PRODUCT APPLICATION GUIDE | DOAS

DESIGNING A DEDICATED OUTDOOR AIR SYSTEM (DOAS)

Bringing outdoor air into a building is vital for maintaining good indoor air quality. However, outdoor air can be expensive to temper and, if not properly conditioned, can cause building humidity problems. Designers have found that using a dedicated outdoor air system (DOAS) allows them to design energy-efficient HVAC units that comply with ASHRAE Standard 62.1, with easily verified ventilation rates.

WHAT IS DOAS?

Dedicated outdoor air systems condition all outdoor air brought into a building for ventilation and deliver that air directly to occupied spaces or other HVAC units that maintain space temperature. In summer, DOAS units deliver cooled, dehumidified outdoor air, and in winter deliver heated outdoor air. DOAS units often include air-to-air energy recovery.

DOAS APPLICATIONS

Dedicated outdoor air systems are ideal for:

- Individual spaces requiring a high percentage of outdoor air
- Individual spaces with a high number of air changes
- Individual spaces with tight tolerances for space temperature and/or relative humidity
- Delivering outdoor air to multiple spaces with local HVAC units
- Spaces requiring verifiable ventilation airflows

DOAS FOR HIGH LATENT LOADS

In many climates, the majority of DOAS annual operating hours are spent dehumidifying ventilation air. In summer, DOAS units dehumidify outdoor air before it enters the space. Incoming ventilation air often represents more than 80% of a building's annual dehumidification load. Most traditional HVAC systems cannot handle such high latent loads over a wide range of ambient conditions.

Select a DOAS unit capable of delivering the required amount of conditioned outdoor air with the capacity to handle the latent loads of both the ventilation and space air. This will require a unit supply air dew point lower than the target space air dew point, often resulting in cooling coil leaving air temperatures of 48-50 °F or less. A DOAS unit that handles the entire latent load (ventilation plus space) effectively decouples the space sensible load from the latent load, allowing precise humidity control. Thus, the local/terminal HVAC units (i.e., parallel VAV systems, water source heat pumps, fan coil units) are only responsible for sensible heating and cooling to maintain the desired temperature in each space. This design approach minimizes humidity control problems that are often associated with part-load conditions.

DESIGN COOLING VS. DESIGN DEHUMIDIFICATION CONDITIONS

When designing a DOAS or high outdoor air system, both design dehumidification and design enthalpy conditions should be evaluated. In the *ASHRAE Design Guide for Dedicated Outdoor Air Systems* the authors state:

> *For dehumidification load calculations, the designer should use the peak dew point and/or peak enthalpy conditions for outdoor air displayed in* ASHRAE Handbook—Fundamentals *and not the peak dry-bulb condition. All three groups of data usually appear on the same page.*[1]

Designing just for temperature can result in not meeting desired space humidity conditions, which can lead to mold, structural degradation, and poor indoor air quality caused by excessive moisture in the space.

CONSIDER THE FOLLOWING EXAMPLE

- Location: Oklahoma City, OK
- Application: 100% outdoor air
- Desired space set point: 75 °F
- Desired space humidity: 50% RH

DESIGN USING ASHRAE CLIMATIC DESIGN CONDITIONS[2]

ASHRAE 0.4% Cooling Design Day Conditions (100.6 °F DB/73.9 °F WB)

- If equipment is designed using design cooling (dry bulb) conditions, the DOAS equipment will not be able to maintain the desired space humidity set point when outdoor dew points are above 62 °F.

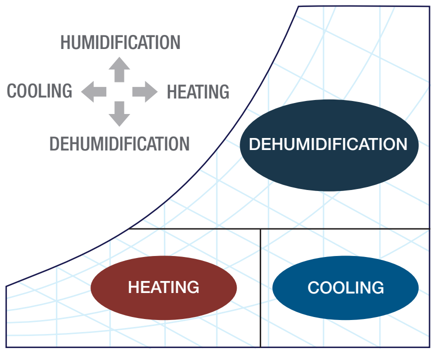
ASHRAE 0.4% Dehumidification Design Day Conditions (84.1 °F DB/74.5 °F dew point)

- If equipment is designed using dehumidification design (dew point) conditions, the equipment will meet desired conditions for both temperature and humidity at outdoor dew points up to 74.5 °F.

To ensure proper dehumidification, the required DOAS cooling capacity should be checked at each design condition listed in the ASHRAE Climatic Design Conditions Table.[2] The design condition that generates the highest latent load is generally the one to use.

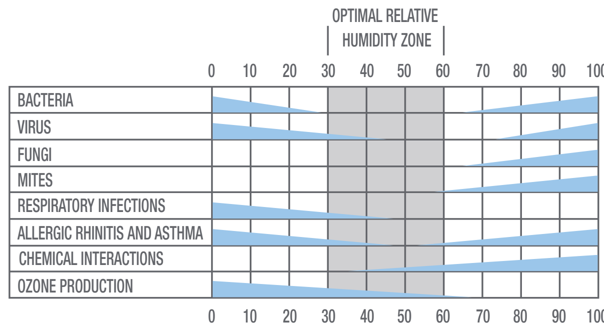
When introducing large amounts of outdoor air, it is much easier to maintain a cool and dry space than to regain control of a humid space. Systems that simply control the unit leaving air temperature cannot meet or maintain desired space temperature and relative humidity.

