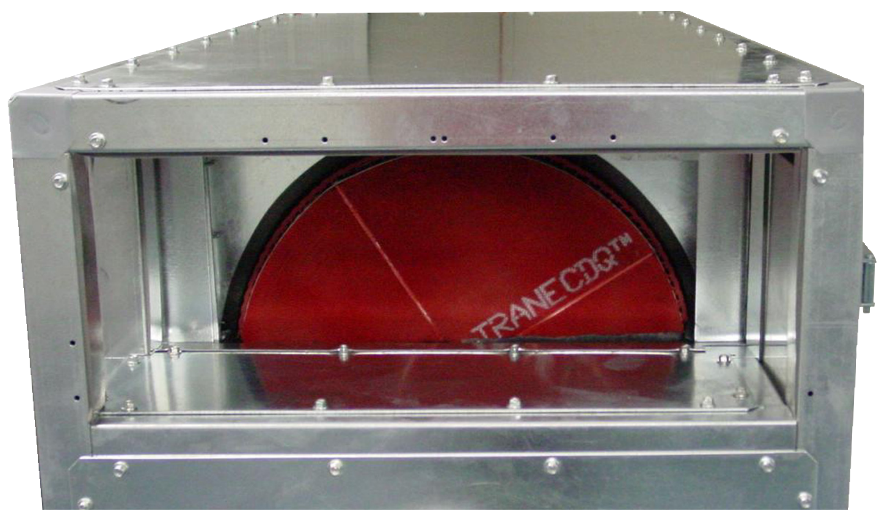
Engineering Bulletin

Trane CDQ™ Desiccant Dehumidification



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Preface

This engineering bulletin presents the Trane CDQ™ desiccant dehumidification system. It explains the features and benefits provided by the Trane CDQ™ desiccant wheel, provides a detailed selection procedure, and reviews specific guidelines to assure an effective cooling and dehumidifying system design. This material should be reviewed carefully before beginning the design process.

Please contact your local Trane sales engineer for additional information beyond the scope of this engineering bulletin.

Contents

Features and Benefits

Trane CDQ wheels can greatly improve the dehumidification capabilities of an air-conditioning system.

CDQ system features and benefits include:

- Increased cooling coil latent (dehumidification) capacity.
- Lower achievable supply-air dew points.
- Decreased need for reheat.
- Lower unit cooling sensible heat ratios.
- Warmer required chilled water temperatures.
- Improved energy efficiency for dehumidification.
- Decreased required cooling capacity when dehumidifying.
- Eliminates exhaust air as a requirement.

Moisture Management in Buildings

Preventing moisture-related problems in buildings and in HVAC systems is a *shared* responsibility among all parties involved in building design, specification, construction, commissioning, maintenance, and use.

Managing building moisture involves many components and it is important to realize that the HVAC system alone cannot prevent all moisture-related problems.

A few examples are listed below:

- Building envelope design and construction (including the location of vapor barriers)
- Flashing installation
- Roof maintenance
- Quickly repairing leaks
- Proper cleaning techniques

For more information, refer to the Trane "Managing Building Moisture" application engineering manual (literature order number SYS-AM-15).

One component of moisture control is to limit indoor humidity. When properly designed and controlled, an HVAC system can provide effective dehumidification over a wide range of conditions. The Trane "Dehumidification in HVAC Systems" application engineering manual (literature order number SYS-APM004-EN) discusses the challenges of dehumidifying, especially at part-load conditions, and presents several ways to improve the dehumidification performance of commonly-used HVAC systems.

This engineering bulletin introduces the Trane CDQ desiccant dehumidification system and how it can be used to greatly improve the dehumidification performance of an HVAC system.

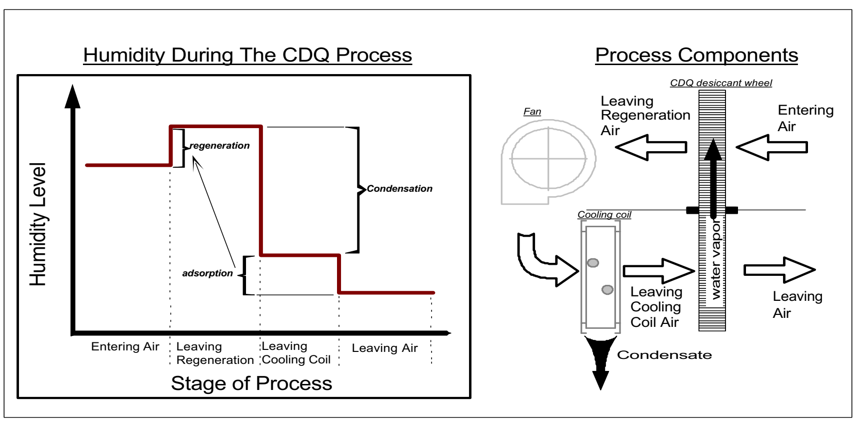
Note: Please be advised that final design and application decisions are your responsibility. Trane disclaims any responsibility for such decisions.

CDQ
System Concept

The Trane CDQ desiccant wheel is used to enhance the dehumidification performance of a traditional cooling coil. The wheel is configured in series with the coil (see Figure 1) such that the "regeneration" side of the wheel is located upstream of the coil and the "process" side of the wheel is located downstream of the coil. The CDQ desiccant wheel adsorbs water vapor from the air downstream of the cooling coil and then adds it back into the air upstream of the coil where the coil removes it through condensation. This process is accomplished without the need for a second regeneration air stream.

The addition of the CDQ desiccant wheel to the system enhances the dehumidification performance of the traditional cooling coil. The CDQ wheel transfers water vapor, and the cooling coil does all the dehumidification work in the system. The latent (dehumidification) capacity of the cooling coil increases without increasing its total cooling capacity. The system can achieve a lower supply-air dew point without lowering the coil temperature. Unlike a system with a cooling coil alone, the dew point of the air leaving the system can be lower than the coil surface temperature.

Figure 1. CDQ dehumidification processes

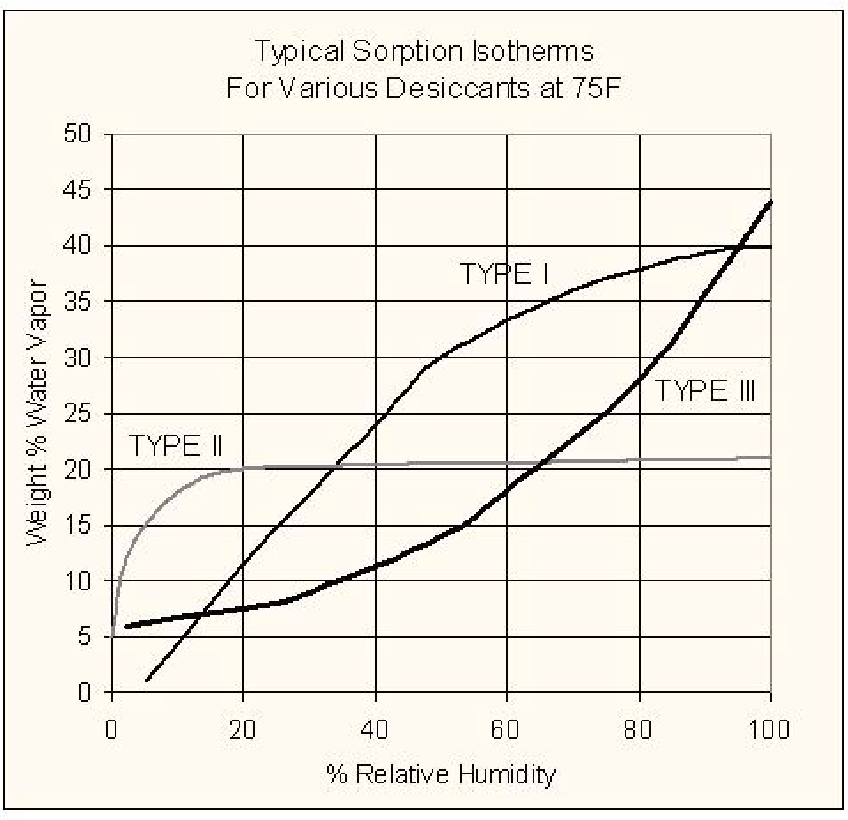


Overview of Desiccants

Desiccants are substances specially designed to attract water vapor from the air. The water vapor is transferred from the air to the desiccant through the process of *adsorption*. Adsorption occurs at the molecular level; water vapor molecules are adsorbed into the desiccant. Adsorbents are micro-porous materials that do not change phase when they exchange water vapor. Examples of adsorbents are activated aluminas, silica gels, and molecular sieves (zeolites). This is different than *ab*sorbents, which change phase during this exchange of water vapor. Examples of *ab*sorbents are hygroscopic salts, such as lithium chloride. Absorbents are more subject to chemical change and are often in liquid form.

Adsorbents can vary greatly. Most people are unaware that there are hundreds of variations of silica gels, molecular sieves, and activated aluminas; each is designed and manufactured for a specific task. These different desiccants can be further categorized based on their ability to hold water vapor at a specific temperature and relative humidity. This characteristic curve is called the *desiccant isotherm*. The typical isotherms of the three basic categories of desiccants (Types I, II, and III) are shown in Figure 2.

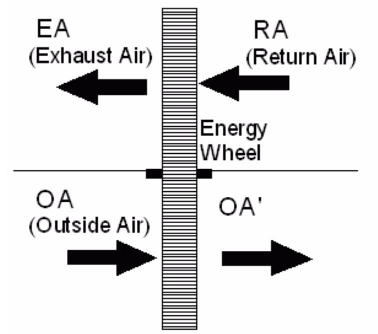
Figure 2. Example of desiccant isotherms



Energy Wheels

Total-energy wheels (also called enthalpy wheels) are used to transfer both sensible heat and moisture (latent heat) between the outdoor air stream and the exhaust air stream (see Figure 3). Most total-energy wheels use a Type I or Type II desiccant. The desiccant wheel rotates quickly—between 20 and 60 rotations per *minute*—through the outdoor and exhaust air streams. When it is hot and humid outdoors, sensible heat and moisture are transferred from the outdoor air to the exhaust air stream, cooling and dehumidifying the entering outdoor air. When it is cold and dry outdoors, sensible heat and moisture are transferred from the exhaust air to the outdoor air stream, heating and humidifying the entering air.

Figure 3. Total energy recovery wheels



Total-energy wheels can significantly reduce the ventilation cooling and heating loads, especially at peak conditions, but they do not dehumidify the space. Theoretically, an energy wheel can only be 100 percent effective. The outdoor air leaving the wheel can only get as dry as the exhaust air entering side. The exhaust air comes from the space. Thus, at best, the outdoor air leaving the wheel can only get as dry as the space, but no drier. If supply air is no drier than the space, it cannot dehumidify the space. The system still requires a cooling coil to dehumidify the space.

Active Desiccant Wheels

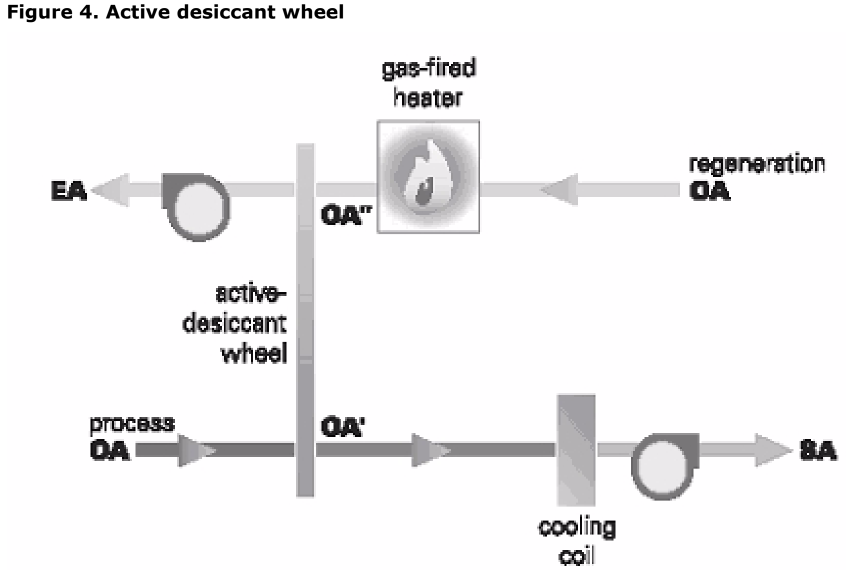
Active (heat-regenerated) desiccant wheels use a Type II desiccant. As the sample isotherm in Figure 2 shows, these desiccants can hold a significant amount of moisture even when the air stream is very dry. This is useful when you are trying to make dry air even drier. Type II desiccants are typically used in industrial and pharmaceutical applications where dew points of 0°F or lower may be required.

