PoolPak®
DEHUMIDIFICATION THAT WORKS

Dehumidification Considerations & Options

Sorting Through Pool Room Dehumidification Options

Whether you are building a new indoor pool facility, refurbishing an older one or wishing to optimize an existing operation, there are a number of considerations that should be examined before committing to an expensive decision on choosing a dehumidification system. Balancing comfort, cost and appearance all have trade-offs, and it's important to establishing your priorities in advance.

Indoor pool rooms are complex environments that need constant care and maintenance. There is an ongoing relationship between internal and external temperatures, humidity level, structure type, ventilation, pool water chemistry and equipment. When all are working in harmony, the facility will provide a comfortable, healthy environment that is cost effective. When the variables begin to change, comfort, operating cost and/or maintenance can suffer greatly.

Indoor pool designers and owners need to control and balance five crucial variables:

1. Pool water chemistry
2. Indoor air quality (IAQ)
3. Occupant comfort
4. Energy cost
5. Asset protection.

The interrelationship between the variables is complex, and changing one or more may affect the others. Small variations in the pool environment may result in discomfort; large imbalances in the pool environment can result in very high operating cost, destruction of equipment and structure and even occupant injury.

It is important to clearly understand and identify your goals for the facility. Typical conditions for general purpose pools are normally considered to be 82° for water temperature, 84° for air temperature and 50% to 60% relative humidity.

Athletic pools hosting swim meets generally operate with cooler water/air temperatures and health/therapy facilities tend to have higher water/air temperatures.

Today's even larger indoor waterparks are a breed unto their own. These facilities with their great expanses of space, sprays, slides and water cannons generate huge volumes of evaporated water, and ideal conditions can be difficult as well as expensive to maintain.

Knowing Your Pool Environment is the First Step

It All Starts With Pool Water Chemistry

No discussion on indoor pools would be complete without mentioning pool water chemistry and its relationship to maintaining a desirable environment. Dehumidification/ ventilation equipment is not designed to remedy the effects of poor pool chemistry, but is designed to deliver prescribed ventilation to manage smaller amounts of pollutants generated from normal pool activity.

Pool water chemistry is critical to the proper operation of the pool, and chlorination is the primary pool treatment method. It controls pathogens and organic contaminants introduced into the water by the normal activity of bathers. Under-treated pool water can result in unsanitary conditions while over treated water can facilitate the off-gassing of chlorine compounds, such as chloramines, into the air.

Incorrect chemistry affects not only water but also indoor air quality. A strong "chlorine" odor is an indicator of poor pool water chemistry, and is generally offensive to the occupants. Higher levels of chloramines can cause skin/eye irritation and respiratory problems commonly known as "lifeguard lung".

Chloramine-laden condensate that may form on cold surfaces is also very corrosive and will damage or destroy structural components and furnishings if not controlled.

The Pool-Spa Operator's Handbook recommends that the chloramine levels not exceed 0.2 ppm. In addition to protecting the health of the bathers, a level is above 0.2 ppm, the corrosion process caused by the chloramines in the air may be accelerated.

Newer non-chemical sanitization systems such as Ultraviolet (UV) and Ozone generators are coming on the market and are used in conjunction with chlorine-based systems. Properly applied, these systems can reduce the amount of chlorine needed making it easier to maintain proper chemistry.

Did You Know?

- Mechanical dehumidifiers can remove an entire swimming pool worth of water from the pool room air in a year. In some locations this water can be recycled back into the pool.
- Hot tubs and spas contribute more moisture to the air than an equally sized pool.
- Spray features in waterparks can double or triple the dehumidification load.
- Stainless steel is not the preferred material for ductwork or supports. Commercial grades of stainless steel are subject to stress corrosion and become brittle over time. Coated galvanized steel or aluminum performs better in this environment.
- Local Departments of Health require pool operators to maintain a detailed journal of pool chemistry conditions.
- Heating pool water faster than 1 degree F per hour can crack the pool foundation and pop tiles off the sides of the pool.