CONTROL MODES



Dehumidification comprises the majority of DOAS annual operating hours, in many climates.

OPTIMAL SPACE RELATIVE HUMIDITY



Relative humidity in habitable space should be maintained between 30% and 60% RH to minimize the growth of allergenic or pathogenic organisms.

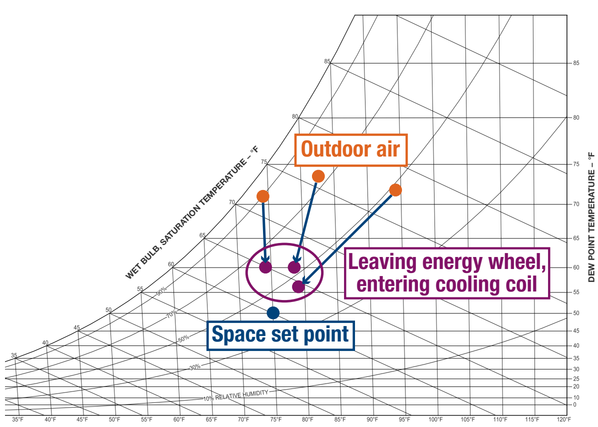
OPTIMIZING THE DOAS UNIT

There are several issues to consider when designing DOAS units. Items to evaluate include the use of energy recovery, cooling coil leaving air temperature (supply dew point) reset, reheat requirements, and the unit sequence of operation.

ENERGY RECOVERY

Since dedicated outdoor air units, by definition, introduce 100% outdoor air into a building, energy recovery is required in most cases per ASHRAE 90.1-2019.[3]

ENERGY WHEEL PSYCHROMETRICS



Energy wheels transfer sensible and latent energy. This chart shows how an energy wheel cools and dries outdoor air before it enters the cooling coil, reducing cooling coil requirements.

Even without the ASHRAE Standard requirement, energy recovery makes good economic sense. Energy recovery wheels can significantly reduce the mechanical cooling load of a DOAS unit. This reduction of the outdoor air heating and cooling loads will also lead to substantial energy savings.

Energy wheels also ease the burden of dealing with part-load conditions. Because the wheel transfers both sensible and latent energy, the energy wheel reduces the range of conditions entering the downstream cooling coil. Therefore, instead of having to design a heating/cooling system capable of handling all potential ambient air conditions, the conditions entering the cooling coil are held to a smaller radius of values.

This may be particularly important for DX cooling equipment where compressor cycling can occur at low load conditions, which may then lead to a loss of humidity control. (Note that most DOAS units have modulating compressors to avoid excessive cycling.)

Depending on climate and end-user preference, plate heat exchangers, which provide sensible and/or latent energy recovery, can also be incorporated into a DOAS unit.

CONTROL STRATEGIES

Delivering correct unit supply air dry bulb and dew point temperatures from a DOAS unit is important for achieving maximum energy savings and space comfort. As discussed previously, to handle the entire latent load, the supply air is often dehumidified to a dew point lower than the temperature required to maintain the space temperature set point. Over-cooling ventilation air requires reheat, either at the DOAS unit or the space, to maintain proper space temperature.

Controlling a dedicated outdoor air system is straightforward: when the building is occupied, the DOAS unit is energized and supplies conditioned ventilation air to the building. Local HVAC units are energized upon a call for sensible cooling or heating from the space. A dedicated outdoor air system allows a precise volume of ventilation air to be delivered to each space, independent of cooling or heating status.

Resetting the DOAS unit's supply air temperature based on outdoor air conditions is a basic control strategy. The DOAS unit controller monitors outdoor air dry bulb and dew point temperatures and resets the unit supply air dry bulb and dew point set points accordingly. A more advanced approach to this same strategy is to use a building management system (BMS) that can monitor multiple spaces and determine the critical space. Once the critical space is identified, the BMS can adjust the outdoor air unit supply air temperature set point to prevent the critical space from being either overcooled or overheated.

Another control strategy is to use the BMS to monitor relative humidity in multiple spaces. As the critical space relative humidity fluctuates, the DOAS unit controller resets the coil leaving dew point set point accordingly. This ensures the critical space is neither too humid nor too dry. As the cooling coil leaving temperature is being reset up or down by this critical room RH control loop, the reheat control loop, described above, continues to ensure the critical room remains at the room temperature set point.

SUMMARY

Dedicated outdoor air systems provide a straightforward, energy-efficient approach for managing ventilation air. To deliver the required ventilation air at a dew point temperature that maintains the space relative humidity set point, reference the ASHRAE dehumidification climatic conditions table, and select the design condition that yields the highest coil latent load. Integral energy recovery and adaptive control strategies will help maximize energy savings and improve occupant comfort.

Notes

1 Chapter 2: Outdoor Air and Load Requirements/Outdoor Air Loads/Dehumidification, ASHRAE Design Guide for Dedicated Outdoor Air Systems. 2017. ASHRAE.

2 Chapter 14: Climatic Design Information, ASHRAE Handbook--Fundamentals. 2021. ASHRAE.

3 Section 6.5.6.1 Exhaust Air Energy Recovery, Table 6.5.6.1.2-1, Table 6.5.6.1.2-2, ANSI/ASHRAE/IES Standard 90.1-2019.