System Catalog

CoolSense™ Integrated Outdoor Air System

A configured system from Trane

APP-PRC004D-EN
September 2021

Systems from Trane

Systems from Trane are comprehensive approaches to HVAC system design and operation.

Systems with this designation leverage high-efficiency HVAC equipment in a system designed with best practices, and with pre-packaged, advanced controls to optimize the operation of the entire system, not just its individual components.

Higher efficiency, code compliance

Systems from Trane reduce energy costs associated with cooling and heating, with documentation to help demonstrate complance with applicable codes and standards.

Advanced alternatives

Alternatives to traditional HVAC systems are attractive for a variety of reasons, including comfort, energy use, and indoor environmental quality. Building designers and their clients want options—at the zone, at the HVAC plant, and at the meter—and don't want to reinvent the wheel. Pre-packaged solutions reduce uncertainty when trying something new.

Advanced technologies, applied properly, take buildings to the next level. But they're not just for new buildings. Existing buildings benefit even more from system features such as exhaust air energy recovery, condenser heat recovery, variable-speed equipment, variable ventilation airflow and optimized controls.

Guidance and support for system choices

Trane supports and encourages energy modeling during the system design phase. Trane Air-conditioning Economics (TRACE®) software can be used to evaluate system choices, help your building earn high performance designation, and improve the building's value to your business.

Simplified design and implementation

Systems from Trane standardize and repeat the items needed for implementation, and unlock the full potential of high-performing HVAC system designs. System controls are written and fully documented, by experienced programmers. Unit controls are installed and commissioned at the factory. The two combine for smooth installation and commissioning.

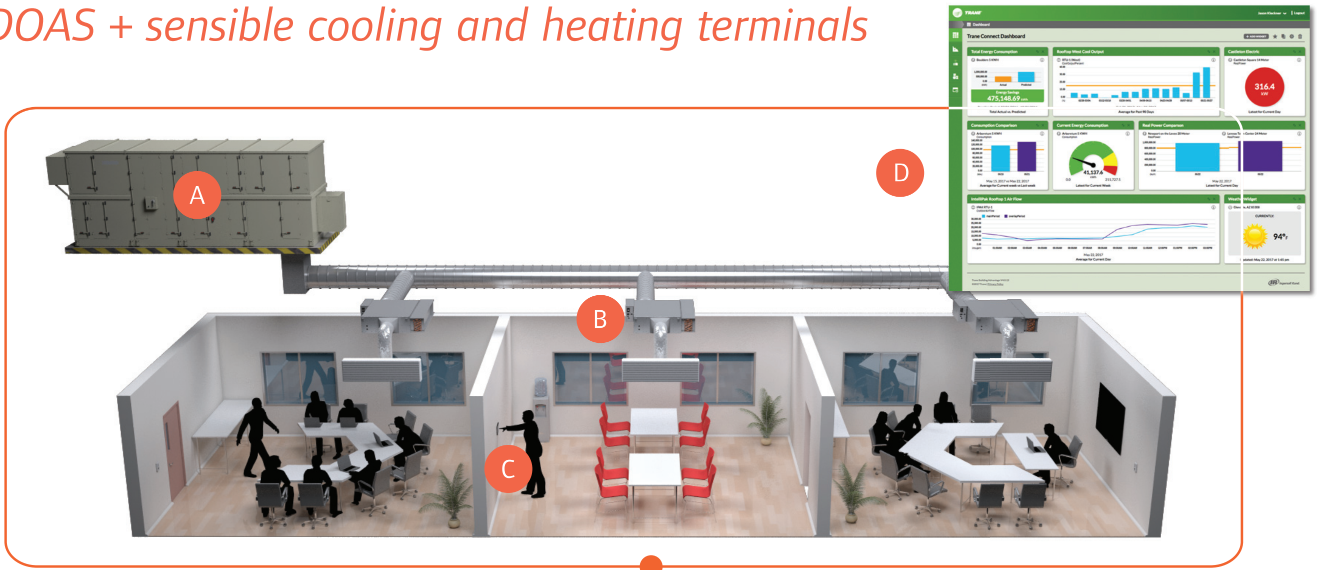
Standard apps and operator dashboards, supported by thorough documentation, take the mystery out of how your system works, so that you and Trane can keep it running optimally over the system's lifetime.

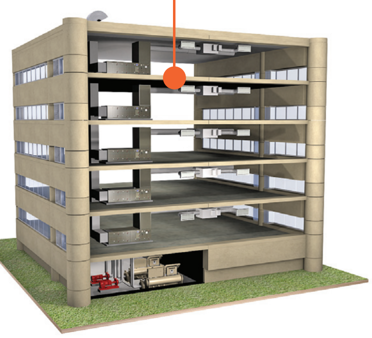
The CoolSense™ integrated outdoor air system was developed to solve a number of issues that are difficult to overcome in other systems.

"Only Trane has provided the packaging of equipment and controls for the specific purpose of operating this system. It would take multiple products from multiple vendors, with field-programmed sequences to deliver the same result and that will result in higher costs."
— Lea Burt, Mechanical Contractors, Inc.

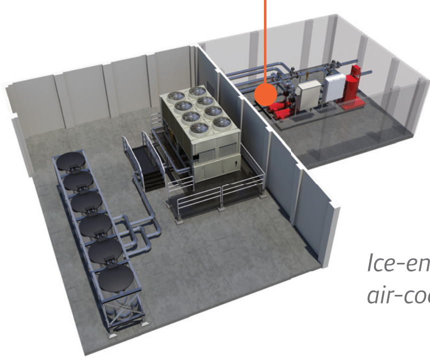
CoolSense™ integrated outdoor air system

DOAS + sensible cooling and heating terminals





Dual-temperature chilled-water plant



Ice-enhanced air-cooled chiller plant

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

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

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

A **Trane dedicated outdoor air-handling units** provide high efficiency, low leakage, installation flexibility and factory-installed controls. Options include exhaust-air energy-recovery, desiccant dehumidification, and a variety of air-cleaning options.

B **Trane terminal units** serve room sensible cooling and heating loads with variable-speed fans using pre-packaged, factory-installed controls that include demand-controlled ventilation and active condensation avoidance.

C Wired or wireless **zone sensors** communicate with the controller on the terminal to deliver highest performance and maintain occupant comfort. Four function sensors combine temperature, humidity, CO_2 and occupant sensing.

D **Tracer® system controls** coordinate the operation of the ventilation and terminal systems to ensure occupant comfort and eliminate energy waste. Dashboards give real-time feedback.

System benefits

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 ducted outdoor air and recirculated room air to cool and heat the zones. They're capable of controlling the temperature in many zones with dissimilar cooling and heating loads while performing the minimum amount of reheat on previously cooled air. This is because most of the sensible cooling is done at the zone level. Also, reclaimed energy in the recirculated room or plenum air provides the first stage of heating. Because only ventilation air is ever reheated, there are no code limitations on using new energy for reheat. The use of recovered energy is an option and encouraged for high performance operation.

High indoor air quality

The foundation of good indoor air quality is proper ventilation, which consumes energy as it is conditioned over many hours of the year. The CoolSense system balances energy efficiency with proper ventilation by bringing in no more than the desired amount of outdoor air for ventilation, at all operating conditions, to all zones.

In addition, coils in the zones are dry, which means they typically stay cleaner. Centralized condensate collection at the air-handler 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. Chilled water pipes may be about the same as a typical terminal chilled water system. Using wireless controls eliminates the need for low-voltage control wiring and simplifies commissioning.

Warmer chilled water, lower chiller energy

Sensible-only cooling in the terminals is accomplished with warmer water than in systems that combine the sensible and latent cooling. Chillers operated at a warmer setpoint use less energy. Latent loads are handled by a different coil that uses colder water. Properly conceived and operated dual-temperature, chilled-water systems lead to significant building energy savings. This warmer water temperature also expands the effective waterside economizer hours. These additional hours plus the chiller energy reduction combine to compensate for the reduced airside economizer opportunities of dedicated outdoor-air systems (DOAS).

Coordinated, integrated system

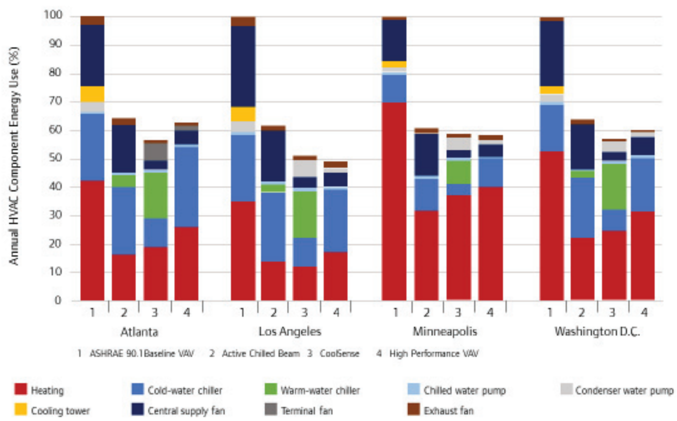
Other terminal (zone-based) systems with DOAS have often been comfortable and flexible. But comfort can mask energy waste, due to uncoordinated system components. This is in part due to some designers' preference to dehumidify and reheat ventilation air to "space neutral" temperatures. Space-neutral delivery of ventilation simplifies the interaction between two or more independent systems but uses more energy. CoolSense doesn't need this simplification because the air is delivered to the inlet of the terminal, equipped with a pressure-independent air valve. Cooling performed as part of dehumidification at the outdoor air unit off-loads some or all of the cooling required in the zones. This limits energy waste in the outdoor air system (less reheating) and in the zones (less recooling).

Demand-controlled ventilation, simplified

In densely occupied spaces, or in intermittently occupied spaces, zone controls use a combination of CO_2, schedule, or occupancy sensors to modify the zone's ventilation airflow using the integral airflow modulation damper. The only system-level effect of zone-level DCV is a change in duct static pressure, which the CoolSense System uses to control fan speed in the outdoor air unit to save energy.

Annual energy use is estimated using TRACE® building energy analysis software. The analysis compares the CoolSense system to active chilled beams (ACB) and high-performance VAV systems in a 6-story, 268,000 ft² office application. The results vary based on location, and have been normalized to the baseline system performance for each climate, to show relative performance. For hotter climates, and in an office application with lower outdoor air requirements, the CoolSense system excels compared to high-performance VAV—there are fewer airside economizer hours lost. In cooler and drier climates, a high-performance mixed-air VAV system may be more efficient because a higher available ventilation airflow means more airside economizer free cooling. See page 12 for further discussion of the relative differences in system energy use.

Energy consumption of active chilled beam, CoolSense integrated outdoor air and high-performance VAV systems in four locations



Simpler to design ventilation system

Because 100% outdoor air is delivered to the zones, each zone is a “single-zone” ventilation system per ASHRAE Standard 62.1. This avoids the need to use the “Multiple-Zone Recirculating” system equations. Because each zone measures the ventilation air being provided, it’s also easier to document outdoor airflow delivered to each zone.

Smaller ductwork, higher ceilings

Ductwork is sized for only the outdoor airflow required, rather than total cooling supply airflow. Sensible-cooling terminals are 10.5 inches in height. Smaller ducts and shorter terminals can help solve space constraints on retrofits, or to make indoor environments more aesthetically pleasing through higher ceilings.

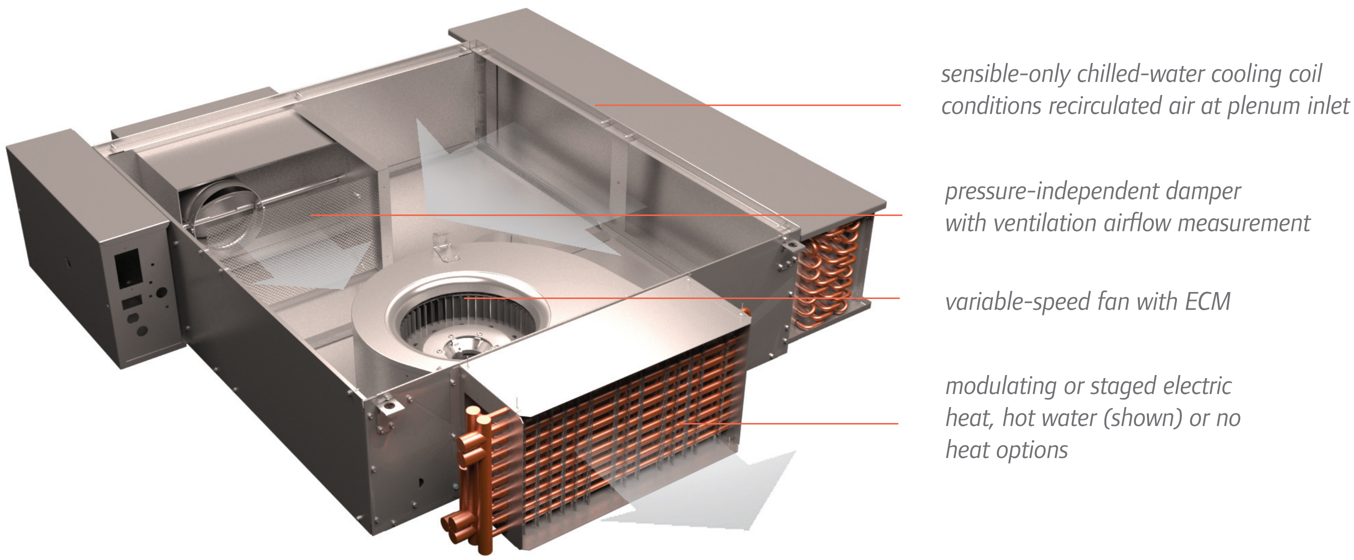
Efficient fan operation

Because each zone has a damper and airflow measurement, the CoolSense system adjusts the speed of the DOAS fan in response to changes in duct static pressure. Traditional dedicated outdoor air systems are constant speed with no dampers.

