Natatorium Economizer Vs. Conventional Dehumidifier

INTRODUCTION

This technical bulletin will review how an economizer-type indoor pool dehumidifier functions, and provide details on its control sequence. It will also outline the system's advantages and disadvantages versus a conventional dehumidification system.

STANDARD DEHUMIDIFIER

A pool dehumidifier is defined as an air handler that is sized to remove the moisture in a Natatorium at a rate equal to the evaporation rate of the pool water. (Figure 1) To achieve this, mechanical refrigeration is used to cool the air below its dew-point, and then use the compressor discharge hot gas to reheat the air or heat the pool water to reduce energy costs. During the summer cooling season, the system provides air conditioning to the space. An exhaust fan can easily be incorporated into this system to relieve the ventilation outside air being introduced into the unit/space.

The outside air is introduced into the dehumidification system after the evaporator coil for several reasons. First, during the winter, the cold outdoor air may condense the return air at undesirable locations within the unit or ductwork. Second, the variability of the outdoor air will influence the design and performance of the evaporator coil. When cold outside air mixes with warm return air from the poolroom, a lower mixed air condition will result.

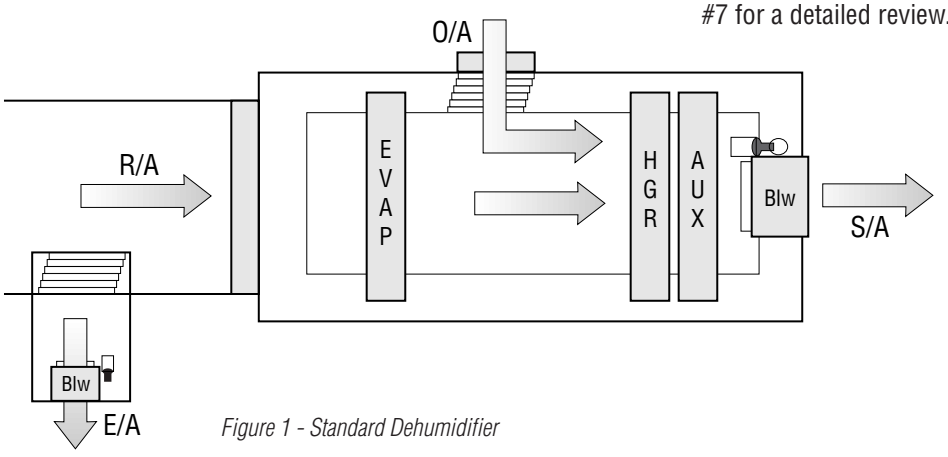

Figure 1 - Standard Dehumidifier

This lower temperature mixed air would reduce the capacity of the refrigeration system and create unpredictable moisture removal and cooling capacity. To eliminate these issues, the outside air is introduced between the evaporator and hot gas reheat coil.

ECONOMIZER DEHUMIDIFIER

An economizer-type dehumidifier uses the same components, but adds a mixing box between the evaporator and hot gas reheat coils. It also needs to add a full-sized return air blower prior to this mixing box. (Figure 2) This system now has the capability to exhaust, and introduce 0 - 100% outdoor air into the pool facility by modulating the dampers on the mixing box. Like the standard dehumidifier, the mixing box is placed between the coils to insure proper operation in a pool facility.

The economizer-type system functions as a standard dehumidifier by controlling the humidity, heating or cooling the space, and providing code amounts of outdoor air. Under certain weather conditions, the outdoor air can supply the dehumidification requirements for the pool facility. When this occurs, the compressors are turned off and the dehumidifier acts as a modulating 100% outside air system. The actual amount of time that conditions are acceptable for economizer operation varies from location to location but is estimated to be less than 1500 hours per year. Bin hour programs are available that can be used to estimate economizer operation for the specific location. Refer to Desert Aire Technical Bulletin #7 for a detailed review.

