ADIABATIC DESIGN GUIDE

HUMIDIFICATION SYSTEM

driSteem™

Table of contents

Table of contents

Introduction to the Design Guide

Let us know what you think!

We're constantly trying to improve the information we share with you. If you have comments or suggestions for improvements to this guide, please contact us at 800-328-4447 or e-mail us at sales@dristeem.com.

The tools you need

Review Table 5-1, which describes DriSteem resources, to see how this guide fits in with our overall plan of educating you about humidification issues.

HUMIDIFICATION SYSTEMS FOR ANY APPLICATION

DriSteem designs and manufactures humidification systems to meet the unique requirements of health care, industrial, process-critical, commercial and residential humidification applications worldwide. Since 1965, DriSteem has been the humidification industry leader of product excellence, innovation, and responsive customer service.

WHO WE ARE

EXPERTS

We design and manufacture humidification systems to meet your unique humidification requirements. We have earned our reputation as the humidification experts by supporting customers' unique commercial, health care, industrial, and process-critical applications since 1965.

INNOVATORS

Through extensive research and development efforts, we continue to develop industry-leading innovations that greatly improve methods for adding moisture to air with precise control.

OUR MISSION

Our mission is to provide customers with exceptional service and superior products that condition or control air for HVAC applications.

WHAT WE DO

CREATE HEALTHY ENVIRONMENTS

Studies show that when room RH drops below 40 percent, incidents of respiratory illness increase. Proper humidification can significantly reduce student and employee absenteeism.

IMPROVE PRODUCTION PROCESSES

Controlling a building's RH significantly improves production processes. RH affects the moisture content of hygroscopic materials, such as wood, textiles, paper, leather, fibers, and foods. Such materials either absorb or release moisture until an equilibrium moisture content is reached, which may affect many of the properties critical for production.

PRESERVE MATERIALS AND ARTIFACTS

Fluctuating RH causes material to repeatedly absorb and release moisture. These changes may impact a material's weight, strength, and appearance, which may damage the material and shorten its longevity.

Introduction to the Design Guide

Table 5-1:
The tools you need — DriSteem's educational resources

Tool	Purpose	Description	Location
Brochures	Overview of product specific information.	Available for all DriSteem products.	View, print, or download pdf file at: http://www.dristeem.com/support-and-literature/literature-product-resources
Case studies	Humidification education	Application-specific stories about installed humidification systems.	View, print, or download pdf file, or order a preprinted copy at: http://www.dristeem.com/humidity-university
Catalogs	Product-specific information needed to make a purchase decision and create a schedule	Available for the following products: • CRUV® humidifier • GTS® humidifier • RTS® humidifier • Humidi-tech® (available only in Europe) • STS® humidifier • Ultra-sorb® steam dispersion panels • Vapormist® electric humidifier • Vaporstream® electric humidifier • Adiatech® evaporative cooling and humidification • XT series electrode steam humidifiers	View, print, or download pdf file at: http://www.dristeem.com/support-and-literature/literature-product-resources
Design Guide	Explains the humidification system design process	With this document and a product catalog, HVAC engineers can design a humidification system.	View, print, or download pdf file at: http://www.dristeem.com/
LoadCalc	Allows you to make a quick calculation of the humidification load for your application.		
Building Information Modeling	BIM content	Download DriSteem products in a 3D BIM file to create a digital representation to support your decision-making..	www.dristeem.com/products/bim-content
DriCalc® software	Automates the humidification system design process	DriCalc sizing and selection software automatically sizes loads, selects equipment, writes specifications, and creates as-configured installation instructions and equipment schedules for DriSteem products.	http://www.dristeem.com/calculators-and-selection-software
EnergyCalc™ energy savings software	Compare what your costs would be using gas versus electric humidification	Easy-to-use and comprehensive, and includes weather data from numerous cities. Savings from switching from electricity to gas will usually cover the cost and installation of a new GTS humidifier.	http://www.dristeem.com/calculators-and-selection-software
Installation, Operation and Maintenance manuals (IOM)	Product-specific operation and maintenance information	Available for all DriSteem products.	View, print, or download pdf file at: http://www.dristeem.com/support-and-literature/literature-product-resources
Psychrometric chart	For calculating humidification load	Laminated chart with steam absorption charts on the back.	View, print, or download pdf file at: http://www.dristeem.com/support-and-literature/more-literature
Videos	General product information in video format		http://www.dristeem.com/support-and-literature/video-library
Website	Comprehensive information about DriSteem products and humidification issues	Information available includes: • Detailed product information • Downloadable catalogs and manuals • Humidification education • New product announcements • Representative locator • News about trade shows	www.dristeem.com