Indoor Air Quality (IAQ)

Depending on the geographic location and season of the year, treating the outside air has a direct effect on energy consumption. Some facilities prefer higher than minimum ventilation rates, up to 100% of OA, to maximize indoor air quality, but the cost of treating this air can be significant.

Another situation where ventilation plays a critical role is during purging. Chloramines can build up in the pool water to the point where super-chlorination or "shocking" of the pool is required. Shocking is used to achieve a break-point chlorine level, and once that's reached, a chemical reaction occurs converting the chloramines back to free chlorine, nitrogen gas (which settles in a thin blanket over the water) and water.

One common strategy to quickly remove these gases is a pool room purge cycle which flushes the room to remove the gases generated by shocking. There is no practical way to measure the off-gassing concentrations, so the turnover quantity of outside air, as well as the duration of the purge cycle, can vary.

Depending on the desired outside air quantity, purge cycles can dramatically increase the instantaneous outside air heating load in the winter. Deciding how much heated air will be introduced is an important consideration because if the purge air is too cold, the pool room may "fog up". Also, in some climates, a 100% OA purge cycle may not be a practical option. Selecting gas furnaces requires particular care because the heating capacity required for a purge cycle could create condensation or control problems during low heating load conditions. When considering a purge cycle, a balance with air change rates, pool room downtime, equipment cost and operational issues should be carefully reviewed during the design process.

Occupant Comfort

Occupant comfort is easy to understand, especially if you've ever swam in an outdoor pool on a cold, windy day, or exited a pool in a dry, desert location--you will probably notice an immediate chill. The opposite is true where high humidity is not adequately controlled either through ventilation or by mechanical means. The moisture level can reach such a state where it is oppressive or stuffy. Common complaints are difficulty in breathing and the room being perceived to be warmer than the actual dry bulb temperature would suggest.

Regardless of the source of discomfort, users will not enjoy the facility if water/air temperatures and humidity levels are not within a narrow range. Ideal water temperature is around 82° with the air temperature slightly higher to prevent chilling once exiting the pool. Below are some recommended temperatures for pool rooms which can be adjusted to meet specific needs of the bathers. In general, "active" pool rooms are maintained at lower temperature ranges so the users don't overheat, while warmer temperatures are more common for seniors, children and less active pools.

Recommended Pool Room Temperatures

Recommended temperatures for pool rooms which can be adjusted to meet specific needs of the bathers. In general, "active" pool rooms are maintained at lower temperature ranges so the users don't overheat, while warmer temperatures are more common for seniors, children and less active pools.

POOL TYPE	WATER TEMP (°F)	AIR TEMP (°F)
Competitive Swimming	77 to 80	79 to 82
Diving Pool	82 to 86	84 to 86
Residential Pool	82 to 84	84 to 86
Recreation Pool	82 to 85	82 to 86
Therapy Pool	86 to 92	86
Hot Tubs	99 to 104	86

The desirable humidity range is between 50% and 60%. While greater than 60% humidity creates a sticky feeling on the skin and difficulty breathing, less than 50% results in evaporative cooling on the skin and feeling chilled.

Poor air movement caused by improper duct placement within the pool room will also lead to occupant discomfort. Excessive supply air can create drafts, while uneven air distribution may create stagnant zones within the space.

Energy Cost

Energy consumption is a direct function of the variables necessary to satisfy the occupant and protect the facility. These variables include:

- Space heating and cooling
- Water heating
- Humidity removal
- Ventilation

Maintaining ideal and precise environmental conditions has a fairly high cost of operation. And for a majority of the indoor pools, regardless of geographic location, water and space heating are required 70% to 90% of the year.

The pool room environment is in a constant state of flux as outside and inside variables change hour-to-hour and season-to-season. Outside temperatures affect the inside heat loss/gain sometimes resulting in the need for more energy to maintain occupant comfort. The same applies during ventilation. For example, colder incoming air can place an additional load on the heating system.

Likewise, if outside air contains greater amounts of moisture such as summer in the southeast, more energy may be required to condition and cool the ventilation air to effectively control the pool environment.

