BNP BUSINESS NEWS PUBLISHING December 1999

SERVICE & CONTRACTING

REFRIGERATION, AIR CONDITIONING, CLIMATE CONTROL

Why Humidification?

The proper type of equipment and controls can help you achieve effective, economical, and trouble-free control of humidity. Here, from Armstrong International, are some guidelines.

As we consider the importance of humidity among other environmental factors—temperature, cleanliness, air movement, and thermal radiation—it is important to remember that humidity is perhaps the least evident to human perception. Most of us will recognize and react more quickly to temperature changes, odors, or heavy dust in the air, drafts, or radiant heat. Since relative humidity interrelates with these variables, it becomes a vital ingredient in total environmental control.

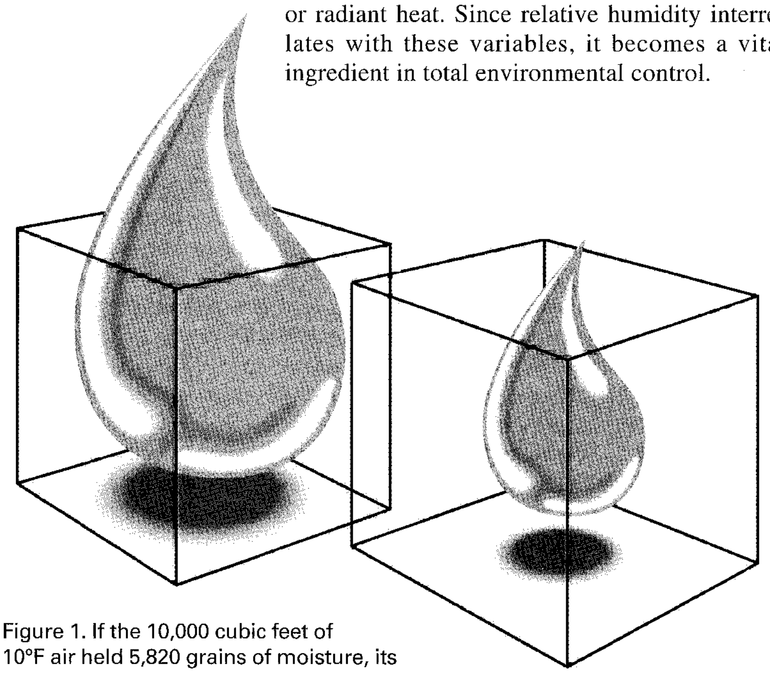


Figure 1. If the 10,000 cubic feet of 10°F air held 5,820 grains of moisture, its relative humidity would be 75%. If your heating system raises the temperature of this air to 70°F with no moisture added, it will still contain 5,820 grains of moisture. However, at 70°F, 10,000 cubic feet of air can hold 80,550 grains of moisture. So the 5,820 grains it actually holds give it a relative humidity of slightly more than 7%. That's very dry...drier than the Sahara Desert.

Humidity and Temperature

Humidity is water vapor or moisture content always present in the air. Humidity is definable as an absolute measure: the amount of water vapor in a unit of air. But, this measure of humidity does not indicate how dry or damp the air is. This can only be done by computing the ratio of the actual partial vapor pressure to the saturated partial vapor pressure at the same temperature. This is relative humidity, expressed by the formula:

$$RH = \frac{vp_a}{vp_s} \; t$$

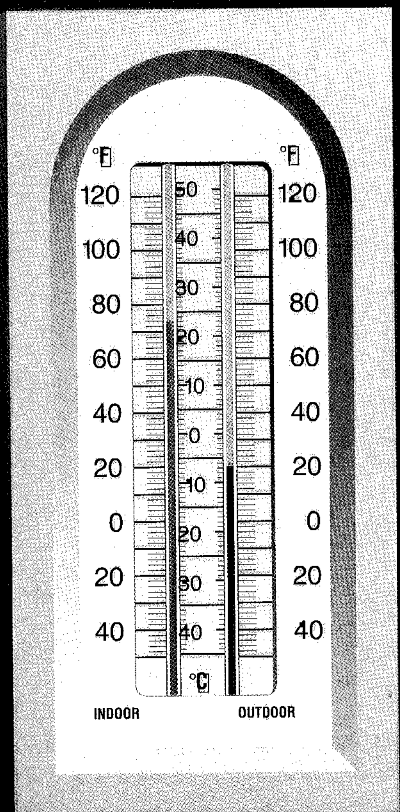
vp_a = actual vapor pressure
vp_s = vapor pressure at saturation
t = dry-bulb temperature

For practical purposes, at temperatures and pressures normally encountered in building systems, relative humidity is considered as the amount of water vapor in the air compared to the amount the air can hold at a given temperature.