Like total-energy wheels, active desiccant wheels use two separate air streams (see Figure 4). The second "regeneration" air stream may be the exhaust air stream or a second outside air stream. A heat source is used to warm up the air entering the regeneration side of the wheel. Adding heat to the regeneration air allows the wheel to remove more water vapor from the air passing through the "process" side of the wheel. The source of heat is usually a direct-fired gas burner or stream heat because the regeneration air must be very hot in order to dry out the process air.

Depending on the required dew point of the process air, regeneration air temperatures typically range from 150°F to 300°F. The warmer the regeneration air (OA'') is, the drier the resulting process air (OA') will be.

Unlike total-energy wheels, however, active desiccant wheels rotate very slowly—between 10 and 30 rotations per *hour*. An active desiccant wheel is very effective at removing moisture from the supply (process) air stream, but for every ton of latent heat (moisture) removed, it adds more than one ton of sensible heat back into the supply air. The air leaving the supply side of the wheel is very dry (low dew point), but its dry-bulb temperature is usually above 100°F, and it often must be cooled back down before it can be used in most applications. Because of this, active desiccant wheels are typically only used when the required supply-air dew point cannot be achieved with standard mechanical (cold cooling coil) equipment.

Figure 4. Active desiccant wheel



Depending on the

CDQ™ Desiccant Wheel

The Trane CDQ desiccant wheel is not an enthalpy wheel, nor is it the same as an active desiccant wheel. It is configured in series with a cooling coil, and requires only one air stream; no exhaust air or second regeneration air stream is required (see Figure 5).

The Trane CDQ wheel uses a Type III desiccant (activated alumina) chosen specifically for this application. The ability of the desiccant to adsorb water vapor is very high when the relative humidity of the air is high (see Figure 6). Its ability to hold water vapor greatly decreases as the relative humidity of the air drops below 80 percent. Air leaving a cooling coil is generally at a very high relative humidity (often greater than 90 percent). At this condition, the CDQ desiccant wheel will have a high affinity for water vapor and adsorb it from the air that leaves the cooling coil. When the wheel rotates into the mixed (or return) air stream, it will be exposed to air that is at a much lower relative humidity (typically 40 to 60 percent). At this lower relative humidity, the desiccant will have a much lower affinity for water vapor, and it will release water vapor into the air stream. The regeneration air stream does not need to be hot in order to drive the process. It is driven by the characteristic of the desiccant specifically chosen for this application, which allows the wheel to be regenerated at low temperatures.

The CDQ desiccant wheel rotates very slowly—less than one rotation per minute. Because of this, very little sensible heat is exchanged. The increase in the supply-air dry-bulb temperature is associated with the amount of heat generated as the desiccant adsorbs the water vapor.

Figure 5. Basic CDQ™ air handler

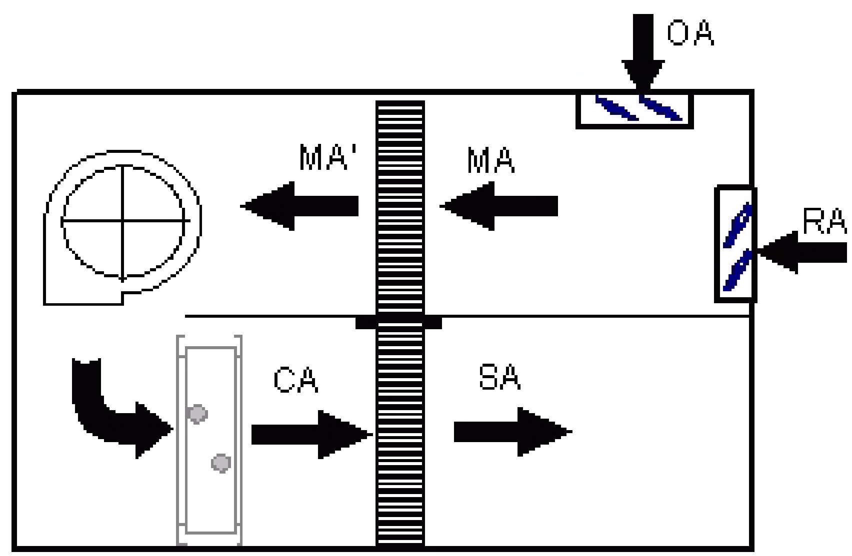
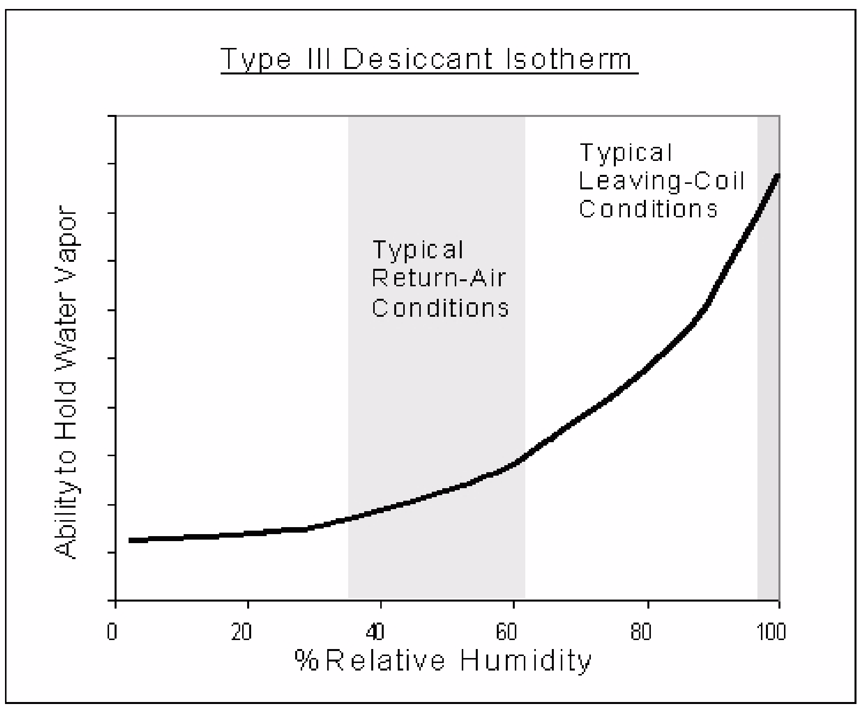


Figure 6. Type III isotherm and CDQ application



CDQ
System Performance

A Basic CDQ Air Handler Example

The most basic CDQ configuration has return air and outside air mixing (MA) before it passes through the regeneration side of the CDQ desiccant wheel. Next is the supply fan blowing into a cooling coil, followed by the process side of the wheel and an optional reheat coil. Below (Figure 7) is just one possible way to obtain this configuration with a Trane M-Series™ air handler. Figure 8 shows the system performance for this unit.

The air leaves the cooling coil (CA) at a very high relative humidity, typically about 97 percent RH. The CDQ desiccant wheel adsorbs water vapor from this air stream, removing 10 grains of water per pound mass of air in this example. This adsorption process results in the addition of some sensible heat, raising the dry-bulb temperature of the supply air (SA) by 4°F in this example. The mixed air entering the regeneration side of the wheel is at a lower relative humidity (50 percent).

At this condition, the CDQ desiccant wheel will no longer be able to hold the water vapor it adsorbed from the air leaving the cooling coil. The water vapor is released (desorbed) off the wheel and into the mixed air (MA'), upstream of the cooling coil. This transferred water vapor is then condensed out of the air stream by the cooling coil. The resulting supply air (SA) is 54°F dry bulb with a 44°F dew point. This low dew point is achieved with only 50°F air leaving the cooling coil.