Why humidify?

Properly controlled humidification enhances occupant health and comfort, improves manufacturing processes, and helps preserve building materials and furnishings. In short, any building housing people or things will benefit from proper humidification, and the cost to add humidification is easily offset by gains in processes, productivity, life of materials, and occupant satisfaction.

HUMIDIFICATION IMPROVES MANUFACTURING PROCESSES

Relative humidity levels affect manufacturing production rates, and product size, weight, strength, appearance, and quality. If you've ever known your laser printer to jam on a humid summer day, then you can understand how changes in texture, strength, or weight can affect the high-speed processing of hygroscopic materials. Static electricity can negatively affect processes. Static electricity can cause high concentrations of oxygen and other gases to ignite. These gases are prevalent in hospitals and laboratories. Dust particles adhere to objects when charged by static electricity. This can be a critical problem with semiconductor, pharmaceutical, and other electronic processing, where one misplaced dust particle can ruin a chip, a batch, or an assembled component. Maintaining RH levels within a range of 30 to 60 percent will significantly reduce problems associated with static electricity.

HUMIDIFICATION PRESERVES MATERIALS AND FURNISHINGS

Many building materials, finishes, and furnishings are hygroscopic — they absorb, retain, and release moisture. Low RH levels cause expensive damage to building interiors because as hygroscopic materials dry, they shrink. This can create gaps in wallpaper seams, floor boards, and furniture joints, and also can damage historic and artistic artifacts. Fluctuating RH levels also cause damage. Maintain a consistent RH level to keep the moisture content of hygroscopic materials in equilibrium (EMC) with their surrounding environments.

HUMIDIFICATION IMPROVES INDOOR AIR QUALITY

Bacteria and viruses thrive in dry air. Studies have shown that when room relative humidity (RH) drops below 40 percent, absenteeism increases due to respiratory illness. Proper humidification can reduce absenteeism as much as 18 percent. Humidified spaces feel warmer and are more comfortable for occupants, especially in cold climates where heating systems run frequently. Of course, controlling RH is important. Keeping RH levels within a range of 40 to 60 percent not only decreases bacteria and viruses in the air, but hinders the development of fungi, mites, chemical interactions, and ozone production. The result is reduced occurrences of allergic rhinitis, respiratory infections, and asthma among building occupants. To ensure that RH levels do not rise above 60 percent, responsive humidification system control is essential.

Why humidify?

HUMIDIFICATION IMPROVES COMFORT FOR BUILDING OCCUPANTS

Also hygroscopic in nature, the human body gives up its moisture to dry air. As our body's moisture migrates (evaporates) to areas of low RH, we become cooled, just as when we perspire. Raising the RH level in a room slows the evaporation rate and will make the room feel warmer. This allows dropping the dry-bulb temperature without a loss in comfort, offsetting humidification energy costs. Adding humidity to a building preserves materials, improves processes, and enhances health and comfort, while paying for itself with increased productivity and lower heating costs.

ADIABATIC HUMIDIFICATION

Imagine a lazy, hot, August afternoon of your childhood, cicadas buzzing, not a leaf stirring, and there's nothing to do. So, you ponder the drops of water on your cold Coke can. "It's sweating," your mother says. On such a hot day you almost believe her.