"At a given temperature" is the key to understanding relative humidity. Warm air has the capacity to hold more moisture than cold air. For example, 10,000 cubic feet of 70°F air can hold 80,550 grains of moisture (Fig. 1). The same 10,000 cubic feet of air at 10°F can hold only 7,760 grains of moisture.

Air Movement and Humidity

Another variable, air movement in the form of infiltration and exfiltration from the building,



Glossary

Relative Humidity(RH): The ratio of the vapor pressure (or mole fraction) of water vapor in the air to the vapor pressure (or mole fraction) of saturated air at the same dry-bulb temperature and pressure.

Sensible Heat: Heat that when added to or taken away from a substance causes a change in temperature or, in other words, is "sensed" by a thermometer. Measured in Btu.

Latent Heat: Heat that when added to or taken away from a substance causes or accompanies a phase change for that substance. This heat does not register on a thermometer, hence its name "latent" or hidden. Measured in Btu.

Dew Point: The temperature at which condensation occurs (100%RH) when air is cooled at a constant pressure without adding or taking away water vapor.

Evaporative Cooling: A process in which liquid water is evaporated into air. The liquid absorbs the heat necessary for the evaporation process from the air; thus, there is a reduction in air temperature and an increase in the actual water vapor content of the air.

Enthalpy: Also called heat content, this is the sum of the internal energy and the product of the volume times the pressure. Measured in Btu/lb.

Hygroscopic Materials: Materials capable of absorbing or giving up moisture.

Phase: The states of existence for a substance, solid, liquid, or gas (vapor).

—Armstrong International

influences the relationship between temperature and relative humidity. Typically, one to three times every hour (and many more times with forced air make-up or exhaust) cold outdoor air replaces your indoor air. Your heating system heats this cold, moist outdoor air, producing warm, dry indoor air.

Evaporative Cooling

Altering RH can also cause temperature to change. For every pound of moisture evaporated by the air, the heat of vaporization reduces the sensible heat in the air by about 1,000 Btu. This can be moisture absorbed from people or from wood, paper, textiles, and other hygroscopic material in the building. Conversely, if hygroscopic materials absorb moisture from humid air, the heat of vaporization can be released to the air, raising the sensible heat.

Dew Point

Condensation will form on windows whenever the temperature of the glass surface is below the dew point of the air. Data in the ASHRAE Handbook & Product Directory indicates combinations of indoor relative humidity and outside temperature at which condensation will form. Induction units, commonly used below windows in modern buildings to blow heated air across the glass, permit carrying higher relative humidities without visible condensation.

Energy Conservation With Controlled RH

Indoor relative humidity as we have computed it is called Theoretical Indoor Relative Humidity (TIRH). It virtually never exists. RH observed on a measuring device known as a hygrometer will almost always exceed the TIRH. Why? Dry air is thirsty air. It seeks to draw moisture from any source it can. Thus, it will soak up moisture from any hygroscopic materials (such as wood, paper, foodstuffs, leather, etc.) and dry out the nasal passages and skin of human beings in the building.

But, is this free "humidification"? No, it is the most expensive kind there is when translated into terms of human comfort, material deterioration, and production difficulties. Moreover, it requires the same amount of energy whether the moisture is absorbed from people and materials or added to the air by an efficient humidification system.

The true energy required for a humidification system is calculated from what the actual humidity level will be in the building, not from the theoretical level. In virtually all cases, the cost of controlling RH at the desired level will be nominal in terms of additional energy load, and in some cases may result in reduced energy consumption.

A major convention center in the Central United States reported that it experienced a decrease in overall steam consumption when it added steam humidification. From one heating season with no humidification to the next with humidifiers operating, the steam consumption for humidification was 1,803,000 lbs., while the steam for heating decreased by 2,486,000 lbs. in the same period. The decreased (metered) consumption occurred despite 7.2% colder weather from the previous year. The records from this installation indicate that it is possible to reduce the total amount of steam required for environmental control by maintaining a higher, controlled relative humidity.

