Dehumidification

For most people, the word condensation brings forth an image of an ice-cold glass of our favorite beverage while enjoying the company of friends and family at a summer picnic; however, for us in the ice-rink industry, condensation is "no picnic" when it has an adverse impact on a facility.

So gentle is a microsized particle of moisture, yet it creates havoc for us by totally destroying the people-friendly environment we strive to create. Not only is this menace very uncomfortable for people, it also destroys our buildings, our operating budgets, and makes the product we offer, ice, less than satisfactory.

Moisture management is one of the most dominating factors in both the design and operation of an ice rink. Condensation on internal fixtures/ceilings, fog, and frost accumulation on the ice sheet are conditions which can be cured with a properly installed dehumidification system. Condensation on the wall and/or ceiling insulation is controllable. When condensation occurs within the roof insulation membrane causing the insulation to sag or fill water, this is an indication of an improperly designed wall or roof composite plan, not a need for dehumidification. No dehumidification can solve this problem if it is present at your facility. Far too often, the dehumidification system is blamed for such problems when in reality the design is to blame!

The dehumidification process is occurring in every ice arena, even those which are not equipped with true dehumidification systems. When arenas operate without a formal dehumidification system, their ice sheet and building becomes their dehumidifier. While very inefficient and equally detrimental, these complexes rely on their ice sheet and ceiling to condense the moisture from the air.

We all know the obvious benefits of installing a dehumidification system: the dripping stops, the upper shielding system of the dashers are clear, painted objects stay fresh looking, and the ice is not overcome with frost or stalagmites, which form from the dripping ceiling. The less obvious benefits include the significant decrease in heat load which affects the ice sheet and the resulting utility consumption. And, let's not forget the benefits of not having that ice-cold drop of water hitting a new skating customer on the back of the neck, or premature aging of the structure.

Often, operators hesitate installing a dehumidification system because of concerns for added operational costs. The paradox of running a dehumidification system is that little-to-no-change should be noticed with the overall complex utility bill. This results from the substantial decrease in heat load, which infiltrates the ice sheet, and in less running time with the ice-making system. Humidity greatly effects the load on the ice sheet in several ways. When no dehumidifier is installed, the ice sheet converts the moisture in the air to moisture on cooled objects, or it sublimates the moisture to frost directly on the ice sheet. When the ice sheet converts vapor to frost, it takes considerably more energy than just converting vapor to water, as would happen with a typical dehumidifier.

Air's transfer of heat through conductance is greatly effected by humidity levels. Moist air significantly increases the conductivity of air. Load calculations by rink designers are always calculated on wet-bulb temperatures, which is a measurement of both temperature and humidity. An arena with a 50 degree wet bulb has a design factor of 52 BTUH per square ft. of ice sheet. By lowering the wet-bulb temperature with the dehumidification system, the design load of the ice sheet is greatly reduced. The dry-bulb air temperature stays the same, but the wet-bulb temperature is reduced with the removal of moisture.

Humidity, or air moisture levels, is measured in relative humidity percentages (RH%). Air with a relative humidity of 0% would be dry air, totally free of moisture. Air at a 100% relative humidity would be air at its maximum moisture holding capacity or what is called "dewpoint". Dewpoint occurs when the air is fully saturated and cannot hold any more moisture in vapor form at any given temperature. When air reaches dewpoint, the moisture vapor within the air changes to liquid form.

Air can hold different amounts of water vapor depending upon its temperature. The warmer the air, the more moisture air can hold before reaching saturation or dewpoint. Warm air has the ability to hold significantly more grains of moisture than cold air. For example, air which was at 75 degrees F. at a 50% RH level, when cooled to 55 degrees, would have a 100% RH level. The same process works in reverse.

If your complex has ceiling condensation and dripping problems, a low emissivity curtain alone is not the answer. Low-emissivity ceiling curtains and designs are ideal for an arena but not for arenas without dehumidification systems.