To illustrate why energy use of pools is high, as the pool water is heated, the evaporation rate increases. The difference in the vapor pressure of the water molecules of the warm water compared to the air vapor pressure creates evaporation. If the air is cooler than the water, the evaporation rate is higher. A good example can be seen in nature, when a warm pond steams on a winter morning.

Evaporation removes heat from the water, which causes the pool water to cool. To maintain water comfort conditions, additional energy is needed to sustain the water's original set points. In most pools, heat energy must be added back into the pool water or it will cool down below a comfortable temperature.

The two most common dehumidification methods are mechanical and ventilation strategies. Both are acceptable, proven methods and both require energy to maintain the pool environment. Other technologies such as desiccant can be used, but are less common.

There are other operating cost considerations that should be taken into account as well.

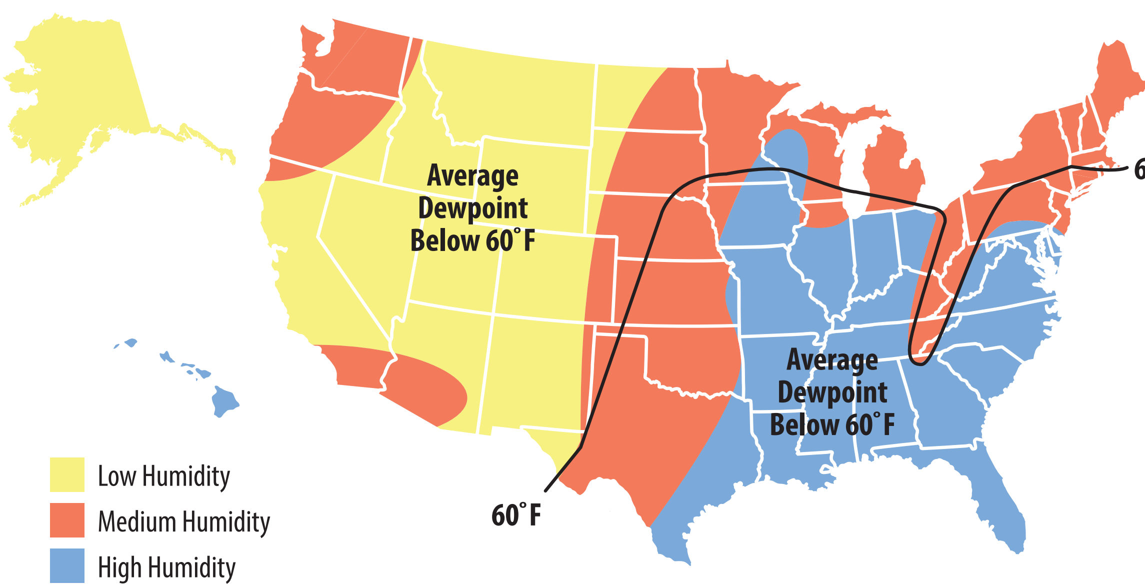
In most northern climates the average annual hours where the outside air temperature is greater than the inside temperature are few. To temper the air and offset the heat of evaporation, auxiliary heat sources are required to maintain comfort conditions.

Pool facilities with open sunlit atriums and windowed walls are candidates for high cooling loads. This greenhouse effect can be offset by increasing ventilation rates during peak periods or simply opening doors and windows.

A more precise method of space cooling can be provided with mechanical dehumidification technology. Comfort increases but so does operating cost.

Energy and the Mechanical Dehumidification Method

A mechanical dehumidification system lowers the indoor humidity to set point conditions. Energy is required to operate the refrigeration system (when used), bring in outside air and operate the air distribution system (blowers) to maintain the proper balance.



The mechanical dehumidifier method uses electricity as the primary energy source and offers a reclaim mechanism in the form of a heat pump cycle, which adds the heat back into the air and water. Thermal COP's of 5 are not uncommon, and this method offers the best control regardless of location and climate. Mechanical dehumidifiers recover more of the latent heat from pool evaporation than passive heat exchangers, which can offset the initial cost of the unit. Where electricity cost is low compared to other fuel types, mechanical dehumidification is attractive.