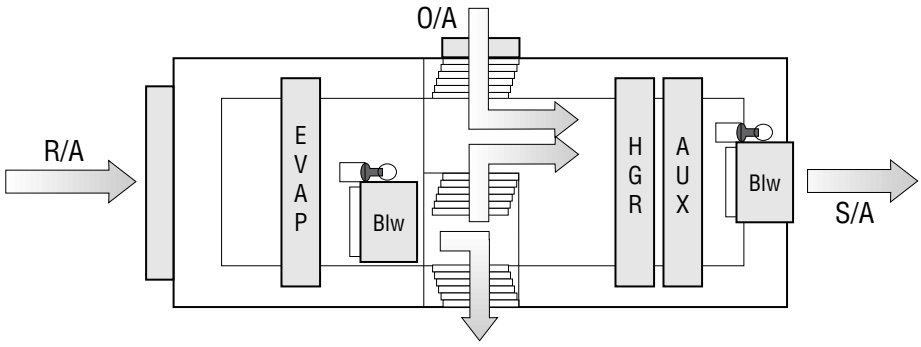

Figure 2 - Economizer Type Dehumidifier

SELECT-AIRE DEHUMIDIFIER

The Select-Aire dehumidifier utilizes the Standard Dehumidifier design and adds an exhaust blower to balance the outside air ventilation requirements. Refer to Desert Aire Technical Bulletin #6 for a detailed description. This exhaust blower is sized to match the code ventilation requirements only and therefore is smaller than the return air blower used on the Economizer Dehumidifier unit. The Economizer Dehumidifier return air blower handles 100% of the airflow while the Select-Aire exhaust blower is sized to match the outside air.

The key element of the Select-Aire system is the use of dampers before and after the evaporator coil for exhaust air. Figures 3 and 4 demonstrate the differences based on the heating or cooling mode.

In the heating mode, warm, moist air travels over the cold evaporator coil transferring it's energy (sensible and latent) to the refrigerant system. Add the energy from the heat of compression to this recovered heat and you now have a highly efficient heat pump adding energy to the mixed air of the dehumidifier. The dehumidifier, in the heat pump/recovery mode, will achieve EER's approaching 16 to 18 at typical pool room conditions of 82F/50 to 60% RH.

The Select-Aire system in the cooling mode exhausts the humid return air prior to the evaporator, thus utilizing the full sensible cooling capacity on the remaining return air that will be cooled and delivered back into the poolroom.

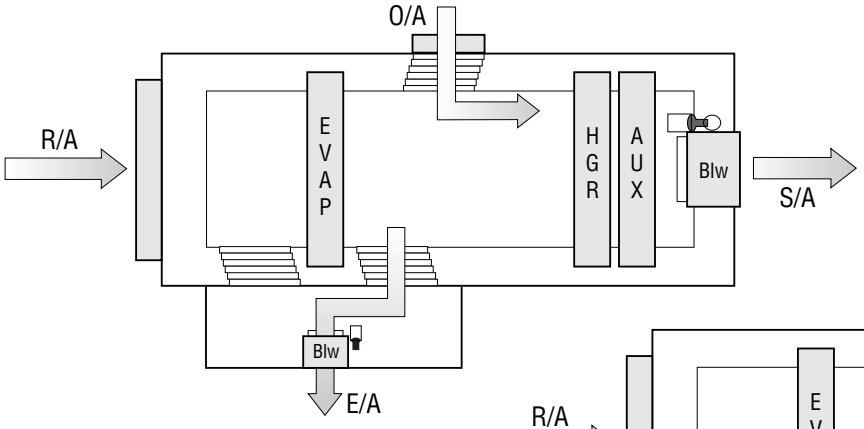

Figure 3 - Select-Aire Dehumidifier - Heating Mode

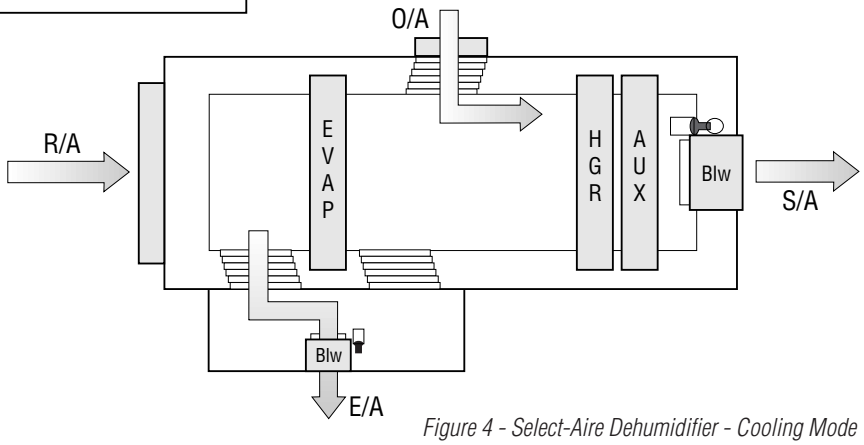

Figure 4 - Select-Aire Dehumidifier - Cooling Mode

ECONOMIZER DEHUMIDIFIER MIXING BOX

The mixing box is located between the return air blower and the hot gas reheat coils, and consists of three dampers, each of which can modulate 0 to 100%. Even though the three dampers can vary, there are several typical positions to which they are controlled. Table 1 provides a summary of the typical damper positions.

