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Avoiding the wet-duct callback: Ensuring humidification absorption in commercial and industrial applications

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A properly humidified building enhances health and comfort, improves manufacturing processes and preserves materials. However, if not specified correctly, humidification systems can cause unexpected wetness, which can lead to microbial growth in moist ducts and a resulting IAQ problem. But with a basic understanding of the issues that affect absorption, you can provide all the benefits of humidification without worrying about the wet-duct callback.

Basics about humidifying commercial and industrial spaces

- To convert a pound of water into vapor requires about 1000 Btus. This can be accomplished isothermally or adiabatically. Isothermal humidification systems use heat from an external source, such as electricity, natural gas or boiler steam, to convert water to vapor. Adiabatic humidification systems use heat from the surrounding air to convert water into vapor for humidification (evaporation).
- Isothermal systems disperse pressurized steam into the air directly from a boiler or unfired steam generator, or nonpressurized steam from a vapor generator (evaporative humidifier). Adiabatic systems disperse mist or fog into the air using pressurized water and/or pressurized air, or water evaporated from a wetted media.
- Both isothermal and adiabatic systems disperse directly into ducts, air handlers, or into open spaces (called area-type systems).
- Absorption distance is the dimension from the leaving side of the dispersion assembly to the point where wetting will not occur. Solid objects such as coils, dampers, or fans beyond this dimension will remain dry, unless they are cooler than the duct air (or space air for area-type systems). Absorption distances in ducts and AHUs are measured in linear inches or feet; area-type systems define absorption distance using rise, spread and throw dimensions (see Figure 1).

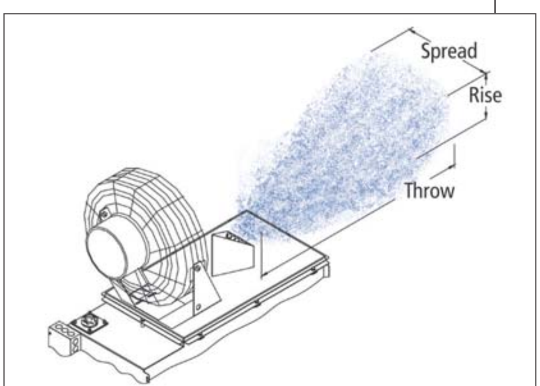

Figure 1: Area-type systems define absorption distance using rise, spread and throw dimensions.

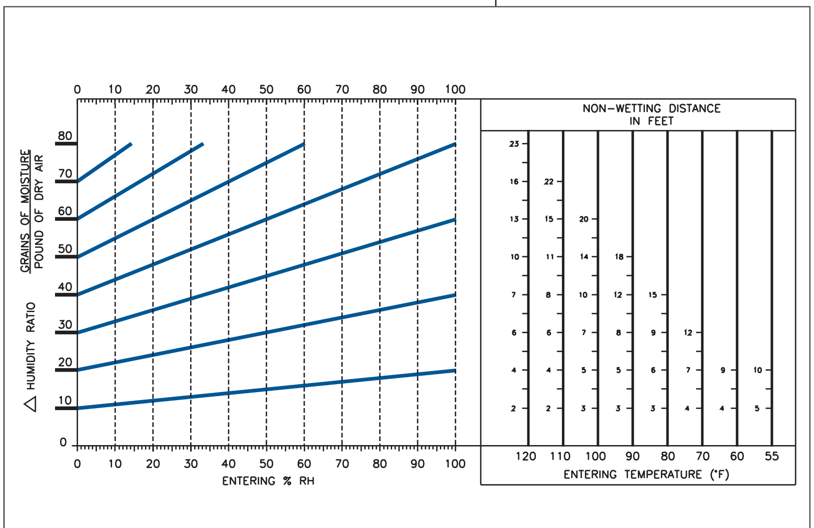

Figure 2: An absorption chart for an adiabatic fogger. Note that absorption distances are listed in feet.

It's all relative

The amount of moisture air can hold correlates directly to air temperature. For example, a pound of air (at sea level) at 55 °F containing 20 grains of moisture per pound of dry air, has a relative humidity (RH) of 31%. That same pound of air at 75 °F also containing 20 grains of moisture has a relative humidity of 15%, meaning that the air is at 15% of its theoretical capacity to hold moisture. In practice, once air reaches 90% relative humidity, absorption in a typical application becomes unpredictable.