Energy and the Ventilation Dehumidification Method

The ventilation method takes advantage of the fact that for most of the year the air outside is drier than the pool room and can be utilized for humidity control. Heat recovery systems such as heat pipes or plate-type heat exchangers recover waste heat from the exhaust air stream and reclaim it into the outside air stream.

Thermal energy usage from fossil fuel is higher with this type of system because the thermal recovery is lower than the mechanical method. Although less latent heat can be recovered than with mechanical systems, the offset in first cost and ease of maintenance can be attractive

Asset Protection and Safety

High humidity within the pool room is not only a detriment to occupant comfort, it is also a major consideration for the appearance and preservation of the facility. When warm moisture in the air comes in contact with cold surfaces, it condenses back to a liquid. The temperature at which this phenomenon takes place is dewpoint.

Pool rooms are by nature very warm and humid, and any cold surface creates condensation. When a cold surface in a pool room reaches a temperature equal to or lower than the space dewpoint, the point where the moisture condenses out of the air, the problems created are significant.

Condensate from moisture laden air can contain chloramines, which as noted earlier is a bi-product of poor pool water chemistry. This compound is very corrosive and will attack metallic surfaces, resulting in the deterioration of railings, chairs, window frames, lockers and structural components.

There are confirmed incidents where corrosive moisture leached into precast concrete roof structures, corroding the rebar, resulting in collapse and injury. A little know fact is that chloramines in the saturated air also attack and discolor most common stainless steels creating "stress corrosion", a potential for structural failure.

Where poor pool water chemistry is left unchecked for prolonged periods, the chlorine-laden condensate will severely damage the dehumidification equipment meant to protect the facility.

Pool occupants appreciate, and expect, clean, well maintained facilities. Condensate formation on windows and walls is unsightly, corrosive, and attracts dirt. Corrosion results in stains, rust and peeling paint, all of which diminishes the pool room experience.

Pool Room Environmental System Choices

We have laid out some basic design considerations for controlling the indoor pool room environment and can now summarize the technologies commonly used. Modern pool room environmental management systems are available to balance all the factors necessary for an optimum indoor pool facility. The choice of systems can be complex, and depending on the selections made, can have long-term repercussions. Packaged dehumidification equipment built for pools incorporate more sophisticated mechanical design and software than conventional systems to minimize the operating cost.

The following are some common approaches to maintaining the pool room, starting with the simplest first.

Dehumidification with Heating and Ventilation System

A heating and ventilation system (H & V) can be best described as the most basic of dehumidification systems. Moisture removal is accomplished through the dilution of outside air. This is a brute force approach to dehumidification under the premise that enough drier, outside air will offset the effects of pool evaporation. This system has no practical means of cooling during the hot summer season, especially when the temperature delta between outside and inside is minimal.

During the cold winter months, the H & V system must raise the inside diluted air temperature from the outside ambient air to 84°F, the desired space temperature. Considering typical winter temperatures hover around freezing, the cost of operation could be quite high. Capital cost is the lowest for a packaged system, and temperature and humidity control are not very good with a ±30% variation during the summer season.

A common misconception is any air handler will operate satisfactorily in a pool environment. Many pool installations with conventional AHU's need replacement after a few years due to unsuitable construction or high cost of operation.

Dehumidification with Heating and Ventilation System Plus Heat Recovery

With the addition of a heat recovery method, operating costs for a heating and ventilation unit can be reduced quite significantly for a small increase in capital cost. Heat is recovered from the exhausted air and used to condition the incoming air. Air-to-air heat recovery systems for this application are passive by design, and include heat pipe, plate, heat wheel and glycol. Although sensible energy

recovery is high, heat is not completely removed from the water vapor, which comprises a large portion of the exhausted air.

The addition of a plate or run-around heat recovery unit to a H & V system can be beneficial during the heating season. Capital cost increases by approximately 25% to 30% depending on the unit.

