GETTING ACQUAINTED WITH Liquid DESICCANT

The technology is transitioning into critical spaces. Complete with museum and critical storage case studies, this frank primer assesses the advantages and challenges of using liquid desiccants to play a role in tight temperature and humidity control.

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There was a time when energy efficiency was not a criterion for designing critical environments. From data centers to museum exhibit spaces, critical environments required tight temperature and relative humidity control at all costs.

To meet the stringent space condition requirements while still mitigating risk, professional engineers have traditionally used precision cooling units that control humidity by cooling the air below the dew point (vapor condensation) and then reheating it to meet the desired space conditions. While this method is tried and true, it is also energy-intensive. Alternatively, engineers have employed solid desiccant systems to achieve the same results. Solid desiccant systems are typically made of silica gel or activated alumina and use a physical process called adsorption, where moisture is condensed and held on the surface of the material. Although they may require less energy than the vapor condensation systems (assuming a recovered source of heat), engineers have been challenged by the fact that solid desiccant systems are still often more expensive to install and maintain.

As owners and operators move towards the design of more environmentally conscious and sustainable critical environments, stakeholders are calling for a better understanding of the standards and metrics for designing and operating critical facilities. The questions being asked are: Do we need to maintain such high level of control? What are its costs, and are we willing to pay for this level of control? What are the risks if we relax the standards? While the answers to these questions are directed at facility owners, they signal a change in the emphasis from tight control no matter the costs to sustainable control where a balance between risk and energy expenditure is sought.

Enter liquid desiccant technology. Traditionally used in industrial applications (like the petroleum industry) to dry the natural gas, packaged liquid desiccant systems are now available for HVAC applications. When integrated into a complete HVAC system, packaged liquid desiccant systems can be less expensive to install and can use less energy than a traditional vapor condensation or a solid desiccant system.

The reason liquid desiccant uses less energy is because of its low regeneration heat requirement, thereby benefiting from the ability to use low grade rejected heat for regeneration. The best way to demonstrate this is by looking at psychrometric charts. In a vapor condensation process (Figure 1), the entering air (EA) is cooled at or below the dew point of the space temperature to the dew point (DP) temperature. The air is then reheated to a leaving air (LA) temperature that will satisfy the space requirements. The total energy used is the change in enthalpy (Δh^1 plus Δh^2).

In a solid desiccant system (Figure 2), the EA passes through a solid desiccant wheel, where it leaves behind moisture and picks up heat. The leaving desiccant (LD) air follows the enthalpy line until it reaches the dew point of the LA. Then the air is cooled to the LA condition as shown. The energy used is the change in enthalpy as shown (delta h). If there is no waste heat available for regeneration, then the total energy for the solid desiccant process is the delta h plus the regeneration energy, which could double the total energy required.

However, a liquid desiccant process is slightly different. Entering air passes through the liquid desiccant and the LD temperature ends up in a range of possible conditions as shown in Figure 3. If required, additional cooling reduces the air temperature to meet the space requirements. The energy required for this process is the change in enthalpy plus any regeneration energy. For liquid desiccants, the regeneration energy is typically less than the heat of rejection from the cooling process, so no additional energy is required. Liquid desiccant is typically a salt solution, such as calcium or lithium chloride, using a process called absorption, which changes the physical or chemical structure of the material.

Here's how liquid desiccant works: There are two chambers — a conditioning chamber and a regeneration chamber. In the conditioning chamber, room air passes through a cooled liquid desiccant solution that extracts the moisture and cools the air. The dry cool air is then delivered to the space. On the regeneration airside, outside or exhaust air is drawn into the regenerator, where heated liquid desiccant transfers heat and moisture to the regeneration air stream. There is a diffusion port between the two chambers where water diffuses from higher to lower concentration to reach equilibrium. Cooling is done via an on-board DX system, and heat is either rejected to the desiccant fluid or a secondary condenser. Units can also use chilled and hot water if available.

ADVANTAGES OF LIQUID DESICCANT

There are several advantages to using liquid desiccant over solid desiccant, including minimal additional regeneration energy required for liquid desiccants. Ultimately, this leads to lower energy costs, less required infrastructure, and decreased electrical service. According to one manufacturer, operating costs can run between 20% and 40% less than solid desiccant systems, and 30% to 60% less than dehumidification operations performed by conventional HVAC systems. Another advantage, according to some manufacturers, is that liquid desiccant does a better job of purifying the air by filtering particulates and killing bacteria in the air stream.

