LIQUID DESICCANT AIR CONDITIONING:

The revolutionary deep drying dehumidification system delivering energy efficiency and healthier indoor air

BY STEVEN WELTY

IT'S NOT THE HEAT, IT'S THE HUMIDITY.

Before the invention of air conditioning, if you wanted to control indoor humidity you'd just open a window or door. Unfortunately, that was a moot exercise if it was humid or raining outdoors. Ironically, human comfort wasn't the motivating factor for the first applications of air conditioning. Early air conditioning systems controlled humidity in factories where moisture was degrading the manufactured products and/or the equipment. Today, Carrier's cooling coils are still quenching airborne moisture by providing a cold dew point on the coil's surfaces for humidity condensation. Delivering 72° air with 50% relative humidity in your healthcare or research buildings is achievable as long as your cooling coils are clean and your systems are sized right and working properly.

So everything is fine until your double-gowned surgeons start demanding 65° air (or colder) with 50% rh. to keep them from sweating out a pound of water *per hour* during long surgeries. They also don't want condensation fogging up their facemasks along with their microscope lenses in these colder temperatures. The challenge is that these mild mannered surgeons are asking you to dial down operating rooms temperatures using 100% outdoor air. Cooling 90° outdoor air to 60° is possible, but you'll need to pump in 47° or lower air to achieve that. Removing enough humidity from 100% outdoor air in order to hit 50% rh. is a bigger problem to solve.

SOLID DESICCANT

Unless you have a dedicated humidity removal system with reheat or desiccant wheels, you can't even think about delivering 50% rh. humidity at 65° with 70% rh. outside air. The challenge with solid desiccant wheels is that they need to be bombarded by 200°+ heat in order to fry off the desiccant's recently captured humidity. The humidity removal process is known as *regeneration*. This allows the newly dried desiccant to once again grab more humidity as the wheel is rotated back around to the outside air stream. The problem is that newly toasted wheel can heat the outdoor air up to 110° or more! This 110° heat train slams into your HVAC unit challenging it to cool it back down to 60° - 65° in one pass. As you can imagine, you'll need significantly more reserve tonnage to achieve that temperature drop. It's likely that your building's engineering forefathers didn't specify that reserve in anticipation of today's low temperature requirements. In addition, they probably didn't anticipate the concurrent humidity requirements with those lower air temperatures. It's no real consolation with desiccant dehumidification wheels that even though you've slain the humidity/latent load, the heat/sensible load still broke into your building.

RAINDROPS KEEP FALLING ON MY HEAD

If you want to merely cool the air from 72° and 50% down to 65° using just your cooling coils then you'll be stuck with 65% rh. tropical conditions. With 65°and 65% rh., your surgeons are not going to be happy for these reasons:

1. With the dew point now at 52.3°, 47° supply air can chill metal surfaces to 52.3° or bellow, causing water droplets to condense.

2. The surface moisture will allow bacteria and mold to grow millions of clones.

3. At 65% rh. your surgeons' sweat will stick to their skin more than at 50% rh, making them highly uncomfortable.

Humidity & Temperature control in the Operating Room			
Temperature	**Humidity**	**Dew Point**	**Grains/lb. of air**
72°	**50%**	**52°**	**58**
65°	**65%**	**52°**	**58**
65°	**50%**	**46°**	**46**

If your cooling coils can't capture enough humidity to drop the relative humidity below 52% then surgical suite condensation droplets start forming on metal surfaces like lights and ceiling air grilles. Condensation droplets will inconveniently drip down as raindrops on the surgeons, staff and patients during surgical procedures. Good thing the patients are sleeping otherwise the spring showers might wake them up. Condensation supports visible and hidden mold and bacteria growth, which can multiply with higher humidity conditions. Bacteria- and mold-contaminated water dropping onto and into patients' bodies can compromise the infection control of any surgical procedure.

During procedures, surgeons sweat profusely[1] in the hospital operating theaters. The surgeons are standing and working with tensed muscles and minds for hours at a time. Many surgeons are doubled-gowned which adds both additional insulation layers and another moisture barrier. Those layers prevent a surgeon's perspiration from diffusing off their skin and out through the garment. Loads of trapped sweat will annoy any surgeon, not to mention whomever they end up complaining to.