Heating and Ventilation Dehumidification System with Heat Recovery and Cooling Coil

Adding a cooling coil to a H & V unit now provides all season temperature control. With ventilation-type cooling equipment, the cooling coil is typically sized for the sensible load and dilution with outside air is still the primary method of moisture removal. However, the cooling coil can provide partial or full dehumidification along with space cooling if sized larger. The cooling coil can be either direct expansion (DX) or chilled water, with chilled water offering the easiest control of humidity.

Operating a cooling coil requires additional energy consumption via a compressor (DX system) or a cooling plant (chilled water) making operating cost higher than the previous two versions. The trade-off is greater comfort during the all-important summer season. This type of application works well in dry, northern climates especially where chilled water is easily available.

Dehumidification Using Mechanical Refrigeration and Hot Gas Reheat

In a conventional air conditioning system, the heat from compression during compressor activity is generally discharged to an exterior condenser. By using hot gas reheat, the energy is reintroduced to the supply air, supplementing space heating.

This type of system is similar to a conventional heat pump cycle except it gathers heat from the excess moisture in the pool room air rather than an outside air or geothermal source. The benefit of this approach is the high coefficient of performance (COP), while providing superior control of the pool room. In most cases a system heating COP of 5 is not uncommon, which simply means that the system thermal output energy is 5 times the work input energy.

As expected, capital cost of the system increases because of the added components, but the cost of operation decreases over the system without the reheat option. Hot gas reheat is only practical on DX systems where the compressor is part of the packaged unit. This system offers very precise facility temperature and humidity control during all seasons for occupant comfort.

Mechanical refrigeration is probably the most common dehumidification system used for small to medium pool room applications due to its control of the space temperature as well as overall good life cycle cost. These systems are complex and more expensive to install and maintain than the ventilation method of design, but offer superior control and energy recovery capability.

Mechanical Dehumidification with Hot Gas Reheat and Pool Water Condenser Option

This configuration is the most efficient of all dehumidification systems as it relates to facility management. Hot gas reheat can be directed to either the space or to heat the pool via a pool water condenser. Operating costs are at their lowest because all available energy sources are utilized, limiting the reliance of fossil fuels to maintain occupant comfort.

The pool water offers an additional heat sink for recovered energy, which would normally be rejected after the air is satisfied. Some owners have reported that their conventional pool water heating equipment seldom operates except in the coldest weather conditions.

Hybrids and Alternatives Technologies

Each of the systems described above can be combined into various hybrid technologies which are best suited for the local climate, owner preferences, first cost considerations and operating requirements.

As an example, passive heat recovery systems such as heat pipe and plate-type technologies found in ventilation dehumidification systems can easily be added to the ventilation circuit on mechanical refrigeration systems to maximize heat recovery.

Desiccant dehumidification has been applied to pool rooms but is limited in application to treating the clean outside air rather than the return air stream. The chemicals in the air may degrade the matrix especially at high operating temperatures.

Heat wheels have also been used but corrosion may be an issue with these designs since they do not seem too popular in pool room applications.

All of these systems are commercially available, but care should be used in their application.

Construction Techniques Save Energy, Reduce Condensation and Improves Comfort

Proper Airflow Distribution

Efficient dehumidification will not take place if the air distribution system is designed improperly. Careful consideration must be given to the location of supply air ducts, the location of the air return grill, use of moisture barriers and high thermal performance doors and windows.

The objective of an air distribution system within a high moisture environment is to maximize air flow of warm, dry supply air over any surface that is prone to condensing temperatures, including all walls, windows and skylights.

Most of the supply air (80%) should be directed at the walls with the remaining 20% directed along the ceiling to break up any stratifications and stagnation occurring near the ceiling. "Wall washing" with air reduces the incidence of cool, dead air spaces that may form around windows or walls and migrate to the pools edge.

A ceiling supply arrangement should be located near the windows, preferably close enough to sufficiently wash the cold glass with an even blanket of air. For low set windows and sliding glass doors, the supply air should be ducted below grade around the inside perimeter of the enclosure using corrosion-resistant PVC piping and linear slot diffusers.

Position the return inlet(s) so that all of the moist, warm air flows efficiently back to the dehumidification system, eliminating dead areas where air stagnation can occur.

