

Indoor Pool Dehumidification Analysis & Comparison of Current Methods

INTRODUCTION

Several different 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 are:

1. Push-pull ventilation (constant and VAV make-up air).
2. Push-pull ventilation with air-to-air heat exchanger.
3. Standard dehumidifier.
4. Dehumidifier with “economizer” (free cooling).
5. DESERT AIRE SA (Select Aire) dehumidifier with exhaust air heat recovery.

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 has been ignored, because it will be the same for all methods of dehumidification.

VENTILATION / MAKE-UP AIR SYSTEM

Code ventilation will have a direct influence on the actual indoor moisture load. A commercial pool must follow standard ASHRAE 62. DESERT AIRE’s *Technical Bulletin 5 -Ventilation Air for Indoor Pools* provides a detailed analysis of this code. A residential pool normally does not need to meet this code.

In all cases, the required ventilation code CFM will not take care of the dehumidification moisture load. Therefore, the make-up air system must be designed with larger volumes of outdoor air to compensate for the dehumidification demand. 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.

Another problem occurs when the outdoor air moisture content approaches the inside air moisture content. There are times when it is impossible to bring in enough outdoor air to dehumidify the inside air at all. During these periods, the pool enclosure is out of control and the ventilation system cannot perform its required duty. Figure 1 shows the percentage of time ventilation-type control systems cannot control humidity levels.

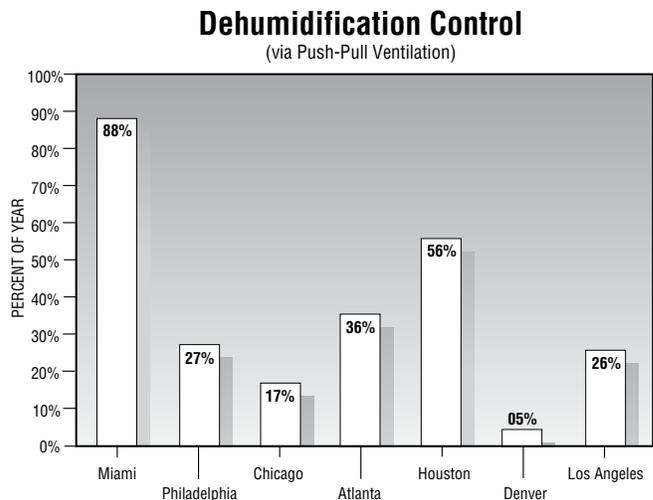


Figure 1 - Percentage of Time Humidity is Out of Control

A ventilation “push-pull” 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.

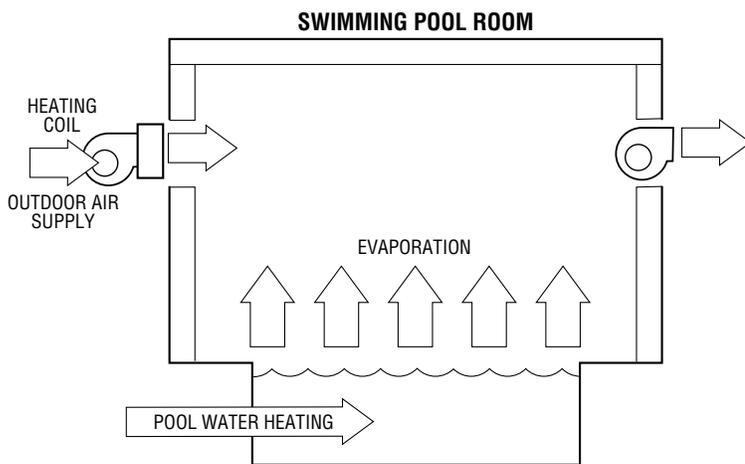


Figure 2 - Push-Pull Ventilation System Schematic

VENTILATION W/ AIR-TO-AIR HEAT EXCHANGER

This dehumidification method is a variation of the ventilation make-up air system, with the addition of an air-to-air heat exchanger for heat recovery. The incoming outdoor air passes through a series of plates 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.

