System Catalog

CoolSense® Integrated Outdoor Air System

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CoolSense™ Integrated Outdoor Air System

As buildings are designed for lower energy use, the resulting reduction in cooling loads presents an economically-feasible opportunity for systems that use zone-level, sensible-only cooling equipment.

The Trane® CoolSense™ system combines a dedicated outdoor-air system (DOAS) with chilled-water, sensible-cooling terminal units to deliver a flexible, energy-efficient solution to provide comfortable spaces and simplify maintenance.

Efficient operation

CoolSense™ integrates variable-speed fan control in both the terminal units and DOAS to minimize fan energy. Decoupling dehumidification from zone sensible cooling allows for higher-efficiency cooling with warmer chilled water. The airflow-measuring damper in each terminal unit maintains the outdoor airflow required in each zone at any given time. Plus, demand-controlled ventilation (DCV) sequences (using either a CO_2 sensor or occupancy sensor) are pre-engineered into the factory-mounted unit controller. All of these features lead to efficient operation.

Engineered for repeatable performance

Trane factory-installed and -commissioned Symbio® controllers and Air-Fi® Wireless controls allow for fast project completion. Pre-engineered applications in Tracer® SC+ ensure coordinated control of the chiller plant, DOAS, and terminal units.

Comfortable spaces

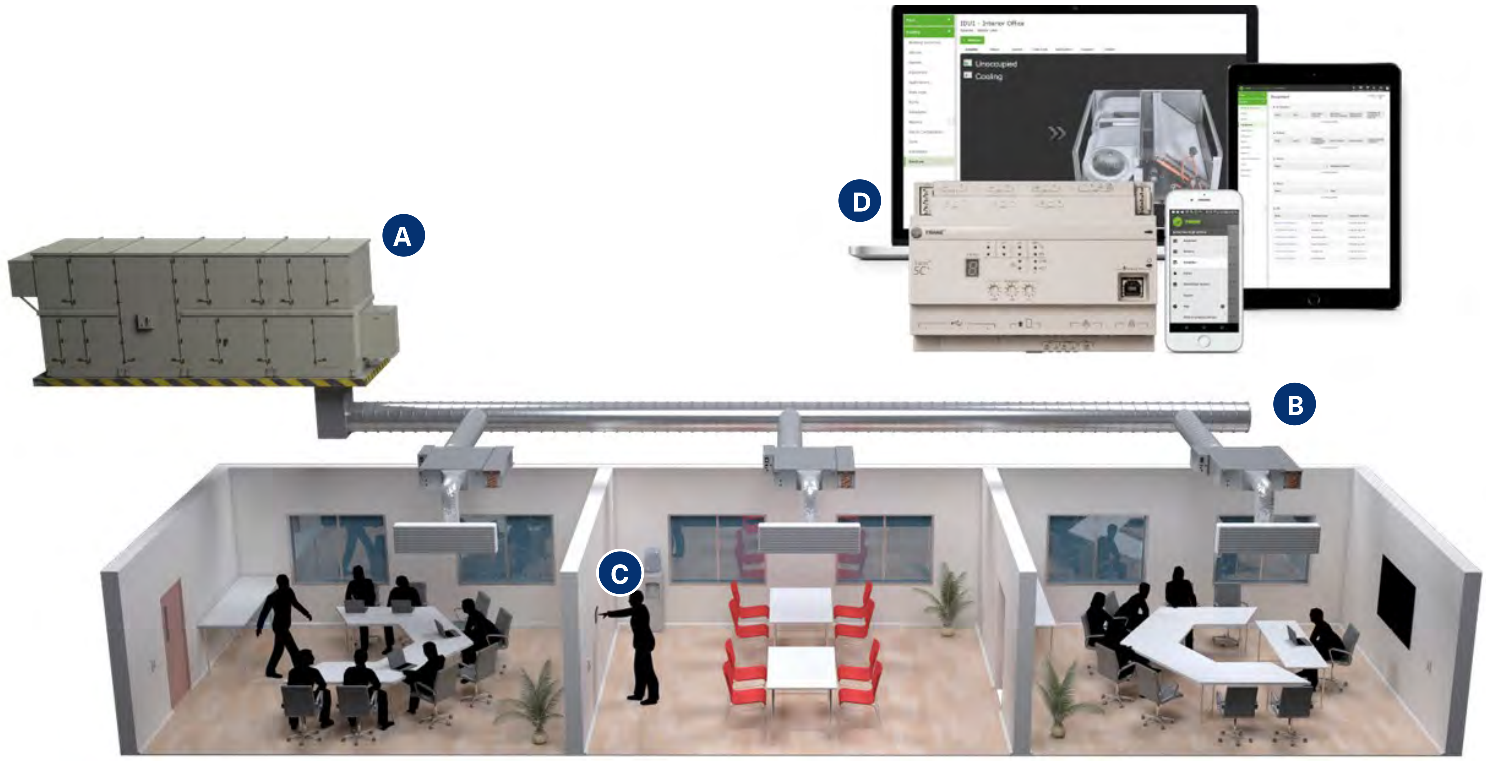
Each terminal unit is controlled by a zone temperature sensor, and contains its own cooling coil and (optionally) either a hot-water coil or electric heater, allowing each zone to receive cooling or heating as needed. Dehumidification is provided by the centralized DOAS; and when equipped with a zone humidity sensor, the terminal unit adjusts dehumidified airflow from the DOAS to actively control humidity in the space, ensuring a comfortable environment.

Flexibility in design and remodel

The DOAS is typically sized for only the minimum ventilation airflow required, in turn requiring less ceiling plenum height and allowing for more usable space inside the building. Reconfiguring a zone often requires moving only the downstream flex duct and supply-air diffusers; the sensible-cooling terminal units and water piping often do not need to move. And the sensible-cooling terminal units can be equipped with a separate hot-water coil or electric heater, if necessary, or the chilled-water coil can be used for heating in a “changeover” system.

Low maintenance

No condensation occurs at the zone-level terminal units, meaning no drain pans to clean and no condensate traps and piping to install and maintain. And since the cooling coil in each terminal unit operates dry, an upstream filter is optional.



CoolSense™ Integrated Outdoor Air is a pre-packaged HVAC system that:

- Combines a dedicated outdoor air system (DOAS) with sensible cooling and heating terminals in the zones
- Decouples ventilation and dehumidification from zone sensible cooling and heating, and reduces (or shuts off) ventilation in response to zone occupancy

More information can be found at www.trane.com/CoolSense

A Trane air-handling units provide high efficiency, low leakage, installation flexibility, and factory-installed controls. Options include indoor or outdoor models, a variety of exhaust-air energy-recovery options, and desiccant dehumidification. Alternatively, some system designs use a Trane Horizon® DX dedicated outdoor-air unit.

B Trane terminal units offset zone sensible cooling and heating loads with variable-speed fans, using pre-packaged, factory-installed controllers that include demand-controlled ventilation, active humidity control, and condensation avoidance.

C Wired or wireless zone sensors communicate with the terminal unit controller to maintain occupant comfort. Four-function sensors combine temperature, humidity, CO_2 and occupant sensing.

D Tracer® SC+ system controls coordinate operation of the terminal units, DOAS, and chiller plant to ensure occupant comfort and minimize energy use.

System Benefits

The CoolSense™ Integrated Outdoor Air System was developed to solve a number of issues that are difficult to overcome in other systems.

Comfort control without reheat

Terminal systems use a combination of conditioned outdoor air and recirculated room air to cool and heat each zone. They are capable of controlling the temperature in many zones with dissimilar cooling and heating loads, while avoiding (or minimizing) the reheating of previously-cooled air. This is because most of the sensible cooling is done at the zone level. Also, reclaimed heat in the recirculated air from a ceiling plenum can provide the first stage of heating. Because only the minimum outdoor air required for ventilation is ever reheated, there are no code limitations on the use of reheat.

High indoor air quality

The foundation of good indoor air quality is proper ventilation, which uses energy to properly condition this air over many hours of the year. The CoolSense™ system balances energy efficiency with proper ventilation by bringing in no more than the minimum amount of outdoor air required for ventilation or dehumidification, at all operating conditions, to all zones. In addition, sensible-only cooling coils in the zone-level terminal units are dry, which means they typically stay cleaner. Centralized condensate collection at the DOAS allows for easier condensate recovery for on-site reuse and water savings.

Lower installation costs

Decoupling ventilation from space temperature control means smaller ducts that cost less to install. Sensible-only cooling coils eliminate the need for condensate traps and drain lines installed throughout the building. Using wireless controls eliminates the need for low-voltage control wiring and simplifies commissioning.

Coordinated, integrated system

Other terminal (zone-based) systems with DOAS can provide comfort and flexibility. But comfort can mask energy waste, due to uncoordinated system components. This is in part due to some designers' preference to dehumidify the outdoor air to a low dew point, and then reheat it to a "space neutral" dry-bulb temperature. This neutral-air delivery may simplify the interaction between the DOAS and terminal units, but it wastes energy. The CoolSense™ system does not need this simplification because the dehumidified outdoor air is delivered to the inlet of each terminal unit, via a pressure-independent airflow-measuring damper. Any sensible cooling performed by the dehumidified outdoor air reduces the sensible cooling required by the terminal unit's cooling coil. This limits energy waste in the DOAS (less reheating) and in the terminal units (less recooling).

Warmer chilled water, lower chiller energy

Sensible-only cooling in the terminals is accomplished with warmer water than in systems that combine both sensible cooling and dehumidification. This can allow a chiller to operate at a warmer setpoint and use less energy. Latent loads are handled by a dehumidifying coil in the DOAS that requires colder water. A properly-designed and -operated dual-temperature, chiller plant can lead to significant building energy savings. The warmer water temperature for sensible cooling also increases the number of hours when a waterside economizer can be used, compensating for the reduced airside economizing opportunity afforded by the DOAS.

Demand-controlled ventilation, simplified

In spaces with a varying number of occupants, the terminal unit controller dynamically adjusts the outdoor airflow delivered to the zone, using a pressure-independent airflow-measuring damper and a CO_2 (or occupancy) sensor. This minimizes the quantity of outdoor air that must be conditioned and delivered by the DOAS, and minimizes the use of zone-level heating to avoid overcooling any zones.

Simpler-to-design ventilation system

Because 100% outdoor air is delivered by the DOAS, each zone is considered a "Single-Zone" ventilation system by ASHRAE Standard 62.1. This avoids the need to use the complicated "Multiple-Zone Recirculating" system equations. And because each terminal unit is equipped with a pressure-independent airflow-measuring ventilation damper, it's easy to document outdoor airflow delivered to each zone.