What your childhood mind was trying to understand was phase change caused by energy transfer: Heat in the air transferred to the cold can, causing water vapor in the surrounding air to convert to liquid water (condensation).

Of course you drink that refreshingly cold soda, get distracted (from the caffeine, no doubt), and return to find the can dry on the outside.

What happened? Heat in the air transferred to the liquid water droplets on the can, causing them to revert back to vapor (evaporation).

The above story serves as an example of an adiabatic process, for if that cold can were placed into a theoretically closed system, no heat would be extracted from or added to that system; heat would just transfer, changing vapor to water and water to vapor.

The coolest thing about an adiabatic process is that it can be harnessed to reduce air temperature and provide humidification via an adiabatic humidifier.

Adiabatic humidifiers utilize a variety of technologies to introduce water into air, either by dispersing water droplets or by allowing water to evaporate from wetted media, causing relative humidity (RH) levels to increase and air temperature (dry bulb) to decrease.

Why humidify?

WHY HUMIDIFY – AND WHY CONSIDER EVAPORATIVE TECHNOLOGY?

Facility managers, owners and operators humidify their buildings for many reasons – the most common being the health of the people in the building and to protect equipment or products from dry air. Of course, humidification has a cost to operate. Evaporative humidification and cooling, regardless of the climate, can be the most cost-effective way to keep your building healthy, comfortable, and profitable.

WHAT IS EVAPORATIVE HUMIDIFICATION AND COOLING?

Humidification is simply adding water to the air of a building – for health, comfort, preservation, or process. One common way to humidify is to boil water and add the steam to the air, which is known as steam humidification. In comparison, evaporative humidification draws water into the air through the natural effect of evaporation (hence the name). Hanging laundry to dry and using hair dryers are common examples of this. Evaporation also causes the air to cool down, like the cool breeze off a lake or the cooler air near a waterfall.

Minnehaha Falls in Minneapolis, Minnesota

Why humidify?

The primary methods for evaporative humidification and cooling are High Pressure nozzles and Wetted Media Systems. High Pressure simply uses a pump to pressurize clean water and push it through small nozzles to atomize the water into the air handler or space. Wetted Media Systems distribute water over a pad in the air handler, and the airflow over the wetted media causes evaporation. Other options include ultrasonic and pressurized air systems.

WHY CHOOSE EVAPORATIVE HUMIDIFICATION AND COOLING?

As discussed, humidification is important for your commercial or industrial building. Whether you need to protect your employees, or your manufacturing line needs to operate at peak efficiency, choosing the correct humidification for your application can make order-of-magnitude differences in your annual utility costs. And this is true from the deserts of California through the frigid winters in Minneapolis.

ENERGY CONSIDERATIONS – WHY EVAPORATIVE HUMIDIFICATION

Steam humidification takes energy from electricity or gas as a power source and uses it to make steam. That steam is then added to the air for humidification. This means that every pound of water that enters the air has an easy-to-define cost associated with it. Evaporative humidification and cooling removes energy out of the air to evaporate the water, which can mean reduced cooling costs. Since the energy is in the air, the cost per pound of water that enters the air can even be considered a "negative cost" because the cooling is beneficial to the building.

Evaporative cooling and humidification can make a massive dent in a building's utility bills. On top of this, many utilities and governments allow energy rebates for switching over to evaporative humidification and cooling. More governments are implementing energy regulations, and there are more benefits everyday to managing energy usage per square. The free cooling and low-energy use of these evaporative humidification and cooling systems can be a win-win-win for quality, for comfort and for operational costs. Payback on switching to evaporative humidification and cooling can often be realized in less than one year.

"Choosing the correct humidification for your application can make order-of-magnitude differences in your annual utility costs."

Why humidify?

ENERGY CONSIDERATIONS – DOLLARS AND CENTS

For this example, average American utility cost information was used. The building is a general manufacturing facility in Minneapolis and has reasonable setpoints, including night-time setback. The building uses an airside economizer and minimizes outside air when it is not beneficial to the building. The chart shows the estimated total annual humidification cost for the building. The numbers are rounded for easy viewing.