And, unlike traditional DOAS, this system minimizes fan and ventilation conditioning energy when only some zones require ventilation. A traditional dedicated outdoor air system may operate at full speed whenever the building is minimally occupied as there are no dampers to prevent ventilating unoccupied zones.

ASHRAE Standard 62.1 now allows ventilation to be reduced to zero (dropping the area-based ventilation requirement) during unoccupied periods, when an occupancy sensor indicates no people are currently present in the zone (occupied standby mode).

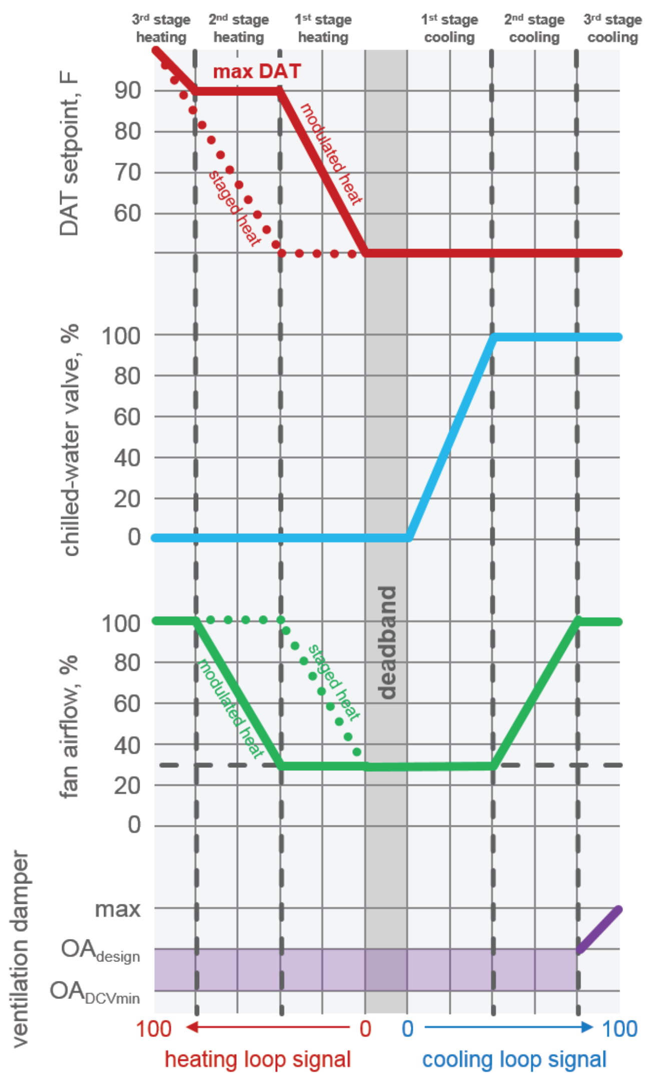
Heating and sensible cooling in terminal unit



Modes of operation

The easiest way to understand how this system is different from other terminal systems is through the terminal unit sequence of operation. This graphic progresses from left to right from full heating to full cooling.

Heating capacity, chilled water valve position, terminal fan airflow and ventilation damper position are shown in each mode. See the next page for a narrative of cooling and heating during occupied modes, as well as other sequences such as demand-controlled ventilation and condensate avoidance.



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 the minimum OA 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 the deadband to the right in the chart:

1st stage cooling. First, 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 minimum OA 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 minimum OA 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) 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 the minimum OA setpoint. Moving from the 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) can further modulate open to maintain zone temperature at its heating setpoint.

For terminal units equipped with a staged electric heat (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) mode

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 ventilation air 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) if additional cooling capacity is needed, or if additional dehumidification is needed.

Condensate avoidance mode

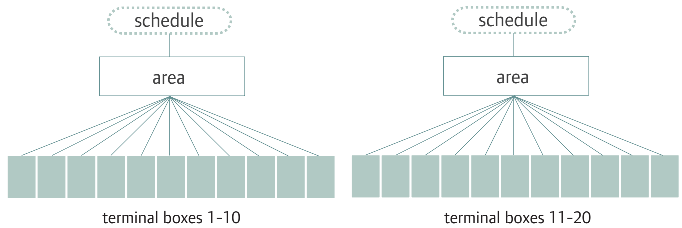
While the cooling coil in the terminal unit is intended to operate dry (no condensation), a drip pan is installed underneath this coil in the event that unintended condensation does occur. If the moisture sensor installed in this drip pan detects the presence of condensate, the chilled-water valve is closed while the terminal fan and ventilation air damper continue to operate as normal, through the 2nd and 3rd stages of cooling. A diagnostic is generated. The chilled-water valve is allowed to open again when condensate is no longer detected.

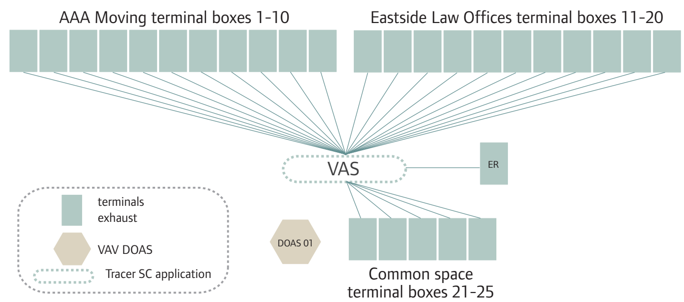
If a zone humidity sensor is installed and the measured zone dew point temperature rises above the entering chilled water temperature, the ventilation air damper can be modulated further open (increasing the flow rate of dehumidified air) until the zone dew point temperature drops back down again.

Application considerations

System controls

System controls for the CoolSense™ system benefit from Tracer® standard applications such as AREA and VAS. Air-handler and chiller plant controls are easily designed and implemented using the configurator in the Trane Contracting Scoping and Engineering Tool (CSET).





Tracer® SC standard applications

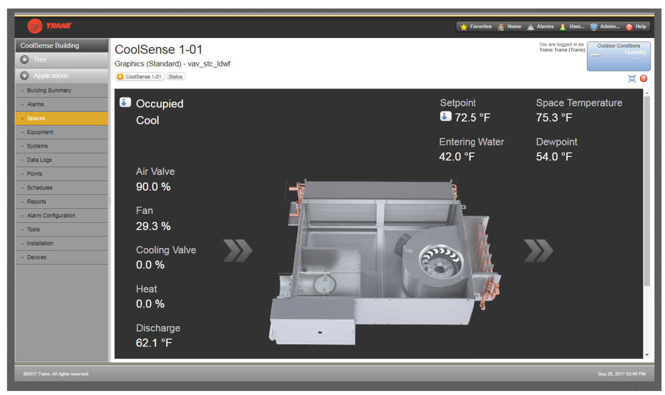
The Tracer SC system controller provides many of the coordinating and optimization functions for the system, through the use of these standard applications:

AREA is the application used to define groups of zones, which can be dictated by the physical layout (office groupings, walls, etc.) and the logical layout (tenants, departments, etc.) of the building. Zones are assigned to an area to enable coordinated control and prevent heating and cooling systems from "fighting" each other.

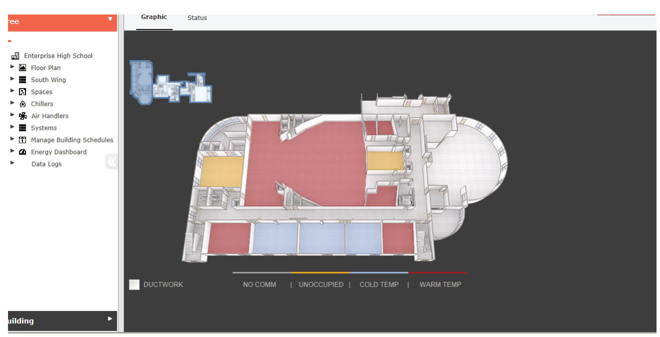
VAS is a virtual representation of the physical equipment in the building. This application coordinates the operation of the dedicated outdoor air unit with the connected sensible-cooling terminals, ensuring safe, efficient, and reliable performance during the various operating modes. It also optimizes the performance of the system using data gathered from the individual terminals.

Schedules are time-based controls. Tracer SC integrates schedules with the Area and VAS applications to define the desired operating mode of the HVAC equipment based on time, temperature and humidity. Operating modes typically include occupied, unoccupied heat/cool/dehumidify, optimal start and stop, and humidity pull down. Mode charts (like the one shown on the opposite page) explain what the various components of the system are doing during each operating mode.

Easily understood interfaces for controls implementation



Floor plan graphics



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. And it is so much more than simple web connectivity. Interfaces are intuitive and easy to use and translate seamlessly across all web-enabled devices.

Ease of implementation

Setting up schedules, areas and VAS is accomplished through the Tracer SC standard graphical interface using setup "wizard" routines, autodiscovery, drop-down selections and check boxes, not custom programming.

Systems by Trane make the controls setup even easier and more standardized, with more programming installed at the factory.

Air-Fi® Wireless

Air-Fi Wireless controls minimize the wires between equipment and system controllers for Tracer® building automation systems supporting BACnet® standard protocol, and provide wireless connectivity to zone sensors. The 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 spaces change 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.

Washington State Energy Code: For information on how this system complies with the 2015 Washington State Energy Code, see CoolSense™ Integrated Outdoor Air System and the Washington State Energy Code, DOAS-PRB001*-EN.

Mode chart

	dedicated OA air handler				terminal units			
mode	supply fan	OA damper	recirculating damper	heating/ cooling	terminal fan	air damper	cooling coil	heating coil
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
ventilation only (deadband)	modulate to nmaintain duct static pressure setpoint	open	closed	modulate to maintain discharge air setpoints	min. speed	modulate to maintain ventilation setpoint	off	off

Optimized system control strategies and features

To help achieve its system efficiency, CoolSense™ systems pre-package the following optimized system control strategies in Tracer® system and equipment controls.

Demand-controlled ventilation

Unlike traditional mixed air VAV systems, the air-handling unit delivers 100% outdoor air to each terminal unit with no centralized recirculation. And unlike traditional dedicated-outdoor-air systems, CoolSense also includes a damper and airflow measurement device at each and every terminal. As a result, zones can be configured to automatically reduce outdoor air during periods of partial occupancy. While commonly implemented using carbon dioxide (CO_2) sensors, occupancy sensors or time-of-day schedules can also be used for determining ventilation amounts. Humidity sensors in the zones can be used to override DCV if more airflow is needed to dehumidify.

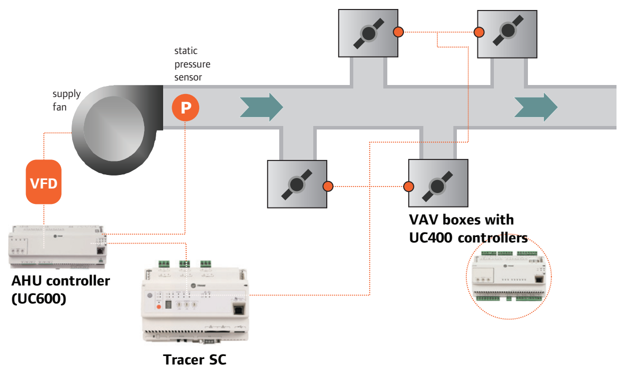
This ability to reduce ventilation is especially useful in zones that are either intermittently occupied, or that experience widely varying patterns of occupancy. The controller on each terminal continuously monitors ventilation airflow being delivered to the zone. This is also helpful for compliance documentation purposes, to prove that adequate ventilation is provided at all times.

It also means that zones are much less likely to be overventilated during operation, as they would be in many other systems.