Smaller ductwork, higher ceilings

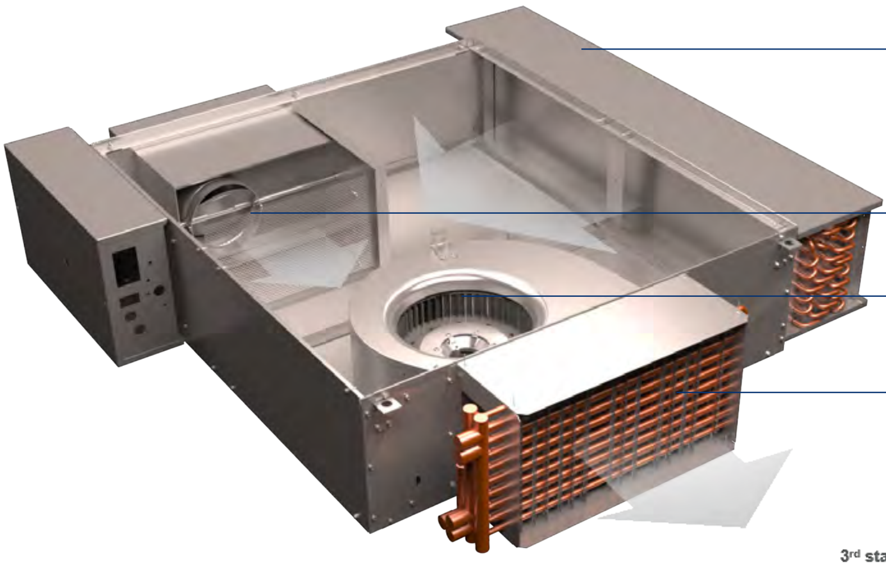
DOAS ductwork is typically sized for only the minimum outdoor airflow required for ventilation and dehumidification, rather than the total cooling load. Trane sensible-cooling terminals are available in heights as low as 10.5 in. tall. Smaller ducts and shorter terminals can help solve space constraints in retrofits, or to make indoor environments more aesthetically pleasing through higher ceilings.

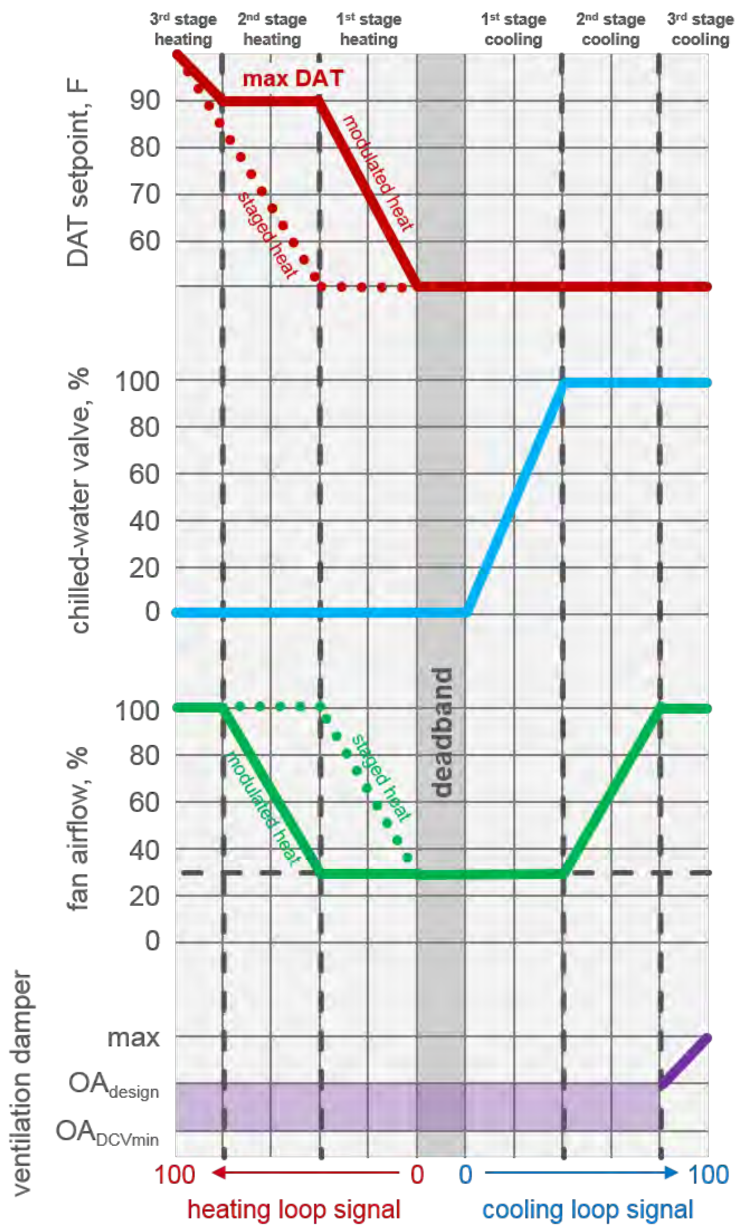
Efficient fan operation

Each terminal fan is equipped with a high-efficiency, electronically-commutated motor that varies fan speed to match the current cooling or heating demand in the zone. And because each terminal is equipped with an airflow-measuring ventilation damper, the CoolSense™ system can minimize airflow delivered by the DOAS to meet the current ventilation and dehumidification need of each zone. Oftentimes, traditional dedicated outdoor air systems use constant-speed fans with no zone-level dampers.

For many types of spaces, ASHRAE Standard 62.1 allows outdoor airflow to be reduced to zero during "occupied standby" mode, which is when a zone is scheduled to be occupied but an occupancy sensor indicates that no people are currently present in the zone.

Sensible-Cooling (and Heating) Terminal Unit



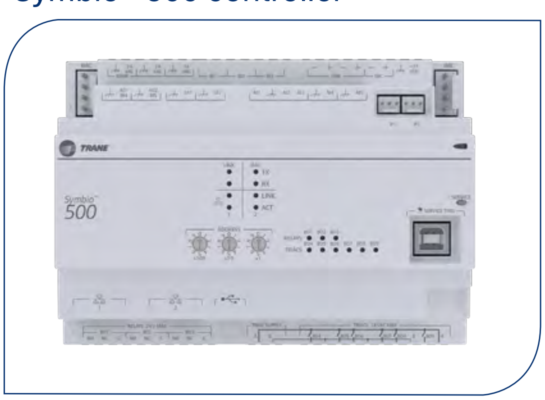


Modes of operation

The easiest way to understand how the CoolSense™ system is different from other terminal systems is to study the terminal unit's Symbio® 500 controller sequence of operation. In the control mode chart shown, the X axis is the sensible load in the zone, with design heating load on the far left and design cooling load on the far right.

Heating capacity (and the discharge-air temperature setpoint), chilled-water valve position, terminal fan airflow, and ventilation damper position are shown on the Y axes. See the next page for a narrative of cooling and heating operation during occupied modes, as well as other sequences such as demand-controlled ventilation, active humidity control, and condensate avoidance.

Symbio® 500 controller



Occupied mode, deadband

When the zone temperature is satisfied (in the deadband between its heating and cooling setpoints, depicted by the vertical grey bar in the center of the chart), the terminal fan operates at its minimum fan airflow setpoint, with both the chilled-water and hot-water valves closed (or electric heater off). The ventilation damper is controlled to its active ventilation airflow setpoint.

Occupied mode, cooling

When the zone temperature rises to its cooling setpoint, both the terminal fan speed and chilled-water valve are modulated to maintain zone temperature at setpoint, while the hot-water valve remains closed (or electric heater remains off). Moving from deadband to the right in the chart:

1st stage cooling. The chilled-water valve is modulated further open to maintain zone temperature at its cooling setpoint, while the fan remains operating at its minimum fan airflow setpoint and the ventilation damper remains at its active ventilation airflow setpoint.

2nd stage cooling. When the requested cooling capacity has increased to the point where the chilled-water valve is 100% open, the fan speed is increased to maintain zone temperature at its cooling setpoint, while the chilled-water valve remains fully open and the ventilation damper remains at its active ventilation airflow setpoint.

3rd stage cooling ("boost" mode). If the fan reaches its maximum fan airflow setpoint, but even more cooling capacity is required, the ventilation air damper can be modulated further open (increasing the flow rate of cool, dehumidified air from the DOAS) to maintain zone temperature at its cooling setpoint, while the chilled-water valve remains fully open and the fan continues operating at its maximum airflow setpoint.

Occupied mode, heating

When the zone temperature drops to its heating setpoint, both the terminal fan speed and hot-water valve (or electric heater) are modulated to maintain zone temperature at setpoint, while the chilled-water valve remains closed, and the ventilation damper is controlled to its active ventilation airflow setpoint. Moving from deadband to the left in the chart:

1st stage heating. First, the hot-water valve (or SCR electric heater) is modulated to maintain zone temperature at its heating setpoint, while the fan remains operating at its minimum fan airflow setpoint.

2nd stage heating. When the discharge-air temperature (DAT) has reached the desired maximum limit (90°F, in this example), the fan speed is increased to maintain zone temperature at its heating setpoint, while the hot-water valve (or SCR electric heater) modulates to maintain DAT at this maximum limit.

3rd stage heating. If the fan reaches its maximum fan airflow setpoint, the hot-water valve (or SCR electric heater) is allowed to modulate further open to maintain zone temperature at its heating setpoint.

For terminal units equipped with a staged electric heater (or without a DAT sensor), the heating sequence is reversed (depicted by dashed lines in the chart). First, fan speed is increased while the electric heater remains off. Then when the fan has reached its maximum fan airflow setpoint, the electric heater is staged on to maintain zone temperature at its heating setpoint.

Demand-controlled ventilation (DCV)

By installing a CO_2 sensor (or an occupancy sensor) in the zone, outdoor airflow delivered to the terminal unit is adjusted by modulating the airflow-measuring ventilation damper between the outdoor airflow required at design population (OA_{design}) and the minimum allowable outdoor airflow with DCV (OA_{DCVmin}), based on the current CO_2 concentration in the zone.

This DCV sequence can be overridden (increasing the flow rate of cool, dehumidified air from the DOAS) if additional cooling (see "3rd stage cooling") or dehumidification (see "Active humidity control) is needed.

Condensation Prevention

One of the most common concerns expressed about sensible-cooling systems is the fear of condensation. Trane has addressed this by providing three levels of condensate protection in the Symbio® 500 controller on the sensible-cooling terminal unit.

Moisture sensor in the drip pan

While the sensible cooling coil in the terminal unit is intended to operate dry (no condensation), every Trane sensible-cooling terminal unit is equipped with a drip pan underneath this coil in the event that unintended condensation should occur. A moisture sensor is mounted in this drip pan as standard.

If condensation is detected by this moisture sensor, the controller will temporarily close the chilled-water valve and send a diagnostic message. The terminal fan and ventilation continue to operate as normal, providing dehumidified air from the DOAS. When condensate is not longer detected, the controller will return to normal operation and allow the chilled-water valve to open.

Moisture sensor

Active humidity control

If the optional zone humidity sensor is installed, the controller will monitor the current dew-point temperature in the zone. If the zone dew point rises above the desired limit, the controller can modulate the ventilation damper further open. This increases the flow rate of dehumidified air from the DOAS, lowering the zone dew-point temperature.

