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Paper

# HUMIDIFICATION DESIGN CHECKLIST: GETTING IT RIGHT THE FIRST TIME.

It's not enough for a humidification system to simply add moisture to dry air. Control of relative humidity is essential – even critical – in some applications. Yet, there are a variety of factors and individuals that converge making it complex and challenging to design proper humidification systems.

Factors such as communications capability, energy economics, water conservation, and sustainability need to be considered. There is also the input and influence that comes from a variety of stakeholders including owners, construction managers, architects, mechanical engineers, designers, mechanical contractors, sheet metal contractors, controls contractors, humidifier manufacturer's representative, and even the manufacturer. So how do these parties, most of whom wouldn't consider themselves humidification system experts, work together to get it right?

A project manager from a large consulting engineering firm asked Armstrong's Humidification Group that question a few years ago. The question will be addressed here, but let's start with the basics first.

## The Plan & Spec Process

The "plan and spec" process begins with the owner. The owner may already be equipped with knowledge and experience that he shares with a consulting/specifying engineer or there may be some corporate specifications in place that dictate and guide the process. In some cases, the owner may only know what he doesn't want. In most instances, the owner relies upon a hired consulting engineer as his professional guide or expert.

## The Consulting/Specifying Engineer

The plan includes a mechanical engineer laying out his design. Many engineering firms have a general humidifier specification that they use. These specifications sometimes originate with a specification service, prior to the engineer customizing the spec to his liking.

Engineers that typically get the best results are the ones that keep the specifications up to date. When six manufacturers are listed as approved, including two that are out of business, the immediate impression is that low price is all that matters. Some believe details are not important while other specifications are clear and concise, calling for features that demonstrate measurable performance.

Humidifier specifications are generally segmented by type. Some engineers supply specs that inadvertently combine two or three generic humidifier types together to form an indecipherable mash. When this occurs, the spec must be ignored and the humidifier equipment schedule takes priority.

## Engineer as Problem Solver

What if the architect has a problem in regard to a vapor barrier? Or, perhaps the engineer needs to go back to the architect for a change regarding required length of a certain pipe run. Or, there's a question about the use of powerhouse steam for humidification. Perhaps a certain area is known for having particularly "hard" water. Will that impact the humidifiers? The engineer is the individual responsible for bringing it all together, sitting down with the owner, and talking about options.

## Construction Managers

The construction manager is hired by the owner and is looking out for the owner's interests. The construction manager may become involved in "value engineering" a project and may provide input to the engineer with cost cutting in mind in areas such as pipe size, duct size, elimination of a boiler, etc., but seldom will the CM comment on the humidifiers, themselves.



### An Informed Owner/Operator

Owners are the ultimate beneficiaries of a well-designed system and educated owners/operators can make informed decisions about the options available. If a system is designed, purchased, and installed simply on the basis of a weak humidifier specification where the lowest priced technology wins, the owner may feel the potential consequences from an inferior operating system over the long term.

Providing owners with an objective comparison and analysis of the various technologies available may avoid a common pitfall of selecting the least cost option and the trade off that will be made in capturing long-term operating efficiencies.

### Mechanical Contractors

Experienced, quality mechanical contractors are invaluable. They solicit pricing and typically submit for approval equipment from manufacturers they know and manufacturer's representatives that they trust. The mechanical contractor is also responsible for installation of the humidifier and proper installation is critical in attaining desired performance. The mechanical contractor competes to win jobs, so low priced equipment is attractive. However, the mechanical contractor is typically responsible for initial equipment start-up and performance through the first year. Thus, it's important that the humidification equipment he supplies performs.

### Avoiding Potential Problems

And now back to our original question: How do the various parties influencing a project work together to "get it right"?

Giving consideration to several key questions at the design stage of a humidification project benefits both the installer and the equipment's owner. Informed decisions contribute value to system performance, impact energy consumption, and affect long-term maintenance requirements.

