Ventilation Air for Indoor Pools

INTRODUCTION

This technical bulletin reviews the outdoor air ventilation requirements for indoor swimming pool enclosures. It provides in-depth analysis of what the existing standard means and how ventilation air should be introduced to the air handler/dehumidification system. A review of energy recovery and conservation is also included.

As with all rules and regulations, interpretations vary. DESERT AIRE has provided the following summary in order to address the issue of ventilation air. This bulletin is for discussion only and is not intended to overrule the opinion of the consulting engineer.

DEHUMIDIFIER SYSTEM AIR VOLUME

ASHRAE Standard 62-2019, the industry accepted ventilation code for indoor air quality, defines the minimum volume of outdoor air which must be introduced into the indoor pool enclosure. This volume is generally only a small percentage of the total air volume required by a dehumidification system to maintain the space humidity. Air velocities across the pool surface should be minimized to avoid excessive evaporation. The design of the dehumidifier should target approximately four to six air changes per hour.

Ventilation Air Standard

Pool & Wetted Deck Area:	0.48 cfm/ft^2 2.4 l/s/m^2
Non-Wetted Deck Area:	0.06 cfm/ft^2 0.3 l/s/m^2
Spectator Area:	7.5 cfm/spectator + 0.06 cfm/ft^2 3.8 l/s/spectator + 0.3 l/s/m^2

ASHRAE 62 requires a ventilation air volume of 0.48 cfm per sq. foot of pool and wetted deck area plus 0.06 cfm per sq. foot of non-wetted deck area. In addition to this volume, an additional amount is required if the facility has a dedicated spectator area (bleachers). For these facilities, 7.5 cfm per person needs to be introduced in addition to 0.06 cfm per sq. foot of spectator area floor space during times that spectators are present.

DEFINITION OF POOL AND DECK AREA

Wetted Deck area is defined in ASHRAE 62 as the area surrounding the pool that would be expected to be wetted during normal pool use. Dedicated Spectator areas are not included in the Wetted Deck Area. Locker rooms, vestibules and hallways are not included in this measurement. Note that Non-Wetted Deck Area is not the same as Wetted Deck Area (See Figure 1.)

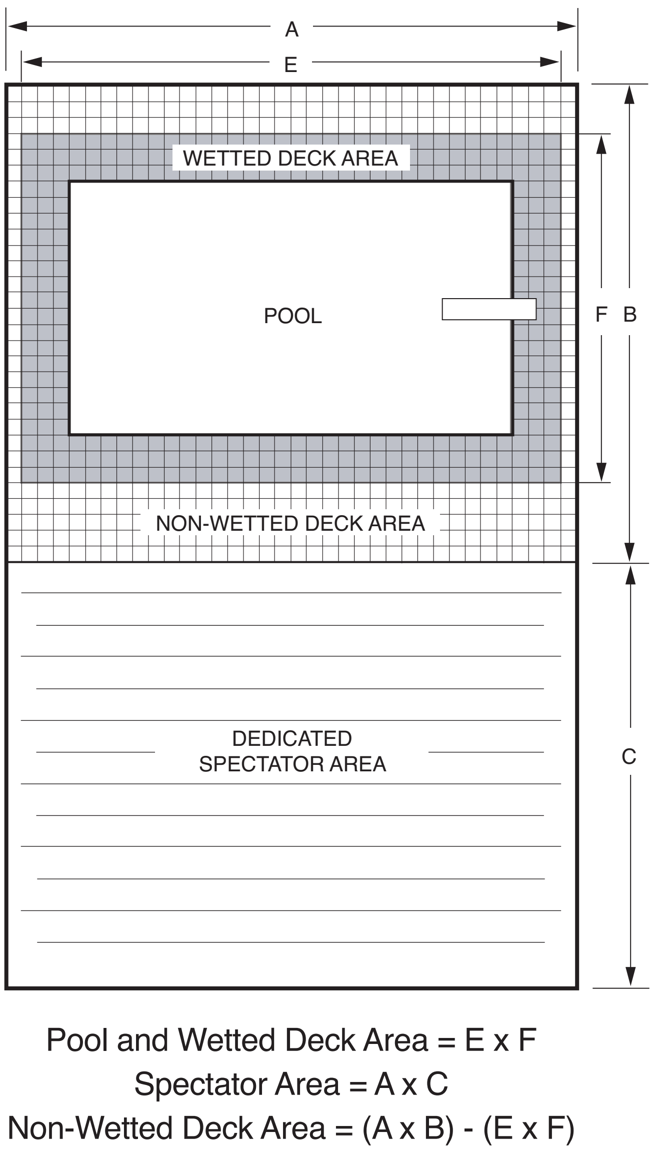

Figure 1 - Pool, Deck, and Spectator Area Calculations

WATER CHEMISTRY AND ODOR

When planning natatoriums, designers are concerned about preventing any unpleasant odors. Typically, they design a ventilation system which brings in an excess amount of outdoor air in order to control any potential odor problems. While a complete analysis of pool water chemistry is beyond the scope of this bulletin, a quick review is required to eliminate some myths with respect to ventilation air requirements. Refer to *Desert Aire Technical Bulletin #9* for a more detailed explantation of pool water and air chemistry.

Many people often complain about a strong, objectionable "chlorine" odor found in pool rooms. Actually, this odor is not chlorine (which cannot be smelled by humans until it is above toxic levels), but an intermediate compound formed during the disinfection process. The odor is produced by the combination of chlorine and organics (sweat, oils and urine) in water. What we smell are chloramines, which are volatile. They are readily released to the air and are detectable by humans at low concentrations.

Chloramines are heavier than air so the use of a low exhaust has proven effective for the removal of chloramines. Removing the odor causing chloramines at their source has improved the air quality in the natatorium and is a recommended solution by many designers for odor reduction and improved air quality. Refer to *Desert Aire's 21st Century Natatorium Design Guide* on suggested air distribution and exhaust layout for the improvement of indoor air quality.

INTERPRETATION OF THE VENTILATION CODE

The standard exists to protect the health of pool users. Proper interpretation, however, can also enhance energy conservation by reducing the volume of outdoor air required to the minimum allowed by code.

The interpretation is based on the following assumptions:

1) that normal pool user load is small and spectator crowds will be handled as an exception;

2) that automatic chemical feed systems are installed and operational; and

3) that a dehumidifier is installed and operational.

Ventilation may be regulated based upon occupancy. When the facility is unoccupied, outdoor air flow may be discontinued. During normal operation, outdoor air flow may be set to a minimum code-approved level. For higher-than-normal occupancy (such as a swim meet), an increased outdoor air flow rate is engaged. (See Figure 2.) Optimizing outdoor air will have a dramatic effect on operational heating and cooling costs.

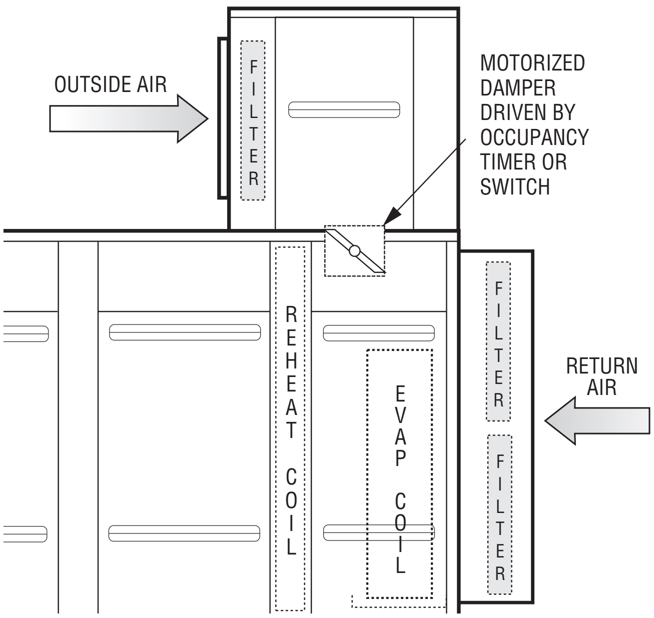

Figure 2 - Damper Assembly

The control of outdoor air dampers can be accomplished in two ways: a manual switch or a timer.

For either of these two actuation methods, the system will establish three control points to automate the outdoor air damper: closed for unoccupied conditions; minimum code ventilation for normal activity; and an event mode to handle spectator load requirements. Additional indexing of the OA damper may also be established such as a Max OA Mode or Purge Mode.

Spectator occupancy is not constant in most facilities except during swim meets. Spectator ventilation air can be introduced by a dedicated outdoor air system (DOAS) that has its duct work deliver spectators with clean, fresh air. The DOAS can also produce temperatures that are a couple of degrees lower than the pool space temperature to help keep fully clothed spectators cooler. To further reduce energy costs, the code ventilation for this area can be controlled via a manually activated switch or a building management system with a scheduling program. In this way the facility can reduce its energy costs by conditioning the air only when spectators are present.

INTRODUCTION OF OUTDOOR AIR

The dynamics of a pool enclosure are unique because of the need for humidity control. Most other applications can accept outdoor air upstream of the air handler without affecting the system's performance. This is not true in the case of a dehumidifier. If outdoor air is introduced into the return air duct, two problems can occur in cold weather (winter). The first problem is condensation in the duct when cold air meets the moist return air from the pool room. The second problem is that the mixed air temperature will be lower than the pool return air and will decrease the moisture removal capacity of the dehumidifier.

To eliminate these problems, the outdoor air should be introduced downstream of the evaporator (see Figure 3.) Then the dehumidifier has maximum moisture removal capacity and the reheat and auxiliary heating coils can raise the temperature of the outdoor air, avoiding cold drafts to the swimmers.

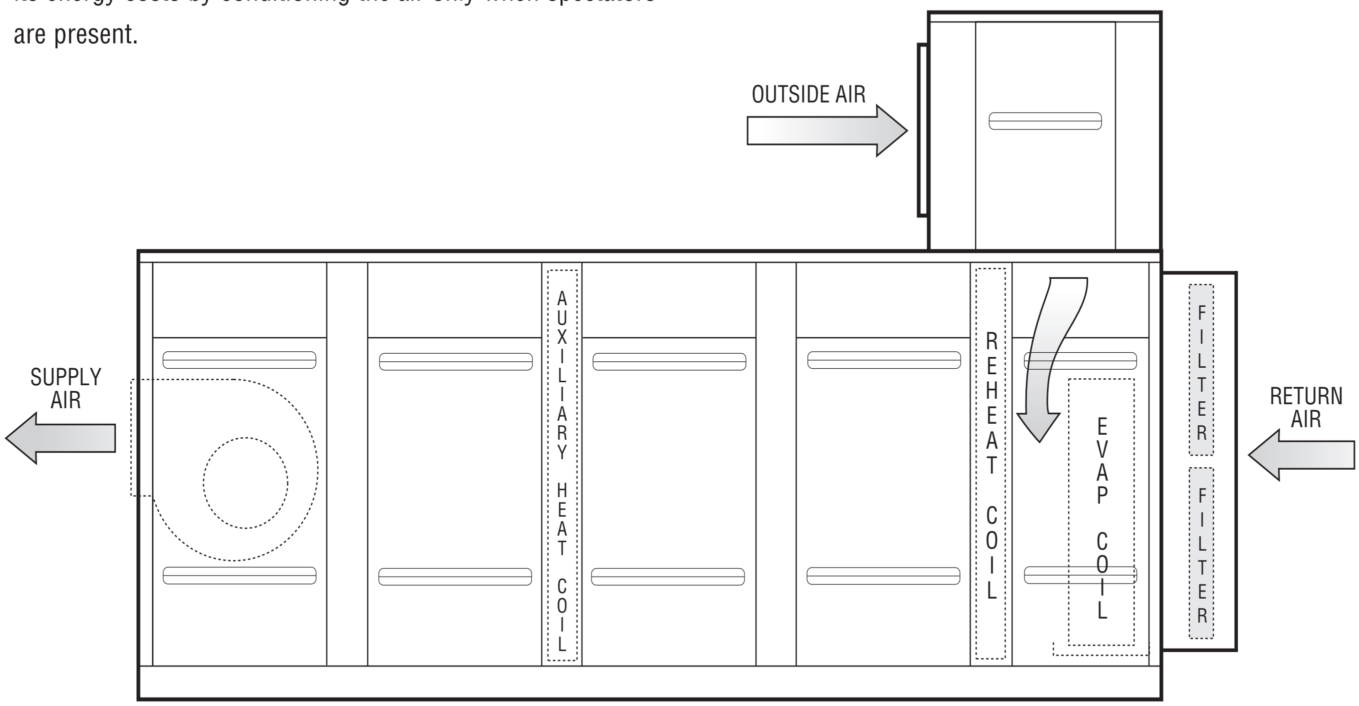

Figure 3 - Outdoor Air Introduction to Dehumidification System

ECONOMICS OF HEATING AND COOLING

WINTER

An indoor pool enclosure has several sources of energy loss:

1) ***convection through the ceiling, windows, and walls***

2) ***exhaust air***

3) ***evaporation of the pool water***

The convection heat loss and the exhaust air heat loss in a pool enclosure is a function of the coolness of the outdoor air temperature. The greater the temperature differential between indoor and outdoor, the greater the loss of energy. Uncontrolled heat loss causes swimmer discomfort and also increases the pool water evaporation rate. Heat loss through ceilings, walls, and windows can be minimized by using adequate insulation and multipaned windows. Heat loss through exhaust air can be minimized by eliminating exhaust during unoccupied times and by bringing in the minimum amount of outdoor air that code permits.

The water's heat loss can be minimized by maintaining the air temperature at several degrees above the water temperature. A key factor is maintaining the room relative humidity at 50-60 percent. Should the relative humidity drop below 50 percent, the evaporation rate will increase significantly. Relative humidity below 50 percent can occur when extra amounts of outdoor air are introduced in the wintertime.

The simplest method to calculate the effects of ventilation is the total enthalpy method. This method compares the difference in enthalpy (BTU/lb) of indoor versus outdoor air at different ventilation rates. A direct energy cost can then be calculated.

