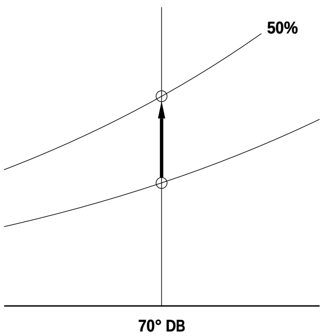
How Humidifiers Work

Steam Humidification

Unlike other humidification methods, steam humidifiers have a minimal effect on dry-bulb (DB) temperatures. The steam humidifier discharges ready-made water vapor. This water vapor does not require any additional heat as it mixes with the air and increases relative humidity. Steam is pure water vapor existing at 212°F (100°C). This high temperature creates a perception that steam, when discharged into the air, will actually increase air temperature. This is a common misconception. In truth, as the humidifier discharges steam into the air, a steam/air mixture is established. In this mixture steam temperature will rapidly decrease to essentially the air temperature.



The psychrometric chart helps illustrate that steam humidification is a constant DB process. Starting from a point on any DB temperature line, steam humidification will cause movement straight up along the constant DB line. The example illustrates that 70°F DB is constant as we increase RH from 30%-50%. This is true because steam contains the necessary heat (enthalpy) to add moisture without increasing or decreasing DB temperature. Actual results utilizing high pressure steam or large RH increases (more than 50%) increase DB by 1° to 2°F. As a result, no additional heating or air conditioning load occurs.

Direct Steam Injection Humidifiers

The most common form of steam humidifier is the direct steam injection type. From a maintenance point of view, direct steam humidification systems require very little upkeep. The steam supply itself acts as a cleaning agent to keep system components free of mineral deposits that can clog water spray and evaporative pan systems.

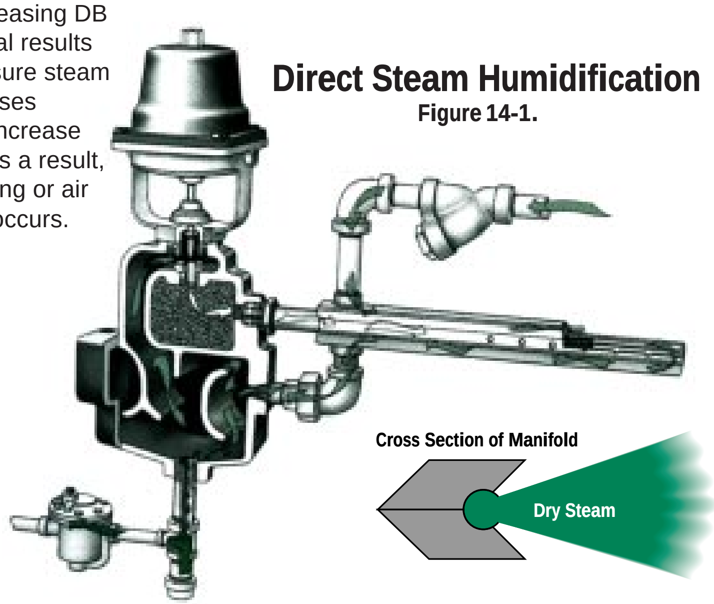
Response to control and pinpoint control of output are two other advantages of the direct steam humidification method. Since steam is ready-made water vapor, it needs only to be mixed with air to satisfy the demands of the system. In addition, direct steam humidifiers can meter output by means of a modulating control valve. As the system responds to control, it can position the valve anywhere from closed to fully open. As a result, direct steam humidifiers can respond more quickly and precisely to fluctuating demand.

The high temperatures inherent in steam humidification make it virtually a sterile medium. Assuming boiler makeup water is of satisfactory quality and there is no condensation, dripping or spitting in the ducts, no bacteria or odors will be disseminated with steam humidification.

Corrosion is rarely a concern with a properly installed steam system. Scale and sediment—whether formed in the unit or entrained in the supply steam—are drained from the humidifier through the steam trap.

Direct Steam Humidification

Figure 14-1.



Steam-to-Steam Humidifiers

Steam-to-steam humidifiers use a heat exchanger and the heat of treated steam to create a secondary steam for humidification from untreated water. The secondary steam is typically at atmospheric pressure, placing increased importance on equipment location.

Maintenance of steam-to-steam humidifiers is dependent on water quality. Impurities such as calcium, magnesium and iron can deposit as scale, requiring frequent cleaning. Response to control is slower than with direct steam because of the time required to boil the water.