Figure 7. Example of CDQ™ air handler

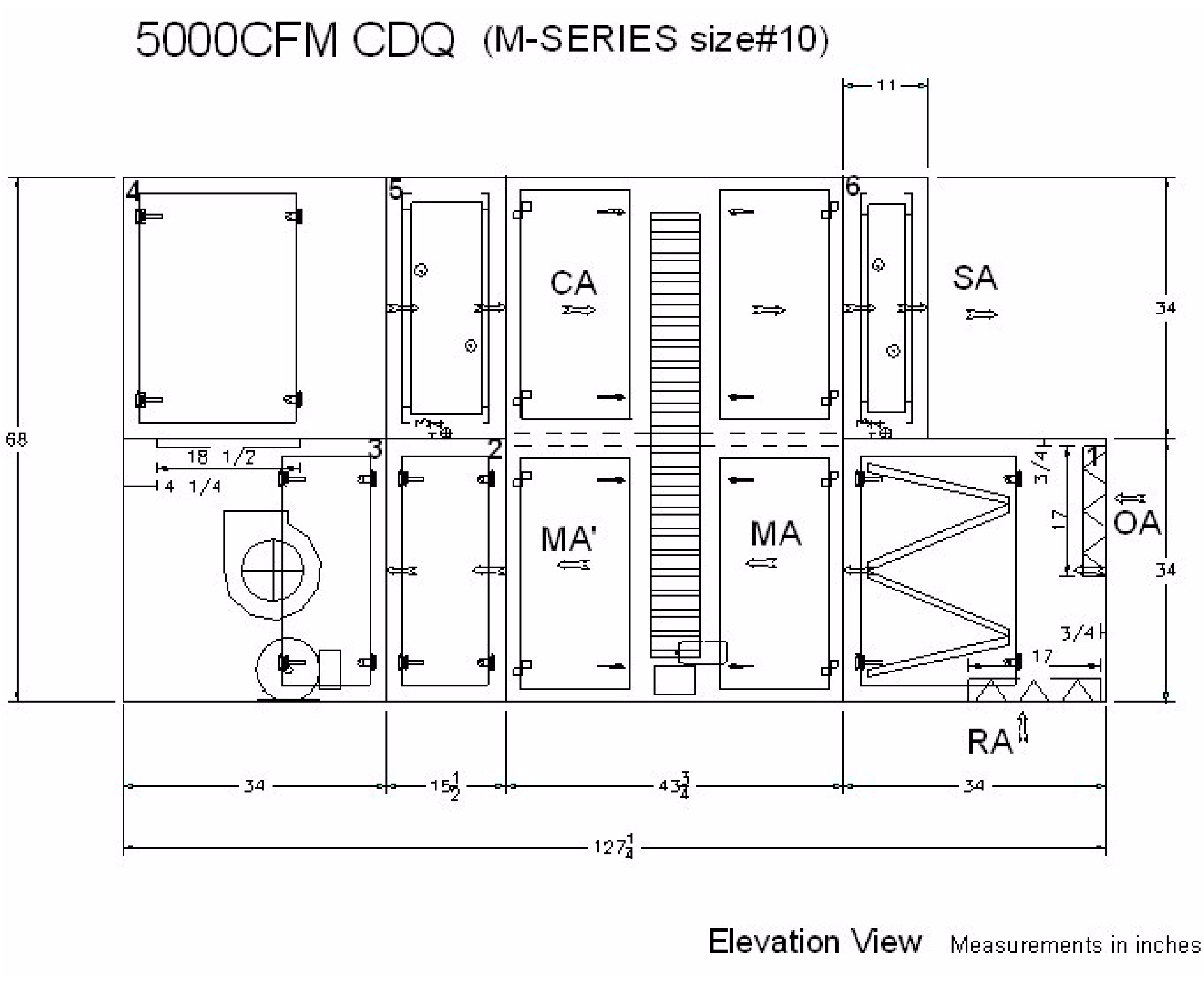
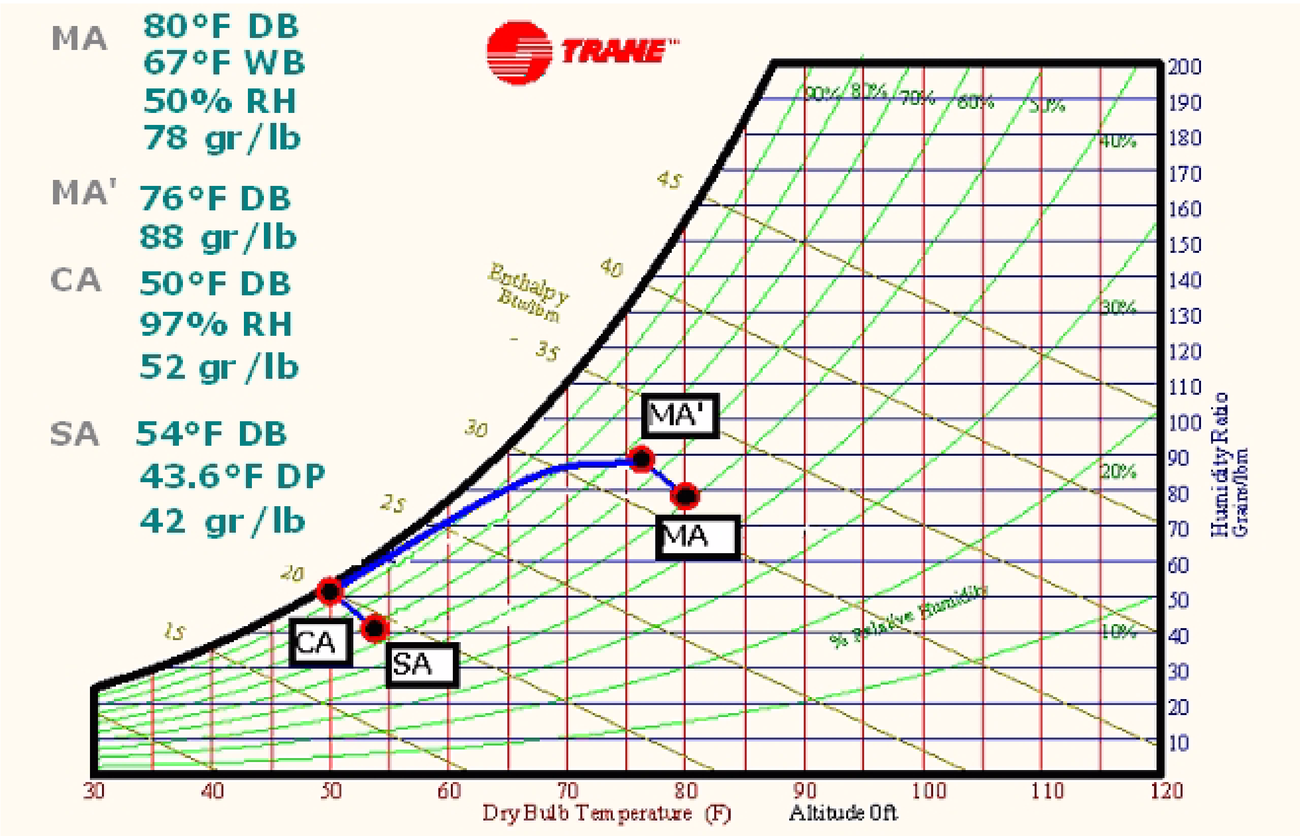


Figure 8. Sample performance and psychrometric plot



CDQ System - The Benefits

The benefits of dehumidifying with a CDQ system compared to cooling and reheat are evident by examining the psychrometric plot of both systems.

Using the CDQ wheel enhances the dehumidification capabilities of a cooling coil. To remove the same amount of moisture, a cool-reheat system would require more cooling capacity and need to reheat (see Figure 9). A CDQ system would save cooling and reheat energy and, depending on the application, may even allow for downsizing of the cooling equipment.

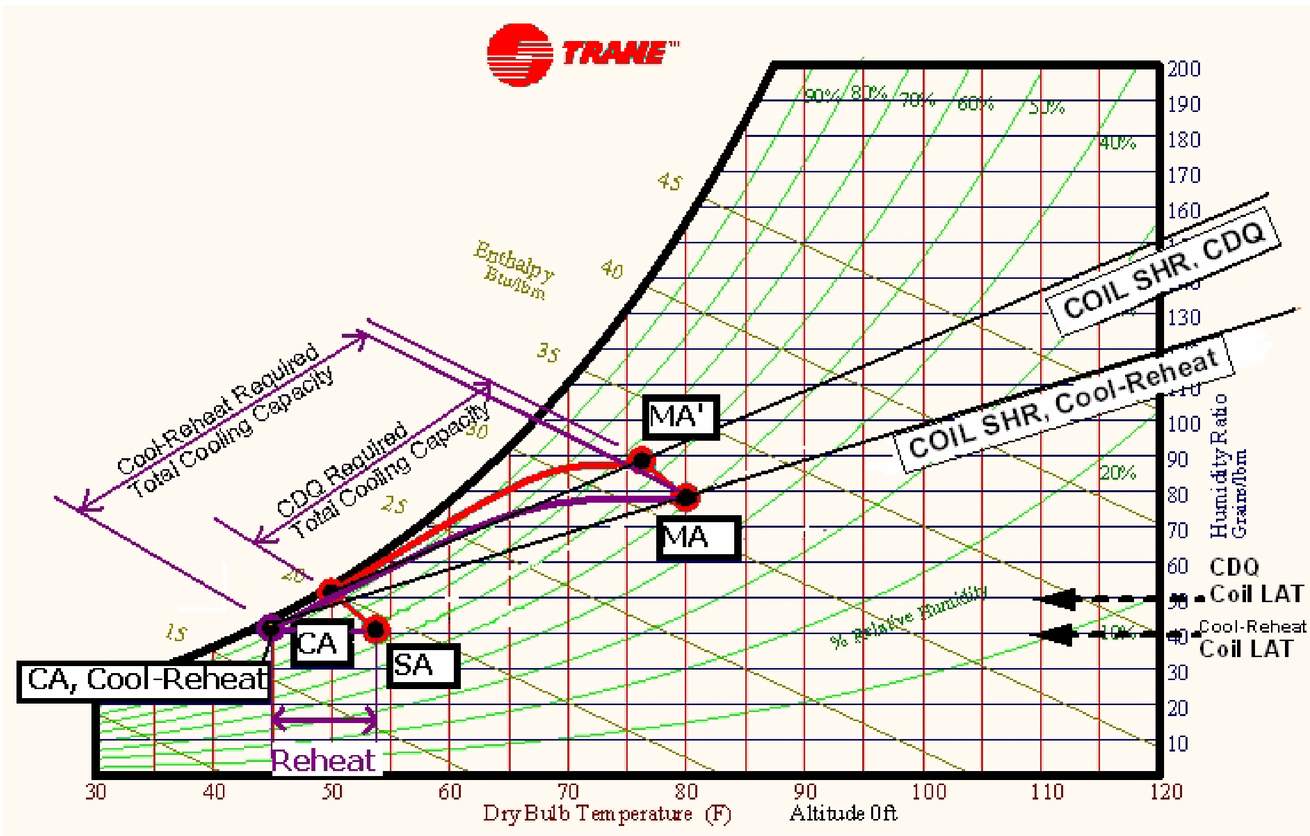
The cooling coil SHR, sensible heat ratio (the ratio of sensible cooling to total cooling), is also lowered with a CDQ system without using reheat. This helps the unit better match building loads, especially during part load conditions and reduces the need of reheat. The temperature gain from the wheel is minimal, typically 3°F to 9°F, thus the system can cool and dehumidify.

A unique benefit of the CDQ system is that it can deliver a lower supply-air dew point than the cooling coil temperature. A cooling coil can typically dehumidify air to a dew point that is 5°F to 10°F above the temperature of the fluid or refrigerant that flows through its tubes. For example, 45°F chilled water (depending on the flow rate and coil characteristics, of course) can dehumidify air to a dew point of 50°F to 55°F. By adding a CDQ desiccant wheel to the process, the supply-air dew point can be 0°F to 10°F *below* the chilled-water temperature. This can extend the achievable dew points of traditional DX or chilled-water systems.

It can also improve the energy efficiency of chilled-water systems. Because the chillers can produce warmer water temperatures to achieve lower supply-air dew points, the chiller can be more efficient. A CDQ system may also reduce the pumping power by allowing reduced chilled-water flow rates and may eliminate or reduce the need for glycol in the system.

Finally, in low dew point applications, a CDQ system may reduce overall energy use by eliminating the need for a coil defrost system or an active (heat regenerated) desiccant system.

Figure 9. Psychrometric plot: A CDQ system vs. a cool-reheat system



CDQ Performance Data

The Trane CDQ selection software can be used to obtain performance data on the CDQ desiccant wheel. The sample data in Figure 10 can be used as a guide to see if a CDQ system would be a good fit for your application.

Typical Achievable Dew Points

Figure 10 represents the typical supply-air dew points of a CDQ air handler at nominal airflow rates, as a function of the cooling coil leaving air temperature and the entering mixed-air relative humidity. This data assumes that the entering mixed air dew point is higher than the coil leaving air temperature. If the entering air dew point is lower than the coil leaving air temperature, in many cases, the system will still remove moisture from the air. However, one should use the CDQ selection software to determine the expected supply-air dew point.

The lower the relative humidity of the air entering the regeneration side of the CDQ wheel, the drier the air will be as it leaves the process side of the wheel. This is different than a conventional air-conditioning system where the achievable dew point is based on how cold the air is leaving the cooling coil. For example, if the mixed air enters the regeneration side of the CDQ wheel at 80°F dry bulb/60 percent RH, and the dry-bulb temperature of the air leaving the cooling coil is 50°F, the dew point of the air leaving the CDQ wheel will be approximately 45°F. With the same 50°F leaving-coil temperature, but 80°F dry bulb/40 percent RH mixed air, the supply-air dew point will be approximately 42°F.

By contrast, in a system with a cooling coil only (no CDQ wheel), if the dry-bulb temperature of the air leaving the cooling coil is 50°F, the supply-air dew point will be slightly below 50°F and will vary only a little with this change in mixed-air relative humidity. To reach the same dew point as the CDQ system, the cooling coil will not only require more capacity, but it will likely need to operate at less efficient conditions—colder water temperatures or lower suction temperatures.