When RH reaches 100%, the air is saturated, it has reached its dew point and condensation occurs. Condensation can also occur when moist air comes in contact with objects cooler than the airstream such as cooling coils. Direct steam injection assemblies typically run steam through jackets surrounding the dispersion tubes to preheat the tube and eliminate condensation. Dispersion tube orifice material is often made from a temperature-neutral material such as resin to allow steam to pass through to the air without touching metal. Much effort in humidification system design is focused on condensation, because it causes dripping and wet ducts.

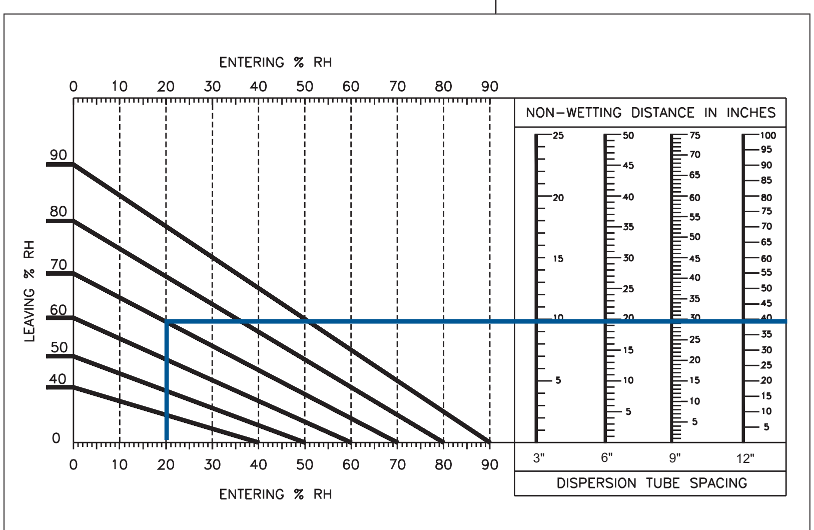

Figure 3: An absorption chart for a steam dispersion panel, with absorption distances of 6" achievable.

Just as important as temperature is the amount of moisture you plan to disperse. The more vapor you need to add, the more volume of air you will need for absorption to occur. In a duct or air handler, this means a longer required absorption distance or warmer air.

Disperse cold water or hot steam?

An adiabatic system requires warm air to convert water to vapor and to keep that air above the dew point. The advantage of adiabatic humidification is that it cools air while humidifying. The drawback is that the cooled air doesn't hold as much moisture as it did when it was warm and, consequently, there needs to be a larger volume of unobstructed air to achieve absorption adiabatically. This means you may need several more feet of duct or AHU length than what is available if dispersing into an open space (see Figure 2).

An isothermal system needs to take Btus out of the air to convert water to vapor and it will typically add heat to the air. Therefore, isothermal systems can disperse in lower temperatures and smaller volumes than adiabatic systems can and still achieve absorption. The advantage with isothermal systems is absorption can occur within inches in almost any application; the disadvantage is the energy used to heat water to vapor (see Figure 3).

Manage wetness when using adiabatic systems

Adiabatic fogging systems are frequently used in high-end industrial applications such as semiconductor manufacturing, and in applications where air handlers were designed specifically to accommodate long absorption distances and moisture fallout. Most foggers and atomizers spit at startup and shutdown (think of that sound in the grocery store produce section) and many systems require mist eliminators, which must be maintained to preclude mold growth (the same is true of the wetted-media-type humidifiers). Most manufacturers of foggers and atomizers recommend drip pans with multiple drains installed under the humidifier; some recommend stainless steel for drain pans and AHU walls and ceilings. Ducts also need special coatings to limit microbial growth or they must have maintenance access for cleaning. For these reasons, using an adiabatic system in a retrofit application is difficult. A fundamentally wet system such as an adiabatic system can be acceptable if you manage the expected moisture.

Factors that affect absorption

The smaller the water droplet size, the more quickly it will be absorbed. Steam droplets are the smallest, followed by foggers and atomizers. Droplet size is especially relevant to adiabatic humidification, for you may only have the time it takes for a drop of water to fall to the floor for absorption to occur. And if there is no airflow, such as in an area-type application, you have even less time for absorption to occur.