SUMMER

During the summer months, heat gain - not loss - is a problem. A higher volume of outdoor air increases the cooling demand and introduces extra moisture in most climates. The increased load requires a larger sensible cooling capacity, and the increased moisture requires a larger dehumidifier that must run longer. This effect must be included in the dehumidifier sizing calculation.

CONCLUSION

A dehumidification system in an indoor pool facility not only protects the structure and recovers energy, but it also allows a reduction of outdoor air, thereby increasing energy savings. If your state has adopted ASHRAE 62 ventilation codes, then the following design specifications should be incorporated into your plans:

- Dehumidification system - designed to provide four to six air changes per hour while maintaining a relative humidity of 50 percent to 60 percent.
- Automatic chemical feed system - designed to eliminate the need to introduce extra outdoor air to control the odor of treatment chemicals.
- Provide the base ventilation air during normal usage, and base plus the spectator ventilation rate during swim meets.
- Outdoor air introduced after the evaporator coil in the pool dehumidifier -maximizes the capacity of the unit. A DOAS can be used for the spectator outdoor air volume.
- Use of Source Capture Exhaust in order to maintain indoor air quality while minimizing the OA volume.

N120 W18485 Friestadt Road, Germantown, WI 53022 sales@desert-aire.com

Ph: (262) 946-7400 - www.desert-aire.com

Technical Bulletin 9

Interaction of Pool Water and Air Chemistry

INTRODUCTION

With the acceptance of ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Standard 62 concerning indoor air quality, more stringent reviews are required of an indoor pool's air quality. This technical bulletin summarizes the chemistry involved for pool water using chlorine and its effects on air quality, and vice versa. It also reviews the impact of ventilation air on air quality, as well as the use of Source Capture Exhaust to remove airborne contaminants in a pool facility.

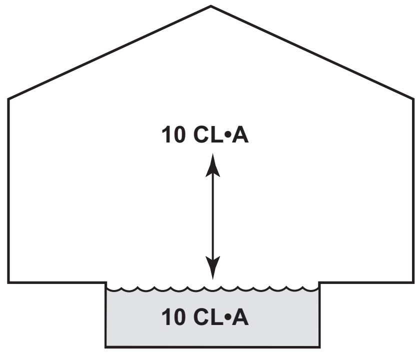

Figure 1 - Pool facility at equilibrium. (Note: CL•A = chloramine concentration)

WATER CHEMISTRY

Many detailed articles are available about this subject from other sources. This bulletin summarizes only the basics about pool chemistry to provide an overview. Contact the PHTA (Pool and Hot Tub Alliance) for more information.

Chlorine is added to water to form hypochlorous acid (HClO), an excellent bactericide. In this solution it is known as "free chlorine," and is highly reactive. The free chlorine reacts with organic wastes introduced into the pool water – such as sweat, urine, perfumes and other ammonia-based impurities – to form new "combined chlorine" compounds. These new compounds have very poor bactericide properties. If enough free chlorine is present, it reacts with the combined chlorine compounds to further break them down into basic elements, such as H_2O (water), CO^2 (carbon dioxide gas), N_2 (nitrogen gas) and various salts. When this breakdown process occurs, the pool is deemed to be safe for swimmers.

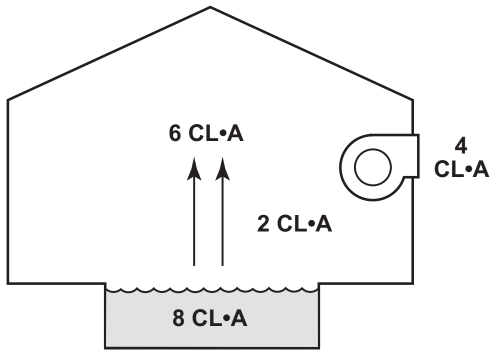

Figure 2 - Outdoor air changes equilibrium point. (lower CL•A concentration yields higher ratio)

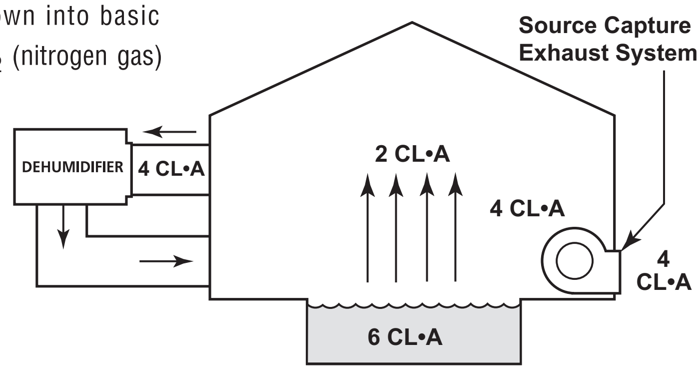

Figure 3 - Outdoor air and Source Capture Exhaust significantly change equilibrium point for highest ratio.

Whether or not the complete breakdown can occur, however, is a function of the amount of free chlorine available as compared to the amount of ammonia-containing wastes present. Table 1 summarizes the pool conditions resulting from various ratios of free chlorine to chlorine compounds.

Table 1

Ratio	Compound Present	Comments
<5:1	Mono-chloramines	Quick reaction; very poor disinfecting capacity (100x less)
5:1 to 10:1	Di-chloramines	"Chlorine" odor; poor disinfecting capacity
>10:1	Basic elements	Properly treated pool

As Table 1 shows, a constant source of free chlorine is needed to ensure the complete reaction. This is known as breakpoint chlorination. If the combined chlorine compounds are not eliminated, pool "shocking" is required: a larger dose of chlorine is added to the water to complete the reaction and balance the pool.

AIR CHEMISTRY

The pool room odor commonly described as "chlorine" (which, in fact, is the odor produced by chloramine compounds, a disinfectant by-product) occurs when the pool water chemistry is improperly balanced. The chloramines readily release into the air and reach a balance based on a chemical law known as the partial pressure law. In laymen's terms, this law states how much chloramine remains in the water and how much is released to the air under various conditions.

The ASHRAE 62 ventilation standard recognizes this "chlorine" smell as a potential indoor air quality problem and offers specific recommendations for the introduction of outdoor air based on the size of the pool and deck. (Refer to Desert Aire's *Technical Bulletin 5 – Ventilation Air for Indoor Pools,* for details on these recommendations.) The standard attempts to replace the indoor air once per hour to eliminate the odor.

Since nature requires a balance, removing some of the chloramines from the air will cause more chloramines to be released from the water. Table 1 shows that the release of more chloramines to the air will improve the free chlorine ratio, bringing the pool chemistry a step closer to proper balance.

MORE OUTDOOR AIR

The response of some pool designers is to go beyond ASHRAE 62 outdoor air ventilation recommendations. That scenario, however, can introduce other problems.

First, in cold climates, wintertime outdoor air must be heated. For even the smallest pools, this adds up to thousands of dollars per month in increased utility bills.

Second, the standard requires that relative indoor humidity remain below 60 percent. Summer conditions in most locales add humidity to the space, so when an increased outdoor air volume is introduced, larger equipment may be required to meet the increased latent loads.

SOURCE CAPTURE EXHAUST

Source Capture Exhaust will assist with removing the airborne chloramines if designed properly. The airborne chloramines are 4X heavier than air and will accumulate above the pool water surface. Incorporating a source capture exhaust at the deck level has shown to dramatically improve the air quality. See *Desert Aire's 21st Century Natatorium Design Guide* for more details.

CONCLUSION

While this technical bulletin does not attempt to cover all chemistry issues (for example, the influence of pH on free chlorine), it does demonstrate the basic chemical interaction occurring in an indoor pool facility.

The following design specifications are recommended:

1. **Automatic chlorate control system.** The chemical feed pump must be sized to match worst case pool loading.
2. **High water turnover** to better mix the pool, to avoid dead spots, and to provide better chlorine concentration measurement and control.
3. **Ensure ASHRAE 62 outdoor air compliance** to aid in breakpoint chlorination.
4. **Incorporate Source Capture Exhaust** systems to improve air quality in high activity pool rooms.

N120 W18485 Friestadt Road, Germantown, WI 53022 sales@desert-aire.com

Ph: (262) 946-7400 - www.desert-aire.com

Refrigerant Condenser vs. Fluid Cooler

INTRODUCTION

For most D/X refrigeration-based dehumidification systems the traditional method to provide air conditioning to the space was to add an outdoor air-cooled condenser and reject the absorbed heat to the outdoors via the refrigerant.

When the application installation requires a very large distance between the unit and the condenser, it becomes challenging to design and execute a proper refrigeration line set for proper pressure drop and oil return. When this is the case, a fluid cooler would be considered as an alternative method of rejecting the heat. Lately a design fad has been to use a fluid cooler even for short line set designs. The main reason provided is to reduce the refrigerant charge.

This technical bulletin will summarize the design differences between the condenser and the fluid cooler and compare their design and energy efficiency.

REFRIGERANT CONDENSER SYSTEM COMPONENTS

A dehumidifier will have the means to reheat the air when there is a call for dehumidification but not a call for cooling. The typical system uses a hot gas reheat coil that captures all of the energy (sensible, latent and heat of compression) and returns it to the space. The example below is of such a system that also has a three-way diverting valve to send the hot gas to the remote condenser.

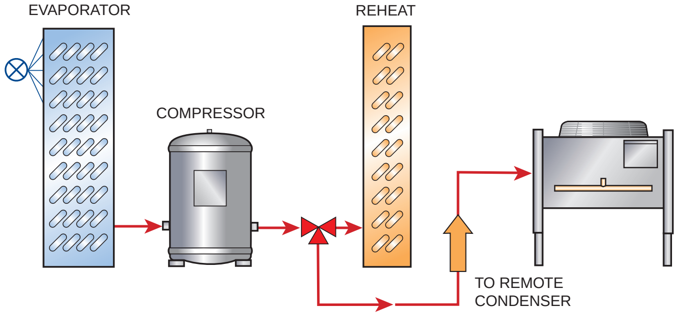

Figure 1 - D/X Dehumidifier with Hot Gas Reheat and Remote Condenser

This system uses a single heat exchange method to transfer the refrigerant's energy to the air (via the hot gas reheat or remote condenser coil). With the large temperature differential, these two coils can be easily sized to maintain the system's condensing temperature constant in all modes. The lift (difference between condensing and suction temperatures) is a key element in determining the power consumption of the compressor.

The heat exchangers that utilize refrigerant directly are very effective at keeping condensing temperature low as possible since the temperature of the refrigerant throughout the coil is substantially the same. This is because the majority of the coil is used for two-phase heat exchange. This means that the refrigerant inside of the coil is releasing its energy by condensing rather than strictly dropping temperature. Keeping all the surfaces at a higher temperature means that the full surface of the coil is effectively used and even a small exchanger can cool effectively. The heat exchanger can easily be designed for a close approach temperature (the difference between the leaving air temperature and the refrigerant condensing temperature). This minimizes the condensing temperature and reduces the lift. The system moves the refrigerant directly through the compressor. A minimum number of moving parts are needed since the compressor creates the pressure differences required for the heat transfer and also the flow of the refrigerant to move the energy from one place to another.

FLUID COOLER SYSTEM COMPONENTS

A dehumidifier that utilizes a water loop for the heat rejection must first reject the total heat of rejection to a water condenser. A fluid pump circulates the water through the condenser and transfers the heat to the air via a hot water coil (for reheating the air) or a fluid cooler for rejection to the outdoors. This process requires two heat transfer processes versus the outdoor air cooled condenser method described above.

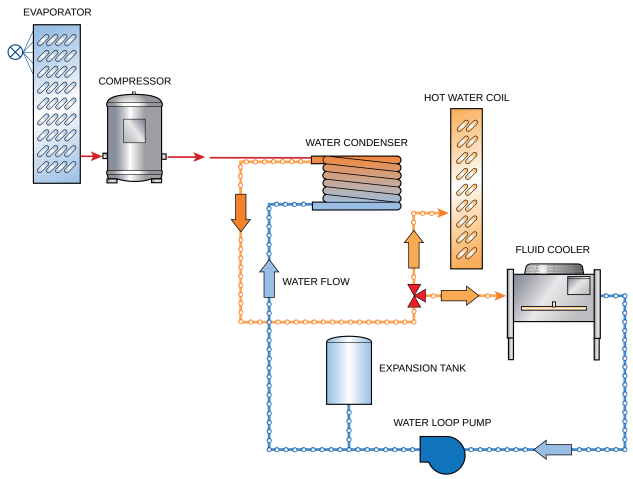

Figure 2 - D/X Dehumidifier with Water Loop Heat Rejection

Relative to the direct exchange of the air-side refrigerant condenser coils, a system with a fluid-cooler glycol loop has the following disadvantages:

- More components may increase initial costs.
- The pump is an additional moving part in the system that requires more energy and may require additional maintenance and service.
- Glycol must be added to the system and additive packages must be maintained to avoid corrosion.
- The additional heat exchanger in the chain requires another approach (refrigerant-to-water then water-to-air). This increases condensing pressure and lift.
- The single-phase heat exchange in the fluid cooler and hot water coil is less effective than more direct methods. As soon as the fluid starts to exchange energy with the air, the fluid starts to cool. This makes the subsequent portions of the heat exchanger less effective than with two-phase heat exchange where the temperature does not change. Either the heat exchanger must be designed to be larger or the lift will increase even further.

MOISTURE REMOVAL EFFICIENCY

AHRI Standard 910 defines Moisture Removal Efficiency (MRE) as the pounds per hour of condensate removed by the dehumidifier divided by the total kilowatts of energy needed to run the system. The power to run the system includes the compressor, blower/motor, transformers and pumps.

When comparing a basic refrigerant based system to one utilizing a fluid condenser, there are several additional power consuming elements to be considered:

- Water pump electrical power to move the fluid around the water loop.
- A hot water coil with low temperature water is significantly larger than a D/X hot gas reheat coil. This increases the system static pressure and the dehumidifier blower must work harder.
- An outdoor fluid cooler's air volume across the coil is higher than a refrigerant condenser's air volume, thus larger size fan motors are required.
- An outdoor fluid cooler's approach temperature is higher, increasing compressor energy consumption.
- Glycol in the water loop must be maintained and decreases the energy transfer efficiency of the fluid. This adds to the approach temperature.