HEAT EXCHANGER EFFICIENCY

DRY EFFICIENCY = 55%

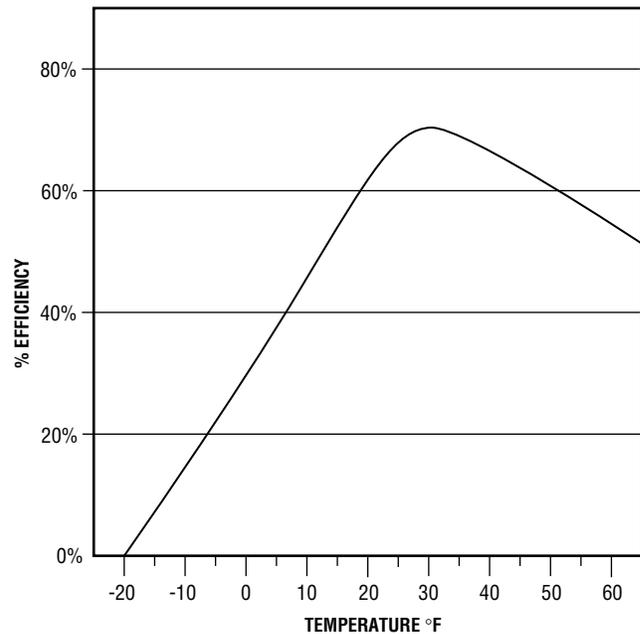


Figure 3 - Heat Exchange Efficiency

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 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 conventional ventilation systems, there are times when the outdoor temperature and humidity level 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 perform as required.

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.
- Saves energy.

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.

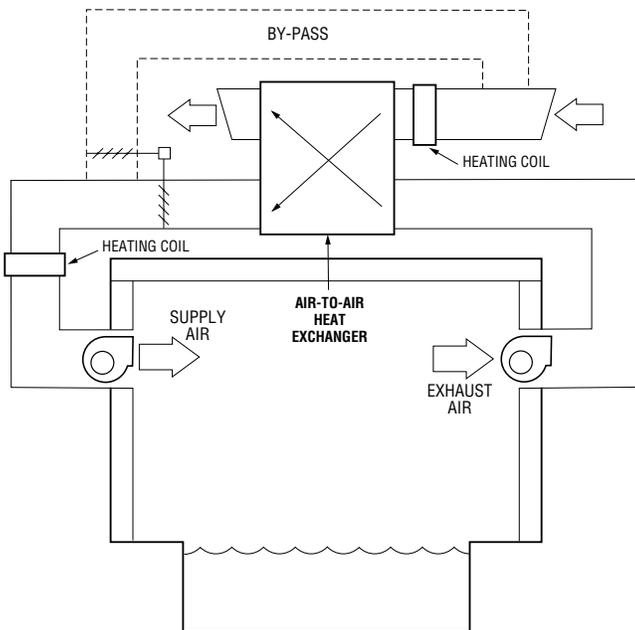


Figure 4 - Push-Pull Ventilation with Exchanger System Schematics

STANDARD DEHUMIDIFIER SYSTEM

During the mid '70s, it was realized that a refrigerant-based dehumidifier could be designed to remove the total moisture in a pool enclosure 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.)

Since the dehumidifier controls the humidity, the outdoor air volume can be turned off or reduced (when allowed by code). This small act saves significant energy. Since most pools are open at least

12 hours per day, the savings can be translated to over 4,000 hours per year. For residential pools the savings are even more dramatic.

A refrigerant-based dehumidifier acts like an air conditioner in the summertime. The space cooling it provides enhances the comfort level of the pool enclosure. 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

- Expensive capital costs.
- Expensive installation costs.

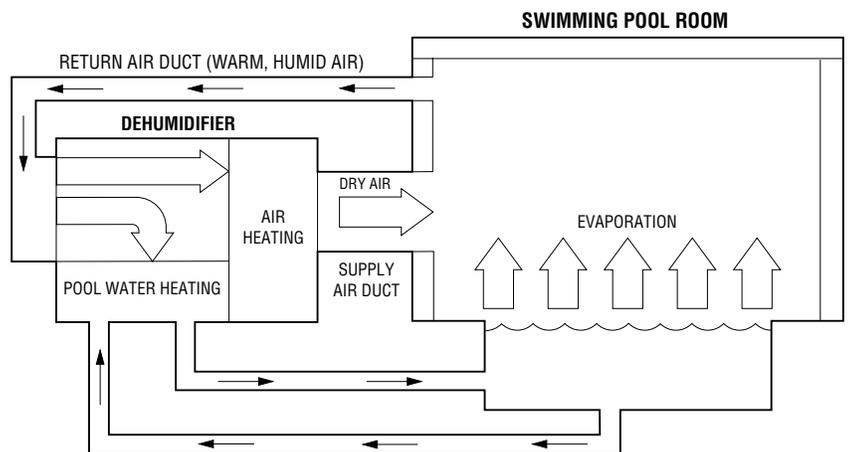


Figure 5 - Standard Dehumidifier Schematic

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 right for taking advantage of “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 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).
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. Some 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. (Except in the dry, mild west coast.)