Adding to our surgeon's misery is that operating rooms have multiple lamps which crank out two types of heat:

1. Convection heat causing the air temperature to rise around the table.

2. Radiant heat which penetrates through the surgeons clothes and heats up their body.

Add all these together can cause surgeons to lose up to 2 pounds of sweat an hour. The keys to preventing your surgeons from sweating are lowering dry bulb air temperatures while maintaining a 50% relative humidity and keeping an eye on your grains of moisture per pound of air.

LIQUID DESICCANT AIR CONDITIONING TO THE RESCUE

When surgeons are demanding that you cool 100% outside air to 65° and remove enough humidity to hit 50% rh., the only way to accomplish this is by supplementing your HVAC systems with desiccant dehumidification. Desiccant dehumidification can successfully remove the extra latent/humidity loads in order to prevent dew point conditions from occurring in the operating suites.

While dry/solid desiccant dehumidification wheels systems are most common, liquid desiccant dehumidification systems can turbocharge your current system's ability to remove loads of humidity. Historically HVAC systems were designed to deliver 72° and 55% rh. air due to cooling coils ability to condense out enough moisture to hit 55% rh. In humid climate zones, engineers regularly dial in reheat coils in order to raise the delivered air's temperature so that cooling coils can wring out enough moisture to hit that 55% rh. target. Not only is that expensive and energy inefficient but if you want to dry to 65° and 50% rh. or below, you'll need a technology to remove both the extra latent load and sensible load. Here's where a Liquid Desiccant Air Conditioning (LDAC) system can deliver the cool and low-humidity air necessary to satisfy any surgeon's operating room requirements.

THE NEW REVOLUTIONARY OPTION FOR HUMIDITY CONTROL

ASHRAE provides a nice review of HVAC liquid desiccant dehumidification in chapter 23 of the 2008 HVAC Systems and Equipment and in chapter 32 of your 2009 Fundamentals book. These chapters also cover solid desiccants so here's a quick comparison to illustrate the differences between the two.

I'll assume you're already familiar with solid desiccant dehumidification, so I'll focus on liquid desiccant dehumidification. The main benefit of a Liquid Desiccant Air Conditioning system is that it can grab most of your latent load in one pass. Used in a 100% outside air application, an LDAC system can easily dry off your ventilation latent cooling load before it rides into your building to wreak havoc. Since the majority of your latent load is from OA, this deep drying technology can reduce the building's entire latent load.

LIQUID DESICCANT AIR CONDITIONING CAN DRY YOUR COOLING COILS.

While we've leaned on Carrier's invention to dehumidify along with cooling, we've assumed that cooling coils must always function to condense airborne water vapor. Relying on inefficient cooling coils to dehumidify is getting more expensive with rising electrical rates. There are many negative health impacts of airborne mold and bacteria growth on any HVAC interior surface. Wet coils are mold and bacteria growth factories because condensate does an excellent job of plucking them out of the air and nestling these germs in the warm waters of life. That's why dry cooling coils are the most significant health improvement in HVAC systems; they prevent germ capture and replication.

Richard Shaughnessy et al.[3] measured a 1,000% increase in airborne mold after a coil was wet for only 4 months. This airborne attack was due to condensate soaked cooling coils spewing their resident germs into the airstream. Imagine

		Liquid Lithium Chloride Desiccant Panels	Solid Desiccant Wheels
1	% of humidity captured vs. desiccant weight	**130%**	17%
2	Reduces air temperature	**Yes**	No
3	Additional cooling required	**No**	Yes
4	Hot days can require disabling desiccant wheel[2]	**No**	Yes
5	Degraded desiccant recyclable	**Yes**	No
6	Live germs aren't transferred to incoming air	**Yes**	No
7	Maximum humidity capture in one pass	**Best Choice**	Alternative

this: the rushing airflows over the air handling unit scrubs the mold and bacteria off the coil's surfaces along with aerosolizing them off the drain pan's frothy surfaces lifting them up into the airstream. Technically, this is called "entrainment", but you can envision the picture of all those germs launching into the air like paratroopers jumping out of a plane. These paratrooper germs and their attending odors end up wafting into the occupant air spaces to be inhaled by everyone in the building. That explains why in condensate season, HVAC cooling coils can compromise those patients, staff who are mold and bacteria sensitive.

