ENGINEERING WHITE PAPER

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Humidity Basics

We all know about space temperature but when it comes to relative humidity or humidification in general not many have a good grasp on the subject. This white paper is meant to give you a basic understanding of humidity & humidification. Typically, moisture in the air is removed through the cooling process or outside air, controlling the high end of humidity. We will focus on the low end of humidity (dry air) and the addition of moisture (humidification) to maintain a minimum relative humidity.

What do we mean when we say “control humidity” in a building?

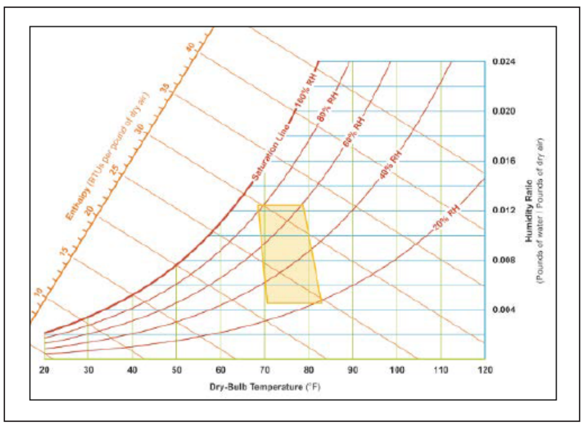

Figure 1 Psychrometric Chart

- First, we must understand the difference between absolute & relative humidity. For this we go to the psychrometric chart (Figure 1).
- Absolute humidity is the ratio of lbs of water per lb of dry air shown in fractional values on the right vertical axis in black.
- Relative humidity is the percent of water in air vs the amount of water that air could hold at a fixed dry bulb temp.
- When the air is cold it cannot hold as much moisture as when the air is warm, as illustrated in the lines of relative humidity (%RH) in red curved lines on the psychrometric chart. As the dry bulb temperature decreases the lines of relative %RH converge (low & to the left) at very low absolute humidity ratio. For example, in the winter, we can be at 25°F and 80% RH (15.3 gr/lb). At this same moisture content at 70°F inside, the relative humidity is only 14.1%.
- We can control a space to absolute humidity or relative humidity by either adding or removing moisture. But the more common and useful method is to control to relative humidity. The focus of this document is controlling the space at or above a minimum %RH to avoid a dry environment and adding moisture through a humidifier is necessary to achieve this goal.

Why do we control humidity in a building?

If we only controlled the dry bulb temperature in a building the %RH can drop significantly (especially in winter) creating an overly dry environment. Since we spend the majority of our time indoors this dry environment can adversely affect the people, materials, furnishings, & processes.

- **People:** Controlling relative humidity between 40-60%RH reduces the risk of infection along with other respiratory illnesses (see Figure 2 below). Virus infection is reduced above 40%RH for 3 reasons: viruses inactivate above 40%RH, their transmission as an aerosol is hampered above 40%RH, & our bodies do better fighting viruses above 40%RH. It also makes for a comfortable environment.

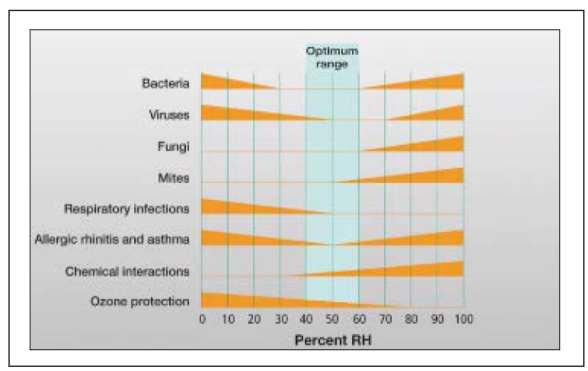

Figure 2 Health Impacts of Relative Humidity

- **Process:** Many industries require control of relative humidity (textiles, printing, semiconductor assembly, data centers, MRI, etc.). Ensuring a minimum %RH can also reduce the risk of static electricity discharge which is important in protecting electronics & surgery equipment.