Emissivity ceilings maintain a warmer surface temperature; accordingly, they will not attract as much moisture until the humidity reaches a higher level.
What is often overlooked is the Low "E" ceiling design is only as good as the weakest component when it comes to emissivity design and how it effects surface temperatures of the ceiling components. The weaker points of a ceiling design, when it comes to condensation points, include any exposed objects over the ice sheet which do not have the same Low "E" surface characteristics as the ceiling being installed. For example, an exposed sprinkler pipe, because of its poor E-value and relative small mass, will be the weakest point of any ceiling. These will be the first objects to drip. Exposed-structural steel would be second, not because of their better "E" value, but because of their large mass.

In a typical ice-rink, considering average ice temperatures, roof insulation values, and resulting indoor air temperatures; the ceiling surface of a white ceiling scrim with an E-value of .9 will start to condensate surface moisture between 53% RH to

58% RH. A facility equipped with a Low "E" ceiling would not show signs of surface moisture until 70% RH to 74% RH. While the Low "E" ceiling would fundamentally permit higher humidity levels of operation without ceiling drippage, this is not practical simply because of the added heat-load burden to the ice sheet under this environment. Further, in many complexes with stagnant air conditions, it is very likely that fogging of the upper shielding system would occur, along with significant condensation on the ice sheet, resulting in a substandard skating surface.

We have already touched on the energy saving benefits of the dehumidification systems when a complex is operating within a humid environment. But what is the best humidity level to maintain in an ice rink? We know structural steel needs to be maintained at a RH level of 40% to 45% or less, depending upon temperature, to truly remain rust free in the temperatures of a typical indoor arena. Accordingly, this appears to be a good upper-end benchmark, since it provides exceptionally good energy efficiency with its low-heat conductance of air, while also providing a sustained building without internal deterioration.

One could then ask, 40% is good, but will a RH% level of 20% or 30% be better for a reduced load on the ice sheet, thereby, offering better energy efficiency? While it may appear practical, another problem evolves at these lower levels. At approximately 31% RH, an ice sheet will begin to change from ice directly to vapor in the typical ice-rink environment, this is called sublimation. In addition to actually having the ice evaporate, materials, such as rubber and wood, could begin to experience fatigued conditions. It also begins to dehumidify at these levels. With every lower RH% targeted, it takes increasingly more dehumidification capacity and energy to achieve. With lower levels achieved and maintained, the rate at which moisture vapor enters a building will increase.

Based upon the conditions noted, we have found a RH level of 40% to 45% to be the ideal design condition. Large arenas are governed by different operational parameters than the typical indoor ice rink. It is not practical for these larger facilities to maintain this same RH% benchmark, nor do they require it because of their differences in building size, ventilation, and usage.

Dehumidification Types

The job of keeping ice rinks dry has been accomplished with three (3) primary types of mechanical systems. They include air handlers, refrigerated dehumidifiers, and desiccant-type dehumidifiers.

Air handlers are units which feature a blower system that passes the rink air through two (2) separate air-treatment coils similar to a radiator. The first coil is a cold coil which condensates moisture out of the air while also cooling the air. The moisture will run off of this first coil and deposit water down a condensate drain.

The second coil is a hot coil where the air is re-heated to the same temperature, or more, then it enters the system, resulting in air at a lower RH % level.

Air handlers rely on a cooling and heating source from an outside mechanical system. Most often for ice rinks, this source has been the ice-making plant. Chilled secondary fluid (often referred to as brine) is circulated through the cooling coil at a controlled rate, and heat reclaim/condenser water is circulated through the hot coil for reheating. Sometimes these systems are also connected to a boiler for supplemental-winter heating.

Overall, air handlers have proven to be the most inefficient methods used to dehumidify an ice rink. Air handlers have not been popular for many years, as a result of their marginal performance and higher cost of operation verses the other alternatives.