Fan-pressure optimization

As occupancy changes, the sensible terminals in a CoolSense system modulate to vary ventilation airflow supplied to the zones. This causes the pressure inside the DOAS ductwork to change. In many systems, the AHU controller varies the speed of the fan to maintain static pressure in the ductwork at a constant setpoint. With this approach, however, the system usually generates more static pressure, and uses more fan energy, at part load than necessary.

Fan pressure optimization



When communicating controllers are used on the terminals, it is possible to optimize this static pressure control function to minimize duct pressure and save fan energy. Tracer® SC continually polls the individual terminal-unit controllers, looking for the terminal with the most-open damper. The duct static pressure setpoint for the DOAS fan is then dynamically reset to provide just enough pressure so that at least one damper is nearly wide open. At part-load conditions, the DOAS fan is able to operate at a lower static pressure, which results in less energy use, lower sound levels, and reduced risk of fan surge.

Integrating to reduce energy waste

Traditionally, systems with dedicated outdoor air separate the outdoor air control from the zone or terminal device control. The two systems may be only superficially connected in the control system. This often leads to simplifications such as always heating or reheating the outdoor air to "space neutral" conditions. This in turn causes terminals to recool the ventilation air unnecessarily.

The CoolSense™ system integrates the dedicated outdoor air equipment' control with the terminals in the zone, by delivering the outdoor air to a damper at the inlet of the terminal. This enables not only fan pressure optimization and demand-controlled ventilation, but simplifies system balancing and pressure relationships. The two systems are inherently managed as one, through the pressure-independent dampers in the terminals. This removes the need for simplifying the DOAS in ways that might waste energy.

In addition, unlike induction systems that rely on primary air to induce room air into the terminal, CoolSense systems don't need any primary air in order to provide space cooling or heating—fans in the terminal simply recirculate room air and cool or heat it. This allows the central outdoor air system to remain off for more of the unoccupied periods, while also reducing the amount of air delivered to each zone during occupied periods.

Implementing optimized controls

Optimized control strategies, such as humidity pull-down, condensation avoidance, fan-pressure optimization, and demand-controlled ventilation, are pre-packaged in Tracer® controllers. Others, such as DOAS supply air temperature reset, can be quickly implemented using standard code.

Many of these optimized control strategies are implemented by simply "checking the box" to enable a strategy, or to add or remove zones from the logic.

Sustaining high performance

Tracer® SC presents data as usable information with an intuitive user interface to help operators sustain building efficiency for the life of the system. Tracer makes it easy to identify and remove overrides. "Temporary" changes to setpoints or operating schedules, when left in place long after the triggering event or condition, are another potential energy waste. Removing these overrides is often essential for the system to operate at a sustained high level of performance. Tracer SC makes it easy to identify these overrides and remove them to return the system to normal operation.

Avoiding condensate in the terminals

Tracer controls can monitor zone dew point, and modulate the ventilation air damper further open (increasing the flow rate of dehumidified air from the DOAS) if needed, to lower the zone dew point back below the desired threshold. This monitoring happens even, and especially importantly during, unoccupied periods when zone cooling requests and ventilation airflow are likely to be lower. See page 16 for more detail on condensation avoidance mode.

Reducing system energy with deadband controls

When the zone temperature is in the deadband between the heating and cooling setpoints, the terminal fan operates at its minimum fan airflow setpoint. Fan energy is minimized in this mode, as its primary purpose is to deliver outdoor air for ventilation; fan airflow may be slightly higher if desired for air circulation in the space.

Energy analysis of the CoolSense™ system

CoolSense benefits from variable-speed fan control in both the terminal units and in the dedicated OA unit to minimize fan energy. In addition, decoupling dehumidification from zone sensible cooling allows for more of the cooling to be provided by warmer chilled water, and minimizes (or eliminates) zone-level reheat. Integrated, demand-controlled ventilation (DCV) minimizes energy used to condition and deliver outdoor air to each zone.

TRACE® 700 was used to compare CoolSense to other systems in an example six-story office building (268,000 ft^2). In this example, CoolSense uses less energy than an active chilled beam system (ACB) and either slightly less or slightly more energy than a high-performance VAV system, depending on climate. All three systems showed advanced performance.

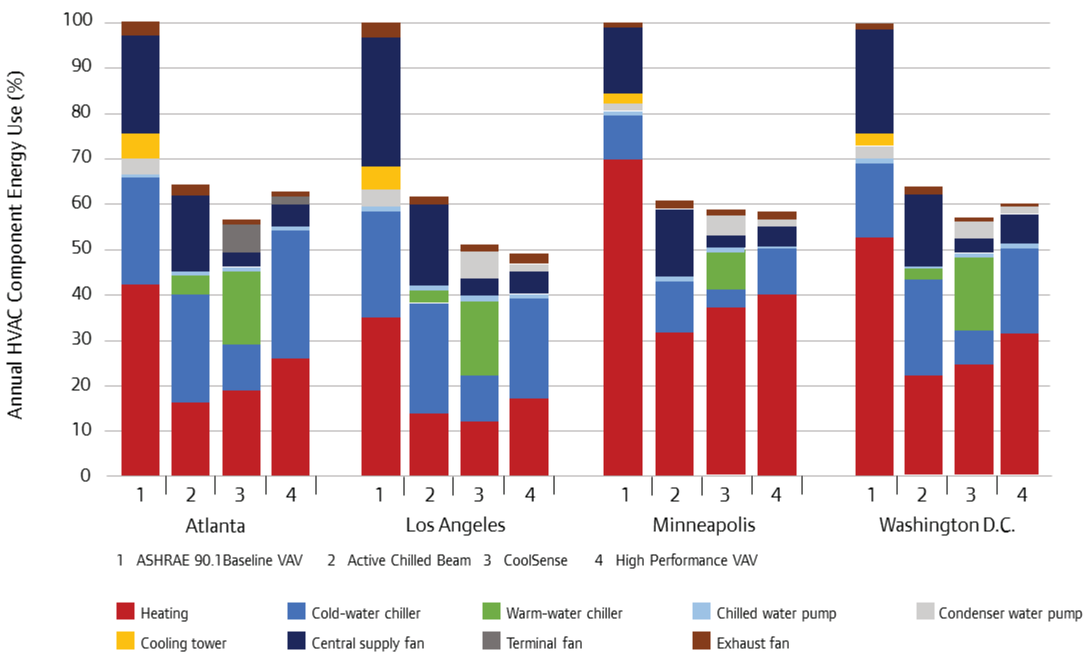
Design cooling conditions

Total fan power is lower in the CoolSense system than in the chilled beam system. Even though the terminal unit includes a fan, the central fan in the primary air unit serving the chilled beams uses more power because it must deliver more airflow at a higher static pressure required for induction.

The "cold-water" chiller sends water to the DOAS unit (45°F for the chilled beam and VAV systems, 40°F for CoolSense). It uses less power in the CoolSense system at design conditions. Even though the chiller must produce colder water, the load from the DOAS unit is significantly less than the load from the primary AHU in either the chilled beam or VAV systems. A "cool-water" chiller (57°F) sends water to the terminal units. It uses more power at design conditions in the CoolSense system than in the chilled beam system. This is because the higher primary airflow of the ACB system offsets more of the space sensible cooling load, so the CoolSense system provides more cooling using this "cool-water" chiller. See Trane Engineers Newsletter *"Dedicated Outdoor Air System with Sensible-Cooling Terminal Units"* for more discussion and diagrams of the chiller plants, available from trane.com/CoolSense.

Part load operation

The fan in the CoolSense terminal unit is variable speed, so it reduces airflow (and fan power, by the cube of the airflow reduction) at part load. And DCV reduces DOAS fan energy during periods of partial occupancy. The VAV system benefits from airside economizing during mild weather, which provides more savings than waterside economizing used in both the chilled beam and CoolSense systems. When waterside economizing is used, CoolSense benefits more than the active chilled beam system because (as described above) more of the cooling load is shifted to the "cool-water" chiller, which is the one that benefits most from waterside economizing. At less-extreme outdoor conditions, the load on the "cold-water" chiller decreases similarly in all three systems.



Acoustic analysis of the CoolSense™ system

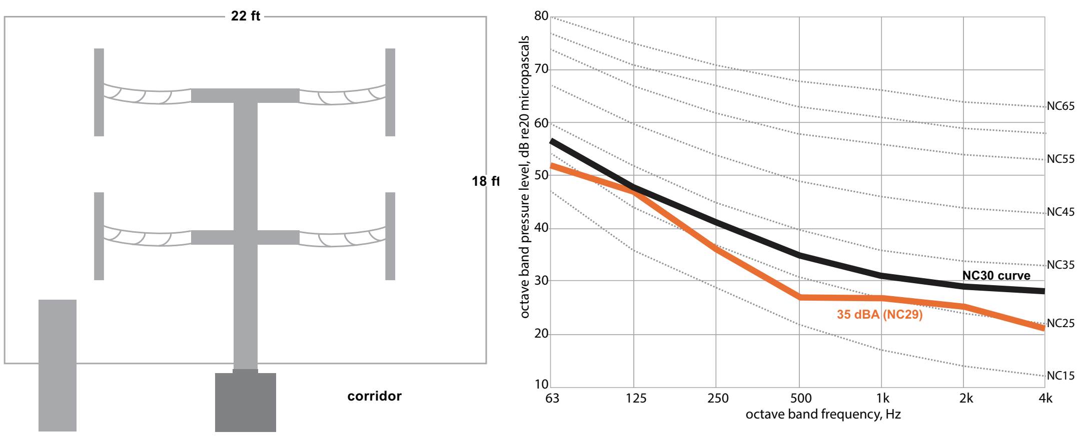
HVAC equipment when applied well provides an appropriate level of background sound for speech isolation and permits clear communication in a classroom. When poorly applied, HVAC equipment sound can be considered noise if it disrupts the intended function of the building.

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, based upon ANSI®/ASA 12.60. 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.

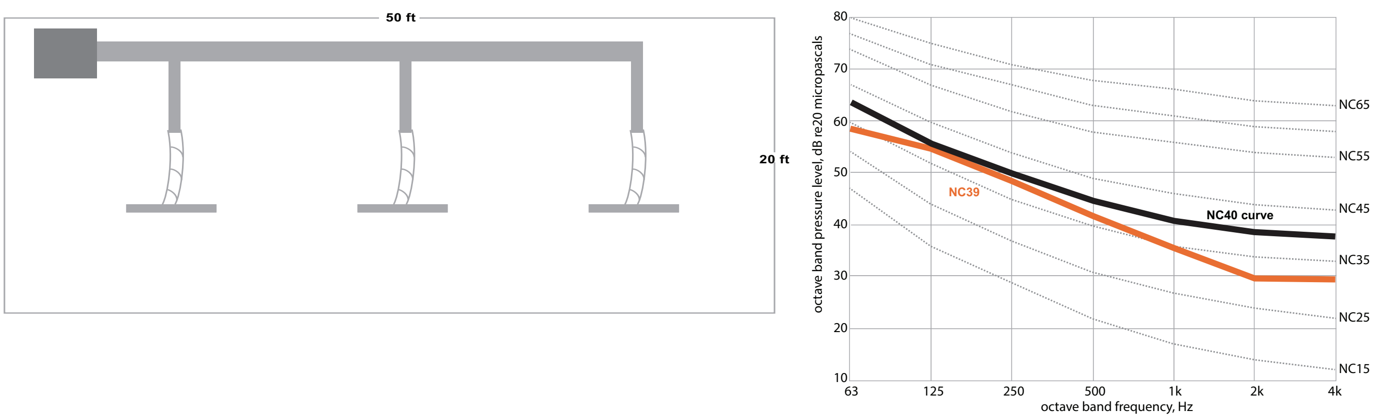
The second analysis was for an open-plan office space where the indoor sound pressure target was NC 40, based on design guidelines from the 2015 ASHRAE® Handbook. To achieve NC 40, the terminal was located inside the ceiling plenum with acoustical ceiling tiles. The office was assumed to have carpeted 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 880-2011. These are available in both the product catalog and the selection program.

Acoustic model of an example classroom using the CoolSense system



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



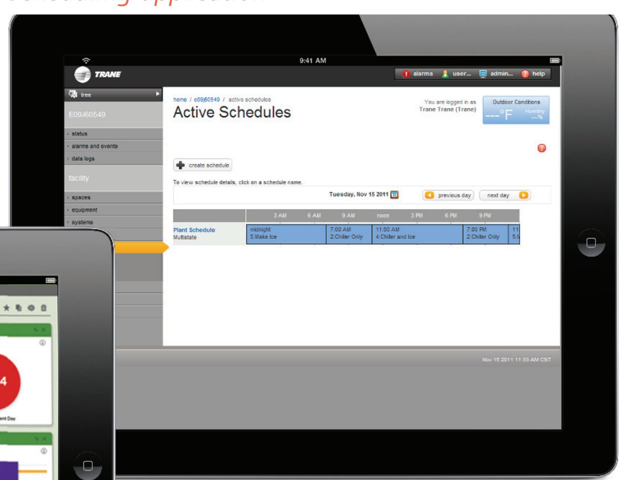
Intuitive, accessible interfaces

It's one thing for the controls installer to understand how to set up the system, but it's imperative that the operator understand how the system works. Standard apps and operator dashboards, supported by thorough documentation, take the mystery out of how your system works, so that you and Trane can keep it running optimally over the system's lifetime.

