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Terminal Systems–Reviving IEQ!

How terminal systems can be designed for IEQ

For the past several years, indoor environmental quality has dominated HVAC considerations and discussions. For the decades prior to the COVID-19 pandemic, comfort and energy efficiency seemed to eclipse indoor environmental quality. However, going forward, all elements of indoor environmental quality will likely remain important, along with energy efficiency. At the same time, terminal systems coupled with a separate ventilation system are growing in popularity, and buildings designed in this manner offer some unique opportunities and challenges for indoor environmental quality.

Indoor Environmental Quality

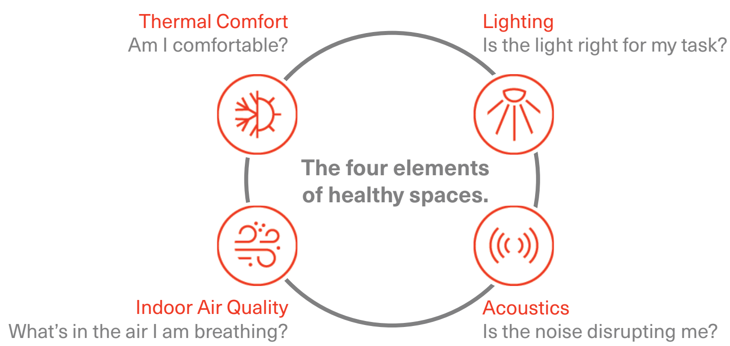
Indoor *air* quality (IAQ) focuses on the cleanliness of air, but IAQ is merely one element of indoor *environmental* quality (IEQ). IEQ includes indoor air quality, thermal comfort, lighting, and acoustics. All four elements are important to ensure occupants have a satisfactory building (Figure 1).

With respect to these individual elements of IEQ, terminal systems present new opportunities and challenges. This EN focuses on air quality while briefly discussing two of the other three elements important to HVAC system design: thermal comfort and acoustics.

When evaluating indoor air quality, it's critical to understand what must be cleaned from the air. ASHRAE® Standard 62.1 "Ventilation for Acceptable Indoor Air Quality" requires regional and local air quality studies to identify what contaminants are present in the outdoor air. Similarly, it's important to understand what contaminants could be generated in the occupied space.

Knowing these contaminants allow the designer to make informed air cleaning decisions. See the Common Air Cleaning Technologies sidebar on page 3 for a discussion of various technologies and their capabilities.

Figure 1. Elements of healthy spaces



Terminal Systems

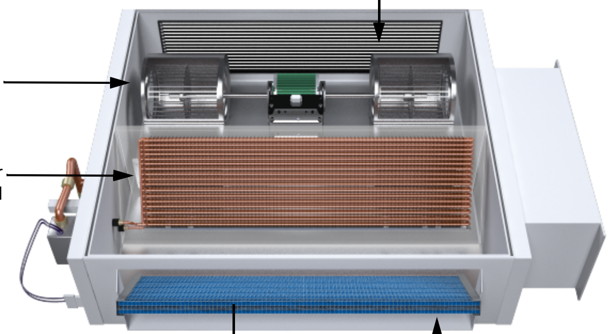
A typical terminal system includes a dedicated terminal unit for each zone that is designed to provide the heating and cooling to maintain the desired zone temperature. Terminal unit installation may be beside the wall, suspended from the ceiling, in the ceiling plenum above the occupied space, or near the occupied space in a closet or vertical chase. The terminal system is designed to offset most of the space loads, such as envelope loads and internal loads from people, lighting, and equipment.

Terminal systems may employ chilled- and hot-water for cooling and heating, respectively. Examples of hydronic terminal systems include fan-coils, classroom unit ventilators, sensible-cooling terminal units, and chilled beams. Alternatively, some terminal systems use a mechanical refrigeration system to provide cooling and heating. Examples include packaged terminal air conditioners, water-source heat pumps, and variable refrigerant flow systems.