Dialogue between a well-versed specifying engineer and the owner helps to identify priorities and establish the type of equipment to be used. General considerations and questions should include:

- Survey of building construction – can the space or building hold the levels of humidity desired and are vapor barriers properly located?
- Availability of utilities

- Selection of the proper water type for the humidifier to be used (if other than direct steam injection). Types include:
  - Potable (tap) water from the city or a well source
  - Softened water
  - Reverse osmosis (RO) water that's filtered to remove most minerals
  - De-ionized (DI) water that's high quality and mineral free
- What are the tolerance requirements for humidity control?
- Where are the humidifiers to be located?
- How important is energy consumption of the humidification equipment?
- How is the equipment to be controlled and monitored?
- What type of manpower support will be available to maintain the equipment?
- Is priority on low first cost or reliability and long term operating and maintenance cost?

### Humidification Design Checklist for the Design Engineer

Once some of the key project parameters have been outlined, a humidification design checklist, organized by humidifier type, can be used to assist the engineer in evaluating humidifier technologies in order to:

- Inform the owner of options
- Form and make solid recommendations
- Avoid potential problems that occur when certain aspects are not considered

The common types of commercial/industrial humidifiers used today and some general comparisons are found in Table 3-1. Our checklists focus on direct steam injection (separator type), direct steam injection (short absorption panel type), steam-to-steam humidifiers, electric steam generating humidifiers, gas fired steam generating humidifiers, and fogging systems.

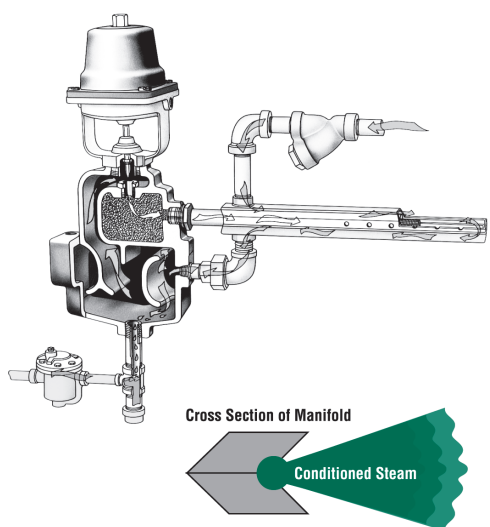
The Humidification Design Checklists outlined within this document are intended to be simple tools to remind engineers of considerations when evaluating various technologies prior to designing a humidification system. Following these checklists will help the engineer to better inform his client of the options available. This isn't an all-inclusive list, but rather an aid to help more humidification projects perform up to expectations in order to benefit engineers, contractors, and owners.

## HUMIDIFICATION DESIGN CHECKLIST: GETTING IT RIGHT THE FIRST TIME.

**Table 3-1. Comparison of Humidification Methods**

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	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 very large
Vapor quality	Excellent	Good			Average	
Response to control	Immediate	Slow	Fair			Immediate
Control of output	Good to excellent	Below average	Average		Below average	Good to excellent
Sanitation/corrosion	Sterile medium; corrosion free	Bacteria can be present	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	Medium
Cost						
Price per unit of capacity	Low	High	Medium	Medium	High	Low to 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

### Direct Steam Injection (conventional separator type)



- Is there steam available?

This humidifier type requires pressurized steam from a boiler or unfired steam generator. The availability of central steam opens up several potential economic and performance benefits, sometimes justifying the use of a steam boiler dedicated specifically to humidification.

- Is chemically treated steam acceptable to the client for his application?

Chemicals are used in steam systems for corrosion inhibition. OSHA and ACGIH each have published permissible treatment concentration levels (threshold limit values or permissible exposure limits) for approved chemicals in steam humidified room air. Treated steam continues to be a popular and successful approach today in a variety of applications, including healthcare.

- What steam pressure can be delivered to the humidifier?

These humidifiers are often rated to work on pressures from 2 psig to 60 psig. However, 15 psig steam and less is commonly available for HVAC applications and use in this pressure range helps minimize noise that might otherwise be objectionable. Steam pressure impacts valve sizing and the ability to lift condensate.

- Valve turndown or rangeability is an important characteristic of separator type steam humidifiers and relates directly to performance.
- Is the steam supply properly piped and trapped?

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- Is the steam and condensate piping to be constructed of black iron or stainless steel?

Beware of the term “clean steam” because it means different things to different people. If the steam is generated from de-ionized water, piping system components should be stainless steel, as should all wetted parts of the humidification system.

- If this is a direct area discharge application, can the humidifier be mounted far enough below the ceiling and with sufficient “throw” distance before the first obstruction for absorption of the vapor?
- If steam is to be discharged into a duct or air-handling unit, how much non-wetting or absorption distance is available downstream?