Dashboards are all about giving the operator information that is actionable—gauges with minimum and maximum values identified, warnings, alerts and error messages—helping identify opportunities to optimize system operation.

Tracer® SC provides access to your system from any connected device: PC, tablet, or smartphone.

Scheduling application



Energy performance dashboard

CoolSense control elements

Tracer Ensemble™ enterprise building management

- Control one building or many from one seat
- Web-based and easy to operate
- Daily building operation through enterprise management and reporting

Tracer® SC system controller

- Standard applications such as AREA and VAS simplify design and control

Tracer UC™600 air-handler controller

- Support for energy recovery, economizer with bypass, desiccant dehumidification, other advanced options
- Outdoor airflow measurement
- Pre-packaged control sequences
- Wired or wireless communication
- Optional color display

Tracer UC™400 unit controller

- Standard, pre-packaged control sequences
- Easy-to-use interfaces
- High-quality graphics
- Wired or wireless communication
- Optimized for mobile operation

Zone sensors

- Wired or wireless models
- Options for digital display, setpoint override, or occupancy override
- Four-function sensor includes temperature, humidity, occupancy and CO_2
- Lifetime batteries as standard

Condensation prevention

One of the most common concerns expressed about sensible-cooling terminals is a fear of condensation. The terminal units come with drip pans that include a moisture sensor as standard. Two different controls are used to either sense when condensation has occurred, or identify and avoid conditions when it might be likely to occur.

The system and zone controls work together to activate the outdoor air unit, for example during unoccupied periods, if either condition is triggered.

The terminal unit can be flipped upside down depending on installation requirements, and it doesn't require the installation and design of traditional condensate systems. And, all condensate from dehumidification can be reclaimed at a central location: in the DOAS air-handler or packaged unit.

Moisture sensor

Moisture sensor in the drip pan

While the cooling coil in the terminal unit is intended to operate dry (no condensation), a drip pan is installed underneath this coil in the event that unintended condensation does occur. When condensation is detected by the moisture sensor (provided in the drip pan as standard), the chilled-water valve closes while the terminal fan continues to operate. The air damper opens or remains open, providing cool, dry air from the outdoor air unit.

Unit operation returns to normal when condensate is no longer detected

Condensation avoidance mode

This mode requires an optional humidity sensor in the zone. This could be a separate sensor, or a module that's added to the zone's existing multi-function sensor. This mode predicts situations that could lead to condensation, and acts before any moisture is sensed in the drip pan.

If the measured zone dew point is greater than the entering chilled-water temperature, the chilled-water valve closes while the terminal fan continues to operate with the air damper open. This increases the flow rate of dehumidified air from the DOAS until the zone dew point temperature drops below this threshold.

Dehumidification best practices

Humidity pull-down mode

If indoor humidity increases during unoccupied periods, for example overnight or over a weekend, humidity pulldown may be needed to reduce indoor dew point and avoid condensation in the zone terminals at startup.

When these conditions are identified, the system opens the zone dampers and starts the dedicated OA unit, ideally with 100% recirculated air if outdoor conditions are unfavorable. The chilled-water valves in the terminal units remain closed. The system operates long enough for the humidity inside the building to reach the desired dew point, 55°F (13°C) for example, before the chilled-water valves on the terminal units are allowed to open.

Neutral- versus cold-air delivery

Many dedicated OA systems are designed to dehumidify the outdoor air and then reheat it to approximately zone temperature (neutral). Delivering the dehumidified outdoor air at a neutral dry-bulb temperature can simplify control because it has no impact on the zone sensible cooling or heating loads.

However, when a chilled-water or DX coil is used for dehumidification, a by-product of that process is that the dry-bulb temperature of the air leaving the coil is colder than the zone. If the dehumidified outdoor air is reheated to neutral, most of the sensible cooling performed by the dedicated OA unit is wasted.

While the conditioned outdoor air should be delivered cold whenever possible, situations when the dedicated OA unit should reheat the dehumidified outdoor air are:

- To avoid overcooling at part-load conditions
- In applications with widely dissimilar sensible cooling loads between zones
- When using very low dew points, reheating all the way to neutral air temperature is likely unnecessary, and should use one of the more efficient methods mentioned in this catalog and in other Trane publications.

Cool, Dry, Quiet (CDQ®) desiccant device

Some of the air-handling units configured to support the CoolSense™ system include both a total-energy device and a desiccant wheel, for improved dehumidification at warmer chilled-water temperatures. The CDQ wheel adsorbs water vapor from the air downstream of the cooling coil and re-leases the collected moisture upstream of that coil, enabling the DOAS air handler to deliver drier supply air (at a lower dew point) without lowering the coil temperature. In addi-tion, because the moisture transfer occurs within a single air stream, a separate, regeneration air stream is not needed.

Hot gas reheat (DX packaged equipment)

When DX packaged equipment is used for the dedicated OA system, one advantage is the proximity of the hot gas line exiting the compressor to the airstream. Using this heat as a source of reheat is commonly called hot-gas reheat. While this energy is not completely "free" to recover, as it requires additional devices and controls, superheat is plentiful in the types of refrigerants used in DX equipment. Desuperheating doesn't make the compressor work harder.

Condenser heat recovery (chilled water systems)

In a system using chilled-water air-handlers for the dedicat-ed OA system, heat recovered from the chiller's condenser is suitable for reheat. This is analogous to hot-gas reheat, but the energy is transferred in water rather than refrigerant pipes. Some air-cooled chillers are available with an integral refrigerant-to-water heat exchanger which recovers heat from the hot refrigerant vapor for use within the facility. Water-cooled chillers can use either onboard or stand-alone water-to-water heat exchangers in the condenser-water circuit.

Exhaust-air energy recovery

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

What is exhaust-air energy recovery?

Air-to-air energy recovery refers to the transfer of sensible heat, or sensible heat and moisture (latent heat), between air streams. The most common application is to recover energy from the exhaust-air stream to precondition outdoor air brought in for ventilation.

Best practices

- Strive for balanced airflows
- Select technology suitable for the application
- Bypass device to avoid overheating at some operating points (see control chart, below)
- Provide a means to control the capacity of the device at part load
- Provide a method for frost prevention in cold climates

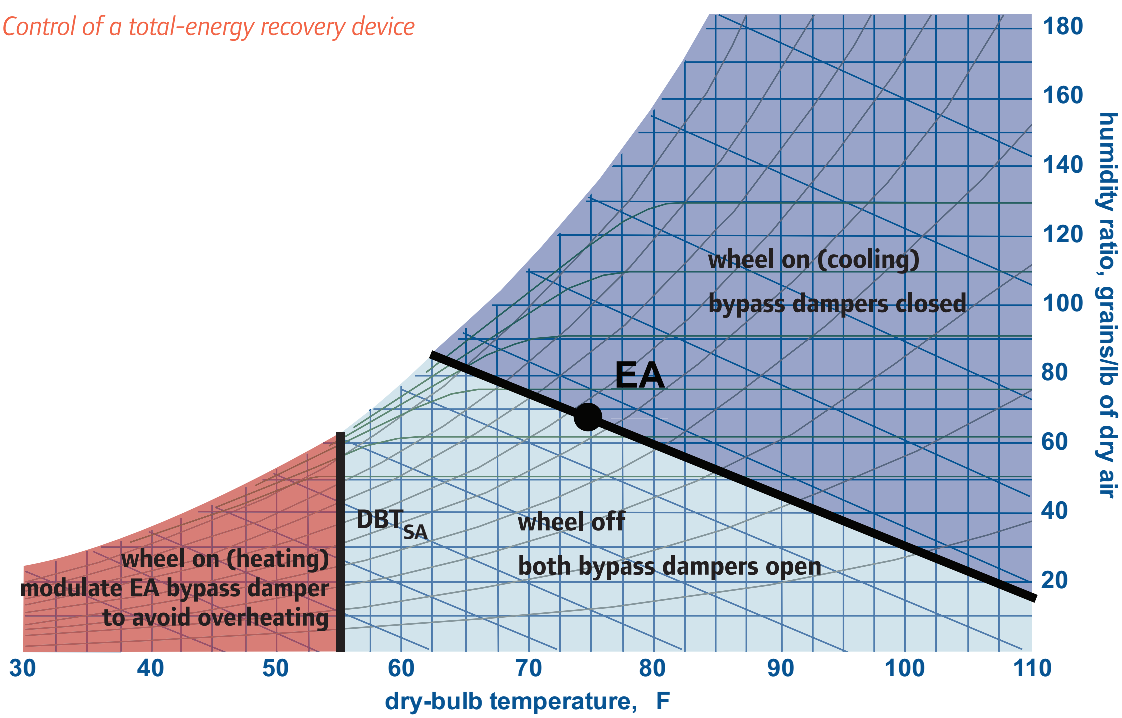
Frost prevention

Any air-to-air energy-recovery device that preconditions outdoor air is subject to frost buildup during very cold weather. If the surface temperature of the device falls below the dew point 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, eventually blocking airflow. One of the benefits of total energy recovery over sensible-only energy recovery is that frost forms at a much colder outdoor temperature, which may even eliminate the need for frost prevention.

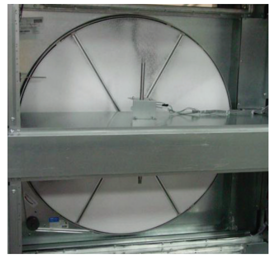
If frost prevention is required, the options are:

- Modulate an outdoor air bypass damper to reduce the heat-transfer capacity of the energy-recovery device, or
- Preheat either the outdoor or exhaust air before it enters the device, for applications with extremely cold outdoor air and higher indoor humidity levels during cold weather.

Control of a total-energy recovery device

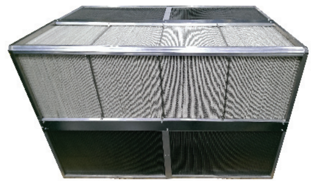


Total-energy wheel offers an excellent combination of high (60 to 80 percent) total effectiveness ideally suited for hot and cold climates, where latent energy recovery in both the summer and winter seasons is desirable. Cross leakage is limited by choosing the right locations for supply and exhaust fans. In many applications and locations, the total-energy wheel's higher levels of effectiveness may be required by the energy code.



Fixed-plate (sensible) heat exchanger. Cross-flow aluminum plates deliver 55 to 70 percent sensible effectiveness with low pressure drop (0.25 to 1.0 in. w.g.). Capacity modulation is accomplished using face-and-bypass dampers. The advantage of this technology is little or no cross leakage; however, of the available technologies, this unit is the most susceptible to frost.

Total-energy recovery with sensible-assisted membrane.
The SAM™ sensible-assisted membrane from Trane substitutes membrane modules into half of the fixed-plate heat exchanger framework. This boosts the effectiveness and lowers the pressure drop compared to other designs. SAM also allows different airflow configurations for better design flexibility.



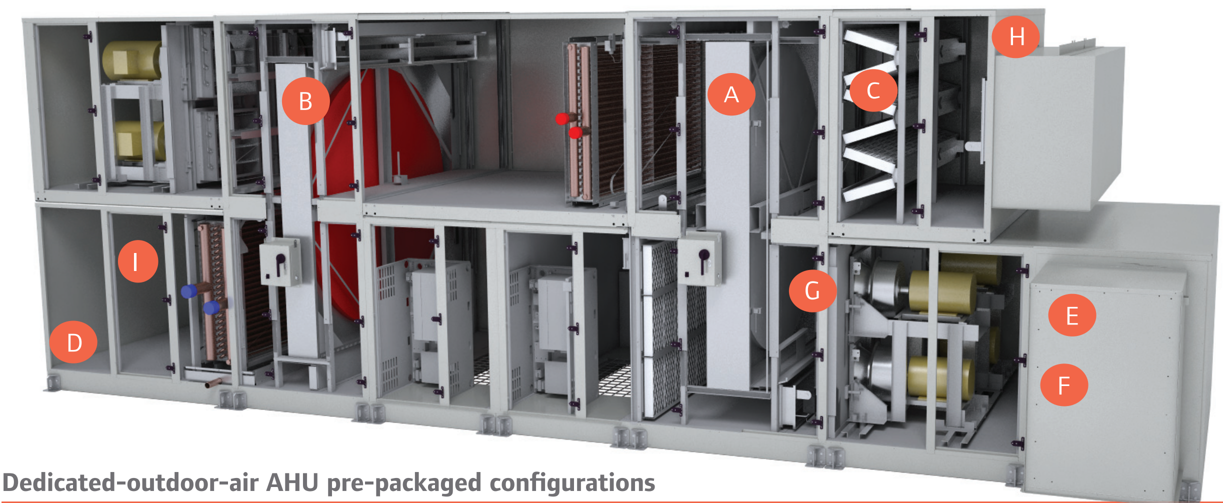
Impact of DOAS configuration on coil loads and chilled water temperatures

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
leaving-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

Consider several DOAS configurations delivering 20,000 cfm of 47°F dew point temperature air (see page 23). Without any energy recovery (left column), the system would require 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 64°F dry bulb temperature air. But, warmer air from the DOAS requires the terminal devices to be sized for more cooling capacity. Adding the CDQ wheel allows the unit to deliver the same leaving-air dewpoint with warmer water in 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 see Engineers Newsletter *"Dedicated Outdoor Air System with Sensible-Cooling Terminal Units"* available from trane.com/CoolSense.