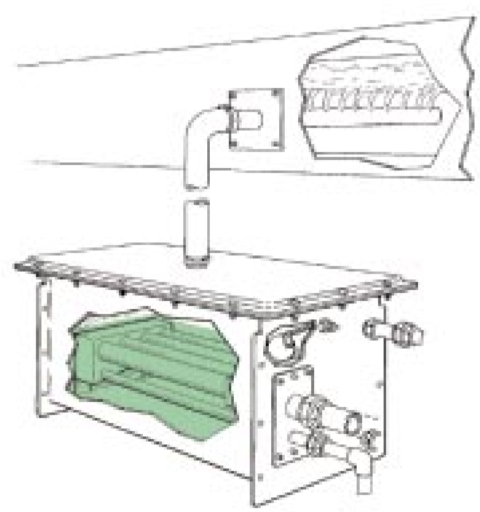
Electronic Steam Humidifiers (Electrode)

Electronic steam humidifiers are used when a source of steam is not available. Electricity and water create steam at atmospheric pressure. Electrode-type units pass electrical current through water to provide proportional output. Use with pure demineralized, deionized or distilled water *alone* will generally not provide sufficient conductivity for electrode units.

Water quality affects the operation and maintenance of electrode-type humidifiers. Use with hard water requires more frequent cleaning, and pure softened water can shorten electrode life. Microprocessor-based diagnostics assist with troubleshooting.

Steam-to-Steam Humidification

Figure 14-2.



Electrode units are easily adaptable to different control signals and offer full modulated output. However, the need to boil the water means control will not compare with direct-injection units.

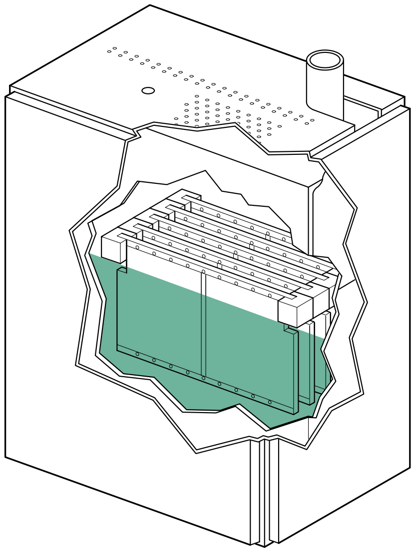
Electronic Steam Humidifiers (Ionic Bed)

Ionic bed electronic humidifiers typically use immersed resistance heating elements to boil water. Since current does not pass through water, conductivity is not a concern. Therefore, ionic bed technology makes the humidifier versatile enough to accommodate various water qualities. These units work by using ionic bed cartridges containing a fibrous media to attract solids from water as its temperature rises, minimizing the buildup of solids inside the humidifier. Water quality does not affect operation, and maintenance typically consists of simply replacing the cartridges.

Ionic bed humidifiers are adaptable to different control signals and offer full modulated output. Control is affected by the need to boil the water, however.

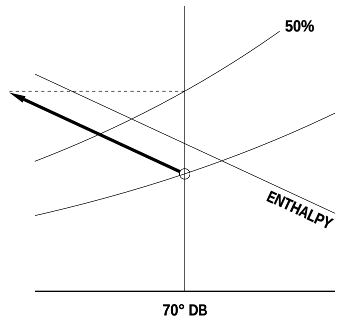
Electronic Steam Humidification

Figure 15-1.



Water Spray

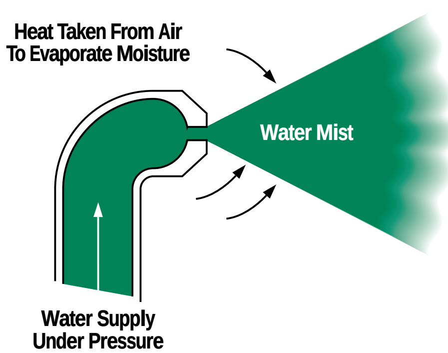
The water spray process can create potential temperature control problems. In order to become water vapor or humidity, water requires approximately 1,000 Btu per pound to vaporize. This heat must be drawn from the air, where it will hopefully vaporize. If not enough heat is available quickly enough, the water remains a liquid. This unvaporized water can result in overhumidification, and the water can "plate out" on surfaces, creating a sanitation hazard.



Water spray contains virtually none of the heat of vaporization required to increase the RH of the air to desired conditions. For this reason, water spray humidification is a virtually constant enthalpy process. However, as the psychrometric example illustrates, DB temperature changes as we increase RH from 30%-50%. The result of this loss of DB temperature is an increased heating load to maintain 70°F.

Water Spray

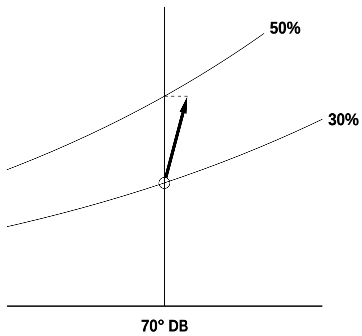
Figure 15-2.



