Indoor Pool Dehumidification
Analysis & Comparison of Current Methods

INTRODUCTION

Several methods can be used to dehumidify an indoor commercial pool facility. This publication will compare the effectiveness of each method.

In addition, we will compare the operating costs of the various dehumidification methods. The variable that most greatly impacts the operating cost is outside weather. Does the building and ventilation air need to be heated or cooled? How much outside air must be introduced, and can it help dehumidify the indoor air? When operating costs are understood, an intelligent decision can be made about purchasing the most cost-effective dehumidification system.

The five methods reviewed will be:

1. Push-pull ventilation systems
2. Push-pull ventilation with air-to-air heat exchanger
3. Refrigeration based dehumidifiers
4. Refrigeration based dehumidifiers with “economizer” (free cooling).
5. DESERT AIRE SA Select Aire™ (SA) dehumidifier

A detailed analysis cannot be made for every pool, since weather conditions and utility costs vary significantly between projects. However, a systematic approach can be used to understand humidity control systems and their associated purchase, installation and operation costs. With this understanding, running a bin-method computer software program will calculate actual control times and operational costs.

Please note that building skin heat loss or gain will be the same for all methods of dehumidification and will be ignored for this comparison. Additionally it is important to know that the desired pool room humidity level is between 50-60% RH. At a space temperature of 82°F this equates to a moisture content of 82 to 99 grains/lb of dry air.

PUSH-PULL VENTILATION SYSTEMS

Code ventilation will have a direct influence on the actual indoor moisture load. ASHRAE 62.1 provides the ventilation requirements for a commercial pool. DESERT AIRE’s *Technical Bulletin 5 -Ventilation Air for Indoor Pools* provides a detailed analysis of this code ventilation requirement. It should also be noted that ASHRAE 62.1 does not apply to residential pool applications but only to commercial installations such as YMCAs, schools, hotels & resorts.

In all cases, the ASHRAE 62.1 code ventilation requirement will be insufficient to treat the moisture load in the pool room. Therefore, the Push-Pull Ventilation system must be designed with larger volumes of outdoor air than the code requirement in order to control the dehumidification load.

In general, for approximately eight months of the year in colder climates, the volume of outdoor air required for dehumidification is twice the code ventilation volume. In warmer climates, it is four times the code amount for this same 8 month period.

A major limitation of the Push-Pull ventilation system is when the outdoor air moisture content is greater than the pool room moisture content or above 99 grains/lb. When this situation arises the Push-Pull ventilation system will not be able to control the pool room moisture content within the desirable range. Figure 1 shows the percentage of time Push-Pull ventilation systems cannot control indoor humidity levels based on ASHRAE Weather Bin data.

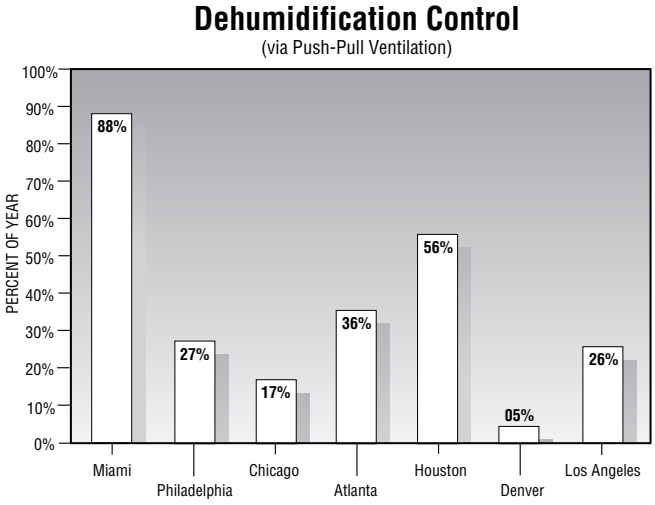

Figure 1 - Percentage of Time Humidity is Out of Control

A Push-Pull ventilation system wastes a significant amount of energy by exhausting both the sensible and latent heat of the enclosure. (See Figure 2.) A true operational cost analysis must take the following into consideration:

Heating large quantities of cold outdoor air.
Heating pool water to compensate for heat loss (evaporation).
Cost to operate supply air blower.
Cost to operate exhaust air blower.

