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HOT CORRIDOR, COOL SOLUTIONS

Hotels and high-rises can be prone to humidity issues if the outside air strategy is off. Check into waste heat reclamation tactics that can make for a pleasant stay, via one Chicago condominium.

INSIDE

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HOT CORRIDOR, COOL SOLUTIONS

Hotels and other high-rise buildings can easily develop indoor humidity issues if they don't deal properly with the outside air component of their ventilation design. Reclaiming waste heat in a way that suits the circumstances can be a pivotal step toward correcting or avoiding such problems. With a Chicago condo as one example, learn to work through assorted benefits and caveats to reach the right fix.

By David Brooks, P.E., and Daniel McJacobson, P.E.

In 2015, residential and commercial buildings accounted for about 40% of total U.S. energy consumption.[1] It's no wonder, then, that every building — large and small, public and private — is looking to reduce its energy expenditure. Whether working toward a certification of sustainability or simply acting as an environmental steward, most companies realize that building and operating an efficient facility makes good business sense. It is up to the building designers to implement cost-effective strategies for conditioning and for the building operators to use the strategies wisely.

An often overlooked casualty of energy conservation is latent heat, or moisture. A good example of this is the use of free cooling with outside air by way of an air-side economizer. By taking advantage of cool exterior temps, compressors can be shut off, and instead the building can be conditioned with free outside air. But, when the air-side economizer system isn't designed or operated correctly, bringing outside air in can lead to another major problem — high moisture levels in the building. This can cause damage to the building and comfort issues for the occupants.

In the case of high-rise residential and hotel buildings, 100% outside air is commonly supplied as makeup for toilet and kitchen exhaust. The result is sometimes stepping out of a comfortable, air-conditioned suite or apartment only to find a stuffy hallway because cool, moist outside air was dumped into the building's common area with little to no latent conditioning. This can also lead to mold growth.

Another situation that can lead to potential high humidity levels is when a DOAS is used as a system strategy without accounting for latent loads. There are many variations, but generally, the building conditioning loads are bifurcated from the outside air loads with the use of a dedicated outdoor air handling system (DOAS). A DOAS is used in conjunction with interior conditioning strategies such as chilled beam and VRF systems. If the DOAS simply tempers the air to be neutral to space temperature, large quantities of moisture can be introduced into the building during humid outdoor air conditions. High indoor humidity levels can also cause unwanted condensation at chilled beams and VRF fan coils.

Preventing high indoor moisture levels is extremely important for the health of the building and its occupants. Why doesn't every system employ dehumidification? The answer is that it's a costly endeavor. A tried and true method of dehumidification requires cooling the air down to below the dew point of the desired interior space condition (commonly between 55°F and 60°F dew point) in order to shed the moisture, and then sometimes heating it back up to meet occupant comfort needs, as the blue line shows in Figure 1.

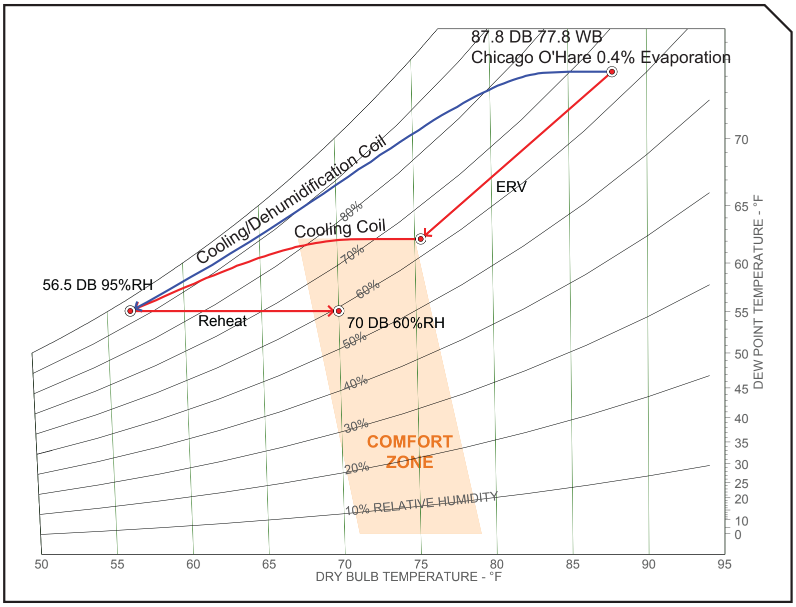

FIGURE 1. Psychrometric chart contrasting cooling coil with vs ERV process. A 1.0 clo thermal comfort zone is shaded for reference.

