System Catalog

Zoned Rooftop Systems

Packaged rooftop systems from Trane

March 2021

APP-PRC005H-EN

Trane® Zoned Rooftop Systems

Trane® Zoned Rooftop Systems provide customers with affordable options for small buildings, to increase comfort and efficiency, while simplifying maintenance.

Cost-effective, superior comfort for small buildings

Trane® Zoned Rooftop Systems are available in single- or multiple-zone configurations to provide cost-effective comfort control for different areas of the building with varying comfort needs.

The Tracer® Concierge™ control system offers the benefits of a building automation system—without the complexity—and goes beyond managing individual rooms by operating the building smartly and efficiently. It provides advanced capabilities for multiple-zone systems, is easy to use, and offers worry-free operation.

Easy to design, install, and operate

Packaged rooftop units provide cooling, heating, and ventilation in a single piece of equipment, simplifying system design, installation, and maintenance.

Trane® Zoned Rooftop Systems use pre-engineered components and factory-installed controls that are designed to work together, contributing to on-time and on-budget installation. They use familiar components and are easy to reconfigure if the space use changes in the future.

The pre-packaged Concierge™ system control panel, with its auto-discovery and configuration capabilities, allows for easier and faster installation. It includes an intuitive, easy-to-use operator interface on a 10-inch touchscreen display, along with mobile apps that allow the operator or service provider to manage the building from anywhere.

The use of Air-Fi® Wireless controls results in faster project completion, increased sensor location flexibility, greater reliability due to self-healing mesh networking, and easier relocation to accommodate future space use changes.

Efficient system operation

Trane® Zoned Rooftop Systems take advantage of the newest technologies to improve comfort and increase efficiency in small buildings.

Trane rooftop units are available in a range of efficiency tiers to match your budget and energy use goals. Variable-speed technologies are available to adjust compressor and fan speeds to more precisely match load requirements. This improves comfort in the space while reducing energy use at the same time. Zoned Rooftop Systems also offer integrated demand-controlled ventilation and economizer free cooling, further reducing energy use.

To fully capitalize on the performance benefits offered by these advanced technologies, integrated system control is a vital part of the solution. The Tracer® Concierge™ control system provides advanced optimization strategies to reduce energy use while improving occupant comfort, and is smart enough to let you know when service is needed to sustain optimal performance.

Trane.com/ZonedRooftopSystems

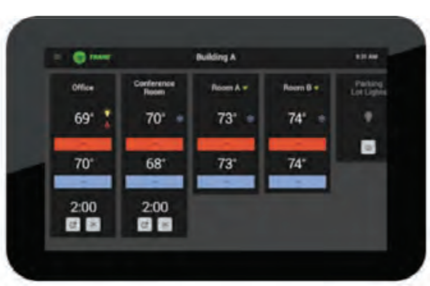
Components of a Trane® Zoned Rooftop System

Packaged rooftop units (3 to 50 tons)

- Pre-engineered, factory-assembled cooling, heating, and ventilation in a single piece of equipment
- Supports single- or multiple-zone applications, with constant- or variable-speed fan control
- Three tiers of efficiency: standard, high, or ultra-high
- Optional eFlex™ variable-speed compressor and condenser fan control
- Integral ventilation control, including options for demand-controlled ventilation and air economizing—with fault detection and diagnostics
- Pre-programmed, factory-installed ReliaTel® DDC controls with wired or Air-Fi® Wireless communications

VAV terminal units (200 to 8000 cfm)

- Trane flow ring provides unmatched airflow measurement accuracy and control
- Durable, heavy-gauge air valve cylinder
- Options for electric or hot-water heat, with staged, two-position or modulating control
- Pre-programmed, factory-commissioned Tracer® UC™210 DDC controls with wired or Air-Fi® Wireless communications
- Retrofit dampers available for upgrading existing systems



Tracer® Concierge™ control system

- Pre-packaged system control panel allows for easier and cost-effective installation
- Standard, pre-packaged applications with optimized system control sequences
- Intuitive, easy-to-use operator interface on a 10-inch touchscreen display
- Mobile apps allow access from virtually anywhere
- Wired or Air-Fi® Wireless communications

Air-Fi® Wireless controls

- Eliminates wires between equipment controllers and zone sensors, and between equipment and system controllers, allowing for faster installation, increased location flexibility, and easier relocation
- Self-healing wireless mesh and extended signal range maximize reliability
- Supports open communication protocols through conformance with ASHRAE® Standard 135 (BACNet/ZigBee®)
- Up to four sensing functions in one zone sensor: temperature, humidity, occupancy, and CO_2
- 15-year lifetime batteries

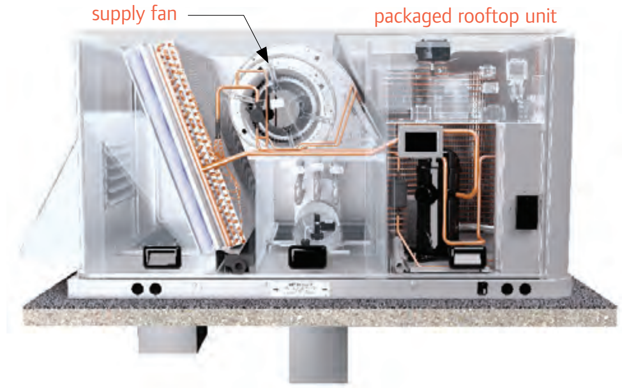
Zoned Rooftop System Configurations

There are six configurations of Trane® Zoned Rooftop Systems. See page 10 for an energy and temperature control comparison.

	Single-Zone Systems		Multiple-Zone Systems			
	Constant-Volume	Single-Zone VAV	Changeover Bypass	Changeover VAV	VAV with Terminal Electric Heat	VAV with Terminal Hot-Water Heat
number of zones served	single-zone only	single-zone only	multiple zones	multiple zones	multiple zones	multiple zones
supply-fan speed control	constant-speed	variable-speed (or two-speed)	constant-speed	variable-speed	variable-speed	variable-speed
VAV terminal units	not applicable		required (available with optional heat)		required (with electric heat)	required (with hot-water heat)
bypass damper	not applicable		required	may be required[1]	typically not required	
Pivot™ Smart Thermostat	x	two-speed only	not applicable			
Tracer® Concierge™ control system	x	x	x	x	x	x

[1] If the rooftop unit is equipped with staged gas or electric heat, a bypass damper is required. If equipped with a modulating gas heater, a bypass damper may be required if the system airflow during heating mode is expected to drop below the minimum threshold for the heater (see page 41).

Single-zone constant-volume system



This system is comprised of a single rooftop unit with controller, and at least one zone temperature sensor. The rooftop unit's supply fan operates at a fixed speed to provide a constant volume of conditioned air. As the load in the zone changes, cooling or heating capacity is cycled on and off to maintain zone temperature at setpoint. This cycling results in a variable supply air temperature. Fixed-speed scroll compressors provide cooling, while heating is provided by a gas or electric heater (or hot-water coil as a special, see page 38) or by reversing the refrigeration system to operate as a heat pump.

A thermostat or zone sensor provides zone temperature information to the rooftop's controller. When multiple spaces are combined into a single thermal zone, and served by one rooftop unit, placement of the zone sensor—or multiple, averaged sensors (see page 43)—requires careful consideration.

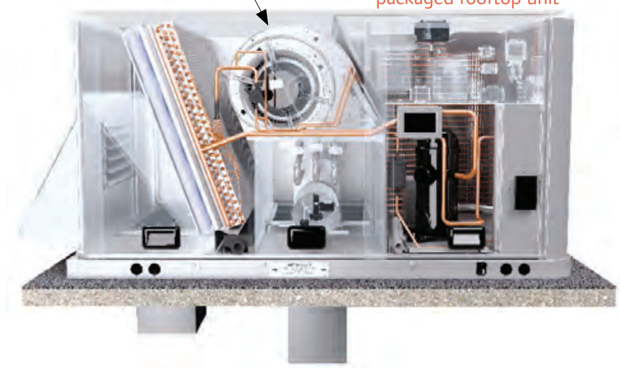
Advantages

- Simple, well-known system used by many industry professionals and customers
- Good solution for large, open spaces, such as: cafeterias, auditoriums, gymnasiums, warehouses, and open retail
- Can be used to provide separate systems for multiple small tenants, such as in a strip mall
- Multiple units can be grouped for ease of managing large spaces
- Simple building pressure control

Limitations

- Comfort complaints are more likely if dissimilar spaces are served by a single-zone system due to control by one zone temperature sensor
- Using several small rooftop units to provide more zones of control increases installation cost, utility connections, and building penetrations
- Typically has higher energy use than VAV systems
- Often requires hot gas reheat for adequate dehumidification at part load

Single-zone VAV system



This system is comprised of a single rooftop unit with controller, and at least one zone temperature sensor. The rooftop unit's supply fan varies its speed to provide a variable volume of conditioned air. Either two-speed or variable-speed fan control is available. As the load in the zone changes, the variable-speed fan is modulated to maintain zone temperature at setpoint, while cooling or heating capacity is staged or modulated to maintain the supply-air temperature at setpoint. When the fan has turned down to its minimum operating speed, this supply-air temperature setpoint is reset to prevent overcooling or overheating the zone. Fixed- or variable-speed scroll compressors provide cooling, while heating is provided by a gas or electric heater (or hot-water coil as a special, see page 38) or by reversing the refrigeration system to operate as a heat pump.

A thermostat (for two-speed fan control) or zone sensor (required for variable-speed fan control) provides zone temperature information to the rooftop's controller. When multiple spaces are combined into a single thermal zone, and served by one rooftop unit, placement of the zone sensor—or multiple, averaged sensors (see page 43)—requires careful consideration.

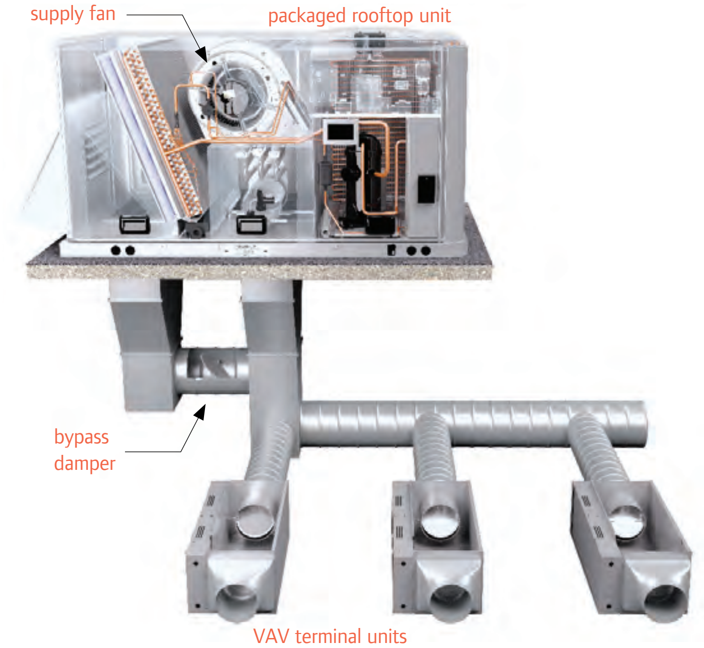
Advantages

- Good solution for large open spaces such as: cafeterias, auditoriums, gymnasiums, warehouses, and open retail
- Can be used to provide separate systems for multiple small tenants, such as in a strip mall
- Multiple units can be grouped for ease of managing large spaces
- Typically has lower energy use than a single-zone constant-volume system
- Typically operates quieter than a single-zone constant-volume system at part-load conditions
- Better dehumidification at part load than a constant-volume system (see page 16)

Limitations

- Comfort complaints are more likely if dissimilar spaces are served by a single-zone system due to control by one zone temperature sensor
- Using several small rooftop units to provide more zones of control increases installation cost, utility connections, and building penetrations

Changeover bypass system



This system is comprised of a single rooftop unit with controller, two or more VAV terminal units (each with a controller and a zone temperature sensor), and a bypass damper. The rooftop unit's supply fan operates at a fixed speed to provide a constant volume of conditioned air. As the loads in the zones change, cooling or heating capacity in the rooftop unit is cycled on and off to maintain the zone temperatures at setpoint. This cycling results in a variable supply air temperature. Fixed-speed scroll compressors provide cooling, while heating is provided by a gas or electric heater (or hot-water coil as a special, see page 38) or by reversing the refrigeration system to operate as a heat pump.

The Concierge™ system control panel uses a polling (or voting) strategy to determine whether the rooftop unit should provide cooling or "changeover" to heating mode. Each VAV terminal unit "votes" toward the overall system mode—heating or cooling—based on the difference between the current zone temperature and its active setpoint. When this temperature difference exceeds 2°F, the voting strength is increased.

A VAV terminal unit serves each zone, with a zone temperature sensor connected to it. The VAV terminal modulates zone airflow to maintain zone temperature at its active setpoint. To improve occupant comfort, some (or all) of the VAV terminal units can be equipped with electric or hot water heat.

Because the fan delivers a constant volume of air and zone airflow downstream of the VAV terminal unit is variable, a bypass damper is required between the supply and return air paths to allow the excess supply air to recirculate. The position of this bypass damper is modulated to maintain the duct static pressure at setpoint. Due to this bypassed air, the supply air temperature can become very cold or very warm. This requires the controller to limit cooling or heating capacity to prevent overcooling or overheating.

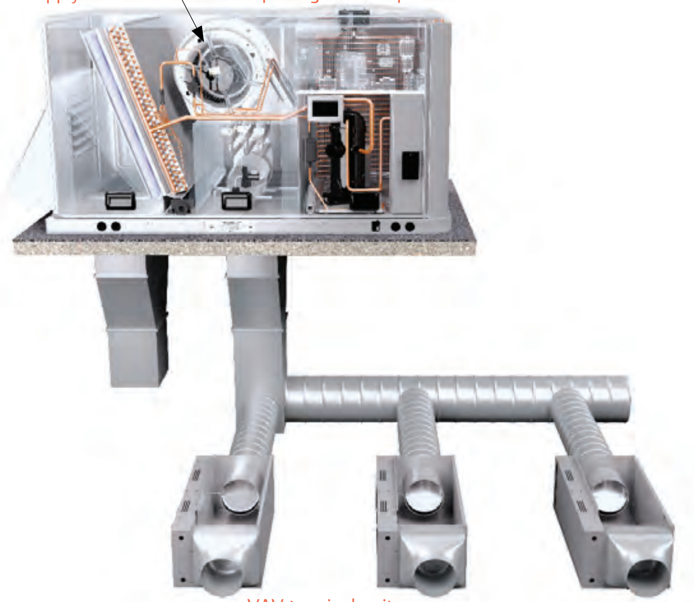
Advantages

- One rooftop unit can serve several zones with independent temperature control in each zone
- Works with any constant-volume rooftop unit
- Can be more economical than installing several small, single-zone rooftop units
- Common system type with many installations

Limitations

- Although it provides additional zones of temperature control, there can still be comfort issues if the zones being served have dissimilar loads – such as interior and exterior zones served by the same rooftop unit
- Higher energy use than VAV system options

Changeover VAV system



This system is comprised of a single rooftop unit with controller, and two or more VAV terminal units (each with a controller and a zone temperature sensor). The rooftop unit's supply fan varies its speed to provide a variable volume of conditioned air. Fixed- or variable-speed scroll compressors provide cooling, while heating is provided by a gas or electric heater (or hot-water coil as a special, see page 38) or by reversing the refrigeration system to operate as a heat pump.

The Concierge™ system control panel uses a polling (or voting) strategy to determine whether the rooftop unit should provide cooling or "changeover" to heating mode. Each VAV terminal unit "votes" toward the overall system mode—heating or cooling—based on the difference between the current zone temperature and its active setpoint. When this temperature difference exceeds 2°F, the voting strength is increased.

As the loads in the zones change, the variable-speed fan is modulated to maintain the duct static pressure at setpoint, while cooling or heating capacity is staged or modulated to maintain the supply-air temperature at setpoint. If the rooftop unit is equipped with a modulating gas heater, the supply fan varies airflow during heating modes. If the rooftop unit is a heat pump or equipped with an electric or staged gas heater, the supply fan will operate at design airflow when the heater is activated, thus requiring a bypass damper (not shown in the image above) to allow excess supply airflow to recirculate to the rooftop unit (see page 41).

A VAV terminal unit serves each zone, with a zone temperature sensor connected to it. The VAV terminal modulates zone airflow to maintain zone temperature at its active setpoint. To improve occupant comfort, some (or all) of the VAV terminal units can be equipped with electric or hot-water heat.

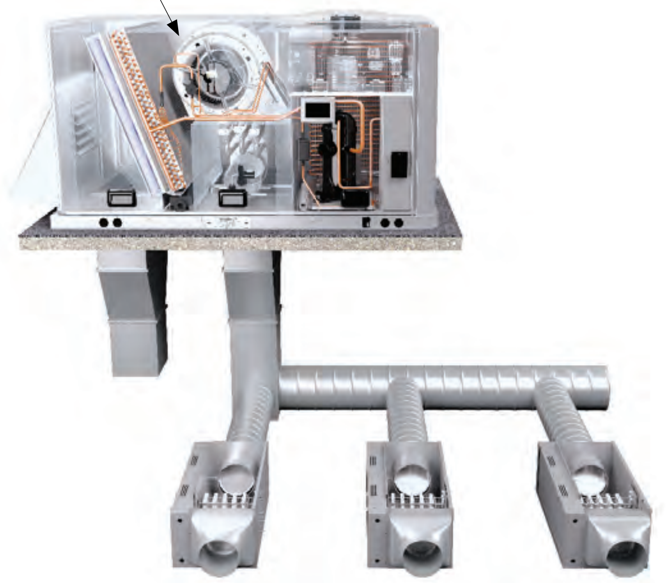
Advantages

- One rooftop unit can serve several zones with independent temperature control in each zone
- Can be more economical than installing several, small, single-zone rooftop units
- Typically has lower energy use than a changeover bypass system
- Typically operates quieter than a changeover bypass system at part-load conditions

Limitations

- Although it provides additional zones of temperature control, there can still be comfort issues if the zones being served have dissimilar loads – such as interior and exterior zones served by the same rooftop unit
- For a heat pump model, or if electric or staged gas heat is provided, a bypass damper must be supplied to allow excess supply airflow to recirculate to the rooftop unit

Multiple-zone VAV system with terminal heat (electric or hot water)



This system is comprised of a single rooftop unit with controller, and two or more VAV terminal units (each with a controller and a zone temperature sensor). The rooftop unit's supply fan varies its speed to provide a variable volume of conditioned air. Fixed- or variable-speed scroll compressors provide cooling, while an optional gas or electric heater (or hot-water coil as a special, see page 38) or heat pump in the rooftop provides heat for morning and daytime warmup modes, and possibly supply-air tempering (see page 19).

A VAV terminal unit serves each zone, with a zone temperature sensor connected to it. The VAV terminal modulates zone airflow to maintain zone temperature at its active setpoint. Most (or all) of the VAV terminal units are equipped with electric or hot-water heat.

As the load in the zone decreases, the damper in the VAV terminal is modulated to reduce supply airflow and maintain the zone temperature at setpoint. This causes the static pressure in the supply duct to increase. The variable-speed fan is modulated to maintain the duct static pressure at setpoint, while cooling or heating capacity is staged or modulated to maintain the supply-air temperature at setpoint. During normal daytime operation, the rooftop unit supplies cool air to each VAV terminal.

When the VAV terminals are equipped with hot-water heat, additional control hardware and programming may be required to control the boiler(s) and hot-water pumps.