The operational cost of a "push-pull" system in different climatic zones will be similar. In colder climates, smaller volumes of outdoor air are required to dehumidify inside air, thereby reducing blower sizes; but this still creates significant heating costs. In warmer climates, larger outdoor air volumes are required, but there is a reduction in the cost to heat this outdoor air.

ADVANTAGES

- Least expensive system to purchase.
- Least expensive system to install.

DISADVANTAGES

- Most expensive operation costs.
- Humidity and temperature control extremely limited.
- No summer cooling available.
- Space humidity conditions dependent upon outdoor conditions.

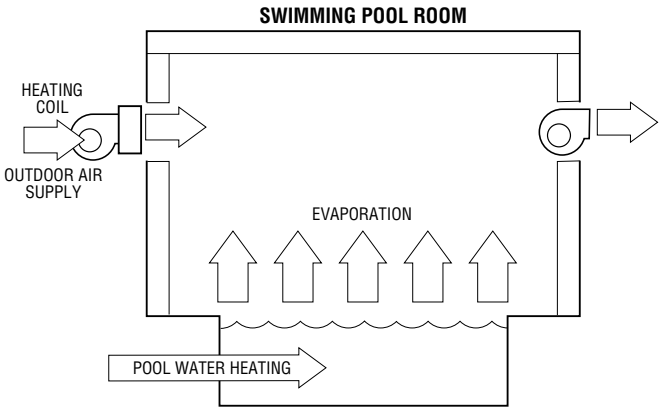

Figure 2 - Push-Pull Ventilation System Schematic

PUSH-PULL VENTILATION W/ AIR-TO-AIR HEAT EXCHANGER

This dehumidification method is a variation of the Push-Pull ventilation system, with the addition of an air-to-air heat exchanger for heat recovery. The incoming outdoor air passes through a series of plates or an energy or sensible wheel and picks up the heat being transferred by the warmer exhaust air. (See Figure 4.) All air-to-air heat exchangers claim impressive efficiency data, but when a total energy analysis is made, based on sound psychrometric principles and seasonal efficiencies, the figures are less impressive.

At low ambient outdoor temperatures, the make-up air must be preheated, reduced, or partially bypassed to counteract the possibility of freezing the exchanger assembly to a block of ice. Under these low ambient conditions, efficiency is substantially reduced. Furthermore, only a percentage of the latent energy of the exhausted air is recovered. The total efficiency of the heat exchanger varies with the temperature and humidity, but follows the general

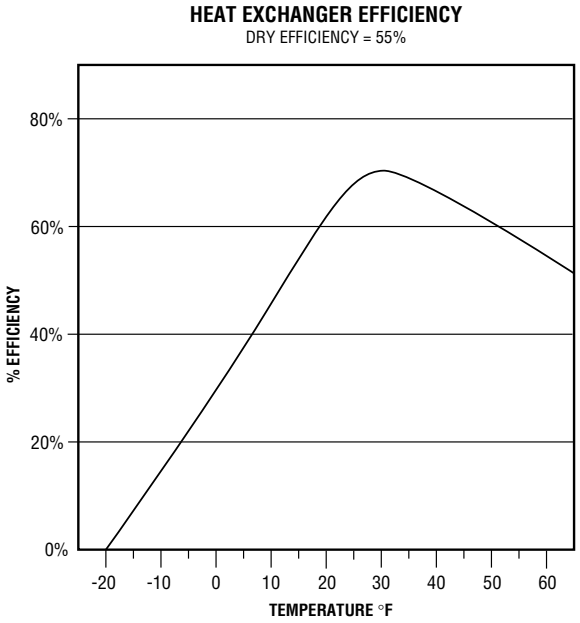

Figure 3 - Heat Exchange Efficiency

curve shown in Figure 3.When the most recovery is needed (at the coldest temperatures),the exchanger exhibits the least amount of recovery. In addition, no summertime cooling is possible.