Make certain that sufficient application parameters are identified on the humidifier schedule so that accurate non-wetting distance calculations can be made

(CFM, face area, EAT, available distance, steam load requirement, RH leaving the humidifier).

- Is the inner duct wall lined with insulation downstream of the humidifier?
  - Is control to be pneumatic or electric?
  - Should a temperature switch be included in the specification?
  - Will condensate from the steam trap be returned or piped to a drain?
- If condensate will be returned, do we have sufficient pressure to do so or will a pump (non-electric or electric) be required. If condensate is to be wasted, do I need a temperature-tempering device?
- Always include high limit humidistats and air proving switches.

### Direct Steam Injection (short absorption panel type)

- Requires pressurized steam from a boiler or unfired steam generator.

Any discussion of a humidification project begins with a simple question: Is there steam available? The availability of central steam opens up several potential economic and performance benefits.

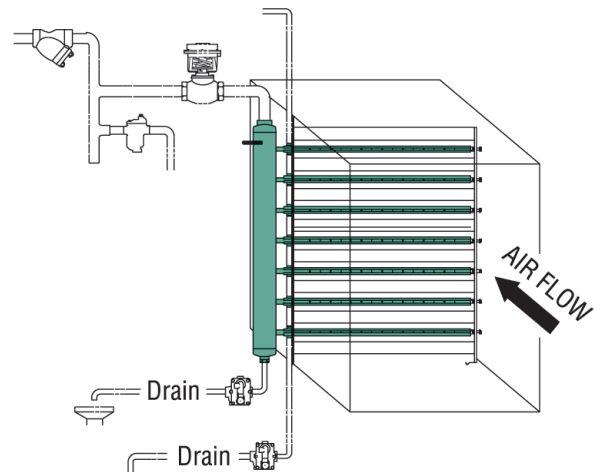
- If three feet or more of non-wetting distance is available, the use of a separator type humidifier should be considered rather than a panel to save money, possibly save energy, and aid in condensate handling.
- Is chemically treated steam acceptable to the client for his application?

Chemicals are used in steam systems for corrosion inhibition. OSHA and ACGIH each have published permissible treatment concentration levels (threshold limit values or permissible exposure limits) for approved chemicals in steam humidified room air. Treated steam continues to be a popular and successful approach today in a variety of applications, including healthcare.

- What steam pressure can be delivered to the humidifier?

Steam pressure of 15 psig and less is commonly available for HVAC applications and use in this pressure range helps minimize noise that might otherwise be objectionable. Steam pressure impacts valve sizing.

- Locate the control valve in close proximity to the panel.



- Is the steam supply properly piped and trapped?
- Beware of the term “clean steam” because it means different things to different people. Are the steam and condensate piping to be constructed of black iron or stainless steel?

If the steam is generated from de-ionized water, the piping should be stainless steel as should all wetted parts of the humidification system.

- How much non-wetting or absorption distance is available downstream?

Make certain that sufficient application parameters are identified on the humidifier schedule so that accurate non-wetting distance calculations can be made (CFM, face area, EAT, available distance, steam load requirement, RH leaving the humidifier).

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- Is the inner duct wall lined with insulation downstream of the humidifier?
- Do I desire optional factory insulation of the panel?
- Is control to be pneumatic or electric?
- Will condensate from the steam trap be returned or piped to a drain?

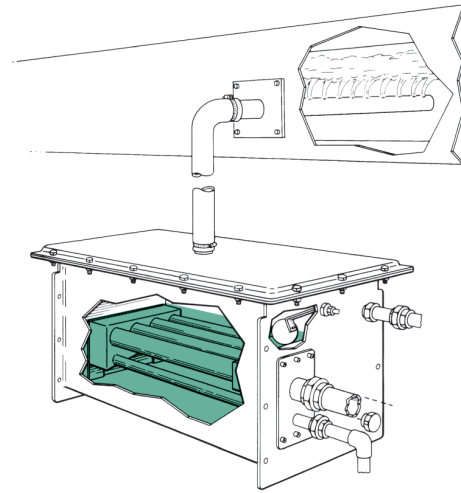
If condensate will be returned, please note that

most panel type humidifiers do not allow for lifting of condensate or moving it into a pressurized return. A pump (non-electric or electric) will be required. If condensate is to be wasted, do I need a temperature-tempering device?