Advantages

- One rooftop unit can serve several zones with independent temperature control in each zone
- Can be more economical than installing several, small single-zone rooftop units
- Capable of providing heat to some zones while simultaneously providing cooling to other zones
- Typically has lower energy use than single-zone constant-volume and changeover bypass systems because of the variable-speed supply fan
- Bypass damper is typically not required, making field installation simpler
- Has been in use for many years and is well understood

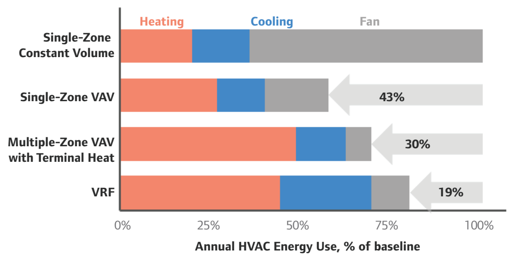
Limitations

- Often impractical to upgrade constant-volume single-zone units to multiple-zone VAV; consider upgrading to changeover bypass
- Requires VAV terminal units with electric or hot-water heat
- Hot-water systems may require additional, field-installed controls for boilers and pumps

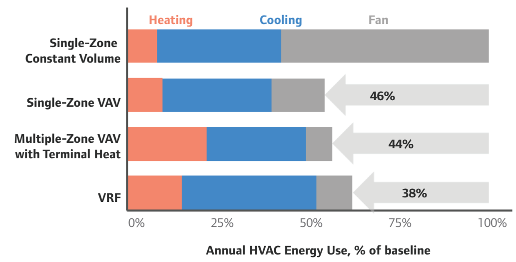
Systems Comparison

The whole-building analysis software program TRACE 3D Plus™ was used to evaluate the energy use of a single-zone constant-volume rooftop unit, a single-zone VAV rooftop unit, a multiple-zone VAV rooftop system, and a variable refrigerant flow (VRF) system in a 2300 ft^2 branch bank building. The charts below compare annual HVAC energy use, expressed as a percentage of the baseline system—single-zone constant-volume—for eight different climate zones. In every location, the single-zone VAV, multiple-zone VAV, and VRF systems all used less energy than the single-zone constant-volume system. The primary reason for this was the overall reduction in fan energy. In addition, the single-zone VAV and multiple-zone VAV systems used less energy than the VRF system in every location. The primary reason for this was the ability of the rooftop systems to use airside economizing.

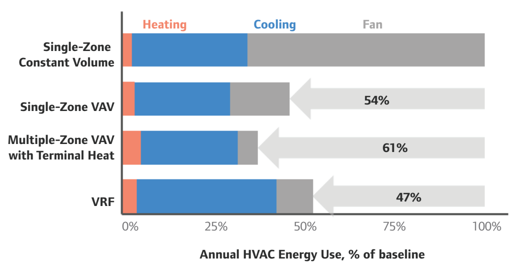
Boston, MA



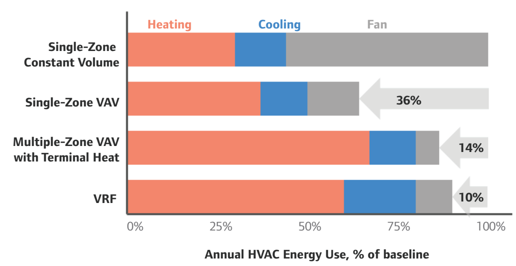
Memphis, TN



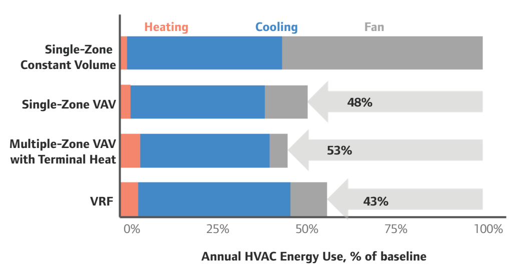
El Paso, TX



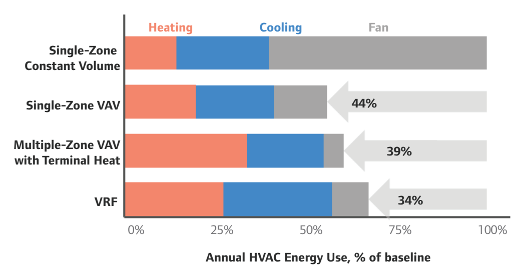
Minneapolis, MN



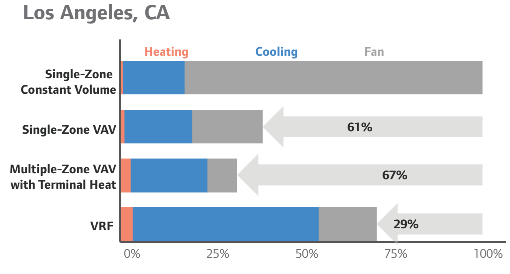
Houston, TX



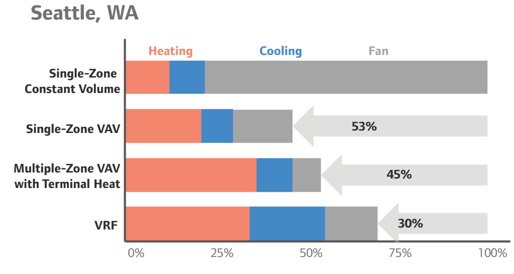
St. Louis, MO



Los Angeles, CA



Seattle, WA

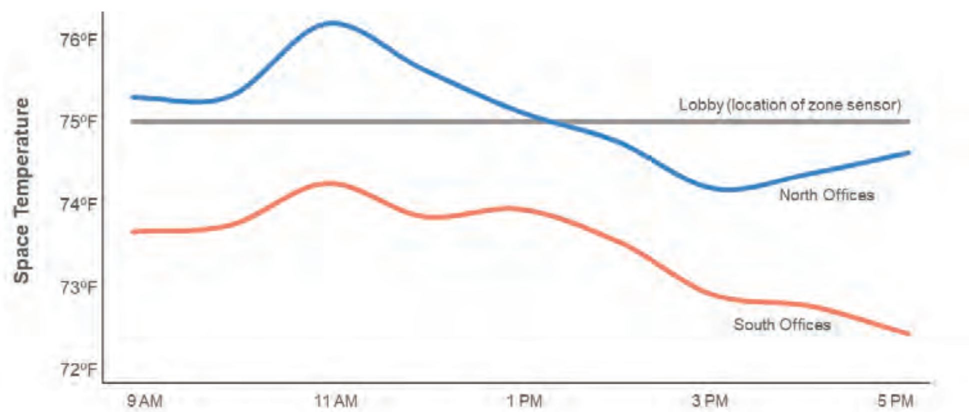


Key modeling assumptions: All rooftop systems use a single rooftop unit (with a variable-speed scroll compressor and modulating gas heat) to serve the entire building. The multiple-zone VAV system includes VAV terminal units with electric heat, and uses supply-air temperature reset and fan-pressure optimization. The VRF system uses an air-cooled heat pump model (or heat-recovery model for the colder climates zones) and an air-cooled DX dedicated outdoor-air unit with a total-energy wheel.

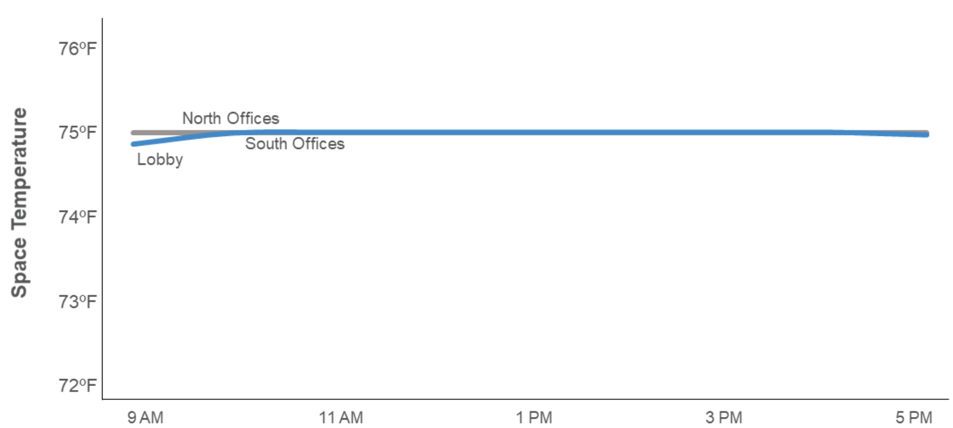
The charts below demonstrate temperature control in different areas of this same 2300 ft^2 branch bank building. For the single-zone systems, one rooftop unit serves the entire building, with the zone temperature sensor mounted in the lobby. For the multiple-zone systems, a VAV terminal unit with electric heat (or a VRF terminal) serves each zone, with a temperature sensor mounted in each zone.

For the single-zone systems, the temperature in the lobby (where the sensor is mounted) is controlled to the desired setpoint, but the temperatures in the north and south office areas vary above or below this setpoint. In contrast, for the multiple-zone systems, the temperatures in all three zones are controlled to the desired setpoint.

Temperature Control in Single-Zone Systems (Minneapolis, July)



Temperature Control in Multiple-Zone Systems (Minneapolis, July)



Application Considerations

There are a variety of design and selection considerations when choosing or designing a Zoned Rooftop System.

Zoning

The Trane® Zoned Rooftop System offering includes six system configurations, comprised single-zone systems and multiple-zone systems. The **single-zone systems** are sized and designed to serve a single thermal zone. Comfort complaints may arise when rooms with disparate thermal loads, such as interior and exterior rooms, are grouped into a single zone and served by one single-zone system.

For **changeover bypass** and **changeover VAV systems**, the Concierge™ system control panel uses a polling (or voting) strategy to determine whether the rooftop unit should deliver cool or warm air down the duct. To ensure acceptable comfort, a changeover system should serve only a few zones with similar thermal loads and zone temperature setpoints. Comfort issues are more likely to occur when a changeover system serves many zones with diverse thermal loads or differing setpoints. For a changeover system, adding a small electric heater (or hot-water coil) to some of the VAV terminal units can increase overall comfort and flexibility. For example, when both interior and exterior zones are served by the same rooftop unit currently operating in cooling mode, adding some heat to the exterior zones will provide better comfort during cool weather. In this case, the local heat only needs to be sized for assisting during moderate weather. During cold weather, the rooftop unit will change over to operate in heating mode and use the heater in the rooftop unit.

For **multiple-zone VAV systems with terminal heat**, consideration should be given when grouping rooms or areas served by a single VAV terminal unit. The rooms/areas should have similar thermal load and population characteristics. For example, group rooms/areas on the same exposure to ensure similar envelope loads. Be careful grouping interior and exterior rooms/areas together in a single zone. Finally, rooms/areas that have unique thermal loads or operating profiles, such as server rooms, are best served by dedicated systems.

Component Sizing

A whole-building load design software program, like TRACE® 700 or TRACE 3D Plus™, can be used to estimate the sizes of the various HVAC system components.

Rooftop unit. Single-zone constant-volume, single-zone VAV, changeover bypass, and changeover VAV systems work better with smaller rooftop unit sizes. As the size of the rooftop unit increases, the number of zones and the load diversity of those zones typically increase as well, which can lead to comfort issues—so a system with VAV terminals and terminal heat should be considered instead.

Oversizing rooftop units can create control issues leading to poor temperature and humidity control.

VAV terminal units. It's important to correctly select the VAV terminal unit size for each zone to be properly controlled. The terminal unit should have adequate capacity to meet the cooling and heating needs of the zone, yet not be oversized. Oversized VAV terminals can lead to airflow control, operation, and acoustic problems. Therefore, select the smallest size that meets the maximum airflow requirement of the zone, and avoid sizes where the maximum (design) airflow is less than half of the factory-designed nominal flow (see page 39).

Consult the "Selection Procedure" detailed in either the VariTrane® Round Inlet/Round Outlet product catalog (VAV-PRC016*-EN) or the VariTrane® Single-Duct Units product catalog (VAV-PRC011*-EN).

Bypass damper. Avoid oversizing the bypass damper. Oversizing often results in airflow control problems, and even excessive noise. See page 41 for guidance on sizing the bypass damper for various system types.

Supply Fan Modulation

In a **single-zone VAV system**, the rooftop unit controller modulates the supply fan speed to maintain zone temperature at setpoint. In this type of system, percent minimum supply fan airflow (cfm) is generally equal to the percent minimum supply fan speed (rpm).

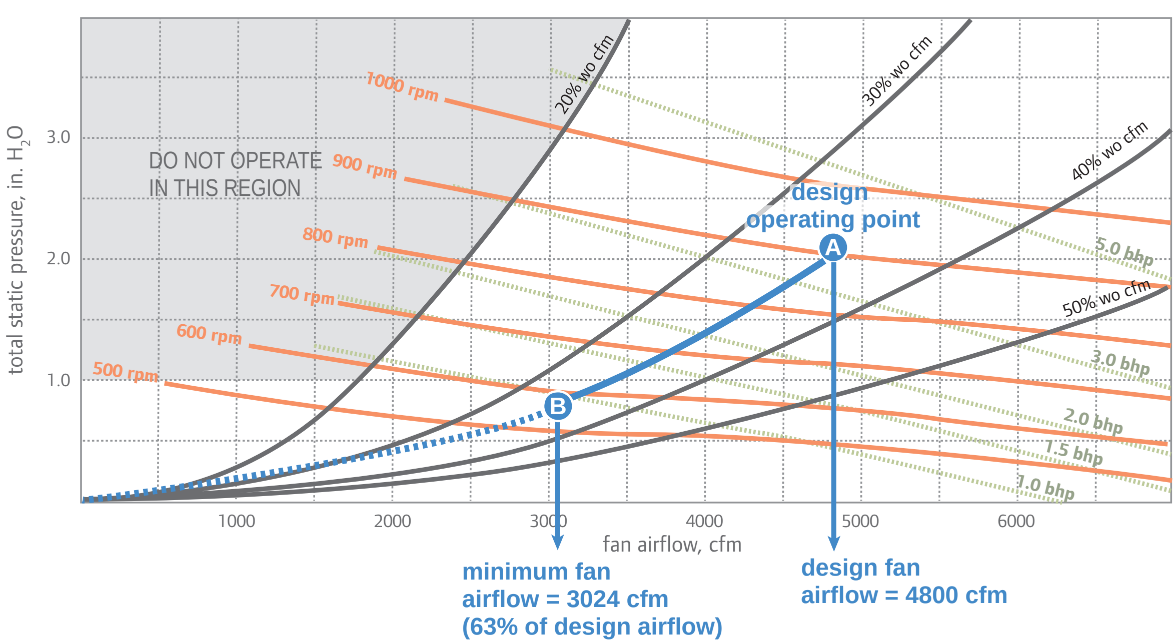
The generic fan curve below shows a rooftop unit selected to operate at 4800 cfm and 2.1 in. H_2O of total static pressure at design conditions (**A**). At these conditions, the fan operates at 910 rpm. If the minimum allowable fan speed is 63 percent, this equates to 574 rpm (910 rpm × 0.63).

In a single-zone VAV system, the supply fan unloads along a constant system curve (blue line). Where this system curve intersects the 574 rpm (63 percent of design fan speed) performance curve (**B**), the fan will deliver 3024 cfm (63 percent of design fan airflow).

The table on pages 32-33 lists the percent minimum supply airflow for Trane Precedent®, Voyager®, and Voyager® Commercial rooftop models that can be used in a single-zone VAV system.

For a single-zone VAV system, the fan laws depict how both airflow and shaft power vary as the supply fan speed changes. In the example above, the supply fan delivers 4800 cfm when operating at 910 rpm, with shaft power equal to 3.2 bhp. When the fan slows to 63 percent speed (574 rpm), the supply airflow decreases to 3024 cfm—4800 cfm × (574 rpm /910 rpm)—and shaft power decreases to 0.8 bhp—3.2 bhp × (574 rpm /910 rpm)^3—an 75 percent reduction in power.

Supply fan turndown in a single-zone VAV system (variable-speed fan)



In either a **changeover VAV system** or **multiple-zone VAV system with terminal heat**, each VAV terminal unit modulates to vary airflow delivered to its zone, to maintain its temperature setpoint as the load in that zone changes. This causes the pressure inside the supply ductwork to change, and the rooftop unit controller modulates the supply fan speed to maintain static pressure in the ductwork at setpoint. In this type of system, percent minimum supply fan airflow (cfm) is typically much lower than the percent minimum supply fan speed (rpm).

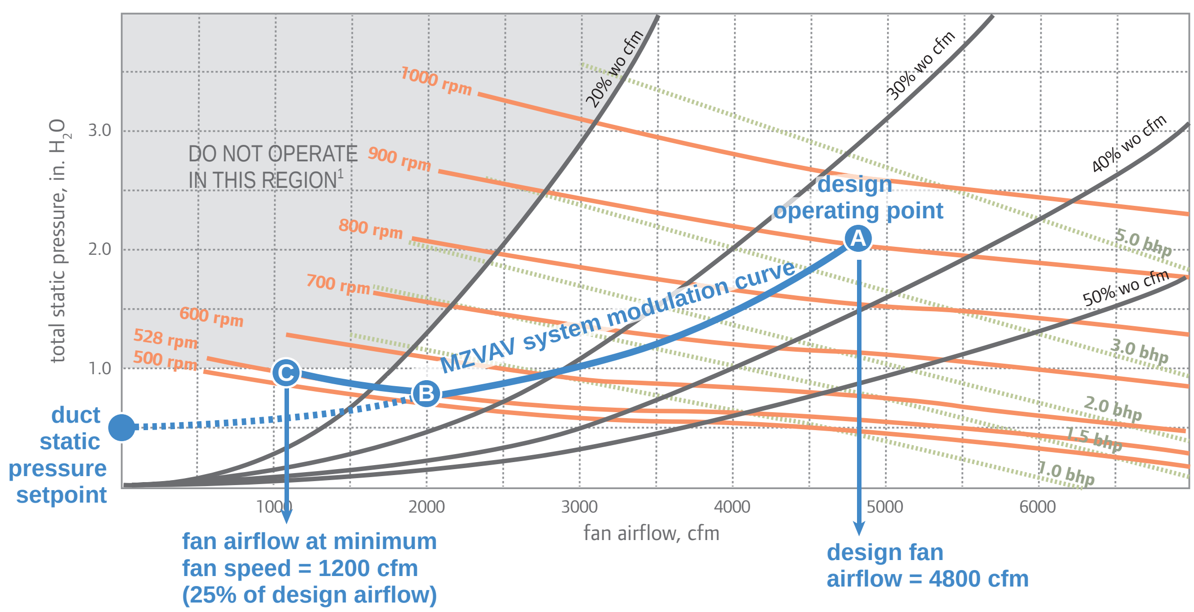
The generic fan curve below shows a rooftop unit selected for the same design conditions—4800 cfm and 2.1 in. H_2O of total static pressure—which requires the fan to operate at 910 rpm (**A**). If the minimum allowable fan speed when operating in fan only or cooling modes is 58 percent, this equates to 528 rpm (910 rpm × 0.58).

As the dampers in the VAV terminal units modulate, the system curve changes. This causes the supply fan to unload along a "multiple-zone VAV system modulation curve" (blue line in the chart below, which intersects the Y-axis at the duct static pressure setpoint—0.5 in. H_2O in this example. Where this multiple-zone VAV system modulation curve intersects the 528 rpm performance curve, the fan will be delivering 2000 cfm (**B**)—which equates to 42 percent of design airflow. Once the supply fan is operating at its minimum speed, the fan will "ride the fan curve" to deliver even less airflow down the duct (blue line between points **B** and **C**) when the dampers in the VAV terminal units modulate further closed. The minimum supply fan airflow is where the minimum-rpm curve intersects with the "DO NOT OPERATE" region. In this example, the 528-rpm performance curve intersects this region when the supply fan is delivering 1200 cfm, which is 25 percent of design airflow.