Refrigerated type systems operate with a similar two coil system as air handlers; however, they function fully independent of an outside system for their heating and cooling needs. Internally, they feature their own refrigeration system complete with compressors and related components. The primary refrigerants, typically R-22, will work with these two (2) coils similar to any refrigerant cycle with the cold coil being the evaporator and the hot coil being the condenser.

While using the two (2) coil system, the refrigeration models do have some extra benefits which are not easily obtainable with air handlers and, thus, not implemented with such systems. Refrigerated systems have the ability to bring the cold coil below the freezing point and actually building ice onto the coil. The benefit of ice building on the coil meant a lower RH% was obtainable with these systems verses the air-handler method. All refrigerated models properly designed for low temperature include this feature. Part of the normal control sequence includes a timed, or sensed, defrost cycle where the condenser (hot coil) and evaporator (cold coil) are reversed, with the air flow discontinued. The unit will operate this way until the ice on the evaporator coil is fully melted off the system, where upon, it will then return to normal operation.

A properly designed defrost system is mandatory for the successful operation of a refrigerated-type unit in the cold environment of an ice rink. Be wary of companies which offer models originally designed for swimming pools or other standard applications, with some slight internal modifications. These units have proven not to work in many ice rinks. Many internal functions of a refrigerated type unit must be changed, including the physical size of the internal coils, which are often overlooked by dehumidification companies in quest of a new market.

The concept of desiccant dehumidification on the "personal use level", can best be identified by those small packets placed in new luggage, or select food/pharmaceutical products to keep them dry and stating "DO NOT EAT". The materials used for desiccant purposes have a greater propensity to absorb moisture than most materials. With these small packets, once the material has absorbed moisture, they no longer provide dehumidification and must be discarded.

In a mechanical desiccant dehumidifier, similar type materials are used; however, the same desiccant absorbing material must be re-used. To use the desiccant material on an ongoing basis, the material is put through a series of processing and reactivation. Processing is when the rink air is passed over the active desiccant material where it absorbs moisture, thereby, drying the rink air. Reactivation is a process of heating the desiccant material, drying it out for re-use.

To accomplish the processing operation and reactivation procedure, the desiccant absorbing material is manufactured into a large circular wheel which is positioned between two air-flow chambers. The wheel slowly rotates at approximately nine (9) rotations per hour, so both processes can occur simultaneously in a smooth ongoing operation.

The processing operation consists of a blower pulling air from the rink, passing it through the desiccant wheel, and returning this air to the rink area. The reactivation process involves a blower taking outside air, heating it with a natural gas-fired burner, and forcing this air through the wheel before venting it back outside. The moisture absorbed on the process side of the wheel is heated out on the reactivation side, which is normal with a drying process.

Why Desiccant-Type Units Have Become The Trend

Since the 1970's, refrigeration-based dehumidifiers began to dominate the maturing ice-rink industry by companies specializing solely in arena construction. Refrigerated-type units were simple to install since they only needed a power source and drain connection to operate.

Today with energy expenses being a dominating concern in arena design, we have become more enlightened to many aspects of the building design and what is ideal environments for peak system efficiency. With this insight, buildings are being constructed with increased insulation values which results in much lower internal air temperatures - even during the hottest summer conditions.

On newer, properly built complexes, it is not uncommon for the inside air temperatures to remain below 55 degrees even when the outside air is 95 degrees at a 100% RH level. We know, too, of the benefits to maintaining a lower internal RH level, even below the levels needed to avoid ceiling condensation because of the energy benefits to the rink floor.

Both of these elements are detrimental to the range in which refrigerated-type dehumidifiers work best. Refrigerated units remove moisture better at warm temperatures and at higher humidity levels. The lower the temperature, the less their effectiveness. In fact, the lower end operating level of refrigerated-type systems is approximately 50% RH. The lower air temperature also brings with it a lower dewpoint temperature. Once the dewpoint temperature falls below freezing, the amount of energy required to remove moisture with a refrigerated system goes up dramatically, and the quantity of water removed goes down just as significantly.