Condensation avoidance mode

This mode also requires installation of the optional humidity sensor, and predicts a situation that could lead to condensation; acting before any moisture is sensed in the drip pan.

If the current zone dew-point temperature was to rise above the entering chilled-water temperature, the controller will temporarily close the chilled-water valve and send a diagnostic message. The terminal fan and ventilation continue to operate as normal, providing dehumidified air from the DOAS. When the zone dew point drops back down again, the controller will return to normal operation and allow the chilled-water valve to open.

Dehumidification Best Practices

Determining the DOAS supply-air dew point

In a CoolSense™ system, all of the zone latent load is offset by the dehumidified outdoor air delivered by the DOAS. To enable the terminal units to operate dry (no condensation), the DOAS must dehumidify the outdoor air to a dew-point temperature that is dry enough to offset the entire space latent load and maintain the zone dew point at or below about 55°F.

This required DOAS supply-air dew-point temperature depends on the zone latent load, zone outdoor airflow, and desired space dew point. The chart below illustrates how different space types require different DOAS supply-air conditions. For specific guidance on how to calculate the required DOAS supply-air dew point, see the Trane application guide "CoolSense™ System Design" (DOAS-APG001*-EN).

Trane CDQ® desiccant wheel

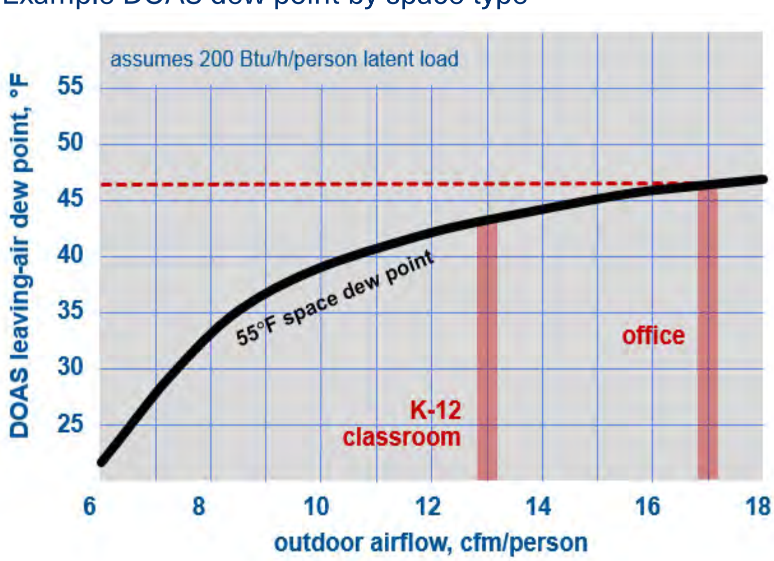
Trane air-handling units can be equipped with a desiccant wheel for improved dehumidification. The CDQ desiccant wheel adsorbs water vapor from the air downstream of the cooling coil and releases the collected moisture upstream of that coil, enabling the DOAS air handler to deliver drier supply air (at a lower dew-point temperature) without requiring a colder chilled-water temperature. Because the moisture transfer occurs within a single airstream, a separate regeneration airstream is not needed.

Humidity pull-down mode

If indoor humidity levels increase during unoccupied periods (e.g., overnight or over a weekend), humidity pull-down may be needed to lower the indoor dew-point temperature and avoid condensation at the zone-level terminal units at startup.

When these conditions are identified, the Tracer® SC+ system-level controller directs the terminal units to open their ventilation dampers and start their terminal fans, while keeping the chilled-water valves on the sensible cooling coils closed. The DOAS starts up (ideally using 100% recirculated air, if it is humid outside) and begins supplying dehumidified air to lower ("pull-down") the indoor dew-point temperature. The system operates in this mode long enough for the humidity level inside the building to reach the desired dew point (55°F for example), before the chilled-water valves in the terminal units are allowed to open.

Example DOAS dew point by space type



Exhaust-Air Energy Recovery

Because the CoolSense™ system uses 100% outdoor air, many energy codes may require exhaust-air energy recovery.

What is exhaust-air energy recovery?

Exhaust-air energy recovery refers to the transfer of sensible heat, or sensible heat and moisture (latent heat), between the incoming outdoor airstream and the leaving exhaust airstream. This preconditions the outdoor air being brought in for ventilation, reducing the cooling, dehumidification, and heating loads on the DOAS equipment.

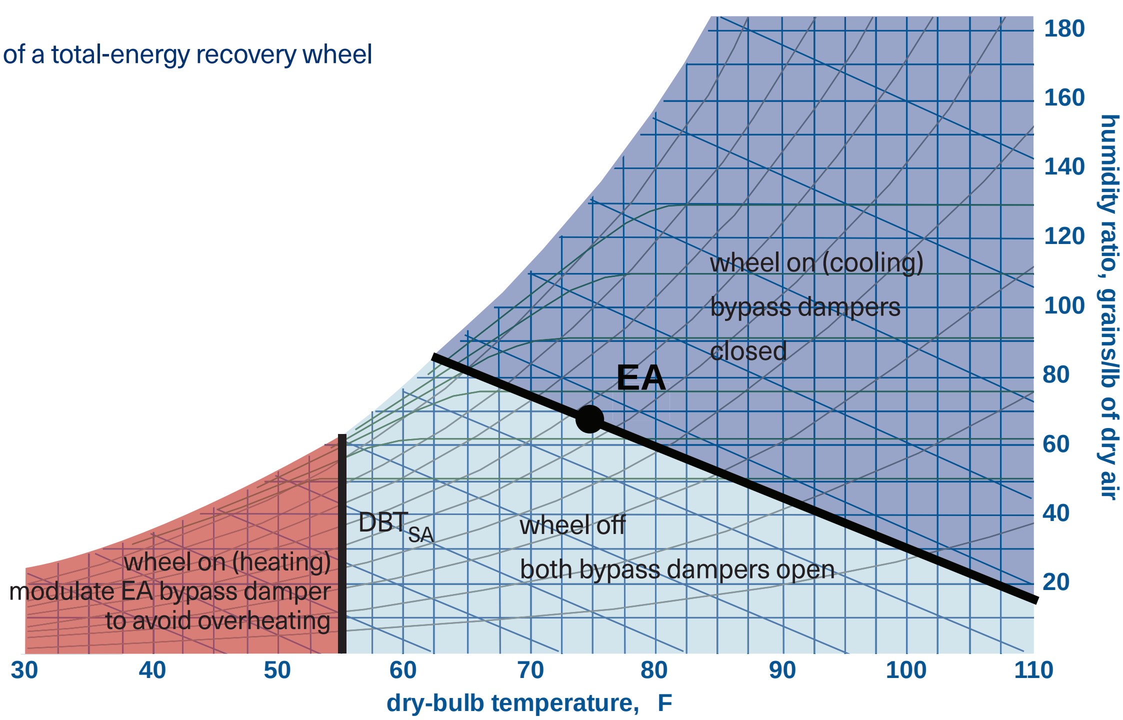
Best practices

- Strive for balanced outdoor and exhaust airflows
- Select the technology most suitable for the application
- Provide a method to control the capacity of the device to avoid overheating at part load (see control mode chart, below)
- Provide a means for frost prevention in cold climates

Frost prevention

Any exhaust-air energy-recovery device that preconditions outdoor air may be subject to frost buildup during very cold weather. If the surface temperature of the device falls below the dew-point temperature of the exhaust air, water vapor can condense on the exhaust side of the device. If the exhaust-side surface temperature falls below 32°F, this water freezes (frosts), eventually blocking airflow. One of the benefits of a total-energy recovery device over sensible-only energy recovery is that frost forms at a much colder outdoor temperature, which may even eliminate the need for frost prevention.

Control of a total-energy recovery wheel



Total-energy wheel. This desiccant-coated wheel offers an excellent combination of high sensible and latent effectiveness, and is ideally suited for hot/humid and cold climates, where latent energy recovery during both the summer and winter seasons is desirable. Capacity modulation is best accomplished using an exhaust-side bypass damper. Cross leakage is limited by choosing the proper locations for supply and exhaust fans.

Fixed-plate (sensible) heat exchanger. Cross-flow aluminum plates deliver high sensible effectiveness. Capacity modulation is accomplished using integral face-and-bypass dampers. A primary advantage is little to no cross leakage. However, this technology is the most susceptible of all technologies to frost formation during cold weather.

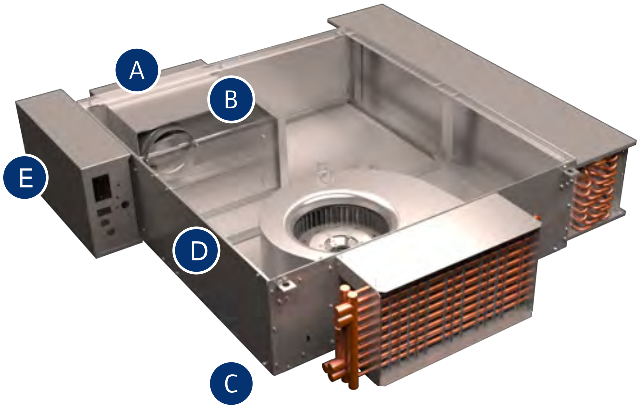
Sensible-assisted membrane. The sensible-assisted membrane (SAM™) substitutes membrane modules into half of the fixed-plate heat exchanger framework. This boosts sensible effectiveness, provides good latent effectiveness, and lowers the pressure drop compared to other membrane designs. SAM also allows different airflow configurations for greater layout flexibility.

Impact of DOAS configuration on coil loads and chilled-water supply temperatures

DOAS configuration component	cooling coil and reheat only	cooling coil(s), total-energy wheel, reheat		cooling coil(s), total-energy wheel, CDQ® wheel		cooling coil(s), total-energy wheel, fixed-plate HX		cooling coil, SAM, reheat
upstream cooling coil	single coil	single coil	dual coil	single coil	dual coil	single coil	dual coil	single coil
design load, tons			30		37		8	
supply-water temperature			57°F		57°F		57°F	
downstream cooling coil								
design load, tons	172	107	77	96	59	85	77	117
supply-water temperature	40°F	40°F	40°F	45°F	45°F	40°F	40°F	40°F
supply-air conditions								
dry-bulb temperature	49°F	49°F	49°F	55°F	55°F	64°F	64°F	49°F
dew-point temperature	47°F	47°F	47°F	47°F	47°F	47°F	47°F	47°F
sensible cooling by conditioned OA, tons	68	47	47	36	36	20	20	67
total DOAS design loads								
on warm-water chiller, tons			30		37		8	
on cold-water chiller, tons	172	107	77	96	59	85	77	117

This example compares several DOAS configurations, each delivering 20,000 cfm of conditioned OA at a 47°F supply-air dew-point temperature. Without exhaust-air energy recovery (left column), the system requires 172 tons of cooling capacity. A system with a total-energy wheel and a fixed-plate heat exchanger for reheat requires as few as 85 tons and uses no new energy for reheating to supply air at 64°F dry bulb. But warmer supply air from the DOAS requires the terminal units to be sized for more cooling capacity. Adding a CDQ wheel allows the DOAS to deliver the same supply-air dew point with warmer water supplied to the cooling coil. The impact of using two cooling coils in series with different temperatures is also shown, which in turn affects chiller and pump energy. For further discussion of these configurations, the CoolSense System Design Guide (DOAS-APG001*-EN).