The tables on pages 34-35 list the minimum supply airflow (CFM) for Trane Precedent®, Voyager®, and Voyager® Commercial rooftop models that can be used in a changeover VAV or multiple-zone VAV system. Note that when the heater is activated, the minimum fan airflow is often higher.

Trane® Zoned Rooftop Systems can implement a pre-engineered control strategy—called fan-pressure optimization—to further reduce fan energy use. By automatically lowering the duct static pressure setpoint during operation, this strategy also allows for even greater supply fan turndown, lower sound levels, and reduced risk of fan surge. And the duct static pressure sensor can be installed anywhere in the supply duct, even at the rooftop unit discharge, allowing for it to remain in the factory-installed location.

Supply fan turndown in a changeover VAV or multiple-zone VAV system (fan only or cooling mode)



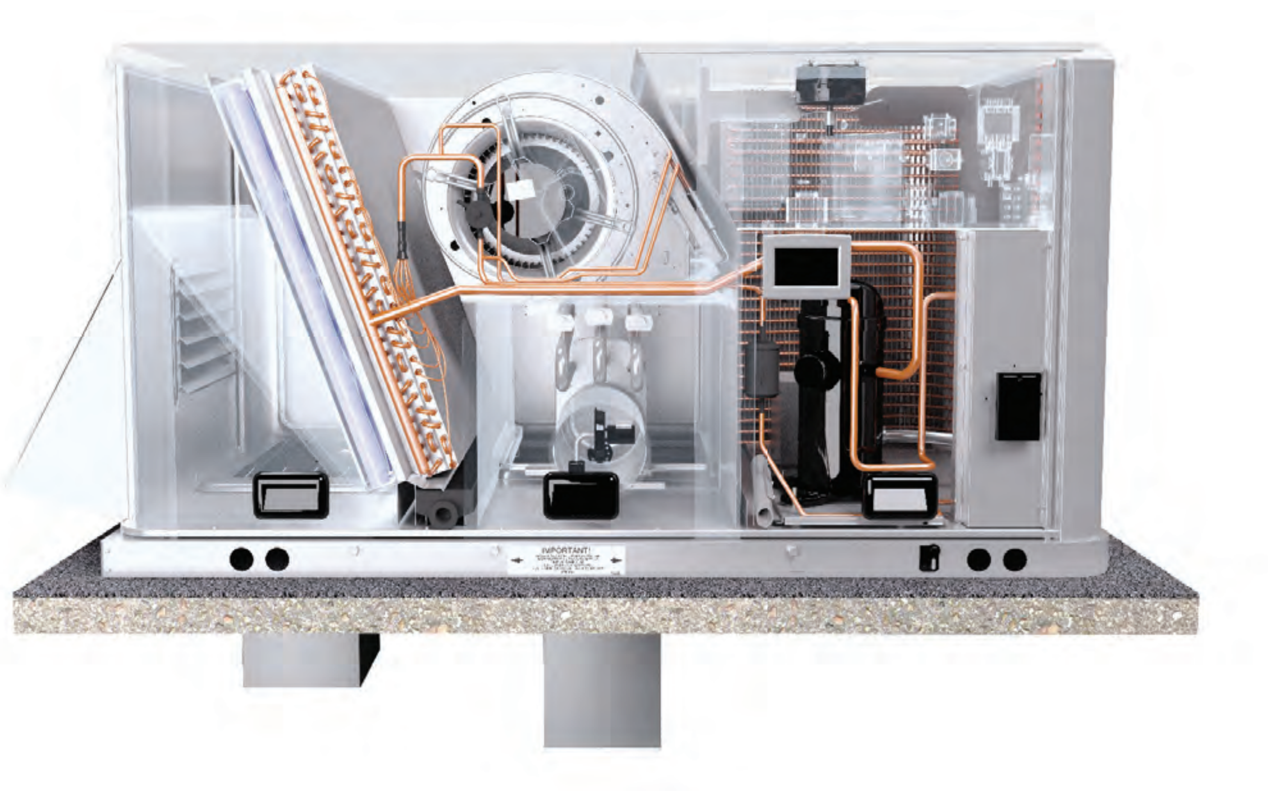
[1] A supply fan can safely modulate into the "surge area" as long as this occurs below 1.0 in. H_2O. Below this pressure, the amount of energy in the fan is very low and will not cause noise or mechanical problems.

Cycled vs. Variable-Speed Compressor(s)

The "ultra-high" efficiency models of Trane Precedent® and Voyager® rooftop units are equipped with eFlex™ technology—which consists of a variable-speed compressor, variable-speed condenser fan, and variable-speed supply fan. For Trane rooftops equipped with eFlex™ and two or more compressors, one variable-speed compressor is paired with one or more fixed-speed compressor(s), resulting in part-load operation down to 10 percent of full capacity.

The use of a variable-speed compressor results in less compressor cycling at part-load, which can increase reliability. Also, a variable-speed compressor better matches cooling capacity to the changing zone thermal load, thereby reducing zone temperature variation. And, by reducing the cycling of the compressor, variable-speed operation allows longer compressor operation at part load and better dehumidification. All of these advantages are coupled with reduced energy use at part-load conditions.

Using an ultra-high efficiency Voyager® rooftop unit with eFlex™ technology is recommended for use in a single-zone VAV system because it allows greater supply fan turndown, thereby further reducing energy use and improving part-load dehumidification—by keeping the supply-air temperature colder, and therefore drier, at low-load conditions. It is also recommended for use in a changeover VAV or multiple-zone VAV system with terminal heat because it allows greater cooling capacity turndown, resulting in more consistent control of supply-air temperature at low load conditions.



Dehumidification

Single-zone constant-volume systems: Since a constant volume of air is delivered to the zone, at part-load conditions this system must supply warmer air to avoid overcooling the zone. This is accomplished by periodically cycling the compressor on and off. As the compressor operates for a smaller percentage of the hour, dehumidification capacity decreases significantly.

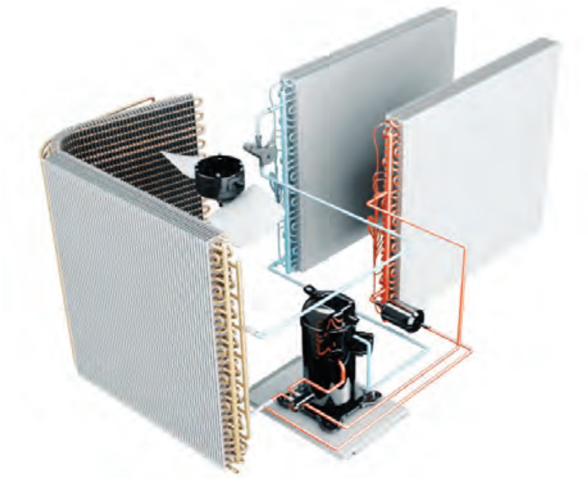
Several models of Precedent®, Voyager®, and Voyager® Commercial rooftop units can be equipped with hot gas reheat (HGRH) for improved part-load dehumidification when used in a single-zone constant-volume system.

Hot gas reheat allows active control of zone humidity by recycling heat energy that would otherwise be rejected outdoors. If zone humidity exceeds the desired limit, a valve diverts hot gas leaving the compressor through a reheat coil located downstream of the evaporator (cooling coil). The compressor continues to operate, dehumidifying the air, while reheat avoids overcooling the zone.

Single-zone VAV systems: Compared to a single-zone constant-volume system, a single-zone VAV system results in better dehumidification performance because it delivers cooler, drier air at part-load conditions.

Additionally, if the rooftop unit is equipped with an eFlex™ variable-speed compressor, adding an optional zone humidity sensor enables use of an "enhanced dehumidification" control sequence. If zone humidity exceeds the desired limit, the ReliaTel® controller will further reduce the supply-fan speed while maintaining the current compressor speed, thereby increasing the unit's dehumidification capacity.

For many applications, a properly-sized rooftop unit with variable-speed fan control will do a sufficient job of limiting indoor humidity levels, so that hot gas reheat is not required. However, if needed (as might be the case for a zone with extreme variable occupancy or where the equipment is significantly oversized), several models of Precedent®, Voyager®, and Voyager® Commercial rooftop units can also be equipped with hot gas



reheat, for use in a single-zone VAV system. In this case, the variable-speed fan may sufficiently limit indoor humidity most of the time, but the hot gas reheat can be activated if needed.

Changeover VAV or multiple-zone VAV systems: VAV systems typically do a good job of limiting indoor humidity levels over a wide range of indoor loads, because the rooftop unit supplies cool—and, therefore, dry—air at part-load conditions. To ensure adequate dehumidification:

- Avoid using supply-air-temperature reset during humid weather. Warmer supply air means less dehumidification at the cooling coil and higher humidity levels in the zone.
- Also, consider equipping the VAV terminal units with a heater. This allows the rooftop unit to continue dehumidifying the air to a lower supply-air temperature setpoint (and, therefore, a lower dew point) when it's humid outside, and the terminal heat can be used to reheat this cool air, if necessary, to avoid overcooling the zone.

For comfort applications, hot gas reheat is typically not needed in a changeover VAV or multiple-zone VAV system, since the rooftop unit is already dehumidifying the air to a low dew point, even at part-load conditions. If the humidity level in a zone were ever to rise higher than desired, the supply-air temperature can be temporarily lowered to increase dehumidification.

Selection of Heat

Trane® Zoned Rooftop Systems are available with a choice of heating options to best meet the needs of the project.

Heat in the rooftop unit

Precedent®, Voyager®,and Voyager® Commercial rooftop units can be equipped with either a staged electric heater, a staged gas heater, or on many models, a modulating gas heater (see page 28). Alternatively, the rooftop unit can be fitted with either a different gas heater with greater turndown, a hot-water coil with modulating valve, or a modulating (SCR) electric heater as a special (see page 38). Alternatively, models are available that reverse the refrigeration system to operate as a heat pump.

- **Single-zone constant-volume systems:** When the zone requires heat during occupied mode, the heater stages or modulates to maintain zone temperature at its heating setpoint. During morning warmup mode, the heater stages or modulates until the zone temperature rises to its occupied heating setpoint.

  Selection of either electric or staged gas heat, or heat pump, is recommended for single-zone CV systems. Since the compressors are staged on and off during cooling mode, staging the heater (or heat pump) on and off will likely result in equally-acceptable comfort control.

- **Single-zone VAV systems:** For units equipped with a **two-speed supply fan**, the fan operates at full speed whenever the heater is activated. In this case, either electric or staged gas heat, or heat pump, is recommended. Since the fan cycles between high and low speed and the compressors are staged on and off during cooling mode, staging the heater (or heat pump) on and off will likely result in equally-acceptable comfort control.

  For units equipped with a **variable-speed supply fan and staged heat or heat pump**, when the zone requires heat during occupied mode, the fan ramps up to full speed and the heater (or heat pump) stages to maintain zone temperature at its heating setpoint. For units equipped with a **variable-speed supply fan and modulating heat**, the fan will operate with variable-speed control when the heater is activated; then the heater modulates to maintain the current supply-air temperature setpoint. During morning warmup mode, the supply fan operates at full speed and the heater stages or modulates until the zone temperature rises back up to its occupied heating setpoint.

  For units equipped with a variable-speed supply fan, use of modulating heat (modulating gas burner, hot-water coil, or SCR electric heater) is recommended for single-zone VAV systems in colder climates, because comfort will likely be improved compared to cycling the heater on and off.

  Caution: If the zone is expected to require cooling when the mixed-air temperature is below 45°F—as might be the case for an interior meeting room in a colder climate, where the zone load is not dependent on the weather—consider equipping the rooftop unit with either a special modulating gas heater that is capable of greater turndown, a hot-water coil with modulating control valve, or an SCR electric heater (see page 38).

- **Changeover bypass systems:** The Concierge™ system control panel determines whether the rooftop unit should operate in cooling mode—and deliver cool air down the duct—or in heating mode—and deliver warm air down the duct. When the rooftop unit operates in heating mode, the Concierge™ panel also directs the heater to stage or modulate as needed to maximize comfort in all the zones it serves. During morning warmup mode, the heater stages or modulates—as directed by the Concierge™ panel—until the zone temperatures rise back up to their occupied heating setpoints.

Use of either electric or staged gas heat, or heat pump, is recommended for changeover bypass systems. Since the compressors are staged on and off during cooling mode, staging the heater (or heat pump) on and off will likely result in equally-acceptable comfort control.

To improve occupant comfort, consider equipping some (or all) of the VAV terminal units with a heater. This allows some amount of heat to be provided to a zone that requires heating, even through the rooftop unit is operating in cooling mode.

- **Changeover VAV systems:** The Concierge™ system control panel determines whether the rooftop unit should operate in cooling mode—and deliver cool air down the duct—or in heating mode—and deliver warm air down the duct. For units equipped with **staged heat or heat pump**, when operating in heating mode—occupied mode or morning warmup mode—the supply fan ramps up to full speed and the heater stages to maintain the current supply-air temperature setpoint. This requires a bypass damper to be installed between the supply and return ductwork (see page 41). For units equipped with **modulating heat**, when operating in heating mode the supply fan speed modulates to maintain the current duct static pressure setpoint and the heater modulates to maintain the current supply-air temperature setpoint. A bypass damper may be required if the system airflow in heating mode is expected to drop below the minimum threshold required for the modulating gas heater (see page 41).

Use of modulating heat (modulating gas burner, hot-water coil, or SCR electric heater) is recommended for changeover VAV systems. Comfort will likely be improved due to more-stable control of the supply-air temperature when heating. Plus this may avoid the need to install a bypass damper.

Caution: If the area served by the system is expected to require cooling when the mixed-air temperature is below 45°F—as might be the case for interior meeting rooms in a colder climate, where the zone load is not dependent on the weather—consider equipping the rooftop unit with either a special modulating gas heater that is capable of greater turndown, a hot-water coil with modulating control valve, or an SCR electric heater (see page 38).

To improve occupant comfort, consider equipping some (or all) of the VAV terminal units with a heater (see page 21). This allows some amount of heat to be provided to a zone that requires heating, even through the rooftop unit is operating in cooling mode. This can also improve dehumidification by allowing the rooftop unit to deliver cooler, drier air at low cooling load conditions.

- **Multiple-zone VAV systems with terminal heat:** For applications where the mixed-air temperature is not expected to drop below 45°F during occupied hours, consider upsizing the heaters in the VAV terminal units such that the heater in the rooftop unit does not need to operate during occupied mode. In this case, the rooftop unit might not be equipped with a heater, or it might be equipped with staged heat (or heat pump) that is used only for morning warmup mode.

  For rooftop units equipped with **staged heat or heat pump**, the heater operates in the following modes:

  1. *Morning warmup mode:* When the Concierge™ system control panel determines warmup is required, it commands the dampers in all VAV terminal units to their maximum heating airflow setpoints. The supply fan in the rooftop unit ramps up to full speed and its heater (or heat pump) stages until the zone temperatures rise back up to their occupied heating setpoints.

  2. *Daytime warmup mode:* During cold weather, the mixed-air temperature decreases. When the heater (or heat pump) in the rooftop unit is off, this cool air is supplied down the duct. If the heaters in the VAV terminal units are not sized large enough to adequately warm this air, the temperature in one or more zones may drop below its heating setpoint. If this occurs, the Concierge™ panel can initiate a "daytime warmup" mode during which it commands the dampers in all VAV terminal units to their maximum heating airflow setpoints, the supply fan ramps up to full speed, and the heater (or heat pump) in the rooftop unit is staged on. Once the zones are warmed back above their heating setpoints, the heater (or heat pump) in the rooftop unit turns off, the supply fan ramps back down and modulates to maintain the current duct static pressure setpoint, and the VAV dampers are allowed to return to normal operation.

  For rooftop units equipped with **modulating heat**, the heater operates in the following modes:

  1. *Morning warmup mode:* When the Concierge™ panel determines warmup is required, it commands the dampers in all VAV terminal units to their maximum heating airflow setpoints. The supply fan in the rooftop unit ramps up to full speed and its heater turns on and modulates until the zone temperatures rise back up to their occupied heating setpoints.

  2. *Supply-air tempering* (occupied mode): During cold weather, if the mixed-air temperature drops below the desired supply-air temperature setpoint, the heater in the rooftop unit turns on and modulates to maintain the current supply-air temperature setpoint, while the supply fan modulates to maintain the current duct static pressure setpoint.

     Caution: If this supply-air tempering mode is desired—as might be the case in colder climates where higher ventilation rates cause the mixed-air temperature to drop well below 45°F during occupied hours—consider equipping the rooftop unit with either a special modulating gas heater that is capable of greater turndown, a hot-water coil with modulating control valve, or an SCR electric heater (see page 38).

     For projects where the VAV terminal units are equipped with hot-water coils, consider equipping the rooftop unit with a hot-water coil also—or having it field-installed in the supply ductwork, just after the air discharges from the rooftop unit—since the building is going to have a hot-water system anyway. In this case, if sub-freezing outdoor air is expected to enter the rooftop unit, it is recommended that the hot-water system include some means of freeze protection, such as glycol.

Heat in the VAV terminal units

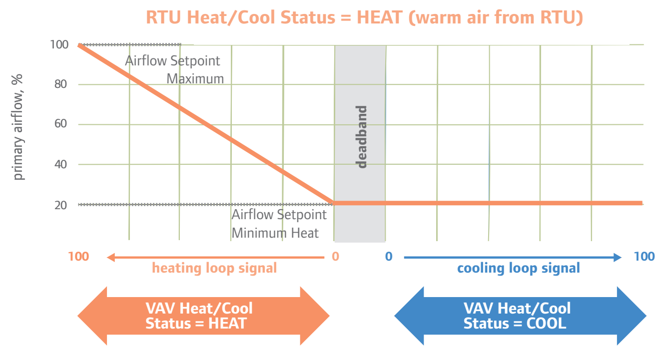
VariTrane® VAV terminal units can be equipped with either an electric heater—with staged or modulating SCR control—or a hot-water coil—with two-position or modulating valve control.

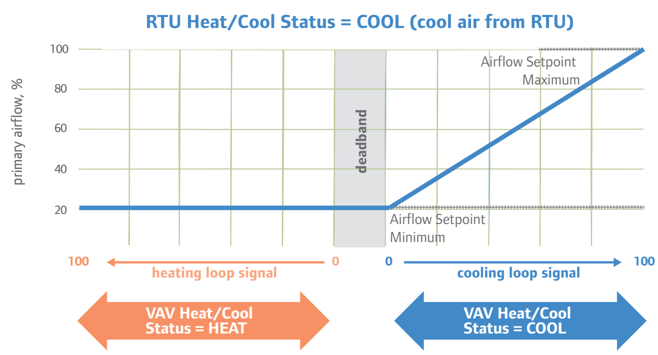
- **Changeover bypass or changeover VAV systems:** If the VAV terminal unit is **not equipped with a heater**, its control sequence is as follows:

    1. When the RTU Heat/Cool Status = HEAT (upper chart), the rooftop unit delivers warm air to all the VAV terminal units. If the zone requires heating (VAV Heat/Cool Status = HEAT), the VAV damper modulates primary airflow between its maximum and minimum heating airflow setpoints, as required to maintain zone temperature at its heating setpoint. If the zone requires cooling (VAV Heat/Cool Status = COOL), the VAV damper closes to its minimum heating airflow setpoint and the controller begins to "vote" for the rooftop unit to switch to cooling mode.