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 standard dehumidifier the remainder of the year. Both the economizer and the dehumidifier show energy recovery, but

Economizer Runtime

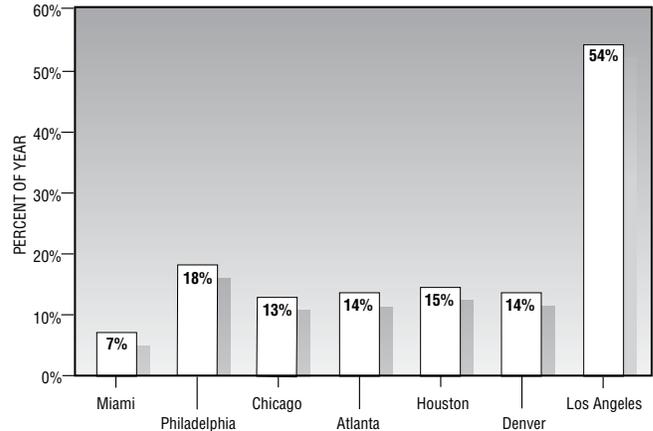


Figure 6 - Economizer Dehumidification Control

since the economizer requires a full capacity exhaust blower and motor, and a dehumidifier with code O/A requires only a partial capacity blower motor, there is a significantly lower operational cost 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).
- Air conditioning.
- “Free cooling,” when possible.
- Complete integrated package.

DISADVANTAGES

- Most expensive capital costs.
- Most expensive installation costs.
- Expensive operational costs.

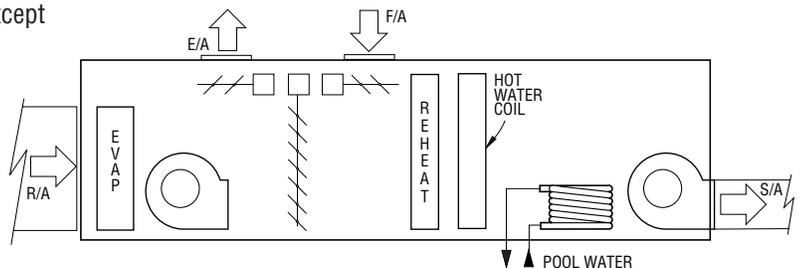


Figure 7 - Economizer Schematic

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 (heating season), 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 (cooling season), 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*.

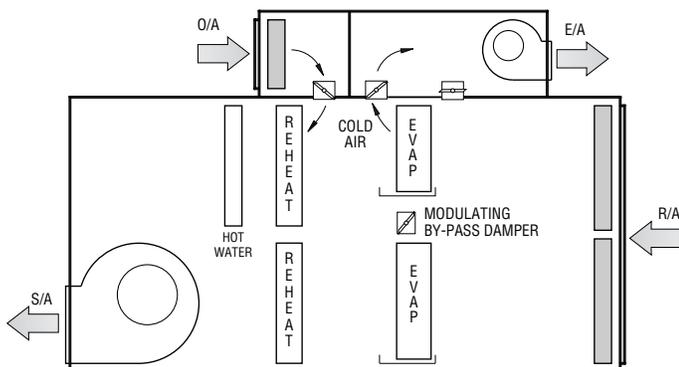


Figure 8 - Heating Mode Schematic Occupied

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).
- Air conditioning.
- Complete integrated package.
- Lowest operating costs.

DISADVANTAGES

- Expensive capital cost.
- Expensive installation cost.

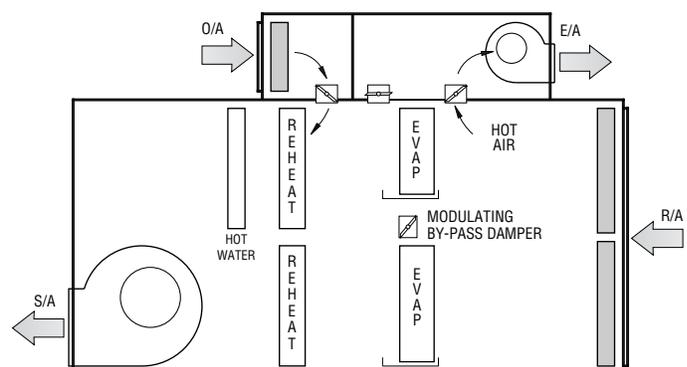


Figure 9 - Cooling Mode Schematic Occupied

C ONCLUSION

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.

	Ventilation	Heat Exchange	Economizer	Dehumidifier	Select-Aire
% Time Humidity Controlled	83%	83%	100%	100%	100%
OPERATING COSTS					
Electricity	\$7,842	\$10,456	\$29,008	\$16,900	\$20,529
Vent Gas Heat	\$23,031	\$23,031	\$4,169	\$3,966	\$3,966
Water Gas Heat	\$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.

METHOD	INSTALLED COST RANKING	OPERATION COST RANKING
Push-Pull Ventilation	1	5
Air-to-Air Heat Recovery	2 (tie)	3
Standard Dehumidification	2 (tie)	2
Select Aire Dehumidifier	4	1
Dehumidifier “Economizer”	5	4

(1 is least expensive; 5 is most expensive)



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