Most terminal units include a fan, which is used to move air through a cooling and heating coil. For example, consider a fan-coil unit, like the one shown in Figure 2. Return air from the zone is drawn into the fan-coil intake, or through the return air plenum, or through a small section of return duct. The air passes through a filter, a fan, and at least one coil. The conditioned air is then discharged directly into the zone or through ductwork and supply air diffusers. Some terminal units provide a single coil which can heat or cool, rather than two separate coils. Others include an electric heating element instead of hot water. Often, terminal units do not circulate air between different zones, which can serve to provide some isolation between various zones.

Often, outdoor air for ventilation is conditioned and delivered by a separate system, which will be discussed later. The terminal units are sized to offset most of the zone loads but not the ventilation load when a separate ventilation system is designed to condition the outdoor space. In

Figure 2. Fan-coil example



some cases, the terminal system might be used to provide outdoor air to the zones. In these cases, outdoor air that is unconditioned or partly conditioned is drawn into the terminal unit and mixed with the recirculated air. Locating the filter upstream of the coils helps ensure the heat exchangers stay relatively clean, which allows better heat transfer efficiency.

Terminal System Indoor Air Quality

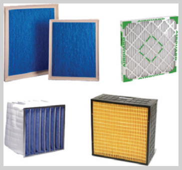
In terminal systems, individual zone temperature is controlled by its respective terminal unit. Each terminal unit can be equipped with a filter and sometimes an additional air cleaning device. Terminal units may offer constant- or variable-speed fans. The former often modulates the leaving air temperature during periods of reduced load to maintain zone temperature while keeping airflow constant. Variable-speed fan control reduces the amount of air passing through the terminal, while controlling the discharge air temperature to maintain zone temperature.

Most terminal systems pass recirculated return air through a particulate filter to remove airborne particulate matter. The filter is often located upstream of any coils. In fact, ASHRAE® Standard 62.1-2019 requires a MERV 8 filter or better, upstream of any wetted surfaces, including coils that produce condensate due to dehumidification. This MERV 8 requirement is often satisfied with throwaway or pleated filters. Manufacturers may offer filters with a higher MERV rating to increase particulate capture for some terminal units, but this is not always an option. It may be difficult to meet the ASHRAE® recommendation of MERV 13 or better for attached viruses like the virus that causes COVID-19.

Terminal System Fan Operation

Variable-speed terminal units save energy by reducing fan speed, however as an unintended consequence, the amount of air passing through a terminal unit air cleaning device is also reduced. As the fan speed decreases to reduce the volume of conditioned air delivered to the space, the amount of recirculated air passing through the unit filter decreases. Designers might look to provide a new set of operating modes specifically designed for times of reduced indoor air quality or increased viral loads—some have used the phrase "epidemic conditions in place" (ECIP) to describe the latter mode. For example, the ECIP mode could be used to disable demand-controlled ventilation. If the unit is equipped with reheat, the cooling-mode airflow rate can be kept high while reheat is used to ensure the space is not overcooled. As a result, this keeps the airflow rate higher through the filter, helping ensure more room air is cleaned. For a new system design, a better alternative would be to use a system that can stage or modulate the cooling capacity when the fan is running at a higher speed.

Common Air Cleaning Technologies



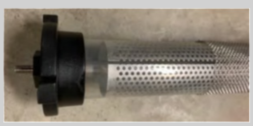
Filtration

Filters are used to capture airborne particulate matter from the air stream which passes through it. Often, filters are used upstream of coils and other HVAC components to keep them clean, which helps maintain heat transfer performance. There are a variety of air filtration options available, ranging from panel filters to high-performing cartridge filters. Smaller panel and pleated filters are commonly used in terminal units. No matter the type, the filter adds an air pressure drop to the system that must be overcome by the supply fan. The filter must be installed in a way that ensures proper sealing, preventing air from bypassing around it.

