PRODUCT APPLICATION

A technical bulletin for engineers, contractors and students in the air movement and control industry

Applying Rooftop Units and Dedicated Outdoor Air Systems (DOAS)

Modern building designs have incorporated energy-saving upgrades such as enhanced insulation, double-paned windows, and efficient lighting. In office settings, desktop computers have largely been replaced by cooler-running laptops, and employees more often work from home. These developments reduce the sensible (heating or cooling) load on HVAC systems, lowering the overall load. With the sensible load reduced, the latent (moisture) load now makes up a larger share of the total.

Figure 1. Rooftop unit (RTU).

At the same time, ventilation standards aimed at improving indoor air quality (IAQ) are becoming stricter. To ensure occupant comfort and maintain building health while meeting these standards, effective humidity control has become more critical.

Rooftop units (RTUs) and Dedicated Outdoor Air Systems (DOAS) are designed to manage both temperature and humidity while modulating their operation to maximize efficiency and reduce energy expenses. Engineers frequently face questions about the appropriate use and placement of each system. This guide addresses those decisions and provides example application scenarios.

Important Features of Rooftop Units and DOAS

The Air-Conditioning, Heating, and Refrigeration Institute (AHRI) classifies unitary air conditioners and heat pumps that use partial air recirculation under Standard 340/360 when their heating and cooling capacity exceeds 65,000 BTU/hour. This category includes commercial and industrial systems.

These units are factory-assembled, electrically powered systems that contain a cooling coil, an air-moving component, and a combination of a condenser and compressor(s).[1]

DOAS units, which are designed for 100% outdoor air applications and capable of providing cooling, are certified under AHRI Standard 920.

These systems must be able to dehumidify outdoor air to a low dew point and include “reheat that is capable of controlling the supply dry-bulb temperature of the dehumidified air to the designed supply air temperature. This conditioned outdoor air is then delivered directly or indirectly to the Conditioned Space(s).”[2]

Beyond these technical definitions, rooftop and DOAS units must have certain features to ensure healthy and comfortable building environments for the long term.

- **Variable-speed compressors**: These use an inverter scroll to adjust the compressor motor's speed, enabling precise modulation of cooling capacity during part-load conditions. This helps maintain setpoints more efficiently.
- **Foam-insulated cabinet construction**: Cabinets insulated with injected foam reduce air leakage, minimize noise, and have rugged durability in extreme weather conditions.
- **Optional modulating hot gas reheat (HGRH)**: This feature, commonly used on DOAS units to meet the reheat requirement, can also be added to RTUs to improve indoor comfort. It uses hot refrigerant from the compressor discharge to reheat dehumidified air, controlling humidity without overcooling the space.
- **Optional modulating gas furnace**: This allows the furnace to incrementally adjust heat output to better match the actual heating load, improving energy efficiency and maintaining steady indoor temperatures.
- **Modulating direct drive fans**: These fans adjust airflow based on demand, managing air pressure to reduce infiltration and improve comfort. They also increase energy efficiency while lowering wear and maintenance needs.

In either a DOAS unit or an RTU, incorporating modulating components and foam-insulated cabinet construction is key to maintaining occupant comfort and controlling operating costs over time.

Figure 2. Foam-insulated cabinet construction.

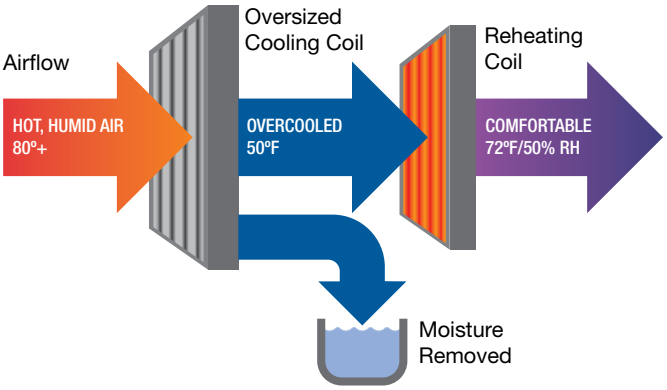

Figure 3. Modulating hot gas reheat.

Design Considerations

RTUs are a common choice for commercial buildings where a single system can efficiently manage both comfort loads and ventilation. By mixing outdoor air with return air, these units provide heating, cooling, and required fresh air in one package. They are well-suited for offices, retail, schools, and other general-purpose buildings where internal loads from people, lighting, and equipment drive most of the HVAC demand. Their simplicity and cost-effectiveness make them a reliable option when ventilation requirements are moderate and can be balanced within the same system.

In contrast, DOAS are designed to handle ventilation independently, or decoupled, from space conditioning. These systems treat outside air only—often with advanced dehumidification and energy recovery—before delivering it directly to the space or to zone-level equipment like variable refrigerant flow (VRF) or fan coils. These units are especially valuable in humid climates, with high-occupancy spaces, or applications where indoor air quality and humidity control are critical. By decoupling ventilation from comfort conditioning, DOAS ensures consistent code compliance and optimized air quality regardless of space load.

Example Applications

These example applications show where it is advantageous to use an RTU, DOAS, or both.