As with Push-Pull ventilation systems, there are times when the outdoor temperature and humidity levels are higher than the internal space design condition. During these periods, the pool enclosure is out of control and the ventilation/heat recovery system cannot improve the conditions in the pool room. A true operational cost analysis must take the following into account:

Heating cold outdoor air.
Heating pool water to compensate for heat loss (evaporation).
Cost to operate supply air blower.
Cost to operate exhaust blower.
Cost of additional controls, dampers, coils, and ductwork.
Total sensible energy savings (credit).

ADVANTAGES

- Recovers sensible heat. (plate or wheel)
- Recovers latent heat. (wheel only)
- Saves energy over push-pull alone.

DISADVANTAGES

- Seasonal efficiency is less than 50%.
- Initial high cost of system; additional cost of controls, dampers, coils and ductwork..
- Cannot recover 100% of latent heat.
- Humidity and temperature control extremely limited.
- No cooling capability
- Space humidity conditions dependent upon outdoor conditions

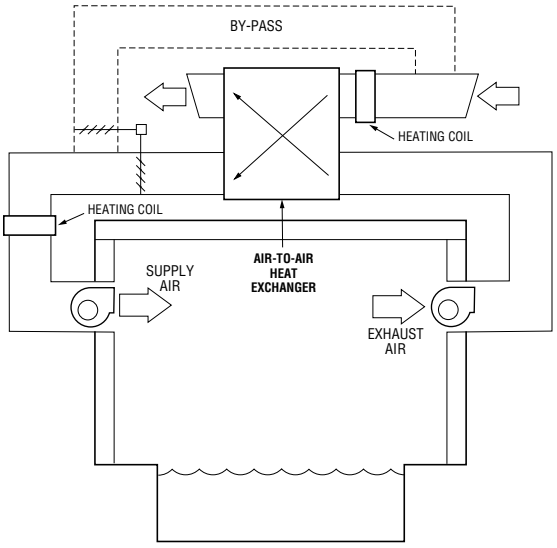

Figure 4 - Push-Pull Ventilation with Exchanger System Schematics

REFRIGERANT BASED DEHUMIDIFIER SYSTEM

During the mid '70s, it was realized that a Refrigerant-based dehumidifier could be designed to dramatically reduce the moisture content of the air in indoor pool enclosures regardless of outdoor conditions. A by-product of the dehumidifier was the "heat pump" type energy recovery system, which returned both the sensible and latent energy back to the pool enclosure or pool water. (See Figure 5.)

Another benefit of the Refrigeration based dehumidifier is the introduction of code ventilation. ASHRAE 62.1 only requires code ventilation when the space is occupied. Therefore when the pool room is closed the unit can discontinue the introduction of code ventilation. This small act saves significant energy due to the dehumidifier not having to treat the outdoor air. A dramatic reduction in energy can be seen by removing the outdoor air load for 10 hours a day. The dehumidifier will continue to control the indoor humidity level during these unoccupied hours but will not have to expend additional energy to treat the outdoor air requirement. For residential pools the savings are even more dramatic since there is no ventilation code requirement at any time. In these instances the dehumidifier can be sized for the internal moisture removal loads only.

Refrigerant-based dehumidifiers are similar to air conditioners in some ways. A Refrigerant based Dehumidifier uses a compressor and an evaporator coil like an air conditioner, albeit the evaporator coil on a dehumidifier is typically designed more for latent moisture removal rather than just sensible temperature change. A major difference between the Refrigerant based dehumidifier and the air conditioner is that the dehumidifier is equipped with a Hot Gas Reheat Coil in the airstream. This Hot Gas Reheat Coil is used to reheat the airstream when the temperature coming off the evaporator coil is not desirable for the conditioned space. On a hot day the pool room may require air conditioning in addition to moisture removal. In this instance the Refrigeration based dehumidifier can elect to not use the Reheat Coil and supply the cool air to the space. During this cooling mode, energy can still be recovered to heat the swimming pool water or to preheat domestic hot water. The operational cost analysis of the mechanical dehumidifier consists of the following:

Heating cold outdoor air (per code).
Heating pool water (evaporation).
Cost to operate exhaust air blower.
Total electrical consumption costs (compressor and blowers).
Total recovered energy savings (credit).