DOAS equipment
Performance Climate Changer® air-handler

- A **Exhaust air energy recovery options:** total-energy wheel, fixed-plate, sensible-assisted membrane, dual-exhaust streams
- B **Desiccant dehumidification options:** CDQ® type III desiccant wheel raises chilled water temperature by 5°F for same dew point
- C **MERV filters:** Exceed LEED® requirements and reduce pressure drop up to 50 percent over previous designs
- 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:** Pre-packaged sequences, wired or wireless, optional color touchscreen controller display
- F **Single-point power, quick connect wiring:** Factory wiring minimizes installation cost and ensures wiring integrity between sections
- G **Efficient fan selections for all pressure requirements:** Three to five percent more efficient than previous designs
- H **Low leak casing, rated and tested to ASHRAE® Standard 111 Class 6:** Achieves less than one percent leakage rate
- I **Optional second cooling coil, upstream:** Allows a portion of the cooling load to use warm chilled water from a dual-temp plant



Dedicated-outdoor-air AHU pre-packaged configurations

	supported features					
pre-packaged solution ID	controller	supply fan modulation	cooling type	desiccant dehumidification	heating type	energy recovery
AH0591	UC600	variable speed	modulating CHW	none	modulating hot water	total-energy wheel
AH0592	UC600	variable speed	modulating CHW	none	staged electric	total-energy wheel
AH0593	UC600	variable speed	modulating CHW	none	modulating electric	total-energy wheel
AH0594	UC600	variable speed	modulating CHW	none	modulating gas	total-energy wheel
AH0595	UC600	variable speed	modulating CHW	CDQ wheel	modulating hot water	total-energy wheel
AH0596	UC600	variable speed	modulating CHW	CDQ wheel	staged electric	total-energy wheel
AH0597	UC600	variable speed	modulating CHW	CDQ wheel	modulating electric	total-energy wheel
AH0598	UC600	variable speed	modulating CHW	CDQ wheel	modulating gas	total-energy wheel
AH0599	UC600	variable speed	modulating CHW	none	modulating hot water	total-energy wheel + fixed-plate HX
AH0600	UC600	variable speed	modulating CHW	none	staged electric	total-energy wheel + fixed-plate HX
AH0601	UC600	variable speed	modulating CHW	none	modulating electric	total-energy wheel + fixed-plate HX
AH0602	UC600	variable speed	modulating CHW	none	modulating gas	total-energy wheel + fixed-plate HX
AH0603	UC600	variable speed	modulating CHW	CDQ wheel	staged electric + modulating hot water	total-energy wheel

CDQ® desiccant dehumidification

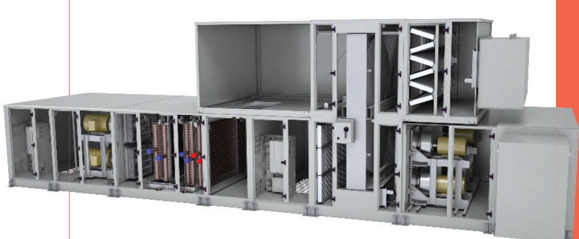
- Type III desiccant removes moisture from saturated coil leaving conditions, allowing better dehumidification and the use of warmer cooling coil fluid temperatures
- 5-15°F lower dew point with warmer fluid temperature— 45°F water creates 47°F dew point leaving air temperature and saves chiller energy
- Requires little or no added heat for regeneration

Air and coil cleaning

- UVC cleaning modules disinfect wet surfaces
- MERV filters remove small particles
- Pre- and post-filter options meet special application requirements
- Terminals are generally not required to have filtration, as the coil remains dry. An optional MERV 8 filter can be installed at the zone cooling coil inlet

Exhaust-air energy recovery options

- Sensible-only, fixed-plate design for dry/marine climates or cross-leakage intolerant applications
- Total-energy wheel for hot and cold climates
- Sensible-assisted membrane (SAM™) option for high effectiveness than fixed-plate, lower air pressure drop than total energy recovery wheel
- Dual exhaust energy recovery captures energy from other exhaust streams while minimizing recirculation, in a single unit



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
- Air-handler configurations for CoolSense™ applications adjust to efficiency and space requirements

DOAS air-handler configurations

The CoolSense™ system is similar to other terminal-based systems that use sensible-only cooling in the zone with dehumidification accomplished in the DOAS portion of the system only. Terminal units in this system are typically supplied with 57°F to 60°F water. This water temperature is not cold enough to dehumidify outdoor air during the cooling season. This can lead to using a packaged or split DX DOAS unit or air handler with a refrigerant coil and a chiller that makes 55°F water, or to a dual-temperature chilled-water system.

Two temperatures—two cooling coils?

For systems using two chilled-water temperatures, an energy-saving option is to add another cooling coil upstream of the other, to accomplish some of the cooling in the DOAS unit using the warmer water that the terminal units require. This gives the chiller(s) more of the cooling load at the warmer temperature.

The downstream coil is supplied with water cold enough (typically 40°F to 45°F) to successfully dehumidify the space to about a 55°F dew point. Some applications require lower dew point air to be discharged by the DOAS unit. Pages 34-35 describe the process for selecting the appropriate DOAS leaving-air dew point temperature.

The table on page 19 shows coil loads, water and air conditions in an example 20,000 cfm unit with 84°F /76°F DPT entering outdoor air, by configuration. A step-by-step narrative about the differences can be found in the Trane Engineers Newsletter *"Dedicated Outdoor Air System with Sensible-Cooling Terminal Units"*, 46-2 (2017).

Energy recovery and desiccant dehumidification?

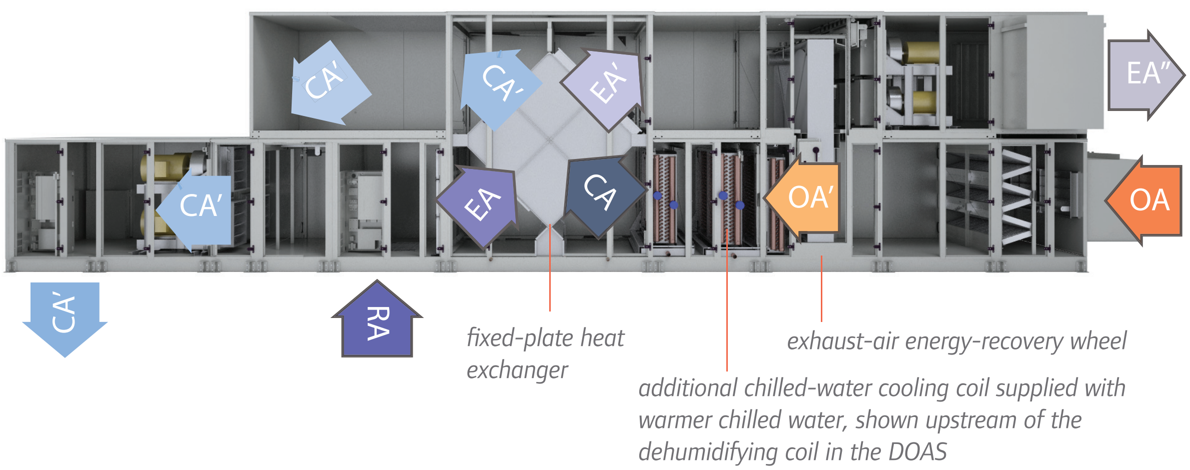
Energy recovery is most likely required by the energy code for dedicated outdoor air systems. This saves heating and cooling energy by using exhaust air to precondition the incoming ventilation air.

Desiccant dehumidification further saves chiller energy by increasing the effectiveness of the cooling coil. The Trane type III desiccant CDQ® wheel allows the unit to achieve its target dew point temperature with warmer-temperature water than a unit without CDQ.

Best practices in air-handler design for DOAS

- Evaluate various configurations based on the application. Classrooms need more dehumidification than offices, see pages 34-35 for guidance.
- Consider air-handler configurations that maximize the efficiency of the chilled-water system.
- Select technology such as SAM, dual-exhaust energy recovery, desiccants, based on the dew point necessary and the objectives of the application.

Example air path through DOAS air-handler

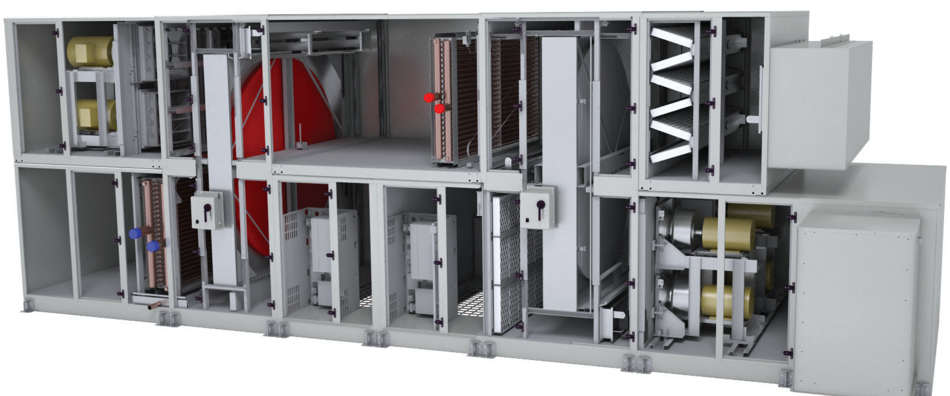


Cooling coil(s) with exhaust-air energy-recovery and reheat

In this configuration, exhaust-air energy-recovery works with one or two cooling coils and a reheat coil to condition the outdoor air. Recirculation air dampers are used during unoccupied periods. The version shown here uses a total-energy wheel; other total-energy devices, such as a sensible-assisted membrane (SAM™), may be used instead with similar performance.

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

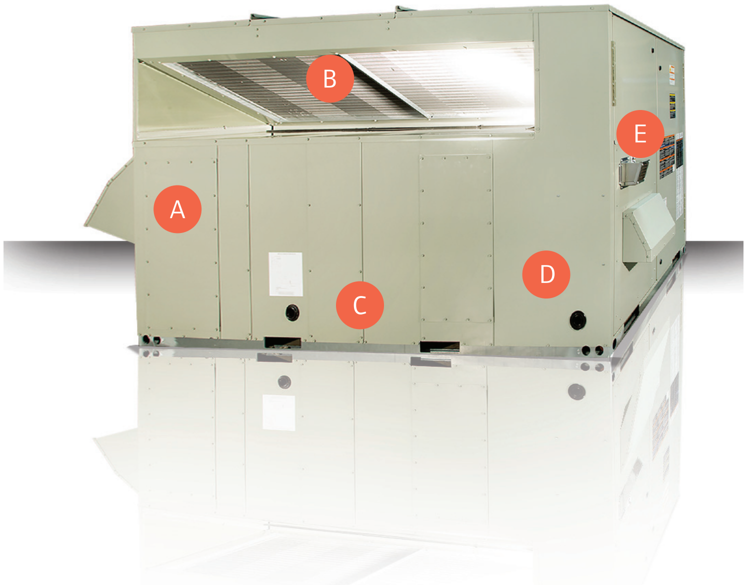
One or two cooling coils work with a total-energy recovery wheel and a downstream fixed-plate heat exchanger. Cold air leaving the cooling coil is tempered with heat scavenged from the return air, via the fixed-plate heat exchanger. The fixed-plate heat exchanger reheats the leaving air by pre-cooling the exhaust air and increases the cooling energy recovered in the total-energy wheel. Bypass dampers within the fixed-plate heat exchanger adjust the leaving air dry-bulb temperature.