Particulate filter efficiency is expressed using a minimum efficiency reporting value (MERV) after being tested in accordance with ASHRAE® Standard 52.2. Using the MERV rating, practitioners can understand how efficiently a filter removes particles of various sizes from 0.3 to 1.0 microns. The MERV scale runs from 1 to 16, with larger numbers indicating a better ability to remove smaller particles. Although not often available in a terminal system, it's worth mentioning that high efficiency particulate air (HEPA) and ultra-low particulate air (ULPA) filters provide better particulate capture beyond MERV 16.

Filters with higher MERV ratings provide better capture of microbiological organisms, such as viruses and bacteria attached to particulate matter. As of this publication, ASHRAE® recommends MERV 13 or better filtration for attached viruses, including the virus that causes COVID-19.

Filters are only effective when air is passing through them. Less air is filtered when the terminal unit is operating at reduced speed or off. Filters have no effect on volatile organic compounds (VOCs), such as odors and gases. Filter systems must be maintained with periodic replacement.
(Filter photos courtesy of Parker Hannifin Corporation.)



Bipolar Ionization

Bipolar ionization devices use electricity to create a local plasma field that reaches three to five feet and has strong electrostatic interactions. When the supply air passes through the device, atoms or molecules acquire an electrical charge, a process called ionization. Manufacturers claim oppositely charged dust particles stick together to form larger particles, a process called agglomeration. As a result, the larger particles are easier to capture in filters or fall out of the air.

Some devices, particularly older models, have the potential to create ozone, which is widely accepted to be harmful to humans. ASHRAE® Standard 62.1-2019 now requires air cleaning devices comply with UL 2998, which limits ozone production to less than 5 parts per billion.

Bipolar ionization devices can be installed in a variety of units, including ventilation systems, terminal units, ductwork, and in the occupied space.

Unit manufacturers claim the technology increases the effectiveness of lower-MERV rated filters due to agglomeration. They also claim effective airborne pathogen mitigation for certain viruses and bacteria. The technology typically has a very low air pressure drop, meaning there is little impact to unit fan operation.

Trane® has observed viral and bacterial efficacy with UL 867-compliant bipolar ionization devices. In the same testing, Trane was unable to verify surface disinfection efficacy and VOC reduction. Units do require maintenance to maintain the components producing ions.

Hydrogen Peroxide

Liquid hydrogen peroxide is commonly used as an antiseptic. Some technologies vaporize liquid hydrogen peroxide and disinfect an unoccupied room while other technologies produce hydrogen peroxide at dosages less than Environmental Protection Agency (EPA) safety limits. These other technologies produce airborne "dry" hydrogen peroxide without vaporizing a concentrated solution. Often, a photocatalytic reaction is used to separate hydrogen and oxygen atoms from water molecules in the airstream passing through a device to create gaseous hydrogen peroxide. The hydrogen peroxide molecules oxidize a microbe's cell membrane and disrupt its chemical structure to inactivate the pathogen. Devices may be installed with a filter to ensure the catalyst stays clean. The technology itself has a low air pressure drop, however this increases when an upstream filter is used.

Manufacturers claim dry hydrogen peroxide is effective against air- and surface-borne microbiological organisms. They also claim the technology is effective at reducing VOCs and odors. Devices can be installed in a variety of locations, including inside equipment, inside ductwork, or standalone. Devices should be installed as close as possible to the occupied space to ensure the largest amount of dry hydrogen peroxide reaches the zone. Standalone units can operate continuously and independently of HVAC systems.

Dry hydrogen peroxide systems do not reduce particulate matter so they may be paired with filters. Systems do require periodic maintenance to replace the photocatalytic system and any unit filters.

Photocatalytic Oxidation

Photocatalytic oxidation (PCO) uses an ultraviolet lamp to shine onto the surface of a catalyst to create highly reactive hydroxyl radicals. A microbiological organism's membrane or cell wall is destroyed upon contact with the hydroxyl radical—a process called lysis.