ADVANTAGES

- Total humidity control.
- Energy savings by heat recovery (air/water).
- Air conditioning.

DISADVANTAGES

- Equipment is more expensive than Push-Pull Ventilation Systems

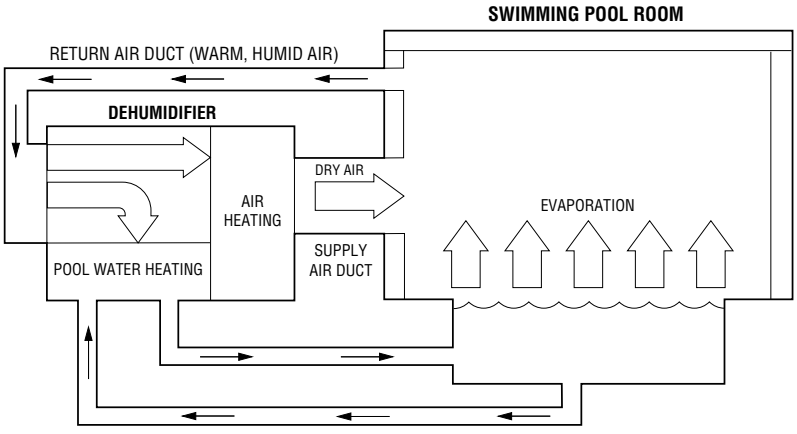

Figure 5 - Standard Dehumidifier Schematic

REFRIGERATION BASED DEHUMIDIFIER WITH "ECONOMIZER" MODE

One of the "hybrid" systems on the market recognizes that, during certain times of the year, ventilation air is more cost effective than refrigeration dehumidification. This system functions like an air conditioner with an "economizer" mode, turning off the compressor when the outdoor temperature is acceptable for "free cooling." (See Figure 7.)

To calculate when the economizer will function, several control parameters must be established. In order to take advantage of the outdoor air for free cooling, the following conditions must be considered:

1. In the Unoccupied Mode there is no code ventilation requirement. Does the control logic consider the cost of running the full sized exhaust fan or will the unit only recirculate the indoor air and maintain the humidity level with refrigeration equipment?

2. The Economizer function can only operate effectively when the outdoor air temperature is between 55F and 80F and when the moisture content is below 100 grains/lb. Otherwise the outdoor air conditions will not improve the indoor pool room moisture conditions. If the outdoor conditions are outside of these parameters then the unit should provide the minimum amount of outdoor air to meet the code ventilation.

3. Priority of the dehumidifier between humidity control of air versus water heating of pool.

Additionally, the following overrides must be satisfied:

1. When the pool is unoccupied, code ventilation can be turned off, so the economizer is also locked out. This alone can represent 50% "off time."

2. If the outdoor air temperature is below the "off" evaporator temperature (typically 55°F), then it is more cost effective to use the compressor with the economizer locked out, and provide reheat (heat recovery).

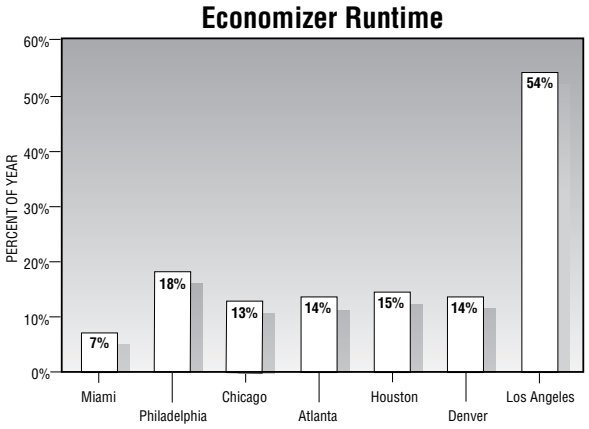

Figure 6 - Economizer Dehumidification Control

3. During the cooling season, the internal air temperature will rise due to the hot ventilation air and solar gain. To prevent overheating, the economizer is locked out, and compressors dehumidify and cool the space.