CONCLUSIONS

Although a fluid cooler loop can help to address issues with difficult installations where refrigeration line length or large liquid line risers are unavoidable, extreme care must be exercised in selecting this configuration. A reduction in refrigerant charge may be possible, but this could come at the expense of increased energy consumption and/or reduced system capacity.

A fluid cooler system's additional approach temperature of 6°F to 10°F generally increases lift by the same amount and this roughly translates to 12% to 20% efficiency decrease when compared to the conventional refrigeration condenser systems. Additional components such as higher horsepower blowers and fans plus a recirculating pump will increase the efficiency losses even more.

Such a fluid cooler system would significantly increase the operational costs of an indoor pool dehumidification system which runs 24 hours per day, 365 days per year.

Using a refrigerant to air exchanger provides the most effective method for optimizing the compressor power consumption and thus the unit's efficiency and should be considered first.

A Guide to an Integrated HVAC System Design for the 21st Century Natatorium

Foreword

Desert Aire has written this document to provide owners, mechanical contractors and engineers with a helpful guide to designing or retrofitting an indoor pool facility.

Just in the past few years there has been a major breakthrough in understanding the complexity of maintaining the indoor air quality of a pool facility. This guide tries to tie together the many independent design elements of a very complex system, including HVAC, building structure, water loop, facility programming and energy consumption. For too long these elements were designed independently and rarely was an effort made to integrate them to create the best indoor pool for all stakeholders.

It is our expectation that this guide will assist in developing the dialog to solve problems in existing designs as well as serve as the benchmark for new construction. The guide will also refer to other documents or industry knowledge to support creation of final design specifications and the construction document.

This guide will be a living document so we welcome the opportunity to receive your feedback on innovations and innovative thinking that can help produce the highest quality indoor pool facility. Feel free to reach out to any Desert Aire sales representative or staff member with your feedback.

Keith Coursin
President
Desert Aire Corp.
Keith@desert-aire.com

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A Guide to an Integrated HVAC System Design for the 21st Century Natatorium

Overview

The Purpose of the Natatorium

The natatorium is a building that contains one or more aquatic venues and structures where the general public is exposed to water intended for recreational or therapeutic use.

Although we most often think of aquatic venues as indoor pool facilities for swimming and diving, they may not only contain standing water. The term can be used to describe indoor water parks where the public is exposed to water by contact or spraying, such as with waterslide landing pools and spray pads.

A natatorium can be housed in a dedicated building or non-dedicated building such as a school building or fitness club. The natatorium may also house locker rooms, lavatories and offices. Locker rooms, staff offices and storage rooms should not be part of the pool room mechanical HVAC system.

This design guide focuses on larger natatoriums and aquatic centers but many of the concepts would apply to smaller commercial and residential indoor pool facilities.

The Goals of HVAC Design

The many ways people use buildings with enclosed pools for recreational, competitive and health purposes continue to evolve. These uses place demands on HVAC systems and on the buildings themselves that weren't present even a generation ago. Fortunately, there are advances in knowledge, understanding, strategies and technology that meet the challenges of today's natatorium.

Reflecting the depth and breadth of demands, the scope of HVAC design considerations for large natatoriums and aquatic centers has expanded in the 21st Century.

Objectives now include protecting the health of swimmers, divers, coaches and spectators; promoting the long-term structural integrity of the building and supporting systems; and conserving energy, water and water treatment resources.

But there is a guiding principle that applies to HVAC system design no matter the purpose, size and location of the natatorium: the HVAC system must work in harmony with systems that control water temperature and water quality.

For engineers who must translate these objectives into design goals an integrated, sustainable approach is required. These design goals must reconcile the intensive tasks of dehumidifying the space, heating and cooling the interior, heating pool water, and meeting outdoor air requirements.

Fortunately, today's design engineers have access to a range of problem-solving equipment technologies and strategies. These technologies and strategies complement resources made available by professional associations and engineering societies; and the goals manifest in building codes and standards. For example, the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) provides guidance and resources for pool room design.

The Model Aquatic Health Code (MAHC), published by the Centers for Disease Control and Prevention (CDC), is a more recent addition to the resources available to mechanical engineers.

First published in late 2014, the MAHC is a set of guidelines for public aquatic facilities. According to the CDC, the MAHC "brings together the latest knowledge based on science and best practices to help state and local government officials develop pool codes. Pool codes are specific rules that designers, builders, and managers of spas, pools, water parks, and interactive fountains must follow to keep the fun going and reduce injuries and illnesses."

The MAHC encompasses traditional aquatic venues such as those enclosing swimming pools and spas. The MAHC also covers contemporary water-containing structures including wave pools, surf pools, therapy pools and spray pads.

As part of bringing together the best knowledge and practices, the MAHC states the design, construction and installation of indoor aquatic facility air handling systems shall comply with local codes as well as the proven ANSI/ASHRAE standard 62.1- 2019, Ventilation for Acceptable Indoor Air Quality.

Together, this matrix of technologies and strategies provides mechanical engineers with essential tools for balancing diverse operating conditions, seasonal variations and special event needs with building codes and standards for the ongoing, critical concerns of indoor air quality and relative humidity.

Heating, Cooling and Moisture Load Determination

The heating, cooling and moisture loads of a natatorium are a product of seasonal variations in outdoor air temperature and humidity, solar gains and losses as well as the presence of spectators and bleacher areas.

- The heating load is the amount of heat energy that must be added to the natatorium to achieve or maintain a target temperature level. This is often considered the heat loss calculation and is a dominant factor due to the high internal design temperature of an indoor pool area.

- The cooling load is the amount of heat energy that needs to be removed to attain the target temperature. This is the heat gain calculation with solar gain and lighting heat being the most significant portions of this load.

- The moisture load is the amount of moisture that needs to be removed to attain a target relative humidity level. The moisture load has three components: evaporation from the water surface; moisture content from the ventilation air; and evaporation from spectators.

To calculate heating, cooling and moisture loads to specify and size HVAC equipment, these loads are expressed as sensible and latent. Sensible heat and loads are the heat swimmers and building users feel on their bodies and are temperatures that can be measured by a thermometer. Latent heat and loads are the energy and heat stored in humidity, a product of its change in state from liquid to gaseous. These two components when combined provide the total system rating that the HVAC equipment must be designed to remove.

The overarching goal in managing heating, cooling and moisture loads is sustainability: ensuring the natatorium can continue to fulfill the purposes for which it was built in a safe and cost-effective manner. Related HVAC design considerations, as stated earlier, are protecting the health of swimmers, divers, coaches and spectators; promoting the long-term structural integrity of the building and supporting systems; and conserving energy, water and water treatment resources.

The ASHRAE Applications Handbook provides formulas for calculating the natatorium moisture load. The factors that are used in those formulas include the air and water temperatures, relative humidity, airflow rate across the water, activity factor, spectator load, and the ventilation load. Each of those will be discussed below.

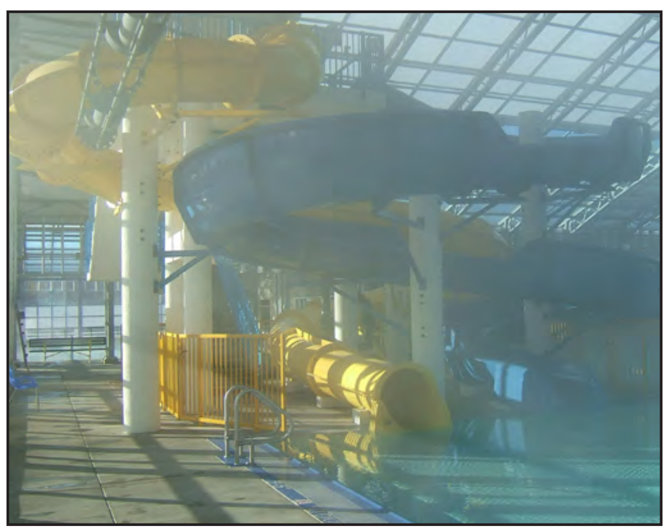

Figure 1. A pool room with an overwhelmed HVAC system

A pool room that does not maintain the proper temperature of its air and pool water along with setting the correct relative humidity range can quickly overwhelm even the best HVAC equipment.

Air and Water Temperatures

There are many combinations of air and water temperatures being utilized in pool facilities and no one condition is more correct than the other. Therefore the owner must make a decision on what air and water set points they will use in their facility as this will be a key factor in dehumidifier selection. Changing design conditions after the HVAC systems are installed may not be possible.

ASHRAE recommends maintaining the natatorium air temperature at two to four degrees above the pool water temperature but not above the comfort threshold of 86°F. There are several reasons for this recommendation. This is an effort to create a design condition that seeks a balance in the overall dehumidifier sizing and the energy costs associated with maintaining the conditions in the space and pool water. In addition, the warmer air temperature will help make the swimmers not feel as cold when leaving a pool.

However, recent changes in the average water temperature of an indoor pool can make it difficult to maintain the air temperature higher than the pool water temperature. An analysis of commercial pools found that the average pool water temperature had increased from 82°F to 86°F between 2003 and 2013 due to the prevalence of swim lessons serving those 10-years-old and younger and vertical swim classes for senior citizens; both of these swimmer groups desire warmer water temperatures than recreational or competitive swimmers.

It is very important when designing a dehumidification system for a new or remodeled facility that the pool owner communicates to the engineer the desired operating set points. Similarly, it is important the engineer communicate to the pool operator the importance of maintaining conditions in the natatorium and adhering to design set points.

A 3,500 square foot natatorium, designed for 82°F pool water temperature and 84°F air temperature will have an evaporation rate of approximately 159 lbs/hr at 55% relative humidity. Raising the water temperature to 86°F and keeping all other factors the same will increase the evaporation rate by 33% to 211 lbs/hr. The dehumidification system designed for the lower water temperature will now be significantly undersized to handle the larger load of the warmer pool water. As mentioned earlier, communication between the engineer and the pool operator is essential when designing for a specific evaporative load.

Relative Humidity

As the equipment centerpiece of natatorium HVAC systems, the dehumidifier controls humidity in pool enclosures to counter what is created by evaporation, regardless of outdoor conditions. This improves indoor air quality and the comfort of swimmers and occupants. Humidity control also protects building structural elements, furnishings, and support systems such as lighting.

ASHRAE recommends that the relative humidity in a natatorium be maintained between 50% to 60% relative humidity. Lower relative humidity increases operation costs due to increased evaporation and it can lead to swimmer discomfort due to evaporative cooling from their bodies when exiting the pool. Higher relative humidity increases the risk to the building structure.

Airflow Across Water

One of the recent changes in natatorium design is moving away from designing ductwork to have grilles aimed at the pool water surface. It is now recommended that air be pulled across the pool water surface at less than 30 feet per minute. All of the air supply should be aimed at exterior walls and windows and not at the pool. The reasons for this are discussed in the Source Capture Solution section of this guide.

The ASHRAE formula for the evaporation load of a pool assumes that the air will not exceed 30 fpm. Using the same pool as mentioned above (3,500 sq. ft. at 82°F water and 84°F air) and increasing the airflow across the pool water from 30 fpm to 125 fpm will increase the evaporative load by 40%. If the design engineer for that pool uses the standard ASHRAE formula for computing the evaporative load but has air supplied directly across the pool surface, then the dehumidification equipment selected will most likely be substantially under designed.

Activity Factor

Another factor in the formula for finding the natatorium evaporative load that an engineer needs to consider is the pool usage. The ASHRAE formula gives an activity factor based on the type of pool, ranging from an unoccupied baseline for any pool of 0.5 up to an activity factor of 2 or greater for a water park. Different activity factors are given for condominiums, therapy pools, hotels, public pools, spas, and water parks. Underestimating the activity factor can have substantial consequences. A public pool, school, or YMCA has an activity factor of 1. By adding water features such as a wavepool or waterslide the evaporative load for that pool can double. The activity factor is significantly higher with these added water features.

It is very important for the architect, engineer, and pool operator to discuss any water features that might be added to a public pool that is not considered to be a water park. Any remodeling of an existing pool must take into account the capacity of the present dehumidification equipment before adding water features.

Spectator Load

Spectators are not the swimmers using the pool or the pool deck, but rather the fully clothed observers in a separate area. For spectator areas an additional amount of airflow needs to be introduced, when spectators are present. This will enhance spectator comfort and the quality of air around them. ASHRAE recommends an airflow rate of between 6 to 8 air changes per hour over the spectator area. The evaporative load of the spectators must also be taken into consideration when calculating the total load. Swimmers are not considered as part of the spectator load.

Ventilation Load

The local building ventilation code protects public health and safety by providing minimum safeguards and standards for ventilation. Most codes have a set amount of outdoor air that must be brought into the pool area with factors based on the pool surface area, the swimmer drip area, and spectator areas.

Most local codes are based on ASHRAE Standard 62.1, the industry accepted ventilation code for indoor air quality, which defines the minimum volume of outdoor air to be introduced into the indoor pool enclosure. The standard exists to protect the health of natatorium users.

This volume is generally only a small percentage of the total air volume required by a dehumidification system to maintain the space humidity. Proper interpretation can also enhance energy conservation by reducing the volume of outdoor air required to the minimum required by code.

ASHRAE 62.1, table 6.1 provides the following levels of outdoor air to the breathing zones listed below.

- Pool and wet deck outdoor airflow
  Pool and wet deck area (ft^2) x 0.48 (cfm)/(ft^2)

- Remaining floor area outdoor airflow
  Room (ft^2) – Pool and wet deck (ft^2)
  – Bleacher (ft^2) x 0.06 (cfm)/(ft^2)

- Spectator/Bleacher outdoor airflow
  Spectator area (ft^2) x 0.06 (cfm)/(ft^2)
  + (# of spectators) x 7.5 (cfm)

The interpretation of “wet deck” is sometimes difficult. ASHRAE defines the wet deck as the deck area that becomes wetted during a normal occupied condition. The accepted practice is to define the wet deck for a pool as a defined perimeter around the body of water. The width of this “wet deck” can vary from 2 to 5 feet.

Ventilation may be regulated based upon occupancy to establish an expanded range and sequence of operation that maintains acceptable indoor air quality. When the facility is unoccupied, outdoor airflow may be closed. During normal operation, outdoor airflow can be set to a minimum code-approved level. When a swim meet creates higher-than-normal occupancy an increased outdoor airflow may be engaged.