The technology is often applied with a pre-filter to keep the catalyst clean. If installed immediately downstream of a cooling coil, the system's ultraviolet lamp also irradiates the coil and drain pan. The technology itself has a low air pressure drop, however this increases when an upstream filter is used. Photocatalytic oxidation systems can be installed in a variety of manners, including inside air handling equipment, in duct systems, and standalone.

Manufacturers claim the technology can inactivate microbiological organisms and when combined with a pre-filter, its ability to capture and inactivate organisms improves. Photocatalytic oxidation can be used to reduce VOCs and odors.

Care must be taken to ensure people and some materials are not exposed to ultraviolet radiation, a type of radiant energy. Some materials degrade when exposed and the energy can damage human skin and eyes. The system does require design expertise for sizing and specification. As a result, it's often available from equipment manufacturers as a factory-designed, factory-installed option. Units require periodic filter replacement, and the ultraviolet lamps must be maintained. Finally, the catalyst may require periodic replacement.

Ultraviolet Germicidal Irradiation (UVGI)

Ultraviolet germicidal irradiation, sometimes abbreviated as UV, GUV, or UVGI is used to produce a chemical reaction in several of the previous technologies, but it also has a germicidal effect, which allows it to be used standalone. The technology has been used in HVAC and medical systems for decades. Installations include inside HVAC equipment, in ductwork, or as separate, standalone equipment.

UVGI devices emit energy which damages cell DNA and RNA preventing the organism from replicating. Today, a combination of mercury-vapor and LED fixtures are used to produce the energy.

Inside HVAC equipment, UVGI fixtures might be installed downstream of the cooling coil for airstream cleaning. Or they could be installed in a duct system to treat the passing air. In addition, there are some applications where UVGI is applied in the occupied space. One variant irradiates surfaces and the air, only when the space is unoccupied. Another variant, called an upper-air system, irradiates the air above head-level in the space, during occupied *and* unoccupied periods.

UVGI dosage is equal to the average irradiance multiplied by time. The required dosage to inactivate microbiological organisms vary by species and type. The average irradiance is often expressed as microwatts per square centimeter and the exposure time is expressed in seconds. In an application where the microbiological organism is in the airstream, passing by the UVGI lamp, the dosage is assumed to be single pass, therefore inactivating it by the end of the pass. As the distance between the fixture and the surface or airstream increases, the dosage decreases. As a result, single pass "fly-by" applications that are meant to treat airflow require a large amount of UVGI dosage compared to stationary applications.

In a stationary application where UVGI is designed to shine upon a cooling coil and provide surface cleaning, the irradiance won't need to be as great, because the lamps are shining on the surface continuously. However, in an application where a stream of air must be disinfected, time is short. As a result, the irradiance must increase. And it's important to consider whether this "fly-by" application is at a cooling coil, where velocities might be around 500 feet per minute, or in a duct system where the velocity could be much higher! Surfaces inside the air handler, rooftop, or ductwork can reflect the UVGI energy, affecting dosage. So, for these reasons, it's a good idea to work with a manufacturer to design and size UVGI systems.

UVGI works well for inactivating microbiological organisms, but it does not capture particulate matter. So, it is still often paired with a filtration system. UVGI does not reduce VOCs either. UVGI fixtures do need to be replaced when their energy output degrades below manufacturer-specified levels. As a result, bulbs must be accessible for inspection and replacement.

An upper air fixture does not treat surfaces, like tables, desks, and furniture in the occupied space. If a UVGI fixture does shine downward onto these surfaces, it can only be used when the space is unoccupied. And it's important to consider what materials comprise the surfaces and furniture that are being irradiated to ensure degradation does not occur.

Continued on page 4.