- Always include high limit humidistats and air proving switches.

### Steam-to-Steam Humidifiers

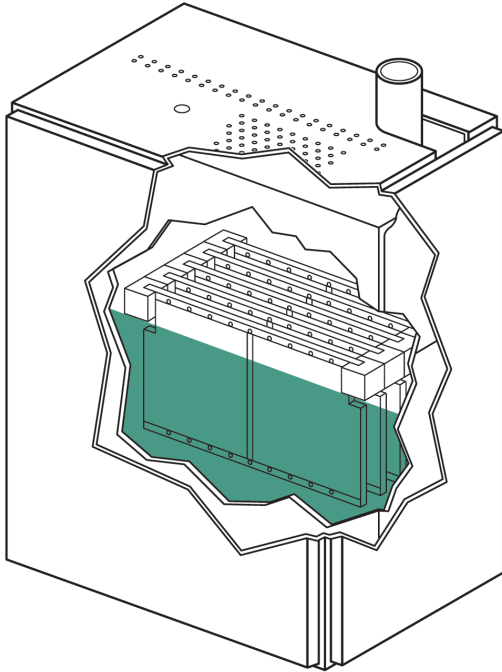
- Requires a pressurized steam source.
- This approach runs higher in first cost, energy consumption, and maintenance cost in comparison to direct steam injection and is not as responsive to changes in demand. Does the boiler treatment being used justify this economic and performance cost?
- Steam-to-steam humidifiers are rated to accept a maximum steam pressure of 15 psig.
- Water quality impacts the output performance and cleaning/ maintenance requirements and use of a special integral means of solids removal (beyond normal blowdown) or pretreatment of the water supply may be beneficial.
- Is there available space for this type of humidifier? They're substantially larger than direct injection units.
- Is the tubing or piping material used for water supply, blowdown, and steam distribution compatible with the water type to be used?
- Steam-to-steam humidifiers are available with either copper or stainless steel heat exchangers, but copper is suggested for tap water service for greater steam production potential.
- Periodic automatic blowdown of these units is required to avoid foaming and chloride stress cracking corrosion.
- The "chemical free" steam discharged from these humidifiers is at atmospheric pressure, thus the steam distribution piping should be insulated rigid copper on tap water service, with pipe runs and elbows kept at a minimum. Piping should be stainless steel if the water is supplied from a reverse osmosis or de-ionized water system. Pipe runs must be properly sized and pitched to make sure that slugs of condensate do not form. A good rule of thumb is to keep runs less than 40 equivalent (including elbows) feet.
- How much non-wetting or absorption distance is available downstream?



Make certain that sufficient application parameters are identified on the humidifier schedule so that accurate non-wetting distance calculations can be made (CFM, face area, EAT, available distance, steam load requirement, RH leaving the humidifier).

- Is the inner duct wall lined with insulation downstream of the humidifier?
  - If a short absorption panel is required, the steam-to-steam humidifier should be sized to compensate for the panel's condensation rate.
  - Should the panel be factory insulated?
  - Do I desire optional legs (recommended) to support the humidifier?
  - Do I desire optional factory insulation for the humidifier tank?
  - Is control to be pneumatic or electric?
  - Will condensate from the steam trap be returned or piped to a drain?
- If condensate will be returned, please note that steam-to-steam humidifiers do not allow for lifting of condensate or moving it into a pressurized return. A pump (non-electric or electric) will be required. If condensate is to be wasted, do I need a temperature-tempering device?
- Always include high limit humidistats and air proving switches.

## Electric (steam generating) Humidifiers



- Is high quality water available?

Performance and maintenance/cleaning are impacted by water quality. Some electric types offer features to address mineral accumulation in addition to normal blowdown. These types of features can help conserve both water and energy.

- For applications requiring critically tight RH control, note that a loss of steam output occurs during required tank blowdown.
- Electrode types are not compatible with RO or DI (purified) water.
- Space requirements: electrode types are wall mounted while some versions of resistance heating element types are wall mounted and others stand on legs for use in mechanical rooms.
- Electric units not including a cabinet to insulate the steam generation tank should be specified with insulated tanks for safety.
- Is the electric unit properly located?

