Steam Humidification Systems

Suggestions for selecting, installing, and maintaining plant humidification equipment

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Humidification can be a key ingredient in the efficient operation of an industrial plant. Improper humidification can be costly and harmful to the products being made and can create an uncomfortable working atmosphere. Among the most common ways to control the plant environment is to humidify the area with steam.

Humidity refers to the moisture content of the air. As an absolute measure, it is the amount of water vapor contained in a specific unit of air. This value, however, does not reflect how dry or damp the air is. That figure, the actual water vapor in the air compared to the amount of water vapor it can hold at a given temperature, is called relative humidity (RH). For example, an RH of 50% means that a given volume of air contains only half the amount of moisture that it can hold.

An important element in understanding relative humidity is the phrase "at a given temperature." Warm air can hold more moisture than cold air. For instance, 10,000 cu ft of air can hold 80,550 grains of moisture at 70 F but only 7760 grains of moisture at 10 F. If 10,000 cu ft of 10-F air contained only 5820 grains of moisture, its RH would be 75%. Heated to 70 F, that same volume of air would still contain 5820 grains of moisture but would be able to hold up to 80,550 grains. Its RH at 70 F would be just 7%, drier than the Sahara desert.

Although circumstances vary, an RH between 35% and 55% is considered most comfortable to humans. No one level of RH provides adequate moisture for all hygroscopic materials in process environments. Moisture content requirements vary widely from material to material. The levels listed in the table may require some adjustment, depending on the process or the building conditions.

Proper humidity levels are necessary to protect humidity-sensitive materials, delicate machinery and equipment, as well as personnel. Relative humidity combines with temperature and air movement to create either a comfortable or uncomfortable environment. Air that is too dry parches throats and nasal passages, and because moisture evaporates from the skin more readily in dry air, people may feel cooler in a dry atmosphere even at temperatures of 75 F or above.

Dry air or fluctuating humidity also can complicate the handling and processing of such materials as wood, paper, textile fibers, leather, and a variety of food and chemicals and even cause them to deteriorate. Inadequate humidity may also cause problems for process equipment. Today, a lot of machinery is electronically controlled. This change in the nature of manufacturing and processing makes proper humidification critical. Many electronic components, integrated circuits in particular, may be weakened or damaged by electrical transients or voltage spikes. For example, electrostatic discharge is more likely to occur when the RH is too low.

Selecting the Equipment
Steam humidification is common in most industrial environments, Fig. 1. Typically, steam is readily available, and when it is not, small capacity needs of 50 to 75 lb/hr can be met using self-contained steam-generating units.

Steam systems are chosen primarily because of their fast response time. Separator-type, conditioned-steam humidifiers introduce water vapor directly into an air stream or space. The steam does not require energy from the air to be absorbed. It is easily mixed with and absorbed by the air and the amount of moisture can be controlled rapidly.

Usually, steam is a sterile medium that contains no contaminants. Solids are neither entrained nor deposited. If the boiler makeup water is of good quality and there is no condensation, dripping, or spitting in the ducts, then microorganisms will not grow, and odor will not be a problem. Steam humidification also provides a high capacity per dollar of initial cost. Installation costs vary with the availability of water, steam, and electric power. Generally, operating costs for steam humidification are insignificant compared with heating/cooling costs.

<table>
<thead>
<tr>
<th>Process or Product</th>
<th>Temperature, °F</th>
<th>Relative Humidity, %</th>
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</thead>
<tbody>
<tr>
<td>Abrasives</td>
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<td></td>
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<tr>
<td>Manufacture and storage</td>
<td>78</td>
<td>50</td>
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<tr>
<td>Ceramics</td>
<td></td>
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</tr>
<tr>
<td>Refractory Clay storage</td>
<td>60-80</td>
<td>50-90</td>
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<td></td>
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<td>35-65</td>
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<tr>
<td>Electrical Products</td>
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<tr>
<td>Instrument manufacture and test Switchgear</td>
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<td>50-55</td>
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<td></td>
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<td>50</td>
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<tr>
<td>Foundries</td>
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<tr>
<td>Wood pattern storage</td>
<td>73</td>
<td>45-55</td>
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<tr>
<td>Leather</td>
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<tr>
<td>Drying Storage</td>
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<td>75</td>
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<td></td>
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<td>Pharmaceuticals</td>
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<tr>
<td>Manufactured powder storage Tablet compressing</td>
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<tr>
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<tr>
<td>Plywood</td>
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<tr>
<td>Hot pressing (resin)</td>
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<td>60</td>
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<td>Cold pressing</td>
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<td>16-25</td>
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<tr>
<td>Textiles</td>
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<td>Wool Storage</td>
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<tr>
<td></td>
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<td>50-60</td>
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<td>Weaving, woolen and worsted</td>
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<td>Cotton, weaving</td>
<td>75-80</td>
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<tr>
<td>Synthetic fibers, manufacturing</td>
<td>75</td>
<td>45-65</td>
</tr>
<tr>
<td>All fibers, knitting</td>
<td>75</td>
<td></td>
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</table>

*Depends on the process or conditions
Steam humidification systems are commonly used in industry to control the plant environment.