Let's examine a theoretical system using enthalpy (heat content) as our base.

- Assume a winter day with outside temperature of 0°F at 75% RH.
- The enthalpy of the air is .6 Btu/lb. dry air (DA).
- If the air is heated to 72°F without adding moisture, the enthalpy becomes 18 Btu/lb. DA.
- Theoretical relative humidity becomes 3.75%, but actual RH will be about 25%.
- At 72°F and 25% RH, the enthalpy is 22 Btu/lb. DA.
- The additional moisture is derived from hygroscopic materials and people in the area.

But, what about the additional energy—the difference between the 18 Btu/lb. DA and 22 Btu/lb. DA? This 22% increase must come from the heating system to compensate for the evaporative cooling effect. If a humidification system is used and moisture added to achieve a comfortable 35% RH, the enthalpy is 23.6 Btu/lb. DA.

This is only a 7% increase over the "inevitable" energy load of 22 Btu/lb. DA—substantially less than the theoretical increase of 31% from 3.75% RH (18 Btu/lb. DA) to 35% RH (23.6 Btu/lb. DA) at 72°F. If the temperature was only 68°F at 35% RH (because people can be comfortable at a lower temperature with higher humidity levels), the enthalpy is 21.8 Btu/lb. DA, or a slight decrease in energy.

Graph 1. Relative humidities at which condensation will appear on windows at 70° F when glass surface is unheated.

Outdoor Temp.	Single Glass	Double Glass (Storm Windows or Thermal Glass)
-10	11%	38%
0	16%	42%
+10	21%	49%
+20	28%	56%
+30	37%	63%
+40	48%	71%

Graph 2. Effect of humidity on electrostatic voltages.

Means of Static Generation	Electrostatic Voltages (Relative Humidity) 10%-20%	65%-90%
Walking across carpet	35,000	1,500
Walking over vinyl floor	12,000	250
Worker at bench	6,000	100
Vinyl envelopes for work instructions	7,000	600
Common poly bag picked up from bench	20,000	1,200
Work chair padded with polyurethane foam	18,000	1,500

Problems With Dry Air

Dry air can cause a variety of costly, troublesome, and sometimes dangerous problems. If you are not familiar with the effects of dry air, the cause of these problems may not be obvious. You should be concerned if you are processing or handling hygroscopic materials such as wood, paper, textile fibers, leather, or chemicals. Dry air and/or fluctuating humidity can cause serious production problems and/or material deterioration.

Static electricity can accumulate in dry atmospheric conditions and interfere with efficient operation of production machinery or electronic office machines. Where static prone materials such as paper, films, computer disks, and other plastics are handled, dry air intensely aggravates the static problem. In potentially explosive atmospheres, dry air and its resultant static electricity accumulations can be extremely dangerous.

Humidity and Human Comfort

Studies indicate people are generally most comfortable when relative humidity is maintained between 35% and 55%. When air is dry, moisture evaporates more readily from the skin, producing a feeling of chilliness even with temperatures of 75°F or more. Because human perception of RH is often sensed as temperature differential, it's possible to achieve comfortable conditions with proper humidity control at lower temperatures. The savings in heating costs are typically very significant over the course of just a single heating season.

The Need for Humidity Control in Today's Electronic Workplace

Electronics are revolutionizing the way the office and plant floor operates, communicates, collects data, and maintains equipment. In the office, xerographic copies, phone systems, word processors, typewriters, and even wall thermostats are electronically controlled. Personal computers and CRT access points are sprouting everywhere. What's more, office decor has far more work stations incorporating wall panels and furniture with natural and synthetic fabric than ever before.

In manufacturing areas, more machines are electronically controlled. In fact, you see more control rooms (just to house electronic control systems) than in previous years.

All this means that the nature of today's business makes proper humidification a virtual necessity. ❑

EDITOR'S NOTE: This material was prepared by Armstrong International, 816 Maple St., P.O. Box 408, Three Rivers, MI 49093, ph: (616) 273-1415, Fax: (616) 279-5728.