Sensible-Cooling Terminal Units



- **A** Trane flow ring for accurate measurement of ventilation
- **B** Heavy gauge air valve cylinder for durability
- **C** Interlocking panels for extremely rugged construction
- **D** Insulation edges encapsulated with metal to prevent erosion into the airstream
- **E** Factory-commissioned DDC controls with pre-engineered sequences; wired or wireless communication

Trane sensible-cooling terminal units feature proven components, such as the patented Trane flow ring and the Trane Symbio® 500 controller. All products are UL listed for safety and provide proven performance in accordance with industry standard AHRI® 880, Performance Rating of Air Terminals.

All unit controls are factory commissioned, meaning that airflow and temperature setpoints, and addressing are performed in a controlled, factory environment. One hundred percent factory run testing ensures that terminal units arrive and function properly upon job startup. Factory-commissioned controls result in a higher quality installation at a lower cost.

Symbio® 500 controller

Trane sensible-cooling terminal units

- Up to 2200 nominal cfm
- Variable-speed fan with EC motor adjusts airflow as the zone load changes
- 4-row or 6-row sensible-cooling coil mounted at the inlet from the ceiling plenum; modulating control valve; drip pan with factory-installed moisture sensor
- Options for no heat, modulating hot-water valve, staged electric heater, or modulating (SCR) electric heater
- Optional MERV 8 or MERV 13 filter for recirculated air
- Conditioned outdoor air from the DOAS unit enters through a pressure-independent, airflow-measuring ventilation damper

Terminal control using the Symbio® 500

Pre-engineered, factory-commissioned programming in the DDC controller, includes all cooling, heating and ventilation functions for the zone, as well as condensate detection using a moisture sensor mounted in the drip pan. An optional CO_2 sensor enables the pre-engineered demand-controlled ventilation (DCV) sequence, while an optional space humidity sensor enables the pre-engineered active humidity control and condensate avoidance sequences.

Option for Air-Fi Wireless controls

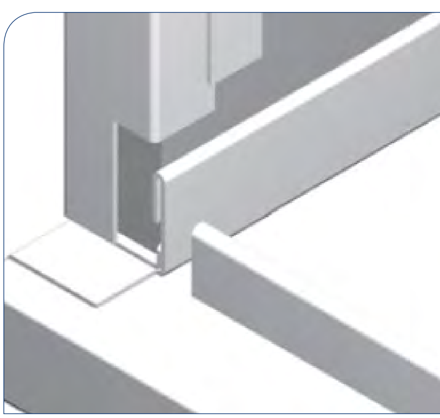
- Wireless zone sensors increase location flexibility with less disruption to occupants
- Self-healing wireless mesh, extended signal range, and conformance to the ZigBee® Building Automation standard
- Up to four functions in one sensor (dry-bulb temperature, humidity, CO_2 and occupancy)

Accurate airflow measurement

- Patented, multiple-point, averaging flow ring for unmatched measurement accuracy
- Air valve designed to limit inlet deformation and provide consistent and repeatable airflow across the flow ring
- Ensures proper ventilation at all times

Factory-commissioned controls

- Pre-engineered controls and factory commissioning lead to fast, easy installation and standardized operation
- Options for demand-controlled ventilation, active humidity control, and condensate avoidance
- Mobile apps allow access from virtually anywhere

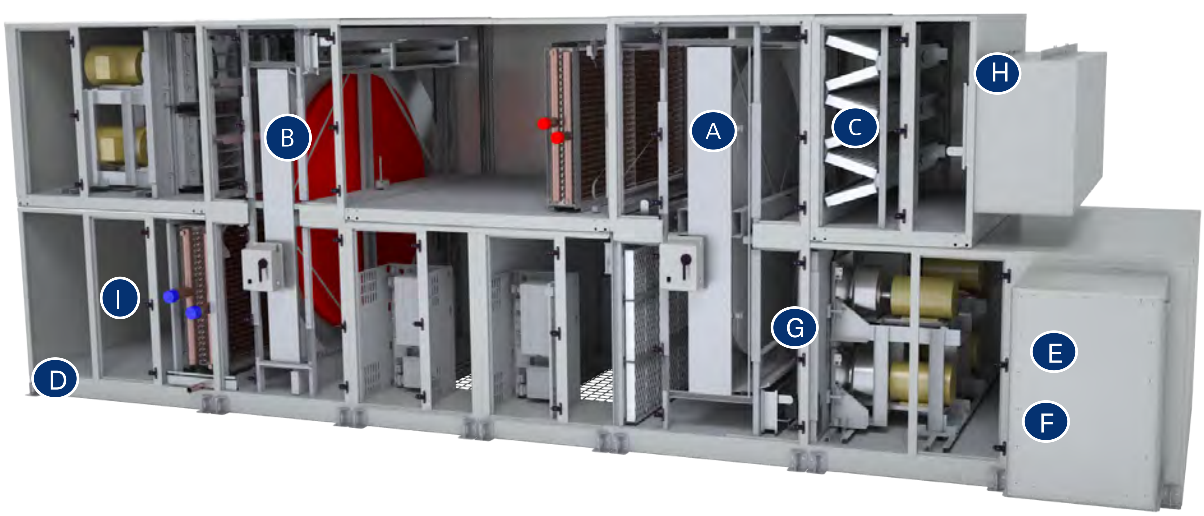


Other features

- Insulation options include matt-faced, foil-faced, double-wall or closed-cell, all with encapsulated edges
- Proportional 2-way or 3-way control valves
- Automatically-calibrated air valve at time of power cycle or as requested
- Optional MERV 8 or MERV 13 filter may be installed at inlet to the cooling coil

Performance Climate Changer® Air Handler

- **A** Exhaust-air energy recovery options: total-energy wheel, fixed-plate HX, sensible-assisted membrane, coil runaround loop
- **B** Trane CDQ® desiccant wheel deliver lower leaving-air dew point without requiring colder chilled water
- **C** Options for MERV-rated filters, including angled orientation for reduced pressure drop
- **D** Thermally-isolated, rigid casing design: R-13 foam-injected panels and doors, full thermal breaks, withstands ± 8 in. w.g.
- **E** Factory-installed DDC controls
- **F** Single-point power and quick-connect wiring minimizes installation cost and ensures wiring integrity between sections
- **G** Efficient fan selections for a wide range of pressure requirements
- **H** Low-leak casing, rated and tested to ASHRAE® Standard 111 Class 6
- **I** Optional second (upstream) cooling coil allows a portion of DOAS cooling load to use warm chilled water from a dual-temp plant



CDQ® desiccant dehumidification

- Type III desiccant wheel enables a lower leaving-air dew-point temperature without requiring the use of colder chilled water
- Requires little or no added heat for regeneration of the desiccant

Air cleaning options

- UVC cleaning modules disinfect wet surfaces
- MERV-rated filters remove small particles
- Pre- and post-filter options available
- Sensible-cooling terminal units typically do not require a filter, since the coil operates dry. An optional MERV 8 filter is available for enhanced cleaning of the recirculated air.

Exhaust-air energy recovery options

- Total-energy wheel for hot/humid and cold climates
- Sensible-assisted membrane (SAM™) for high sensible effectiveness, good latent effectiveness, and no moving parts
- Sensible-only, fixed-plate heat exchange for dry/marine climates or to minimize cross leakage
- Dual-exhaust energy recovery (DEER) can recover energy from restroom exhaust

Space-conforming flexibility

- FlexFit® knock-down solution allows full or partial assembly on-site for tight installs
- Variable aspect ratio allows air-handler to be configured to fit uniquely shaped equipment rooms or existing footprint
- Direct-drive plenum fans, fan arrays, and motorized impellers shorten the cabinet and create new configuration options

DOAS Air Handler Configurations

In a CoolSense™ system, all the zone latent load is offset by dehumidified outdoor air delivered by the DOAS. To enable the terminal units to operate dry (no condensation), the DOAS must dehumidify the OA to a dew-point temperature that is dry enough to offset the entire zone latent load and maintain the space dew point at or below about 55°F. The terminal units are then supplied with 57°F water for sensible-only cooling. But this water temperature is not cold enough to sufficiently dehumidify the OA, so the chiller plant must be designed to supply two different water temperatures (see page ??). Alternatively, some designs use a packaged DX dedicated OA unit and a chiller plant that supplies 57°F water (see page ??).

Two temperatures, two cooling coils?

For a system that includes a dual-temperature chiller plant, an energy-saving option is to add a second upstream cooling coil supplied with the 57°F water produced for the terminal units. This upstream coil handles a portion of the DOAS cooling load, shifting it to the more-efficient chiller(s) that produce the warmer water temperature.

The downstream cooling coil is supplied with water cold enough (typically 40°F to 45°F) to dehumidify the OA so it is dry enough to offset the zone latent loads and maintain 55°F dew point in the space.

Exhaust-air energy recovery and desiccant wheel

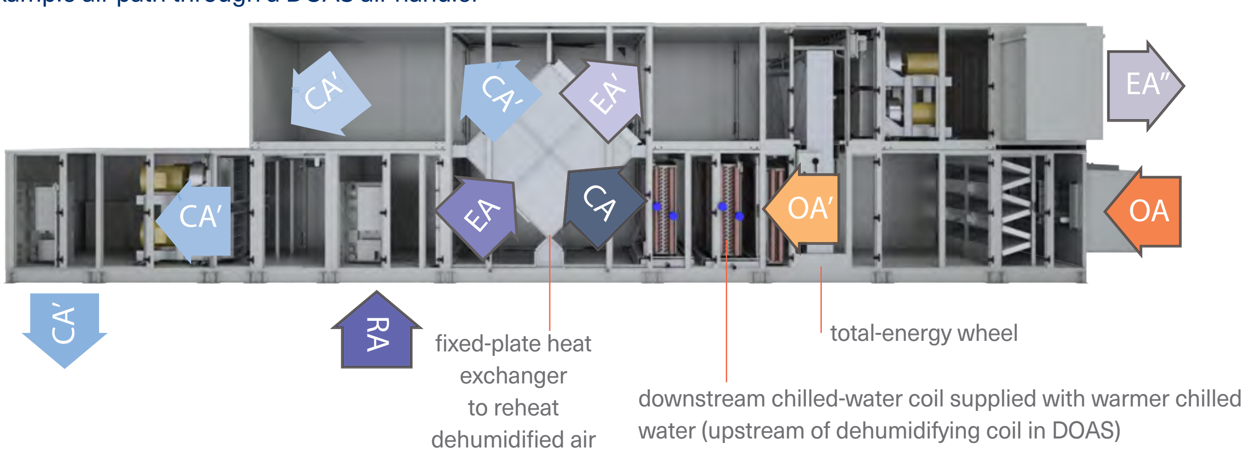
Exhaust-air energy recovery is likely required by the energy code for a DOAS. This reduces heating and cooling energy by using exhaust airstream to precondition the incoming outdoor airstream.

