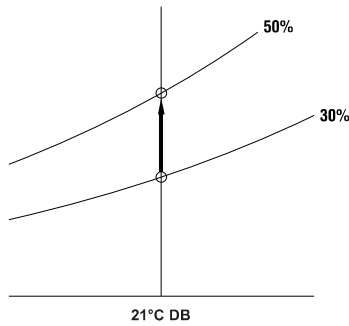


Steam Humidification (Isothermal)

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 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 21°C 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 0,5° to 1°C. 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 many forms of 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.

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.

Direct Steam Humidification

Figure 16-1. Separator Type

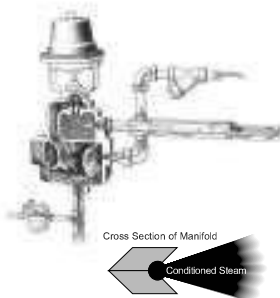
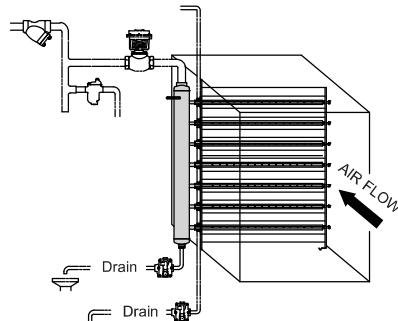


Figure 16-2. Panel Type



Steam-to-Steam Humidification

Figure 16-3.



Electric Steam Humidifiers (Electrode)

Electric 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.

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.

Electric Steam Humidifiers (Resistance)

This type of electric humidifiers typically use immersed resistance heating elements to boil water. Since current does not pass through water, conductivity is not a concern. Ionic bed technology makes the humidifier versatile enough to accommodate various water qualities. These units work by using ionic bed inserts containing 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 inserts.

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

Gas-Fired Steam Humidifiers

In gas-fired steam humidifiers, natural gas or propane are combined with combustion air and supplied to a gas burner. The heat of combustion is transferred to water through a heat exchanger, creating atmospheric steam for humidification. Combustion gasses must be vented per applicable codes. Fuel gas composition, combustion air quality and proper venting can affect operation.

Water quality also can impact the operation and maintenance of gas-fired humidifiers. Ionic bed-type gas-fired humidifiers use ionic bed inserts containing fibrous media to attract solids from water as its temperature rises, minimizing the buildup of solids inside the humidifier. Therefore, water quality does not affect operation, and maintenance typically consists of simply replacing the ionic bed inserts.

Ionic bed gas-fired humidifiers are adaptable to various control signals and offer modulated output. However, control of room RH is affected by the need to boil water and limitations inherent in gas valve and blower technology.

Fogging Systems (Adiabatic)

Fogging systems use compressed air to atomize water and create a stream of microscopic water particles, which appears as fog. In order to become vapor, water requires approximately 2 300 kJ per kilogram. The water particles quickly change from liquid to gas as they absorb heat from the surrounding air, or air stream. Properly designed fogging systems include sufficient heat in the air to allow the water to vaporize, avoiding "plating out" of water on surfaces, which might lead to control or sanitation problems.

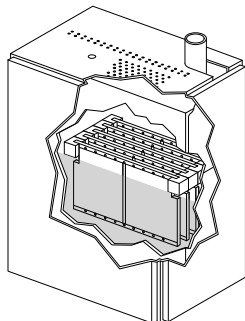
Fogging systems contain virtually none of the heat of vaporization required to increase RH to desired conditions. For this reason, fogging systems humidification is a virtually constant enthalpy process. As the psychrometric example illustrates, DB temperature changes as RH increases from 30% to 50%. This evaporative cooling can provide energy benefits for systems with high internal heat loads.

Unlike many adiabatic humidifiers, properly designed fogging systems are able to modulate both compressed air and water pressures to provide modulated output. Although time and distance (in an air handling system) are required for evaporation, response to control is immediate. High evaporation efficiency guarantees maximum system performance.

A water analysis is suggested prior to applying fogging systems when reverse osmosis (RO) or deionized (DI) water is not available.