As a means of ensuring indoor air quality and providing for system accuracy and flexibility, a Volatile Organic Compound (VOC) sensor should be installed as part of the ventilation control system. In a short amount of time VOCs can build up in a pool room that has become busy for an extended period. The VOC sensor can override programmed set points that don’t reflect current conditions and call for the ventilation system to increase outdoor and exhaust airflow.

Condensation and Building Integrity

While the design of the building does not fall under the responsibility of the mechanical engineer, it is a key HVAC system component. The engineer and the architect must be in communication on construction materials that will influence the size and capacity of the HVAC system through the heat gain and heat loss of the structure; the location of the vapor barriers; the quality and quantity of the doors and windows in the natatorium; and, controlling humidity within the entire structure with proper vapor barriers. Nowhere is this communication more important than the area of condensation and building integrity.

We will be discussing in the duct design section the proper amount of airflow that is necessary to prevent condensation but it is important that all external areas be completely washed with airflow. In the photo on the following page (Figure 3) you can see that the lower areas of the windows did not receive adequate airflow and are fogged; while the upper areas did receive the proper airflow and they are clear. This was solely an issue of air distribution and not dehumidifier operation. This is an area where the engineer must communicate with the architect. Whenever there are large glass areas there must be adequate air distribution to keep these surfaces above dew point to prevent condensation in winter months.

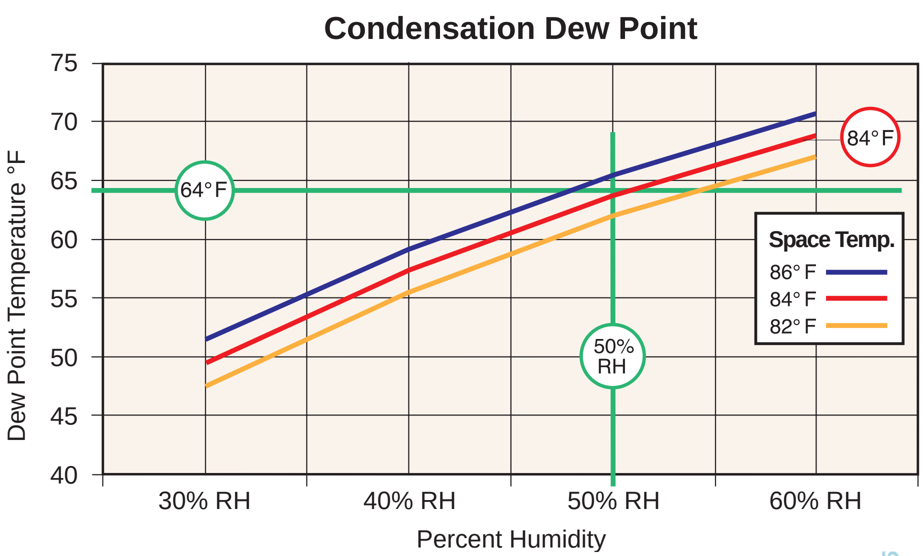

Figure 2. Condensation dew point for a natatorium

Dew Point Control

All external walls, windows, and doors must be kept above the dew point in order to prevent condensation. Condensation control is essential to maintaining building integrity. As can be seen in the graph above (Figure 2), the dew point for a natatorium is fairly high. That means any surface that has a temperature below the natatorium dew point will see condensation form.

Over time, if condensation is allowed to form, the acidic content of the condensation can destroy key building features such as doors, windows, fixtures and, in the worst-case scenario, can destroy a building.

Figure 3. Examples of condensation and poor air distribution

Figure 4. Example of natatorium without vapor barrier showing white chalking on building exterior

Vapor Barrier

A vapor barrier is a material or film that prevents moisture migration or penetration. Moisture will travel from high moisture content air to low moisture content air. In non-pool room building designs, the vapor barrier is located on the outside of the building's insulation. Location is dependent upon your geographical location but in general the vapor barrier should be placed on the side where the highest moisture is present. Because of the high moisture load inside a pool room, the vapor barrier is required to be on the inside of the structure in all North American locations.

Figure 4 shows white chalking on the outside of the brick building. The white chalking is caused by moisture from the pool room penetrating the brick, a result of having no vapor barrier installed on the inside of the wall structure.

If the facility is in a cold climate and the temperature outside is below freezing and a proper vapor barrier is not installed, moisture will condense inside the wall cavity. Once condensation occurs inside the wall cavity the remaining insulation value is lost and the problem will get worse. Condensation inside a wall cavity may also prompt decay or mold to the building structure.

Similarly, all windows and doors need to have a very tight seal to prevent moisture migration. The photo below (Figure 5) shows a facility that did not seal the wall to roof interface. Higher moisture content pool room air migrated to the roof and wall joint, condensed into water and then froze, forming icicles.

Moisture does not have to travel only to the outside of the building to cause damage. Adjacent interior rooms, such as offices, are typically maintained at 75°F and approximately 40% RH. Because this air has a lower moisture content, the moist air in the pool room will travel to these interior rooms. All pool room partitions need an appropriate vapor barrier or moisture damage will happen between the walls.

Negative Pressure

According to ASHRAE, natatoriums should be maintained at a negative air pressure (0.05 to 0.15 in. of water) relative to the outdoors and adjacent areas of the building to prevent the forming of condensation in the wall and ceiling interstitial spaces; and to prevent the dispersal of chloramines, other noxious fumes and moisture to other occupied spaces in the building. The space pressurization scheme must be maintained during every hour of the year and for all possible operating conditions.

Figure 5. Example of natatorium with improper seals showing moisture migration and icicle formation

To maintain the favorable negative air pressure, HVAC systems use static and active methods of pressure control to provide the correct proportions of return air and outdoor air.

Static methods employ pressure sensors to measure airflows (differential pressure) across HVAC system components. For example, a dehumidifier's evaporator coil, exhaust blower and reheat coil. Dampers respond to the measurements through an automated control system, opening or closing to deliver the correct amount of air to the equipment or space.

One active method of pressure control that meshes well with automatic control systems, as well as energy efficiency objectives, is using either a Variable Frequency Drive (VFD) or an Electronically Commutated Motor (ECM) for the exhaust air stream.

This may be installed in new or retrofit installations. VFDs and ECMs reduce or increase the speed of the fan to match the load and real-time needs of the natatorium's negative pressure requirements. They will speed up or slow down the exhaust air to maintain the desired negative pressure.

VFDs and ECMs also deliver pressure control benefits if installed as part of chloramine low exhaust systems. Because mechanical engineers must specify HVAC equipment and systems for worst-case scenarios, low exhaust systems may be oversized or running constantly if not modulated.

On the other hand, if sensors measure an air pressure or air contaminant level that is not within the tolerances for proper indoor air quality, the VFDs can increase the exhaust volume in concert with dampers.

To promote the negative pressurization function of the HVAC system, the natatorium must be separated from adjacent spaces by effective partitions and air barriers. These include tightly gasketed doors and sealed cracks in the frames of doors and windows.

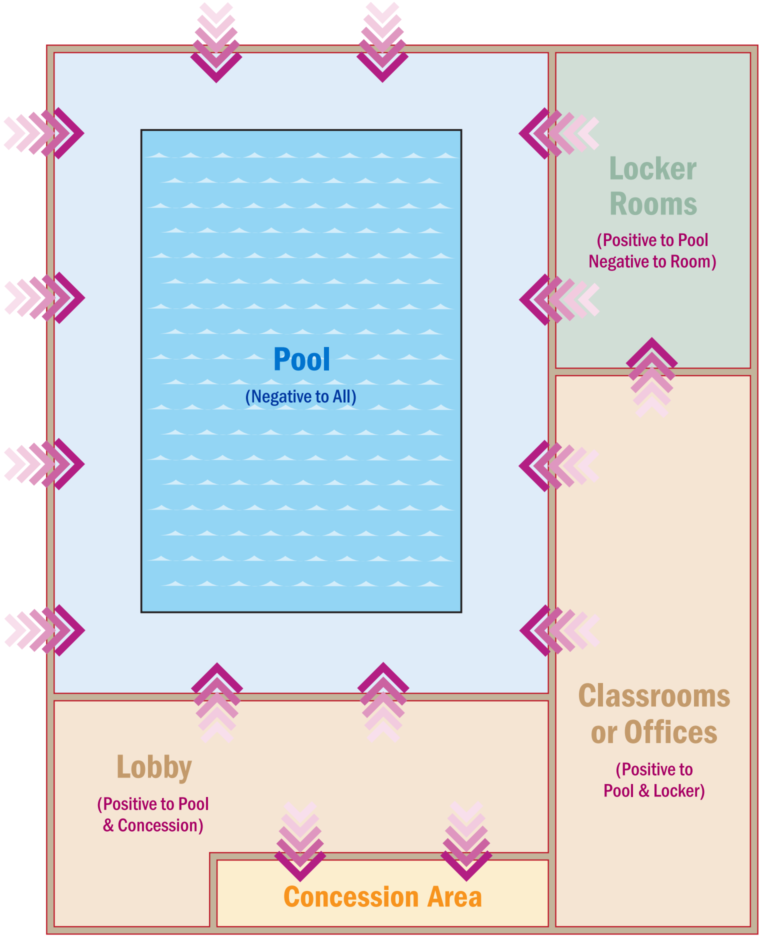

Figure 6. Building pressurization

The ASHRAE 62.1 ventilation standard also requires that HVAC systems introduce additional outdoor air into the space during spectator events. As noted earlier, the standard requires a ventilation air volume of 0.06 cfm/ft^2 for the dedicated spectator area plus 7.5 cfm per spectator during times when spectators are present. This is in addition to the ventilation rate for the pool and wet deck.

In event modes, HVAC systems and equipment increase outdoor air volumes as a percentage of air supplied to the space. The dehumidifier's ventilation damper will open to a greater position to introduce the required amount of event air. The exhaust system will then respond to maintain the proper negative pressure set point. This is a higher rate than the occupied mode setting, providing the required volume for pool plus spectators. HVAC equipment such as dehumidifiers can increase the amount of fresh and exhaust air by re-balancing dampers and exhaust fans.

Because spectator occupancy is not constant in most facilities, the scheduling programs of building management systems can reduce the energy costs related to conditioning spectator areas.

Locker rooms, dressing rooms and food preparation spaces also need to be maintained at negative pressures with respect to their adjacent spaces, but they must be positive relative to the pool space. Chemical storage areas however, need to have negative pressures with respect to the pool space and all other spaces. Chemical storage areas must also have their own exhaust systems to prevent moisture and airborne chemicals from coming into contact with each other.

Spectator Areas

Natatoriums and aquatic centers with spectator areas require multi-level strategies from mechanical engineers and their HVAC systems. Spectators may not be present at all times when the building is being used by swimmers. If a swim meet brings in spectators, loads increase. Spectators can impact the temperature of the space and create additional internal moisture through breathing and perspiration.

To increase the comfort of fully clothed spectators many building owners and HVAC engineers choose to separate the spectator load by using dedicated outdoor air systems (DOAS) that flush spectators with clean, fresh air. These can be designed to supply an air temperature that is approximately two degrees less than air supplied to the pool space.

A DOAS allows for independent control of the temperature and a separate duct system for air delivery. This independence can reduce energy costs compared to HVAC systems that would serve combined pool and spectator areas. When spectators are not present, the DOAS recirculates air to provide dehumidification of air within spectator areas.

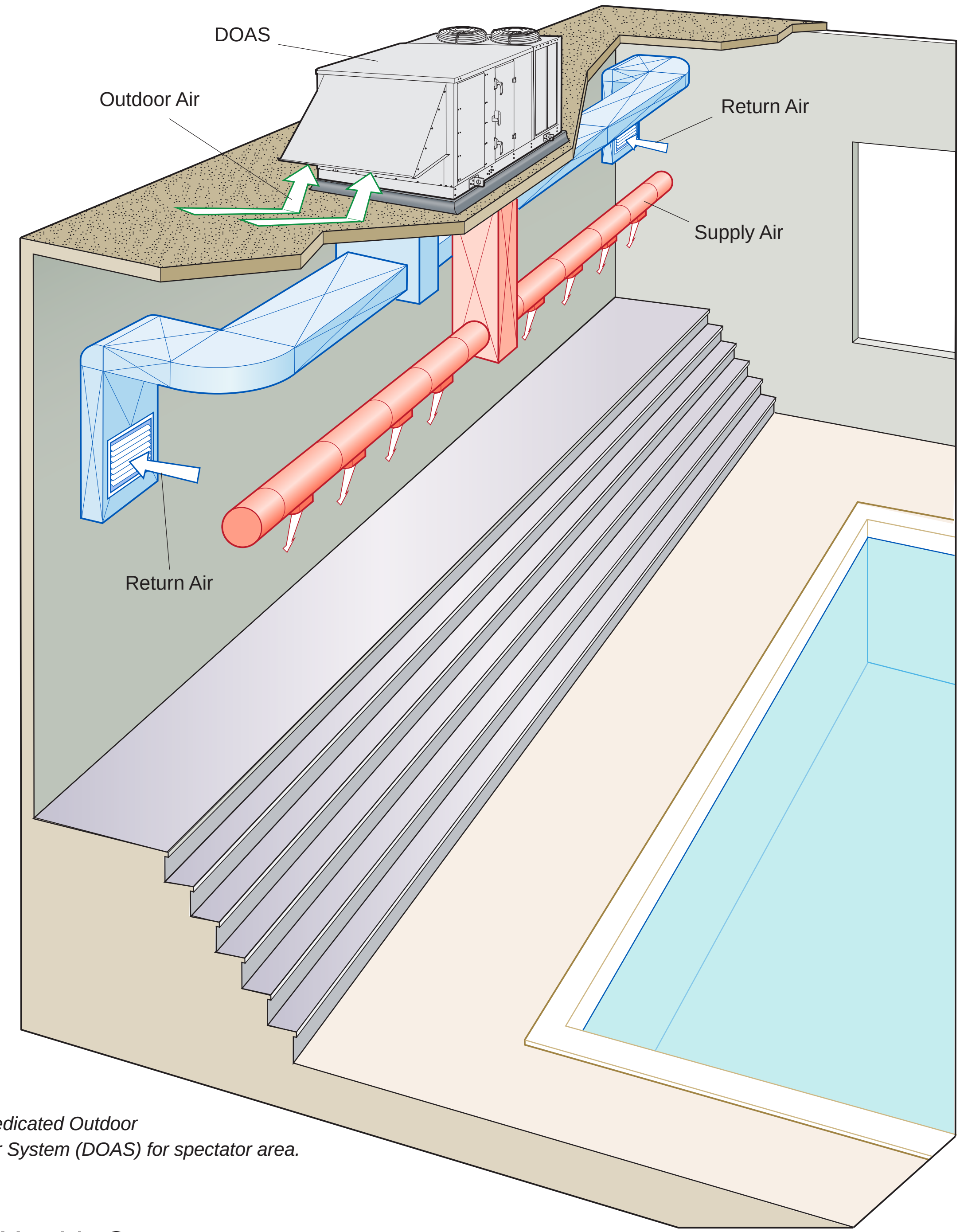

Figure 7. Dedicated Outdoor Air System (DOAS) for spectator area.