Desiccant dehumidification can further reduce chiller energy. The Trane CDQ® desiccant wheel allows the DOAS to achieve its target leaving-air dew-point temperature with warmer-temperature water than a unit without CDQ.

Best practices in DOAS air handler design

- Incorporate exhaust-air energy recovery to reduce cooling and heating energy use.
- Compare the various configurations based on the required supply-air dew-point temperature.
- Consider an air handler configurations that maximize the efficiency of the chilled-water plant.

Example air path through a DOAS air handler

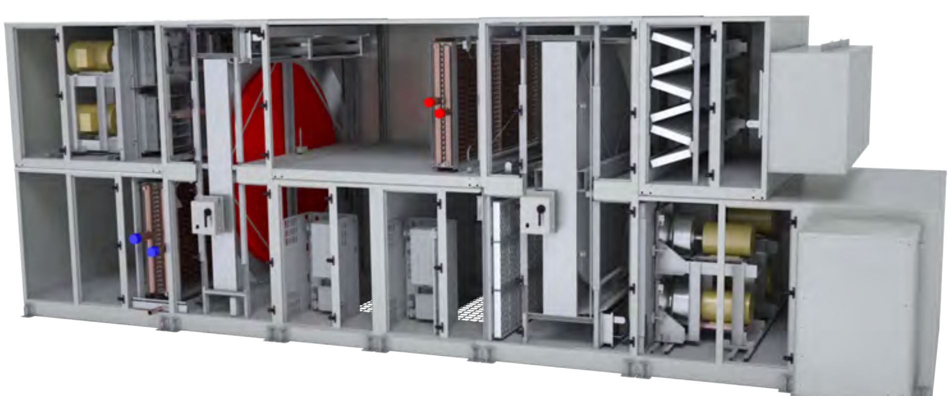


Cooling coil(s) with exhaust-air energy-recovery

This configuration depicts a total-energy wheel for exhaust-air energy-recovery and two cooling coils in series. A recirculating air damper is used during unoccupied periods. A sensible-assisted membrane (SAM™) could be used in place of the wheel.

Cooling coil(s) with exhaust-air energy-recovery and fixed-plate heat exchanger

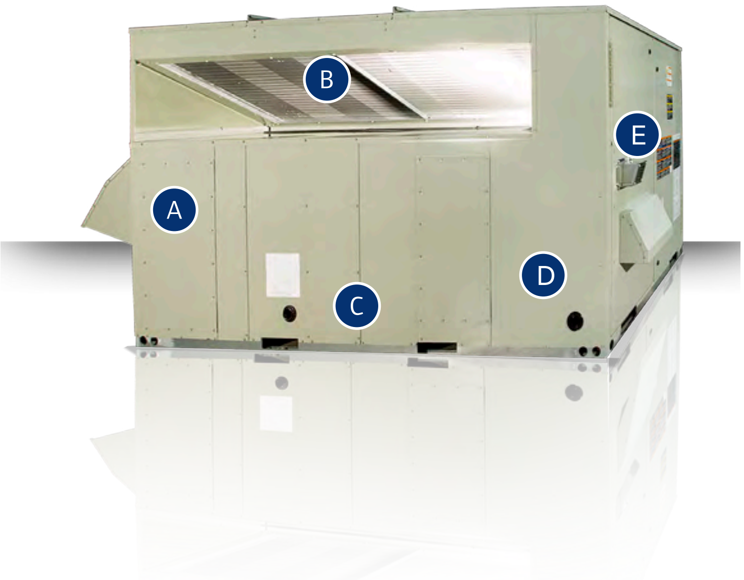
This configuration depicts a total-energy wheel for exhaust-air energy-recovery, two cooling coils in series, and a downstream fixed-plate heat exchanger to reheat the dehumidified air. Cold air leaving the cooling coils is reheated using heat recovered from the exhaust airstream; this has the added benefit of pre-cooling the exhaust air, which improves the performance of the total-energy wheel. Face-and-bypass dampers within the fixed-plate heat exchanger allow for adjusting the leaving-air dry-bulb temperature.



Cooling coil(s) with exhaust air energy recovery and CDQ® desiccant wheel

This configuration depicts a total-energy wheel for exhaust-air energy-recovery, a single cooling coil (although two coils in series could be used), and a CDQ desiccant wheel in series with (wrapped around) the cooling coil. The CDQ wheel allows the air handler to use warmer chilled water to deliver required leaving-air dew-point temperature.

Horizon® Dedicated Outdoor-Air Unit



A DX cooling, air-source heat pump, water-source heat pump, or chilled-water configurations available

B High-performance condenser and evaporator coils with optional treatment for corrosion resistance

C Selectable discharge-air dew point temperature down to 43°F

D Variable-speed fans increase energy efficiency

E Factory-commissioned DDC controls with pre-packaged sequences of operation

The Trane Horizon™ dedicated outdoor-air unit is a packaged option for conditioning outdoor air (DOAS) and dehumidifying in a CoolSense™ system. Chilled water for the sensible-cooling terminal units would then be supplied by other equipment.

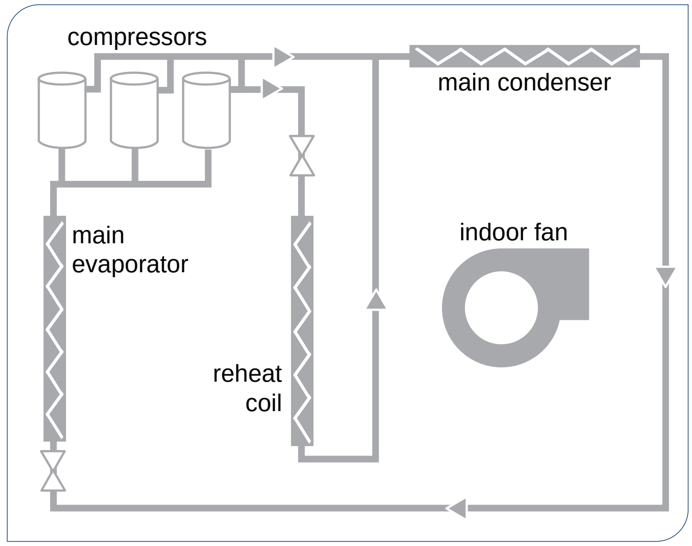
Options are available for exhaust-air energy recovery and hot gas reheat, which uses heat recovered from the DX refrigeration circuit to reheat the dehumidified outdoor air.

Horizon models and option availability

model	capacity range (DX cooling only)	capacity range (heat pump)	maximum airflow	exhaust-air energy recovery	hot gas reheat	airflow measurement
OAB	3 to 9 tons	3 to 9 tons	3000 cfm	optional	optional - DX only	optional
OAD	10 to 30 tons	10 to 20 tons	8000 cfm	optional	optional - DX only	optional
OAK	12 to 30 tons	22 to 30 tons	9000 cfm	optional	optional - DX only	optional
OAN (rev5)	35 to 60 tons	35 to 54 tons	13,500 cfm	optional	optional - DX only	optional
OAN (rev6)	65 to 80 tons		20,000 cfm	optional	optional - DX only	optional

Hot gas reheat

An advantage of a packaged dedicated OA unit is the proximity of condenser heat for reheating the air downstream of the evaporator coil. The CoolSense™ system requires the DOAS to supply air at a low dew-point temperature. Hot gas reheat can used to "temper" this cold, dry air to a more suitable supply-air dry-bulb temperature, without using new energy for reheat.



Options to save energy

- Exhaust-air energy recovery with bypass to reduce cooling and heating loads associated with conditioning outdoor air for ventilation
- Hot gas reheat uses condenser heat to "temper" the leaving-air dry-bulb temperature
- Variable-speed compressors available to improve part-load efficiency
- Variable-speed indoor fan ideal for use with the zone dampers in a CoolSense system
- Air- or water-source heat pump options available

Factory-installed controls

- Factory-installed and -tested controls minimize startup time
- Human interface with touchscreen for monitoring, editing and setpoint control; can be remote mounted for indoor access
- Airflow monitoring available for outdoor, exhaust, and/or supply airstreams

Chiller Plant Configurations

Because the CoolSense™ system requires the use of warmer chilled water in the sensible-cooling terminals, the configuration of the chilled-water system may deviate from traditional designs. The CoolSense System Design Guide (DOAS-APG001*-EN) describes several configurations that designers may consider for supplying two different water temperature.

Why two water temperatures?

In a CoolSense™ system, all the zone latent load is offset by dehumidified outdoor air delivered by the DOAS. To enable the terminal units to operate dry (no condensation), the DOAS must dehumidify the OA to a dew-point temperature that is dry enough to offset the entire zone latent load and maintain the space dew point at or below about 55°F. Dehumidifying the air to this dew point typically requires chilled water in the 40°F to 45°F range.

To avoid condensation on the sensible-only cooling coils in the terminal units, they are supplied with water that is warmer than the dew point in the space; typically in the range of 57°F to 60°F.

Why chilled water for both temperatures?

Some systems are designed with a chiller plant to provide 57°F water to the sensible-cooling terminal units, but then use a standalone, packaged DX unit for the DOAS, such as the Trane Horizon® dedicated outdoor air unit. While this approach simplifies the design of the chiller plant and benefits from operating the chiller at the warmer temperature, there is no redundancy if either the chiller or DX unit needs to be repaired, replaced, or serviced.

In addition to providing this redundancy, designing a chiller plant to serve both the space sensible cooling load and the ventilation/dehumidification load can increase system efficiency and employ other strategies like waterside heat recovery, thermal storage, and/or water economizing.

Best practices in dual-temperature plant design

- Evaluate the various configurations to find the one that best meets the objectives of the project.
- Keep glycol out of the terminal unit cooling coils. If glycol is needed for freeze protection at the chiller, use an intermediate heat exchanger to separate the glycol loop from the water loop serving the sensible-only cooling coils.
- Consider air handler configurations that maximize the efficiency of the chiller plant (see page 19).
- Make use of condenser heat recovery, thermal storage, and waterside economizing to maximize overall system efficiency.