Electric units must be located so that they're accessible for maintenance and should not be located where malfunction could cause damage to valuable assets.

- Electric units should offer Class II alarm circuit for fault indication and many offer MODBUS, BACnet, or LonWorks communication protocol.
- Electrical constraints including voltage, wire gauge, and breaker size must be planned.
- Periodic automatic blowdown is a requirement (per manufacturer's recommendation) to avoid foaming in electrode and resistance heating element type or chloride stress cracking corrosion in resistance heating element type in addition to removal of tank mineral content.
- Cabinet drain connections should include an air gap and be properly sized and pitched.
- Some electric models temper their own blowdown, while others require a separate tempering device.
- Steam distribution piping should be insulated rigid copper, with pipe runs and number of elbows kept at a minimum. Stainless steel piping is typically used for de-ionized water applications. Pipe runs must be properly sized and pitched to make sure that slugs of condensate do not form. A good rule of thumb is to keep runs less than 40 equivalent (including elbows) feet. Use of long pieces of steam hose for steam distribution should generally be avoided.
- Electric humidifiers are susceptible to high static duct (>4 In. W.C.) pressures as well as backpressures impacted by long or restricted pipe runs. Optional fill cup extension kits are sometimes helpful.
- How much non-wetting or absorption distance is available downstream? Make certain that sufficient application parameters are identified on the humidifier schedule so that accurate non-wetting distance calculations can be made (CFM, face area, EAT, available distance, steam load requirement, RH leaving the humidifier).
- Is the inner duct wall lined with insulation downstream of the humidifier?
- If a short absorption panel is required, the electric humidifier should be sized to compensate for the panel's condensation rate.
- Should the panel be factory insulated?
- Always include high limit humidistats and air proving switches.

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### Gas Fired Humidifiers

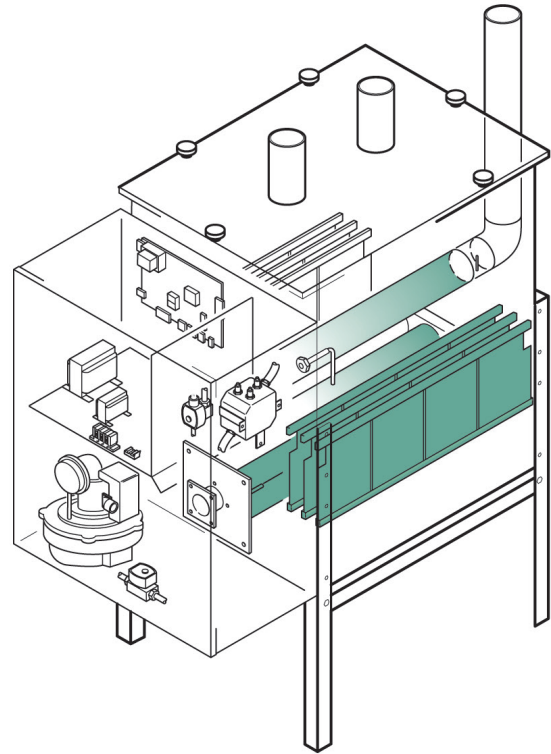
- Is natural gas or propane readily available?
- Gas supply pressure should be 7" W.C. on natural gas and 11" W.C. on LP gas.
- Does the local cost of natural gas provide sufficient energy savings over the cost of electricity for the humidification load requirement?

Gas Fired humidifiers cost more than electric units and their installation is more costly.

- Location: gas fired humidifiers must be located where the products of combustion can be vented per code.
- Electric units should offer Class II alarm circuit for fault indication and many offer MODBUS, BACnet, or LonWorks communication protocol.
- Many gas units do not control steam output as well at low demand as electric units.
- Buildings with unusually tight construction should have combustion air and ventilation air supplied from outdoors, or a freely ventilated attic or crawl space.
- Combustion air may not be common vented with any other natural draft gas appliances or power or forced exhausted appliances.
- There must be sufficient combustion air.
- Is sealed combustion required?
- Is high quality water available?

Performance and maintenance/cleaning are impacted by water quality. Some gas fired humidifiers offer features to address mineral accumulation in addition to normal blowdown. These features can conserve both water and energy.