Swimmer Health Concerns

Toxic Air

In natatoriums, the presence of "pool smell" or chlorine odors is often confused with the use of chlorine disinfectants added to pool water to destroy germs that can give swimmers diarrhea, earaches and athlete's foot. When the smell builds up and accumulates at the pool or deck level, it can irritate the eyes, lungs and skin of swimmers and occupants. The chemicals that are associated with these smells have a toxicity factor and should be removed in a manner that does not cause more swimmer discomfort or a higher evaporative load.

In fact, the chemical smell results from the interaction of the chlorine disinfectants with perspiration, urine, oils and organic materials from swimmers. Chloramines are chemical compounds formed from the reaction of chlorine disinfectants with the ammonia in perspiration and urine. When there is a pool smell present or swimmers get reddened, bloodshot eyes, there is actually not enough chlorine present.

There are three chloramine by-products of the disinfection process. Monochloramines and dichloramines are predominately waterborne and can be removed by ultraviolet (UV) and other sanitation systems. Trichloramine, which is also known as nitrogen trichloride, becomes almost instantaneously airborne and does not stay in the water long enough to reach the UV or surge tank protection systems. Since it is approximately four times heavier than air it stays at the pool surface and is then inhaled by swimmers moving through the water.

Most Common Airborne Contaminants

The top four airborne disinfection by-products are listed below.

- Nitrogen trichloride
- Cyanogen chloride
- Trihalomethane
- Hydrogen cyanide

The way these by-products move from the pool water to the air is through a process similar to evaporation. If the air has a lower concentration of the by-product than the water (lower partial pressure), then it migrates from the water to the air. As noted earlier, traditional chemical treatment systems do not remove these by-products from the water.

Source Capture Solution

Source capture strategies and technologies have evolved to where they can assist in removing the by-products from the facility, improving the quality of the air and water. They should be used in any natatorium designed to hold a large number of swimmers or swimmers who will be in the water for long periods of time.

These source capture strategies employ bench, drain or wall-mounted systems positioned along the sides and decks of pools. They work in concert with code-mandated duct designs and ventilation standards that deliver supply air. The supply air is pulled over the water surface at a rate not to exceed 30 fpm so that contaminated air is moved toward a low exhaust point, in this case the source capture systems. The contaminated air is exhausted directly outdoors.

These low exhaust source capture strategies minimize and prevent the recirculation of chloramines and other airborne pollutants, helping maintain the quality of supply air to the breathing zone in the pool and deck area. The absence of chloramines and corrosive pollutants also helps protect natatorium equipment and other HVAC system components.

Pool Chemical Usage

A. Chlorine

The question is often asked as to why chlorine is used if the off-gassing is so bad for humans. The answer is simple: the good far outweighs the bad. Chlorine is put in the water to kill microorganisms and bacteria. If done properly, it does an excellent job. The chlorine in the pool water breaks down into hypochlorous acid and hypochlorite ions. Both will instantaneously attack and kill any microorganism or bacteria they come in contact with by attacking the lipids in their cell walls. This is the positive outcome of putting chlorine in pool water.

However, chlorine also reacts with sweat, skin cells, urine, and other organic compounds found in water to create the disinfectant by-products such as trichloramine and cyanogen chloride. It is these airborne by-products that can be hazardous to one's health if not removed properly.

B. Chlorine Alternatives

There are alternatives to using chlorine as the primary sanitizer in a pool, if local codes allow. Bromine is the second most used disinfectant. Bromine can be as effective as chlorine in killing bacteria although the dosage has to be higher. In addition, bromine is a less powerful oxidizer than chlorine and thus is not as effective as chlorine in eliminating swimmer waste products. For this reason, oxidizers such as monopersulfate are often used in conjunction with bromine and can be more expensive in large pools.

C. Salt Water Pools

Salt water pools have become popular among swimmers because of the softer feel of the water. It can be popular with pool operators because salt is safer to store than chlorine.

However, a common misperception is that this is a chlorine-free environment. The reality is that a salt water pool is also a chlorine pool. The salt system works by sending pool water through a salt cell with metal plates. These plates receive an electrical charge and the electrolysis produces chlorine. As the water returns to the pool it will now have chlorine and hypochlorous acid in it, the same as in a regular chlorinated pool although the concentrations may be less.

The design engineer and pool operator must use caution with a salt water pool since the salt in the water can conduct low level electrical current that can cause a galvanic reaction if separate metal components are not on the same earth ground connection.

If a pool water condenser is being specified for a dehumidifier serving a salt water pool then it should also be specified that the water condenser's inlet and outlet connections are wired back to the electrical box to connect to the common earth ground.

Proper Airflow Design

The Overview section of this guide noted how natatoriums and aquatic centers create a challenging application environment for air handling systems. These systems must move significant volumes of air to control temperature, humidity and pressure. The speed of airflow created, location of ductwork that delivers the airflow, and nature of construction materials also play roles in providing acceptable indoor air quality for swimmers; and protecting the building and its equipment.

The designer can use either fabric duct or metal to meet the objectives of proper air distribution. Each has its own merits and comes down to personal preferences.

The American National Standards Institute (ANSI) has accredited the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) as the lead standards-setting organization for HVAC duct design and construction.

The SMACNA standards for duct systems address duct construction and installation, indoor air quality and energy recovery. HVAC Duct Construction Standards - Metal and Flexible is the fourth and current edition recommended for use by design professionals as well as the HVAC Systems Duct Design, 4th edition.

Duct Design

Supply air ductwork should form a "U" around three sides of the pool. This provides for airflow that travels across or "washes" windows and outside walls with dry supply air. The ductwork configuration also raises the temperature of the inside surface while flushing it with the lowest dew point air in the facility. The duct size and dimensions should follow the SMACNA design standards or the design guidelines provided by the fabric duct manufacturers.

As noted in the condensation section, proper airflow on exterior walls, windows, and doors eliminates or minimizes condensation that can be caused by the high humidity and high temperature levels of an indoor pool facility coming in contact with a cold surface. Depending on the window and wall surface area, the flow of dry supply air is set at 3 to 5 cfm per sq. ft.

HVAC engineers locate return air and exhaust air grilles on the fourth side or wall of natatoriums. High and medium height grill locations work best for the return air. The higher locations optimize the recovery of the higher temperature and humidity containing air since hot, humid air rises. This also keeps the air returns from being blocked by pool furniture and spectator stands. High returns should be as close to the ceiling as possible; medium returns 6 to 8 feet above the pool deck and spectator levels.

This combination of the "U" shaped supply air and fourth wall return air provides the best solution to utilize a source capture exhaust air technique (see Figures 8 and 9).

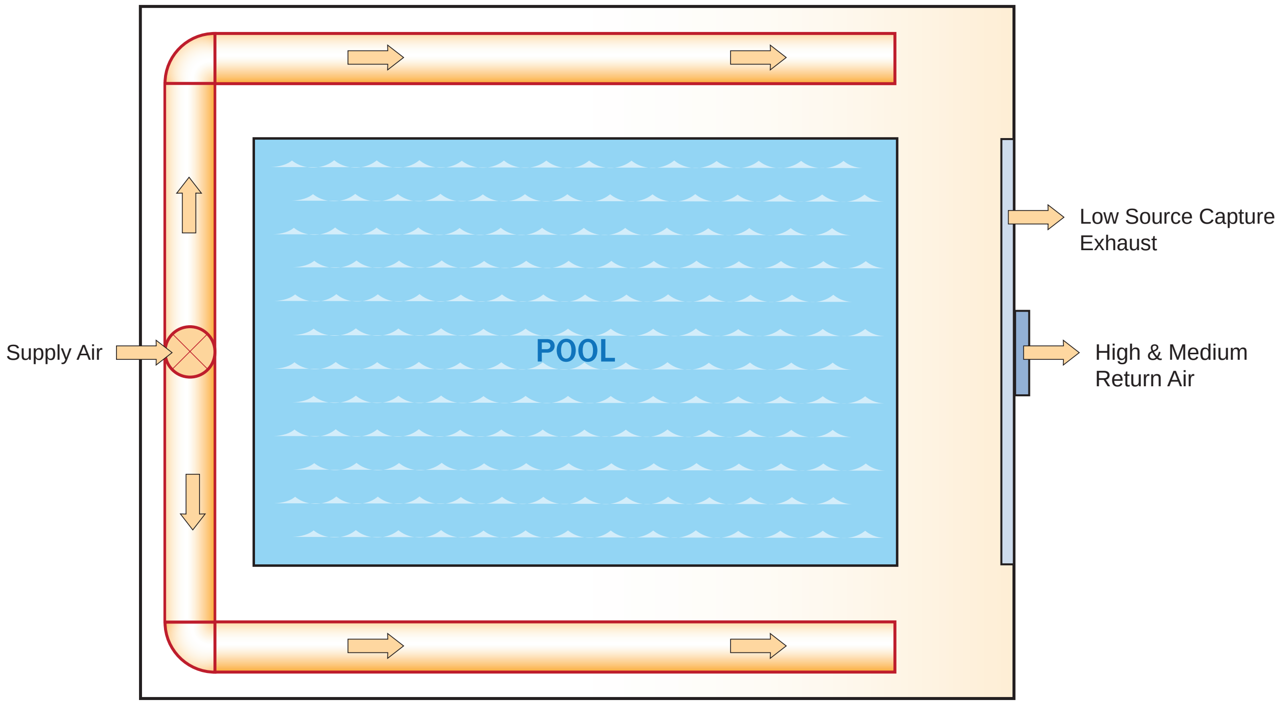

Figure 8. Top view of duct design

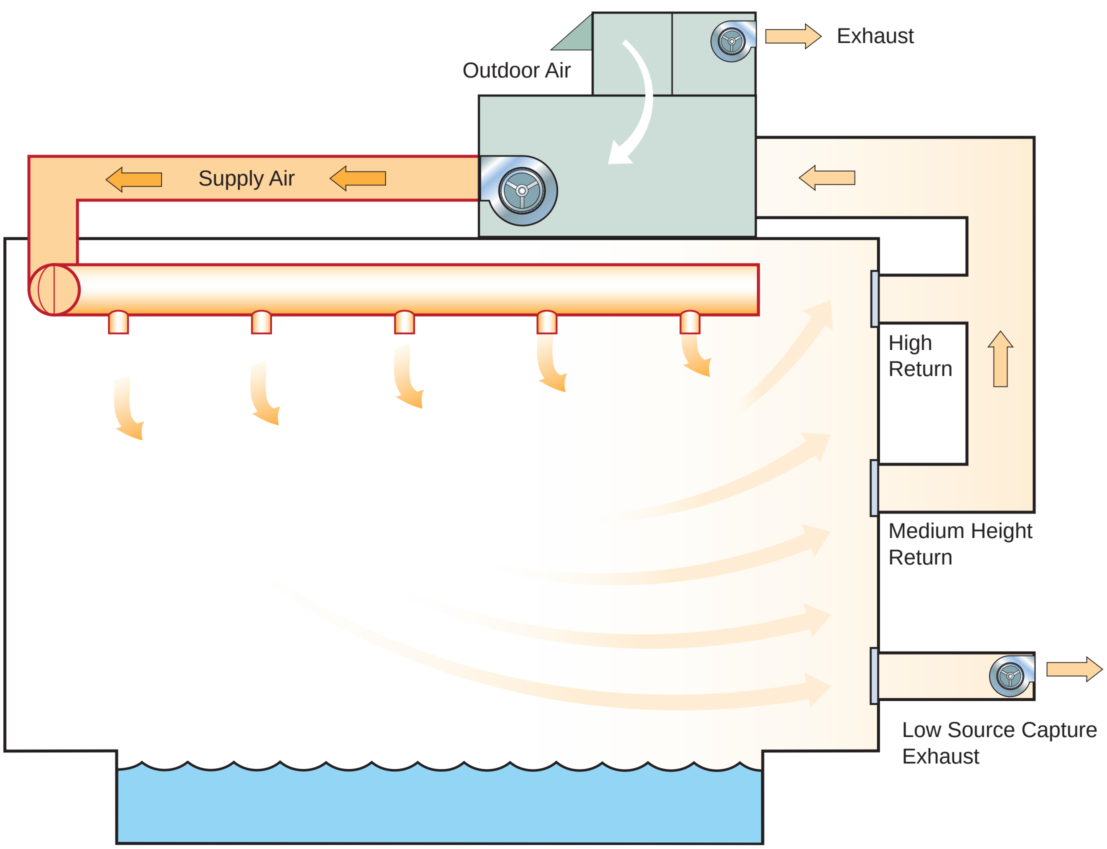

Figure 9. Plan view of duct design

Engineers and architects should choose duct materials and construction methods that are suitable for environments that are humid, wet and where airborne chemicals are present. Moisture and chemicals attack ducts, grilles, registers, diffusers and equipment enclosures. Fabric duct, galvanized steel or aluminum is used for above grade duct, PVC for below grade. Special epoxy paint is used to improve corrosion resistance on galvanized steel, aluminum ducts and 316 stainless steel. Aluminum or plastic is the material of choice for grilles, registers and diffusers.

Supply Air Rate

Supply air should be delivered at a constant rate in order to continuously wash the walls, windows, and doors. The rate of supply air should not be lowered during unoccupied hours.