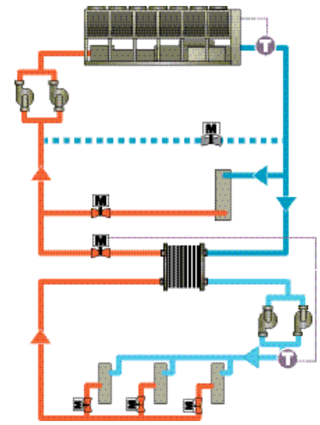
Comparison of dual-temperature chiller plant configurations

configuration	redundancy	waterside economizing	chiller freeze protection†	blending valve	thermal storage	condenser heat recovery
Single-chiller, dual-temp plant with heat exchanger	half (dual circuits)	option	yes	no	option	option
Single-chiller, dual-temp plant with blending valve	half (dual circuits)	option	no	yes	option	option
Single-chiller, dual-temp plant with energy storage	full (1-5 days typically)	option	yes	no	yes	option
Dual-chiller, dual-temp plant with heat exchanger	yes, option (chiller sizing)	option	yes	no	option	option
Dual-chiller, dual-temp plant with blending valve	yes, option (chiller sizing)	option	no	backup only	option	option
Dual-chiller, dual-temp plant with dedicated chillers	yes, option (chiller sizing)	option	no	backup only	option	option
Triple-chiller, N+1 dual-temp plant, dedicated chillers	yes	option	no	backup only	option	option

†Refers to the ability to use glycol for freeze protection, particularly in air-cooled chillers installed outdoors, without impacting sensible cooling-coil performance.

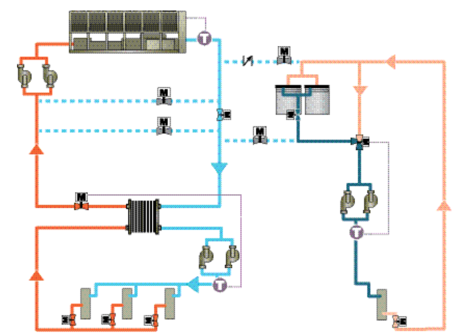
Single-chiller, dual-temperature plant with intermediate heat exchanger

In the configuration, the chiller produces cold fluid (typically 40°F, or 45°F if CDQ® wheel is used.) Some of this fluid is distributed to the cooling coil in the dedicated OA unit; the rest passes through an intermediate heat exchanger that is controlled to produce 57°F water for the sensible-only coils in the terminal units. The benefit of this configuration is simplified hydronics and control. But it precludes the efficiency benefit from operating the chiller at a warmer leaving-water temperature for space sensible cooling. During drier weather, when the DOAS dehumidifying coil is no longer needed (when the outdoor dew point is low), the leaving-water temperature setpoint for the chiller may be reset upwards.



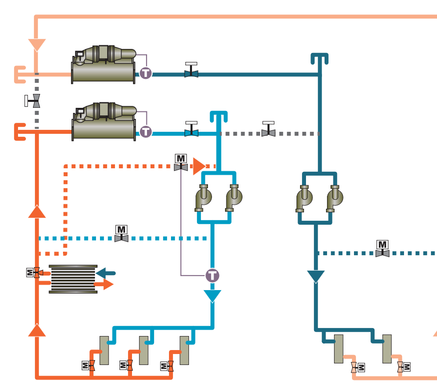
Single-chiller, dual-temperature plant with thermal energy storage

This configuration regains the chiller efficiency advantage of a warmer fluid temperature, which was lost in the preceding single-chiller plant. During daytime operation, stored energy from the tanks is used to produce cold fluid for the DOAS dehumidifying coil. The chiller setpoint is raised to 55°F and brine is sent to an intermediate heat exchanger, which produces 57°F water for the sensible-cooling terminal units. When the building is unoccupied at night, the chiller is used to stores energy in the tanks for the next day. This shifts the “cold-water” chiller load to the nighttime hours, when the cost of electricity is lower and chiller efficiency is higher due to cooler ambient temperatures.



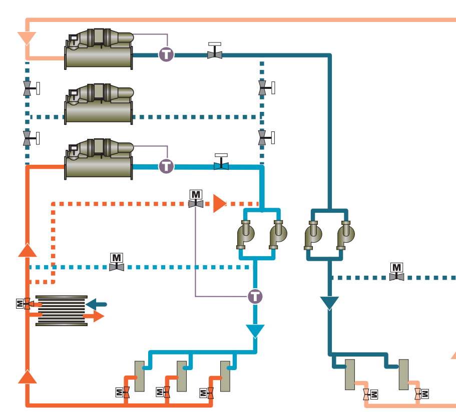
Dual-chiller, dual-temperature plant, no blending in normal operation

Many chiller plants include more than one chiller, to improve plant efficiency and provide redundancy if either of the chillers were to fail or require service. One chiller is selected and optimized to supply 57°F water to the sensible-cooling terminal units, while the second is optimized to supply colder water to the DOAS dehumidifying coils. The diagram shows a waterside economizer in the warmest section of the system, increasing the hours of free cooling operation. Interconnecting pipes and shutoff valves provide redundancy, enabling one chiller to serve both loops if needed; with the blending valve (which is not used in normal operation) ensuring that 57°F water is sent to the terminal units.



Triple-chiller, N+1 dual-temperature plant, no blending in normal operation

In addition to interconnecting pipes and shutoff valves, a third (N+1) chiller further increases redundancy if it is capable of providing either cool (57°F) or cold water, in the event that one of the other chillers is in need of service. If waterside economizing is desired, it is typically provided by a separate plate-and-frame heat exchanger connected to the condenser-water loop, or by equipping the “warm-water” chiller with a free cooling option. Chillers may be smaller because they don’t have to be the only chiller in operation. The blending valve is not used in normal operation, but can ensure that only 57°F water is sent to the terminal units.



Hydronic Branch Conductor

Four-pipe versus two-pipe distribution

Many terminal systems use one set of water pipes to distribute chilled water to the cooling coil in each terminal unit, and another set of water pipes to distribute hot water to a separate heating coil in each terminal unit. This is commonly called a four-pipe distribution system. The primary benefit of a four-pipe system is that some terminal units can receive chilled water for cooling while the remaining terminal units simultaneously receive hot water for heating.

Alternatively, some terminal systems use a common set of water distribution pipes to supply either chilled water or hot water to a dual-purpose (shared) coil in each terminal unit. This is commonly called a two-pipe system, and all of the terminal units receive only chilled water or only hot water. During mild weather, this may result in comfort problems in some zones. Of course, the primary benefit of a two-pipe distribution system is reduced installation costs, since only one set of pipes need to be installed throughout the building and each terminal unit is equipped with only one dual-purpose coil.

Combining four-pipe and two-pipe distribution

An alternate approach combines four-pipe and two-pipe distribution, to balance the benefits of each one. In this case, separate sets of chilled-water and hot-water pipes are routed to a Hydronic Branch Conductor that serves each unique AREA of the building. Downstream of each Conductor, a branch run that consists of one set of pipes connects to a dual-purpose coil in each terminal unit.

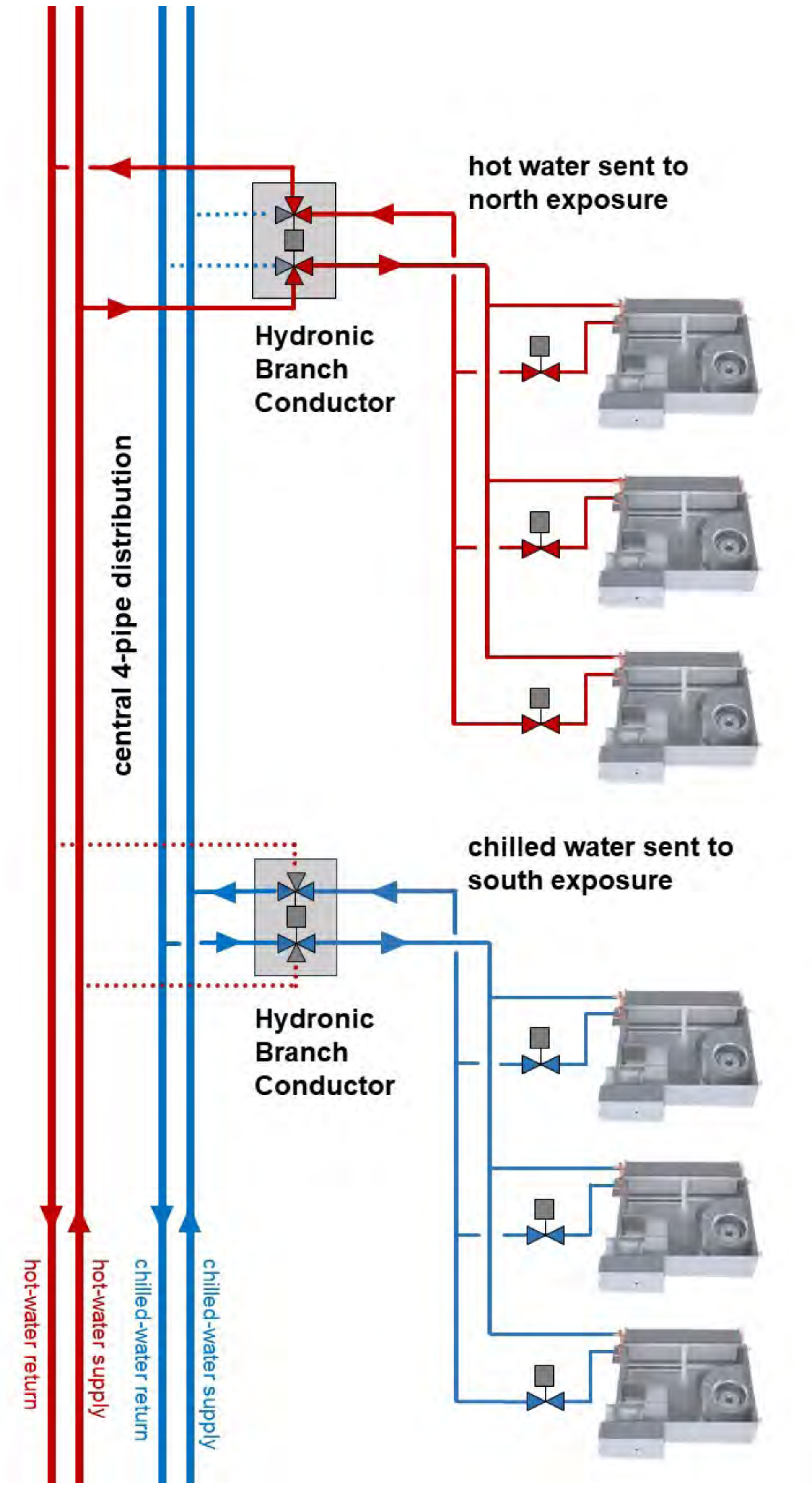
Each AREA is comprised of one or more zones that have similar thermal loads and temperature setpoints; each zone being served by a terminal unit. Based on information communicated from the terminal unit controllers, the building automation system determines if that AREA currently requires cooling or heating.

When cooling is required, the Hydronic Branch Conductor is instructed to position its valves to draw chilled water from the main chilled-water supply pipe and deliver it to the coils in all the terminal units in that AREA; water returning from these coils is directed back into the main chilled-water return pipe. When heating is required, the Conductor is instructed to position its valves to draw hot water from the main hot-water supply pipe and deliver it to the coils in all the terminal units in that AREA; water returning from these coils is directed back in to the main hot-water return pipe.