4. The economizer must control the humidity in the space.Therefore, it is locked out or returned to minimum code requirement when the outdoor conditions become too humid to dehumidify.

5. When control strategy establishes pool water heating priority. In this mode, the economizer also is locked out.

Individually, each of the above control parameters changes with different cities and projects. But an interesting result occurs when the combination of these controls is analyzed. The economizer will function only when all control points are acceptable. Figure 6 shows the combined results for our example cities using a 14-hour-per-day occupancy schedule. Regardless of the climatic zone, an economizer provides "free cooling" only between 7% to 18% of the year.

A detailed analysis of the economizer method will show cost savings over the push-pull ventilation technique. The economizer operates only a small percentage of the year, and the system essentially acts like a refrigeration based dehumidifier the remainder of the year. Both the economizer and the refrigeration based dehumidifier show

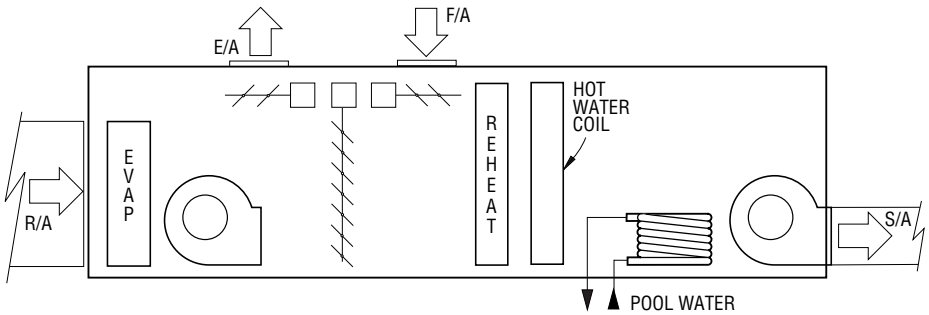

Figure 7 - Economizer Schematic

energy recovery. However the economizer unit will require a full capacity exhaust blower assembly while the refrigeration based dehumidifier will only require a partial capacity exhaust blower assembly. This will result in a significantly lower operational cost for the unit without the economizer. The full capacity blower must operate 24 hours per day, 365 days per year - driving up overall electrical consumption costs. A true cost analysis must take the following into account:

Heating cold outdoor air.
Heating pool water (evaporation).
Total unit electrical consumption costs.
Total recovered energy savings (credit).

ADVANTAGES

- Total humidity control
- Energy savings by heat recovery (air/water)
- Cooling capability (Air conditioning).
- "Free cooling," when possible.
- Complete integrated package.

DISADVANTAGES

- Equipment is more expensive than Push-Pull Ventilation Systems
- Most expensive installation costs.
- Expensive operational costs.

DESERT AIRE SELECT AIRE DEHUMIDIFIER

Code-required outdoor air ventilation is the largest source of energy loss in a pool enclosure. The optimum dehumidification system should address this energy loss. The DESERT AIRE SA series, with its exclusive Select Aire exhaust heat recovery system, integrates all of the requirements of ventilation, air-to-air heat recovery, heat recovery to pool water, and air conditioning into a single-package dehumidifier. No additional equipment is required, since the dehumidifier includes all the necessary parts, components, and controls. This assures reliability and single-source responsibility for the complete integrated system. The special design of the Select Aire option allows the controller to follow basic thermodynamic principles, which translates to increased energy savings and human comfort.

In the heating mode, air is exhausted after the evaporator coil has recovered its energy (exhaust air is at its coldest point), to be given up by the hot-gas reheat coil. (See figure 8.) In the cooling mode, warm, humid air is exhausted before the evaporator coil (exhaust air at its warmest point). (See Figure 9.) The Select Aire system uses the principle of a heat pump to recover energy in the heating mode by operating one of the dual compressors in conjunction with exhaust air. This option provides high COP (coefficient of performance) efficiency to the exhaust air-recovery cycle. A detailed review of this system is found in DESERT AIRE's *Technical Bulletin 6 - Select Aire Heat Recovery System.*

A true operational cost analysis must take the following into account:

Heating cold outdoor air (per code).
Heating pool water to compensate for heat loss (evaporation).
Total unit electrical consumption costs (compressor and blowers).
Total recovered energy savings (credit).
Exhaust air heat recovery savings (credit).