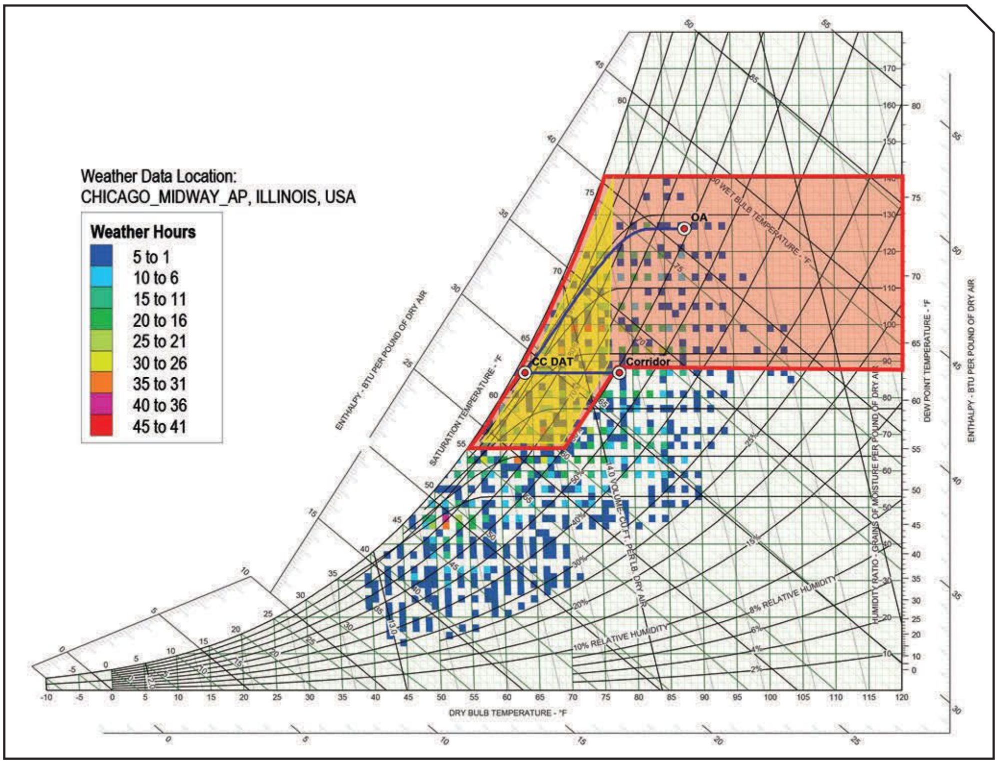

FIGURE 2. Bin data heat map for the cooling season, with yellow area indicating high humidity conditions that do not require sensible cooling. Red area indicates conditions where sensible cooling and dehumidification are required.

This process consumes substantial energy, leading to high operational costs and requiring a serious investment in equipment. For those who employ an air-side economizer to preserve energy and expense, dehumidifying the air can seem to defeat the purpose. As seen in Figure 2, when the outdoor air is in the area shaded red, dehumidification is required. Further, the area shaded yellow is where a dry-bulb controlled air side economizer would supply highly moisture-laden air into a building.

ACHIEVING OPTIMAL ENVIRONMENTAL CONTROL

Moisture removal is key to maintaining optimal IAQ and occupant comfort as well as for maximizing the life of a facility's interior furnishings and equipment. A number of existing conditions will determine the optimal dehumidification solution for a facility, including occupant density and building function. The maximum desirable humidity level for interiors is around 65% rh.

There are several reasons for this. First, this falls within the recommended range of human comfort as defined by ASHRAE Standard 55-2013 (Figure 1 shows the human comfort zone). Additionally, humidity above 65% increases the likelihood of microbial growth.