    2. When the RTU Heat/Cool Status = COOL (lower chart), the rooftop unit delivers cool air to all the VAV terminal units. If the zone requires cooling (VAV Heat/Cool Status = COOL), the VAV damper modulates primary airflow between its maximum and minimum airflow setpoints, as required to maintain zone temperature at its cooling setpoint. If the zone requires heating (VAV Heat/Cool Status = HEAT), the VAV damper closes to its minimum airflow setpoint and the controller begins to "vote" for the rooftop unit to switch to heating mode.

VAV terminal unit control sequence for changeover systems (no terminal heat)





To improve occupant comfort and flexibility in either changeover system, consider equipping some (or all) of the VAV terminal units with either an electric heater or hot-water coil. When the rooftop unit is operating in cooling mode, this allows some amount of heat to be provided to a zone that requires heating. In this case, the local heat need only be sized to provide sufficient capacity during mild or cool weather, not for full heating capacity during the coldest weather. During very cold weather, the rooftop unit will changeover to operate in heating mode. Common examples include entryways, lobbies, and conference rooms.

In either changeover system, if a VAV terminal unit **is equipped with a heater**, its control sequence is as follows:

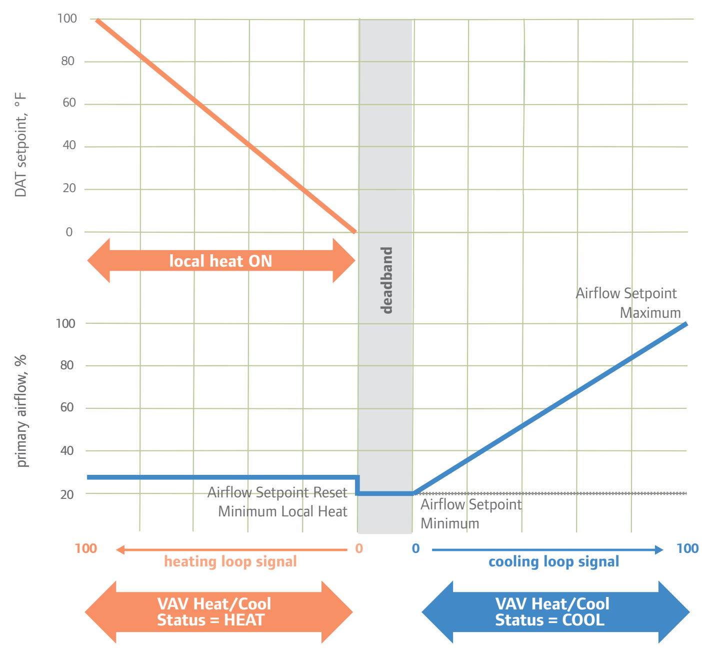
1. When the RTU Heat/Cool Status = HEAT—rooftop unit delivering warm air down the duct—the control sequence for the VAV terminal unit is unchanged (see upper chart on page 20), and the local heater is turned off. If the zone requires heating (VAV Heat/Cool Status = HEAT), the VAV damper modulates primary airflow between its maximum and minimum heating airflow setpoints, as required to maintain zone temperature at its heating setpoint. If the zone requires cooling (VAV Heat/Cool Status = COOL), the VAV damper closes to its minimum airflow setpoint and the controller begins to "vote" for the rooftop unit to switch to cooling mode.
2. When the RTU Heat/Cool Status = COOL—rooftop unit delivering cool air down the duct—the VAV terminal unit will be controlled as described on the following pages: if equipped with either staged electric or two-position hot-water heat, see chart on page 22; or if equipped with either modulating SCR electric or modulating hot-water heat and a DAT sensor, see chart on page 23. In either case, the controller will not "vote" for the rooftop unit to switch to heating mode unless the local heater is no longer able to maintain zone temperature at its heating setpoint—this is also referred to as "priority local heat" in the control system.

Equipping the VAV terminal units with a heater can also improve the part-load dehumidification performance of a changeover system, as it allows the rooftop unit to continue dehumidifying the air to a lower supply-air temperature setpoint (and, therefore, a lower dew point temperature) when it's humid outside.

To further improve occupant comfort, and minimize the number of times a system has to changeover between heating and cooling modes, a supply-air temperature reset sequence can be implemented (see page 47). However, be sure to consider its impact on dehumidification (see page 16).

- **Multiple-zone VAV systems with terminal heat:** The chart (right) depicts the control sequence for a VAV terminal unit equipped with either **staged electric** or **two-position hot-water** heat. If the zone requires cooling (VAV Heat/Cool Status = COOL), the VAV damper modulates airflow between maximum and minimum primary airflow setpoints, as required to maintain zone temperature at its cooling setpoint. When primary airflow has reached its minimum airflow setpoint, and the zone temperature has cooled to its heating setpoint, local heat is activated to avoid overcooling the zone (VAV Heat/Cool Status = HEAT). The VAV damper opens to its minimum local heating airflow setpoint and the controller stages the electric heater on and off (or cycles the hot-water valve open and closed), as required to maintain zone temperature at its heating setpoint.

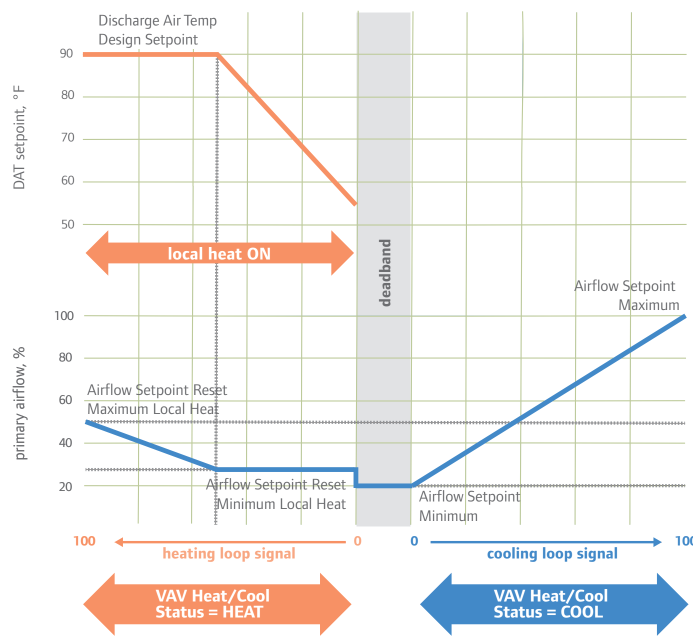
VAV terminal unit control sequence with staged electric or two-position hot-water heat



The chart (right) depicts the control sequence for a VAV terminal unit equipped with either modulating **SCR (silicon controlled rectifier) electric** or **modulating hot-water** heat and a discharge-air temperature (DAT) sensor. If the zone requires cooling (VAV Heat/Cool Status = COOL), the VAV damper modulates airflow between maximum and minimum primary airflow setpoints, as required to maintain zone temperature at its cooling setpoint. When primary airflow has reached its minimum airflow setpoint, and the zone temperature has cooled to its heating setpoint, local heat is activated to avoid overcooling the zone (VAV Heat/Cool Status = HEAT). The VAV damper opens to its minimum local heating airflow setpoint and the controller resets the DAT setpoint upward, as required to maintain zone temperature at its heating setpoint. The SCR electric heater (or hot-water valve) then modulates to maintain the current DAT setpoint. If the DAT reaches the DAT design setpoint, and the zone requires more heat, the VAV damper modulates between minimum and maximum local heating airflow setpoints as required to maintain zone temperature at its heating setpoint, while the SCR electric heater (or hot-water valve) continues to modulate to maintain the current DAT design setpoint.

Selection of SCR electric or modulating hot-water heat is recommended to enable use of the "dual max" control sequence. This improves comfort by minimizing thermal stratification when delivering warm air through overhead diffusers.

VAV terminal unit control sequence with SCR electric or modulating hot-water heat (i.e., "dual max" sequence)



Ventilation Control

For some zones, delivering a fixed (constant) quantity of outdoor air may be desired. For other zones, demand-controlled ventilation (DCV) may be desired. DCV is a control strategy that dynamically adjusts the ventilation airflow delivered to a zone based on the changing population in that zone, thereby reducing the energy needed to condition excess outdoor air.

Trane® Zoned Rooftop Systems offer several strategies to consider for providing adequate ventilation. The top table on page 24 includes the strategies for when DCV is not required, while the bottom table on page 24 includes the strategies for implementing DCV. This provides flexibility, allowing the customer or design team to select the ventilation strategy that is most appropriate for the specific project.

Ventilation Control

Ventilation control strategies for Zoned Rooftop Systems (if DCV is not required)

Control Strategy	Single-Zone Systems			Multiple-Zone Systems		
	Constant Volume	Single-Zone VAV: Two-Speed	Single-Zone VAV: Variable-Speed	Changeover Bypass	Changeover VAV	VAV with Terminal Heat
control strategy in rooftop unit						
Fixed minimum OA damper position	recommended[1]	not recommended[2]	not recommended[2]	recommended[1]	not recommended[2]	not recommended[2]
Reset minimum OA damper position based on supply fan speed	not applicable	recommended[3]	recommended[4]	not applicable	recommended[4]	recommended[4]
Reset minimum OA damper position based on measured OA flow	not applicable	requires OA flow measurement[8]	requires OA flow measurement[8]	not applicable	requires OA flow measurement[8]	requires OA flow measurement[8]
control strategy in VAV terminal unit						
Fixed zone ventilation airflow setpoint	not applicable	not applicable	not applicable	recommended[5,6]	recommended[5,7]	recommended[5,7]

[1] Pre-engineered in the ReliaTel® rooftop unit controller. Requires installer to configure one minimum OA damper position setpoint.
[2] Use of a fixed minimum OA damper position is not recommended in a system that uses two-speed or variable-speed supply fan control.
[3] Pre-engineered in the ReliaTel® rooftop unit controller for units equipped with two-speed supply fan control. Requires installer to configure two minimum OA damper position setpoints (at high fan speed and at low fan speed).
[4] Pre-engineered in the ReliaTel® rooftop unit controller for units equipped with variable-speed supply fan control (referred to as "Outdoor Air Compensation"). Requires installer to configure three minimum OA damper position setpoints.
[5] Pre-engineered in the Tracer® UC™210 VAV terminal unit controller. Requires the installer to configure one ventilation airflow setpoint for each zone.
[6] Use this VAV terminal unit control strategy in conjunction with the "Fixed minimum OA damper position" strategy at the rooftop unit controller.
[7] Use this VAV terminal unit control strategy in conjunction with the "Reset minimum OA damper position based on supply fan speed" strategy at the rooftop unit controller.
[8] Requires field installation of a V-TRAQ airflow measurement accessory (in Precedent® or Voyager® rooftop units) or equipping the unit with the Traq™ Outside Air Measurement System (in Voyager® Commercial rooftop units).

Demand-controlled ventilation (DCV) strategies for Zoned Rooftop Systems

Control Strategy	Single-Zone Systems			Multiple-Zone Systems		
	Constant Volume	Single-Zone VAV: Two-Speed	Single-Zone VAV: Variable-Speed	Changeover Bypass	Changeover VAV	VAV with Terminal Heat
control strategy in rooftop unit						
Reset minimum OA damper position based on CO_2 concentration	recommended[1]	recommended[1]	recommended[1]	recommended[2]	recommended[2]	recommended[2]
Reset minimum OA flow setpoint based on CO_2 concentration	requires OA flow measurement[3]	requires OA flow measurement[3]	requires OA flow measurement[3]	requires OA flow measurement[2,3]	requires OA flow measurement[2,3]	requires OA flow measurement[2,3]
control strategy in VAV terminal unit						
Reset zone minimum primary airflow setpoint based on CO_2 concentration (or sensed occupancy)	not applicable	not applicable	not applicable	recommended[4,5]	recommended[4,5]	recommended[4]
Reset zone ventilation airflow setpoint based on CO_2 concentration (or sensed occupancy)	not applicable	not applicable	not applicable	requires OA flow measurement[6]	requires OA flow measurement[6]	requires OA flow measurement[6]

[1] Pre-engineered in the ReliaTel® rooftop unit controller (referred to as "DCV") when equipped with either a wall-mounted or duct-mounted (return air) CO_2 sensor. Requires installer to configure four or five minimum OA damper position setpoints and two CO_2 limits (high and low).
[2] Using a single CO_2 sensor in the common return-air duct measures the average concentration of all zones served by the rooftop unit, so use of this approach should be limited to where all the zones served by the system are similar or when used in conjunction with the "Reset zone minimum primary airflow setpoint based on CO_2 concentration" strategy at the VAV terminal unit controllers.
[3] Requires field installation of a V-TRAQ airflow measurement accessory (in Precedent® or Voyager® rooftop units) or equipping the unit with the Traq™ Outside Air Measurement System (in Voyager® Commercial rooftop units).
[4] Pre-engineered in the Tracer® UC™210 VAV terminal unit controller and Tracer® Concierge™ system control panel (referred to as "Ventilation Optimization"). Requires the installer to configure two ventilation airflow setpoints, and possibly two CO_2 limits (high and low), for each zone. Use this VAV terminal unit control strategy in conjunction with the "Reset minimum OA damper position based on CO_2 concentration" strategy at the rooftop unit controller.
[5] To improve comfort in a zone where this DCV strategy is being implemented, equip that zone's VAV terminal unit with electric or hot-water heat.
[6] Pre-engineered in the Tracer® UC™210 VAV terminal unit controller and Tracer® Concierge™ system control panel (referred to as "Ventilation Optimization"). Requires the installer to configure two ventilation airflow setpoints, and possibly two CO_2 limits (high and low), for each zone. Requires field installation of a V-TRAQ outdoor airflow measurement accessory (in Precedent® or Voyager® rooftop units) or equipping the unit with the Traq™ Outside Air Measurement System (in Voyager® Commercial rooftop units).

Ventilation control strategies implemented using the ReliaTel® rooftop unit controller

The following strategies are used to define the minimum outdoor-air damper position needed for sufficient ventilation. When airside economizing is enabled, the outdoor-air damper will be allowed to modulate further open.

- **Fixed minimum outdoor-air damper position:** This strategy is recommended for rooftop units equipped with constant-speed supply fan control—single-zone constant volume or changeover bypass systems—when DCV is not required. (This strategy is not recommended for units equipped with two-speed or variable-speed supply fan control.) During occupied mode, the outdoor air damper is opened to a fixed minimum position.

- **Reset minimum outdoor-air damper position based on supply fan speed:** This strategy is recommended for rooftop units equipped with either two-speed or variable-speed supply fan control—single-zone VAV, changeover VAV, or multiple-zone VAV systems—when DCV is not required. When two-speed or variable-speed supply fan control is used, to ensure that the same quantity (cfm) of outdoor air enters the system, the minimum position of the outdoor-air damper is dynamically adjusted in proportion to the changing supply fan speed.

- **Reset minimum outdoor-air damper position based on measured outdoor airflow:** This strategy can be used if the rooftop unit is equipped with a means to directly measure outdoor airflow, and is most useful for rooftop units equipped with variable-speed supply fan control. During occupied mode, the minimum outdoor-air damper position setpoint is dynamically adjusted to maintain the desired outdoor airflow setpoint.

- **Reset minimum outdoor-air damper position based on CO_2 concentration:** This strategy is recommended for rooftop units that serve a single zone—single-zone constant-volume or single-zone VAV systems—when DCV is required. During occupied mode, the minimum position of the outdoor-air damper is dynamically adjusted based on the CO_2 concentration measured by a sensor installed in either the zone or return-air duct.

  Also, it may have application in rooftop units that serve more than one zone—changeover bypass, changeover VAV, or multiple-zone VAV systems. However, installing a single CO_2 sensor in the common return-air duct measures the average concentration of all zones served by the rooftop unit. So use of this approach should be limited to either a) applications in which all the zones served by the rooftop unit have similar population, activity levels, and occupancy schedules or b) systems that also use the "Reset zone minimum primary airflow setpoint based on CO_2 concentration" strategy at the VAV terminal unit controllers.

- **Reset minimum outdoor-air flow setpoint based on CO_2 concentration:** This strategy can be used if the rooftop unit is equipped with a means to directly measure outdoor airflow. During occupied mode, the minimum outdoor-air flow setpoint is dynamically adjusted based on the CO_2 concentration measured by a sensor installed in either the zone or return-air duct.

These control strategies can be combined with the use of the following ventilation control strategies in the Tracer® UC™210 VAV terminal unit controller.

Ventilation control strategies implemented using the Tracer® UC™210 VAV terminal unit controller and the Tracer® Concierge™ system control panel

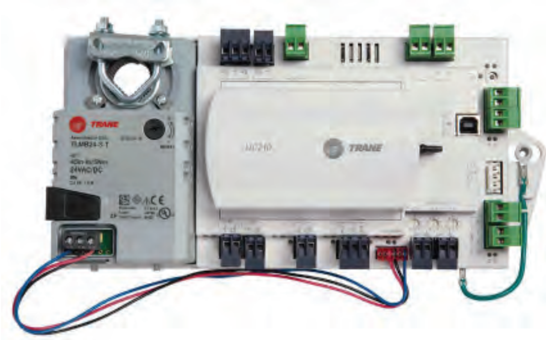
- **Fixed zone ventilation airflow setpoint:** This strategy is recommended for VAV terminals serving zones in which DCV is not required. Whenever the zone is scheduled to be occupied, the VAV terminal unit controller enforces a fixed ventilation airflow. If the primary airflow being delivered to the zone drops below this ventilation airflow setpoint, the controller will modulate the VAV damper further open to enforce the higher airflow setpoint.

- **Reset zone minimum primary airflow setpoint based on CO_2 concentration (or sensed occupancy):** This strategy is recommended for VAV terminals serving zones in which DCV is required. Whenever the zone is scheduled to be occupied, the VAV terminal unit controller dynamically calculates the zone's ventilation airflow setpoint based on the CO_2 concentration (or occupancy status) measured by a sensor installed in the zone. In addition, each Tracer® UC™210 controller also calculates the current primary airflow setpoint required to maintain zone temperature at setpoint. If the current ventilation airflow setpoint is higher than the primary airflow being delivered, the controller will modulate the VAV damper further open to enforce the higher of these two airflow setpoints.

  Increasing primary airflow results in more outdoor air delivered to the zone; but increasing this flow of cool air causes the zone to over-cool and possibly activate electric or hot-water reheat. Often, this increase in reheat energy is likely a more efficient choice than opening the outdoor-air damper further. To improve comfort in any zone where this DCV strategy is being implemented, consider equipping that zone's VAV terminal unit with either electric or hot-water heat and use in conjunction with the "Reset minimum OA damper position based on CO_2 concentration" strategy at the rooftop unit controller.

- **Reset zone ventilation airflow setpoint based on CO_2 concentration (or sensed occupancy):** This strategy can be used if the rooftop unit is equipped with a means to directly measure outdoor airflow. Whenever the zone is scheduled to be occupied, the VAV terminal unit controller dynamically calculates the zone's ventilation airflow setpoint based on the CO_2 concentration (or occupancy status) measured by a sensor installed in the zone it serves. In addition, each Tracer® UC™210 controller also measures the current primary airflow being delivered to the zone and calculates its current ventilation ratio—the current ventilation airflow setpoint divided by the current primary airflow being delivered.

  Then the Concierge™ system control panel periodically gathers this data from all the UC™210 VAV controllers and—using the equations prescribed in ASHRAE® Standard 62.1—calculates the quantity of outdoor air that must be brought in at the centralized rooftop unit to satisfy all the zones that it serves. Finally, the Concierge™ panel communicates this new outdoor airflow setpoint to the rooftop unit controller, which modulates a flow-measuring outdoor-air damper to maintain outdoor airflow at this new setpoint.