Because the newer, better insulated arenas are consistently operating at much lower temperatures, the ability of refrigerated units to sustain their practical role in the ice-rink industry has deteriorated. In fact, older arenas, which have retro-fitted new Low "E" ceilings or insulation packages, have found their old refrigerated type, or handlers, are not effective in keeping their rinks dry in lieu of the building enhancement. This results from the overall lower sustained building temperature. The same units which worked well when the building was warmer will not maintain the building in a dry condition with colder building temperatures.

Desiccant-type dehumidifiers are not effected by the lower temperature in this manner. Actually, they excel in the lower temperatures created today, and can operate effectively down to a 20% RH, which is substantionally lower then 40% to 45% of the ice-rink goal.

The overall cost of operation for a desiccant-type dehumidifier equals or is significantly less than the cost of operation of a good, refrigerated-type system, depending upon the conditions. At lower temperatures, they drastically surpass a refrigerated type unit, since most refrigerant-type systems simply will not function adequately in this environment.

Desiccant-type systems offer numerous other benefits as well. These systems have very few moving parts making their maintenance requirements substantially less than refrigerated units, which have a history of high maintenance resulting from their complexity and extensive mechanical function. Many gas utility companies offer substantial incentive programs for complexes to consider a gas operated device, such as a desiccant system. Duct work is a minimum, and these units can be located indoors or out. First cost equals a refrigerated system for a single rink complex, and is actually less money for a twin complex which can usually operate on one large unit for both surfaces.

Some Overlooked Sources Of Dehumidification Loads

Dehumidification loads can often be reduced in most arenas by implementing some uncomplicated, mechanical modifications, to the building to the most simple changes in how the staffing services the arena.

Moisture in an ice rink can be attributed to three (3) primary sources: moisture infiltration from outside the building structure, moisture produced by spectators, and moisture created by the daily internal functions of ice maintenance.

When designing a building to repel external infiltration, we cannot put a greater emphasis on the proper placement of vapor barrier into all walls, ceilings, and floor compositions. Improperly placed, or omitted vapor barriers, are one of the largest design flaws made in ice-rink construction. Vapor barriers serve to reduce dehumidification loads, but they also eliminate condensation from occurring within the batt insulation.

Misappropriated vapor barrier installations will cause ceiling insulation to fill with water, block walls to bleed through the toughest paint, and even cause rubber flooring adhesive to continually fail. All it takes is 1% moisture in fiberglass insulation to reduce 78% of its insulating properties. Vapor barriers are important to both the dehumidification system and the building. Even the best, largest dehumidification system alone cannot avoid these conditions, if the vapor barrier was not installed properly from the onset. (See the BRS Section on Insulation and Vapor Barriers in our Building Design Section.)

An investment in quality/insulated doors, fixtures, and external mechanical dampers for exhaust fans are a wise investment. When maintaining the lower RH levels of 40%, any openings in the structure are like flood gates for the moisture to enter the building. These openings are sometimes very obvious as when a Zamboni driver leaves a garage door open to the outside. Sometimes they are far more subtle, such as doors without weather stripping.

Take a simple 6'x6' emergency exit door which has as little as an 1/8" gap around the door. The area this gap represents is like having a 7" square, open air hole, right through the side of your building. Amazing isn't it. Assume your complex has ten such doors. These gaps then provide an almost 2' x 2' open air window to the outside. We all know what an opening of this size would do to a rink, particularly on a humid summer's day. So take care to seal your building well. This should go for any leakage into the building, which is not managed air with the mechanical system.

Another high humidity producer is the snow melting pit. Snow pits, with their 80 to 100 degree water, are like a Turkish-steam bath for an ice rink. Snow pits should only be heated when needed, and should always be located in a room isolated from the ice-rink environment. The room they are in should be well ventilated to an outside source. All ventilation of the snow pit and Zamboni areas should be pulled out of the room by the mechanical device, as opposed to blowing inward and venting out with a louver. When the air is pulled from the room, it prevents the room from being pressurized, which would force air/humidity past garage doors and other openings more rapidly into the rink space.

