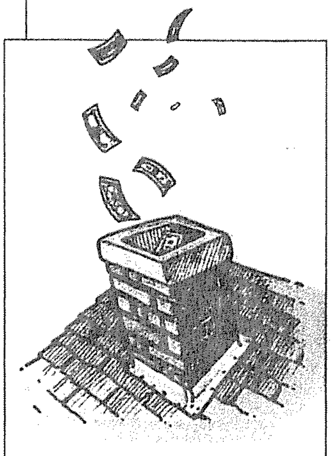

POOL/SPA HUMIDITY CONTROL

by Joseph E. Kielec

Correctly managing indoor pool and spa humidity not only protects the structure they're in, it can guard the health of the people using the facilities.

Heating water for an indoor swimming pool or spa has about the same effect as putting a pot of water on the kitchen stove. As the water temperature increases, so does the evaporation rate and the relative humidity of the surrounding air.

As this moisture laden air encounters cool surfaces such as windows, ceilings, or outdoor walls it also cools, losing its ability to hold moisture, and water condenses onto the surfaces.

This process continues as long as the water is heated. In a typical indoor residential swimming pool, it can result in as much as 100 gal. of water being given up by the pool every day of the year.

These gallons of moisture can permeate an indoor pool enclosure creating problems wherever it cools to the dew point and condenses. Areas where the moisture carried in the air condenses on cooler surfaces may become havens for fungus, mold, and mildew which can give off potentially dangerous biotoxins.

This moisture-laden, hot, humid air is uncomfortable for everyone in the area except the swimmers, and it limits the area for other recreational activities.

Gaps in moisture barriers can give this water vapor access to low temperature building structural members, where hidden condensation deposits accumulate unseen for years. Add unavoidable decay accelerated by mold and fungus to the fact that wet wood has a fraction of dry wood's strength, and long term building problems and premature structural and equipment failures are inevitable.

Evaporation also transfers energy from the pool or spa to the surrounding air then to the condensing surfaces or exhaust air. This energy loss from a typical indoor pool can be in the range of 40,000 BTU/hr., which is what you might expect from an entire moderately sized (2,000 sq.ft.) home.

One traditional approach to dealing with all this humid air is to simply open all the doors and windows in the pool area and let Nature dehumidify with drier outdoor air. This passive approach might work on days when the outdoor air is at the same temperature as that desired in the pool area and with a lower relative humidity.

These conditions rarely exist, however. So you get the same nasty results as listed above, with the added unpleasantness of high pool heating costs, because the pool heat energy is literally being "thrown out the window."

A second, and slightly more sophisticated, dehumidification method is to build a ventilation system where exhaust fans remove the humid air and make-up air units bring in fresh air and either heat or cool it to the desired temperature.

This "conditioned" air is then circulated around the pool area in

Active dehumidification systems control damaging and health threatening humidity in indoor pool and spa enclosures. Registers at the base of each window provide warm, dry air from the dehumidifier to wash over these condensation surfaces.

the hope that it will be dry enough to absorb some of the excess moisture, become humid itself, and be vented through the exhaust fans.

The HVAC equipment required to accomplish this is costly to both install and operate. It consists of a pool water heater, and large, noisy exhaust fans. There are also high capacity heaters to bring the large volume of incoming air up to comfortable temperatures in winter, and large capacity cooling equipment to cool and dehumidify the air in summer. When you add in proper controls, this can be the most expensive of all dehumidifying alternatives.

Operating costs of old fashioned ventilation systems are also the highest of any available alternative.

Energy is just poured into the system to heat the pool water as well as to either heat or cool the large volumes of ventilation air, which is all simply exhausted from the structure along with the latent heat of evaporation from the pool.

This traditional ventilation and exhaust method simply cannot work when the outdoor air has the same or higher moisture content than the indoor air (above 61F and saturated). Further, it requires high enough air volumes to make the structure drafty and uncomfortable, and is so costly to operate that many pool owners end up turning it off to save money.

This then produces the same unhappy results as the "Mother Nature" approach to dehumidification, but it costs a lot more to operate.

Active dehumidification is the modern way to treat excess pool humidity. The technology is in place today for a closed loop energy recovery system based on the *Carnot Cycle* (which, according to ASHRAE's 1986 Terminology guide, represents the maximum theoretical conversion of heat energy into mechanical energy). These systems actively dehumidify warm, humid, indoor pool air, recapture both the sensible and latent heat energy and recycle it back to the pool water and surrounding air.

When properly sized and custom engineered for a particular pool, you'll find this type of system maintains specific design relative humidity and water and air temperature operating conditions independently of outdoor weather. And it does it at predictable and reduced operating costs.

Figure 1 illustrates a typical basic system composed of a chilled dehumidifier coil, refrigeration compressor, pool water heater, air reheat coil, and a blower.

When the system is operating, the blower pulls warm moist air through the dehumidifier coil, which is chilled to maintain a surface temperature lower than the dew point. This creates condensation of the evaporated pool water in a controlled process and location so it can be drained.

As the moisture cools and changes state back to a liquid, it releases sensible and latent heat energy which is captured by the refrigerant flowing through the dehumidification coil.

The refrigerant vapor is drawn into the compressor where its pressure and temperature rise. From the compressor, this *superheated* vapor is discharged to the pool water heater.

Filtered pool water is pumped through the inner tube of a double wall, vented, coaxial tube-in-tube heat exchanger where it absorbs heat energy from the superheated refrigerant vapor and is then returned to the pool with a typical temperature rise of 8F to 10F.