Table 1. Common air cleaning technology capabilities

Air Cleaning Technology	Particulate Matter	Microbiological Organisms	Volatile Organic Compounds
Filtration	•	•	
Bipolar Ionization		•	
Hydrogen Peroxide		•	•
Photocalytic Oxidation		•	•
Ultraviolet Germicidal Irradiation		•	

Air Cleaning Outside of Terminal Units

While many terminal units will accept at least a MERV 8 filter, some units will not be able to accommodate filters with higher MERV ratings due to some limiting factors. Filters with a higher MERV rating may require more physical space. In addition, these filters may have a higher air pressure drop which cannot be overcome by the supply fan. In some limited cases, a field-provided filter with a smaller size might be an option if the air pressure drop is acceptable. So, additional air cleaning solutions may need to be considered.

Portable or Stationary Air Cleaning Units

Designers may choose to install portable or stationary air filtration units to recirculate room air through additional cleaning devices. In most cases, units will include a fan to circulate air through an air cleaning device, or several devices. For example, a unit may utilize a pre-filter, fan, and high-MERV or HEPA filter. Other devices may utilize other air cleaning technologies, such as UVGI or hydrogen peroxide. These devices can be operated and controlled independently of the existing HVAC system making them a good air cleaning solution when existing HVAC cannot accommodate new air cleaning requirements or where additional ventilation cannot be introduced.

Portable units allow placement to be dictated based upon space needs and proximity to electrical service. This also allows placement to be adjusted as needed. Alternatively, units may be ceiling- or wall-mounted for a permanent installation. Some models can be integrated with existing ductwork and HVAC equipment while others are completely standalone and operate independent of existing systems.

Most units include a fan to circulate room air through the air cleaning device. As a result, it is important to pay particular attention to generated sound to ensure the addition of a portable or stationary air cleaning device does not disrupt the intended purpose of the room. This is of particular concern where maximum background sound pressure levels are relatively quiet, such as a school classroom. Another consideration is placement so as not to disrupt existing room airflow patterns.

Consider alternate "applied" system configurations.

As mentioned previously, some terminal units do not have the ability to support upgraded particulate filters, such as MERV 13, because they lack the space or fan static pressure capability. For example, a **ductless** VRF terminal unit may not support an upgraded filter, however a **ducted** VRF terminal might. Manufacturers may produce separate, factory- or field-installed filter boxes that are used to extend the casing to accommodate a larger filter.

An "applied" VRF system combines the use of a VRF condensing unit with an air handler using a linear expansion valve kit (LEV kit). Some manufacturers use alternate nomenclature, including electronic expansion valve kit (EEV kit) and an air handling unit integration kit (AHU kit). The LEV kit serves as an interface to connect VRF outdoor equipment to other types of traditional airside equipment. The kit includes a means to meter refrigerant to the coil, provide feedback and control, and

Figure 3. LEV kit enabled air handling unit

communicate with a building automation system. The air handler coil is selected to follow any VRF-specific guidelines.

This allows a terminal system to be combined with traditional air handling equipment, which allows more air cleaning options such as high-MERV filters, HEPA filters, photocatalytic oxidation, "fly-by" ultraviolet germicidal irradiation, and more.

The application of "applied" air handling terminals is certainly not limited to VRF systems—some manufacturers offer several water-source system options which can be used to produce chilled- and hot-water for a hydronic air handler.

Ventilation System Indoor Air Quality

Often, a separate system is used to clean, condition, and deliver outdoor air for ventilation while the terminal system is designed to offset the remaining space loads. So, two separate air systems must be considered.

First, the ventilation system often utilizes a dedicated outdoor air system (DOAS) or energy recovery ventilator (ERV) to precondition the outdoor air. The unit typically includes a filter section designed to remove airborne particulate matter from the ventilation air before it is sent to the occupied spaces. ASHRAE's Standard 62.1 requires MERV 8 filtration in those areas designated "nonattainment" where particulate matter 10 microns and smaller is a concern. The standard also requires MERV 11 filtration in areas designated "nonattainment" where particulate matter 2.5 microns and smaller is a concern.