The traditional return location is at a point high enough to capture the warm, humid air that naturally rises, or about 10 to 15 feet above the floor. It has been found, however, that chloramine-saturated air blankets the pool surface and does not adequately re-circulate through the dehumidification system. This results in poor indoor air quality that poses a health risk for the pool occupants.

A better strategy is to position return(s) near the surface to lightly draw off the chloramine layer and moist air while not overly affecting evaporation rate or creating uncomfortable air currents.

Never position ducts in a way that will result in short cycling of the supply air. Short cycling is caused when the location of the return duct is too close to or directly in line with the supply duct causing the warm, dry supply air to recycle prematurely.

Maintain a slight negative pressure of 0.05 to 0.15 in. of water in the pool area relative to surrounding spaces to prevent moisture and chlorine odors from being pushed into other areas of the building.

Vapor Barriers to Prevent Moisture Migration

Vapor barriers should be installed immediately behind the interior wall surface. The goal is to prevent moisture within the pool room from migrating into the wall where it will reach dew point much quicker because of the colder air temperature.

If not installed or installed improperly, the dew point will be reached within the wall and the moisture will impregnate the insulation, decreasing its R-value.

Good thermal performance doors and windows limit heat migration and condensation formation.

Glass doors and windows that are exposed to outside air should have good thermal performance. Double and triple glass panels are best and they should be insulated or sealed in metal or vinyl clad frames wherever possible. Window frames must have thermal breaks and be sealed to adjacent walls and insulated with a non-porous insulating material.

Pool Operating Strategies: It's Not Just the Equipment But How You Use It

Good operating practice can determine when outside conditions are capable of free dehumidification and cooling. Generally, control strategies require sophisticated software and a dehumidification system capable of monitoring internal and external conditions. But there are also simple, inexpensive techniques that manage the rate of evaporation.

One of the simplest and best energy saving strategies when the pool is unoccupied is the use of a pool cover. It eliminates the water-to-air interaction by providing an impermeable membrane over the pool surface. This can be impractical for larger pools because of the time and manpower required. Mechanized pool covers have become more common making this an economical option.

Another factor when managing water evaporation is pool water agitation. Pool water agitation creates more surface area, resulting in increased evaporation. It can be as simple as occupants splashing to more sophisticated man-made toys like waterslides, cannons and sprinklers. Wise management of peak loads along with shutting off unused water features can help.

Often overlooked is the deck area. Avoid the use of absorbent deck coverings such as carpet within the pool area because it absorbs and holds water. Also limit wet deck areas by installing adequate drainage and reducing deck over spray.

During off-peak hours or when outside conditions permit during occupancy, reducing outside air rates can greatly reduce operating costs.

In hybrid equipment where mechanical cooling is employed, and when outside air conditions are favorable, ventilation can supplement the mechanical refrigeration plant by using dry outside air to dehumidify the facility. Energy is saved by eliminating compressor operation, which can be significant in high electrical cost areas.

Cold surface sensors allow for higher humidity levels by monitoring temperature at an exterior window or wall frame. When the surface temperature reaches the room dew point, tighter humidity control is enabled. The controller automatically lowers the humidity setpoint as needed and then returns it to the setpoint conditions as the wall temperature rises. This permits energy savings when appropriate by allowing less stringent control of humidity when it is not required.

In an effort to save energy, there are pool facility managers who routinely de-activate the dehumidification system during off hours. This practice is not recommended because there is no heat and/or dehumidification in the space and the air and structure temperature drops rapidly. The water temperature drops little, escalating the evaporation rate due to the vapor pressure differential. Water condenses on all cold surfaces including walls, ceilings, windows and furniture leaving the facility in poor condition. A better strategy is to ventilate, eliminating the compressor operation if applicable, thereby reducing operating cost.

In summary, building and maintaining an indoor pool facility is a major undertaking and it must operate efficiently to maximize the return on investment. By selecting a packaged dehumidification system designed for your unique location, you can be assured of maximizing user comfort, protecting assets and reducing maintenance to the lowest possible cost.

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