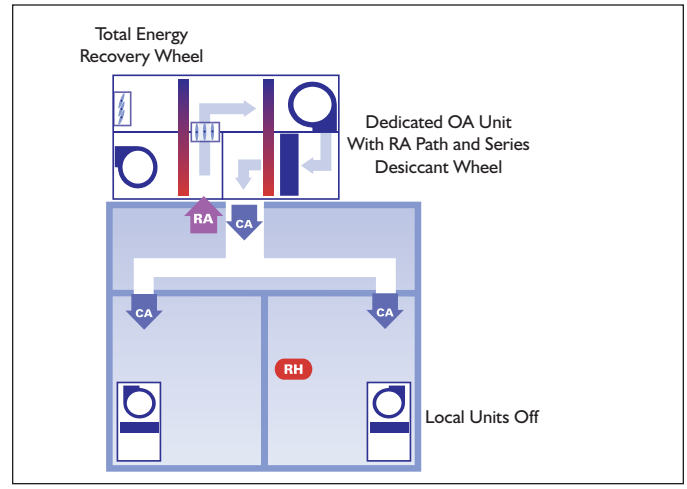


Figure 4: After-hours humidity control & exhaust-air energy recovery.

Providing a Recirculation Path for After Hours

When the DOAS unit delivers conditioned outdoor air directly to the spaces, a return air path permits after-hours humidity control without operating the local HVAC terminals (*Figure 4*).

When after-hours dehumidification is required, the DOAS unit closes the outdoor air damper and opens the return air damper to avoid conditioning unneeded outdoor air.[2,5] Due to the low sensible

Notice to subscribers:

IAQ Applications to End Publication After Fall Issue

ASHRAE will end publication of *IAQ Applications* after the Fall 2008 issue.

The Society appreciates the loyal following that *IAQ Applications* has established since its launch in January 2000. With the launch of other publications such as *High Performing Buildings* and the *HVAC&R Industry* and *Society Connections* electronic newsletters, it is believed that ASHRAE can better focus its resources on these and other publications.

More importantly, the editorial staff for *IAQ Applications* will explore ways to place content that normally would have been presented in *IAQ Applications* into *ASHRAE Journal* and other Society publications that have broader circulations and which will gain wider exposure for those views.

ASHRAE will continue to devote 100% of its energies to maintaining the editorial quality of *IAQ Applications* through its last issue.

The editorial and publishing staffs of *IAQ Applications* thank subscribers for their past support, especially those volunteers who provided the publication's content. This group includes some of the world's leading practitioners and experts. They have doggedly maintained the quality of this publication.

Paid subscribers with subscriptions extending beyond October 2008 will receive coupons in September 2008 that can be redeemed for other ASHRAE products.

Technical Feature

cooling loads during this time, a source of reheat in the DOAS unit is typically necessary to avoid overcooling the building.

Because all the outdoor air is brought in at a central location, consider including an air-to-air energy recovery device to precondition the outdoor air (*Figure 4*). This reduces operating costs and may allow downsizing of the mechanical cooling, dehumidification, heating and humidification equipment. Also, it can help justify the added cost of routing the building exhaust back to the DOAS handler when a return air path is desired for after-hours humidity control.

Summary

Many of the DOAS installed today are suboptimal, but there are ways to design and control these systems to lower both installation costs and energy use.

Consider delivering the conditioned outdoor air cold directly to the occupied spaces when possible, and use recovered energy to reheat only when needed. Providing cold (rather than neutral) air from the DOAS unit offsets a portion of the space cooling loads, allowing the local HVAC units to be downsized and use less energy. In addition, implementing system-level control strategies and exhaust-air energy recovery can help minimize the additional energy cost of separately treating outdoor air.

References

1. Morris, W. 2003. "The ABCs of DOAS: dedicated outdoor air systems." *ASHRAE Journal* 45(5):24–29.
2. Murphy, J. 2002. *Dehumidification in HVAC Systems:* Applications Engineering Manual SYS-APM004-EN. La Crosse, Wis.: Trane.
3. Shank, K., S.A. Mumma. 2001. "Selecting the supply air conditions for a dedicated outdoor air system working in parallel with distributed sensible cooling terminal equipment." *ASHRAE Transactions* 107(1):562–570.
4. Mumma, S.A. 2008. "Terminal Equipment with DOAS: Series vs. Parallel." *Engineered Systems* 25(5):86–89.
5. Murphy, J. 2006. "Smart dedicated outdoor air systems." *ASHRAE Journal* 48(7):30–37.

John Murphy is an applications engineer with Trane in La Crosse, Wis.

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle N.E.
Atlanta, GA 30329-2305

NONPROFIT
U.S. POSTAGE
PAID
PERMIT #1545
ATLANTA, GA