To provide sufficient air to flush the walls and windows, prevent stratification and deliver air down to the breathing zone, ASHRAE Applications Handbook 2019 recommends the air change rates listed below.

- 4 to 6 air changes per hour for pools with no spectator areas
- 6 to 8 air changes per hour for pools with spectator areas
- 4 to 6 air changes per hour for therapeutic pools

It should be noted that these are air changes within the room. The outdoor air ventilation rate is considered under a different formula as noted earlier in this guide.

Another strategy to address indoor air quality concerns are low velocity/high volume fans. These can be included in natatorium HVAC system designs to provide airflow to ceiling areas that would be difficult for the supply ductwork to reach. They should not be used in the down flow configuration as this can impact airflow across the pool surface.

Dehumidification Equipment Design Considerations

Dehumidifier System Components

At a minimum, the natatorium dehumidifier is an air handler sized to remove the moisture at a rate equal to the evaporation rate of the pool water plus (or minus) the summer ventilation air load.

Desert Aire SelectAire™ and SelectAire Plus™ dehumidifiers for natatoriums and aquatic centers go above and beyond the standard air handler definition. Desert Aire SelectAire™ and SelectAire Plus™ dehumidifiers meet the integrated requirements of natatoriums and their owners to protect the health of building users, maintain ideal temperature and humidity levels, promote the structural integrity of the building and its contents, and conserve energy.

Desert Aire SelectAire™ and SelectAire Plus™ dehumidifiers are refrigerant-type dehumidifiers providing closed loop systems that effectively transfer both latent and sensible heat from an indoor environment to a variety of alternate heat sinks.

Figure 10. SelectAire™ (top) and SelectAire Plus™ (bottom) dehumidifiers

An air reheat or condenser coil is present in all Desert Aire dehumidifiers and is the most common heat sink. The condenser or combination of condensers must be sized for the total heat of rejection (THR) of the system.

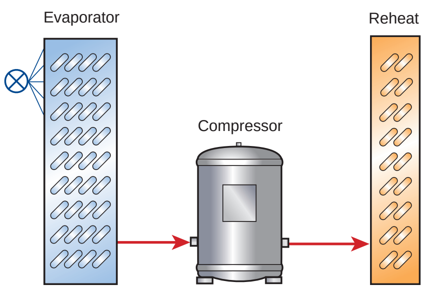

Figure 11. Refrigeration schematic without pool recovery

A water heater coil may be added as an additional heat sink. This component is generally a tube in tube heat exchanger that allows water to absorb the heat from the hot refrigerant. A diverting valve controls whether the refrigerant goes to the air reheat coil or the water heater coil. In most applications the air reheat coil has priority.

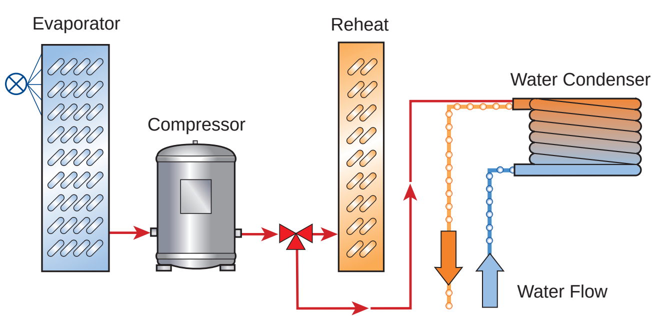

Figure 12. Refrigeration schematic with pool recovery

There are several potential water uses for this heat sink energy. Examples include pool water, spa water, potable water, and hydronic heat water. The actual water heater coil is selected to be compatible with the water source used. If the refrigerant to water heat exchanger is included it should not be replacing the primary pool water heating appliance. Desert Aire's pool water heating option will supplement the pool heating by using energy recovered energy, but it should not be used as the only pool heating method.

An air-cooled remote condenser may also be added to the dehumidifier. This would only be used when there are no other uses for this energy. This becomes similar to a standard air conditioner by adding a condenser outside the conditioned space.

When all other heat sinks have satisfied the respective set points, then a valve diverts the hot refrigerant outside where the remote condenser dissipates the heat to the surrounding environment. This condenser must be sized to the dehumidifier to ensure proper charging and operation.

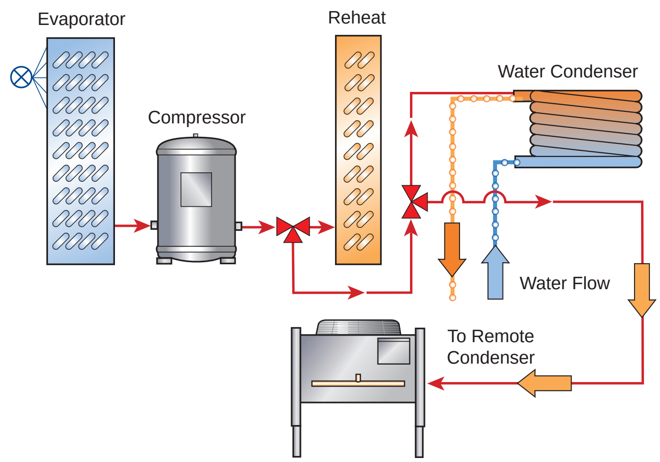

Figure 13. Refrigeration schematic with all modes

When the remote condenser is utilized, the cool air from the evaporator coil does not get reheated. The air leaving the dehumidifier is cooler than the entering air. The total air conditioning capability is a function of the latent and sensible load in the room.

For applications where an air-cooled remote condenser is not practical, such as a long line set, a refrigerant to water heat exchanger and a fluid cooler can be used to meet the space cooling needs.

Dehumidifier Design Options

When planning a dehumidifier application there are several key specifications that must be considered.

First, how much moisture must be removed from the natatorium? This is generally calculated in pounds per hour of water. Once a size is selected, then a decision on what heat sinks are appropriate must be made. Answers to the heat sink question will then dictate whether an air-cooled or water-cooled unit is selected and if a remote condenser or fluid cooler is required.

Key features and benefits of the Desert Aire SelectAire™ and SelectAire Plus™ dehumidifiers include meeting ventilation codes; exhaust air recovery; ventilation air flexibility; pool water condenser capabilities; integration with a source capture system; and, latent and sensible energy recovery. Return of the condensate to the pool water system is also available where codes allow.

Desert Aire dehumidifiers integrate all ventilation air components through the dehumidifier to ensure the correct proportions of return air, supply air, exhaust air and outdoor air, and to maintain a negative pressure in the space.

Because conditioned air returning to the dehumidifier contains sensible energy in the form of heat and latent energy in the form of humidity, there is an opportunity to incur energy savings before conditioned air is exhausted from the HVAC system.

Economizers

Building designers often ask mechanical engineers to include in their system designs HVAC equipment with energy efficiency features such as economizer functions. They want the new buildings to comply with ASHRAE 90.1, a standard that provides minimum requirements for energy efficient designs for buildings. HVAC equipment in this classification includes air conditioners, heat pumps, furnaces and boilers.

Including dehumidifiers in this classification is a common mistake. The code specifies that any air conditioner with a supply air volume greater than 5,000 cfm utilize an economizer in most weather zones.

Dehumidifiers are not in the same equipment classification as air conditioners, because they function mostly in the dehumidification and heating modes; not air conditioning modes. Therefore ASHRAE 90.1 does not directly apply to the pool room dehumidifier.

Nevertheless, to meet building owner requests and meet local codes, dehumidifiers with economizer features do exist and may theoretically be suitable for some climates under certain conditions. When certain weather and enthalpy conditions are present, outdoor air may be able to supply the cooling and dehumidification requirements for the pool facility.

Simulations typically show that an economizer-equipped dehumidifier for an indoor pool will not provide operational "economy". This is due to the significant energy penalty of the full-sized blowers and their low Energy Efficiency Rating (EER) in the cooling and dehumidification modes. It will cost more money to operate the economizer-equipped dehumidifier compared to other dehumidifiers.

Purge Mode

Many design engineers and pool operators require a purge mode. This allows the room to be quickly purged of indoor air and replaced with outdoor air. In all cases this purging occurs during unoccupied hours.

The Model Aquatic Health Code recommends the purge mode be set at a minimum of twice the code required outdoor air rate. The Desert Aire SelectAire™ and SelectAire Plus™ system can provide up to 50% of the total airflow when in the purge mode.

A common design mistake is to schedule 100% outdoor air for purge. The difference in time between a full purge of a natatorium space at 100% as compared to 50% is usually about 20 minutes or less. However, the backup space heater must be double the size to handle the full heating requirement of a 100% purge that happens on a design load winter day. This will add substantial equipment cost plus an increased structural load.

Maximizing Energy Recovery

Desert Aire employs techniques and designs to maximize recovered energy. The dehumidifiers achieve energy efficiency without weighing down the equipment with fan systems and motors designed for introducing and exhausting 100% outdoor air. This system also saves substantial energy compared to an outdoor air system during non-occupied periods due to not having to exhaust all of the latent energy from the building while bringing in outdoor air that needs to be heated.

Desert Aire's SelectAire™ and SelectAire Plus™ systems have two exhaust air dampers. One is upstream of the evaporator coil and one is downstream. This special design feature allows SelectAire™ dehumidifiers to take advantage of two basic thermodynamic principles while not impacting the sensible cooling capacity of the units: exhaust air at its coldest point; and, exhaust air at its warmest point.

When the space requires heating, air is exhausted after the evaporator coil to recover the energy contained in the exhaust air prior to its discharge. In the cooling mode, air that is warm and humid is exhausted before the evaporator coil.

SelectAire™ and SelectAire Plus™ systems use the principle of a heat pump to recover energy in the heating mode by operating one of the two circuits in conjunction with exhaust air. As previously noted, exhaust air consists of two energy components: sensible and latent. The cold evaporator coil absorbs both of these components. In addition to this energy, the energy required to operate the compressors is returned in the form of heat. This option provides high coefficient of performance (COP) efficiency to the exhaust air recovery cycle.

This Desert Aire design is the most efficient method to recover the total energy of the exhaust air. Since the airflows and loads are maintained through the special airflow control sequence, the amount of recovery can be optimized.

Other systems that use passive heat exchangers cannot recover latent energy during the majority of the operation and the amount of sensible recovery is dependent on the outdoor temperature. In addition, their actual recovery effectiveness is variable as it changes based on the temperature differential. Passive heat exchangers require additional fan energy and cannot take full advantage of free outdoor air cooling unless bypass dampers and controls are installed.

SelectAire™ and SelectAire Plus™ systems have a constant rate of energy recovery when activated and are always controlled automatically based on the zone condition.

Integrated With Source Capture

If natatorium HVAC designs include chloramine source capture evacuation systems such as the Evacuator®*, Desert Aire dehumidifiers can provide all of the ventilation air, including what is required for operation of the Evacuator®.

Desert Aire's control system modulates the Evacuator® exhaust speed based on the required mode of operation. The Desert Aire dehumidifier can vary the volume of outdoor air and exhaust air based on the level of contaminants within the natatorium.

*Evacuator® is a registered trademark of Paddock Industries.

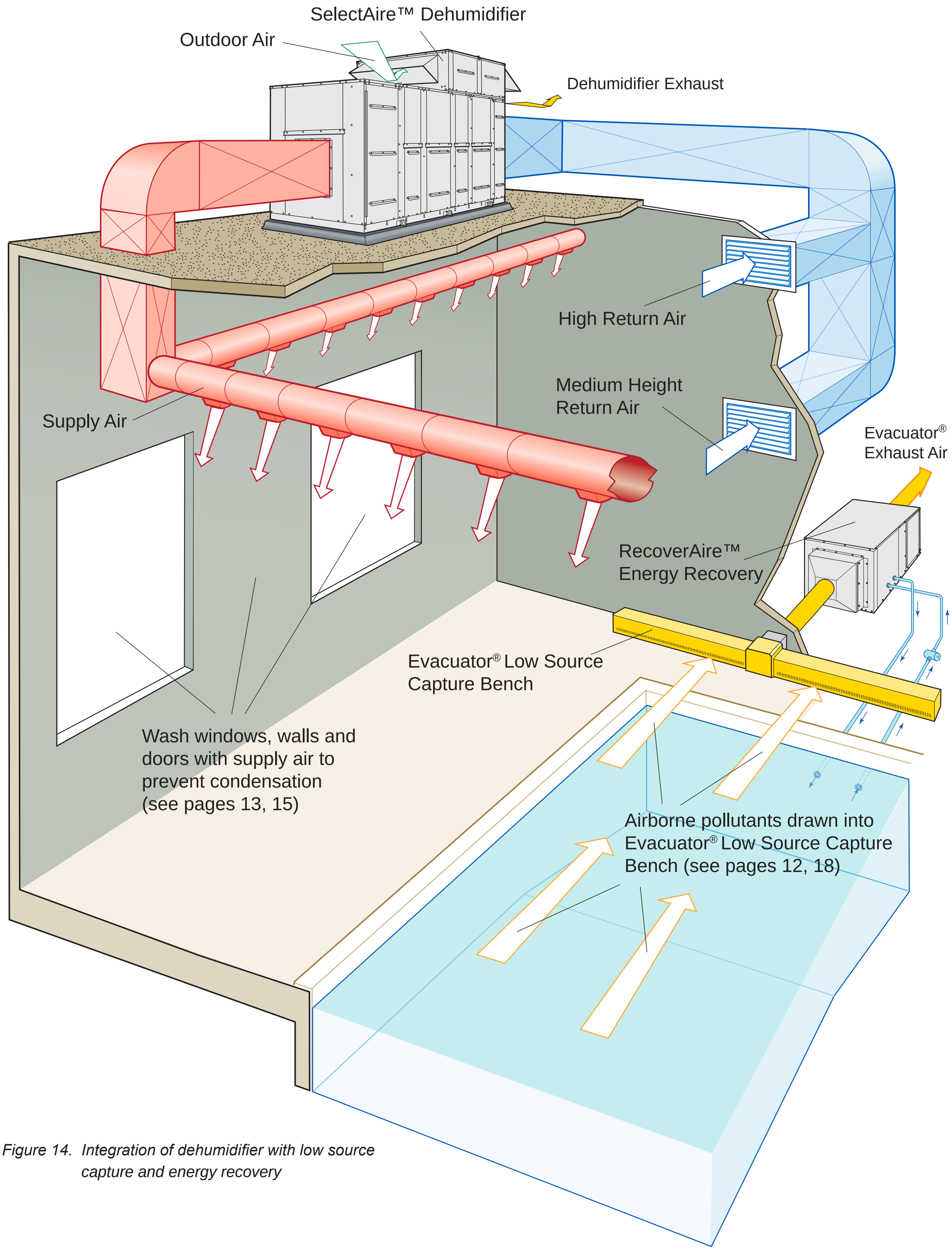

Figure 14. Integration of dehumidifier with low source capture and energy recovery

The key to this integration is the use of a VOC sensing element that can detect when interior levels of chemicals such as chloramines are present. This is similar to the use of CO_2 sensors in general ventilation applications but since the main source of contamination is a volatile organic compound, the VOC sensor is more appropriate for the pool environment.