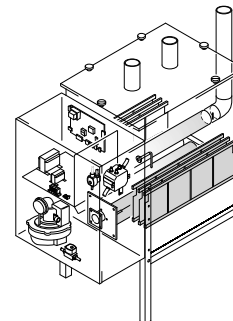
Electric Steam Humidification with Ionic Beds

Figure 17-1.



Gas-Fired with Ionic Beds

Figure 17-2.



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 500 kilograms of humidification per hour costs less than two 250 kg/h units of the same type.

Direct steam humidifiers will provide the highest capacity per first cost Euro; fogging systems and gas-fired humidifiers are the least economical (first cost), assuming capacity needs of 45 kg/h 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. Fogging system and gas-fired (ionic bed) operating costs are also low. Energy costs are higher for electric humidifiers.

Direct steam humidifiers have the lowest maintenance costs, followed by fogging systems. Ionic bed electric and gas-fired 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 19-1, Page 19 summarizes the capabilities of each humidifier type.

Figure 18-1.

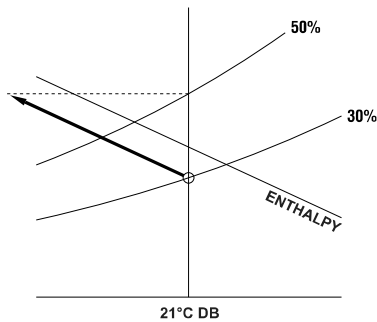
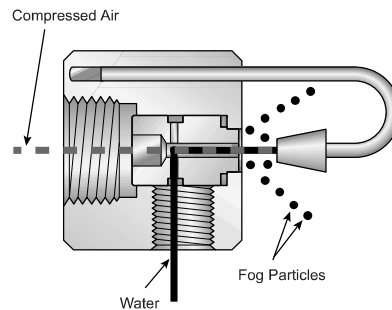
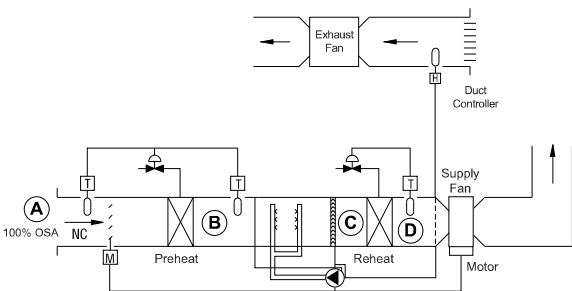


Figure 18-2. Fogger Head

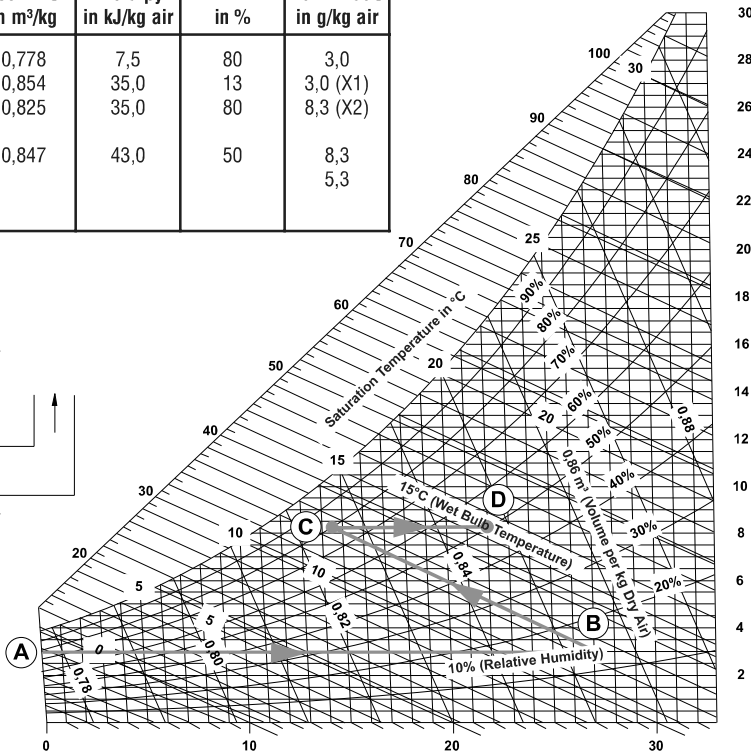


	Dry Bulb t° in °C	Wet Bulb t° in °C	Specif. Vol. in m³/kg	Enthalpy in kJ/kg air	RH in %	Hum. Ratio in g/kg air
A Outside conditions	0	-1,2	0,778	7,5	80	3,0
B Preheat	27,0	12,3	0,854	35,0	13	3,0 (X1)
C Humidification with unheated recycled water*	14,5	12,3	0,825	35,0	80	8,3 (X2)
D Reheat	22,0	15,4	0,847	43,0	50	8,3
$\Delta X (X2-X1)$						5,3

