What is a DOAS anyway?

WHITE PAPER SEPTEMBER 2021

Introduction

There is a lot of buzz in the AEC industry about DOAS. Along with that buzz comes a certain amount of confusion and misinformation. In this white paper we will try to demystify this technology that has actually been around in the HVAC industry for decades.

Recent advances in energy recovery technology, and the implementation of sensible-only induction unit and chilled beam HVAC systems has brought DOAS to the forefront as an energy efficient solution for providing fresh air to today's low-energy, low-carbon buildings.

The many names of DOAS

There are many different names for a dedicated outdoor air system, and designers often use them interchangeably.

Common terms include:

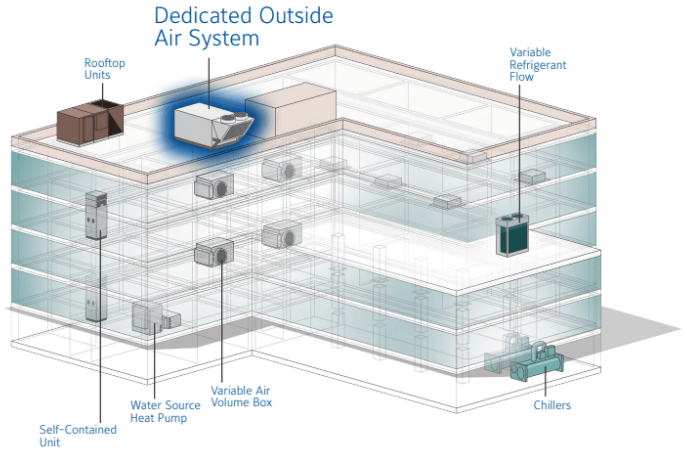
- Dedicated Outdoor Air System (DOAS)
- Fresh Air Unit (FAU)
- Outdoor Air Unit (OAU)

Make-up Air Units (MAU) may also be included with dedicated outdoor air systems as they serve a similar purpose. While there is not a technical distinction between MAU and DOAS equipment, the terms "DOAS", "FAU", and "OAU" are more commonly used to describe systems that provide fresh air intended to provide ventilation air, whereas the term "MAU" is more commonly used to describe systems that are intended to replace air that has been exhausted[1].

What is the purpose of a DOAS?

The sole purpose of a DOAS is to supply outdoor/ventilation air to a building.

Every building intended for human habitation is required by code to be ventilated with outdoor air. Certain types of mechanical equipment, notably rooftop units (RTUs), draw ventilation air directly from the outside into the unit. Smaller distributed terminal units such as water source heat pumps, hydronic fan coil units, variable refrigerant flow (VRF) fan coil units, chilled beams, and induction units require a field installed ventilation system. In some cases a wall cap, roof cap, or louver is added and ducted into the unit return or mixing box for ventilation; however, for large systems it is



beneficial to pretreat the ventilation air at a central location. A centrally located DOAS is often used to heat and cool ventilation air to "room neutral" conditions, i.e. approximately the same temperature (and often humidity) as the room air, so the terminal equipment does not need to condition it[2].

What does a DOAS look like?

Most commercial DOAS are simply specialized rooftop units, and therefore they look a lot like a traditional RTU. They may be larger and they may have more components, but they look like large, boxy RTUs.

DOAS units are sometimes installed indoors, in penthouses or mechanical rooms. These units also look a lot like their conventional counterparts, however they are specialized units dedicated to treating the fresh air.

RTU

DOAS

What are the benefits of a DOAS?

Energy savings

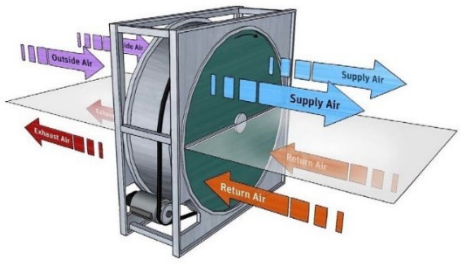
Ventilation in buildings is important, but a lot of energy is required to condition the outdoor air. For every CFM (cubic foot per minute) of ventilation air that is brought into a building one CFM of air must be somehow exhausted or relieved from the building. This exhausted air is conditioned,

and there is a significant amount of energy wasted by exhausting conditioned air.

A DOAS is often provided with an energy recovery system, most commonly an energy recovery wheel, to transfer energy from the exhaust airstream to the incoming airstream. This removes heat and humidity from the incoming ventilation air in the summer and adds heat and humidity to the incoming ventilation air in the winter. It is important to note, that the exhaust airstream is not reused, recycled or mixed with the outside air. It is only used to extract energy from the outgoing airstream to be utilized (recovered) by pretreating the incoming airstream.

Energy recovery systems are not 100% efficient. There will still be an energy cost associated with ventilation[3]; however, they can provide a significant reduction in that energy cost by providing "free" capacity. This additional capacity can reduce the quantity of compressors required for heating or cooling the ventilation air and in many cases can actually lower the cost of the DOAS.