When the mixing box is added to the system between the coils, it creates a poor airflow pattern across the hot gas reheat and auxiliary heating coils by forming a dead zone. This poor airflow can cause improper functioning of the downstream coils, and increases the system's internal static pressure.

As with many air handlers that have outside air and return air dampers linked together, the physical installation creates havoc on system airflows. When dampers are almost closed, they exhibit pressure drops up to ten times that of the dampers in the open position. This high-pressure drop increases the blower motor sizes, which increases the operational cost.

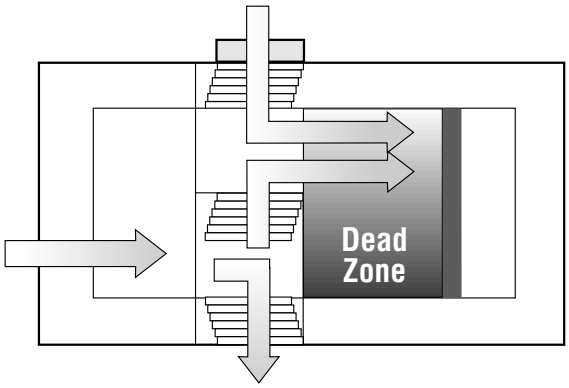

Figure 5 - Mixing Box Airflow

FOOTPRINT COMPARISON

Due to the extra space required for the mixing box and the full-sized return air blower, the Economizer Dehumidifier requires significantly more floor space than the Standard or Select-Aire Dehumidifiers. In addition to the actual enclosure, the economizer requires that ductwork capable of moving the full system air volume be installed on both sides of the unit, which increases the needed floor space. Exhaust air and outside air dampers can be installed on the top of both the conventional, and Select-Aire dehumidifiers. This will increase the height slightly, but does not require that more valuable floor space be used.

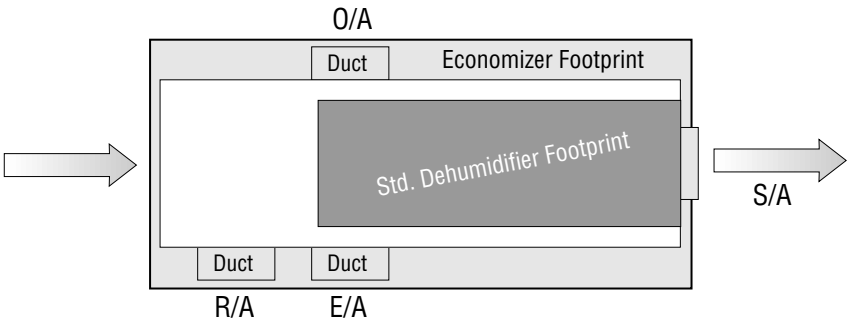

Figure 6 - Footprint Comparison

Mode	Damper % Open		
	O/A	By-Pass	E/A
Unoccupied (All Units)	0%	100%	0%
Standard Dehumidifier including Select-Aire	20% to 30%	70% to 80%	20% to 30%
Economizer Dehumidifier(depends on condition of outside air)	50% to 100%	0% to 50%	50% to 100%

Table 1 - Damper positions

IMPACT OF BLOWERS

Blower sizes for Standard or Select-Aire Dehumidifiers are significantly smaller than those found on the Economizer Dehumidifiers. The Standard or Select-Aire Dehumidifier has one full sized supply air blower and an exhaust air blower. The exhaust blower will be sized to discharge at a similar volume to the amount of code ventilation that is being introduced. The Economizer Dehumidifier requires (2) full sized blowers, a return air blower and a supply air blower. These units must overcome higher internal static pressures caused by the dampers, double filtration and dead-headed mixing of the air plenum.

Because of the high break horsepower requirements of the economizer's blower components, it increases the operational costs of the system. When the Select-Aire system is compared to the economizer system at similar air volumes, the blower energy operational costs are significantly different. This is due to the high break horsepower requirements of the economizer's blower components. Table 3 summarizes the different costs for a typical system.

The use of two full-size blowers that must operate 24 hours per day and overcome the higher static pressure virtually doubles the blower operational costs of an economizer system.