Figure 10. Typical achievable dew points

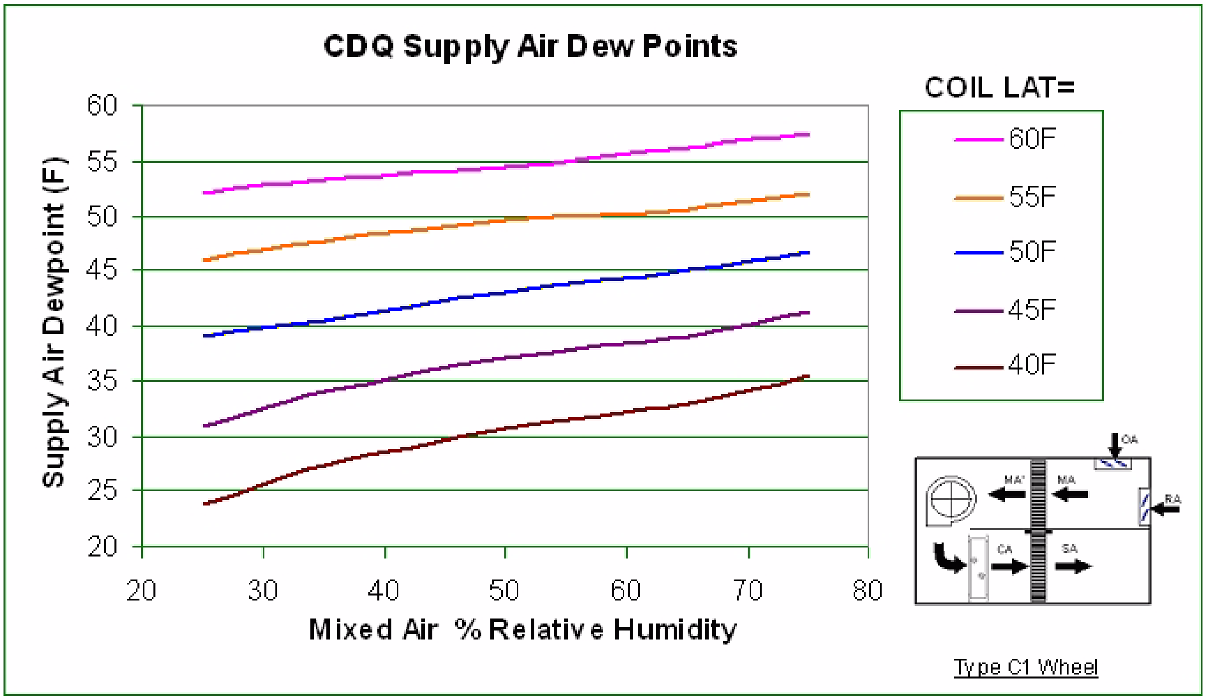
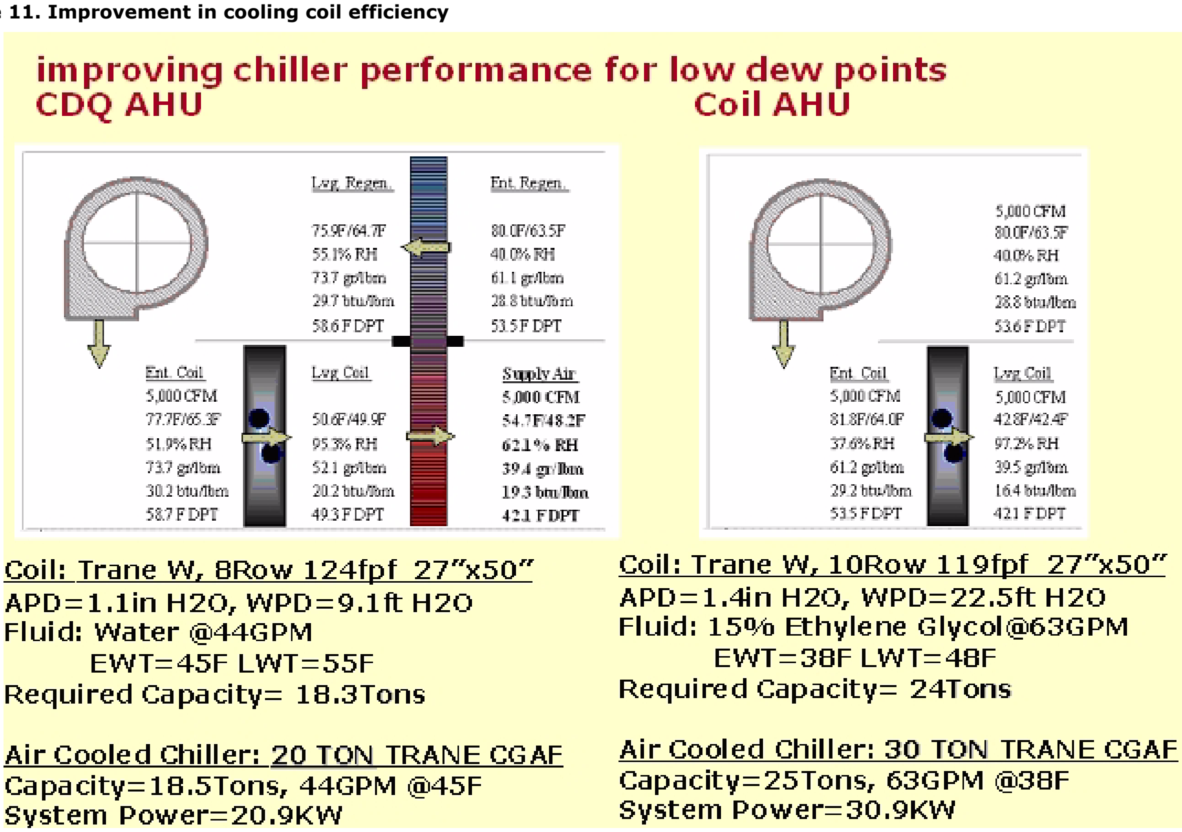


Figure 11. Improvement in cooling coil efficiency



The example in Figure 11 shows 5,000 cfm of mixed air at 80°F dry bulb/40 percent RH, with a target supply-air dew point of 42°F and an outdoor dry-bulb temperature of 90°F. Using a cooling coil alone (without a CDQ wheel) requires 30 percent more cooling capacity by the coil (24 tons compared to 18.3 tons with a CDQ wheel). But because this example also requires a colder water temperature (38°F), the system without a CDQ wheel will require a chiller that has a 50 percent larger nominal capacity (30-ton chiller compared to a 20-ton chiller with a CDQ wheel). At these conditions, the system without a CDQ wheel will use 50 percent more power. The CDQ benefit not only occurs at design but also results in annual energy savings. Most of this cooling energy is realized because even though the CDQ wheel will add fan energy, it will save on pump energy. The Type C1 CDQ wheel will add an additional 1.0 bhp in fan power for this example. However, the system without a CDQ wheel requires a higher flow rate, as well as a glycol mixture (because the chiller has to produce water at such a low temperature), so it will require an additional 1.3 bhp in pumping power.

Latent Capacity

Figure 12 shows the sensible heat ratio (SHR, sensible capacity divided by the total capacity) of a system with a cooling coil and a CDQ wheel versus a system with just a cooling coil. A range of typical mixed-air conditions is shown along with the corresponding unit SHR at various cooling capacities. This figure shows that, in most cases, adding the CDQ wheel lowers the "unit SHR" by 0.10 to 0.14.

This reduction in unit SHR is not accomplished by adding heat. It is a result of increasing the latent capacity of the coil with the CDQ wheel. This increase in latent capacity is achieved without increasing the total capacity. Figure 13 is the same data

Figure 13. Latent capacity improvement

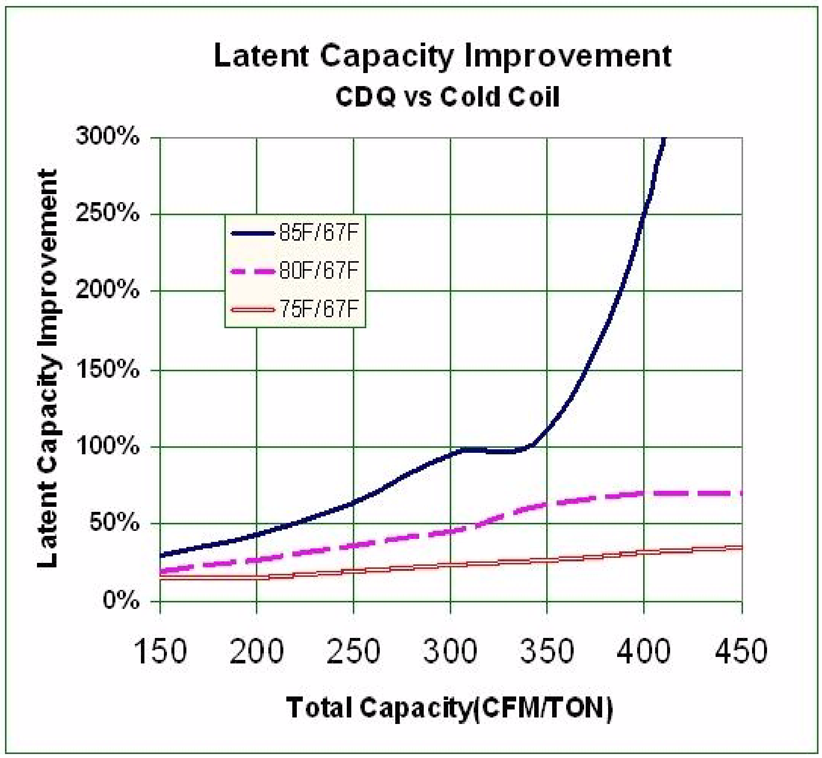
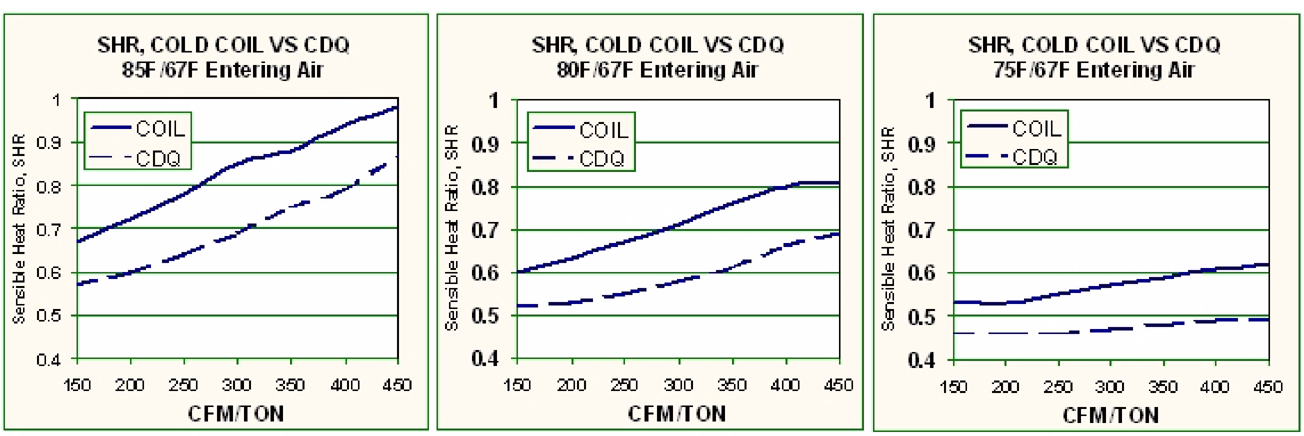


Figure 12. SHR improvement



represented in terms of latent capacity improvement. The latent capacity improvement at the examples conditions range from 15 to 550 percent.

The improvement in latent capacity makes a CDQ system beneficial not only in low dew point applications but also in comfort cooling applications, especially at part load conditions. For example, at 400 cfm/ton, the CDQ system will remove 70 percent more water vapor from 80°F/67°F air than a cooling coil would remove by itself.

Figure 14 shows a comparison of using a CDQ wheel on an example DX system sized at 400 cfm/ton. At this example part-load condition, to get more dehumidification, the compressor would run 50 percent longer and the extra sensible cooling that results from this extended runtime would need to be offset by reheat. The CDQ unit can increase the amount of moisture removed without the need for reheat. The example in Figure 14 shows how adding a CDQ wheel is more efficient than cool-reheat. It saves compressor energy by shortening runtime, and it eliminates the need for reheat.

Pressure Loss

The pressure drop across the CDQ wheel is similar to, or less than, a total-energy (enthalpy) wheel. Figure 15 is the pressure drop per pass for the Type C1 CDQ wheel.

