Specifying Humidifiers

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Humidification is used to improve comfort, control static electricity, and maintain relative-humidity (RH) levels. Applications include health-care facilities, computer rooms, museums, refrigeration warehouses, and food-processing plants.

As diverse as the areas they serve are humidification units themselves, utilizing various processes and methods of moisture delivery.

This article will discuss humidification processes, available technologies, and factors to consider when evaluating competing products.

HUMIDIFICATION PROCESSES

Basically, there are two processes of humidification: adiabatic and isothermal.

In the adiabatic process, the energy required for evaporation is obtained from ambient air. This process is characterized by constant enthalpy. While enthalpy remains constant, the moisture content of the air increases, and the temperature decreases.

The isothermal process, on the other hand, involves the addition of energy for the evaporation of water. Isothermal steam humidifiers increase the enthalpy of air, but do not change air temperature.

ADIABATIC HUMIDIFIERS

In adiabatic humidifiers, water can be circulated and returned to the reservoir or sprayed and not returned.

Some adiabatic humidifiers use mechanical energy to generate fog or mist of water particles. These particles absorb heat from air and evaporate. This process adds moisture to air and lowers its temperature, thus, providing a cooling effect. This effect must be considered in the determination of the heating capacity of a system.

Adiabatic humidifiers can be classified into one of two groups, based on their method of introducing water into air:

- Atomizing, which fracture water into particles 1 to 200 microns in size and discharge the particles directly into the air stream, where they evaporate.
- Evaporative, which evaporate water before introducing it into the air stream.

Atomizing type

Ultrasonic. In ultrasonic humidifiers, electronic oscillation is converted to mechanical oscillation using a piezo disk immersed in a reservoir of mineral-free water. The mechanical oscillation is directed at the surface of the water, where it creates—at very high frequencies—a fine mist of 1-micron water droplets.

Immersion-type germicidal ultraviolet (UV) lamps can be mounted inside the stainless-steel water tanks of humidifiers. The tanks drain automatically when not in operation.

Advantages of ultrasonic humidifiers include:

- Lower energy consumption than with electrical steam humidifiers.
- Lower system cost than with electrical steam humidifiers.

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• Additional cooling effect.
• Low-temperature humidification.

Disadvantages of ultrasonic humidifiers include manufacturer-recommended use of mineral-free, deionized, or reverse-osmosis treated water.

Ultrasonic humidifiers are well-suited for data-processing centers, cleanrooms for electronics and pharmaceutical manufacturing, and telecommunications centers. They also work well in the refrigerated storage of fruit and vegetables, food processing and storage, the cultivation of mushrooms, plant nurseries, orchid culturing, wine cellars, the storage of cut flowers, and other industrial applications.

Centrifugal. Centrifugal humidifiers draw water from the reservoir onto large rotating discs. Centrifugal force accelerates the water across the discs and throws it against an atomizing screen. Water is fractured into non-wetting particles of 5 to 10 microns and discharged directly into the air, where it evaporates, creating an even distribution of droplet-free mist throughout the room.

For easy maintenance and cleaning, air used by a centrifugal unit is drawn through a built-in filter, which protects working parts from dust and dirt in the air.

Advantages of centrifugal humidifiers include:

• Lower energy consumption than with electrical steam humidifiers.
• Lower system cost than with electrical steam humidifiers.
• Additional cooling effect.
• Work with reverse-osmosis or demineralized water, as well as potable water.
• Charcoal filters.
• Safety overflow or level control.
• Automatic flushing device.

Disadvantages of centrifugal humidifiers include a lack of provisions for UV and other germicidal devices that would prevent algae formation in the reservoir.

Centrifugal humidifiers work well in the lower capacity ranges (several pounds per hour) and may be used locally to store and protect perishables and raw and finished goods. Also, they are well-suited for use on a room-by-room basis in small laboratories, tobacco humidors, and greenhouses.

Compressed air/water nozzle. A pneumatic atomizing system that uses only air under pressure and draws water from open, non-pressurized tanks is called a gravity system. It is susceptible to algae and bacteria growth in the tanks. A system that uses both water and air under pressure typically is called "dual pneumatic," as it utilizes dual pneumatic atomizing heads. Minimum water and air pressure, consumption, and droplet size vary from manufacturer to manufacturer.

Advantages of compressed-air/water-nozzle humidifiers include:

• Lower energy consumption than with electrical steam humidifiers.
• Lower system cost than with electrical steam humidifiers.
• Additional cooling effect.
• Reduced maintenance with use of reverse-osmosis or demineralized water with all-stainless-steel construction.
• Use of control cabinets.
• Fail-safe shutdown upon loss of air.
• Various control options.
• Connection to building-automation system.

Disadvantages and limitations of compressed-air/water-nozzle humidifiers include:

• The relatively high cost of oil-less compressors and water pumps.
• The energy consumed by the compressors and pumps.
• Mineral fallout, or "dusting."
• Sensitivity to distance for proper evaporation.
• Water-quality limitations.
• Noise.
• Sensitivity to dirty, unfiltered, and oily air.