This provides the ability to optimize the volume of exhaust air required with the energy cost of doing so and ensures a suitable pool environment for the occupants. If the VOC sensor is not included in the installation, the SelectAire™ and SelectAire Plus™ dehumidifiers will exhaust all air without optimizing its volume.

The following table (Figure 15) shows an example of the flexibility of the Desert Aire control system to meet the IAQ needs for pool rooms at various levels of occupancy.

	CFM			
Mode of Operation	**Low Exhaust Air**	**Dehumidifier Exhaust Air**	**Total Exhaust Air**	**Total Outdoor Air**
Unoccupied	2,200	0	2,200	1,800
Normal Occupancy	2,200	2,200	4,400	4,000
Event Occupancy	2,200	3,000	5,200	4,800
Maximum Occupancy	4,400	4,400	8,800	8,400
Purge (no cmpr)	4,400	6,600	11,000	10,600

Figure 15. Example of SelectAire™ dehumidifier airflow configuration

Low Exhaust Energy Recovery

A properly functioning system will not recirculate the air being removed from the low exhaust system; otherwise the system would reintroduce the highly concentrated chemicals back into the space. A perceived negative for this low exhaust is that it has a significant energy content that is bypassing the recovery capability of the SelectAire™ dehumidifier. To minimize this loss, a Desert Aire RecoverAire™ air to water heat pump recovery system should be installed in place of a basic exhaust air blower. By using a high coefficient of performance (COP) heat pump, the system can recover up to 75% of the heat loss of the pool.

Desert Aire's RecoverAire™ system has been designed to meet the challenges of the low exhaust system and interfaces directly with the SelectAire™ system to allow easy field set-up and balancing. Exhausting too much air is an energy waste, but since every natatorium is different the SelectAire™/ RecoverAire™ tandem provides the end user with the control to optimize the volume of air in all 5 modes of operation. This capability balances the volume of outdoor air to ensure proper IAQ while minimizing the cost of treating this outdoor air.

Installation Considerations

SelectAire™ and SelectAire Plus™ dehumidifiers can be installed either indoors or outdoors. Units intended for outdoor installation are factory equipped with additional insulation, heavy-duty weather sealing and special rain hoods mounted on the outside air intake. When required they can also be installed on roof curbs that permit bottom return and supply air to meet HVAC design specifications.

Proper installation of the dehumidifier into the total HVAC system takes careful planning. All of the heat available from the dehumidification process is derived from the compressor and the conversion of latent energy through refrigeration technology.

With a seasonally fluctuating moisture load or maintenance condition, such as the draining of the natatorium pool, supplemental pool heaters must be added to compensate for the lack of heat from dehumidification. In the same manner, the dehumidifier should also include an auxiliary form of space heating. This can be in the form of an integral electric, hot water coil, or a gas heater downstream of the blower.

Figure 16. Desert Aire RecoverAire™ air to water heat pump recovery system

Figure 17. The Desert Aire SelectAire Plus™

Another factor requiring attention is condensate removal from the dehumidifier. Some local codes state that condensate must be plumbed to a drain; but many allow the return of the condensate to the sump upstream of the filter and chemical feed system. The volume of recovered water can be significant and can equal the entire volume of the pool per year.

This should be a consideration on a natatorium designed to achieve high levels of recognition under the Leadership in Energy & Environmental Design (LEED) green building certification program. To recover the condensate water the dehumidifier employs a gravity drainage system. An unpressurized drain connection or a condensate pump then returns the condensate upstream of the sump.

Many older natatoriums with indoor mechanical rooms did not take into consideration that the dehumidification system would need to be replaced during the life of the facility. The removal of the failed system is the easiest part of the retrofit project while moving the new dehumidifier into the mechanical room can be quite challenging. Desert Aire offers a solution to this problem through the sectioning of our SelectAire™ Series dehumidifiers. Desert Aire works with the customer to determine the maximum size and weight of the largest section that can be moved into the mechanical room. This information is used by Desert Aire engineering to create a sectioned SelectAire™ Series unit that meets the performance needs of the natatorium while taking into consideration the logistical problems caused by mechanical room access. Refer to Figure 18 for an example.

The key features of Desert Aire sectioned units include the following:

- Refrigeration valves provided when sectioning of refrigeration circuits is required
- Wiring harnesses with mating connectors and terminal strips to distribute power through the unit
- Flanged edges and gaskets for sealing sections

Figure 18. SelectAire™ sectioned unit ready for shipment

Commissioning

A design process that includes an integrated approach to the natatorium's HVAC system should include commissioning. Commissioning encompasses a set of techniques and procedures to check, inspect and test each operational component of the system to confirm everything is working together as designed.

The system must be completely tested to verify airflow rates; negative pressurization; operation during all modes of occupied and unoccupied states; space heating and cooling; humidity control; water heating; and integration with the source capture system.

Factory Certified Start-up

Due to the complexities of a natatorium's HVAC design, the start-up of a Desert Aire SelectAire™ or SelectAire Plus™ system should be done by either factory technicians or local technicians certified as having been factory-trained by Desert Aire.

Facility Staff Training

The equipment start-up and commissioning process should include training of the natatorium maintenance staff. The maintenance staff should have a basic understanding of HVAC and pool dehumidification systems. This training should include the pool room design conditions, general overview of the sequence of operation, and navigation of the dehumidifier's operating control user interface. This training should also include the scheduling setup of Unoccupied, Occupied and Event modes.

Other natatorium personnel, such as aquatic directors and lifeguards, should be advised of the design conditions of the pool room and the importance of maintaining these conditions.

Conclusions

The new ways people use natatoriums and indoor pool facilities place demands on HVAC systems and buildings that weren't present just a few years ago.

In addition to working in harmony with systems that control water temperature and water quality, the HVAC system for the 21st Century natatorium must protect the health of building users; promote the long-term structural integrity of the building and supporting systems; and conserve energy, water and water treatment resources.

Today there is a matrix of strategies, technologies and industry resources to provide building owners, mechanical contractors and engineers with solutions to these challenges.

As a key component of HVAC systems and their designs, Desert Aire SelectAire™ and SelectAire Plus™ dehumidifiers help meet the holistic needs of natatoriums and aquatic centers. A Desert Aire system properly removes humidity to promote greater comfort, protect structural integrity, improve indoor air quality and conserve resources.

For more information on meeting the HVAC design challenges of your 21st Century natatorium, contact Desert Aire at the address below.

Desert Aire Corp.
N120 W18485 Freistadt Road
Germantown, WI 53022 USA
Phone: (262) 946-7400 FAX: (262) 946-7401
www.desert-aire.com sales@desert-aire.com

Est. 1978

Optimizing Solutions Through Superior Dehumidification Technology

N120 W18485 Freistadt Road
Germantown, WI 53022 USA
www.desert-aire.com sales@desert-aire.com
Telephone: (262) 946-7400 FAX: (262) 946-7401

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Swimming Pool Dehumidifier Sizing

INTRODUCTION

This application note highlights the cause of humidity in pool room enclosures and it's harmful effects if left uncontrolled.

CAUSES OF HUMIDITY

Indoor pools have three main sources of moisture:

1. Evaporation of pool water.
2. Outdoor make-up air.
3. People.

The vapor pressure differences between pool water and air cause continuous evaporation, producing high humidity conditions in the pool room. The evaporation rate is a function of the activity of the pool. If water is calm, there is a known evaporation rate. if people are swimming or playing in the pool, however, the surface area increases (the wave action tends to double the actual pool surface area, and water is spilled on to the deck), which increases the effective evaporation rate. Larger commercial pools must take this factor into consideration.

During the summer months, outdoor air entering the pool room through code-required ventilation can increase the moisture content of the indoor air because it's humidity content is equal to or higher than that of the pool room air. This compounds the indoor humidity problem.

The presence of people in the pool room adds to the space's moisture content. This factor negligible for residential pools, but can be significant for pool facilities with spectator seating.

PROBLEMS WITH HUMIDITY

Air is a gas and, like most gasses, it expands in volume when heated and contracts in volume when cooled. This expansion or contraction with the changing temperature increases or decreases the percentage of moisture that the air can hold. In other words, as air expands, it's ability to hold moisture increases. With the same moisture content, the percentage of moisture to air volume (relative humidity) is reduced when air is heated.

Condensation will form on glass surfaces whenever the temperature of the glass is below the temperature of the air. When the warm air contacts the cool glass it contracts to the point that it releases excess moisture. The combination of indoor relative humidity and indoor/outdoor temperature at which condensation will form is shown in Table 1.

High humidity in a pool facility can cause rapid structural deterioration and corrosion problems. During the winter months and on cool summer evenings, outdoor temperatures may be significantly lower than the indoor air. Warm air retains moisture, but cooler wall or window surfaces will cause the moisture to condense.

RELATIVE HUMIDITY AT WHICH MOISTURE WILL CONDENSE ON WINDOWS								
Outdoor Temp. (°F)	Inside Building Temperature (°F)							
	65		70		75		80	
	Single Pane	Double Pane	Single Pane	Double Pane	Single Pane	Double Pane	Single Pane	Double Pane
-20	-	46%	-	46%	-	44%	-	42%
-10	-	50%	-	49%	21%	48%	20%	46%
0	29%	55%	27%	55%	25%	52%	24%	50%
10	36%	60%	33%	59%	31%	57%	29%	54%
20	43%	66%	40%	63%	37%	62%	35%	59%
30	52%	73%	50%	71%	45%	68%	42%	65%
40	63%	80%	60%	79%	53%	74%	50%	71%

Table 1 - Condensation Chart

Damage to the structure occurs when relative humidity levels reach 62% or above for an extended period of time. Chloramines from pool chemicals reacts with the condensed water to form organic acid, which accelerates the corrosive effects on wood and metal surfaces.

High humidity can also effect the air quality by providing an excellent environment for bacteria, fungi and viruses to grow and multiply. Keeping the relative humidity in the range of 50 to 60% will reduce the number and activity of these organisms.

Finally, high humidity is uncomfortable for those using the pool room.

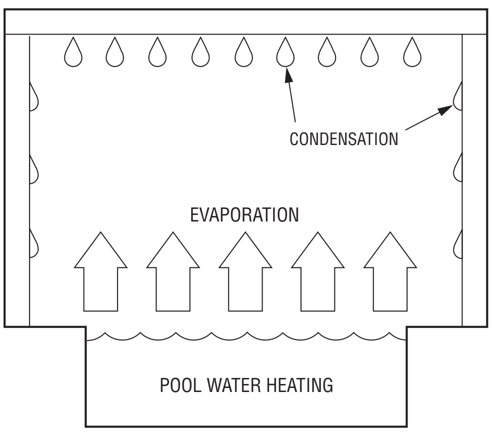

Figure 1 - Condensation Problems

ELIMINATION OF HUMIDITY

Several different techniques can be used to reduce humidity in the pool room. The most common technique is the make-up air exhaust method (refer to Figure 2). Warm moist air is exhausted to the outdoors, while outdoor air (which normally has a lower moisture content) is brought in as make-up air. When this make-up air is heated, the effective relative humidity of the outdoor air is reduced. Two problems are associated with this method. First, heat energy is lost when the warm indoor air is discharged outdoors, thus requiring a heat recovery method. Second, during the summer months the outdoor air may have a higher humidity than the indoor air, thus actually increasing indoor humidity.

When the pool water evaporates, significant energy is expended. This energy, known as latent heat, is replaced by the pool water heater. Another source of energy expenditure in the pool enclosure results from heating the make-up air. This is known as sensible heat. A method of addressing the lost energy is to add

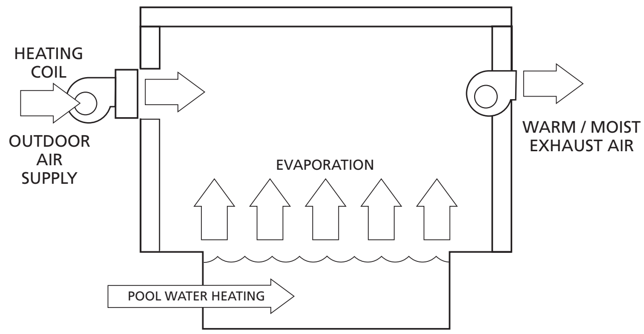

Figure 2- Make-up / Exhaust Method

a heat recovery unit to the exhaust system. This technique takes the sensible heat from the exiting air and exchanges it to the incoming air. This partially reduces the energy loss.

A method that has the advantage of recovering all of the heat (latent and sensible) is refrigerant dehumidification. The warm, moist air is condensed and cooled on a dehumidifier coil, transferring all of the energy to a refrigerant. The recovered energy can be given back to the air stream at the reheat coil in the form of sensible heat, thus recovering almost 100% of the energy (refer to Figure 3). This heat is returned to the pool room environment, maintaining the appropriate air temperature. Additional heating is required only to compensate for heat loss through the windows and walls. Other dehumidifier designs offer alternate heat sinks, such as a water-cooled heat exchanger to heat the pool water in addition to the air. A third alternative is a remote condenser which transfers the heat outdoors to provide summertime cooling in the pool enclosure.

CALCULATION OF MOISTURE LOAD

The following table indicates the generally accepted design temperatures for pool water. Air temperatures should be maintained 2° F to 4° F higher than water temperatures to keep evaporation to a minimum. The exception is a whirlpool, where air temperatures should be 78°F to 86°F.