Building Pressure Control

When the rooftop unit brings in outdoor air for ventilation, the same quantity of air must leave the building to maintain desired pressurization. Typically, some of this air is exhausted by dedicated fans from restrooms or other spaces. And some air leaks out through the building envelope as a result of the pressure inside the building being maintained slightly higher than the pressure outside the building ("positive" building pressurization).

Particularly when the rooftop unit is equipped with an airside economizer, a properly-designed relief system should be used to avoid over-pressurizing the building when the outdoor-air damper opens to bring in a larger quantity of air from outside. For smaller buildings in which Zoned Rooftop Systems are typically used, either a barometric relief damper or relief fan are included in the rooftop unit to help mitigate this over-pressurization.

- **Barometric relief dampers:** Non-motorized, gravity-operated relief dampers are located in the return-air section of the rooftop unit. When the pressure inside the building increases, the pressure inside the return-air section also increases, forcing open the relief dampers and allowing air to leave the building.

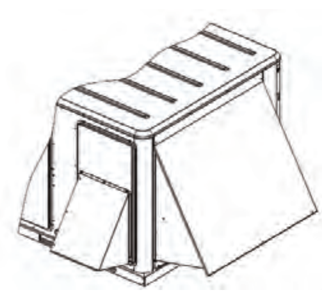
  Barometric relief dampers are available as a field-installed accessory for Trane Precedent® and Voyager® rooftop units or as a factory-installed option for Trane Voyager® Commercial rooftop units. They are typically used in smaller buildings that use an open ceiling plenum for the return-air path. They are relatively inexpensive and require no sensors or controls, but they require the building pressure to increase before relieving excess air.

- **On/off relief fan:** A powered relief fan is connected to the return-air section of the rooftop unit. The rooftop unit controller turns on this constant-speed fan whenever the supply fan is operating and the outdoor-air damper is opened beyond the "power exhaust setpoint" (damper position), configured in the ReliaTel® controller.

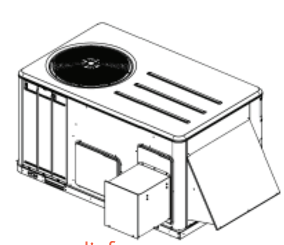
  For systems with either two-speed or variable-speed supply fan control, the ReliaTel® controller will dynamically adjust this "power exhaust setpoint" based on the current supply fan speed.

  An on/off relief fan ("power exhaust") is available as a field-installed accessory for Trane Precedent® and Voyager® rooftop units, or as a factory-installed option for Trane Voyager® Commercial rooftop units, with controls pre-engineered in the ReliaTel® controller. A relief fan is typically used in smaller buildings, when the unit is equipped with an airside economizer, because it's able to overcome the static pressure loss of the return-air path.

- **Modulating relief fan:** A powered relief fan is connected to the return-air section of the rooftop unit, but its capacity is modulated to maintain the measured building pressure at a desired setpoint. A differential pressure transducer is used to compare the static pressure inside the building to the pressure outside. The relief fan is turned on when needed to relieve excess air, and then modulates its speed to control building pressure within a set range. By directly measuring building pressure, the modulating relief fan can respond to pressure changes caused by wind, stack effect, intermittent operation of local exhaust fans, and demand-controlled ventilation. Several third-party providers offer modulating relief fans that can be field-installed on Trane Precedent® and Voyager® rooftop units. Trane Voyager® Commercial rooftop units can be equipped with a factory-installed modulating relief fan, with controls pre-engineered in the ReliaTel® controller.



barometric damper



relief fan

Equipment with Controls: Packaged Rooftop Units

Trane offers a variety of rooftop units, each with an extensive list of standard and optional capabilities to support Trane® Zoned Rooftop Systems (S = standard option: CT = contact your Trane sales representative, see page 38)

Trane Model Number[1]	Nominal Capacity, tons	Efficiency Tier	Zoned Rooftop Systems Supported						Available Options[2]						
			Single-Zone Systems			Multiple-Zone Systems									
				Single-Zone VAV											
			Constant Volume	Two-Speed	Variable-Speed	Change-over Bypass	Change-over VAV	VAV with Terminal Heat	Staged Gas	Mod. Gas	Staged Electric	SCR Electric	Hot Water Coil	eFlex™	Hot Gas Reheat[3]
Trane Precedent® Rooftop Units (3 to 10 tons)															
T/YSC036	3	standard	S			S			S	CT	S	CT	CT	CT	CT
T/YSC048	4	standard	S			S			S	CT	S	CT	CT	CT	CT
T/YSC060	5	standard	S			S			S	CT	S	CT	CT	CT	CT
T/YSC072	6	standard	S			S			S	CT	S	CT	CT	CT	CT
T/YSC090	7.5	standard	S			S			S	CT	S	CT	CT	CT	CT
T/YSC092	7.5	standard	S	S	S	S			S	CT	S	CT	CT	CT	CT
T/YSC102	8.5	standard	S	S	S	S			S	CT	S	CT	CT	CT	CT
T/YSC120	10	standard	S	S	S	S			S	CT	S	CT	CT	CT	CT
T/YHC036	3	high	S			S			S	CT	S	CT	CT	CT	S
T/YHC037	3	high	S		S	S	S	S	S	CT	S	CT	CT	CT	S
T/YHC048	4	high	S			S			S	CT	S	CT	CT	CT	S
T/YHC047	4	high	S		S	S	S	S	S	CT	S	CT	CT	CT	S
T/YHC060	5	high	S			S			S	CT	S	CT	CT	CT	S
T/YHC067	5	high	S		S	S	S	S	S	CT	S	CT	CT	CT	S
T/YHC072	6	high	S			S			S	CT	S	CT	CT	CT	S
T/YHC074	6	high	S	S	S	S	S	S	S	CT	S	CT	CT	CT	CT
T/YHC092	7.5	high	S	S	S	S	S	S	S	CT	S	CT	CT	CT	S
T/YHC102	8.5	high	S	S	S	S	S	S	S	CT	S	CT	CT	CT	S
T/YHC120	10	high	S	S	S	S	S	S	S	CT	S	CT	CT	CT	S
T/YZC036	3	ultra-high			S		S	S	S	CT	S	CT	CT	S	CT
T/YZC048	4	ultra-high			S		S	S	S	CT	S	CT	CT	S	CT
T/YZC060	5	ultra-high			S		S	S	S	CT	S	CT	CT	S	CT
T/YZC072	6	ultra-high			S		S	S	S	S	S	CT	CT	S	CT
T/YZC090	7.5	ultra-high			S		S	S	S	S	S	CT	CT	S	CT
T/YZC102	8.5	ultra-high			S		S	S	S	S	S	CT	CT	S	CT
T/YZC120	10	ultra-high			S		S	S	S	S	S	CT	CT	S	CT
Trane Precedent® Rooftop HEAT PUMPS (3 to 10 tons)															
W/DSC036	3	standard	S			S			S		S	CT			CT
W/DSC048	4	standard	S			S			S		S	CT			CT
W/DSC060	5	standard	S			S			S		S	CT			CT
W/DSC072	6	standard	S	S		S			S		S	CT			CT
W/DSC090	7.5	standard	S	S	S	S			S		S	CT			CT
W/DSC092	7.5	standard	S	S	S	S			S		S	CT			CT
W/DSC102	8.5	standard	S	S	S	S			S		S	CT			CT
W/DSC120	10	standard	S	S	S	S			S		S	CT			CT
W/DSC036	3	high	S		S	S	S	S	S		S	CT			CT
W/DSC048	4	high	S		S	S	S	S	S		S	CT			CT
W/DSC060	5	high	S		S	S	S	S	S		S	CT			CT
W/DSC074	6	high	S	S	S	S	S	S	S		S	CT			CT
W/DSC092	7.5	high	S	S	S	S	S	S	S		S	CT			CT
W/DSC102	8.5	high	S	S	S	S	S	S	S		S	CT			CT
W/DSC120	10	high	S	S	S	S	S	S	S		S	CT			CT

[1] T/Y or W/D: T = rooftop unit equipped with DX cooling and electric (or no) heat; Y = rooftop unit equipped with DX cooling and gas heat ; W = rooftop unit configured as a heat pump; D = rooftop unit configured as a dual-fuel heat pump with auxiliary gas heat

[2] S = standard option from the factory; CT = contact your Trane sales representative (see page 38)

[3] Hot gas reheat is only available for single-zone constant-volume or single-zone VAV system applications. Alternatively, for rooftop units equipped with an eFlex™ compressor, adding an optional zone humidity sensor enables use of an "enhanced dehumidification" control sequence (see page 16).

Trane Model Number[1]	Nominal Capacity, tons	Efficiency Tier	Zoned Rooftop Systems Supported						Available Options[2]						
			Single-Zone Systems			Multiple-Zone Systems									
				Single-Zone VAV											
			Constant Volume	Two-Speed	Variable-Speed	Changeover Bypass	Changeover VAV	VAV with Terminal Heat	Staged Gas	Mod. Gas	Staged Electric	SCR Electric	Hot Water Coil	eFlex™	Hot Gas Reheat[3]
Trane Voyager® Rooftop Units (12.5 to 25 tons)															
T/YS*150	12.5	standard	S	S		S			S	S	S	CT	CT	CT	CT
T/YS*180	15	standard	S	S		S			S	S	S	CT	CT	CT	CT
T/YS*210	17.5	standard	S	S		S			S	S	S	CT	CT	CT	CT
T/YS*211	17.5	standard	S	S		S			S	S	S	CT	CT	CT	CT
T/YS*240	20	standard	S	S		S			S	S	S	CT	CT	CT	CT
T/YS*300	25	standard	S	S		S			S	S	S	CT	CT	CT	CT
T/YS*301	25	standard	S	S		S			S	S	S	CT	CT	CT	CT
T/YH*150	12.5	high	S	S	S	S	S	S	S	S	S	CT	CT	CT	S
T/YH*180	15	high	S	S	S	S	S	S	S	S	S	CT	CT	CT	S
T/YH*210	17.5	high	S	S	S	S	S	S	S	S	S	CT	CT	CT	S
T/YH*240	20	high	S	S	S	S	S	S	S	S	S	CT	CT	CT	S
T/YH*300	25	high	S	S	S	S	S	S	S	S	S	CT	CT	CT	S
T/YZ*150	12.5	ultra-high			S		S	S	S	S	S	CT	CT	S	CT
T/YZ*180	15	ultra-high			S		S	S	S	S	S	CT	CT	S	CT
T/YZ*210	17.5	ultra-high			S		S	S	S	S	S	CT	CT	S	CT
Trane Voyager® Rooftop HEAT PUMPS (12.5 to 20 tons)															
WS*150	12.5	standard	S	S	S	S					S	CT			CT
WS*180	15	standard	S	S	S	S					S	CT			CT
WS*240	20	standard	S	S	S	S					S	CT			CT
Trane Voyager® Commercial Rooftop Units (27.5 to 50 tons)															
T/Y**330	27.5	standard	S	S	S	S	S	S	S	S	S	CT	CT	CT	S
T/Y**360	30	standard	S	S	S	S	S	S	S	S	S	CT	CT	CT	S
T/Y**420	35	standard	S	S	S	S	S	S	S	S	S	CT	CT	CT	S
T/Y**480	40	standard	S	S	S	S	S	S	S	S	S	CT	CT	CT	S
T/Y**600	50	standard	S	S	S	S	S	S	S	S	S	CT	CT	CT	S
T/Y**330	27.5	high	S	S	S	S	S	S	S	S	S	CT	CT	CT	S
T/Y**360	30	high	S	S	S	S	S	S	S	S	S	CT	CT	CT	S
T/Y**420	35	high	S	S	S	S	S	S	S	S	S	CT	CT	CT	S
T/Y**480	40	high	S	S	S	S	S	S	S	S	S	CT	CT	CT	S
T/Y**600	50	high	S	S	S	S	S	S	S	S	S	CT	CT	CT	S

[1] T/Y or W/D: T = rooftop unit equipped with DX cooling and electric (or no) heat; Y = rooftop unit equipped with DX cooling and gas heat ; W = rooftop unit configured as a heat pump; D = rooftop unit configured as a dual-fuel heat pump with auxiliary gas heat

[2] S = standard option from the factory; CT = contact your Trane sales representative (see page 38)

[3] Hot gas reheat is only available for single-zone constant-volume or single-zone VAV system applications. Alternatively, for rooftop units equipped with an eFlex™ compressor, adding an optional zone humidity sensor enables use of an "enhanced dehumidification" control sequence (see page 16).

When selecting Trane packaged rooftop units as part of a Zoned Rooftop System, use the following settings in Trane's selection software:

Packaged rooftop unit selection criteria in Trane® Select Assist™ ot TOPSS® selection software (www.traneselectassist.com)

System Type	Supply Fan Control	Fresh Air Selection	Communications Options	Zone Temperature Sensor or Thermostat
single-zone constant volume	"standard motor" "oversized motor" "CV (ZTC)"	"Econ" required for DCV[1]	"Air-Fi communication interface" (for wireless) or "BACnet communication interface" (for wired)	required[2]
single-zone VAV (two-speed fan)	"multi-speed fan" "two-speed fan"	"Econ" required for DCV[1] or OA comp.[3]		required[2]
single-zone VAV (variable-speed fan)	"single-zone VAV" "SZVAV"	"Econ" required for DCV[1] or OA comp.[3]		required[4]
changeover bypass	"standard motor" "oversized motor" "CV (ZTC)"	"Econ" required for DCV[1]		not applicable
changeover VAV	"true VAV" "VAV" "VAV (DTC)"	"Econ" required for DCV[1] or OA comp.[3]		not applicable
multiple-zone VAV with terminal heat	"true VAV" "VAV" "VAV (DTC)"	"Econ" required for DCV[1] or OA comp.[3]		not applicable

[1] The rooftop unit must be equipped with an economizer to implement DCV
[2] A conventional thermostat or Pivot™ Smart Thermostat can be used for this system. If the Tracer® Concierge™ control system is used instead, a zone temperature sensor is recommended to enable communication.
[3] The rooftop unit must be equipped with an economizer to reset outdoor-air damper position based on supply fan speed (referred to as "Outdoor Air Compensation").
[4] A zone temperature sensor (not a thermostat) is required to enable variable-speed fan control; otherwise the unit will operate with two-speed fan control.

Supply Fan Turndown

As explained on page 13, in a **single-zone VAV system**, the percent minimum supply fan airflow (cfm) is generally equal to the percent minimum supply fan speed (rpm). The table below lists the allowable range for design supply airflow, as well as the supply airflow turndown capability, for Trane Precedent®, Voyager®, or Voyager® Commercial rooftop units when applied in a single-zone VAV system.

As an example, consider the 3-ton high-efficiency Precedent® unit (model T/YHC037). The design supply airflow must be between 960 cfm and 1440 cfm—which equate to 320 and 480 cfm/nominal ton, respectively. When selected for a design supply airflow of 1200 cfm, the supply fan is capable of turning down to 50 percent of design airflow—which equates to 600 cfm (1200 cfm × 0.50)—in “fan only” mode, or down to 57 percent when cooling is activated. When the staged gas or electric heater is activated, the supply fan must operate at 100 percent airflow.

Supply fan airflow range in a single-zone VAV system

Trane Model Number	Nominal Capacity, Tons	Efficiency Tier	Design Supply Airflow, cfm: Minimum Allowable[2]	Design Supply Airflow, cfm: Maximum Allowable[2]	Minimum Supply Airflow,% of Design Airflow[1]: Fan Only	Cooling	Electric or Staged Gas Heat	Modulating Gas Heat
Trane Precedent® Rooftop Units (3 to 10 tons)								
T/YSC092	7.5	standard	2400	3600	50%[3]	50%[3]	100%	
T/YSC102	8.5	standard	2720	4080	50%[3]	50%[3]	100%	
T/YSC120	10	standard	3200	4800	50%[3]	50%[3]	100%	
T/YHC037	3	high	960	1440	50%	57%	100%	
T/YHC047	4	high	1280	1920	50%	57%	100%	
T/YHC067	5	high	1600	2400	50%	57%	100%	
T/YHC074	6	high	1920	2880	50%[3]	50%[3]	100%	
T/YHC092	7.5	high	2400	3600	50%[3]	50%[3]	100%	
T/YHC102	8.5	high	2720	4080	50%[3]	50%[3]	100%	
T/YHC120	10	high	3200	4800	50%[3]	50%[3]	100%	
T/YZC036	3	ultra-high	960	1440	50%	53%	100%	
T/YZC048	4	ultra-high	1280	1920	50%	53%	100%	
T/YZC060	5	ultra-high	1600	2400	50%	53%	100%	
T/YZC072	6	ultra-high	1920	2880	50%[3]	50%[3]	100%	50%[3]
T/YZC090	7.5	ultra-high	2400	3600	50%[3]	50%[3]	100%	50%[3]
T/YZC102	8.5	ultra-high	2720	4080	50%[3]	50%[3]	100%	50%[3]
T/YZC120	10	ultra-high	3200	4800	50%[3]	50%[3]	100%	50%[3]
Trane Precedent® Rooftop HEAT PUMPS (3 to 10 tons)								
W/DSC090	7.5	standard	2400	3600	50%[3]	50%[3]	100%	
W/DSC092	7.5	standard	2400	3600	50%[3]	50%[3]	100%	
W/DSC102	8.5	standard	2720	4080	50%[3]	50%[3]	100%	
W/DSC120	10	standard	3200	4800	50%[3]	50%[3]	100%	
W/DSC036	3	high	960	1440	50%	50%	100%	
W/DSC048	4	high	1280	1920	50%	50%	100%	
W/DSC060	5	high	1600	2400	50%	50%	100%	
W/DSC074	6	high	1920	2880	50%[3]	50%[3]	100%	
W/DSC092	7.5	high	2400	3600	50%[3]	50%[3]	100%	
W/DSC102	8.5	high	2720	4080	50%[3]	50%[3]	100%	
W/DSC120	10	high	3200	4800	50%[3]	50%[3]	100%	

[1] As explained on page 13, the percent minimum supply airflow is equal to the percent minimum fan speed, unless otherwise noted.
[2] When configured for two-speed or variable-speed fan control, the design supply airflow must be selected between 320 and 480 cfm/nominal ton.
[3] Precedent® units equipped with a backward-curved plenum fan include a potentiometer (in Vdc) to set the design supply airflow. In a single-zone VAV system, the minimum supply airflow will be 50 percent of design airflow unless the minimum Vdc value is reached (2.4 Vdc or 3.2 Vdc if modulating gas heat is operating). For example, if the design supply airflow is set at 5 Vdc, during fan-only or cooling operation, the minimum airflow will be 50 percent because 2.5 Vdc (2.5 Vdc × 0.50) is higher than the 2.4Vdc minimum threshold. During modulating gas heat operation, however, the minimum airflow will be 64 percent of design airflow (3.2/5 Vdc = 0.64).
[4] If this unit is equipped with hot gas reheat (HGRH), the Minimum Supply Airflow is higher than without HGRH.