VENTILATION SYSTEM WITH PRIMARY HUMIDIFICATION

The type of equipment varies with conditions and requirements. Humidifiers fall into three categories: duct-type, unit, and steam shower. Duct-type humidifiers are most common. They are found in plants with central air-handling systems and in office areas and computer rooms.

Unit humidifiers discharge directly into a broad, open space. They are used when duct systems are not available. Manufacturing or processing areas for furniture or food, printing plants, and paper mills are typical examples.

Steam shower humidifiers add moisture to materials during processing. Printing presses, leather processing equipment, and paper machines are good examples, as is any sheet film process where static electricity or uneven application of moisture is undesirable.

Steam humidification systems need little maintenance. Because the steam contains no mineral contaminants, the humidifiers are not subject to the clogging that affects other types of humidifiers. Following two simple maintenance practices will keep the equipment operating efficiently:

- Clean the strainer. The screen should be cleaned a few days after the humidifier is installed, and once a season thereafter. Cleaning frequency should be increased if the screen is found to be exceptionally dirty.
- Check the trap. The steam trap used to drain the unit should be inspected or tested each time the strainer is cleaned. Greater attention must be paid to maintenance with self-contained units because they convert mineral-laden tap water to steam. Scale and sediment formed in the unit or entrained in the supply steam drain through the trap and can leave deposits.

Evaluating the Alternatives
The purpose of steam humidification is to introduce dry steam into the air stream or space. How this is done affects the control of the RH. Steam humidification systems should be evaluated according to three essential performance characteristics:

Steam conditioning. The separating chamber in the humidifier body should provide enough volume to optimize velocity reduction and maximize steam/condensate separation. When the steam and condensate are separated properly, a substantial portion of any particulate is carried out of the humidifier through the drain trap by the condensate.

Any liquid remaining in the steam must be removed. Humidifiers equipped with an inner drying chamber jacketed by the steam in the separating chamber can effectively re-evaporate any remaining water before the steam is discharged. A control valve should be integrated into the humidifier. It and the distribution pipe should be jacketed by steam at a supply pressure and temperature that will prevent the steam from spitting when it is discharged.

Control of output. The required RH can be maintained only if system response is immediate and modulation precise. Inadequate control can overload ducts with moisture and create wet spots. Systems are equipped with parabolic plug valves designed expressly to add steam to air precisely. They permit a longer stroke and significantly better control than commercial zone valves. These characteristics promote accurate flow modulation over the complete stroke of the valve.

Distribution of steam. Steam must be discharged uniformly to permit fast absorption with no damp spots or saturated zones. Typically, industrial areas without central air handling systems humidify using unit equipment that discharges steam directly into the atmosphere. Steam and air are mixed by using a dispersing fan mounted on the humidifier or by installing a humidifier with a unit heater positioned so that the air flow from the heater absorbs and distributes the water vapor.

Applying Steam Humidification
Properly locating, installing, and controlling humidifiers are essential for trouble-free performance. Location is most important, although system design sometimes

Key to Abbreviations
EA — exhaust air
E-P Relay — electric-pneumatic relay
H — humidity controller
M — damper motor
MA — mixed air
NC — normally closed
NO — normally open
OSA — outside air
RA — return air
T — temperature controller
makes proper placement difficult to achieve. The following examples demonstrate proper humidification equipment location.

The simple ventilating system in Fig. 2 assumes a final duct air temperature slightly above the desired room temperature. The humidifier should be sized for the maximum design load and the steam jacketed distribution manifold of the primary humidifier should be located downstream from the supply fan. Locating the equipment between the coil and the fan might interfere with the temperature controllers.

The high limit duct humidity controller is optional, but advisable if the capacity of the humidifier at design loads could overload the air when the outside air moisture content is higher than the design level. The high limit controller should be at least 10 to 12 ft downstream of the humidifier so that it will sense the same temperature as the humidifier. If the humidifier senses a cooler temperature than the controller, saturation can occur.

The system shown in this and the following examples have pneumatic controls. A fan switch activates the control system and an electric pneumatic relay bleeds air from the humidifier actuator diaphragm when the fan is off. When electric control systems are used, their location remains the same.

Figure 3 shows a 100% outside air system equipped with preheat and reheat coils. The preheat coil heats outside air to a duct temperature of 50 to 60°F. The reheat coil adds sensible heat in response to the space heat demand. In this case, the primary humidifier is best placed downstream from the reheat coil so that moisture is introduced when the dry bulb air temperature is at its highest. The humidity controller is located in the exhaust air duct. When a good location is not available for the humidity controller in the humidified space, it should be placed in the exhaust air duct as close as possible to the room outlet grille. Again, the high limit controller is optional but recommended.