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

This configuration uses one or two cooling coils, total-energy recovery and desiccant dehumidification. The CDQ wheel allows the unit to use warmer chilled-water to deliver leaving air at the necessary dew-point temperature than units without this technology.

Horizon® outdoor-air unit



A — Air- and water-source heat pump options, variable speed fans increase energy efficiency

B — High performance condenser and cooling coils/evaporator with optional treatments for corrosion resistance

C — Selectable discharge air dew point temperatures to 45°F

D — Options include digital-scroll and variable-speed compressors using eFlex® scroll technology on one or more compressors

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

Trane Horizon outdoor air units are a packaged option for conditioning the ventilation air and dehumidifying the zones in a CoolSense™ system. Chilled and hot water would be supplied by other equipment to the terminal unit for space conditioning.

See pages 18-19 for an extended discussion about exhaust air energy recovery, an option highly recommended (and likely code-required) for minimizing energy for outdoor air conditioning.

Packaged DOAS unit

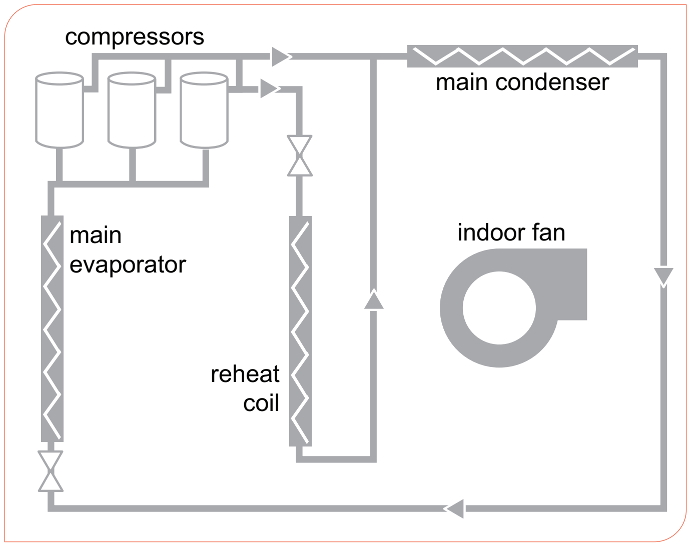
- DX or chilled water/glycol cooling options
- Dual-fuel, gas, electric, hydronic heating options
- Controlled by the Tracer UC™600
- Airflow measurement option
- Exhaust air energy recovery option
- Hot gas reheat option

Horizon outdoor air models, capacity and option availability

					options recommended for CoolSense system application		
model	airflow range	cooling capacity	gas heat capacity	electric heat kW	exhaust air energy recovery	hot gas reheat	airflow measurement
OAB	up to 3,000 CFM	3 to 9 tons	50-200 MBH	10-48 kW	optional	optional - DX only	optional
OAD	up to 3,000 CFM	3 to 9 tons	50-400 MBH	10-48 kW	optional	optional - DX only	optional
OAG	1,500 to 7,500 CFM	10-30 tons	150-600 MBH	20-119 kW	optional	optional - DX only	optional
OAK	1,500 to 7,500 CFM	10-30 tons	150-800 MBH	20-119 kW	optional	optional - DX only	optional
OAN	1,500 to 7,500 CFM	10-30 tons	300-1000 MBH	24-215 kW	optional	optional - DX only	optional

Hot gas reheat (staged or modulating)

An advantage of a packaged DOAS unit is the proximity of the condenser heat to the air downstream of the evaporator coil. The CoolSense™ system requires a lower dew point temperature than systems with dehumidification occurring elsewhere in the system. Hot gas reheat is used for tempering the supply air dry-bulb temperature and limiting new energy for reheat.



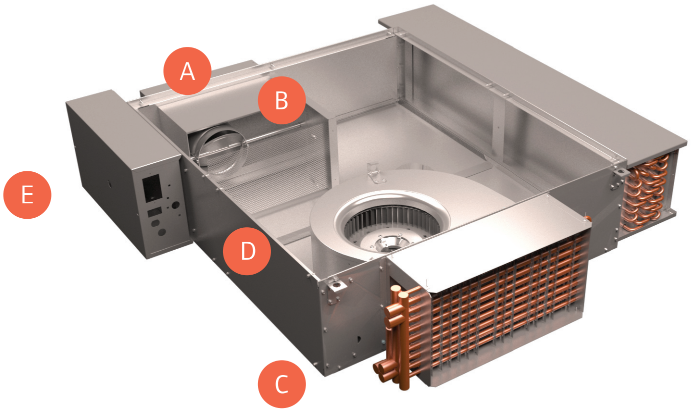
Options save energy, improve operation

- Exhaust air energy recovery with bypass (may be required by energy code)
- Hot gas reheat uses condenser heat to temper the leaving air dry bulb temperature
- Variable speed compressors limit cycling
- Variable-speed indoor fan ideal for use with the zone dampers in the CoolSense system
- Unoccupied space humidity control adjusts leaving air dew point setpoint based on input from one sensor or critical zone sensors via Tracer® SC
- Air- or water-source heat pump options

Accessible, factory commissioned

- Factory-engineered, -commissioned and -tested controls minimize startup time
- Human interface with touchscreen for monitoring, editing and setpoint control— can be remote mounted for indoor access
- BAS Suite for mobile device access means fewer trips to the unit, easier access to data
- Airflow monitoring available for outdoor, exhaust, and/or supply air

Sensible-cooling terminal unit



- **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 air stream
- **E** Factory-commissioned DDC controls with pre-packaged sequences and wired or wireless communication

Sensible-cooling terminals from Trane are manufactured in the most state-of-the-art facility of its kind in the world. They feature proven components such as the patented Trane flow ring and the Trane DDC 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. This means that airflow, temperature setpoints, and addressing are performed in a controlled, factory environment. One hundred percent, factory run-testing ensures that units arrive and function properly upon job startup. With factory-commissioned controls, you have better control over cost and quality. This results in a higher quality installation at a lower cost.

Terminal control using the UC400

There are seven configurations of sensible-cooling terminals, each including programming code for the UC400 controller. Zone control functions are further refined, based on:

- whether or not the zone is occupied
- whether or not the zone requires dehumidification

Fan-powered air terminals

- Two fan sizes, up to 1300 nominal cfm
- Variable-speed fan with EC motorized impeller varies supply airflow as the zone load changes
- 2-, 4- or 6-row sensible-cooling coil at the inlet from the ceiling plenum with modulating control valve, drip pan with moisture sensor and optional filter
- No heat, modulating hot-water heat, staged electric heat, or modulating (SCR) electric heat
- Conditioned outdoor air from the DOAS unit enters the terminal through an airflow-measuring, pressure-independent damper for DCV

Pre-packaged solution IDs for sensible-cooling terminals

supported features			
pre-packaged solution #	controller	cooling type	heating type
TS0233	UC400	modulating chilled water	none
TS0234	UC400	modulating chilled water	staged electric (local)
TS0235	UC400	modulating chilled water	modulating hot water (local)
TS0236	UC400	modulating chilled water	modulating (SCR) electric (local)
TS0237	UC400	modulating chilled water	staged electric (local) + staged electric (remote)
TS0238	UC400	modulating chilled water	modulating (SCR) electric (local) + staged electric (remote)
TS0239	UC400	modulating chilled water	staged electric (remote)

Easy to specify and install

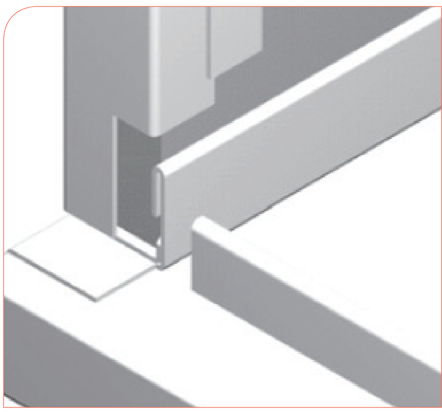
- Wireless options are less disruptive to building occupants, increases location flexibility
- Self-healing wireless mesh, extended signal range, and conformance to the ZigBee® Building Automation standard
- Up to four functions in one sensor (temperature, humidity, CO_2 and occupancy)

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
- Measures velocity of the air at the inlet
- Data to prove proper ventilation

Accessible, factory-commissioned

- Pre-packaged controls and factory commissioning lead to easy installation and standardized operation
- Professional graphics and sensed points
- View and/or override setpoints, depending on pre-established user permissions
- App for mobile devices means fewer trips to the unit, easier access to data



Other features

- Insulation options 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 filter may be installed on inlet to cooling coil

Chilled-water plant configurations

Because the CoolSense™ system relies on a dedicated outdoor air system, and because it uses warmer chilled water in the sensible-cooling terminals, the chilled-water plant configurations used to cool and heat them may deviate from traditional designs. Trane Engineers Newsletter *"Dual-temperature Chiller Plants"* describes in detail some of the ways that designers might consider meeting the two temperature objectives for application with the CoolSense system.

Why two temperatures?

The CoolSense system is similar to other terminal-based systems that use sensible only cooling in the zone with dehumidification accomplished in the DOAS only.

Terminals are typically supplied with water cooled to a temperature in the range of 57°F to 60°F, which is cool enough to provide space sensible cooling, but warmer than the dew point in the space, thereby avoiding condensation in the terminal unit coils.

A separate ventilation and dehumidification system needs to be supplied with water cold enough (typically 40°F to 45°F) to successfully dehumidify the space to about a 55°F dew point.

Why chilled water for both temperatures?

Some systems are designed with a chiller plant providing 57°F water to the terminal units, with a standalone, packaged DX unit for the dehumidification system, such as the Trane Horizon® dedicated outdoor air unit on page 24. While this approach benefits from operating the water chiller at the warmer temperature, there is no redundancy if either the chiller or DX dehumidification 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 and find the one that best meets the objectives of the application.
- Keep glycol out of the terminal cooling coils. If glycol is needed for freeze protection at the chiller, use a heat exchanger to send water to the sensible cooling coils.
- Consider air-handler configurations that maximize the efficiency of the chiller (see page 19).
- Select suitable technology options, such as condenser heat recovery and waterside economizing options.

Condensate prevention

A system that uses mixing valves or sensible coils downstream and in series with dehumidifying coils introduces control complexity and risk of inadvertently sending water that's too cold to the terminal units. If this is a concern, configurations without a blending valve or with dedicated chillers may be preferred.

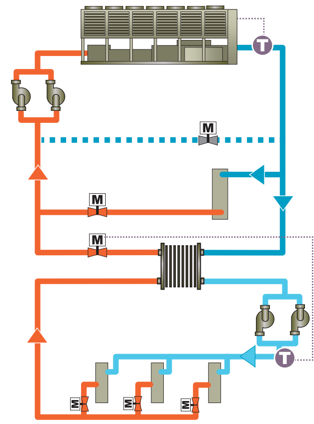
Comparison of chiller plant configurations for dual-temperature applications

configuration	controllers	redundancy	free cooling	chiller freeze protection†	blending valve	thermal storage	condenser heat recovery
Single-chiller, dual-temp plant with heat exchanger	SC, UC600	half (dual circuits)	option	yes	no	option	option
Single-chiller, dual-temp plant with blending valve	SC, UC600	half (dual circuits)	option	no	yes	option	option
Single-chiller, dual-temp plant with energy storage	SC, UC600	full (1-5 days typically)	option	yes	no	yes	option
Dual-chiller, dual-temp plant with heat exchanger	SC, UC600	yes, option (chiller sizing)	option	yes	no	option	option
Dual-chiller, dual-temp plant with blending valve	SC, UC600	yes, option (chiller sizing)	option	no	backup only	option	option
Dual-chiller, dual-temp plant with dedicated chillers	SC, UC600	yes, option (chiller sizing)	option	no	backup only	option	option
Triple-chiller, N+1 dual-temp plant, dedicated chillers	SC, UC600	yes	option	no	backup only	option	option

†Refers to the configuration's support for freeze protection, particularly in air-cooled chillers installed outdoors, without impacting terminal-unit cooling-coil performance

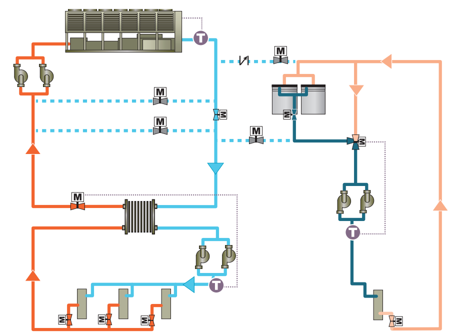
Single-chiller, dual-temperature plant with intermediate heat exchanger

In the configuration, the chiller produces 40°F fluid (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 a plate-and-frame heat exchanger that is controlled to produce 57°F water for the sensible-only terminal units. The benefit of this configuration is simplified hydronics and control. But it precludes the efficiency benefit from operating a chiller at warmer leaving-water temperatures for space sensible cooling only. During drier weather, when the DOAS dehumidifying coil is no longer needed (when the outdoor dew point is below 47°F, in this example), the leaving-water temperature setpoint for the chiller may be reset upwards.