Since dry coils aren't encased in a biofilm layer of bacteria and mold, which acts like insulation, they don't suffer from Btu transfer performance degradation. Liquid Desiccant Air Conditioning systems can create dry, mold free cooling coils which perform close to as-new condition significantly improving their energy efficiency. The best example illustrating the energy inefficiency of mold insulated coils can be found in a 2003 case study documented in Engineered Systems[4]. A mold coated cooling coil was irradiated with UV light and "in a couple of weeks" restored it back to as-new performance. The germicidal (germ-killing) UV light removed the mold insulation layer surrounding the coil allowing it to provide significantly better Btu transfer. The clean coil produced a 4° drop in exiting temperature along with improved air flow. This intervention created a 40% air pressure drop over the coil delivering a 28% increase in the coil's energy efficiency in addition to reducing fan amperage draws from the motors.

Health benefits of dry coils

Another benefit of cool dry air within the HVAC system is it can eliminate condensation on HVAC interior surfaces especially those downstream of the coil. When condensation droplets trap mold spores and airborne food like skin flakes and paper fibers, I call this germy condensation creation phenomenon "mold soup". Since mold quickly replicates in mold soup, preventing its formation will stop airborne germs from flying into occupied air spaces which can negatively impact everyone's health. Infection control officers will love this reduction in your airborne germload/bio-burden.

Dick Menzes et al.[5] documented the impact of nearly eliminating mold and bacteria from coils and drain pans in 3 office buildings finding that:

- 20% of all occupants felt healthier and
- 40% of occupants with allergies or asthma felt healthier.

Since copper is toxic to mold and bacteria, copper cooling coils were installed in an HVAC system in a study headed by Liv Haselbach et al. to investigate the benefits of mold- and bacteria-free coils. The 2009 study documented the health impact of mold-free copper coils in a military housing facility[6]. They tracked the health of the soldiers living in rooms served by copper coils. Soldiers fed by air moving over copper coils were found to have significantly less respiratory illnesses and lost sick time due to lowered airborne levels of bacteria and mold.

Health benefits of Liquid Desiccant Air Conditioning Systems

Liquid Desiccant salt solutions kill germs unlucky enough to be trapped by it. Imagine airborne germs impaling the liquid desiccant solution; it yanks the germs out of the airstream and then transports them away like a bug flying into Niagara Falls and being washed downstream. In 1979, a Batelle[7] study confirmed the toxic power of liquid desiccant's germicidal properties where they showed that lithium chloride was lethal to both bacteria and viruses.

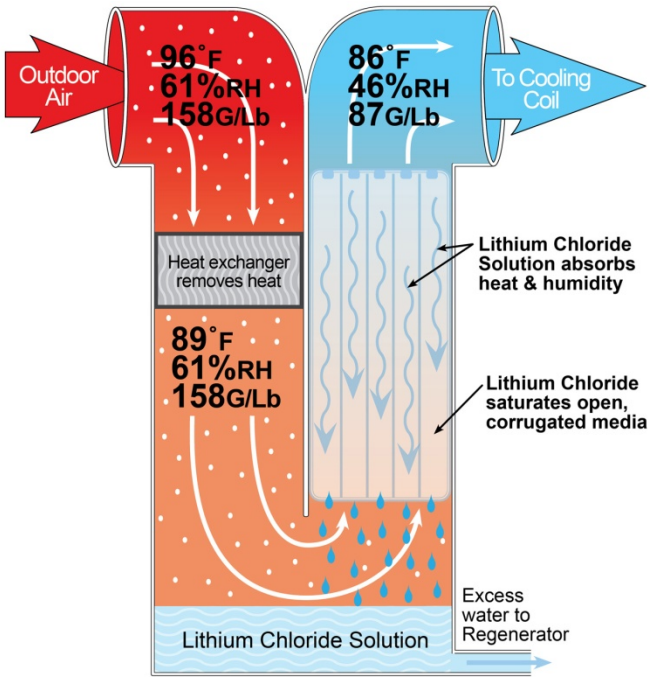
DESICCANTS AND ENERGY SAVINGS

Liquid Desiccant Air Conditioning systems empower you to reduce the humidity in your facility to 45%. Wal-Mart dehumidifies their stores down to 45% rh. allowing them to raise their set point temperature from 72° to 76° F. That 4° increase is saving those stores 15% or more on their HVAC energy due to a solid desiccant dehumidification system drying the outdoor air. Wal-Mart's U.S. operations energy use at 25 kBtu per square foot is one of the lowest in the world. Wal-Mart's stores save $50 million a year from energy efficiency measures which include strategies like desiccant dehumidification. LDAC systems can easily deliver 45% rh. for your entire facility.