The 100% outside air system in Fig. 4 has preheat and reheat coils and two humidifiers (V1 and V2) controlled in sequence from a single space or exhaust air duct humidity controller. The first unit delivers ¼ of the capacity with a 4 to 7-psig spring range. The second is sized for ½ of the capacity with a spring range of 8 to 13 psig. This arrangement allows the moisture input to be closely controlled and prevents overrun and duct saturation, particularly when operating conditions vary from design.

When the outside air is mild, the smaller unit can satisfy humidification requirements using only a portion of the total design capacity. As the outside air becomes colder and drier, the first unit is sized so that it will not be adequate. The second unit will start in response to additional demand. This arrangement allows close control under all kinds of outside air conditions and prevents supersaturated air from forming in the duct at minimum design.

In Fig. 5, air leaving the preheat coil is held at a constant dry bulb temperature in the 55 to 60-F range. The first humidifier is the primary one and the second is a booster or secondary humidifier. This arrangement allows the primary humidifier to be controlled by a duct humidity controller at a level high enough to maintain 35% RH at 75°F. The booster unit, located downstream from a reheat coil and fan, can be sized and controlled to produce the moisture necessary to raise the RH in some zones to 55%. The humidity for each zone can be controlled individually at a higher level than would be possible with one unit.

This combination is important because the capacity of the booster unit can be small enough to prevent supersaturation, even if units with capacities ranging from 8 to 10 lb/hr are 3 ft from the discharge grille. In this air handling system, it would not be possible psychrometrically to introduce humidity into the air downstream from the preheat coil to produce the maximum RH. Using two humidifiers is the only way to control the RH level above 35%.
A properly humidified workplace improves worker health and comfort and increases equipment efficiency

HEAT-VENT SYSTEM WITH SEQUENCE CONTROL

- When the humidifier must discharge into a packaged, multizone air handling system, the distribution manifold must be placed in the center of the active air flow and as close to the fan discharge as possible.
- If the distribution manifold is installed less than 10 ft upstream from a temperature controller, false signals may be received unless multiple manifolds are specially selected.
- The distribution manifold should never be less than 3 ft from the air fan intake. Its best location is at the fan discharge.
- Whenever possible, the distribution manifold should be installed in the center of the duct.
- Distribution manifolds should be as far upstream from the discharge air grilles as possible and never less than 3 ft upstream.
- The distribution manifold should be sized and installed to span the widest dimension of the duct section.
- The steam distribution manifold should always span the maximum width of the duct.
- The manifold should never be installed below the humidifier unless a separate steam trap is used. This position causes a drainage problem in the jacket of the manifold. It may be installed above the humidifier.

Properly humidifying the workplace has numerous benefits: improved health and comfort, greater equipment efficiency, improved handling and even preservation of hygroscopic materials, and protection of sensitive electronic equipment. Humidification is more than merely a desirable option, it is often critical to protecting the company's investment in people, equipment and materials.

For more information...
...or call Jeanine Katsel, HVAC Editor, 708-635-8800.

Fig. 4. This 100% outside air system has preheat and reheat coils and two humidifiers controlled in sequence from a single space or exhaust air duct humidity controller. The first unit delivers ½ of the capacity, and the second delivers ¾. When the outside air is mild, the smaller unit can satisfy humidification requirements using only a portion of the total design capacity. The second unit will not start until there is additional demand.

PRIMARY AND BOOSTER HUMIDIFICATION SYSTEM

- When the humidifier must discharge into a packaged, multizone air handling system, the distribution manifold must be placed in the center of the active air flow and as close to the fan discharge as possible.
- If the distribution manifold is installed less than 10 ft upstream from a temperature controller, false signals may be received unless multiple manifolds are specially selected.
- The distribution manifold should never be less than 3 ft from the air fan intake. Its best location is at the fan discharge.
- Whenever possible, the distribution manifold should be installed in the center of the duct.
- Distribution manifolds should be as far upstream from the discharge air grilles as possible and never less than 3 ft upstream.
- The distribution manifold should be sized and installed to span the widest dimension of the duct section.
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Fig. 5. Secondary unit is a booster unit in this arrangement. The primary humidifier is controlled by a duct humidity controller to maintain a 35% RH at 75°F in certain zones. The booster unit raises the RH level in other zones to 55%.

Installation Guidelines

- Whenever possible, the distribution manifold should be located downstream from the coils if there is less than 3 ft between the manifold and the coil on the upstream side.
- When the humidifier must be placed in the coil section ahead of the fan, the manifold should be located where the air flow is most active and as far upstream from the fan inlet as possible.
- The air flow in ducts 8-in. deep or less should be unrestricted.