If the ventilation system includes wetted surfaces, such as a dehumidifying cooling coil, ASHRAE® Standard 62.1 requires a MERV 8 filter or better, upstream of the wetted surfaces.

Can ventilation rates be increased?

During the COVID-19 pandemic, several cognizant agencies suggested an increase in outdoor air delivery rates to reduce the amount of recirculated air within the zones and the resulting risk of infection. A dedicated outdoor air system is typically only sized for the minimum-required ventilation airflow rate. As a result, it can be difficult to operate an existing ventilation system at an airflow rate higher than the original design ventilation requirements. Similarly, the ventilation unit may not have enough heating or cooling capacity to offset the additional ventilation load imposed by operating at airflow rates greater than design. It may be possible to add system capacity using air-to-air energy recovery technologies, but existing fans and duct systems need to be evaluated as well. For new systems, additional capacity can be built into the design.

Terminal System Thermal Comfort

As with any other HVAC system, a primary requirement for a terminal system is to provide good thermal comfort so occupants are generally satisfied. Many factors affect occupant thermal comfort, including temperature, humidity, air velocity, and several others.

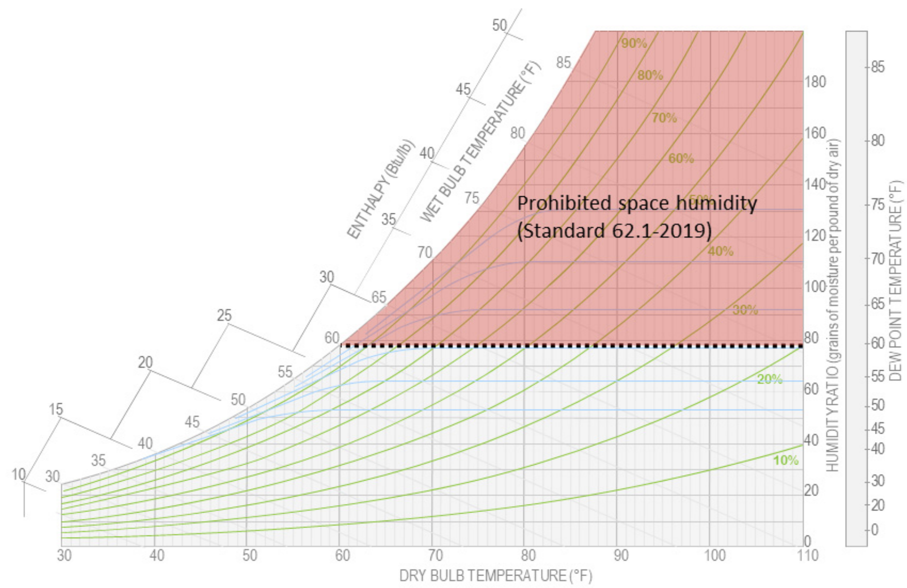
Terminal systems are often sized to offset the zone loads, while the ventilation system is designed to offset the ventilation loads. The ventilation system can also be designed to provide superior dehumidification and humidification control.

For proper dehumidification, the ventilation system should be analyzed and sized using design dehumidification weather, which factors peak dew point temperatures over dry-bulb temperatures. ASHRAE® Standard 62.1-2019 section 5.10 now includes a revised maximum indoor humidity requirement of 60°F dew point during occupied and unoccupied hours, whenever the outdoor air dew point temperature is above 60°F, with several exceptions (Figure 4, p. 6). ASHRAE® Standard 90.1-2019 section 6.5.2.6 prescriptively limits the maximum ventilation system supply air temperature to 60°F when most zones require cooling with several exceptions. This limits the ability to reheat dehumidified ventilation air to a "room neutral" dry-bulb temperature.