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- **Preservation:** Many building materials, artwork, finishes, & furnishings are hygroscopic. This means that they absorb, retain, & release moisture. In humid environments mold & mildew can form while in dry environments these materials can release moisture and shrink causing damage. By controlling the humidity in a room, you can avoid this type of damage to materials.

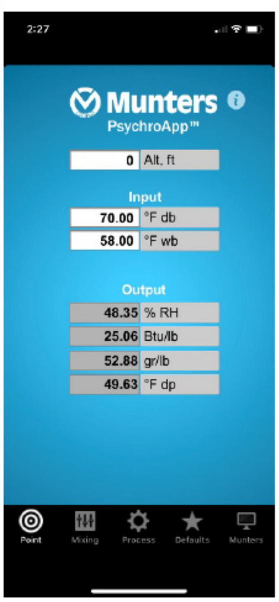
- **Moisture Barriers:** Without an effective moisture barrier, water vapor will pass from an area of higher moisture content to areas of lower moisture. Water vapor can pass through brick, wood, plasterboard and other building materials. A moisture barrier is strongly recommended when trying to maintain minimum humidity levels in a space.

How do we calculate a humidity load so that we can size a humidifier properly?

- Humidity loads are represented in Lb/Hr and calculated as follows:

  Humidifcation Load (lb/hr) = 4.5 x CFM x ΔW / 7000, where W= humidity ratio (grains/lb).

  This equation may be applied using grains of moisture per pound of dry air (W) in lieu of Humidity Ratio. A grain of moisture is the Humidity Ratio x 7000. Grains are used as a unit of measure to visualize moisture easier (i.e. 100 grains of moisture equals 0.0143 Lbs of moisture).



- A room's humidity load is calculated by determining moisture entering the space and subtracting any moisture being removed. Typically, the load is dependent on the condition of the outside air entering the space. The difference in absolute humidity of the outside air (OSA) versus the absolute humidity of the desired space condition x the rate (CFM) of outside air determines the OA component of load. One of two conditions are used for sizing design load; (1) minimum% OSA in winter or (2) economizer mode in the shoulder months.

- A benchmark for estimating a humidity load is 3 lb/hr for every 100 CFM of OSA. This is based on winter design day condition (dry air) and a space desired condition of 72F/50%RH.

What type/methods of humidifiers are there?

We can humidify with either Isothermal or Adiabatic systems.

- Isothermal humidifiers add heat directly to water, boil, and introduce steam into the space or airstream (duct). Isothermal humidifiers (resistive element/electrode/gas) also typically add a few degrees dry bulb to the airstream.

- Adiabatic humidifiers use the air to evaporate tiny droplets of water. These adiabatic systems (atomizing, ultrasonic, & wetted media) remove heat from the air thus providing a cooling effect. This is at a rate of 970 to 1070 BTU per pound of water evaporated depending on air temp.

Placement of a humidifier grid in an air handling unit:

- Because cold air cannot hold moisture, the humidifier grid should be located downstream of a heat source.

- It makes little sense to place the humidifier grid downstream of a cooling coil since air off the coil would be close to saturation and could not absorb as much moisture.

- Placing the humidifier grid between a pre-heat coil and cooling coil is usually the best place as it allows the cooling coil section and drain pan to provide additional space for absorption.

- Try to keep the humidifier away from the upstream side of any filter media.

- Some engineers like the humidifier as the last item in the AHU. This is acceptable but be careful on bottom openings so as not to get moisture carryover into the supply duct.

Other useful benchmarks to know:

- **1KW makes 3 lb/hr, 500 lb/hr = 1 GPM**

- Velocity range for humidifier distribution 250-2000fpm

- There is an excellent smartphone app from Munters called "PsychroApp" which allows you to solve for psycrometric state points, calculate mixed air conditions and estimate process loads.

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