How liquid desiccant systems dehumidify

Ideally you'll start off with a cool lithium chloride (LiCl) solution within the primary process air module. That's possible if chilled water is available from a cooling tower or geothermal well to remove the heat from the liquid desiccant before it enters the top of honeycomb panels.

This cool, concentrated LiCl solution flows down over the honeycomb media surfaces absorbing the air's sensible heat and moisture vapor (humidity) as the air flows upward. The absorbed moisture dilutes the lithium chloride solution within the first module and the excess water is continuously transferred over to the secondary regeneration module. The reconcentrated desiccant solution is cooled again and returned to the top of the vertical panel in the primary module. The secondary module drizzles the diluted lithium chloride down the honeycomb material to desorb off its excess moisture into the upflow airstream while added heat increases the moisture desorption process. This heat may be from scavenged sources or generated by a renewable heat source like solar thermal power. The system is in a self contained unit which usually sits on a rooftop and is connected to the outdoor air intake and to a water line coming off the cool water source. Solar photovoltaic energy can supplement the electric power to the units making LDAC an ideal choice for a 100% renewable energy air conditioning system.



Here's a summary of the benefits of Liquid Desiccant Air Conditioning systems:

1. It allows you to downsize your current cooling equipment capacity.

2. You can raise the temperature set points and still maintain occupant comfort.

3. Higher set points allow you to reduce equipment run times and compressor output levels.

4. You can add renewable energy sources (solar, geothermal) and waste energy to increase your energy efficiency even more.

5. Lithium Chloride solution can capture and kill bacteria and viruses which improves your Indoor Air quality and the health of your occupants.

6. Less bacteria and mold formation in your HVAC systems reduces airborne germ levels which will please your infection control officer.

7. Unlike solid desiccant wheels, liquid desiccant does not transfer germs from the exhaust air over to the incoming outdoor and recirculation airstreams.

8. LDAC systems offer simple installation for new or retrofit applications.

9. LDAC system's energy savings can offset capital equipment costs for a positive ROI and rapid payback timeframes.

#1-4 can reduce your HVAC energy costs by 30% or more depending on your location providing rapid payback times. It's clear that Liquid Desiccant Air Conditioning systems have many unique advantages which make sense for multiple healthcare applications. Happy surgeons, healthier patients and staff, and green energy efficiency benefits make LDAC systems worth the effort of further investigation for your facility or one of your colleagues.

REFERENCES

1. D. Brune 1989 Occupational Hazards in health professions page 44 CRC press
2. Engineered Systems May 2000 page 28/
3. Levetin, Shaughnessy et al. April 2001 Effectiveness of Germicidal UV Radiation for Reducing Fungal Contamination within Air-Handling-Units. Applied and Environmental Microbiology
4. Firouz Keikavousi 2003 UVC: Florida Hospital Puts HVAC Under a New Light. Engineered Systems
5. Dick Menzies et al. November 2003 Effect of Germicidal Lights Installed in Office Ventilation Systems on Worker's Health and Wellbeing: Double-Blind Multiple Crossover Trial Lancet
6. Liv Haselbach et al. 2009 Airborne Transmission via HVAC of Acute Respiratory Infections in Military Facilities? Review of a Basic Training Cohort Study. Journal of Green Building, 4(1)
7. Ralph T Mitchell 1979 Battelle Memorial Institute Project N-0914-5200 Battelle Memorial Institute, Columbus Ohio

About the Author

Steven Welty is a specialist in airborne infectious diseases, filtration and HVAC energy efficiency. Steve uses computer modeling to design airborne infection control systems using ultraviolet light, photocatalytic oxidation, Bi-Polar ionization and high MERV filters. Steve is an IAQ investigator who solves air quality issues in hospitals, office buildings, schools and homes.

Steve is a LEED® AP, CIE (Certified Indoor Air Environmentalist) and a CAFS (Certified Air Filtration Specialist). Mr. Welty is chairman of the Indoor Environmental Standards Organization (IESO) committee which is writing a new school IAQ standard: "Standard Guide for the Inspection of an Educational Facility for Moisture Intrusion and Mold Growth".) Mr. Welty has extensively lectured on and written articles about airborne infectious diseases, HVAC energy efficiency, indoor air quality, air filtration and liquid desiccant dehumidification. Steve is the President of Green Clean Air based in Reston, VA. steve@GreenCleanAir.com 1 703.927.7532.