In many cases, a ventilation system supply air dew point temperature of 55°F is insufficient to maintain space humidity requirements on a design dehumidification day, especially if the terminal unit is cycling or operating at reduced fan speed. A load design analysis can be used with design dehumidification weather to determine the proper ventilation system supply air dew point temperature based upon space latent loads and supply airflow. In many climates, an energy recovery ventilator without a mechanical refrigeration system cannot produce the required supply air dew point temperature to maintain space humidity throughout the year. For more information, see the DOAS and ERV Psychrometric Analysis sidebar on page 6.

If required, humidification is often best applied within the ventilation system. While most terminal systems do not offer humidification, the use of an "applied" option allows the use of a common air handling portfolio which often includes some humidification options. Most packaged ventilation equipment is not available with a humidifier. If humidification is needed for the ventilation system, an air handler can again be used to expand the portfolio. Finally, an in-room humidification unit is also an option.

Figure 4. Psychrometric chart of 60°F cut off



DOAS and ERV Psychrometric Analysis

An example psychrometric analysis of a small office building conference room was performed to see the impact of various ventilation systems and supply air dew point temperature setpoints. A VRF terminal unit serves the room, while the ventilation system supplies conditioned air to meet ventilation requirements and offset some space latent load. At design, there are 25 people in the room requiring a total of 185 cfm of outdoor air for ventilation and the space sensible heat ratio is 0.75.

Additionally, a part-load condition was evaluated with a space sensible heat ratio of 0.61—indicating less sensible load compared to latent load. Design dehumidification weather was also used for this specific load condition. For more information on this analysis, see the Trane Engineers Newsletter Live program "Impact of DOAS Dew Point on Space Humidity" (March 2020) and the Trane *Engineers Newsletter* "Impact of DOAS Supply-Air Dew Point Temperature on Space Humidity" (March 2020).

Table 2. Psychrometric analysis results

	55-degree DOAS		**45-degree DOAS**		**ERV**	
Supply (DBT/DPT)	**55°F/54.4°F**		**45°F/44.4°F**		**81.7°F/62.3°F**	**72.2°F/61.8°F**
Space sensible heat ratio (SHR)	0.75	0.61	0.75	0.61	0.75	0.61
Load offset by DOAS (sensible)	4,015 Btu/hr	4,015 Btu/hr	6,022 Btu/hr	6,022 Btu/hr	-1,345 Btu/hr	-442 Btu/hr
Terminal unit airflow	400 cfm	300 cfm	296 cfm	222 cfm	673 cfm	505 cfm
Load offset by terminal (sensible)	7,785 Btu/hr	2,110 Btu/hr	5,778 Btu/hr	103 Btu/hr	13,145 Btu/hr	6,567 Btu/hr
Space relative humidity	54%	66%	49%	54%	56%	73%
Space dew point temperature	59°F	63°F	58°F	58°F	64°F	66°F

The results of this analysis are presented in Table 2. At full- and part-load conditions, the 45-degree dedicated outdoor air system offsets more space load and maintains space humidity closer to the target of 50 percent better than the 55-degree option.

The energy recovery ventilator transfers heat from the incoming outdoor air to the outgoing exhaust air, however it cannot cool or dehumidify the ventilation air to room neutral conditions, or colder and drier like the dedicated outdoor air system. As a result, ventilation load is **added** to the space which must be handled by the VRF system. At both full- and part-load conditions, the ERV cannot maintain space relative humidity at the desired setpoint.

Finally, with colder supply air, the resulting terminal unit coil capacity and fan airflow can be reduced because the colder ventilation air offsets more space load.

Acoustics

All HVAC equipment produces sound, which can provide an acceptable level of background noise that maintains human comfort. But terminal systems can pose unique challenges when considering overall acoustics, since noise-generating components are located in or near the occupied space. Some terminal systems utilize refrigeration compressors, in addition to supply fans to move conditioned air, which can produce unwanted noise.