Trane Model Number	Nominal Capacity, Tons	Efficiency Tier	Design Supply Airflow, cfm: Minimum Allowable[2]	Design Supply Airflow, cfm: Maximum Allowable[2]	Minimum Supply Airflow,% of Design Airflow[1]: Fan Only	Cooling	Electric or Staged Gas Heat	Modulating Gas Heat
Trane Voyager® Rooftop Units (12.5 to 25 tons)								
T/YH*150	12.5	high	4000	6000	50% (63% if HGRH)[4]	50% (63% if HGRH)[4]	100%	50% (63% if HGRH)[4]
T/YH*180	15	high	4800	7200	50% (63% if HGRH)[4]	50% (63% if HGRH)[4]	100%	50% (63% if HGRH)[4]
T/YH*210	17.5	high	5600	8400	50% (63% if HGRH)[4]	50% (63% if HGRH)[4]	100%	50% (63% if HGRH)[4]
T/YH*240	20	high	6400	9600	50% (63% if HGRH)[4]	50% (63% if HGRH)[4]	100%	50% (63% if HGRH)[4]
T/YH*300	25	high	8000	12000	50% (63% if HGRH)[4]	50% (63% if HGRH)[4]	100%	50% (63% if HGRH)[4]
T/YZ*150	12.5	ultra-high	4000	6000	25%	37%	100%	37%
T/YZ*180	15	ultra-high	4800	7200	25%	37%	100%	37%
T/YZ*210	17.5	ultra-high	5600	8400	25%	37%	100%	37%
Trane Voyager® Rooftop HEAT PUMPS (12.5 to 25 tons)								
WS*150	12.5	standard	4000	6000	63%	63%	100%	
WS*180	15	standard	4800	7200	63%	63%	100%	
WS*240	20	standard	6400	9600	63%	63%	100%	
Trane Voyager® Commercial Rooftop Units (27.5 to 50 tons)								
T/Y**330	27.5	standard	8000	12100	33%	33%	100%	58%
T/Y**360	30	standard	9000	13200	33%	33%	100%	58%
T/Y**420	35	standard	10500	14400	33%	33%	100%	58%
T/Y**480	40	standard	12000	17600	33%	33%	100%	58%
T/Y**600	50	standard	15000	20000	33%	33%	100%	58%
T/Y**330	27.5	high	8000	12100	33%	33%	100%	58%
T/Y**360	30	high	9000	13200	33%	33%	100%	58%
T/Y**420	35	high	10500	14400	33%	33%	100%	58%
T/Y**480	40	high	12000	17600	33%	33%	100%	58%
T/Y**600	50	high	15000	20000	33%	33%	100%	58%

[1] As explained on page 13, the percent minimum supply airflow is equal to the percent minimum fan speed, unless otherwise noted.
[2] When configured for two-speed or variable-speed fan control, the design supply airflow must be selected between 320 and 480 cfm/nominal ton.
[3] Precedent® units equipped with a backward-curved plenum fan include a potentiometer (in Vdc) to set the design supply airflow. In a single-zone VAV system, the minimum supply airflow will be 50 percent of design airflow unless the minimum Vdc value is reached (2.4 Vdc or 3.2 Vdc if modulating gas heat is operating). For example, if the design supply airflow is set at 5 Vdc, during fan-only or cooling operation, the minimum airflow will be 50 percent because 2.5 Vdc (2.5 Vdc × 0.50) is higher than the 2.4Vdc minimum threshold. During modulating gas heat operation, however, the minimum airflow will be 64 percent of design airflow (3.2/5 Vdc = 0.64).
[4] If this unit is equipped with hot gas reheat (HGRH), the Minimum Supply Airflow is higher than without HGRH.

As explained on page 14, in either a **changeover VAV system** or a **multiple-zone VAV system with terminal heat**, the percent minimum supply fan airflow (cfm) is typically much lower than the percent minimum supply fan speed (rpm). Using the method and assumptions illustrated on page 14, the table below lists the allowable range for the design supply airflow, as well as the supply airflow turndown capability, for Trane Precedent®, Voyager®, or Voyager® Commercial rooftop units when applied in either a changeover VAV or multiple-zone VAV system.

As an example, consider the 10-ton high-efficiency Precedent® unit (model T/YHC120). The design supply airflow must be between 3200 cfm and 4800 cfm—which equate to 320 and 480 cfm/nominal ton, respectively. The supply fan is capable of turning down to 800 cfm when cooling is activated (or in "fan only" mode). When the staged gas or electric heater is activated, the fan must operate at 100 percent airflow.

Supply fan airflow range in a changeover VAV or multiple-zone VAV system with terminal heat

Trane Model Number	Nominal Capacity, tons	Efficiency Tier	Design Supply Airflow, cfm		Minimum Supply Airflow, cfm or % of Design Supply Airflow[2, 3]		
			Minimum Allowable[1]	Maximum Allowable[1]	Fan Only or Cooling[4]	Electric or Staged Gas Heat	Modulating Gas Heat[5]
Trane Precedent® Rooftop Units (3 to 10 tons)							
T/YHC037	3	high	960	1440	480	100%	
T/YHC047	4	high	1280	1920	640	100%	
T/YHC067	5	high	1600	2400	800	100%	
T/YHC074	6	high	1920	2880	see footnote 6	100%	
T/YHC092	7.5	high	2400	3600	600	100%	
T/YHC102	8.5	high	2720	4080	680	100%	
T/YHC120	10	high	3200	4800	800	100%	
T/YZC036	3	ultra-high	960	1440	480	100%	
T/YZC048	4	ultra-high	1280	1920	640	100%	
T/YZC060	5	ultra-high	1600	2400	800	100%	
T/YZC072	6	ultra-high	1920	2880	see footnote 6	100%	1200
T/YZC090	7.5	ultra-high	2400	3600	600	100%	1500
T/YZC102	8.5	ultra-high	2720	4080	680	100%	1700
T/YZC120	10	ultra-high	3200	4800	800	100%	2000
Trane Precedent™ Rooftop HEAT PUMPS (3 to 10 tons)							
W/DS036	3	high	960	1440	480	100%	
W/DS048	4	high	1280	1920	640	100%	
W/DS060	5	high	1600	2400	800	100%	
W/DS074	6	high	1920	2880	see footnote 6	100%	
W/DS092	7.5	high	2400	3600	600	100%	
W/DS102	8.5	high	2720	4080	680	100%	
W/DS120	10	high	3200	4800	800	100%	

[1] When configured for variable-speed fan control, the design supply airflow must be selected between 320 and 480 cfm/nominal ton.

[2] Minimum supply airflow to prevent fan surge, as determined using the method illustrated on page 14, with rooftop unit selected at maximum external static pressure (see table on page 36) and a duct static pressure setpoint of 0.5 in. H_2O. Depending on unit configuration and external static pressure, minimum airflows below the value listed may be possible.

[3] Fan airflow performance data is approximate; uncertainties of at least +/- 5 percent can be expected.

[4] Frostat™ and crankcase heaters, provided as standard on MZVAV models, provide protection for the refrigeration system.

[5] Minimum supply airflow (cfm) required when modulating gas heater is operating.

[6] For this model, 25 percent minimum supply airflow is achievable only if design supply airflow ≥ 400 cfm/nominal ton or if external static pressure ≤ 1.5 in. H_2O

To enable this degree of supply-fan turndown, implement fan-pressure optimization (see page 46) or move the duct static pressure sensor sufficiently far down the supply ductwork.

Trane Model Number	Nominal Capacity, tons	Efficiency Tier	Design Supply Airflow, cfm		Minimum Supply Airflow, cfm or % of Design Supply Airflow[2, 3]		
			Minimum Allowable[1]	Maximum Allowable[1]	Fan Only or Cooling[4]	Electric or Staged Gas Heat	Modulating Gas Heat[5]
Trane Voyager® Rooftop Units (12.5 to 25 tons)							
T/YH*150	12.5	high	4000	6000	1000	100%	2320
T/YH*180	15	high	4800	7200	1200	100%	2780
T/YH*210	17.5	high	5600	8400	1400	100%	3240
T/YH*240	20	high	6400	9600	1600	100%	3700
T/YH*300	25	high	8000	12000	2000	100%	4630
T/YZ*150	12.5	ultra-high	4000	6000	1000	100%	2320
T/YZ*180	15	ultra-high	4800	7200	1200	100%	2780
T/YZ*210	17.5	ultra-high	5600	8400	1400	100%	3240
Trane Voyager® Commercial Rooftop Units (27.5 to 50 tons)							
T/Y**330	27.5	standard	8000	12100	2667	100%	4667
T/Y**360	30	standard	9000	13200	3000	100%	5250
T/Y**420	35	standard	10500	14400	3500	100%	6125
T/Y**480	40	standard	12000	17600	4000	100%	7000
T/Y**600	50	standard	15000	20000	5000	100%	8750
T/Y**330	27.5	high	8000	12100	2667	100%	4667
T/Y**360	30	high	9000	13200	3000	100%	5250
T/Y**420	35	high	10500	14400	3500	100%	6125
T/Y**480	40	high	12000	17600	4000	100%	7000
T/Y**600	50	high	15000	20000	5000	100%	8750

[1] When configured for variable-speed fan control, the design supply airflow must be selected between 320 and 480 cfm/nominal ton.

[2] Minimum supply airflow to prevent fan surge, as determined using the method illustrated on page 14, with rooftop unit selected at maximum external static pressure (see table on page 36) and a duct static pressure setpoint of 0.5 in. H_2O. Depending on unit configuration and external static pressure, minimum airflows below the value listed may be possible.

[3] Fan airflow performance data is approximate; uncertainties of at least +/- 5 percent can be expected.

[4] Frostat™ and crankcase heaters, provided as standard on MZVAV models, provide protection for the refrigeration system.

[5] Minimum supply airflow (cfm) required when modulating gas heater is operating.

Supply Fan Pressure Capability

The table below lists the maximum external static pressure for Trane Precedent®, Voyager®, or Voyager® Commercial rooftop units. As an example, consider the 10-ton high-efficiency Precedent® unit (model T/YHC120). When selected for a design supply airflow of 4000 cfm—which equates to 400 cfm/ton—the maximum allowable external static pressure is 2.0 in. H_2O.

Maximum static pressure capability

Trane Model Number	Nominal Capacity, tons	Efficiency Tier	Maximum External Static Pressure, in. H_2O[1]		
			if design = 320 cfm/ton	if design = 400 cfm/ton	if design = 480 cfm/ton
Trane Precedent® Rooftop Units (3 to 10 tons)					
T/YSC036	3	standard	1.5	1.3	1.1
T/YSC048	4	standard	1.5	1.5	1.5
T/YSC060	5	standard	1.5	1.3	1.0
T/YSC072	6	standard	2.0	2.0	2.0
T/YSC090	7.5	standard	2.0	2.0	2.0
T/YSC092	7.5	standard	2.0	2.0	2.0
T/YSC102	8.5	standard	2.0	2.0	1.9
T/YSC120	10	standard	2.0	2.0	1.3
T/YHC036	3	high	1.1	1.0	1.0
T/YHC037	3	high	1.1	1.0	1.0
T/YHC048	4	high	1.5	1.5	1.5
T/YHC047	4	high	1.5	1.5	1.5
T/YHC060	5	high	1.0	1.0	1.0
T/YHC067	5	high	1.0	1.0	1.0
T/YHC072	6	high	2.0	2.0	2.0
T/YHC074	6	high	2.0	2.0	2.0
T/YHC092	7.5	high	2.0	2.0	2.0
T/YHC102	8.5	high	2.0	2.0	1.7
T/YHC120	10	high	2.0	2.0	1.7
T/YZC036	3	ultra-high	1.5	1.3	1.1
T/YZC048	4	ultra-high	1.5	1.5	1.5
T/YZC060	5	ultra-high	1.5	1.3	1.0
T/YZC072	6	ultra-high	2.0	2.0	2.0
T/YZC090	7.5	ultra-high	2.0	2.0	2.0
T/YZC102	8.5	ultra-high	2.0	2.0	1.6
T/YZC120	10	ultra-high	2.0	2.0	1.3
Trane Precedent™ Rooftop HEAT PUMPS (3 to 10 tons)					
W/DSC036	3	standard	1.5	1.3	1.1
W/DSC048	4	standard	1.5	1.5	1.5
W/DSC060	5	standard	1.5	1.3	1.0
W/DSC072	6	standard	2.0	2.0	2.0
W/DSC090	7.5	standard	2.0	2.0	2.0
W/DSC092	7.5	standard	2.0	2.0	2.0
W/DSC102	8.5	standard	2.0	2.0	1.9
W/DSC120	10	standard	2.0	2.0	1.3

[1] Assuming rooftop unit selected with standard filters, wet evaporator coil, horizontal supply and return connections (worst case), and high-capacity modulating gas heater. Maximum external static pressure values will vary by configuration; consult TOPSS® selection software for actual limits.

Trane Model Number	Nominal Capacity, tons	Efficiency Tier	Maximum External Static Pressure, in. H_2O[1]		
			if design = 320 cfm/ton	if design = 400 cfm/ton	if design = 480 cfm/ton
Trane Precedent™ Rooftop HEAT PUMPS (3 to 10 tons), continued					
W/DSC036	3	high	1.1	1.1	1.0
W/DSC048	4	high	1.5	1.5	1.5
W/DSC060	5	high	1.0	1.0	1.0
W/DSC074	6	high	2.0	2.0	2.0
W/DSC092	7.5	high	2.0	2.0	2.0
W/DSC102	8.5	high	2.0	2.0	1.7
W/DSC120	10	high	2.0	2.0	1.7
Trane Voyager® Rooftop Units (12.5 to 25 tons)					
T/YS*150	12.5	standard	2.0	1.8	1.0
T/YS*180	15	standard	2.0	2.0	2.0
T/YS*210	17.5	standard	2.0	2.0	1.4
T/YS*211	17.5	standard	2.0	2.0	1.4
T/YS*240	20	standard	2.0	1.8	see note below
T/YS*300	25	standard	2.0	1.5	see note below
T/YS*301	25	standard	2.0	1.5	see note below
T/YH*150	12.5	high	2.0	2.0	2.0
T/YH*180	15	high	2.0	2.0	1.9
T/YH*210	17.5	high	2.0	2.0	2.0
T/YH*240	20	high	2.0	2.0	1.6
T/YH*300	25	high	1.5	1.3	see note below
T/YZ*150	12.5	ultra-high	2.0	2.0	2.0
T/YZ*180	15	ultra-high	2.0	2.0	1.9
T/YZ*210	17.5	ultra-high	2.0	2.0	2.0
Trane Voyager® Rooftop HEAT PUMPS (12.5 to 20 tons)					
WS*150	12.5	standard	2.0	1.8	1.0
WS*180	15	standard	2.0	2.0	2.0
WS*240	20	standard	2.0	1.8	see note below

[1] Assuming rooftop unit selected with standard filters, wet evaporator coil, horizontal supply and return connections (worst case), and high-capacity modulating gas heater. Maximum external static pressure values will vary by configuration; consult Trane® Select Assist™ or TOPSS® selection software for actual limits.

Trane Model Number	Nominal Capacity, tons	Efficiency Tier	Maximum External Static Pressure, in. H_2O[1]
Trane Voyager® Commercial Rooftop Units (27.5 to 50 tons)			
T/Y**330	27.5	standard	2.25
T/Y**360	30	standard	2.25
T/Y**420	35	standard	2.25
T/Y**480	40	standard	2.5
T/Y**600	50	standard	2.5
T/Y**330	27.5	high	2.25
T/Y**360	30	high	2.25
T/Y**420	35	high	2.25
T/Y**480	40	high	2.5
T/Y**600	50	high	2.5

Accessories and Modifications

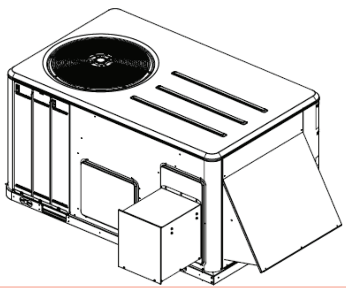
Contact your Trane sales representative for assistance.

Outdoor airflow measurement

For projects where direct measurement of outdoor airflow is desired in either a Precedent® or Voyager® rooftop unit, an accessory (V-TRAQ) can be field-installed inside the intake hood of the rooftop unit.

- Rooftop unit must be ordered with an economizer, but without low-leak dampers.
- Field-installed kit includes Trane Traq® dampers, pressure sensors, actuators, and pre-engineered controls.
- Flow measurement accuracy of +/- 5 percent down to 15 percent of nominal airflow.

A Voyager® Commercial rooftop unit can be equipped with a factory-installed Traq™ Outside Air Measurement System.

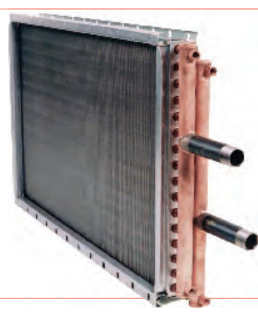


Modulating relief fan

For projects where a modulating relief fan is desired in either a Precedent® or Voyager® rooftop unit, an accessory can be field-installed; this likely requires a separate power connection. A Voyager® Commercial rooftop unit can be equipped with a factory-installed modulating relief fan, with controls pre-engineered in the ReliaTel® controller.

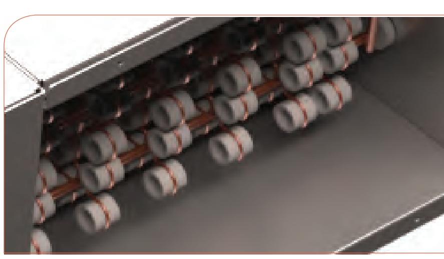
Modulating gas burner

For projects where less capacity or greater turndown are required, the gas burner can be modified as such.



Modulating hot-water coil

For projects where the VAV terminal units are equipped with hot-water coils, a hot-water coil can be mounted in the discharge of the rooftop unit or it can be field-installed in the supply ductwork.



Modulating (SCR) electric heater

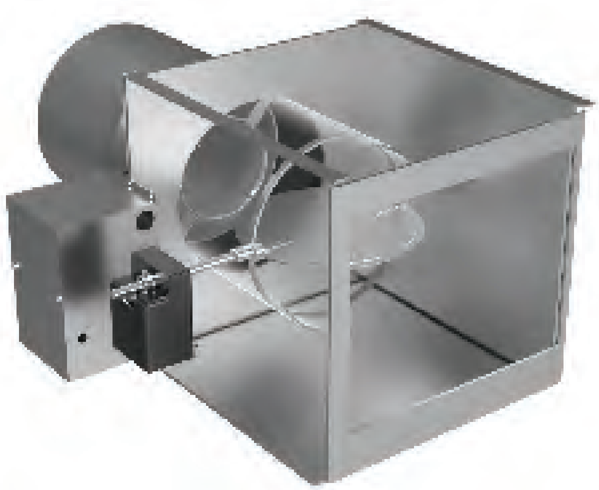
For projects where modulating control is required, the electric heater can be modified with a silicon controlled rectifier (SCR) to enable broader modulation.

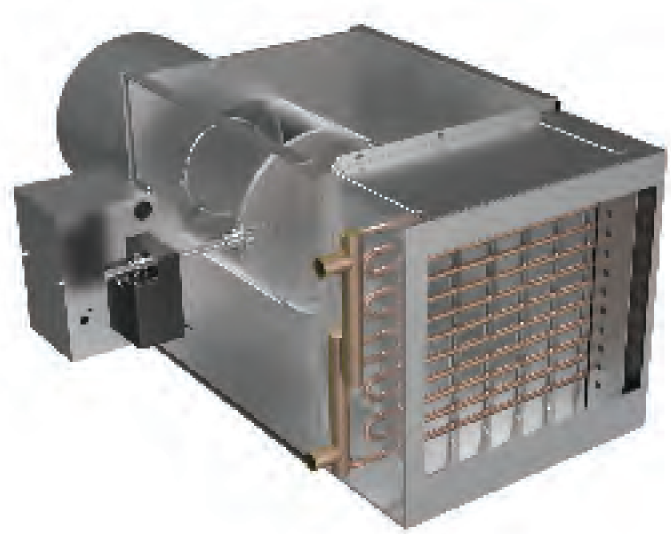
Equipment with Controls: VAV Terminal Units

Trane offers a variety of VAV terminals units, each with standard and optional capabilities to support Trane® Zoned Rooftop Systems.