Response of water spray humidifiers to control is slow due to the need for evaporation to take place before humidified air can be circulated. On/off control of output means imprecise response to system demand and continual danger of saturation. Water spray systems can distribute large amounts of bacteria, and unevaporated water discharge can collect in ducts, around drains and drip pans, and on eliminator plates, encouraging the growth of algae and bacteria. Corrosion is another ongoing problem with water spray humidification. Scale and sediment can collect on nozzles, ductwork, eliminator plates, etc., leading to corrosion and high maintenance costs.

Evaporative Pan

The evaporative pan method uses steam, hot water or electricity to provide energy for heating coils which in turn heat water and create water vapor. This method is most effective when installed in smaller capacity environments either in the air handling system or individually within the area(s) to be humidified.



Evaporative pan humidification can increase dry-bulb temperature as measured on the psychrometric chart. This unwanted temperature change may occur as air is forced across the warmed water in the pan. The increase in DB can cause damaging results in process applications and increase the need for humidity control. The psychrometric chart helps illustrate that evaporative pan humidification is not a constant DB process. This example shows DB temperature increasing as we move from 30%-50% RH. To maintain a constant DB of 70°F some cooling load (air conditioning) is required.

Maintenance of evaporative pan humidification systems demands regular cleaning of the heating coils and pan, which are subject to "liming up."

The use of chemical additives added either automatically or manually to the water in the pan can reduce this problem by as much as half.

Response to control with the evaporative pan method is slow due to the time required for evaporation to take place before humidified air can be circulated. Output is determined by water temperature and surface area.

Evaporative pan humidifiers can sustain bacteria colonies in the reservoir and distribute them throughout the humidified space. High water temperatures, water treatment, and regular cleaning and flushing of the humidifier help to minimize the problem, however.

Cost Comparisons

To fairly evaluate the costs of selecting a humidification system, you should include installation, operating, and maintenance costs as well as initial costs. Total humidification costs are typically far less than heating or cooling system costs.

Initial costs, of course, vary with the size of the units. Priced on a capacity basis, larger capacity units are the most economical, regardless of the type of humidifier, i.e.: one humidifier capable of delivering 1,000 pounds of humidification per hour costs less than two 500 lbs/hr units of the same type.

Direct steam humidifiers will provide the highest capacity per first cost dollar; water spray and evaporative pan are the least economical, assuming capacity needs of 75 lbs/hr or more.

Installation costs for the various types cannot be accurately formulated because the proximity of water, steam and electricity to humidifiers varies greatly among installations. Operating costs are low for direct steam and slightly higher for steam-to-steam. Water spray and evaporative pan operating costs are also low. Energy costs are higher for electronic humidifiers.

Direct steam humidifiers have the lowest maintenance costs. Ionic bed electronic humidifiers are designed specifically to minimize maintenance while adapting to various water qualities. Maintenance costs for other types can vary widely, depending on water quality and applications.

These are the principal considerations in selecting a humidification system. Table 16-1 summarizes the capabilities of each humidifier type.

Evaporative Pan

Figure 16-1.

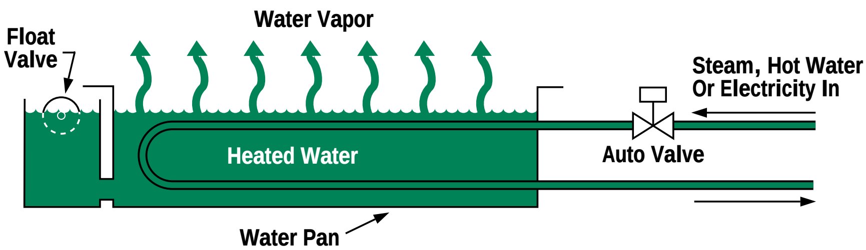


Table 16-1. Comparison of Humidification Methods

	Direct Steam	Steam-to-Steam	Electronic Steam	Ionic Bed Electronic Steam	Evaporative Pan	Water Spray
Effect on temperature	Virtually no change				Small temperature rise	Substantial temperature drop
Unit capacity per unit size	Small to very large	Small	Small to medium	Small to medium	Small	Small
Vapor quality	Excellent	Good	Good	Good	Good	Poor
Response to control	Immediate	Slow	Fair	Fair	Slow	Slow
Control of output	Good to excellent	Below average	Average	Average	Average	Average
Sanitation/corrosion	Sterile medium; corrosion free	Bacteria can be present	Programmed to not promote bacteria	Programmed to not promote bacteria	Pan subject to corrosion; bacteria can be present	Subject to severe corrosion and bacteria problems
Maintenance frequency	Annual	Monthly	Monthly to quarterly	Quarterly to semi-annually	Weekly to monthly	Weekly to bimonthly
Maintenance difficulty	Low	High	Medium	Low	High	High
Costs: Price (per unit of capacity)	Low	High	Medium	Medium	High	Medium to high
Installation	Varies with availability of steam, water, electricity, etc.					
Operating	Low	Low	Medium	Medium	Low	Low
Maintenance	Low	High	High	Low to medium	High	Very high