An acoustical analysis can be used to predict occupied zone sound pressure using the source, path, receiver method. This method uses terminal unit sound power in conjunction with each possible sound path to predict the space sound pressure. In any acoustical analysis, it's important to consider any sound contributions including the ventilation system and any separate air cleaning devices. Such an analysis can be used to help determine whether equipment can be installed in or near the occupied space, or if it should be moved to a different location. In a sound sensitive application, it may be best to move plenum-installed equipment from above the occupied space to above the adjacent corridor.

It is difficult to detail specific recommendations for terminal systems because they vary in type and installation. Here are several general considerations that will apply for most terminal systems:

Properly isolate equipment. To reduce structure-borne noise and vibration, follow manufacturer guidance on equipment vibration isolation. In addition, properly isolate electrical, plumbing, refrigerant, or other connections.

Casing radiated. Sound radiates from the unit casing outward into the place of installation (ceiling plenum, closet, or occupied space). For sound-sensitive applications, consider installing the unit away from the occupied space. If installed in a ceiling plenum, use acoustical ceiling tiles to attenuate sound transmission.

Duct airborne. Sound generated by equipment travels through the supply and return air duct systems into the occupied space. Proper duct design can help reduce sound transmission and regeneration. Acoustical duct lining can be used to absorb sound.

Duct breakout. Sound traveling through a duct system can "breakout" of the duct wall into the surrounding space. The use of acoustical ceiling tiles will help attenuate plenum sound moving into the occupied space. Consider the use of round duct, which is more rigid than rectangular ductwork and, as a result, is less prone to breakout noise. Consider also duct lagging or ductwork with higher mass (e.g., higher steel gauge).

Conclusion

Terminal systems provide opportunities and challenges related to indoor environmental quality. Most of the challenges can be overcome by considering alternate system designs. Terminal systems combined with properly designed ventilation systems can meet temperature, humidity, ventilation, air cleaning, and acoustic project requirements.

By Eric Sturm, Trane. To subscribe or view previous issues of the Engineers Newsletter visit trane.com. Send comments to ENL@trane.com.

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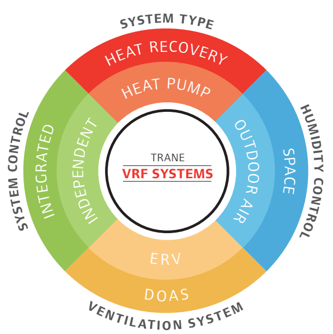
Updated and Now Available!

The Variable Refrigerant Flow Systems catalog (APP-PRC007*-EN) has been updated to reflect our upgraded controls offering—Tracer Concierge® and Tracer® SC+. This systems catalog uses the decision wheel as a guide to detail design considerations for a VRF system.

For more information, please visit www.trane.com.



2022 Engineers Newsletter *Live!* program schedule

MARCH

Applying VRF for a Complete Building Solution Part II. Now available online

MAY

Decarbonization of HVAC Systems Part II. Now available online

SEPTEMBER

Air-to-Water Heat Pump System Design. Building on the previous two Decarbonization of HVAC Systems ENLs, this program will cover electrified building heating systems utilizing air-to-water heat pumps. Topics covered will include operating characteristics of air-to-water heat pump equipment, system load and unit sizing considerations, system hot water design temperature considerations, system configurations and options including heat recovery, storage and auxiliary heat, as well as system control considerations.

NOVEMBER

Chillers and Heat Pumps with Energy Storage. Adding energy storage to buildings not only helps to save energy, energy costs and water, but it also saves carbon. In this program we will revisit the benefits and techniques for incorporating thermal energy storage for cooling. In addition, we will explore ways to use storage to minimize the impact that decarbonization of buildings and electrifying heat are expected to have on energy costs.

Contact your local Trane office for more information or visit www.Trane.com/ENL.

50 YEARS TRANE® ENGINEERS NEWSLETTER

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