- Periodic automatic blowdown is a requirement (per manufacturer's recommendation) to avoid foaming and chloride stress cracking corrosion in addition to removal of tank mineral content.
- Cabinet drain connections should include an air gap and be properly sized and pitched.
- Is drain tempering required? Some gas-fired models temper their own blowdown, while others require a separate tempering device.
- Steam distribution piping should be insulated rigid copper, with pipe runs and elbows kept at a minimum.



Stainless steel piping is typically used for de-ionized water applications. Pipe runs must be properly sized and pitched to make sure that slugs of condensate do not form. A good rule of thumb is to keep runs less than 40 equivalent (including elbows) feet. Use of long pieces of steam hose for steam distribution should generally be avoided.

- How much non-wetting or absorption distance is available down stream?

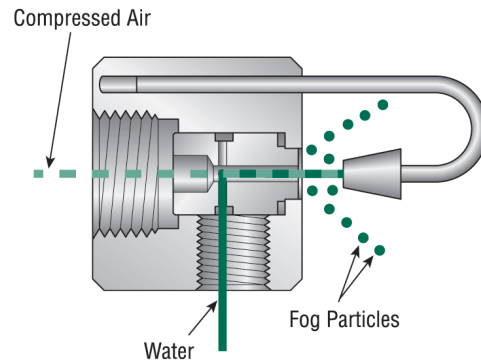
Make certain that sufficient application parameters are identified on the humidifier schedule so that accurate non-wetting distance calculations can be made (CFM, face area, EAT, available distance, steam load requirement, RH leaving the humidifier).

- Is the inner duct wall lined with insulation downstream of the humidifier?
- If a short absorption panel is required, the gas-fired humidifier should be sized to compensate for the panel's condensation rate.
- Should the panel be factory insulated?
- Always include high limit humidistats and air proving switches.

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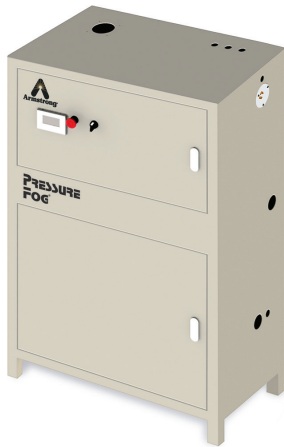
### Fogging Systems (Compressed Air and Water)

- Is there a sufficient quantity of compressed air available?
- Clean, dry instrument air must be supplied to the control panel
- Is a pure (reverse osmosis or de-ionized) water source available?
- Is sufficient preheat of the entering air available, recognizing that a fogging system provides evaporative cooling as it humidifies?
- On air handling systems, is there sufficient evaporation distance before the cooling coil or a mist eliminator? Note that considerably longer distances are required for fog than for steam, making retrofit of old steam applications difficult.
- Fogging systems are typically not suited for duct applications or any application with over 500 feet per minute airflow velocity.



- Fogging systems are frequently located prior to the cooling coil to make sure a drain pan is present downstream. Complete evaporation of the fog prior to the cooling coil may not be possible.
- Do not install fogging systems directly upstream of HEPA filters.
- Always include high limit humidistats and air proving switches.

### Fogging Systems (High Pressure Atomizer)



- Is a pure (reverse osmosis or de-ionized) water source available?
- Use the lower incoming water temperature for sizing as the temperature effects the delivered GPM of output.
- Is sufficient preheat of the entering air available, recognizing that a fogging system provides evaporative cooling as it humidifies?
- On air handling systems, is there sufficient evaporation distance before the cooling coil or a

mist eliminator? Note that considerably longer distances are required for fog than for steam, making retrofit of old steam applications difficult.

- Fogging systems are typically not suited for duct applications or any application with over 500 feet per minute airflow velocity.
- Are the air handler sections sealed at the junctions and drain pans installed in the humidifier section? Materials of construction should be suitable for wet environments.
- Do not install fogging systems directly upstream of HEPA filters.
- Do not install immediately downstream of IFB coils, direct fired burners, or plug fans due to localized high air velocities. The IFB coils and direct fired burners could also cause localized low air temperatures.
- Always include high limit humidistats and air proving switches.
- Electrical constraints including voltage, wire gauge, and breaker size must be planned
- High Pressure systems require the use of a moisture eliminator that is place downstream of the nozzles in a duct/AHU application.
- Is there access to the Humidifier section and humidifier equipment?



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