Trane Model Number[1]	Inlet Size, in.	Nominal Airflow, cfm	Heat Options			Air-Fi™ Available
			Staged Electric	SCR Electric	Hot Water	
VariTrane® Round Inlet/Round Outlet Terminal Units (model VRRF)						
VRRF04	4 Ø	225				X
VRRF05	5 Ø	350				X
VRRF06	6 Ø	500				X
VRRF08	8 Ø	900	not available			X
VRRF10	10 Ø	1400				X
VRRF12	12 Ø	2000				X
VRRF14	14 Ø	3000				X
VRRF16	16 Ø	4000				X
VariTrane® Single-Duct VAV Terminal Units (model VC*F)						
VC*F04	4 Ø	225	X	X	X	X
VC*F05	5 Ø	350	X	X	X	X
VC*F06	6 Ø	500	X	X	X	X
VC*F08	8 Ø	900	X	X	X	X
VC*F10	10 Ø	1400	X	X	X	X
VC*F12	12 Ø	2000	X	X	X	X
VC*F14	14 Ø	3000	X	X	X	X
VC*F16	16 Ø	4000	X	X	X	X
VC*F24	24 x 16	8000	X	X	X	X

[1] VC*F: VCCF = cooling only (no heat); VCEF = equipped with an electric heater; VCWF = equipped with a hot-water coil





When selecting Trane VAV terminal units as part of a Zoned Rooftop System, use the following settings Trane's selection software.

Trane VAV terminal unit selection criteria in Trane® Select Assist™ or TOPSS® selection software (www.traneselectassist.com)

<table>
<tr><th>System Type</th><th>Product/Model</th><th>Trane Supplied Controls</th><th>Wireless Options</th><th>Zone Temperature Sensor</th><th>Discharge Air Temperature Sensor</th></tr>
<tr><td>single-zone constant volume</td><td colspan="5">not applicable</td></tr>
<tr><td>single-zone VAV</td><td colspan="5">not applicable</td></tr>
<tr><td>changeover bypass</td><td>VAV Round Terminal Units (model VRRF)
or
VAV Single-Duct Terminal Units (model VCCF)</td><td>"UC™210 Basic (cooling only)"</td><td rowspan="4">"Air-Fi wireless communication module" (if wireless)[3]</td><td>required</td><td>recommended[1]</td></tr>
<tr><td>changeover VAV</td><td>VAV Round Terminal Units (model VRRF)
or
VAV Single-Duct Terminal Units (model VCCF)</td><td>"UC™210 Basic (cooling only)"</td><td>required</td><td>recommended[1]</td></tr>
<tr><td>multiple-zone VAV with terminal electric heat</td><td>VAV Single-Duct Terminal Units (model VCEF)</td><td>"UC™210 Basic (cooling only)"
or
"UC™210 Basic (staged electric)"
or
"UC™210 Basic (electric- mod SCR)"</td><td>required</td><td>recommended[1]
or
required[2]</td></tr>
<tr><td>multiple-zone VAV with terminal hot-water heat</td><td>VAV Single-Duct Terminal Units (model VCWF)</td><td>"UC™210 Basic (cooling only)"
or
"UC™210 Basic (2-pos. hot water, NC)"
or
"UC™210 Basic (2-pos. hot water, NO)"
or
"UC™210 Basic (modulating hot water)"</td><td>required</td><td>recommended[1]
or
required[2]</td></tr>
</table>

[1] Equipping each VAV terminal unit with a DAT sensor is recommended for monitoring and troubleshooting.
[2] If the VAV terminal unit is equipped with either an SCR electric heater ("UC™210 Basic – electric modulating SCR") or a modulating hot-water valve ("UC™210 Basic – modulating hot water"), it must be equipped with DAT sensor to enable the "dual max" control sequence (page 23).
[3] Preset addressing of Tracer® UC™210 controllers and Air-Fi® Wireless sensors is available as an option

Equipment with Controls: Bypass Damper

When required, the bypass damper should be installed so it connects to the supply duct between the discharge of the rooftop unit and the first supply duct branch or VAV terminal unit. Typically, either a Trane VAV Round Terminal Unit (model VRRF) or VAV Single-Duct Terminal Unit (model VCCF) is selected with a Tracer® UC™210 controller that has been appropriately configured to function as a bypass damper.

In a **changeover bypass system**, a bypass damper is always required. As dampers in the zone-level VAV terminal units modulate further closed, this bypass damper is modulated further open to provide a path for excess supply airflow and maintain the supply duct static pressure at the desired setpoint.

In a **changeover VAV system** where the rooftop unit is equipped with either **staged gas or electric heat**, a bypass damper is required. In this case, when the rooftop unit switches to heating mode the supply fan operates at 100 percent speed, so the bypass damper is needed to provide a path for excess supply airflow and maintain the supply duct static pressure at the desired setpoint.

In the two applications described above, the bypass damper is typically sized for 60 to 80 percent of the rooftop unit's design supply airflow. For example, if the rooftop unit is selected for a design supply airflow of 2000 cfm, the bypass damper is typically sized for 1200 cfm to 1600 cfm (60 to 80 percent of 2000 cfm). Referring to the table below, a 10-inch model VRRF bypass damper would likely be selected, with a nominal airflow of 1400 cfm. The bypass damper programming is a "design special" order that controls to maintain duct static pressure.

In a **changeover VAV system** where the rooftop unit is equipped with a **modulating gas heater**, a bypass damper may be required if the system airflow in the heating mode is expected to drop below the minimum threshold for the heater. As an example, consider a 17.5-ton high-efficiency Voyager® unit (model YH*210) selected for a design supply airflow of 7000 cfm—which equates to 400 cfm/nominal ton. If this rooftop unit is equipped with a modulating gas heater, the tables on pages 34-35 indicates that the minimum supply airflow with the heater activated is 3240 cfm. When all the VAV dampers are at their minimum heating airflow setpoints—assumed to be 20 percent of design airflow in this example—the sum of airflows required by the VAV terminal units is 1400 cfm (20 percent of 7000 cfm). Because this is lower than the minimum airflow required when the heater in the rooftop unit is activated, a bypass damper is required to bypass the 1840 cfm of excess supply airflow (3240 cfm minus 1400 cfm) to the return duct. Referring to the table below, a 12-inch model VRRF bypass damper would likely be selected, with a nominal airflow of 2000 cfm. For this application, the bypass damper uses a standard VAV controller that is configured to control bypass airflow (cfm).

Trane bypass damper selection criteria in Trane's selection software (www.traneselectassist.com)

System Type	Bypass Damper Required?	Product/ Model	Trane Supplied Controls	Duct Temperature Sensor (DTS)	Factory-Installed Wireless Receiver
single-zone constant volume	not applicable				
single-zone VAV	not applicable				
changeover bypass	required	VAV Round Terminal Units (model VRRF) or VAV Single-Duct Terminal Units (model VCCF)	"UC™210 DDC Basic – Cooling Only" (design special)[1]	required	"Air-Fi wireless communication module" (if wireless)[2]
changeover VAV (with staged heat in rooftop)	required				
changeover VAV (with modulating gas heat in rooftop)	may be required		"UC™210 DDC Basic – Cooling Only"	not required	
multiple-zone VAV with terminal heat	typically not required				

[1] The bypass damper programming is a "design special" order that controls to maintain duct static pressure. Contact your Trane sales representative for assistance.
[2] Preset addressing of Tracer® UC™210 controller is available as an option.

Trane bypass dampers that support Zoned Rooftop Systems

Trane Model Number	Inlet Size, in.	Cross Sectional Area, ft^2	Nominal Airflow, cfm	Air-Fi™ Available
VRRF04 VCCF04	4 Ø	0.087	225	X
VRRF05 VCCF05	5 Ø	0.136	350	X
VRRF06 VCCF06	6 Ø	0.188	500	X
VRRF08 VCCF08	8 Ø	0.338	900	X
VRRF10 VCCF10	10 Ø	0.532	1400	X
VRRF12 VCCF12	12 Ø	0.769	2000	X
VRRF14 VCCF14	14 Ø	1.050	3000	X
VRRF16 VCCF16	16 Ø	1.375	4000	X
VCCF24	24 x 16	2.667	8000	X

Sensors

There are several sensors that need to be selected and installed in Trane® Zoned Rooftop Systems. These sensors may be hard-wired to a controller or wireless communication technology can be used.

Pivot™ Smart Thermostat

For a building that includes a relatively few number of single-zone rooftop units, this web-enabled thermostat packs commercial-grade features and functionality into an easy-to-use solution.

- Customizable touchscreen interface shows only the commands that the building occupants need
- Seven-day programmable schedule supporting up to six events (schedule changes) per day
- Options for Ethernet or Wi-Fi connectivity to help avoid IT issues
- Accompanying mobile app provides remote access, including the ability to view the status of multiple thermostats from one screen
- Enables optimal start and optimal stop control strategies (see page 46)
- Support for single-zone systems with either constant-speed or two-speed fan control

Air-Fi® Wireless zone sensors

Selection of Air-Fi® Wireless zone sensors is recommended for Zoned Rooftop Systems. Eliminating the wires between equipment controllers and zone sensors, and between the equipment and system controllers, allows for faster installation, increased location flexibility, and easier relocation when space use changes in the future.

Trane Air-Fi® Wireless zone sensors

Trane Model	Temperature Sensing	Occupancy Sensing	CO_2 Sensing	Humidity Sensing	Digital Display
WCS-SB	X			optional[1]	
WCS-SD	X			optional[1]	X
WCS-SO	X	X		optional[1]	
WCS-SCO2	X	X	X	optional[1]	

[1] An optional relative humidity sensing module (WSC-RH) can be plugged into the circuit board of any Air-Fi® Wireless zone sensor model.

Sensors for single-zone systems

In a single-zone system, each rooftop unit is equipped with at least one zone temperature sensor or thermostat. In some applications, a humidity sensor and/or a CO_2 sensor may be installed in the zone as well. And the rooftop unit may be equipped with one or more additional sensors, depending on the system type.

Sensor Type	Single-Zone Systems		
	Constant Volume	Single-Zone VAV (two-speed fan)	Single-Zone VAV (variable-speed fan)
sensors connected to each rooftop unit controller			
zone temperature	required[1]	required[1]	required[2]
zone humidity	optional[3]	optional[3]	optional[3]
CO_2	optional[4]	optional[4]	optional[4]
supply air temperature	required only for modulating gas heat[5]	required only for modulating gas heat[5]	required[6]
return air temperature	recommended[7]	recommended[7]	recommended[7]

[1] A conventional thermostat or Pivot™ Smart Thermostat can be used for this system. If the Tracer® Concierge™ control system is used instead, a zone temperature sensor is recommended to enable communication.
[2] A zone temperature sensor (not a thermostat) is required to enable variable-speed fan control; otherwise the unit will operate with two-speed fan control.
[3] If the rooftop unit is equipped with hot gas reheat, it must be equipped with a zone humidity sensor. In addition, if the rooftop unit is equipped with an eFlex™ variable-speed compressor, adding an optional zone humidity sensor enables use of the "enhanced dehumidification" control sequence.
[4] If DCV is required, the rooftop unit should be equipped with either a wall-mounted or duct-mounted (return air) CO_2 sensor.
[5] When equipped with modulating gas heat, the rooftop unit ships with a factory-installed supply air temperature sensor. Otherwise, this sensor is still recommended for monitoring and troubleshooting.
[6] When configured for variable-speed fan control (SZVAV), the rooftop unit ships with a factory-installed supply air temperature sensor.
[7] If using Air-Fi® Wireless, a hard-wired return air temperature sensor is recommended for providing temporary heating/cooling during construction and then to serve as a backup to the wireless sensor.

- **Multiple sensors in a single zone:** In a large zone that will be served by a single rooftop unit, it may be desirable to install more than one sensor. Up to six Air-Fi® Wireless zone sensors can be installed in a single zone. If more than one temperature or humidity sensor is installed, the rooftop unit controller will average the measurements from all the sensors to determine the required control action. If more than one CO_2 sensor is installed, the controller will use the highest concentration. And if more than one occupancy sensor is installed, the controller will consider the zone occupied if any of the sensors indicates people are present.
- **Multiple rooftop units serving a large area:** For a large open area, such as a warehouse, auditorium or gymnasium, it may be desirable to install more than one rooftop unit. For this configuration, the pre-engineered AREA application in the Tracer® Concierge™ system control panel can be used to ensure all units operate in the same mode (cooling or heating) to prevent them from operating in opposing modes.

Sensors for multiple-zone systems

In a multiple-zone system, each VAV terminal unit is equipped with at least one zone temperature sensor. In some applications, a humidity sensor, occupancy sensor, and/or CO_2 sensor may be installed in the zone as well. And the rooftop unit may be equipped with one or more sensors, depending on the system type.

	Multiple-Zone Systems		
Sensor Type	Changeover Bypass	Changeover VAV	VAV with Terminal Heat
sensors connected to each VAV terminal unit controller			
zone temperature	required	required	required
zone humidity	optional[1]	optional[1]	optional[1]
zone CO_2 and/or occupancy	optional[2]	optional[2]	optional[2]
discharge air temperature	recommended[3]	recommended[3]	recommended[3] or required[3]
sensors connected to each rooftop unit controller			
supply air temperature	required with mod. gas heat only[4]	required[5]	required[5]
supply duct pressure	not applicable	required[5]	required[5]
return air temperature	recommended[6]	recommended[6]	recommended[6]
CO_2 concentration	limited application[7]	limited application[7]	limited application[7]
sensors connected to the bypass damper			
supply air temperature	required[8]	required[8] (if bypass needed)	bypass damper typically not required
supply duct pressure	required[8]	required[8] (if bypass needed)	bypass damper typically not required

[1] If monitoring of zone relative humidity is desired, or it is used by a supply-air temperature (SAT) reset sequence, an optional relative humidity sensing module can be plugged into any Air-Fi® Wireless zone sensor model.
[2] If DCV is to be used, the VAV terminal unit should be equipped with either an occupancy sensor or a CO_2 sensor installed in the zone.
[3] Equipping each VAV terminal unit with a DAT sensor is recommended for monitoring and troubleshooting. If the VAV terminal unit is equipped with either an SCR electric heater or a modulating hot-water valve, it must be equipped with a DAT sensor to enable the "dual maximums" control sequence (page 23).
[4] When equipped with modulating gas heat, the rooftop unit ships with a factory-installed supply air temperature sensor.Otherwise, this sensor is still recommended for monitoring and troubleshooting.
[5] When configured for MZVAV control, the rooftop unit ships with factory-installed supply air temperature and supply duct pressure sensors.
[6] If using Air-Fi® Wireless, a hard-wired return air temperature sensor is recommended for providing temporary heating/cooling during construction and then to serve as a backup to the wireless sensor.
[7] Using a single CO_2 sensor in the common return-air duct measures the average concentration of all zones served by the rooftop unit, so use of this approach should be limited to where all the zones served by the system are similar.
[8] The Trane model VRRF bypass damper with Tracer® UC™210 controller is equipped with factory-wired supply air temperature and pressure sensors.

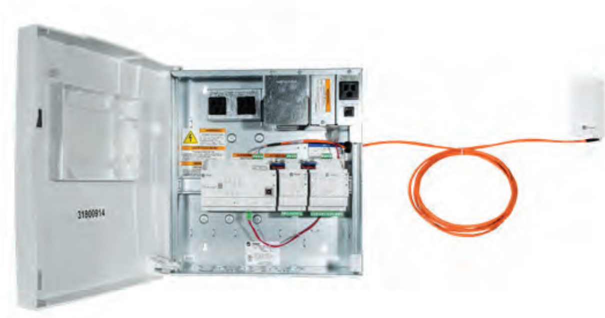
System-Level Control

The Tracer® Concierge™ control system offers the benefits of a building automation system—without the complexity—and goes beyond managing individual rooms by operating the building smartly and efficiently.

Tracer® Concierge™ system control panel

The pre-packaged system control panel, with its auto-discovery and configuration capabilities, allows for easier and faster installation. This panel includes the following components:

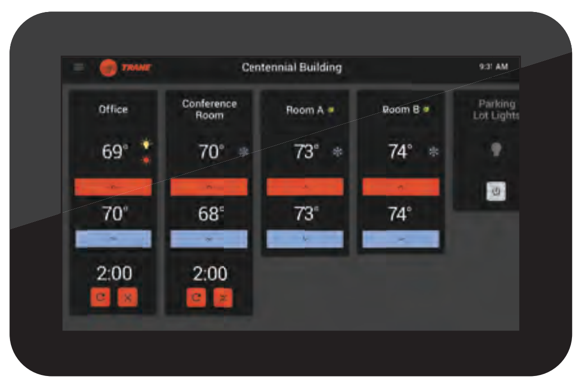
- Sturdy control enclosure with DIN rail and door
- Power transformer (120 VAC/24 VAC) and convenience outlet for service, plus two additional internal outlets for accessories, such as the touchscreen display
- Pre-programmed Concierge™ panel, which includes all system setup and coordination functions, as well as optimized system control strategies (see pages 46-47)
- Factory-wired Air-Fi® Wireless Communication Interface (WCI) with a coiled cable to allow for installation above the panel or in the ceiling plenum
- Optional Tracer® XM30 and/or XM32 expansion modules, which allow for additional inputs and outputs (e.g., outdoor air temperature, lighting control, or exhaust fan control)



10-inch touchscreen display

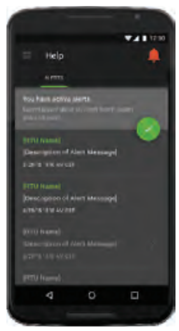
The intuitive, easy-to-use operator interface is displayed on a 10-inch touchscreen and contains standard graphics that can be changed to reflect your unique building. This display provides:

- A single point of control to complete many of the functions you use to manage your building, eliminating the need to go from room to room to program thermostats.
- Built-in functions to help maximize building performance, including overrides, temperature setpoint changes, and daily monitoring.
- Ability to group multiple rooms on the same schedule, and update them all together from one interface, giving you the flexibility to manage your entire building instead of just one space.
- A utility to simplify installation and startup, and to assist with service; including a full-featured system air balancing function.
- An embedded web browser that allows access to more sophisticated functions, including trend logs.
- Capability to also control lighting equipment, so you can manage your entire building from one interface.



Mobile apps

Trane mobile apps allow you to manage or troubleshoot your building from anywhere. And Trane Connect is a pre-engineered remote access technology that provides a standard and secure way to access a Tracer® Concierge™ control system from outside your network.



Trane BAS Occupant app

- Enables management of a building from a smartphone, tablet, or other mobile device
- Designed for a building operator, it allows users to modify schedules and adjust setpoints
- Connects to a Tracer® Concierge™ control system either through a network connection or via Trane Connect
- Available for a variety of mobile devices

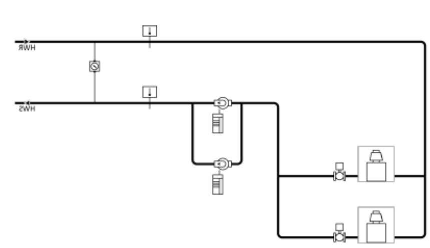
Trane BAS Operator app

- Enables troubleshooting of a building from a smartphone, tablet, or other mobile device
- Designed for a contractor or installer, it allows users to view and override setpoints, occupancy status, schedules, alarms, and RTU or VAV graphics
- Connects to a Tracer® Concierge™ control system either through a network connection or via Trane Connect
- Available for a variety of mobile devices

Hot-water distribution system

For multiple-zone VAV systems with hot-water heat in the VAV terminal units, additional control hardware and programming may be required to control the boiler(s) and hot-water pumps.