Without a DOAS, terminal units (such as fan coil units) must use their fan to draw outdoor air in through louvers or other means. This often imposes more flow restriction (higher "static") than the return path and forces the fan to work harder. Ventilation air from a DOAS is "forced", so there is no additional burden on the terminal unit fan[4].



ENERGY RECOVERY WHEEL

Terminal equipment sizing

Without a DOAS, each piece of terminal equipment must be sized to condition the space *and* to condition the outdoor air. With a DOAS the terminal equipment only needs enough capacity to condition the space. This can result in a significant reduction in terminal equipment sizing in densely occupied spaces.

Increased humidity control

Without a DOAS, any excess moisture in the ventilation air is removed by the space air conditioning equipment. This works, but it has some disadvantages.

- The terminal units must be sized to remove the humidity (latent load).
- Some types of terminal equipment alternate between "on" and "off" to maintain space temperature. This type of equipment will only remove humidity when the equipment is "on", and therefore may result in high indoor humidity during low load conditions.
- All of the supply air must be brought down to a low temperature (typically around 55°F) to control humidity.

With a DOAS, typically only the outdoor air must be brought down to a low temperature to remove humidity, except in high latent load occupancies like gyms or kitchens. Any excess humidity in the ventilation air is removed before it ever enters the space.

Generally speaking, refrigeration systems work more efficiently when they are allowed to operate at warmer temperatures. It is more energy efficient to cool air down to 60°F or 65°F rather than 55°F during low load conditions. Certain system types, including VRF and sensible-only cooling terminals (chilled beams and induction units), take advantage of this to provide highly efficient cooling. These operational temperatures do not provide adequate humidity control in most climates, and often must be paired with a DOAS.

Other benefits

- A DOAS provides a centralized location for enhanced outdoor air filtration. Higher efficiency (MERV) filters can be located in the DOAS, rather than at each terminal unit, to remove allergens.

- If room-neutral air is provided, then insulation can be deleted from the fresh air ductwork, saving construction costs.

- A DOAS comprises significant latent capacity and can produce quite a bit of condensate during the summer months. A DOAS provides a convenient location to

harvest condensate water to reduce cooling tower make-up, irrigation or other needs.

- DOAS are available with many accessories for specialized applications, including:
  - Desiccant based dehumidification for humidity control below what is possible with conventional refrigerant based dehumidification systems.
  - Alternate heat recovery methods, e.g. run-around coils and heat pipes, that reduce the possibility for cross-contamination between the ventilation and exhaust airstreams in critical applications.

Summary

DOAS systems have been around for a very long time, albeit under many different names. They have evolved into a very efficient method of handling outdoor air, while providing greater comfort levels in buildings due to their ability to control humidity at its source. Their widespread use in commercial building design has been on the rise with the increased focus on energy conservation and carbon reduction. Properly applied, they can be an integral part of a well-designed, efficient and environmentally responsible HVAC system. Schnackel Engineers can assist you with determining if a DOAS is right for your building and in achieving the most efficient, cost effective HVAC system for your building.

Footnotes

[1] For example, one may use a MAU to "make-up" air exhausted by a kitchen grease hood and a DOAS to provide ventilation air to common spaces. Both pieces of equipment provide 100% outdoor air, but MAUs generally do not include exhaust and heat recovery. DOAS do not *necessarily* include exhaust or heat recovery, so there is some overlap in the nomenclature.

[2] Providing dehumidified, room neutral air usually requires cooling the air down below the desired temperature and then reheating it with "free" heat from the compressors. In some cases it may be more energy efficient to provide cold (55°F or colder) ventilation air in the summer, rather than reheating it back to room neutral. This ventilation control strategy is beyond the scope of this white paper.

[3] To be precise there will be an energy penalty associated with ventilation except for those times when economizing is favorable, i.e. when the building requires cooling and it is cold outside.

[4] For example: Suppose a terminal unit supplies 200 CFM, including 40 CFM of outdoor air, at 0.3 inches water column (in. WC) external static pressure. If the outdoor air ductwork and louver adds 0.4" WC, then the entire 200 CFM must be delivered across a static loss of 0.7" WC. This is accomplished by adding a damper to the return path to restrict the return air flow. If a DOAS is used, then only 40 CFM must be delivered across 0.7" WC and the remaining 160 CFM may be delivered with only 0.3" WC, resulting in fan energy savings.

About Seth:

Seth Nelsen, P.E., has been involved in the design and drafting of mechanical and electrical systems for malls, mixed-use developments, corporate offices, national retail roll-outs, commercial and institutional buildings for over 8 years with Schnackel Engineers.

Seth has a Masters Degree in Architectural Engineering from the University of Nebraska at Omaha and is a Licensed Professional Engineer in the State of California. Email Seth at snelsen@schnackel.com

About Greg:

Gregory Schnackel, P.E., LEED AP has been involved in the design of mechanical, electrical, plumbing, fire protections and information technology systems for malls, mixed-use developments, corporate offices, national retail rollouts, schools, hospitals, medical facilities, commercial and institutional buildings for over 40 years with Schnackel Engineers. Email Greg at gschnackel@schnackel.com