The air reheat coil is the next step in the refrigeration circuit for the partly condensed refrigerant. It gives up its remaining heat and condenses back to a *subcooled* liquid as the air, which was cooled and dried by the dehumidification coil, is pulled over it and reheated.

Warm dry air is discharged into the pool air distribution system where it's ducted to wash over cool surfaces such as exterior windows and walls and raise the localized dew point to limit condensation.

The typical system includes control circuitry to prioritize calls for dehumidification, water and air heating as well as cooling through a remote outdoor condenser. Supplemental room air heat might be required in colder climates with significant winter heat losses.

Several factors come into play when you're determining evaporation rates. The rate of evaporation is driven by your target relative humidity, as well as the expected evaporation rate which results from the water and air temperatures you wish to maintain. Typical design parameters are:

- Relative humidity: 50 - 60%

  Pool water temperature:
- Commercial 78 - 80F
- Residential 82 - 84F
- Therapeutic 86 - 90F
- Whirlpool 98 - 104F

Air temperatures are usually maintained at 2F to 4F degrees higher than the water temperature of commercial and residential pools. This is done to limit evaporation and the chill effect on

Using ASHRAE prescribed evaporation rates, the calculation at right shows how to determine evaporation and energy loss rates for a typical indoor swimming pool and spa.

Pool Evaporation Rate

(at 60% Relative Humidity)

Pool water temperature 84F
Air temperature 86F
Pool area .... 1,200 sq.ft.
Spa area .... 80 sq.ft.
Spa evaporation rate .... 0.218034 lb./hr./sq.ft.
At rest evaporation rate .... 0.021821 lb./hr./sq.ft.
Moderate activity evaporation rate .... 0.027276 lb./hr./sq.ft.

At rest evaporation = pool at rest + spa at rest
=(Pool area × pool moderate activity evaporation rate) + (Spa area × spa evaporation rate)
=(1,200 sq.ft. × .027276 lb./hr./sq.ft.) + (80 sq.ft. × .218034)
=32.7 lb./hr. + 17.5 lb./hr.
=50.2 lb./hr.

Total at rest evaporation .... 34.9 lb./hr.
Total moderate activity evaporation .. 50.2 lb./hr.

WARNING: evaporation rates will increase substantially if the deck area is wet, if the air temperature is lowered, or if there is considerable splashing.

Evaporation rates are based on ASHRAE Applications Handbook pp. 4.7 to 4.9, at 60% rh.
At rest evaporation rates are at an activity factor of .5
Moderate evaporation rates are at an activity factor of .625

Assuming 4 hrs. of moderate activity per day, this pool and spa will evaporate 108 gal. of water per day, and the average heat loss of the pool and spa water will be 39,322 BTUH.

4 hr. at 50.2 lb./hr. + 20 hr. at 34.9 lb./hr.
=200.8 lbs. of moisture in 4 hours + 698 lbs. of moisture in 20 hr.
=898 lb. of moisture evaporated per day.

At 1,050 BTU latent heat energy/lb. of evaporation, pool heat loss is:
52,710 BTU/hr. when in use
36,645 BTU/hr. when at rest

bathers coming out of the pool. Reducing the air temperature below that of the water increases evaporation and operating costs and should only be considered if the pool area is used for certain other non-pool activities.

Equipment manufacturers usually provide guidelines for sizing their equipment based on evaporation rates derived from the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) *Applications Handbook.*

These are typically used for estimating the base evaporation rate with adjustments for daily hours of use, unusual air velocity over the pool surface, wet floors around the pool, activities such as splashing or agitation, and spectators.

It's reasonable to expect daily fluctuations in usage with resultant variations from specified design parameters that will raise relative humidity to the 60% level temporarily. The moisture removal capacity of a well-engineered and properly-sized system will increase as relative humidity levels rise in order to compensate for this rise and return the pool area to the target range.

A properly sized and installed dehumidification system will operate nearly all the time as it keeps pace with the constant evaporation from the pool. While this may seem costly, life cycle cost comparisons have consistently demonstrated that active dehumidification by design is significantly more economical than any other alternative. CP

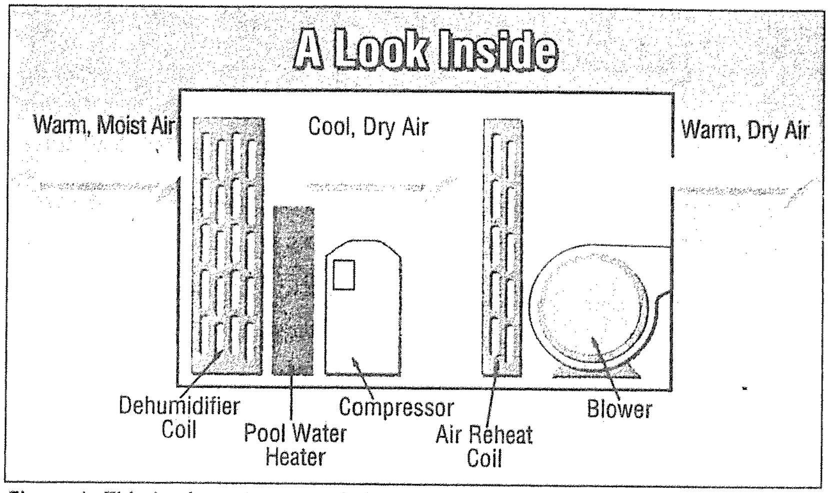

Figure 1. This basic system, consisting of a chilled dehumidifier coil, refrigeration compressor, pool heater, air reheat coil, and blower, dehumidifies the indoor pool air, captures sensible and latent energy and recycles back to the pool water.