CHALLENGES TO LIQUID DESICCANT

While the technology is simple and its benefits are promising, a number of challenges still exist to specifying a liquid desiccant system.

The first is that current technology is only built for dehumidification and therefore requires integration with HVAC equipment. Additionally, because HVAC use is relatively new, there is a lack of available performance data, making it difficult to predict how the system will operate under different conditions and in different field applications. Finally, there is a risk that the liquid desiccant could become entrained in the airstream and carry over into the space. This risk is particularly critical if designing for an archival space, and when applicable, the designer must take necessary precautions.

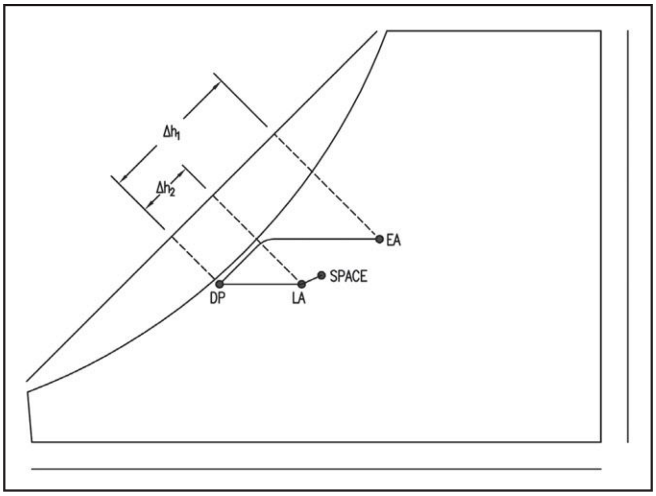

FIGURE 1. A typical vapor condensing dehumidification process requires the air to be over-cooled to drive moisture out of the air stream before being reheated to the required supply air temperature. This process is much more energy intensive.

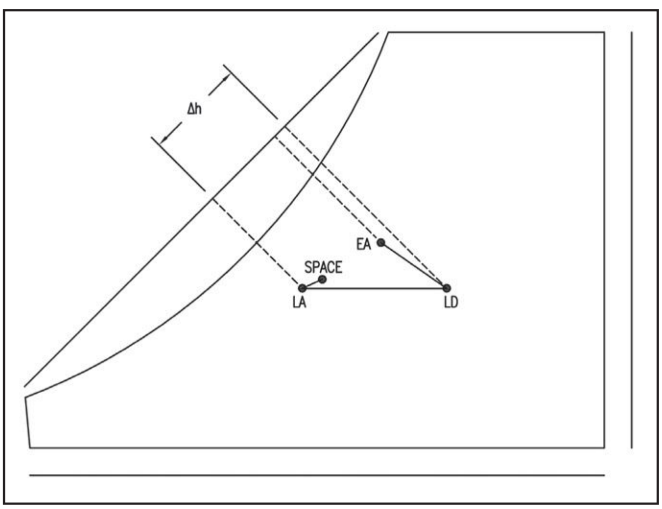

FIGURE 2. A solid desiccant system, or adsorbent process, saves energy vs. a standard vapor condensing dehumidification process since the air is not overcooled to drive moisture out of the air. However, the air must be cooled after the dehumidification process.

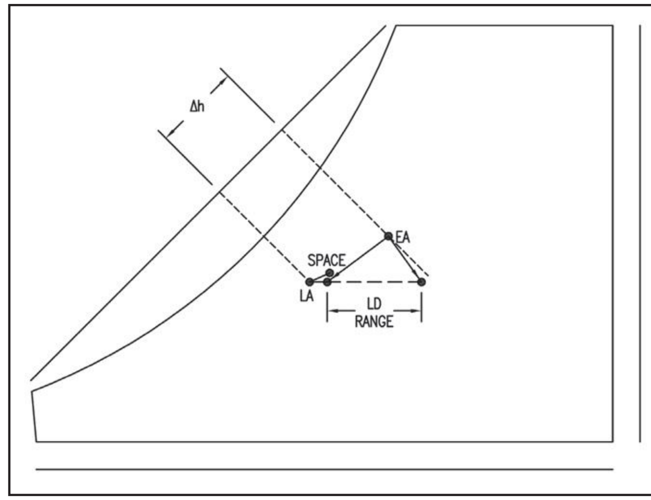

FIGURE 3. The liquid desiccant system, or absorbent process, saves more energy compared to the condensing and adsorbent dehumidification process. The dehumidification process has a more direct route through the psychrometric process to the desired space temperature.