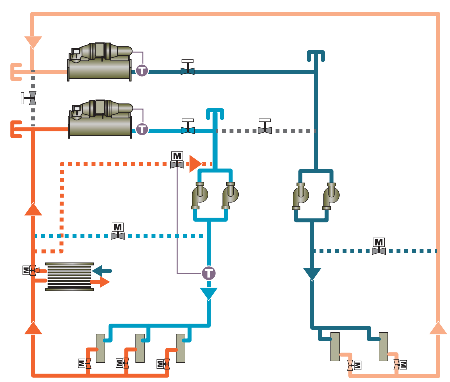
Single-chiller, dual-temperature plant with thermal energy storage

This configuration regains the chiller efficiency advantage from warmer fluid temperatures lost in a single-chiller dual-temperature plant. During daytime operation, stored energy produces the 40°F fluid for the DOAS dehumidifying coil. The chiller setpoint is raised to 55°F and brine is sent to an intermediate heat exchanger; water at 57°F goes to the sensible-cooling terminal units. When the building is unoccupied at night, the chiller 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 the chiller efficiency is higher due to cooler ambient temperatures.



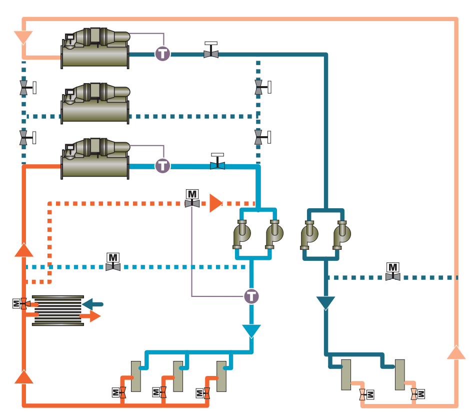
Dual-chiller, dual-temperature plant, no blending in normal operation

Many chiller plants include more than one chiller, to improve plant efficiency and 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 40°F water to the DOAS dehumidifying coils. The diagram shows waterside free cooling in the warmest section of the system, increasing the hours of free cooling operation. Because this design uses two temperatures, a blending valve is not used in normal operation, and there is less likelihood of inadvertently sending terminals with water below space dew point.



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

A third, N+1 chiller further increases redundancy if it is capable of providing either 57°F or 40°F water, in the event that one of the other two chillers is in need of service. If waterside economizing is desired, it is typically provided using either a separate plate-and-frame exchanger connected to the condenser-water loop, or by using a chiller equipped with its free cooling option as the “warm-water” chiller. Because this design uses two temperatures, a blending valve is not used in normal operation, and there is less likelihood of accidentally shocking terminals with water below space dew point. Chillers may be smaller because they don’t have to be the only chiller in operation.



System completion modules

Chiller plant completion modules

There are probably just as many ways to configure a dual-temperature chiller plant as there are chiller plant designers. Schematics for four options can be found on page 29 and the relative merits of these and others are discussed in Trane Engineers Newsletter *"Dual-temperature Chiller Plants"*, available from trane.com/CoolSense. For designers, owners, developers and contractors who want to accelerate design time, minimize risk and streamline installation, a completion module may be the right answer.

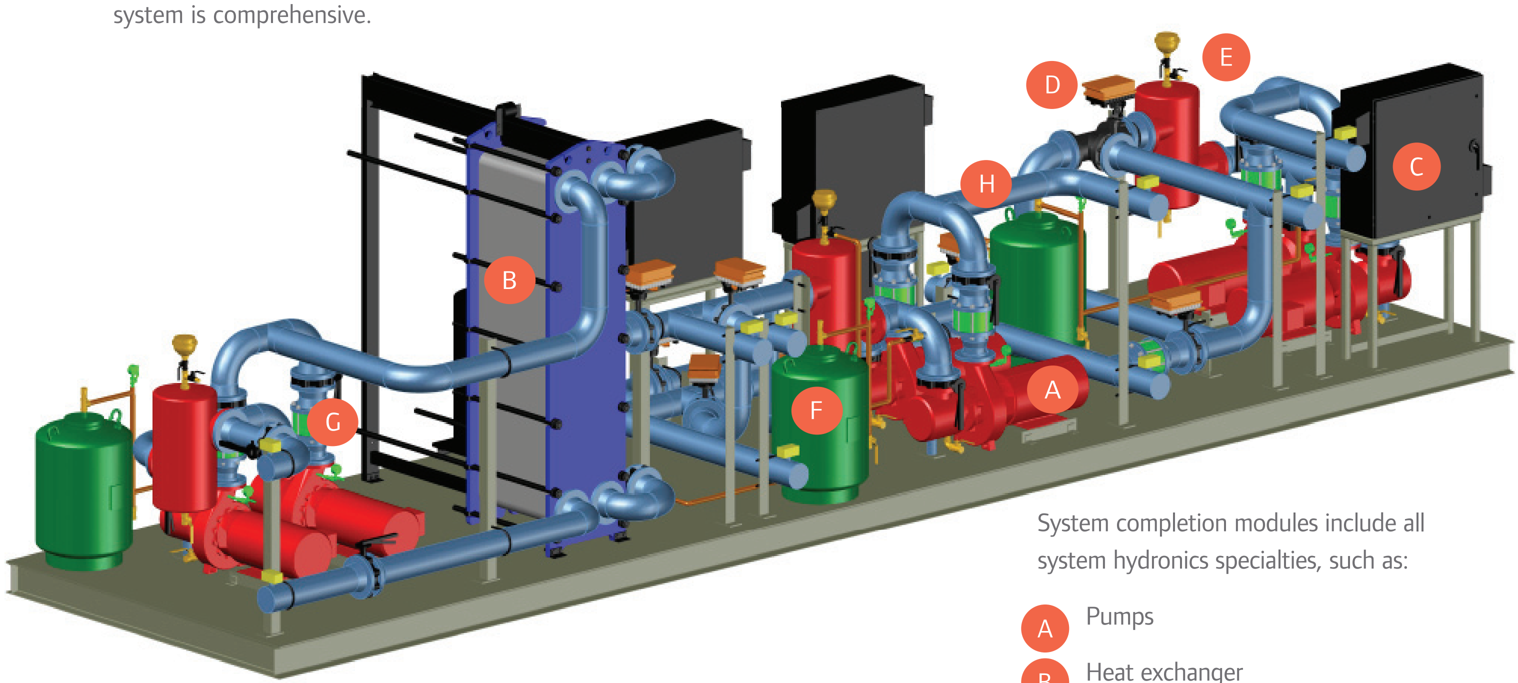
Pre-packaged solutions from Trane do not require the use of a completion module, though they are recommended. The documentation you receive on this system is comprehensive.

Why use a completion module from Trane?

- Shorter design cycle—drawings, pipes, pumps, valve selections and more are done by factory engineers
- Less coordination of trades, fewer staging locations
- Factory quality and functional testing
- Designs informed by past experience
- One vendor handles all warranty and replacement parts

Best practices in chiller plant packaging

- Evaluate various configurations and know the requirements of the application.
- Consider chiller-plant configurations that maximize the efficiency of the system not just the components.
- Select factory start-up to make sure all controls commissioning is accomplished and modified as needed.



System completion modules include all system hydronics specialties, such as:

- A Pumps
- B Heat exchanger
- C Control and electrical panels
- D Motorized control valves
- E Air separator(s)
- F Expansion tank(s)
- G Pump strainers
- H All connective piping

Save time, money, space

- Components and controls rated for indoor or outdoor use
- Enclosure options with service access, lighting, space conditioning save equipment room space
- Reduces design and construction costs, faster install

Enclosure options

- Aesthetics, protection or maintenance concerns may lead to an enclosed module
- Louvers to match chiller
- Removable service panels
- Double wall construction

Customized for each project

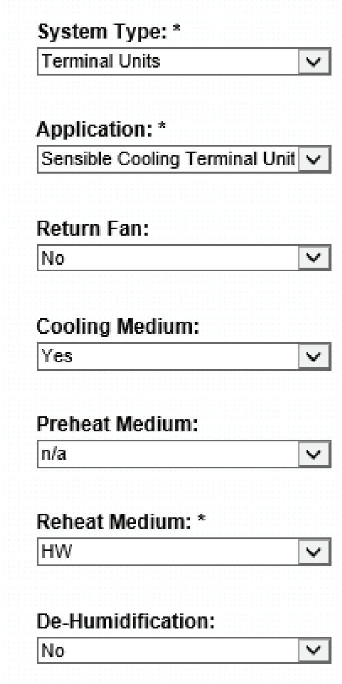
- Break apart or partially assembled modules meet unique installation constraints, such as fitting into a narrow shaft or elevator
- Parts and manufacturers can be chosen to standardize with existing or preferred vendors

Factory quality

- Single source responsibility
- Warranty system support
- Tested and commissioned
- ETL® listed
- Built and backed by Trane

Design resources

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



Pre-packaged solutions (PPS) available from Trane

Consulting engineers are encouraged to discover design resources available from the traneengineer.com portal. One of the resources is what Trane calls Pre-packaged Solutions. Register, then navigate to the type of equipment and select a few key features. If one or more matching solutions are found, they are displayed in a matrix:

System Description	Sequence of Operation	IO Points List	Flow Sketch	
TS0235 - Sensible Cooling Terminal Unit - Fan Powered Series, Hydronic Cooling Coil, Local Hot Water Reheat (proportional) (UC400)				

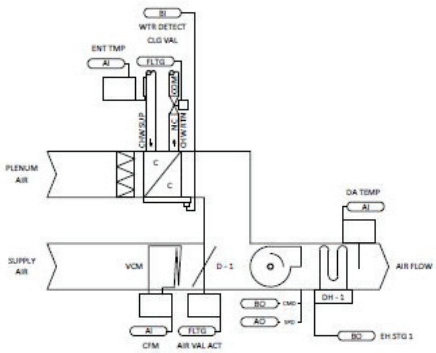
For example, for the sequences, points list, and flow sketches for CoolSense terminal units, select the entries shown on the left side of this page. It may be helpful to leave some of the selections blank initially, in order to have a longer list of options. In some cases, an exact PPS is not available and modifications may be made to a similar PPS.

Trane BAS technicians have access to the PPS Configurator tool that is used to develop control packages for applied solutions such as chilled-water systems.

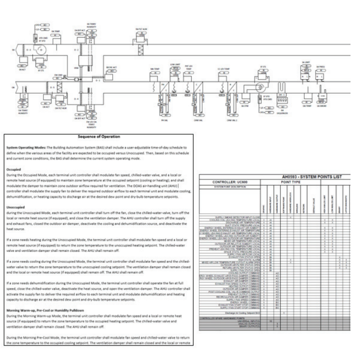
Other Resources

Drawing files, design and analysis software and educational resource such as videos, application manuals and guides, are available from trane.com/continuingeducation. Subscribe to our Engineers Newsletter at trane.com/EN.

Control flow sketch



System control diagrams



Sequences of operation

Sequence of Operations

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

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

Occupancy Mode:
The occupancy mode shall be communicated or hardwired to a binary input. Valid occupancy modes shall 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.