Figure 14. Example: Part load, 400 cfm/ton 80°F/67°F EA

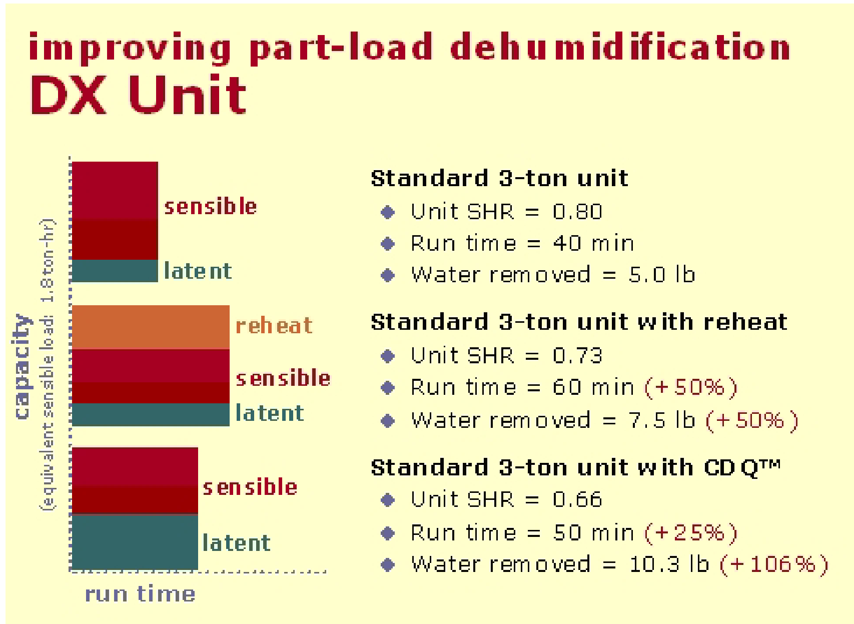
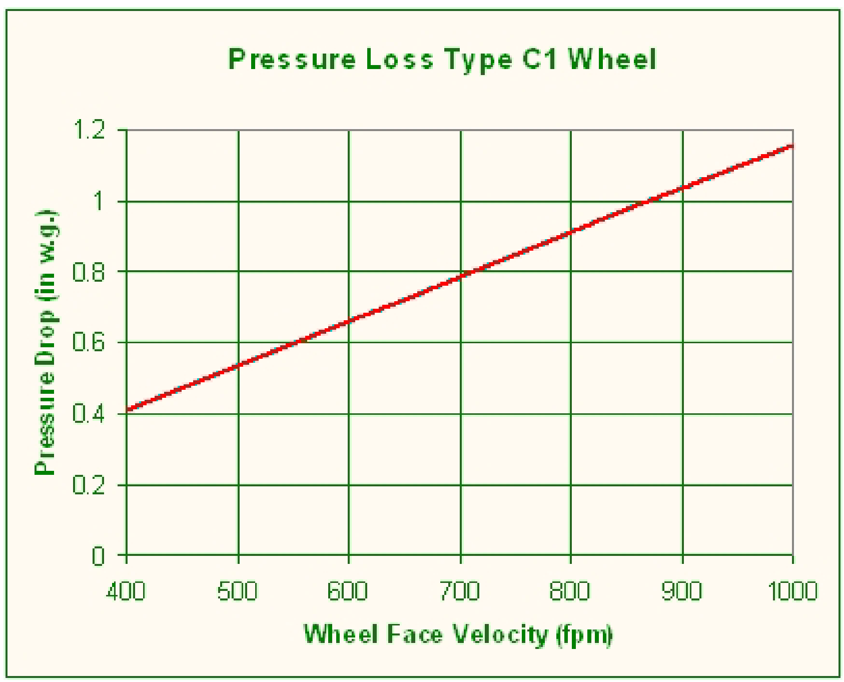
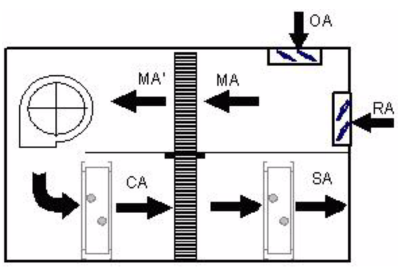


Figure 15. Type C1 wheel pressure drop



CDQ Air Handler Configurations

Figure 16. Sample air handler configuration



Most applications of the CDQ air handler will have components configured as described in the previous examples: outside air and return air inlets, filter, wheel pass one, supply fan, cooling coil, wheel pass two, then optional reheat coil.

Preheat

Preheat may be used to obtain lower supply-air dew points in applications in which there may be an ample supply of chilled water available, but it is not at a cold enough temperature for the system to achieve the required dew point. Figure 8 on page 10 shows that for entering mixed-air conditions of 80°F dry bulb/55 percent RH, a 40°F leaving dew point can be achieved if the air leaves the cooling coil at 47°F. But what if the temperature of the available chilled water is only 45°F, and with this water temperature the coil can only achieve a leaving-air temperature of 50°F? Looking back at Figure 8, if the relative humidity of the entering mixed-air could be lowered to 30 percent RH, then the 40°F supply-air dew point could be achieved with 50°F air leaving the coil. Using a preheat coil to raise the dry-bulb temperature of this entering mixed air by 19°F results in a reduction in the relative humidity of that air to 30 percent RH (see Figure 17). While preheating the mixed air does add to the cooling load, it allows the system to achieve a lower supply-air dew point with only 45°F water.

Table 1 shows an example of the condition in Figure 17 and how it can be achieved in three different ways. In this example, a CDQ system with preheat requires the most cooling capacity, but the temperature leaving the cooling coil is the warmest. Preheat can be modeled and predicted with Trane CDQ Performance Software.

Figure 17. Example: Use of preheat, 5,000 cfm, 80°F, 55% mixed air, 40°F dew point

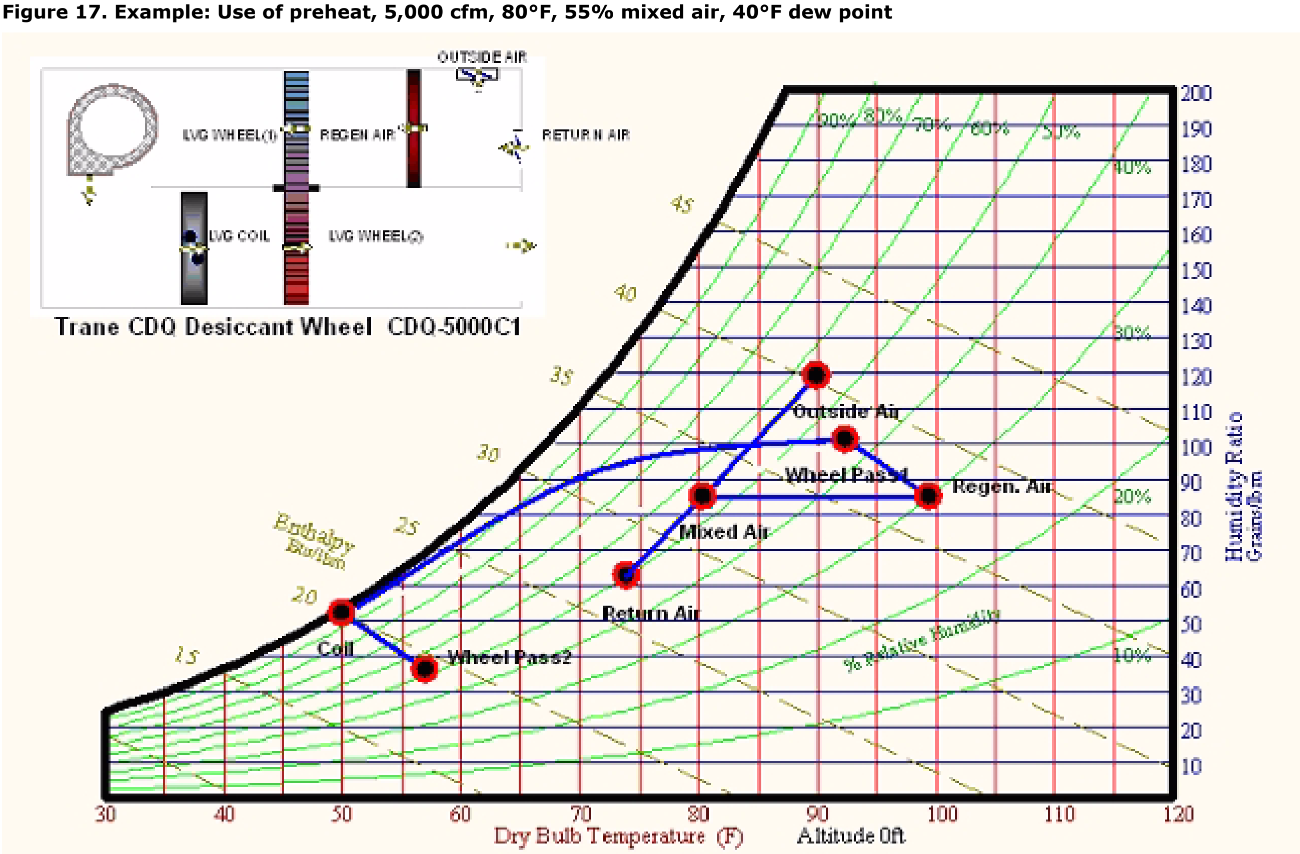


Table 1. Comparison of dehumidification methods

Unit Type	Cooling Capacity Required (Tons)	Leaving Coil Dry Bulb (°F)	Leaving Coil Dew Point (°F)	Leaving System Dry Bulb (°F)
Coil Only	27	40	40	40
CDQ system	22	47	40	51
CDQ system w/ preheat	27	50	40	57

Unlike the heat that is required to regenerate active desiccant systems, the preheat coil used in a CDQ system only raises the temperature of the air entering the regeneration side of the wheel by 5°F to 20°F. Because this temperature is fairly low (between 80°F and 100°F, for example), the heat required for preheat can often be recovered from the condensing process of the refrigeration equipment.

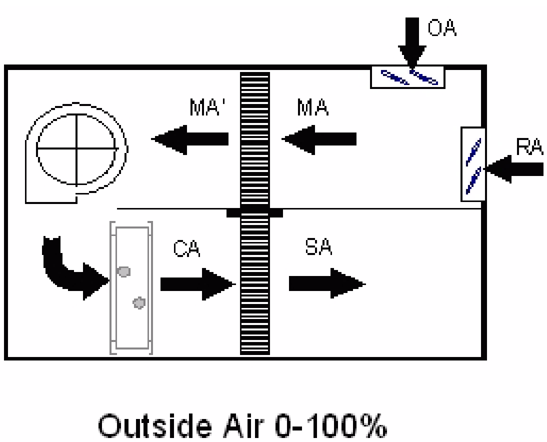
Preheat results in a warmer supply-air dry-bulb temperature, but it also adds to the cooling coil loads. For this reason, preheat should be used only to extend the achievable dew point of the system, not for tempering the supply air. If the supply-air dry-bulb temperature needs to be higher to prevent over-cooling the space, reheat should be used instead. The heat required for reheat, as with preheat, can often be recovered from the condensing process of the refrigeration equipment.

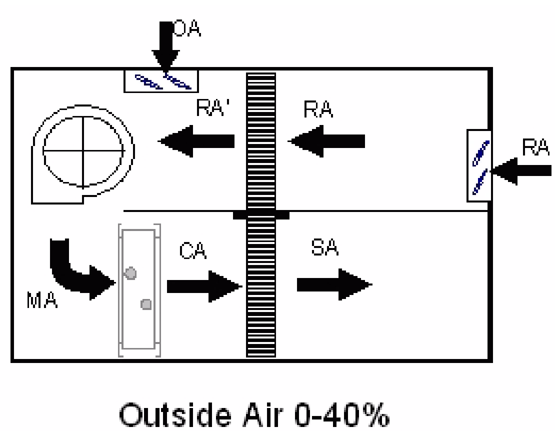
Location of Outside Air Inlet

For mixed-air systems, the outside air can be introduced either upstream or downstream of the regeneration side of the CDQ wheel (see Figure 18). Mixing in the outside air downstream of the regeneration side of the wheel may add to the unit foot print and require the addition of a second filter, but there are benefits to this configuration. If precise control of humidity is desired (rather than keeping humidity below an upper limit) this may be the preferred configuration. If the space is being maintained at a constant temperature and a constant relative humidity, the condition of the air entering the regeneration side of the CDQ wheel is going to be constant throughout the year. Therefore, the wheel will perform the same year round as long as the temperature of the air leaving the cooling coil is constant. A change in the outside air conditions will change the load on the cooling coil, but it will not affect wheel performance.