In addition to vapor barriers and dehumidification systems, the practice of pressurizing the building is a sound-design concept often used in humidity-management systems. This concept offers special benefits to older buildings where the overall envelope is not nearly as tight as a new structure would be.

The practice involves bringing a small amount of air into the suction side of the dehumidifier, permitting the dehumidifier to actually pressurize the building slightly with dehumidified air. By pressuring the building slightly, any areas of leakage will tend to leak dehumidified air out, as opposed to humid air in. When doors are open, an outward flow of air drastically reduces the infiltration into the complex. All air is treated by the dehumidifier before being released into the ice-rink space, eliminating the possibility of glass fogging or condensation forming from this new air introduction. Sometimes it's just not possible to tighten up an old building as much as it should. This provides the best second alternative.

Even small exercises, such as closing dasherboard doors, and using a cooler ice making water during summer conditions, contribute greatly to the improved energy efficiency of a facility.

Indoor Air Quality, Ventilation, & Dehumidification

Air quality has been an active topic for ice arenas in recent years, due to some unfortunate mishaps with poor air quality. Often, with such situations, the pendulum of well-intended safety legislation has a tendency to swing too far away from common sense. Eventually, our legislation will balance on middle ground where safety is assured, but not at the expense of sanity. Being in the early stages of this cycle, we are at the peak of insanity with how some of the most recent codes are written. In an environment where we exercise great care to construct well insulated buildings, some building codes require such an incredible amount of new air being brought into our complexes that high wind-warning signs are needed. While their is much talk in the engineering community to petition changes in these codes for ice rinks, they could be some time away.

The current code for new-air ventilation for our buildings is 15 cubic feet per person. A special exception is provided in the code for complexes with single-event spectator gatherings which do not last for more than three (3) hours. For these complexes, which all ice rinks can petition to design towards, the amount of new air per person is reduced by 50% to 7.5 CF per person. This 50% rule brings the quantity of air to be treated to a manageable level with small modification to standard dehumidification systems. Desiccant-type units have adopted well to today's code offering many design adaptations to treat this extra volume of air.

Before being released into the rink, all new air must be thoroughly dried by the dehumidification process. For occupancies of 300 or less, a larger model of a standard desiccant dehumidifier will accommodate the added humidity of this outside air. For arenas with greater spectator quantities, a refrigerated coil will need to work in conjunction with the desiccant system. The goal with this high air-volume system will be to both cool the air and remove the moisture, as not to disturb the environment of the rink. For some applications ratings of up to 10,000 CFM are required. Yet, despite this large air volume, a well balanced system will not effect the normal ice texture or skating environment.

Refrigeration for these added coils can be produced from several design alternatives. A totally independent refrigeration system can be installed with the dehumidifier. This approach is very effective because it supplies the most energy-efficient treatment, if the ventilation must be provided on an ongoing basis. In most circumstances, a high volume of air is only required for a short period of time until a major spectator event is over. Normal skating activities never required such a large quantity of new-air ventilation.

By considering the usage pattern for the complex, many cost savings, and energy-saving alternatives can be implemented, as opposed to simply buying a large refrigeration package inside the dehumidifier.

An approach which works well is ice storage. With this concept the ice making system produces ice in insulated storage units for later use by the dehumidification system. This ice is produced by the ice-making chiller at night when the ice loads are at their lowest, and so is the electric cost since the night is an off-peak electrical rate. The overall system is designed to accommodate three (3) major events per day at full capacity. In most applications, this works extremely well and saves tens of thousands of dollars off the installation expense, including the benefits in cost of operation.

For any design issue you may encounter about ice rinks, contact BRS. We have dozens of tools to help you with your efforts.