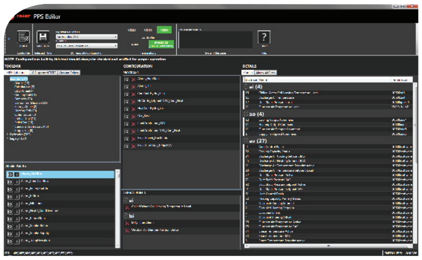
Occupied Standby:
When the unit is equipped with an occupancy sensor, that sensor can be used to indicate that people are not currently present, even though the unit is in the Occupied Mode. In this Occupied Standby mode, the controller shall maintain the zone temperature at the Occupied Standby Cooling 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 lists

CONTROLLER: UC400 VAV	POINT TYPE											
SYSTEM POINT DESCRIPTION	GRAPHIC	HARDWARE INPUT	HARDWARE OUTPUT	SOFTWARE POINT	HARDWARE INTERLOCK	WIRELESS	NETWORK	DEFAULT VALUE	HIGH ANALOG LIMIT	LOW ANALOG LIMIT	BINARY	LATCH DIAGNOSTIC
DISCHARGE AIR TEMPERATURE	X	AI							X	X		
ENTERING WATER TEMPERATURE LOCAL	X	AI							X			
OCCUPANCY INPUT	X	AI				X						
SPACE CO2 CONCENTRATION LOCAL	X	AI				X						
SPACE HUMIDITY LOCAL HUMIDITY	X	AI				X						
SPACE TEMPERATURE LOCAL	X	AI				X						
SUPPLY AIRFLOW	X	AI										
CONDENSATE DETECTION INPUT	X	BI										
SUPPLY FAN SPEED	X		AO									
FAN OUTPUT	X		BO									
HEAT OUTPUT 1	X		BO									
AIR VALVE DRIVE COMMAND	X		FLTG									
CHILLED WATER VALVE COMMAND	X		FLTG									
OCCUPIED COOLING SETPOINT				X				74.0 deg. F	X	X		
OCCUPIED HEATING SETPOINT				X				71.0 deg. F	X	X		
OCCUPIED STANDBY COOLING SETPOINT				X				78.0 deg. F	X	X		
OCCUPIED STANDBY HEATING SETPOINT				X				67.0 deg. F	X	X		
UNOCCUPIED COOLING SETPOINT				X				85.0 deg. F				
UNOCCUPIED HEATING SETPOINT				X				60.0 deg. F				
MINIMUM COOLING AIRFLOW SETPOINT				X								
MAXIMUM COOLING AIRFLOW SETPOINT				X								
MINIMUM HEATING AIRFLOW SETPOINT				X								
MAXIMUM HEATING AIRFLOW SETPOINT				X								
OCCUPIED BYPASS TIMER				X								
BAS COMMUNICATION STATE				X				2 HRS				
CONTROLLER SPARE HARDWARE POINTS												
ANALOG INPUT(S)		4										
BINARY INPUT(S)		2										
UNIVERSAL INPUT(S)		2										
ANALOG OUTPUT(S)			1									
BINARY OUTPUT(S)			3									

PPS Configurator



Enhanced graphics

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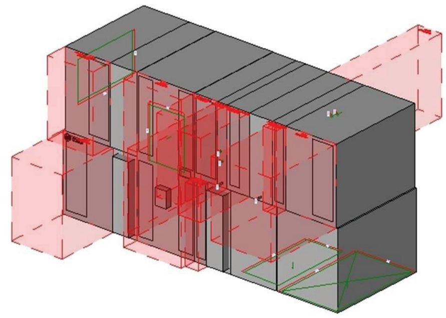
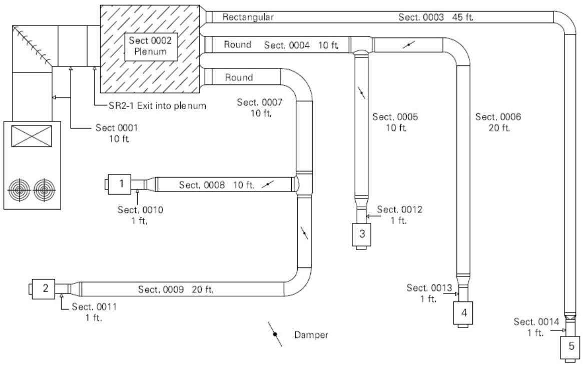
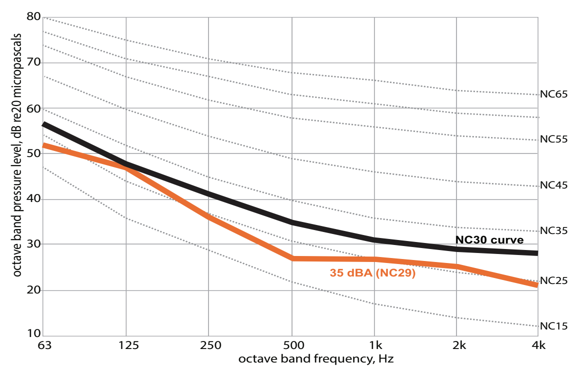


VariTrane® duct design software and support



TAP™ acoustic analysis software and support



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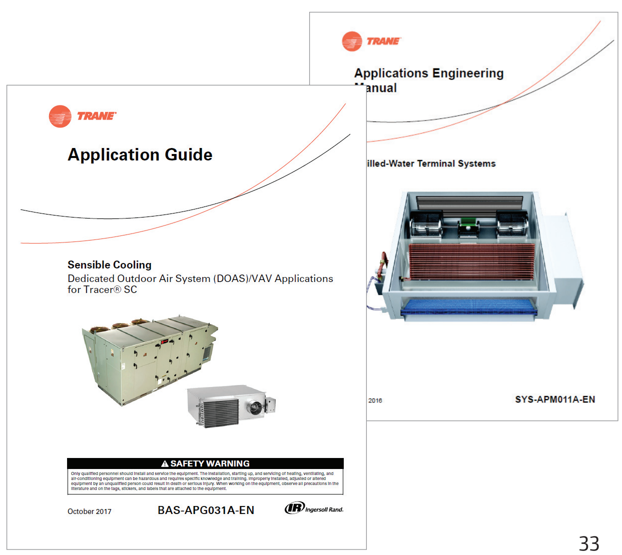


Selection and configuration guidance

Select the right DOAS configuration

Several DOAS configurations are suitable for CoolSense™ systems. Trane Engineers Newsletter *"Dedicated Outdoor Air with Sensible Cooling Terminal Units"* includes a comparison and discussion as to why you might select one over the other. This is available from trane.com/CoolSense. Contact your Trane representative to discuss your options.

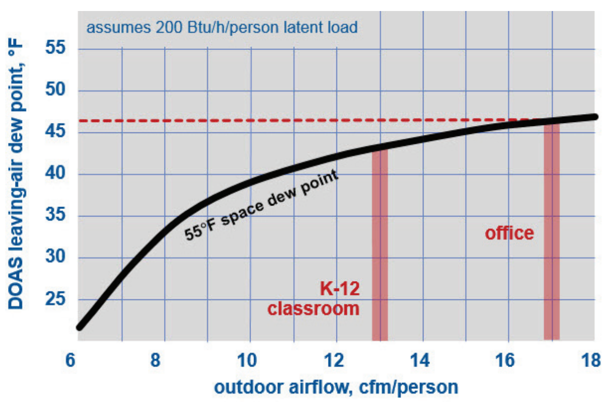
Dew point temperature is determined by a calculation that considers the outdoor airflow and the zone latent load to be handled by the ventilation and dehumidification system. Other considerations such as energy efficiency, space and cost may constrain the selection as well.

Determine the leaving air dew point temperature

In the CoolSense system, all of the zone dehumidification is provided by the dehumidified outdoor air delivered by the DOAS. The required DOAS leaving-air dew point varies based on the zone latent load, zone outdoor airflow, and desired space dew point.

The chart below illustrates how office spaces and classrooms might require quite different DOAS leaving-air conditions in order to keep the zone dew point below 55°F. For specific guidance on how to calculate the required DOAS leaving-air dew point, see the Trane application guide *"Dedicated Outdoor Air Systems"* available from trane.com/CoolSense.

Leaving air DPT varies by space type, occupant density



Note: Assumes 200 Btu/h per person latent load and no other latent loads in the zones

Schedule the terminal unit settings

As described in the modes of operation section on pages 6-7, the terminal unit controller varies both zone airflow and ventilation airflow to provide control of temperature, humidity, and ventilation in each zone.

Minimum and maximum fan airflow setpoints. The maximum fan airflow setpoint for the terminal unit is determined when selecting the unit to meet the desired sensible cooling and heating loads in the zone.

The minimum fan airflow setpoint defines the lowest airflow the terminal unit will be allowed to deliver. However, the controller might force the fan to operate at a higher airflow, if needed, to provide required ventilation or additional dehumidification capacity. That is, the fan airflow is never allowed to be lower than the ventilation airflow setpoint.

Three additional settings for each zone are available, for example to increase discharge air temperature or to raise the airflow in heating mode to protect electric heating coils.

- Heating Maximum Flow Setpoint for terminal unit fan
- Air Flow Setpoint Max, Heat (if different than cooling)
- Air Flow Setpoint Min, Heat (if different than cooling)

Ventilation air damper setpoints. The design ventilation airflow setpoint is the minimum ventilation required by local code, when the zone is at design occupancy. The controller also allows for a separate maximum airflow setpoint, which allows the ventilation air damper to be opened further (increasing the flow rate of cool, dehumidified air from the DOAS) when more cooling or dehumidification is necessary.

When equipped with a CO_2 sensor and/or occupancy sensor, the UC400 controller will adjust the ventilation airflow setpoint based on the current CO_2 concentration (or occupancy state) in the zone.

Example terminal unit schedule (1000 ft² office)

	fan				ventilation air damper						cooling section					heating section				
ID	min (cfm)	max (cfm)	motor size (hp)	external SP (in H_2O)	design OA (cfm)	DCV min OA (cfm)	max (cfm)	inlet size (in.)	CO_2 max (ppm)	CO_2 min (ppm)	rows	sensible capacity (MBh)	entering fluid temp (°F)	water flow rate (gpm)	water pressure drop (ft H_2O)	rows	capacity (MBh)	entering fluid temp (°F)	water flow rate (gpm)	water pressure drop (ft H_2O)
Zone 1	140	675	3/4	0.25	85	60	105	5	950	350	6	10.7	57	5.25	6.53	2	11.1	110	2.16	2.98

CO_2-based demand-controlled ventilation setpoints

The CO_2-based DCV sequence used in the Tracer UC™400 controller is based on the sequence suggested in Appendix A of the ASHRAE® Standard 62.1 User's Manual. Note this sequence is intended for a zone-level terminal unit applied as a "single-zone ventilation system." That is, outdoor air is delivered to the ventilation damper of the terminal unit, where it may then be mixed with recirculated air from a single ventilation zone before it is delivered to that same zone.

The following describes how to determine the appropriate ventilation airflow and CO_2 setpoints for this DCV sequence:

Step 1: Calculate the required outdoor airflow for the zone ($V_{bz\text{-}Design}$) at design occupancy, using the equation from ASHRAE Standard 62.1, for example.

$$V_{bz} = R_p \times P_z + R_a \times A_z$$

where,

V_{bz} = minimum outdoor airflow required in the breathing zone, cfm

R_p = outdoor airflow required per person (from Table 6.2.2.1 in Standard 62.1), cfm/person

R_p = outdoor airflow required per unit of floor area (from Table 6.2.2.1 in Standard 62.1), cfm/ft^2

P_z = zone population, number of people

A_z = zone floor area, ft^2

Step 2: Use the same equation to calculate the required outdoor airflow ($V_{bz\text{-}DCVmin}$) if no occupants are currently present in the zone ($P_z = 0$).

Note this setpoint may need to be increased if the zone requires makeup air to replace air that is exhausted directly from the zone (as might be the case in a kitchen, a laboratory, an art or science classroom, or any space with a restroom connected to it). In this case, the $V_{bz\text{-}DCVmin}$ setpoint may need to be adjusted so it is slightly above the local exhaust airflow to ensure positive building pressurization.

Step 3: Use Equation A-J from the Standard 62.1 User's Manual to calculate the steady-state indoor CO_2 concentration ($CO_{2space\text{-}Design}$) when the zone is fully occupied and at its design outdoor airflow rate ($V_{bz\text{-}Design}$).

$$CO_{2space} = CO_{2outdoors} + [1{,}000{,}000 \text{ x } N/(V_{bz\text{-}Design}/ P_{z\text{-}Design})]$$

where,

CO_{2space} = concentration of CO_2 in the breathing zone, ppm

$CO_{2outdoors}$ = concentration of CO_2 in the outdoor air, ppm

N = rate at which CO_2 is generated by the zone occupants, cfm/person

The rate at which the occupants produce carbon dioxide (N) varies with diet and health, as well as with the duration and intensity of physical activity. The following table suggests typical values for various activities:

occupant activity level	met	CO_2 generation rate (N) (cfm/person)
sleeping	0.7	0.0059
seated, quiet	1.0	0.0084
seated, typing	1.1	0.0092
seated, filing	1.2	0.0101
walking (2 mph)	2.0	0.0168
lifting/packing	2.1	0.0176
light machine work	2.2	0.0185
heavy machine work	4.0	0.0336
sources: A more complete table of Met levels for various activities can be found in Chapter 9 (Table 4) of the 2017 ASHRAE Handbook–Fundamentals. According to the Standard 62.1 User's Manual (Appendix A), the CO_2 generation rate (N) averages about 0.0084 cfm/met/person over the general adult population.		

Unless the outdoor-air intake is located very close to an area with heavy vehicle traffic, it is common for design engineers to assume the outdoor concentration ($CO_{2outdoors}$) to be 400 ppm.

Step 4: The steady-state indoor CO_2 concentration ($CO_{2space\text{-}DCVmin}$) when the zone has no occupants ($P_z = 0$) will be equal to the outdoor CO_2 concentration.

See the example schedule above.

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