Mixing in the outside air upstream or downstream of the regeneration side of the wheel will slightly change the required cooling capacity, and this effect can be modeled using Trane CDQ Performance Software. If the unit is used in a variable air volume (VAV) system, or if the percentage of outside air is greater than 40 percent, the outside air should be mixed in upstream of the regeneration side of the wheel. This helps prevent the relative humidity of the air entering the regeneration side of the wheel from increasing too much.

Figure 18. Acceptable outside air inlet locations



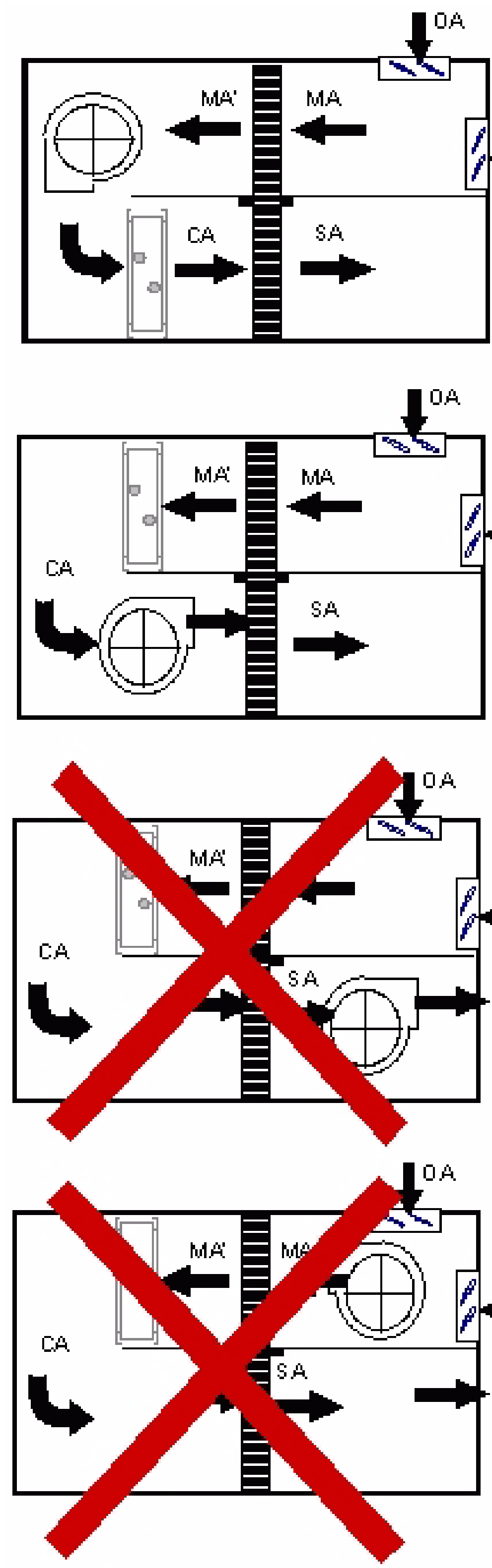


Location of Supply Fan

The location of the supply fan will affect system performance. Figure 19 represents possible configurations. The order of components is an important factor. The higher the relative humidity entering the process (adsorption) side of the wheel, the better it will perform. Therefore, whenever possible, the supply fan should be located upstream of the cooling coil, because the addition of fan heat downstream of the cooling coil will lower the relative humidity and will reduce the amount of water vapor the CDQ wheel adsorbs.

The static pressure to which the wheel is exposed can have a more significant effect. The regeneration side of the wheel should be under negative pressure, and the process (adsorption) side should be under positive pressure, so any air that leaks through the wheel (cross leakage) travels from the process side to the regeneration side. Even though cross leakage has a negligible effect on the performance of the fan or coil, it has a more significant effect on wheel performance. Therefore, the supply fan should be located downstream of the regeneration side of the wheel, but upstream of the process side.

Figure 19. Supply fan locations



Draw-Thru/Blow-Thru Wheel, Blow-Thru Coil

Recommended configuration for optimum performance

Draw-Thru/Blow-Thru Wheel, Draw-Thru Coil

Not recommend for low dew point applications

Acceptable in comfort cooling applications where packaged equipment dictates this configuration

Draw-Thru Wheel, Draw-Thru Coil

Not recommended

Blow-Thru Wheel, Blow-Thru Coil

Not recommended

Filtration Requirements

Minimal filtration is required for efficient operation of the Trane CDQ. At least 30 percent efficient flat throwaway filters are recommended upstream of the first wheel pass (regeneration side). These filters will catch larger size particles. Smaller particles most likely will pass through the wheel's air passages. Higher efficiency filters may be used if desired. In applications where oils or aerosol are present, they should be removed from the air before being introduced to the CDQ wheel. Unlike dust and other particles, aerosols can obstruct the pores of a desiccant and significantly degrade its performance.

Location of Heating Coils

If a preheat coil is used to enhance the CDQ wheel performance, it must be located upstream of the regeneration side of the wheel. If the preheat coil will be used for winter heating only (not for dehumidification), it can be placed either upstream or downstream of the regeneration side of the wheel.

If a reheat coil is used, it should be placed downstream of the process side of the wheel so that it can be used during dehumidification.

Combining Exhaust-Air Energy Recovery with a CDQ Wheel

The Trane CDQ system does not require a separate exhaust air stream to regenerate the desiccant, so recovering energy from the exhaust air stream can easily be used in conjunction with a CDQ wheel. Figure 20 shows a total-energy recovery wheel being used to precondition the entering outdoor air. As with systems without a CDQ wheel, the total energy will reduce required cooling and heating capacity of the system. In this configuration, the exhaust air only passes through the total-energy wheel; it does not pass through the CDQ wheel. The CDQ wheel operates the same as in the basic system.

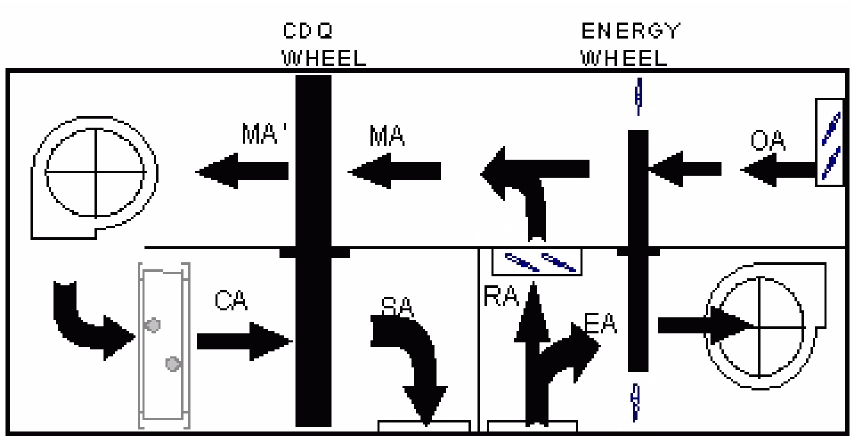
Dedicated Outdoor-Air Systems and a CDQ Wheel

Using a separate, dedicated unit to dehumidify all of the outside air for the system and drying that air out far enough that it also offsets the space latent loads often requires a dedicated outdoor-air unit to deliver air at a lower dew point than a conventional unit. A CDQ system can help achieve these lower dew point conditions.

However, in order to achieve low dew point in dedicated outdoor-air units, a preheat coil will often be required for part-load conditions. When the relative humidity of the entering outdoor air is very high (such as on a mild, rainy day), the preheat coil is required to lower the relative humidity of the air before it enters the regeneration side of the CDQ wheel.

The need of preheat can often be eliminated, and the needed cooling capacity can be reduced, if a total-energy wheel is used in conjunction with the CDQ wheel (see Figure 20). The total-energy wheel can transfer moisture from the outdoor air to the exhaust air, thus lowering the relative humidity of the outdoor air before it enters the CDQ wheel.

Figure 20. An example configuration for mixed air CDQ AHU with energy wheel



A CDQ System vs. Active Desiccant Systems

Active (heat-generated) desiccant systems use a high heat source and a second air stream to remove moisture from the supply air. A CDQ system uses a traditional cooling coil to remove moisture. Active desiccant wheels typically require 1800–2000 Btu of regeneration heat per pound mass of water removed. Figure 21 is an example of an active desiccant system at the same conditions as the CDQ example shown in Figure 17. Air leaves the process side of the wheel (MA') dry, but at 138°F dry-bulb temperature.

Active desiccant systems use significantly more heat than standard cool-reheat or CDQ systems. The energy cost for this amount of heat can be high; thus these systems are usually reserved for applications where there is a high heat source available from onsite power generation or an industrial process. Also, active desiccant systems are used where gas is the desired main energy source. As the above example shows, more cooling capacity is often required at design than with other methods. This cooling may be at a warmer coil temperature, but the extra energy costs of heating the regeneration air to 280°F more than offset any energy savings. At these example conditions, an active desiccant system uses 33 percent more cooling than the CDQ system with a 47°F leaving coil temperature. Also, when considering equivalent supply air temperatures, the active desiccant system uses 10 times more preheat than the CDQ system would need in reheat to obtain 57°F supply temperature, and the reheat in the CDQ example could be recovered condenser heat.

Figure 21. Example: Active desiccant system (eff = 1,950 Btu/lbm of water) 5,000 cfm, 80°F, 55% mixed air, 40°F supply-air dew point

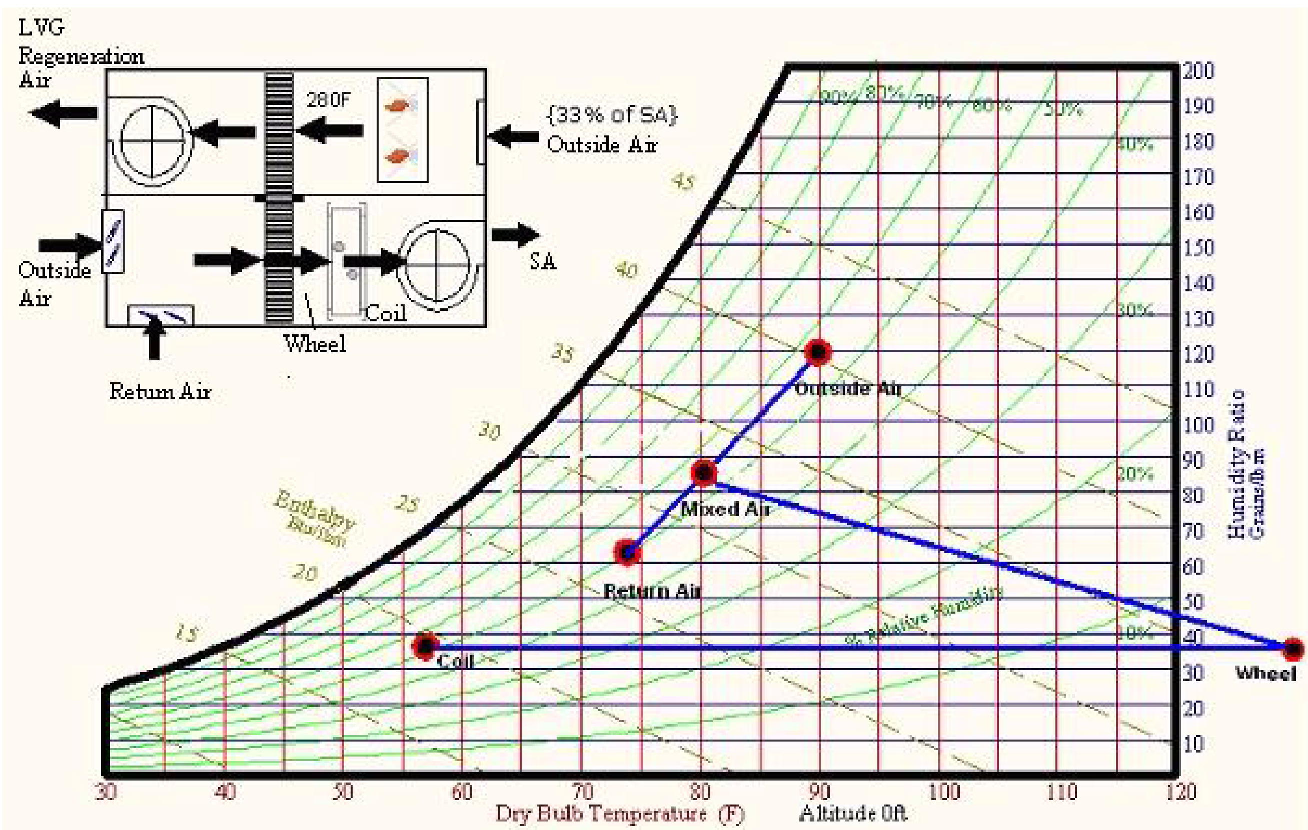


Table 2. Comparison of methods: 5,000 cfm, 80°F/55% RH vs. 57°F/40°F dew point

Unit Type	Cooling Capacity Required (Tons)	Coil Leaving Air Temperature (F)	Unit Leaving Air Temperature (F)	Unit Leaving Air Dew Point (F)	Preheat Required (MBH)	Reheat Required (MBH)
Coil only	33	40	57	40	–	92
CDQ unit	28	47	57	40	–	33
CDQ w/ preheat	34	50	57	40	103	–
Active desiccant	36	57	57	40	311	–

