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.

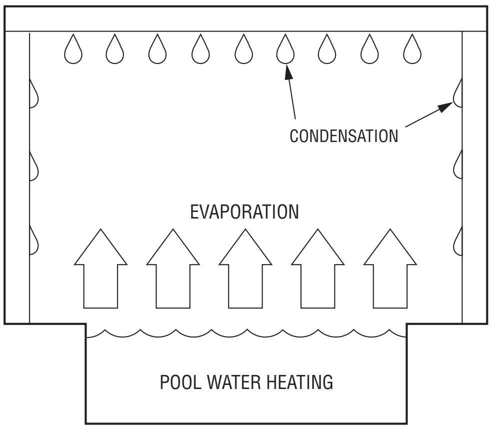

Figure 1 - Condensation Problems

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 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.

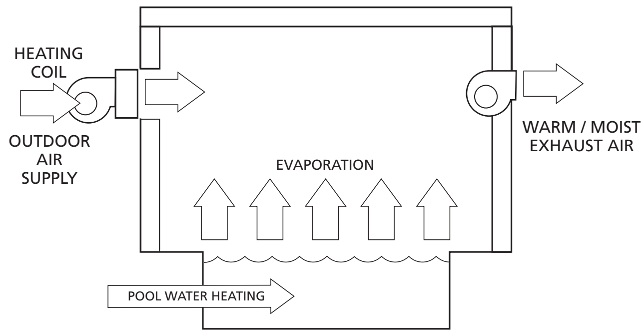

Figure 2- Make-up / Exhaust Method

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

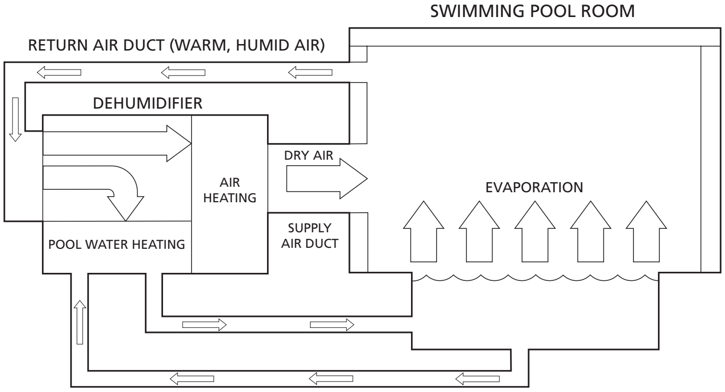

Figure 3 - Dehumidification Schematic

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	CANADA		
CO	Stockton	75	MN	St. Paul	114	PA	Scranton	114			
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%)