School

Design considerations for a school's HVAC system include:

- Different temperature control needs in classrooms due to teacher preference, changes in room occupancy, and other factors
- Humidity variance (locker room vs. administrative office)
- Operational budget
- Equipment noise level in an educational setting

The ASHRAE 62.1 standard, adopted by many states and jurisdictions, establishes:

- Baseline ventilation rates based on occupancy and space type. In classrooms, 10 cfm/person and 0.12 cfm/ft^2.
- Relative humidity below 65%, which can be achieved using control sequences based on:
  - o Outdoor air enthalpy
  - o Return air enthalpy
  - o Space relative humidity
  - o Outdoor air temperature

Figure 4. High school with an HVAC system incorporating multiple types of equipment.

In multi-zone areas with high ventilation requirements such as classrooms, either an RTU or DOAS unit is an effective solution for:

- Providing the ASHRAE-recommended outdoor air rate to each space
- Conditioning using multiple tempering options including direct expansion (DX) cooling, indirect gas, or an all-electric air source heat pump (ASHP)
- Dehumidifying by removing moisture from the incoming airstream to make air room-neutral prior to tempering

In renovation projects, unlike new construction, the existing ductwork and infrastructure are often built around older RTUs that deliver lower amounts of outside air and lack modulating components. Switching to a newer RTU can provide higher efficiency, improved ventilation, and humidity control without the entire system needing to be replaced.

In large, open areas like cafeterias, RTUs maintain consistent temperatures by adjusting supply fan speed based on space temperature. This helps cut energy use during part-load conditions. RTUs also work well in administrative offices as part of a multi-zone variable air volume (VAV) system. In this setup, the RTU connects to air terminal units (ATUs) that serve individual offices. The RTU is sized to handle both the recirculated air load and the required ventilation for the full system area.

Electronics Store

In a large retail store, important considerations include:

- ASHRAE 62.1 guidelines that specify minimum ventilation rates based on occupancy type and floor area, ensuring adequate dilution of indoor contaminants
- Energy consumption due to long operating hours
- Cooling and dehumidification during hot and moist summers
- Comfort so that the space does not feel over-cooled and clammy to shoppers and staff

RTUS can regulate this environment by maintaining a comfortable temperature as well as controlling humidity to maintain a proper dew point and avoid excessive latent load buildup. Energy recovery can also be applied in these spaces through one of the following methods.

A decoupled ERV can precondition the outdoor air and provide it to multiple RTUs on the roof. Since exhausting air is already required for depressurization and code compliance, capturing its energy for pre-treatment makes the ventilation process more efficient. Another option is to use RTUs with integral energy recovery, which requires each unit to have a ducted return from the space.

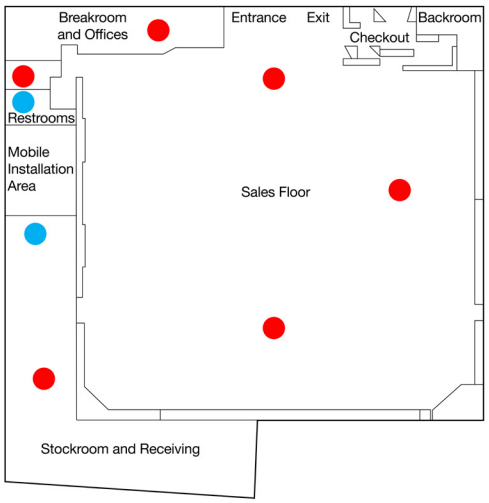

Figure 5. RTU and ERV rooftop placement, with RTUs represented by red dots and ERVs by blue dots.

Hotel

When designing for a hotel, consider:

- Wherever occupants are sleeping, indoor air quality is important.
- Hotels must provide ASHRAE-required ventilation of 5 cfm/person and 0.06 cfm/ft^2 while allowing guests to customize the temperature in their rooms.
- Guests consume different amounts of energy in the rooms, so equipment should be efficient.

When a space requires 100% outdoor air, use a DOAS to deliver dehumidified air to rooms and corridors, decoupling the ventilation load from other HVAC systems. Building codes may mandate energy recovery in the DOAS design. Guest rooms will use smaller recirculation units such as fan coils for sensible heating and cooling, allowing guests to have control over their room temperature.

RTUs work well in areas that do not require 100% OA, such as lobbies, meeting rooms, and ballrooms. These single-zone spaces often experience fluctuating occupancy, and RTUs can respond quickly to changing loads, ensuring consistent comfort throughout the day and evening.

Figure 6. Dedicated Outdoor Air System with energy recovery.

Conclusion

Whether an engineer chooses decoupled ventilation with a DOAS unit or partial recirculation with an RTU, ensure the equipment includes the features noted above to optimize comfort and reduce operating costs. Look for modulating hot gas reheat (Mod HGRH), a modulating gas furnace, variable-speed compressors, modulating direct drive fans, and injected foam-insulated cabinet construction. These components give the system the flexibility to handle high latent loads, maintain indoor air quality, and meet efficiency targets over time. For additional application scenarios and more in-depth information, speak with a Greenheck representative in your area.

References

- *AHRI. Performance Rating of Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment, ANSI/AHRI Standard 240/360-2022 (I-P).* Secs 2.1.1, 3.4, pp. 1–2. Accessed September 5, 2025. https://www.ahrinet.org/system/files/2024-09/AHRI%20Standard%20340-360-2022%20%28I-P%29%20ICS.pdf
- *AHRI. Performance Rating of DX-Dedicated Outdoor Air System Units, ANSI/AHRI Standard 920 (I-P)*-2015. Sec 3.3, p. 1. Accessed September 5, 2025. https://www.ahrinet.org/system/files/2023-06/ANSI_AHRI_Standard_920_I-P_2015.pdf

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