For the purpose of discussion, let's look at a design day in Chicago. If one were to dehumidify using the tried and true cool/reheat method as shown in Figure 1 (blue line), the energy consumed would be about 100 Btuh per cfm, of which 15% is reheat energy. Reducing or eliminating the reheat load would make the dehumidification process much more palatable to building owners and operators.

There are several ways to minimize the reheat energy associated with dehumidification. One way is to use waste heat for reheat, which could come from hot gas reheat, or reclaimed energy from an exhaust stream or condenser water, to name a few. Another is to use liquid desiccant, which has a low energy regeneration requirement. While these methods aren't typically specified for commercial spaces, the equipment they utilize has become more affordable and accessible and therefore, they are increasingly employable in the average commercial facility.

Dehumidification at a glance

There are a number of options for dehumidification including:

- Recycling waste heat
- Liquid desiccant
- ERV
- Solid desiccant wheel
- Heat pipe

Further dehumidification technical resources:

- ANSI/ASHRAE Standard 160-2009 - Criteria for Moisture-Control Design Analysis in Buildings
- The ASHRAE guide for Buildings in Hot and Humid Climates, Harriman, L. G., & Lstiburek, J. W., 2009
- ANSI/ASHRAE Standard 55-2013 - Thermal Environmental Conditions for Human Occupancy
- 2016 ASHRAE Handbook HVAC Systems and Equipment

RECYCLING WASTE HEAT

Europe has been recycling waste energy for years and become somewhat of an expert at it. Denmark gets as much as half of its electricity from recycled heat, Finland 39% and Russia 31%. Here in the U.S., that number is just 12%.[2] But it doesn't have to be. Recycling heat is actually fairly simple.

Today's buildings — yes, even those high-performing ones — are hugely inefficient in terms of minimizing waste. Reclaiming waste energy in a building offers owners and operators the opportunity to "cash in" on energy they've already paid for. Finding the right heat source is the challenge.

One option is to reclaim some of the heat from the building exhaust. ERVs transfer energy from an exhaust stream to the outside air which pre-cools it during warmer weather (or pre-heats in colder weather). These systems can transfer both sensible and latent energy, which reduces the overall cooling (or heating) load. For example, on a hot and muggy day of 88°F and 60% rh, an ERV could reduce the outside air temperature to 77°F and 60% rh. That's a 70% to 80% reduction in enthalpy. Some issues to consider with ERVs include their large size and their static pressure losses, which cut into the energy savings. The red line in Figure 1 shows how an ERV reduces the required energy for dehumidification.

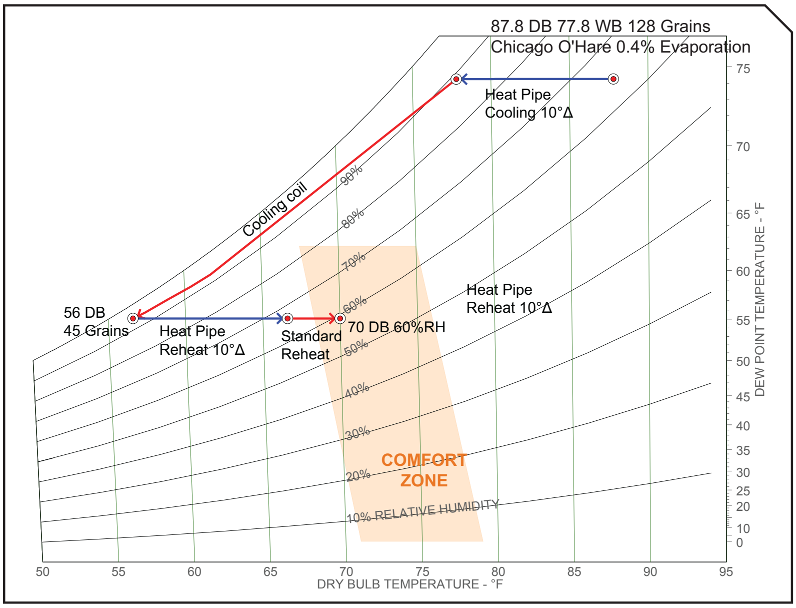

FIGURE 3. Heat pipe energy reduction during cooling and reheat.