Benefits of this combined approach include:

- Each terminal unit need only be equipped with a single dual-purpose coil and a single control valve, which reduces its cost.
- Eliminating the separate hot-water coil in the terminal unit also reduces air pressure drop, which results in terminal fan energy savings.
- Since four-pipe distribution is centralized, and two-pipe distribution is used to serve the zones, less piping is routed throughout the building, further reducing installed costs.
- Since the sensible-only cooling coils in CoolSense™ terminal units are constructed of multiple rows (to enable sufficient cooling capacity when supplied with warmer chilled water), the added rows allow for the use of lower-temperature hot water and more-efficient heat sources (e.g., heat pumps, condensing boilers).

For more information, refer to the Hydronic Branch Conductor product catalog (TD-PRC007*-EN) and application guide (APP-APG024*-EN).


hot water sent to north exposure
Hydronic Branch Conductor
central 4-pipe distribution
chilled water sent to south exposure
Hydronic Branch Conductor
hot-water return
hot-water supply
chilled-water return
chilled-water supply

System Controls

System-level control of a Trane CoolSense™ system uses standard applications in Tracer® SC+, along with pre-packaged solutions, to coordinate and optimize the operation of the sensible-cooling terminal units, DOAS, and chiller plant.

Tracer® SC+ standard applications

The Tracer® SC+ system controller provides many of the coordination and optimization functions for the system, using the following standard applications:

AREA is used to define groups of zones, enabling coordinated control to determine the appropriate operating mode, and prevent heating and cooling from "fighting each other."

VAS is used to coordinate the operation of the DOAS air handler with the sensible-cooling terminals it serves, ensuring safe, efficient, and reliable performance during the various operating modes (see example mode chart below). It also optimizes the performance of the system using data gathered from the individual terminal unit (see page 27).

Mobility and accessibility of Tracer® SC+

Tracer® SC+ delivers the industry's most intuitive user interface, and provides you access to the system no matter where you are, on any connected device. Interfaces are intuitive and easy to use and translate seamlessly across all web-enabled devices.

Air-Fi® Wireless

Air-Fi® Wireless controls minimize wiring between zone sensors and equipment controllers, as well as between equipment and system-level controllers in a Tracer® building automation system. Benefits include faster project completion, less disruption of building occupants, increased location flexibility, increased reliability due the mesh networking and range, and life-cycle savings due to easier relocation when space use changes in the future.

Through the use of its self-healing wireless mesh, extended signal range, conformance to the ZigBee® Building Automation standard, and 15-year lifetime batteries, Trane Air-Fi® Wireless controls provide reliable, expandable operation for the life of the building

System-level coordination mode chart

	dedicated OA air handler				terminal units			
mode	supply fan	OA damper	recirculating damper	heating/ cooling	terminal fan	ventilation air damper	sensible cooling coil	hot-water coil or electric heat
occupied	modulate to maintain duct static pressure setpoint	open	closed	modulate to maintain discharge air setpoints	modulate to maintain space setpoint	modulate to maintain ventilation setpoint	modulate to maintain space setpoint	modulate to maintain space setpoint
unoccupied	off	closed	open	off	off	closed	off	off
unoccupied - cool	off	closed	open	off	on	closed	open	off
unoccupied - heat	off	closed	open	off	on	closed	off	open
unoccupied - dehumidify	modulate to maintain duct static pressure setpoint	closed	open	modulate to maintain discharge air setpoints	on	open	off	off

Optimized system-level control strategies

To maximize overall system efficiency, a CoolSense™ system can implement the following optimization strategies:

Demand-Controlled Ventilation (DCV). Unlike a conventional mixed-air VAV system, the DOAS air-handling unit delivers 100% outdoor air to each zone-level terminal unit, with no centralized recirculation. And unlike many traditional dedicated outdoor-air systems, each terminal unit in a Trane® CoolSense™ system includes a pressure-independent, flow-measuring ventilation air damper. A DCV control sequence pre-engineered into the Symbio® 500 can be configured to automatically reduce outdoor air during periods of partial occupancy, thus saving energy. While commonly implemented using a carbon dioxide (CO_2) sensor, either an occupancy sensor or time-of-day schedule could also be used to implement DCV.

DCV is especially valuable in zones that are either intermittently occupied, or that experience widely-varying patterns of occupancy. And the flow-measuring ventilation damper is useful for documenting that adequate ventilation is provided at all times.

DOAS Duct Static Pressure Optimization. As the ventilation air dampers in the sensible-cooling terminal units modulate to vary outdoor airflow supplied to the zones, this causes the static pressure inside the DOAS ductwork to change. In many systems, the speed of DOAS supply fan is modulated to maintain the static pressure in this ductwork at a constant setpoint. With this approach, however, the system usually generates more static pressure, and uses more fan energy, than necessary.

When communicating controllers are used on the terminal units, it is possible to optimize this static pressure control function to minimize the duct static pressure and save DOAS fan energy. The Tracer® SC+ system controller continually polls the individual Symbio® 500 terminal unit controllers, looking for the terminal with the most-open ventilation air damper. Using Trim-and-Respond functionality, the system controller then dynamically resets the duct static pressure setpoint so that it provides just enough pressure for at least one ventilation air damper to be nearly wide open. At part-load conditions, this allows the DOAS supply fan to operate at a lower static pressure, which results in less fan energy use, lower sound levels, and reduced risk of fan surge.

DOAS Discharge-air Temperature Reset. Some design engineers prefer to design a DOAS to dehumidify outdoor air to a low dew point and then reheat it to a "space neutral" dry-bulb temperature. This is often based on a concern about overcooling zones with the cool, dehumidified outdoor air. This neutral-air delivery would then seem to simplify the interaction between the DOAS and terminal units, but it wastes energy.

The Trane® CoolSense™ system does not need this simplification, because the dehumidified outdoor air is delivered to the inlet of each terminal unit. Any sensible cooling performed by the cool, dehumidified outdoor air reduces the sensible cooling required by the terminal unit's chilled-water coil. Avoiding, or minimizing, reheat at the DOAS limits energy waste both in the DOAS (less reheating) and in the terminal units (less recooling).

The Tracer® SC+ system controller can then be used to continually poll the individual Symbio® 500 terminal unit controllers, to determine if overcooling is imminent. Using Trim-and-Respond functionality, the system controller then dynamically resets the DOAS discharge dry-bulb temperature setpoint just enough to prevent the worst-case zone from overcooling. This minimizes both recooling at the terminal units and reheat at the DOAS.

Energy Analysis of the CoolSense™ System

TRACE® 3D Plus was used to compare the performance a CoolSense™ system with various chiller plant configurations in an example three-story office building (47,000 ft²).

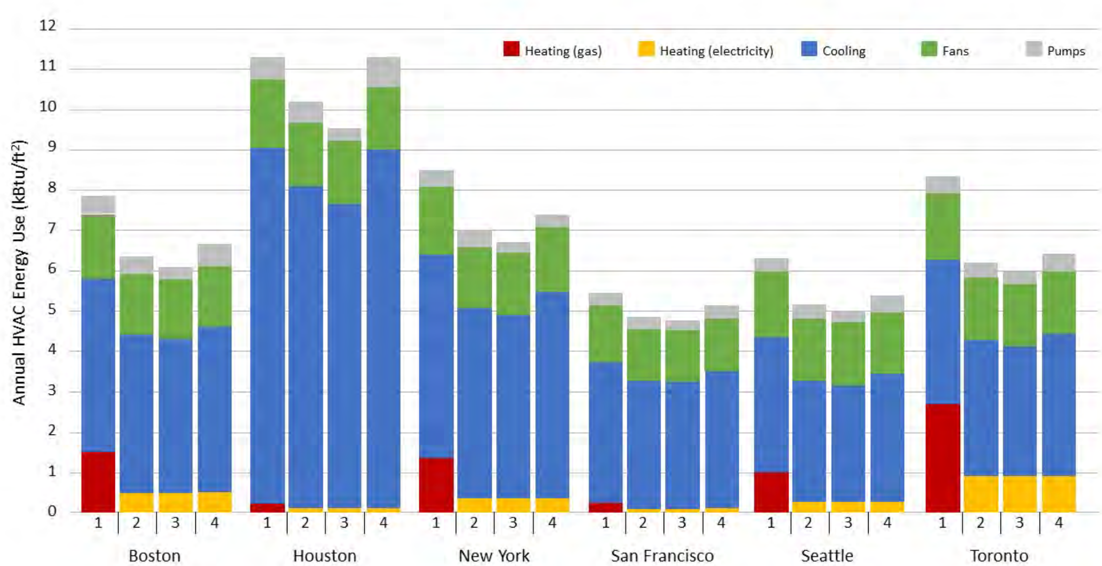
1. Single-chiller, dual-temperature plant + gas boiler. The first (baseline) alternative uses a single-chiller, dual-temperature plant. An air-cooled chiller to cool fluid to a single cold temperature. Some of this fluid is distributed to the cooling coil in the dedicated OA unit for dehumidification, while the rest passes through a plate-and-frame heat exchanger that is controlled to produce 57°F water for delivery to the sensible-only terminal units. A gas-fired boiler produces hot water for heating.

2. Single-chiller, dual-temperature plant using air-to-water heat pumps. The second alternative also uses a single-chiller, dual-temperature plant, but an air-to-water heat pump (instead of a gas-fired boiler) is used to produce hot water for heating.

3. Dual-chiller, dual-temperature plant using air-to-water heat pumps. The third alternative uses a dual-chiller, dual-temperature plant. One air-to-water heat pump produces cold fluid that is distributed to the cooling coil in the dedicated OA unit for dehumidification, while a second air-to-water heat pump produces 57°F water for the sensible-only terminal units. A third air-to-water heat pump produces hot water for heating.

4. Single-chiller, dual-temperature plant with thermal energy storage, using air-to-water heat pumps. The fourth alternative again uses a single-chiller, dual-temperature plant, but includes thermal energy storage. During normal daytime operation, stored energy (in the form of melting ice) produces cold fluid that is distributed to the cooling coil in the dedicated OA unit for dehumidification, while the air-to-water heat pump produces 57°F water for the sensible-only terminal units. When the building is unoccupied at night, the air-to-water heat pump is used to store energy in the tanks (by freezing the water back into ice) for the next day. A second air-to-water heat pump produces hot water for heating.

Comparison. The second, third, and fourth alternatives depict various plant configurations that can be used to electrify the system and reduce the carbon dioxide equivalent footprint of the building. The second alternative will likely result in the lowest installed cost of the three electrified alternatives, while the third alternative will likely result in the lowest annual energy use. The fourth alternative will likely result in the lowest daytime electrical demand and smallest installed heat pump capacity, while also being eligible for various rebates and tax incentives.