Compressed-air/water-nozzle humidifiers work well in greenhouses, cold storage, woodworking, the printing and paper industry, textile-manufacturing areas, cleanrooms, and other industrial applications in which a large amount of humidification is required.

Evaporative type

Because no droplets of water enter the air stream, minerals remain in evaporative humidifiers and must be removed periodically by cleaning, blowdown, and continuous bleed-off. On the positive side, no mineral fallout or "dusting" is experienced with this type of humidifier.

Wetted media. Among the most popular materials for evaporative cooling and humidification are specially impregnated and corrugated cellulose sheets with different bonded flute angles. This design yields a cooling/humidification pad with high evaporative efficiency, but relatively low pressure drop.

A water-distribution system allows uniform supply of water to the cooling pads to minimize dry spots.

Advantages of wetted-media humidifiers include:

• Lower energy consumption than with electrical steam humidifiers.

• Lower system cost than with electrical steam humidifiers.

• Additional cooling effect.

• No mineral carryover.

• Low scaling.

• Use of potable water.

Disadvantages of wetted-media humidifiers include:

• Potential microbial contamination from water being drawn from an open tank.

• High water consumption because of continuous bleed-off and periodic blowdown.

• Additional air-pressure drop from evaporative media being mounted in an air stream.

Air washers. Air washers pass air over a continuous film of water. Because high levels of humidification cannot be achieved with this method, it is less popular than the wetted-media approach.

ISOTHERMAL HUMIDIFIERS

Utilizing a constant temperature, isothermal humidifiers use thermal energy to generate steam, which is introduced into the supply-air stream or directly into a space.

Isothermal humidifiers can be classified into one of two groups, based on the pressure of the vapor or steam and the method of steam generation and injection:

• Boiling-water-vapor injection, which inject a vapor at atmospheric pressure into an air stream.

• Direct-injection steam jacketed (double-wall distribution tube), which introduce 5- to 10-psig steam generated in a central boiler plant or "clean-steam" generator into an air stream.

Boiling-water-vapor-injection type

Electric. At least two types of electric humidifiers are available: electrode and heating element. With both, steam is generated from a wall, floor, or ceiling location and delivered to the supply-air stream via a dispersion assembly.

An advantage of boiling-water-vapor-injection-type humidifiers is that they introduce chemical-free vapor into air streams. Disadvantages of these units include:

• Additional space needs.

• The cost of the equipment.

• Wiring and controls.

• The need for additional water because of drainage.

• The additional cost of the emergency-power system.

• Sensitivity to water impurities.

With an electrode-type unit, the use of water with a high mineral content will result in the need to replace the canisters or clean them frequently, while the use of water with a low mineral content likely will cause the unit to malfunction, as it relies on water conductivity to operate.

Because current does not pass through water in heating-element-type units, purified water may be used to improve performance and greatly reduce maintenance.

Electric humidifiers primarily are used in existing facilities, where only a few are needed. However, they also may be considered where humidification requirements are limited and energy consumption is low.

Gas-fired. Because of an inability to vent the flue or provide combustion air, the use of gas-fired humidifiers often is limited to single-story facilities, where only a limited number of units need to be installed.

Steam-to-steam. In steam-to-steam humidification, steam is delivered from the central boiler plant to a wall-, floor-, or ceiling-mounted converter, where it passes through a heat exchanger, boiling makeup water and generating steam. That steam is conveyed via vapor piping to ductwork and dispersed into the air stream.

When potable water is used, minerals and other impurities are deposited as scale inside the water tank and on the heating coil, reducing the efficiency of the humidifier. To minimize this problem, the use of automatic flush valves and softened or deionized water is recommended.

Disadvantages of steam-to-steam humidifiers include:

• Additional space needs.

• The cost of the equipment.

• The additional costs of makeup-water and drainage piping.

• The need for additional water because of drainage.

• Water-treatment equipment.

If steam is available on site, advantages of steam-to-steam humidifiers are:

• Low energy cost.

• Humidification vapor as pure as the makeup water.

Direct-injection-steam-jacketed type

A direct-injection-steam-jacketed humidifier injects live steam into the air for humidification by a distribution manifold. Steam flows through the outer jacket of the distribution manifold—keeping it hot to prevent condensate formation—into a condensate separator, through a control valve, and into the inner tube of the distribution manifold. From there, it is discharged through holes into the air stream.

Clean steam. An advantage of clean steam is that it is free of boiler-treatment chemicals. Disadvantages include the need for stainless-steel steam and condensate-system piping and components and the need to treat makeup water in reverse-osmosis or deionization equipment.

Central-plant steam. Compared with other vapor and steam systems, central-plant systems with direct-injection-type humidifiers are the best controlled and have the lowest first and operational costs. These systems, however, have a major drawback: Boiler steam carries chemicals used for corrosion control. These volatile neutralizing amines pass through the humidifiers and into air supplies. Proper maintenance and monitoring procedures must be implemented to achieve low ambient-air concentration of amines.