To ensure absorption in a duct or air handler, take advantage of the full airflow. Spread the humidification load among numerous discharge points rather than just a few. Compared to a single tube device, a multiple tube dispersion assembly achieves absorption in a shorter distance because it has more tubes dispersing the same amount of moisture into the airstream and steam is therefore more evenly distributed (see Figure 4). This causes a rapid homogenization of the steam/air mixture, which results in faster re-evaporation or second change of state.

Airflow and velocity also affect absorption. As velocity increases, absorption distance increases. This may become a critical issue if

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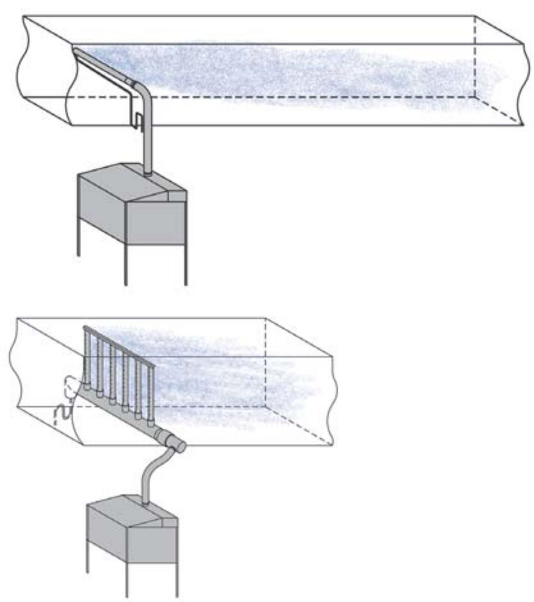

Figure 4: A single dispersion tube dispersing steam into an airstream. The fog shows the distance required for absorption to occur. More tubes and discharge points decrease absorption distance.

you are trying to humidify with an adiabatic system, which already requires a long absorption distance. And if velocity is too low (such as when airflow is interrupted but the humidifier keeps operating) absorption may not occur at all. In addition, we've found that if absorption does not occur before a duct branch, such as when high-velocity air pushes the absorption point beyond the branch, that branch will not be humidified. In an area-type application, fan speeds can become slower than when specified due to mineral buildup or other factors, and this will affect absorption as well. These are all good examples of how absorption can affect your ability to achieve set point in the spaces you plan to humidify.

Size dispersion assembly for maximum load

If a dispersion assembly is undersized for the load, steam velocity will push condensate out with the steam, causing dripping. A dispersion assembly that has both multiple dispersion tubes and discharge points on both sides of each tube fully maximizes air and steam mixing to achieve the shortest absorption distances (see Figure 5). In addition, this assembly can accommodate large humidification loads because of the dual-header design. Steam enters the top header and condensate leaves by the bottom header. Carefully review manufacturer sizing charts to ensure that the dispersion assembly is matched to the maximum humidification load.

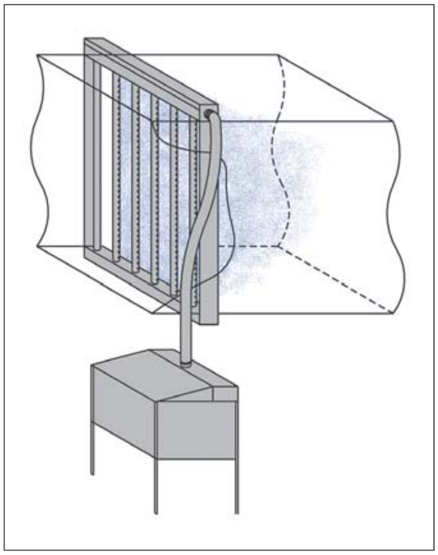

Figure 5: Multiple tubes and two rows of discharge points on each tube shorten absorption distance. Dual-header design allows high capacity.

Summary

Air temperature, air volume, air velocity, available absorption distance and humidification load all affect the capability of air to absorb moisture. If you understand the interrelationships of these factors, you'll have a good understanding of humidification's most critical issue – absorption.

DRISTEEM Corporation designs and manufactures humidification systems and accessories for commercial, industrial and institutional applications. Our engineering and design expertise, proven performance, and local representative network guarantee humidification systems designed to meet any application. To find a local DRISTEEM representative, or to learn more about proper humidification absorption, visit www.dristeem.com or call the humidification experts at 800-328-4447.

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