DESIGN TEMPERATURES FOR SWIMMING POOLS	
Residential	82° F to 84° F
Exercise or Lap Pools	76° F to 80° F
Hotel / Motel	80° F to 84° F
Public / Institutional	78° F to 80° F
Therapeutic	86° F to 95° F
Whirlpools	102° F to 104° F

Table 2 - Design Temperatures

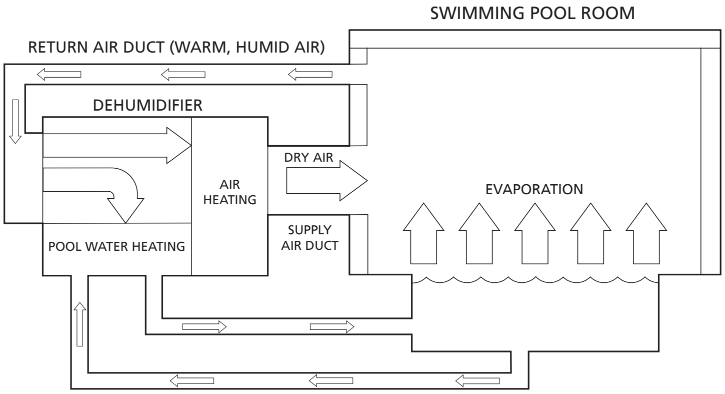

Figure 3 - Dehumidification Schematic

Type of Pool	Typical Activity Factor
Baseline (pool unoccupied)	0.5
Residential pool	0.5
Condominium	0.65
Therapy	0.65
Hotel	0.8
Public, schools	1.0
Whirlpool, spas	1.0
Wavepools, water slides	1.5 (minimum)

Table 4 - Activities Factor Table from ASHRAE Handbook 2007

Evaporation loss formulas and derivations are beyond the scope of this application note. Desert Aire uses the latest information from the ASHRAE Fundamentals Handbook to determine evaporation rates. The handbook's latest simulation uses a vapor pressure differential-based formula. The table below (Table 3) lists the evaporation rate of still water per square foot of pool area. The difference between still and active water is accounted for through the use of an activity factor of 1.5. (See table 4.) This factor determines the evaporation multiplier required to compensate the table value.

The ventilation air required for commercial pools is governed by the ASHRAE 62 code of 0.5 CFM per square foot of pool and deck area plus 15 CFM per person in spectator areas. Although the code does not define "deck area" it is generally accepted to be the tile or concrete area of six to eight feet surrounding the pool. "Spectator area" is generally accepted to be that area occupied by persons viewing a swimming event. If the number of seats cannot be determined, then the estimated maximum occupant load is 150 people per 1,000 square feet. If the pool and deck occupy only a small portion of a larger area, the larger area is not considered spectator and deck area and therefore requires no additional ventilation air. Refer to Desert Aire Technical Bulletin no.5 for additional information on ventilation air for indoor commercial pools.

The final make-up air volume contains a specific moisture content based on the geographic region in which the pool is located. Table 5 on the next page shows approximate guidelines for moisture content. This table was derived by taking the moisture difference between mean July outdoor air moisture content (see Table 6) and an indoor design of 82° F DB, at 50% RH and at 60% RH. A more detailed analysis can be done by the dehumidifier manufacturer.

EVAPORATION RATE IN LB./HR. PER SQUARE FOOT OF SURFACE AREA																				
Water Temp. (°F)	76		78		80		82		84		86		88		90		102		104	
Air Temp. (°F)	50%		60%		50%		60%		50%		60%		50%		60%		50%		60%	
72	0.0255	0.0124	0.0154	0.0106	0.0138	0.0086	0.0138	0.0086	0.0138	0.0086	0.0138	0.0086	0.0138	0.0086	0.0138	0.0086	0.0138	0.0086	0.0138	0.0086
74	0.0241	0.0152	0.0182	0.0133	0.0165	0.0113	0.0165	0.0113	0.0165	0.0113	0.0165	0.0113	0.0165	0.0113	0.0165	0.0113	0.0165	0.0113	0.0165	0.0113
76	0.0226	0.0181	0.0211	0.0162	0.0194	0.0143	0.0194	0.0143	0.0194	0.0143	0.0194	0.0143	0.0194	0.0143	0.0194	0.0143	0.0194	0.0143	0.0194	0.0143
78	0.0211	0.0212	0.0242	0.0193	0.0225	0.0174	0.0225	0.0174	0.0225	0.0174	0.0225	0.0174	0.0225	0.0174	0.0225	0.0174	0.0225	0.0174	0.0225	0.0174
80	0.0194	0.0245	0.0275	0.0226	0.0258	0.0207	0.0258	0.0207	0.0258	0.0207	0.0258	0.0207	0.0258	0.0207	0.0258	0.0207	0.0258	0.0207	0.0258	0.0207
82	0.0177	0.0280	0.0309	0.0261	0.0293	0.0241	0.0293	0.0241	0.0293	0.0241	0.0293	0.0241	0.0293	0.0241	0.0293	0.0241	0.0293	0.0241	0.0293	0.0241
84	0.0159	0.0316	0.0346	0.0298	0.0330	0.0278	0.0330	0.0278	0.0330	0.0278	0.0330	0.0278	0.0330	0.0278	0.0330	0.0278	0.0330	0.0278	0.0330	0.0278
86	0.0139	0.0355	0.0385	0.0337	0.0369	0.0317	0.0369	0.0317	0.0369	0.0317	0.0369	0.0317	0.0369	0.0317	0.0369	0.0317	0.0369	0.0317	0.0369	0.0317
88	0.0119	0.0396	0.0426	0.0378	0.0410	0.0358	0.0410	0.0358	0.0410	0.0358	0.0410	0.0358	0.0410	0.0358	0.0410	0.0358	0.0410	0.0358	0.0410	0.0358
90	0.0097	0.0440	0.0470	0.0421	0.0453	0.0402	0.0453	0.0402	0.0453	0.0402	0.0453	0.0402	0.0453	0.0402	0.0453	0.0402	0.0453	0.0402	0.0453	0.0402
92	0.0074	0.0486	0.0515	0.0467	0.0499	0.0447	0.0499	0.0447	0.0499	0.0447	0.0499	0.0447	0.0499	0.0447	0.0499	0.0447	0.0499	0.0447	0.0499	0.0447

Table 3 - Evaporation Rates of Still Water at Sea Level (Using ASHRAE Fundamentals Method)

CONCLUSION

Commercial pool enclosures must account for all three humidity factors: pool water evaporation, make-up air and the presence of people. The dehumidifier will utilize inactive times to catch up on moisture removal. Generally, the dehumidifier will be able to maintain a 60% RH during active periods and 50% RH during inactive times. Residential pools do not have the make-up air loads nor the people loads of commercial pools, thus their moisture calculations are based on evaporation content only.

For assistance in selecting the correct dehumidifier, please consult your local Desert Aire representative or the factory.

INSIDE AIR MOISTURE CONTENT		
	Grains	
Inside Temp. (°F)	50% RH	60% RH
72	59	71
74	62	75
76	68	81
78	72	86
80	77	92
82	82	96
84	88	106
86	93	113
88	100	120
90	106	128

Table 5 - Moisture Content Guidelines

OUTDOOR AIR MOISTURE CONTENT TO BE REMOVED											
State	City	GR lbs	State	City	GR lbs	State	City	GR lbs	State	City	GR lbs
AK	Anchorage	59	IL	Rockford	119	NY	Albany	109	TX	San Antonio	128
AK	Annette	65	IN	Fort Wayne	121	NY	Buffalo	108	UT	Salt Lake City	76
AK	Kodiak Island	60	IN	Indianapolis	130	NY	New York	121	VA	Norfolk	124
AK	Yakutat	65	KS	Wichita	120	NY	Rochester	116	VA	Richmond	130
AL	Birmingham	126	KY	Louisville	125	NY	Syracuse	110	VA	Roanoke	113
AL	Mobile	137	LA	Baton Rouge	136	OH	Cincinnati	120	VT	Burlington	105
AR	Little Rock	102	LA	New Orleans	143	OH	Cleveland	116	WA	Seattle	71
AZ	Phoenix	102	LA	Shreveport	134	OH	Columbus	119	WA	Spokane	61
CA	Long Beach	91	MA	Boston	112	OK	Oklahoma City	125	WA	Yakima	63
CA	Los Angeles	96	MD	Baltimore	120	OR	Eugene	73	WI	Green Bay	117
CA	Sacramento	72	ME	Portland	106	OR	Portland	72	WI	Madison	115
CA	San Diego	103	MI	Detroit	114	PA	Erie	114	WI	Milwaukee	115
CA	San Francisco	67	MI	Flint	117	PA	Philadelphia	124	WV	Charleston	120
CA	Santa Barbara	85	MI	Grand Rapids	116	PA	Pittsburgh	116			
CO	Stockton	75	MN	St. Paul	114	PA	Scranton	114		CANADA	
CO	Denver	78	MO	Kansas City	126	RI	Providence	114			
CT	Hartford	111	MO	St. Louis	132	SC	Charleston	136	AL	Calgary	69
DC	Washington	129	MS	Jackson	136	SC	Columbia	122	BC	Vancouver	76
DE	Wilmington	121	MT	Billings	70	SD	Sioux Falls	119	MN	Winnipeg	97
FL	Daytona Beach	137	NC	Cape Hatteras	142	TN	Bristol	118	NB	Saint John	87
FL	Jacksonville	134	NC	Charlotte	122	TN	Chattanooga	126	NF	St. John's	89
FL	Miami	137	NC	Raleigh	126	TN	Knoxville	124	NS	Halifax	100
FL	Tallahassee	136	ND	Fargo	109	TN	Memphis	132	ON	Ottawa	101
FL	Tampa	136	NE	Omaha	125	TN	Nashville	126	ON	Sudbury	93
GA	Atlanta	123	NH	Concord	109	TX	Brownsville	136	ON	Thunder Bay	91
GA	Augusta	128	NJ	Atlantic City	123	TX	Corpus Christi	141	ON	Toronto	108
HI	Honolulu	117	NJ	Newark	121	TX	Dallas / Ft. Worth	121	ON	Windsor	115
IA	Des Moines	122	NM	Albuquerque	80	TX	El Paso	99	QC	Montreal	106
ID	Boise	59	NV	Las Vegas	82	TX	Houston	135	QC	Quebec	100
IL	Chicago	118	NV	Reno	59	TX	Lubbock	111	SK	Regina	80

Table 6 - Geographic Outdoor Design Criteria (ASHRAE Fundamentals 1%)

N120W18485 Freistadt Road
Germantown, WI 53022
(262) 946-7400 FAX: (262) 946-7401
www.desert-aire.com

Pool Dehumidifer Sizing
Owner Questionaire

Date:

Facility Name:
City/State:
Altitude @ Jobsite:

Company:
Contact:
Email:
Phone

Describe facility:

Use a separate page to highlight details of pool with special note of water features or other unique design elements.

Pool or Spa Design Details

Pool #1

Area [ ] sq ft
Water Temp [ ] °F

- ❑ Res.
- ❑ Condo
- ❑ Therapy
- ❑ Hotel
- ❑ Public
- ❑ Spa
- ❑ w/ Water Features
- ❑ Wave Pool
- ❑ Flow Rider
- ❑ Other (describe)

Pool #2

Area [ ] sq ft
Water Temp [ ] °F

- ❑ Res.
- ❑ Condo
- ❑ Therapy
- ❑ Hotel
- ❑ Public
- ❑ Spa
- ❑ w/ Water Features
- ❑ Wave Pool
- ❑ Flow Rider
- ❑ Other (describe)

Pool #3

Area [ ] sq ft
Water Temp [ ] °F

- ❑ Res.
- ❑ Condo
- ❑ Therapy
- ❑ Hotel
- ❑ Public
- ❑ Spa
- ❑ w/ Water Features
- ❑ Wave Pool
- ❑ Flow Rider
- ❑ Other (describe)

Pool #4

Area [ ] sq ft
Water Temp [ ] °F

- ❑ Res.
- ❑ Condo
- ❑ Therapy
- ❑ Hotel
- ❑ Public
- ❑ Spa
- ❑ w/ Water Features
- ❑ Wave Pool
- ❑ Flow Rider
- ❑ Other (describe)

Zone Conditions

Room Design Temp		°F
Design Unoccupied RH		%
Design Occupied RH		%

It is recommended that the air temperature be two degrees higher than the pool temperature in order to minimize the evaporation rate. It is recommended that air temperature be set no higher than 86º.

For load calculations, typical relative humidity settings are 50% for unoccupied and 60% for occupied.

Outdoor Air Design Conditions

User-Entered Data	❑	For User-Entered Data	
ASHRAE 0.4%	❑		°F Dry Bulb
ASHRAE 1.0%	❑		°F Wet Bulb
ASHRAE 2.0%	❑		ft Altitude

Outdoor Air Rate Calculation Inputs

Total Pool Area		sq ft	Sum Area of all pools
Gross Room Floor and Pool		sq ft	Total area of facility
Total Pool and Wet Deck		sq ft	Area of wetted surfaces during normal occupied conditions.
Height (avg.)		ft	

Is there a separate spectator area? ❑ Yes ❑ No

If Yes: ______ sq/ft ______ # people

Code Ventilation: ______ cfm

Other Zone Data

Space Sensible Load		BTUH
Space Heating Load		BTUH

Both values are without outside air.
An engineer or contractor to provide using load calculation software.

If outside air is required will it be brought in through our unit?

❑ Yes ❑ No

Outside air is brought in through the top of the unit as standard.
Choose which option you require for this project:

- ❑ No OSA opening
- ❑ OSA duct connection only
- ❑ OSA duct connection with a damper/actuator
- ❑ OSA box with a damper/actuator & filters

Do you want to implement a low source capture exhaust system for chloramine removal?

❑ Yes ❑ No

Do you want to be able to shut off outside air in an unoccupied mode to create more energy savings?

❑ Yes ❑ No

This can be done with an automatic internal bypass damper as well as an automatic outside air damper to insure consistent air flow across the evaporator coil when the outside air damper closes. The payback for this option is usually within the first year.