IN THE FIELD

In the meantime, while liquid desiccant technology continues to evolve into a more fully integrated, packaged system, there are already opportunities to apply the systems in select projects with specific humidity requirements. McGuire Engineers has specified the system in two critical facility applications — an enterprise critical storage facility and a museum — that can each serve as an example of successful liquid desiccant integration.

CASE IN POINT A: MIDWEST CRITICAL STORAGE FACILITY

An existing critical storage facility was looking to expand its capacity by tripling the amount of available storage. However, several problems surfaced. First, the facility's new HVAC system was barely maintaining the required 70 degrees +/- 2 and 40% +/- 5, so expanding the existing concept of using precision cooling units was not an option. Secondly, the existing electrical service and backup generator could not support more storage vaults using precision cooling units. And finally, the project had to be completed in less than four months to meet their demand for additional storage.

McGuire turned to a liquid desiccant system to solve the problem. First, available units for immediate purchase were verified. Luckily, there were two units that would meet the facility's needs at the manufacturer's warehouse. Once confirmed, the process of integrating the liquid desiccant system into the design began. The main concept was to use the liquid desiccant system as the first-pass dehumidifier. In other words, the liquid desiccant system would be responsible for removing the bulk of the moisture from the spaces and from the small amount of outside air introduced for space pressurization. Then, precision cooling units were placed in parallel with the liquid desiccant system so that they could fine-tune the specific vault conditions/temperature. Ultimately, this meant the precision cooling units had heating, cooling, humidification, and dehumidification capabilities.

One last challenge remained, however. The hybrid liquid desiccant and precision cooling system exceeded the available power of the existing backup generator. In order not to exceed the available power, McGuire created a sequence of operations that locked out portions of the precision cooling systems and the outside air. McGuire estimated the vault conditions could be maintained for several days under emergency conditions.

CASE IN POINT B: MIDWEST MUSEUM

On another recent project involving a back-of-the-house storage room at a Midwest museum, there was plenty of power available to condition the air. However, limited space and a tight schedule and budget drove the decision to consider alternatives, including the application of a liquid desiccant system.

Because of the expense and long lead time associated with a traditional, custom-made dehumidification system, the engineers decided to go with a readily-available, off-the-shelf ductless split cooling system and a packaged liquid desiccant system. The two were then integrated together with controls so that they could operate in unison to cool and dehumidify the space with precision.

With the cooling unit programmed to hold the temperature at 65°F and the liquid desiccant system set to keep the relative humidity to 35%, it was soon discovered that additional cooling had to be added because the liquid dehumidifier added a small amount of heat, a result of running the system continuously. Once additional cooling was added, the room was held at a constant temperature, but the humidity was still not stable.

After some troubleshooting, the team eventually discovered that the sensor on the liquid desiccant system was only communicating rough humidity levels, and cycling between the lead and lag desiccant systems was causing the system to fail. To solve the problem, a space humidistat was added and a hard relay was set up to override the desiccant's internal start/stop command. After these minor modifications, the dehumidifier and cooling systems are working well together, achieving the precise temperature and humidity requirements of the museum.

CONCLUSION

While the use of liquid desiccant successfully addressed energy efficiency, budget, and scheduling requirements in these two cases, it took some tweaking to make it work, plus additional cooling and controls had to be specified to fill in the gaps where the liquid desiccant system fell short.

Knowing how to integrate and apply a liquid desiccant system is paramount to its success in any application. As noted, it must be strategically specified as part of a larger HVAC system and controls scheme where the systems main job is to dehumidify the air, while also relying upon other HVAC equipment components to provide precision humidity and temperature control.

Moving forward, as more commercial installations are deployed and more performance data is collected, liquid desiccant manufacturers are expected to work out the kinks and design a more fully integrated cooling, dehumidification, and controls package. At that point, liquid desiccant will likely become a more serious alternative to traditional dehumidification. **ES**

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