* assumed to be 80% efficient



EA.....Exhaust Air	NC..... Normally closed
E-P relay... Electric-Pneumatic relay	NO..... Normally open
H.....Humidity controller	OSA..... Outside Air
M..... Damper motor	RA..... Return Air
MA.....Mixed air	T..... Temperature Controller



Recommended Applications

Steam: Recommended for virtually all commercial, institutional and industrial applications. Where steam is not available, small capacity needs up to 90 kg/h 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.

Fogging Systems: Properly designed compressed air/water fogging systems used with a reverse osmosis (RO) or deionized (DI) water source will avoid problems associated with sanitation, growth of algae or bacteria, odor, or scale. The potential energy benefit associated with fogging systems should be examined for any application requiring over 230 kg/h where steam is not available, or where evaporative cooling is beneficial, such as air side economizers or facilities with high internal heat loads.

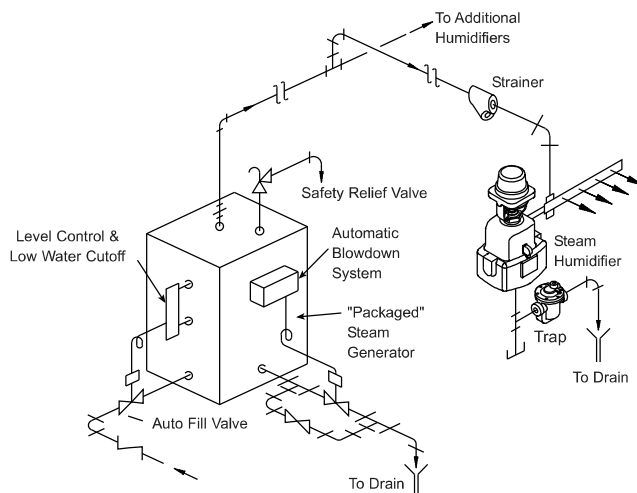
Summary: The evidence supports the conclusion that steam is the best natural medium for humidification. It provides ready-made vapor produced in the most efficient evaporator possible, the boiler. There is no mineral dust deposited, and because there is no liquid moisture present, steam creates no sanitation problems, will not support the growth of algae or bacteria, has no odor and creates no corrosion or residual mineral scale.

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 90 kg/h. 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 Figure 19-1.

Table 19-1. Comparison of Humidification Methods

	Direct Steam	Steam-to-Steam	Electric Steam	Ionic Bed Electric Steam	Ionic Bed Gas-Fired Steam	Fogging Systems
Effect on temperature	Virtually no change					Substantial temperature drop
Unit capacity per unit size	Small to very large	Small	Small to medium	Small to medium	Small to medium	Small to very large
Vapor quality	Excellent	Good	Good	Good	Good	Average
Response to control	Immediate	Slow	Fair	Fair	Fair	Immediate
Control of output	Good to excellent	Below average	Average	Average	Below average	Good to excellent
Sanitation/corrosion	Sterile medium; corrosion free	Bacteria can be present	Programmed to not promote bacteria	Programmed to not promote bacteria	Programmed to not promote bacteria	Designed to not promote bacteria
Maintenance frequency	Annual	Monthly	Monthly to quarterly	Quarterly to semi-annually	Quarterly	Annual
Maintenance difficulty	Low	High	Medium	Low	Medium	Low
Costs: Price (per unit of capacity)	Low	High	Medium	Medium	High	Medium
Installation	Varies with availability of steam, water, gas, electricity, etc.					
Operating	Low	Low	Medium	Medium	Low	Low
Maintenance	Low	High	High	Low to medium	Low to medium	Low

Figure 19-1. 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 1 barg or less.
5. An automatic blowdown system is desirable.
6. All steam supply piping should be insulated.