	Standard Dehumidifier or Select-Aire	Economizer Dehumidifier
Supply	15 HP / 13 BHP	20 HP / 15 BHP
Return	N / A	20 HP / 15 BHP
Exhaust	3 HP / 2 BHP	N / A
Total	18 HP / 2 BHP	40 HP / 30 BHP

Table 2 - Blower Specifications for 250 lb/hr System

	Typical Run Time	Standard Dehumidifier or Select-Aire	Economizer
Supply	24 hrs / day	85,000 kWh	100,000 kWh
Return	24 hrs / day	-	100,000 kWh
Exhaust	14 hrs / day occupied	15,000 kWh	-
	Total	100,000 kWh	200,000 kWh
	Cost @ 0.10 / kWh	$10,000	$20,000

Table 3 - Blower Annual Operational Costs (using BHP)

COOLING MODE FOR ECONOMIZER

A major drawback to the economizer-type dehumidifier occurs in the full-cooling mode. Looking at Figure 2, it can be seen that some conditioned air will be exhausted and its volume replaced by outdoor air. Since the cooling mode occurs most often when the outside air is warm and moist, this outside air adds to the internal load and the system's cooling capacity must be significantly de-rated. For example, a typical 50 HP economizer system with 19,000 cfm of supply air and 5,000 cfm of code ventilation will result in a 26% reduction in cooling capacity.

The system would be required to exhaust the 5,000 cfm of cooled air (approximately at 52°F) to the outdoors, while bringing in air that is 75°F to 95°F. Since you cannot deliver the cooled air to the space, the system must be de-rated.

As table 4 demonstrates, placing the mixing box after the cooling coil significantly impacts the efficiency of the economizer system. The reduction in cooling capacity is normally not considered in the payback analysis of the dehumidification systems.

Another argument is that the economizer system can offer free cooling. Free cooling occurs when the outdoor air is cooler and dryer than the indoor air. It can provide cooling and dehumidification without the use of the compressors. The geographical location of the system determines how often conditions are suitable for the economizer or "free cooling" mode. The frequency of these conditions can be predicted using a detailed bin hour weather program.

As a rule of thumb, many engineers will use a maximum of 1,000 to 1,500 hours per year for their estimate of free cooling. In most geographic areas this time is well below 750 hours. In our example, the compressor consumes 44 kW, which would yield savings of 66,000 kWh by utilizing free cooling for 1,500 hours. At $0.010 electrical cost this translate to a $6,600 annual savings by turning off the compressors. This is a maximum benefit and under most climatic conditions, the savings would be far less.

COMPRESSOR EFFICIENCY

The Economizer Dehumidifier design typically uses a full-face evaporator coil versus a Standard Dehumidifier that uses a 6 or 8 row evaporator coil coupled with a bypass air damper. The full-face coil is less expensive to install, but causes the system to operate at a higher suction temperature to remove the same amount of moisture. When a refrigerant system runs at a higher suction pressure, the compressor must work harder and experiences a reduction in efficiency.

	Economizer Reheat Mode	Economizer Cooling Mode	Select Aire All Operating Modes
Evap Cap BTUH	568,000	568,000	560,000
Lost Evap Cap BTUH	0	149,000	0
Net Evap Cap to Room	568,000	419,000	560,000
System kW	67	67	51.8
EER	8.4	6.2	10.8

Table 4 - EER Calculation for a 250 lb/hr System

CONCLUSION

An Economizer Dehumidifier for an indoor pool will not provide operational "economy". This is due to the significant energy penalty of the full-sized blowers and the low system EER in the cooling and dehumidification modes. It will cost more money to operate the Economizer Dehumidifier compared to the Standard or Select-Aire Dehumidifier.

While the Economizer Dehumidifier allows for cooling of the space, it really is not "free" at all. Table 5 summarizes the impact of comparable systems with the assumption that environmental conditions actually allow the "free cooling"mode for 1500 hours per year.

Without considering the impact of the true sensible cooling capacity of the economizer design, it is easily shown that for a poolroom design, the economizer does not provide an operational benefit. The system must compromise too many items to allow the ability to introduce 100% outside air. In addition, even though it has the capability to bring that air into the space, it most often runs in the identical mode as a conventional dehumidifier, but at significantly higher operating costs.

	Economizer Operating Cost	Select Aire Operating Cost	Economizer/Select Aire Difference
Blower Cost	$20,000	$10,000	($10,000)
Free Cooling	$0	$8,805	$8,805
		Net Impact	$1,195

Table 5 - Operating Cost Summary

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