Another potential heat transfer option is the heat pipe. A heat pipe is a closed evaporator-condenser circuit that pre-cools the air stream before it enters the cooling coil, and then reheats the air after it leaves the cooling coil. This process will pre-cool and reheat the air just 5 or 10 degrees, which is enough to make a difference and minimize energy expenditure. One issue to consider with heat pipes is that they increase the static pressure drop of an air handler. Unless one installs a bypass, this static pressure drop is a year-round parasitic energy loss. Figure 3 shows the energy reduction of a heat pipe cycle on a psychrometric chart. The system would consume about 75 Btuh per cfm at this state.

A third option is to use waste heat for reheating. There are several potential waste heat options worthy of consideration. A very common one is to use hot gas reheat. This is heat that is normally rejected to the condensing coil but instead is used to reheat air. Another option in a similar vein is to use condenser water from a chiller. Both strategies can add 5 to 10 degrees of waste heat to the air stream. Important issues to consider when choosing a waste heat source include location and building function. Because there likely won't be enough of any one type of waste heat to fully cool or heat the outside air to the specifications of the space, it's important that the waste heat source be physically convenient to the recycling process to minimize installed cost and operating efficiency. For example, if chillers are across the building from the air water reheat coil, it will be expensive and impractical to pipe the condenser water to the air handler.

CASE IN POINT: CHICAGO HIGH-RISE CONDOMINIUM

A condominium in Chicago is considering using waste heat from their chillers to provide reheat in their 100% outside air units. The units have adequate capacity to cool and dehumidify the air; however, the units do not have a reheat coil. This results in high rh levels in the corridors as seen in Figure 4. Attempts to lower the supply air temperature to remove more moisture led to complaints that the corridors were too cold and humid. The high rh unaffected by the discharge air temperature results in occupant dissatisfaction, with notable issues like swelling of woodwork and sticking doors.

The condominium was faced with the difficult choices of potentially installing reheat coils. Electric coils were considered first, but there was not enough electricity in the penthouse to power both the chillers and electric coils (power is allocated such that either the chillers or the existing electric preheat coils can operate, but not both simultaneously). Running new electricity up to the penthouse would have been cost-prohibitive. The condominium then considered utilizing an ERV. Exhaust systems were adjacent to the air handlers, which made the proposition feasible. However, the ERVs were very large, and there was not enough room in the mechanical penthouse for them.

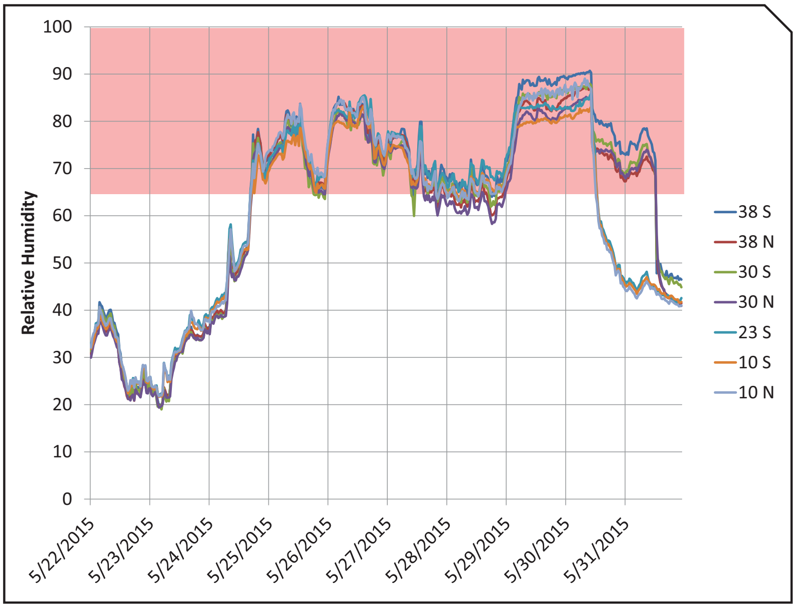

FIGURE 4. Logged relative humidity from condominium corridor showing substantial time above 65% rh threshold.