CDQ Applications

The CDQ system can be applied in most commercial applications that require humidity control. This includes spaces that need to be maintained between 35 to 65 percent relative humidity. The benefit of using a CDQ system versus cool-reheat will vary by application, but the benefits of higher latent capacity per ton of total capacity, lower achievable supply-air dew point, and reduced reheat energy will be seen through the range of applications.

35 to 45 Percent Relative Humidity Spaces

The CDQ system provides the most benefit in 35 to 45 percent relative humidity applications. This range of space relative humidity requires that the supply-air dew point be 30°F to 48°F. The primary benefit of using a CDQ system in these applications is the ability to use warmer coil temperatures (warmer chilled-water temperatures or higher suction temperatures) than would be required by another system. Dry storage/archives, hospital operating rooms, and laboratories are just a few 35 to 45 percent relative humidity applications that may benefit from a CDQ system.

Dry Storage/Archives

This space type has a small latent load in the space and requires very little ventilation air to be introduced. The challenge for humidity control is keeping the space humidity level at the desired low level. Since the mixed-air relative humidity is low, the CDQ desiccant wheel will be operating at its most efficient conditions to help lower the supply-air dew point. This will raise the required coil temperature and also lower the need for reheat.

Hospital Operating Rooms

Operating rooms are not only kept at a low relative humidity but also at cooler temperatures, a good fit for a CDQ system. The improved latent removal capacity not only reduces the required cooling needed but the lower supply-air dew points can eliminate the need for a secondary refrigeration coil or a heat-regenerated active desiccant system. Because active desiccant systems provide hot air (which would then require a significant amount of post-cooling), the use of a CDQ system in this application can produce significant energy savings.

Laboratories

A CDQ system can help achieve the lower relative humidity needed for laboratories. Because the exhaust air often contains contaminants, total-energy (enthalpy) recovery from the exhaust air is usually not permissible. A CDQ system can improve energy efficiency and latent removal from the space without the need to use the exhaust air stream.

50 to 65 Percent Relative Humidity Spaces

Most of the benefits of a CDQ system are also realized in these applications, particularly at part load conditions. The primary benefit in these applications is an increased latent capacity and lower SHR, which allows the unit to better match the space dehumidification requirements. Schools and colleges, retail stores and restaurants, and office buildings are just a few 50 to 65 percent relative humidity applications that may benefit from a CDQ system.

Schools and Colleges

Because of the high occupancy level of classrooms, the space latent load can be high. This load occurs year round, which results in a lower SHR at part load conditions. A CDQ air handler can be used to help achieve the higher latent capacity needed for classrooms. The system can be either constant volume or variable air volume (VAV). Humidity levels in schools can elevate during weekends and other times when the buildings are unoccupied. The same air handler can be used as a recirculating dehumidifier to keep the humidity levels under control during unoccupied hours.

Retail Stores and Restaurants

As shown in the example in Figure 14, using a CDQ air handler with a DX system can provide better part-load dehumidification without requiring as much cooling or reheat energy as a cool-reheat system.

Office Buildings

A constant volume or VAV system can be enhanced to get better humidity control in the space. A CDQ system can also be helpful in offices designed with under-floor air distribution. Air delivered at floor level is at a warmer dry-bulb temperature (typically around 65°F). This can create a dehumidification challenge in many climates. A CDQ system can deliver air at 65°F dry-bulb temperature, and at a dew point of 55°F to 58°F, without the need for overcooling and reheat (or overcooling and mixing in bypassed return air).

Equipment Selection

Outside Air Conditions

As with any system being designed, the worst expected conditions the system will see should be examined. When designing to control humidity with or without a CDQ system, the climatic data for the worst dehumidification day as well as the worst cooling day should be examined. ASHRAE publishes climatic data for various geographic locations around the world. The severity of the design outdoor conditions selected is dependent on how critical it is to keep the space at the desired indoor conditions. In the example below (Table 3), outdoor design conditions for Atlanta, GA, show a cooling design day of 91°F dry bulb and 74°F wet bulb. This is a humidity ratio of 99 grains per pound mass (gr/lbm) of dry air. The dehumidification design day is cooler, 81°F, but it is significantly more humid with 123 gr/lbm.

Sizing Cooling Equipment

Unlike conventional equipment, the dew point of the supply air in a CDQ system is not equal to the dew point of the air leaving the cooling coil. The required cooling coil capacity and air temperature leaving the coil are determined by the CDQ wheel performance. The CDQ performance program can be used to determine the required coil capacity based on the required supply-air dew point, dry-bulb temperature, and airflow. Performance runs should be completed for cooling design day, dehumidification design day, and possibly even a warm, rainy day. This will confirm that the cooling equipment is sized appropriately. In many comfort-cooling applications, the CDQ wheel may only operate at part-load conditions. For these and other cases, it is a good idea to check the performance at a part-load condition to highlight the benefits of a CDQ system.

Sizing Preheat

To size the preheat coil, CDQ system performance should be calculated at the dehumidification design day. Performance should also be calculated at the highest entering relative humidity that can be expected. This typically is at a warm rainy day (for example, 70°F dry bulb and a very high relative humidity). The CDQ performance program will do this calculation for whatever conditions are input.

Sample Selections

Example: 55% RH Limit Application, School Classroom w/Constant Volume AHU

- Location = Jacksonville, FL
- Space Conditions = 74°F dry bulb, 55% RH upper limit
- Supply Air Flow = 1,500 cfm
- Outside Air Flow = 450 cfm
- Required Supply Air Conditions:
  - @ 1% Cooling Design OA (96°F dry bulb/78°F wet bulb) => SA = 56°F dry bulb, 64 gr/lbm
  - @ 1% Dehumidification Design OA (84°F dry bulb/78°F wet bulb) => SA = 63°F dry bulb, 64 gr/lbm

A supply-air humidity ratio of 64 gr/lbm is equivalent to a 55°F dew-point temperature. At cooling design conditions, this is close to the supply-air dry-bulb temperature, thus at cooling design day the CDQ system isn't needed to maintain space RH at or below 55 percent...just 4.8 tons of cooling. At dehumidification design conditions, a CDQ system could be used to save cooling and reheat energy. At dehumidification design conditions, only 4.4 tons of cooling is needed, preventing the need to upsize the cooling equipment (which would have been required in a cool-reheat system without the CDQ wheel). For the CDQ system, no reheat is needed at the dehumidification design conditions.

Table 3. Example: ASHRAE Fundamentals Climatic Data tables
(Source: 2001 ASHRAE Handbook, Fundamentals, Inch-Pound Edition

Table 1B Cooling and Dehumidification Design Conditions—United States

	Cooling DB/MWB						Evaporation WB/MDB						Dehumidification DP/MDB and HR									
	0.4%		1%		2%		0.4%		1%		2%		0.4%			1%			2%			Range
Station	DB	MWB	DB	MWB	DB	MWB	WB	MDB	WB	MDB	WB	MDB	DP	HR	MDB	DP	HR	MDB	DP	HR	MDB	of DB
1	2a	2b	2c	2d	2e	2f	3a	3b	3c	3d	3e	3f	4a	4b	4c	4d	4e	4f	4g	4h	4i	5
West Palm Beach	91	78	90	78	89	77	80	88	79	88	78	87	77	143	84	77	139	84	76	137	83	13.1
GEORGIA																						
Albany	96	76	95	76	93	75	79	90	78	89	78	88	77	141	83	76	136	82	75	133	81	19.8
Athens	94	75	92	75	90	74	78	89	77	87	76	86	75	133	82	74	129	81	73	125	80	18.4
Atlanta	93	75	91	74	88	73	77	88	76	87	75	85	74	133	82	73	128	81	72	124	80	17.3
Augusta	96	76	94	76	92	75	79	91	78	89	77	88	76	135	84	75	130	83	74	127	82	20.2

Figure 22. CDQ Performance Program example for dehumidification design conditions