Sequences of operation, points lists and flow diagrams are available in Trane® Design Assist (www.tranedesignassist.com)



Optimized system control strategies

The Tracer® Concierge™ control system provides several advanced, optimized system control strategies to reduce energy use while improving occupant comfort in Zoned Rooftop Systems.

Control Strategy	Single-Zone Systems		Multiple-Zone Systems		
	Constant Volume	Single-Zone VAV	Changeover Bypass	Changeover VAV	VAV with Terminal Heat
optimal start/stop	X	X	X	X	X
fan-pressure optimization	not applicable			X	X
supply-air temperature reset	not applicable			X	X
demand-controlled ventilation	X	X	X	X	X

Optimal start/stop

During hours when the building is expected to be unoccupied, the HVAC system is typically shut off and zone temperature is allowed to drift away from its occupied setpoint. The time at which the system starts back up again is usually scheduled early enough so that the zone temperature reaches its occupied setpoint prior to scheduled occupancy on the worst-case (coldest or warmest) morning of the year. As a result, on all other days the system starts earlier than it needs to.

The Concierge™ system control panel uses a pre-engineered control strategy—called *optimal start*—which determines the length of time required to bring the zone from its current temperature to its occupied setpoint. Then it waits as long as possible before starting the system, so that the zone reaches its occupied setpoint just in time for scheduled occupancy. It even learns from its historical performance, and can compensate for the current outside temperature, to better predict this optimal starting time. This strategy reduces the number of system operating hours and saves energy.

A similar strategy—called *optimal stop*—uses the Concierge™ panel to determine how early the heating or cooling can be shut off for the zone, so that the temperature in that zone will drift no more than 2°F from its occupied setpoint by the end of the scheduled occupancy period. In this mode, only cooling and heating are shut off; the supply fan continues to operate and the outdoor-air damper remains open to continue ventilating the building. This strategy further reduces the number of system operating hours, saving energy by allowing indoor temperatures to drift early.

Fan-pressure optimization

In a **changeover VAV system** or a **multiple-zone VAV system with terminal heat**, each VAV terminal unit modulates to vary airflow delivered to its zone, as the load in that zone changes. This causes the pressure inside the supply ductwork to change. The rooftop unit controller varies the speed of the supply fan to maintain static pressure in the ductwork at the desired setpoint.

Trane® Zoned Rooftop Systems use a pre-engineered control strategy—called fan-pressure optimization—to minimize duct pressure and save fan energy. Each Tracer® UC™210 controller knows the current position of the damper in its VAV terminal. The Concierge™ system control panel continually polls all the VAV controllers, looking for the terminal unit with the most-open damper. Then it dynamically resets the duct static pressure setpoint as low as possible, until one damper is nearly wide open. This new setpoint is communicated to the rooftop unit controller, allowing the supply fan to deliver the required airflow at as low a static pressure possible.

This results in less fan energy use, lower sound levels, greater supply fan turndown, and a reduced risk of fan surge. Plus, the duct static pressure sensor can be installed anywhere in the supply duct, allowing for it to remain at the factory-installed location in the discharge of the rooftop unit.

Supply-air temperature reset

The purpose and approach used for resetting the supply-air temperature (SAT) setpoint differs between a changeover VAV system (without terminal heat) and a multiple-zone VAV system (with terminal heat). Note: The supply-air temperature setpoint is adjusted in a single-zone system as part of the rooftop unit's control sequence, but not reset as part of an overall system control strategy.

In a **changeover VAV system without terminal heat**, the rooftop unit delivers either cool air or warm air to all the VAV terminal units. Resetting the SAT setpoint can be used to reduce the number of times the rooftop unit switches between cooling and heating modes and improve overall comfort in the building:

- When the majority of zones require cooling, the rooftop unit operates in cooling mode and delivers cool air down the duct. In any zone that requires heating, the VAV terminal unit will reduce primary airflow to its minimum setpoint in an attempt to minimize over-cooling of that zone. Resetting the SAT setpoint upward will help minimize the amount of over-cooling in those zone that require heating.

- When the majority of zones require heating, the rooftop unit operates in heating mode and delivers warm air down the duct. In any zone that requires cooling, the VAV terminal unit will reduce primary airflow to its minimum setpoint in an attempt to minimize over-heating of that zone. Resetting the SAT setpoint downward will help minimize the amount of over-heating in those zone that require cooling.

For a changeover VAV system, the Concierge™ system control panel uses a pre-engineered control strategy to monitor the cooling and heating demands of each zone, and then dynamically reset the SAT setpoint to maximize overall comfort. This new setpoint is then communicated to the rooftop unit controller.

In a **multiple-zone VAV system with terminal heat**, increasing the SAT setpoint at part-load conditions can reduce cooling and reheat energy use, but increases fan energy and can result in elevated zone humidity levels. Therefore, SAT reset should be implemented so that it minimizes overall system energy use—considering the trade-off between compressor, reheat, and fan energy.

To balance these competing issues in a multiple-zone VAV system, the Concierge™ panel uses a pre-engineered control strategy that keeps the SAT setpoint cold when its warm outside, thereby taking advantage of the significant energy savings from unloading the fan and avoiding elevated zone humidity levels. Then the SAT setpoint is reset upward during mild and cold weather to enhance the benefit of the airside economizer (thereby saving cooling energy) and minimize reheat energy use.

Demand-controlled ventilation

As the number of people occupying a zone changes, the quantity of outdoor air required to properly ventilate that zone varies. Demand-controlled ventilation (DCV) is a control strategy that dynamically resets outdoor airflow delivered to a zone based on this changing population, thereby reducing the energy needed to condition excess outdoor air.

- For a **single-zone system**, CO_2-based DCV sequences are pre-engineered in the ReliaTel® rooftop unit controller.

- For a **multiple-zone system**, DCV control sequences—using either an occupancy sensor or CO_2 sensor—are pre-engineered in the Tracer® UC™210 VAV terminal unit controller and the Tracer® Concierge™ system control panel. There is more than one possible approach for implementing DCV in these systems, each with its advantages and drawbacks (see pages 24-26).

Specifications

For many small building projects, specifying engineers prefer a shorter, simpler means of documenting project requirements. Therefore, abbreviated specifications and sequences of operation have been created for Trane® Zoned Rooftop Systems.

Trane selection software is accessible online at www.traneselectassist.com. It has the capability to generate equipment schedules, in Excel format, which can then be copied onto the project plans (see examples below). The user can set up customized templates so the schedule includes only the data desired in the order preferred.

In addition, selection-specific notes are generated under the schedule. For small building projects, these notes typically replace a detailed specification for the equipment.

Rooftop Unit Schedule

		Airflow			Cooling					Heating		Electrical			
Tag	Manufacturer/ Model	Supply (cfm)	Min OA (cfm)	ESP (in H_2O)	Entering DBT (deg F)	Entering WBT (deg F)	Ambient (deg F)	Total Capacity (MBh)	Min Rated SEER	Capacity (MBh)	Fuel	Voltage/ Phase	MCA (amps)	Weight (lbs)	Notes
RTU-1	Trane YCZ060	1920	200	1.0	80	66.6	95	57.5	14	64	Nat. Gas	208/3	27.8	1133	1,2,3,4,5,6,7,8,9

1. Units to be Trane model, size, and configuration as indicated in schedule and on drawings
2. Provide factory-mounted BACnet DDC controller and wireless communication receiver
3. Provide multiple-zone VAV controls, complete with supply fan VFD, discharge air temperature sensor, and duct static pressure sensor
4. Provide reference enthalpy economizer with powered exhaust
5. Provide MERV 8 filter
6. Provide variable-speed compressor
7. Provide hail guards
8. Provide factory-installed disconnect switch, phase monitor, and 120V service outlet
9. Provide with roof curb

VAV Terminal Unit Schedule

		Inlet	Airflow (cfm)			Electric Heater			Electrical		
Tag	Manufacturer/ Model	Size (in.)	Max Cooling	Min Cooling	Max Heating	Capacity (kW)	DAT (deg F)	Stages	Voltage/ Phase	MCA (amps)	Notes
VAV-1	Trane VCEF	8	560	250	450	6	95	SCR	208/3	20.8	1,2,3,4,5
VAV-2	Trane VCEF	6	320	120	260	3.5	95	SCR	208/3	12.1	1,2,3,4,5
VAV-3	Trane VCEF	5	300	120	200	2.5	95	SCR	208/3	8.6	1,2,3,4,5
VAV-4	Trane VCEF	10	970	300	690	9	95	SCR	208/3	31.2	1,2,3,4,5

1. Units to be Trane model, size, and configuration as indicated in schedule and on drawings
2. Provide factory-mounted and pre-programmed, pressure-independent, BACnet DDC controller with airflow measurement and wireless communication receiver
3. Provide with wireless zone temperature sensor
4. Provide with factory-wired discharge air temperature sensor
5. Provide unit-mounted control power transformer and disconnect

Bypass Damper Schedule

Tag	Manufacturer/ Model	Inlet Size (in.)	Maximum Airflow (cfm)	Notes
BYP-1	Trane VRRF	12	1500	1,2,3,4

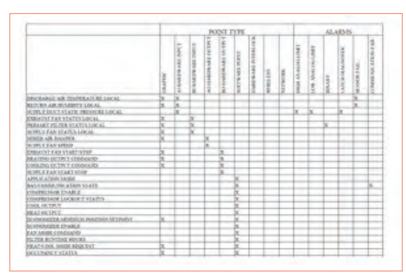
1. Units to be Trane model, size, and configuration as indicated in schedule and on drawings
2. Provide factory-mounted and pre-programmed, pressure-independent, BACnet DDC controller with airflow measurement and wireless communication receiver
3. Provide with factory-wired duct temperature and pressure sensors
4. Provide unit-mounted control power transformer and disconnect

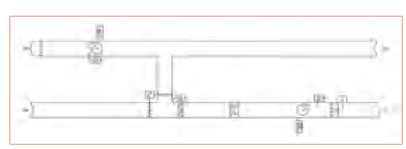
Trane® Select Assist™ or TOPSS® can also generate an abbreviated Tracer® Concierge™ control system specification (see following pages), in Word format, which can then be copied onto the project plans. An abbreviated sequence of operation is included for each of the Zoned Rooftop Systems—single-zone constant volume, single-zone VAV, changeover bypass, changeover VAV, and multiple-zone VAV with terminal heat—but the user can edit to delete those systems not being used on the current project.

When selecting a Precedent® (3 to 10 tons) or Voyager® (12.5 to 25 tons) rooftop unit, choosing Communications Options = "Air-Fi communication interface" (for wireless) or "BACnet communication interface" (for wired) will generate this abbreviated Tracer® Concierge™ control system specification as an output.

Trane® Design Assist

If more-detailed control specifications are desired for either the Pivot™ Smart Thermostat or the Tracer® Concierge™ control system—including guide specs, points lists, and flow diagrams—they are available in Trane® Design Assist (www.tranedesignassist).





Control Specification

A. CONTROL SYSTEM OVERVIEW: Control System shall include a System Controller, all controllers for HVAC equipment and ancillary devices (such as lights and exhaust fans), wireless communication between the System Controller, equipment controllers, and space sensors, and all wiring and end devices required. Control System to be fully programmed and commissioned by the installing contractor.

B. TOUCH SCREEN DISPLAY: Control System shall include a 10-inch color Touch Screen Display for use by building occupants to adjust zone temperature setpoints, override lighting and HVAC equipment for after-hours use, modify schedules, and view service notifications. This display shall have PIN access for users and provide setpoint adjustment limits.

C. MOBILE APP: Control System manufacturer shall provide a Mobile App for cellular devices to allow occupants to perform the same functions (listed above) as the Touch Screen Display.

D. WEB BROWSER INTERFACE: System Controller shall have an embedded Web Browser Interface to allow the installer and service providers to make adjustments to system control parameters and view trend logs and other service information.

E. WIRELESS COMMUNICATION: Control System shall provide wireless communication between the System Controller, HVAC equipment controllers, and space sensors. This wireless communication shall be based on ANSI®/ASHRAE® Standard 135-2016 (BACNet/ZigBee®). Space sensors shall measure temperature, relative humidity, occupancy, and CO2 per the equipment schedule, and shall have a 15-year battery life with low-battery indication and alarm. Multiple space sensors in larger spaces shall be averaged for control and individually monitored.

F. SYSTEM CONTROLLER: System Controller shall provide scheduling and coordination of all HVAC equipment, exhaust fans, and controlled lighting devices. The System Controller shall include a software application that coordinates the operation of rooftop units and VAV terminals. The System Controller shall support multiple system types, including Single-Zone Constant Volume, Single-Zone VAV, Changeover Bypass, Changeover VAV, and Multiple-Zone VAV with Terminal Reheat (electric or hot water). The System Controller shall provide energy optimization strategies including Night Setback, Optimal Start, Fan Pressure Optimization, Discharge Air Temperature Reset, and Demand-Controlled Ventilation.

G. REMOTE ACCESS/NETWORK SECURITY: Installer shall provide secure remote access to the Control System to enable the owner or service provider to access the system remotely using the Mobile App or Web Browser Interface. The Control System must be secured behind a firewall and not allow any inbound ports to be open or exposed to the internet. Control System manufacturer shall provide a remote access portal accessible by the owner and/or a service provider (as authorized by the owner).

Sequence of Operation

A. SYSTEM OPERATING MODES: The System Controller shall send the equipment controllers Occupied/Unoccupied, Morning Warm-up/Pre-cool, and Heat/Cool modes. If communication is lost, the equipment controllers shall operate using default modes and setpoints.

1. NIGHT SETBACK: During unoccupied mode, the system shall shut off. If the zone temperature drifts to the unoccupied heating or cooling setpoint, the system shall start up to heat or cool the zone, while the OA damper remains closed (unless economizing).

2. OPTIMAL START: The System Controller shall automatically determine the optimal start time, such that each zone reaches its occupied setpoint just in time for scheduled occupancy.

3. DEMAND-CONTROLLED VENTILATION: For those zones equipped with an occupancy sensor or CO2 sensor, outdoor airflow shall be reset based on occupancy status and/or measured CO2 concentration.

B. SINGLE-ZONE CONSTANT-VOLUME SYSTEM

1. OCCUPIED HEAT/COOL: The RTU shall operate the supply fan continuously and modulate (or cycle) compressors, modulate (or stage) heat, and/or enable airside economizing to maintain zone temperature at setpoint. The OA damper shall open to bring in the required amount of ventilation.

2. MORNING WARM-UP/PRE-COOL: The RTU shall operate the supply fan and modulate (or cycle) compressors or modulate (or stage) heat to raise/lower zone temperature to its occupied setpoint. The OA damper shall remain closed, unless economizing.

C. SINGLE-ZONE VAV SYSTEM

1. OCCUPIED HEAT/COOL: The RTU shall modulate the supply fan, modulate (or cycle) compressors, modulate (or stage) heat, and/or enable airside economizing to maintain zone temperature at setpoint. The OA damper shall modulate, in proportion to changing supply fan speed, to bring in the required amount of ventilation.

2. MORNING WARM-UP/PRE-COOL: The RTU shall operate the supply fan and modulate (or cycle) compressors or modulate (or stage) heat to raise/lower zone temperature to its occupied setpoint. The OA damper shall remain closed, unless economizing.

D. CHANGEOVER BYPASS SYSTEM

1. OCCUPIED HEAT/COOL: Each VAV terminal shall use pressure-independent control, with airflow measurement, to vary primary airflow to maintain zone temperature at its occupied setpoint. The RTU shall modulate the bypass damper to maintain duct static pressure at setpoint and modulate (or cycle) compressors, modulate (or stage) heat, and/or enable airside economizing based on current zone cooling/heating demands. The OA damper shall open to bring in the required amount of ventilation.

2. MORNING WARM-UP/PRE-COOL: Each VAV terminal unit shall vary primary airflow to raise/lower zone temperature to its occupied setpoint. The RTU shall modulate the bypass damper to maintain duct static pressure at setpoint and modulate (or cycle) compressors or modulate (or stage) heat based on current zone cooling/heating demands. The OA damper shall remain closed, unless economizing.

3. COOLING/HEATING CHANGEOVER LOGIC: The System Controller shall determine the overall system cooling/heating mode based on “voting” from each zone. When the majority of zones require cooling, the RTU shall operate in cooling mode and any zone that requires heating shall reduce primary airflow to minimum. When the majority of zones require heating, the RTU shall operate in heating mode and any zone that requires cooling shall reduce primary airflow to minimum.

E. CHANGEOVER VAV SYSTEM

1. OCCUPIED HEAT/COOL: Each VAV terminal shall use pressure-independent control, with airflow measurement, to vary primary airflow to maintain zone temperature at its occupied setpoint. The RTU shall modulate the supply fan to maintain duct static pressure at setpoint and modulate (or cycle) compressors, modulate (or stage) heat, and/or enable airside economizing to maintain discharge air temperature at setpoint. The OA damper shall modulate, in proportion to changing supply fan speed, to bring in the required amount of ventilation.

2. MORNING WARM-UP/PRE-COOL: Each VAV terminal unit shall vary primary airflow to raise/lower zone temperature to its occupied setpoint. The RTU shall modulate the supply fan to maintain duct static pressure at setpoint and modulate (or cycle) compressors or modulate (or stage) heat to maintain discharge air temperature at setpoint. The OA damper shall remain closed, unless economizing.

3. FAN-PRESSURE OPTIMIZATION: The System Controller shall monitor all VAV damper positions and reset the RTU's duct static pressure setpoint based on the position of the furthest-open damper.

4. DISCHARGE AIR TEMPERATURE RESET: The System Controller shall reset the RTU's discharge air temperature setpoint based on current zone cooling/heating demands.

5. COOLING/HEATING CHANGEOVER LOGIC: The System Controller shall determine the overall system cooling/heating mode based on "voting" from each zone. When the majority of zones require cooling, the RTU shall operate in cooling mode and any zone that requires heating shall reduce primary airflow to minimum. When the majority of zones require heating, the RTU shall operate in heating mode and any zone that requires cooling shall reduce primary airflow to minimum.

F. MULTIPLE-ZONE VAV SYSTEM WITH TERMINAL HEAT

1. OCCUPIED HEAT/COOL: Each VAV terminal shall use pressure-independent control, with airflow measurement, to vary primary airflow and/or modulate (or stage) heat to maintain zone temperature at its occupied setpoint. The RTU shall modulate the supply fan to maintain duct static pressure at setpoint and modulate (or cycle) compressors, modulate (or stage) heat, and/or enable airside economizing to maintain discharge air temperature at setpoint. The OA damper shall modulate, in proportion to changing supply fan speed, to bring in the required amount of ventilation.

2. MORNING WARM-UP/PRE-COOL: Each VAV terminal unit shall vary primary airflow and/or modulate (or stage) heat to raise/lower zone temperature to its occupied setpoint. The RTU shall modulate the supply fan to maintain duct static pressure at setpoint and modulate (or cycle) compressors or modulate (or stage) heat to maintain discharge air temperature at setpoint. The OA damper shall remain closed, unless economizing.

3. FAN-PRESSURE OPTIMIZATION: The System Controller shall monitor all VAV damper positions and reset the RTU's duct static pressure setpoint based on the position of the furthest-open damper.

4. DISCHARGE AIR TEMPERATURE RESET: The System Controller shall reset the RTU's discharge air temperature setpoint based on the current outdoor air temperature or zone cooling/heating demand.

TRANE TECHNOLOGIES

Trane - by Trane Technologies (NYSE: TT), a global climate innovator - creates comfortable, energy efficient indoor environments for commercial and residential applications. For more information, please visit trane.com or tranetechnologies.com.

Trane has a policy of continuous product and product data improvement and reserves the right to change design and specifications without notice. We are committed to using environmentally conscious print practices.

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