Process	Classification	Type	Application
Adiabatic	Atomizing	Ultrasonic	Offices, computer rooms, cleanrooms, industrial
		Centrifugal	Industrial
		Compressed-air/water nozzle	Industrial
	Evaporative	Wetted media	Industrial
		Air washers	Industrial
Isothermal	Boiling-water-vapor-injection type	Electric-electrode type	Health care, museums
		Electric-heating-element type	Health care, museums
		Gas-fired	Industrial
		Local steam-to-steam converter	Health care, museums
	Injector-type jacketed	Boiler-steam-to-clean-steam converter with direct injection	Health care, museums
		Central-plant steam system with direct injection	Health care, museums, industrial

Note: Industrial applications include woodworking, leatherworking, textiles, baking, cold storage, printing, and paper production.

TABLE 1. Recommended application of humidifiers.

HUMIDIFIER SELECTION

A number of considerations go into humidifier selection:

• *Technologies.* The specifying engineer should be thoroughly familiar with all available humidification technologies and methods and understand performance characteristics, product features, utility requirements, and proper applications.

• *Codes and standards.* For a given application, code may prohibit the use of a particular type of humidifier. For example, some states allow only dry-steam humidifiers in health-care facilities, while other states make exceptions for computer rooms in these buildings.

• *User preferences and requirements.* For example, some large users have adopted *Legionella*-prevention policies that allow the installation of steam humidifiers only, thus prohibiting the use of adiabatic-type humidifiers.

• *Humidifier capacity.* Location, project type, and outdoor and indoor conditions should be analyzed to determine the capacity of a humidifier.

• *Application.* The application determines the humidification process and moisture-delivery method. (See Table 1 for recommended applications.)

• *Availability of central steam.* If steam humidification is required, but the central steam boiler is not available, then local electrical and electronic humidifiers should be considered.

• *Chemicals in central-boiler steam.* Chemicals in central-boiler steam may make steam unsuitable for direct injection. In such cases, steam-to-clean-steam converters must be considered.

• *Relative cost of gas and electric power.* The choice of gas or electric power should be based on a life-cycle-cost analysis.

• *Maintenance.* The intensity of maintenance should be considered in a life-cycle-cost analysis.

• *Water quality.* The use of potable or deionized, demineralized water should be verified with the equipment manufacturer. For deionized water, corrosion-resistant stainless-steel components should be specified.

• *Cost of water.* When water carries dissolved minerals in excess of 120 ppm, a water-treatment system should be considered. Also, the most efficient humidifier should be selected to minimize water consumption.

• *Availability of compressed air.* When compressed air of a required pressure and purity is available, compressed-air/water-nozzle humidifiers should be considered.

• *Availability of emergency power.* In applications such as health care, humidification must be on emergency power.

• *Cooling effect.* The cooling effect of adiabatic-type humidifiers should be considered as heating-plant capacity is determined.

EVALUATING COMPETING PRODUCTS

Only humidifiers utilizing the same humidification process (adiabatic or isothermal) can be considered in an evaluation of equivalency. Characteristics that come into play in such a comparison include:

• Performance, including capacity, efficiency, and dispersion distance.

• Quality of the distributed mist or fog, based on the size of the droplets.

• Controls (electric or pneumatic, modulating or on/off).

• Water consumption attributed to the drainage cycle. As local, self-contained steam humidifiers produce clean steam, minerals in the incoming water are left behind, increasing the water-conductivity level. To maintain the conductivity required for proper operation, the cylinder must be drained automatically. Drained boiling hot water is tempered before leaving the humidifier and being discharged into the sewer, as required by code.

• Steam, water, and air pressure and consumption.

• Materials of the humidifier components.

• Maintenance requirements.

• Installation requirements.

• Dripping potential. Atomizing heads in pneumatic systems using only air under pressure and drawing water from non-pressurized tanks often drip at the end of the "on" cycle, while dual pneumatic atomizing heads using air and water under pressure tend to drip on "start-up." A system should include controls to prevent dripping. Products without a non-drip feature should not be accepted.

• Dusting potential. Potable water used in atomizing humidifiers contains soluble and insoluble minerals and impurities. When an atomized water droplet evaporates in air, it leaves behind a white dust made up of these impurities. The amount of this dust depends on the quality of the potable water. If dusting is unacceptable, water must be purified. Other types of adiabatic humidifiers, such as wetted media, do not present a dusting problem.

• Disposability or reusability of components. Engineers should specify equipment with cleanable, reusable components.

Selection Issues

Parameters usually scheduled on drawings include:

- Basis of design.
- Capacity, in pounds per hour.
- Efficiency, in percent.
- Pressure requirements, in pounds per square inch, for steam, water, or air.

Written descriptions in specifications should include:

- Humidifier type.
- Applicable standards and codes.
- Dispersion distance, in feet.
- The environment served.
- Water and compressed-air consumption.
- Makeup-water-quality requirements.
- Materials of all components.
- Type of controls and control components.
- Drain-cycle provisions.
- Accessories.
- Maintenance requirements.

CONCLUSION

The specifying engineer must learn about all available humidification technologies and base his or her specifications on the fundamentals of humidification theory, requirements of the project, the project budget, and costs of the products and utilities involved.

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