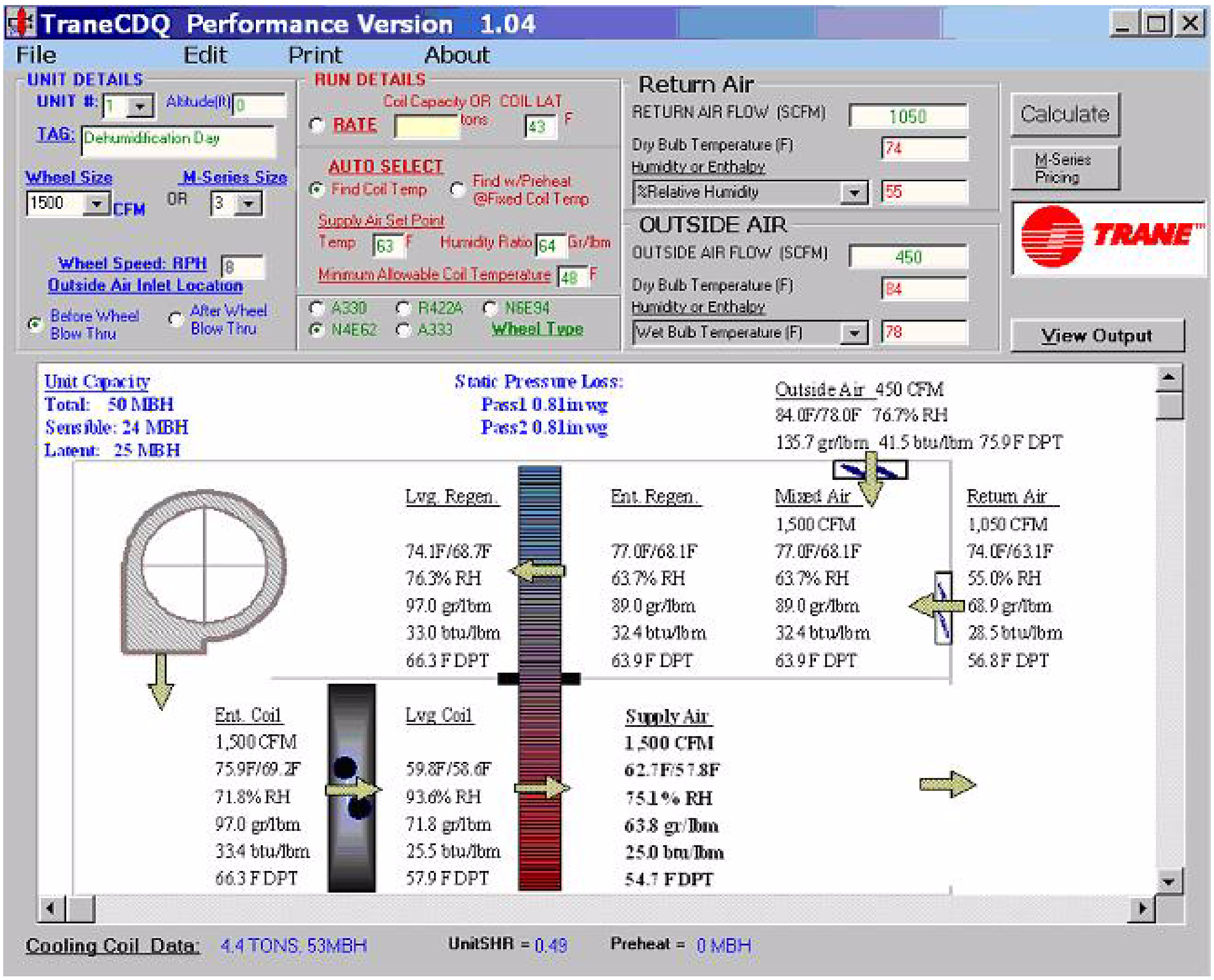


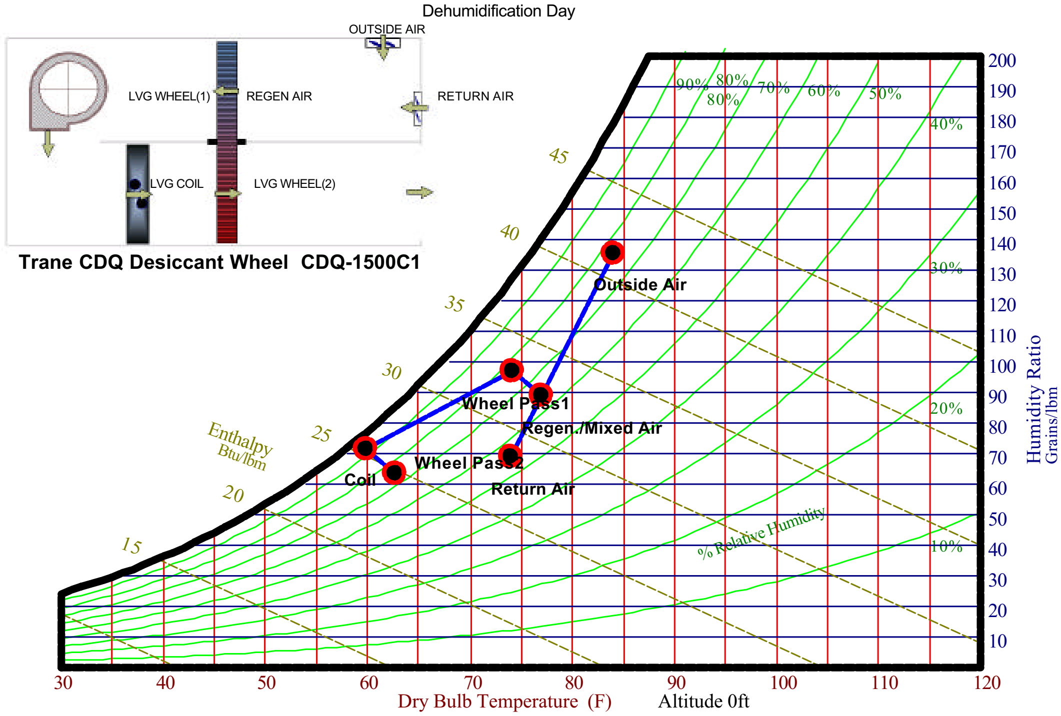
Table 4. Output summary

	Wheel	Cooling (tons)	SA DB	SA Dew Point
@1% Cooling	Off	**4.8**	56°F	55°F
@1% Dehumidification	On	4.5	63°F	55°F

Figure 23. Sample CDQ Performance Program output example for dehumidification design conditions

Cool - Dry - Quiet   Psychrometric Summary

Dehumidification Day



	AIR FLOW VOLUME (SCFM)	DRY BULB TEMPERATURE (F)	RELATIVE HUMIDITY (%)	HUMIDITY RATIO (grains/lbm)	ENTHALPY (btu/lbm)
RETURN AIR	1,050	74.0	55.0	68.9	28.5
OUTSIDE AIR	450	84.0	76.7	135.7	41.5
MIXED/REGEN. AIR	1,500	77.0	63.7	89.0	32.4
LVG WHEEL (1)	1,500	74.1	76.3	97.0	33.0
LVG COOLING COIL	1,500	59.8	93.6	71.8	25.5
LVG WHEEL(2)	1,500	62.7	75.1	63.8	25.0

UNIT SHR = 0.49   SPACE SHR= 0.78

REQUIRED COIL CAPACITY   4.4 TONS, 53 MBH

REDUCTION IN REQUIRED COOLING CAPACITY USING CDQ vs COOLING WITH REHEAT   0.6 TONS,   11.4%

REQUIRED PREHEAT CAPACITY   0 MBH

REDUCTION IN REQUIRED REHEAT USING CDQ: 15.4 MBH

Cooling Efficiency Improvement:

The Coil Leaving Air Temperature Can Be Up To 4F Warmer Than Coil with Standard Cool-Reheat

Version 1.00   6/4/2004

Providing 64 gr/lbm (55°F dew point) air from the unit will require reheat for conditions that require the supply air to be warmer than 63°F dry bulb. If up to room neutral temperature (74°F) is needed, the reheat coil needs to be sized for an 11°F temperature rise. This could be provided by hot gas reheat. This is a significant improvement over a cool-reheat system, which would require reheat anytime the required supply air temperature was greater than 56°F.

Sample Selections

Example: 35% RH Limit Application, Dry Storage

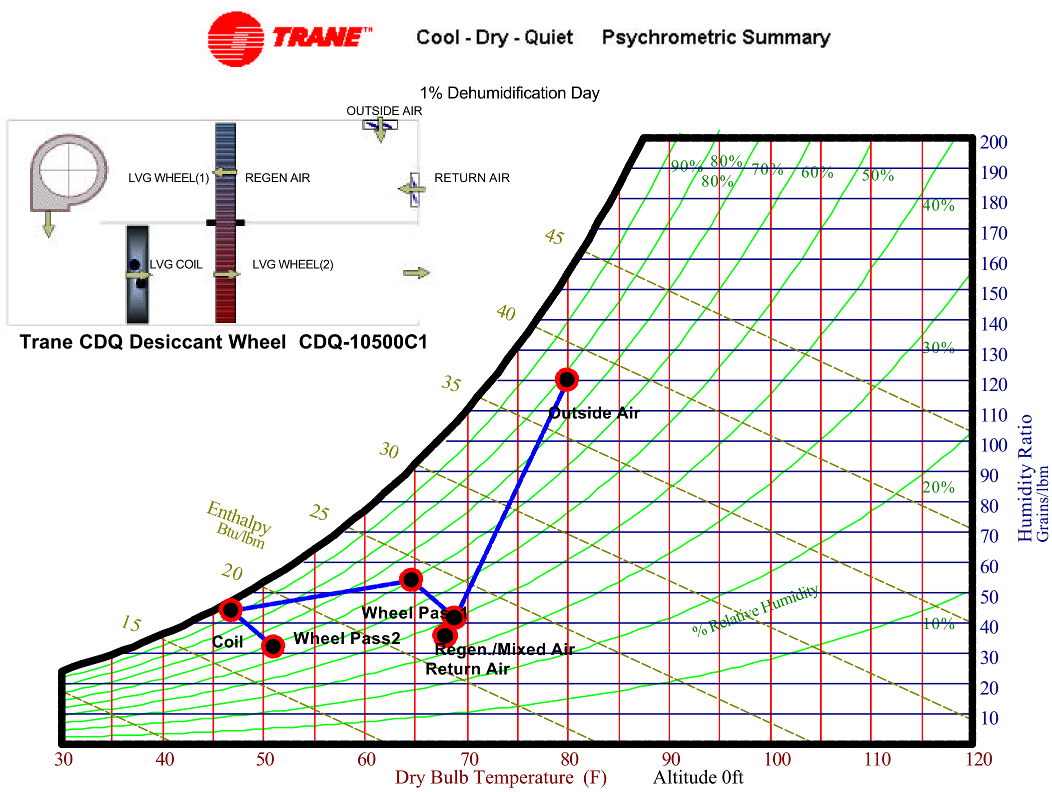
- Location = New York, NY
- Space Conditions = 68°F dry bulb, 35% RH upper limit
- Supply Air Flow = 8,800 cfm
- Outside Air Flow = 700 cfm
- Required Supply Air Conditions:
  - @ 1% Cooling Design OA (88°F dry bulb/72°F wet bulb) =>SA = 52°F dry bulb, 32 gr/lbm (36°F dew point)
  - @ 1% Dehumidification Design OA (80°F dry bulb/120 gr/lbm) => SA = 52°F dry bulb, 32 gr/lbm (36°F dew point)

In this example, the cooling capacity will be sized based on the dehumidification design conditions.

Table 5. Output summary

	Wheel	Cooling (tons)	SA DB	SA Dew Point
@1% Cooling	On	21.0	51.7°F	36.7°F
@1% Dehumidification	On	22.2	51.0°F	36.7°F

Figure 24. Sample CDQ performance program output example for dehumidification design conditions 35% RH application



	AIR FLOW VOLUME (SCFM)	DRY BULB TEMPERATURE (F)	RELATIVE HUMIDITY (%)	HUMIDITY RATIO (grains/lbm)	ENTHALPY (btu/lbm)
RETURN AIR	8,800	68.0	35.0	35.5	21.9
OUTSIDE AIR	700	80.0	77.4	120.0	38.0
MIXED/REGEN. AIR	9,500	68.9	39.8	41.7	23.0
LVG WHEEL (1)	9,500	64.7	59.4	54.0	23.9
LVG COOLING COIL	9,500	46.8	93.4	44.2	18.1
LVG WHEEL(2)	9,500	51.0	57.6	32.0	17.2

UNIT SHR = 0.75 SPACE SHR= 0.89

REQUIRED COIL CAPACITY 22.2 TONS, 267 MBH

REDUCTION IN REQUIRED COOLING CAPACITY USING CDQ vs COOLING WITH REHEAT 9.5 TONS, 30.0%

REQUIRED PREHEAT CAPACITY 0 MBH

REDUCTION IN REQUIRED REHEAT USING CDQ: 164.6 MBH

Cooling Efficiency Improvement:

The Coil Leaving Air Temperature Can Be Up To 9F Warmer Than Coil with Standard Cool-Reheat

Version 1.00 6/4/2004

Wheel Construction

Depending on the wheel type, the construction may vary. Contact your local Trane sales engineer for complete mechanical specifications.

Drive System

The wheel requires a fractional horsepower gear motor that rotates the wheel using a perimeter contact belt. The rotation speed of the wheel is very slow. As an example, the Type C1 wheel uses a 1/80 HP, 0.3 FLA, 115 V motor. Where possible, CDQ desiccant wheels have permanently-lubricated bearings. On larger wheels, pillow block bearings may be used.

Wheel Media

The desiccant is not applied as a glued-on surface coating, so it is not susceptible to erosion, abrasion, or de-lamination. The desiccant is integral to the media, and spokes are used to hold the wheel rigid. To minimize cross leakage from one side of the wheel to the other, the wheel includes both a circumference seal (as an air block-off around the perimeter) and an inner diametric seal (separating regeneration and process sides).

Wheel Life

Unlike active desiccant wheels that are subjected to large temperature swings, the CDQ wheel sees more moderate swings in temperature and humidity, similar to total-energy wheels. Life expectancy of the CDQ wheel media is similar to that of energy wheels. The wheel should not be subject to oils or aerosols that could coat the wheel and clog pores, greatly reducing the effective life of the wheel.

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For more information, contact your local Trane office or e-mail us at comfort@trane.com

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Supersedes	New
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