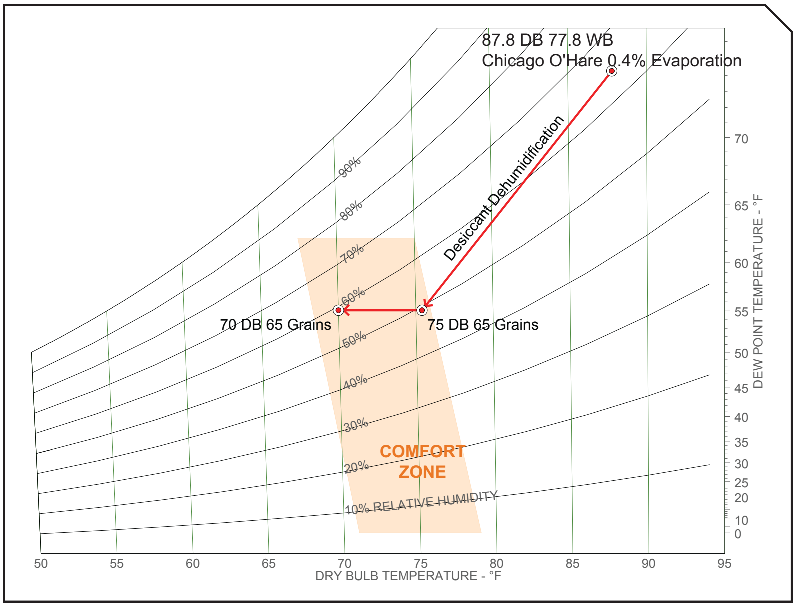

FIGURE 5. Liquid desiccant dehumidification with sensible-only cooling processes.

Finally, cooling tower condenser water was evaluated. With minor modifications to the supply ductwork and condenser water piping, a condenser water coil could be added. The coil would add 10 degrees to the supply air, which would be sufficient to do modest levels of reheat. The system would consume 90 Btuh per cfm, or 10% less energy because of the waste energy usage. The negative aspects of using condenser water in this situation include the maintenance of the condenser coils and the pressure drop. Because the condenser system is an open tower, the condenser coil tubing must be cleaned often to prevent fouling. Also, the system must be drained in the winter, adding some maintenance. Finally, the coil pressure drop is about a 1-in water column, which is, again, a year-round parasitic fan energy loss.

LIQUID DESICCANT

Through a completely different process, liquid desiccants attract moisture, and therefore they can pull humidity from the airstream before it is transferred to the building's occupant zone. Then, the absorbed moisture is moved to an exhaust air stream that subsequently leaves the building. Liquid desiccant coolers require a source of cooling and heating, but both sources can be low-intensity.

Liquid desiccant systems are mostly made up of a water and salt solution. The salt solution is hygroscopic, attracting water. By changing the concentration of the salt solution, moisture can be absorbed in one airstream and then rejected to another. The sources of cooling and heat help regenerate the solution.

One of the biggest challenges to employing liquid desiccant is its high first cost. In addition to the equipment required to process the desiccant, the desiccant itself is corrosive and must not touch other metal components.

As seen in Figure 5, liquid desiccant produces a warm, dry air stream. A small amount of sensible cooling gets the air to appropriate conditions. In this case, the liquid desiccant uses about 80 Btuh per cfm.

DON'T SWEAT IT

With the high cost and high energy expenditure of operating today's buildings, dehumidification tends to be ignored because it is not considered critical. However, lack of dehumidification can cause building damage and occupant discomfort. The above strategies, although not exhaustive, are good examples of how to address moisture control in buildings. The best approach will depend on the building's use and location as well as the owner's budget. An increasingly important ingredient in tomorrow's high-performance buildings is a properly designed dehumidification system. Using waste heat, desiccants, and energy recovery, we can serve facilities today, tomorrow, and long into the future. **ES**

FOTENOTES

1. U.S. Energy Information Administration. http://www.eia.gov/tools/faqs/faq.cfm?id=86&t=1
2. *Popular Science*. http://www.popsci.com/article/science/waste-heat-free-energy-so-why-arent-we-using-it

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