1 air-cooled chiller + gas boiler 2 air-to-water heat pump (single fluid temp.) 3 air-to-water heat pumps (dedicated fluid temps.) 4 air-to-water heat pump + thermal storage for DOAS

Acoustic Analysis of the CoolSense™ System

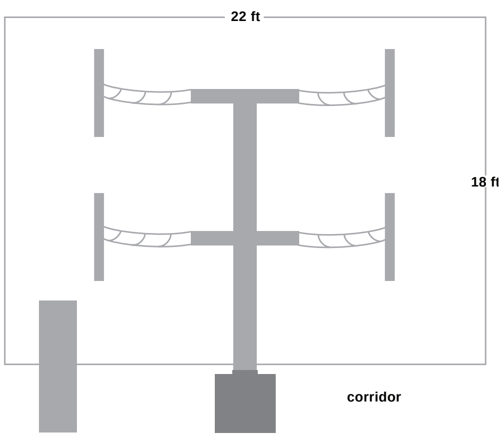
HVAC equipment when applied well provides an appropriate level of background sound for speech isolation and permits clear communication in a classroom. When poorly applied, HVAC equipment sound can be considered noise if it disrupts the intended function of the building.

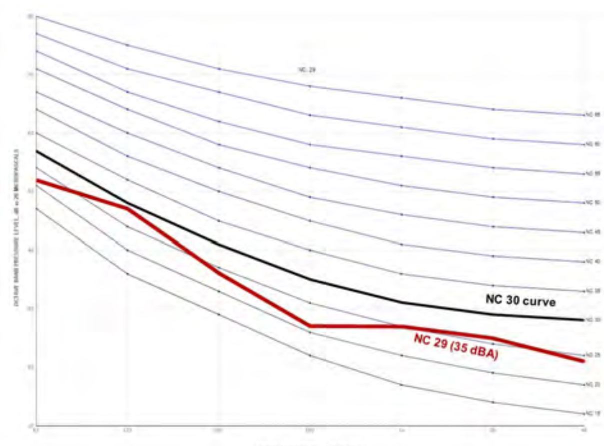
Here are two sample analyses of the CoolSense™ system using the TAP™ Trane acoustics program. The first analysis was for a classroom where the indoor sound pressure target was 35 dBA and 55 dBC, based upon ANSI®/ASA 12.60-2010 Part 1. To achieve this, the terminal was located outside the classroom over the hallway. Acoustically lined supply and return ductwork was used. NC 20 diffusers were selected.

The second analysis was for an open-plan office space where the indoor sound pressure target was NC 40, based on design guidelines from the 2023 ASHRAE® Handbook. To achieve NC 40, the terminal was located inside the ceiling plenum with acoustical ceiling tiles. The office was assumed to have carpeted floors. Sheet metal ductwork was unlined however the flexible duct was lined.

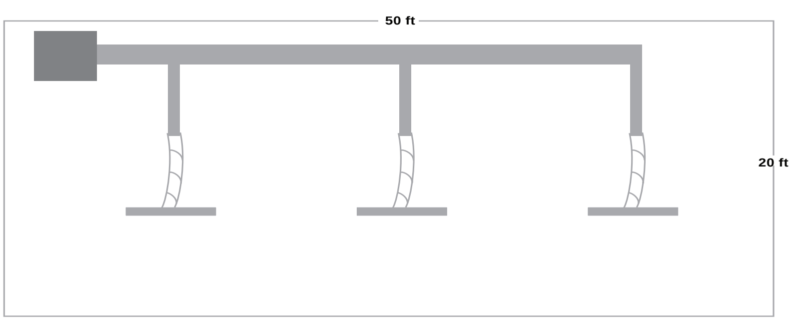
Trane provides a full range of sound data for sensible-cooling terminals boxes measured in accordance with AHRI® Standard 880. These are available in both the product catalog and the selection program.

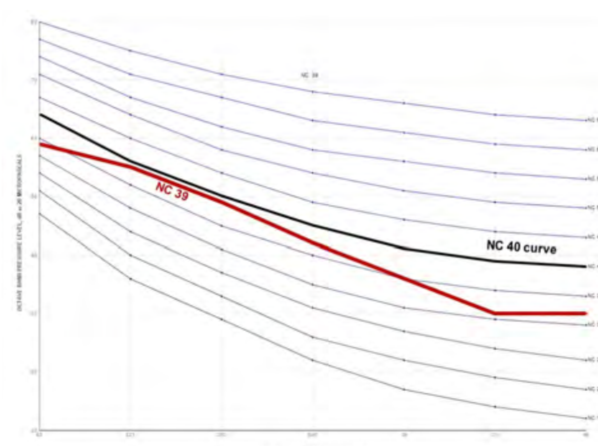
Acoustic model of an example classroom using the CoolSense system (plan view)





Acoustic model of an example open-plan office using the CoolSense system (plan view)





Design Resources

Visit Trane's consulting engineer portal
www.traneengineer.com

CoolSense System Design Guide (DOAS-APG001*-EN)

This in-depth guide addresses many of the key aspects of designing a CoolSense™ system. Topics include:

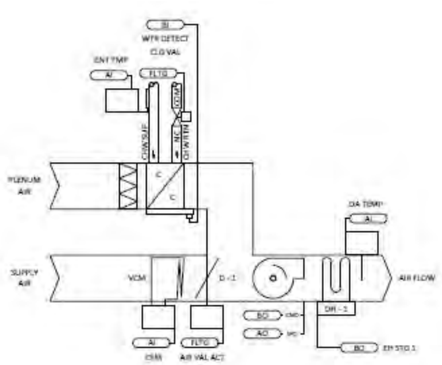
- Determining the DOAS supply-air dew point and airflow
- Selecting Trane chilled-water sensible-cooling terminal units
- Comparison of dedicated outdoor air handler configurations
- Comparison of dual-temperature chiller plant configurations
- Common questions about code compliance
- Acoustics analysis for an open office space and a classroom
- In-depth explanation of terminal unit control sequences and system-level control coordination


TRANE
Application Guide
Trane CoolSense™ System Design
⚠SAFETY WARNING
November 2023 DOAS-APG001B-EN

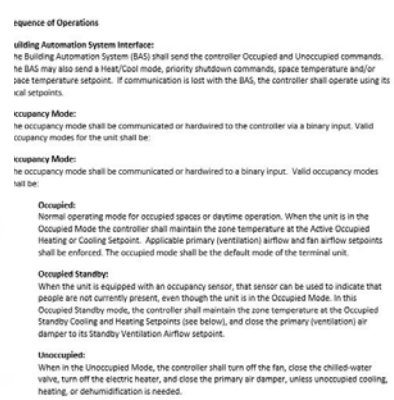
Trane Design Assist

Trane® Design Assist is a powerful platform provided to Trane account managers and specifying engineers across the industry to create building automation control designs. This no cost, self-service tool is used to create scalable control project layouts on a digital design canvas for easy editing and collaboration, regardless of brand. This time-saving tool reduces risk by allowing users to apply industry proven standards, and download coordinated content in the form of flow diagrams, sequences of operation, guide specifications, and point lists. Create an account at www.tranedesignassist.com and get started today!

Control flow diagram



Sequence of operations


equence of Operations

uilding Automation System Interface:
he Building Automation System (BAS) shall send the controller Occupied and Unoccupied commands. he BAS may also send a Heat/Cool mode, priority shutdown commands, space temperature and/or pace temperature setpoint. If communication is lost with the BAS, the controller shall operate using its ocal setpoints.

ccupancy Mode:
he occupancy mode shall be communicated or hardwired to the controller via a binary input. Valid ccupancy modes for the unit shall be:

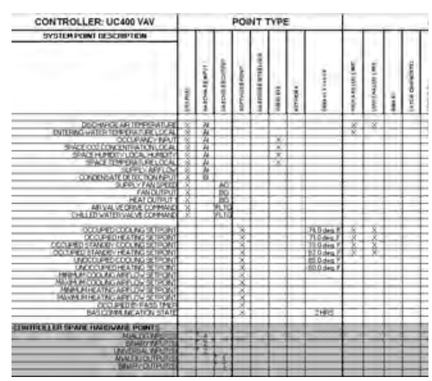
ccupancy Mode:
he occupancy mode shall be communicated or hardwired to a binary input. Valid occupancy modes hall be:

Occupied:
Normal operating mode for occupied spaces or daytime operation. When the unit is in the Occupied Mode the controller shall maintain the zone temperature at the Active Occupied Heating or Cooling Setpoint. Applicable primary (ventilation) airflow and fan airflow setpoints shall be enforced. The occupied mode shall be the default mode of the terminal unit.

Occupied Standby:
When the unit is equipped with an occupancy sensor, that sensor can be used to indicate that people are not currently present, even though the unit is in the Occupied Mode. In this Occupied Standby mode, the controller shall maintain the zone temperature at the Occupied Standby Cooling and Heating Setpoints (see below), and close the primary (ventilation) air damper to its Standby Ventilation Airflow setpoint.

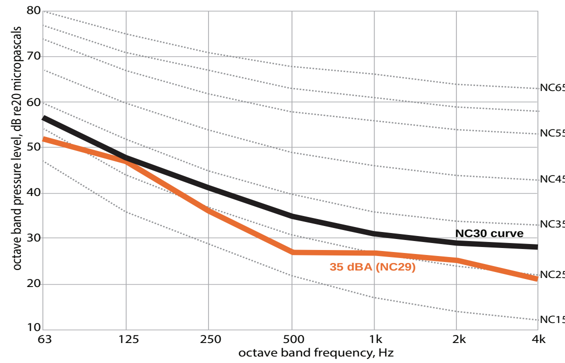
Unoccupied:
When in the Unoccupied Mode, the controller shall turn off the fan, close the chilled-water valve, turn off the electric heater, and close the primary air damper, unless unoccupied cooling, heating, or dehumidification is needed.

I/O point list

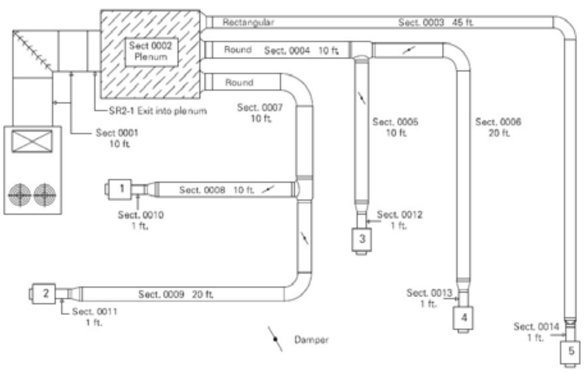

CONTROLLER: UC400 VAV
SYSTEM POINT DESCRIPTION
POINT TYPE
CONTROLLER SPARE HARDWARE POINTS

TRACE® energy and economic software and support

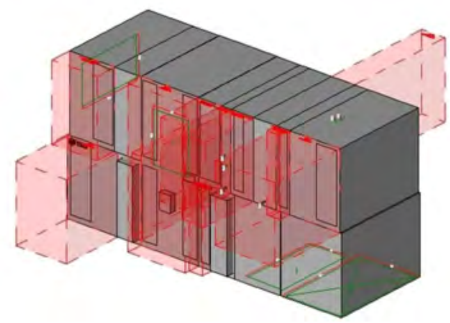
TAP™ acoustic analysis software and support



VariTrane® duct design software and support



CAD and BIM drawing files



Engineers Newsletter Live videos

Application guides and manuals

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