ADVANTAGES

- Total humidity control.
- Energy savings by heat recovery (air/water).
- Energy savings by additional heat recovery (exhaust air).
- Cooling capability (Air conditioning).
- Complete integrated package.
- Lowest operating costs.

DISADVANTAGES

- More expensive capital costs than push-pull systems.
- More expensive installation costs than push-pull systems.

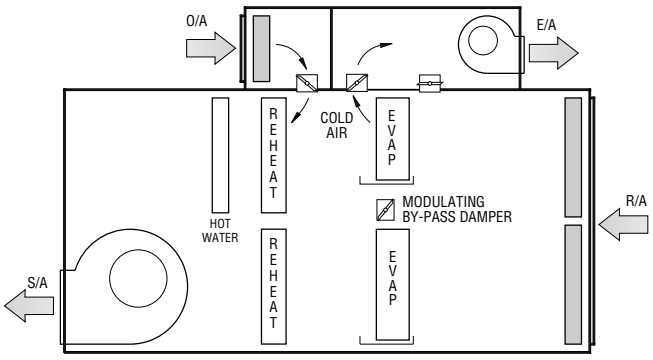

Figure 8 - Heating Mode Schematic Occupied

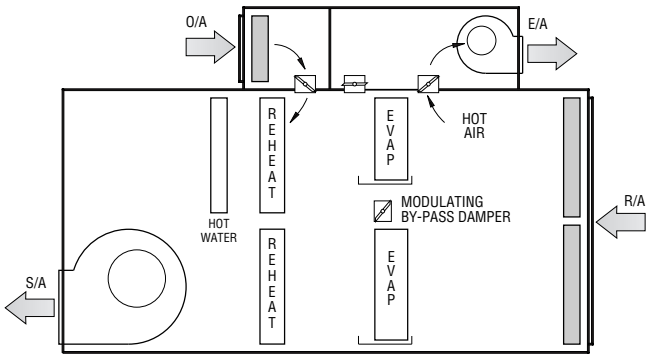

Figure 9 - Cooling Mode Schematic Occupied

CONCLUSION

The primary goal of any dehumidification system is to maintain the internal space conditions at the desired relative humidity. The second goal is to achieve the primary goal in the most cost-effective way. Calculating operating costs requires a computer to "number crunch" the hourly change in outdoor weather conditions. DESERT AIRE has written a program to do just that. It uses Gas Research Institute (GRI) bin data and calculates total operating costs. The following example is based on a 3,000 square foot commercial pool in Chicago.

	Push-Pull Ventilation	Push-Pull w/ Heat Exchange	Refrigeration Based w/ Economizer	Refrigeration Based Dehumidifier	Desert Aire Select-Aire
% Time Humidity Controlled	83%	83%	100%	100%	100%
OPERATING COSTS					
Electricity	$7,842	$10,456	$29,008	$16,900	$20,529
Gas For Heating Outside Air	$23,031	$23,031	$4,169	$3,966	$3,966
Gas For Heating Pool Water	$8,329	$8,329	$8,329	$8,329	$8,329
Est. Building Skin Loss	N/A	N/A	N/A	N/A	N/A
SUBTOTAL	$39,202	$41,816	$41,506	$29,195	$32,824
ENERGY RECOVERY					
Gas Recovery Credit	N/A	$13,894	$8,384	$9,870	$17,413
NET OPERATING COST	**$39,202**	**$27,922**	**$33,122**	**$19,324**	**$15,411**

In today's energy-conscious society, total costs of pool ownership must be considered, not just the up-front costs. An indoor pool is an expensive undertaking and the dehumidification system should ensure that the building's integrity, as well as occupant comfort, will be maintained for many years. Mechanical dehumidifiers best meet these goals. In large commercial pools, DESERT AIRE's Select Aire heat recovery option gives a quick return on investment and is the best choice overall.

OPTIMIZING SOLUTIONS THROUGH SUPERIOR DEHUMIDIFICATION TECHNOLOGY

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