Recommended Applications

Steam: Recommended for virtually all commercial, institutional and industrial applications. Where steam is not available, small capacity needs up to 50-75 lbs/hr can be met best using ionic bed type self-contained steam generating units. Above this capacity range, central system steam humidifiers are most effective and economical. Steam should be specified with caution where humidification is used in small, confined areas to add large amounts of moisture to hygroscopic materials. We recommend that you consult your Armstrong Representative regarding applications where these conditions exist.

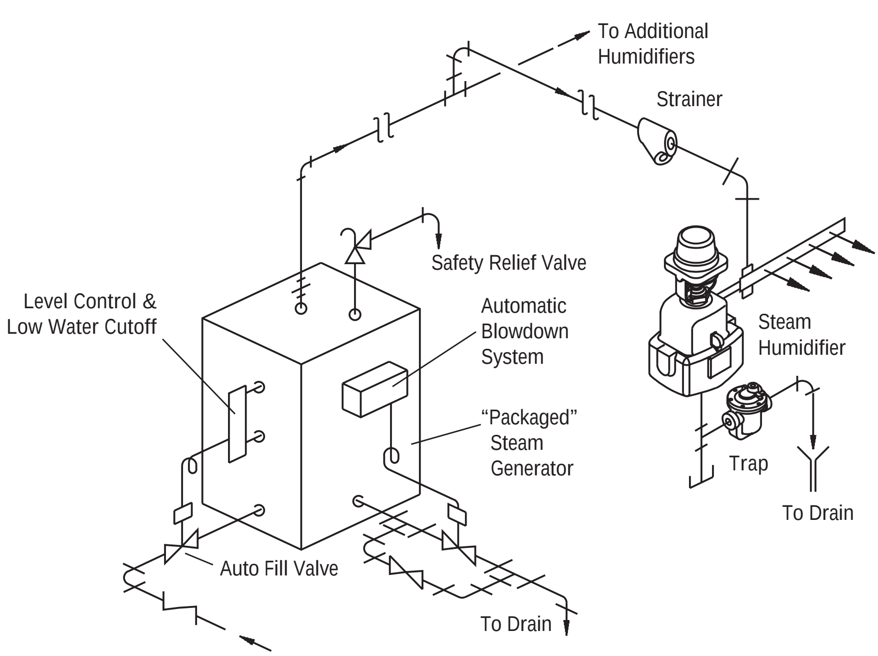
Evaporative Pan: Recommended only as an alternative to self-contained steam generating unit humidifiers for small load commercial or institutional applications. Generally not recommended where load requirements exceed 50-75 lbs/hr.

Water Spray: Recommended for industrial applications where evaporative cooling is required; typical application is summertime humidification of textile mills in the southern U.S.

The evidence supports the conclusion that steam is the best natural medium for humidification. It provides ready-made vapor produced in the most efficient evaporator possible, the boiler. There is no mineral dust deposited, and because there is no liquid moisture present, steam creates no sanitation problems, will not support the growth of algae or bacteria, has no odor and creates no corrosion or residual mineral scale. Unless there are particular requirements to an application that can only be met with evaporative pan or water spray methods, steam humidification will meet system needs most effectively and economically.

With these advantages in mind, engineers specify steam boilers and generators solely for humidification when the building to be humidified does not have a steam supply. The minimum humidification load where this becomes economically feasible falls in the range of 50-75 lbs/hr. Steam generator capacity is generally specified 50% greater than maximum humidification load, depending on the amount of piping and number of humidifiers and distribution manifolds that must be heated. Typical piping for boiler-humidifier installations is shown in Fig. 17-1.

Figure 17-1. Typical Piping for Boiler-Humidifier Installation



Design Guidelines—
Boiler-Humidifier Combinations

1. Boiler gross output capacity should be at least 1.5 times the total humidification load.
2. Water softeners should be used on boiler feedwater.
3. Condensate return system is not necessary (unless required by circumstances).
4. Boiler pressure should be at 15 psig or less.
5. An automatic blowdown system is desirable.
6. All steam supply piping should be insulated.
7. No limit to size or number of humidifiers from one boiler.