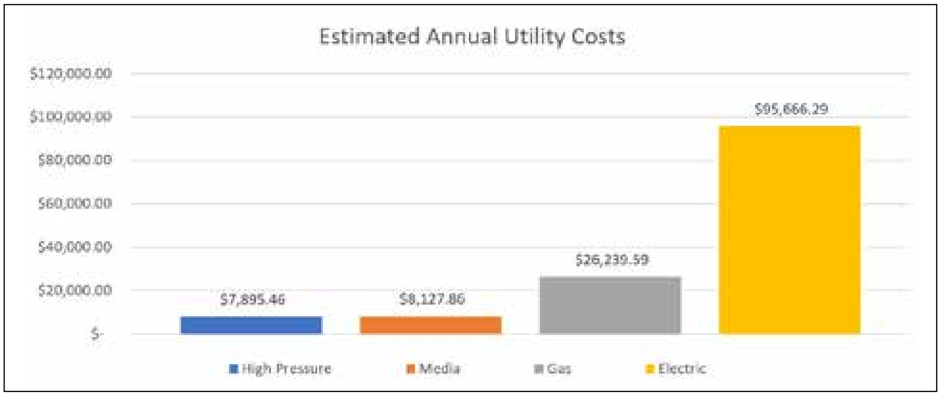
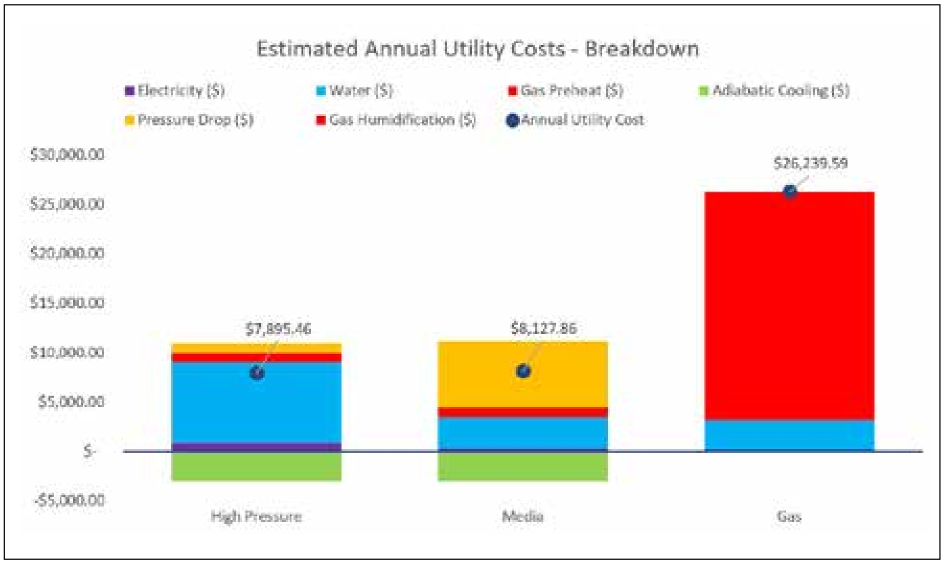


Table 1 - Annual Utility Costs for Humidification of a Manufacturing Facility in Minneapolis

It is interesting to look at how this costing breaks down; where are the savings made, and where do the extra dollars go? The below chart breaks these out in more detail. Only beneficial evaporative cooling is considered as a "negative cost" – a savings. Cooled air that needs to be reheated is considered a cost to the humidifier.



Why humidify?

WHERE CAN THIS BE APPLIED?

There is an assumption that the above energy savings can only be seen in hot desert climates – certainly not in the frigid north! But this is not correct. Evaporative Cooling and Humidification can be applied in every climate – given the right applications.

These "right" applications are common and varied. The most obvious would be a data center; they have a year-round cooling load and they need to be above a certain relative humidity. These buildings could be in Phoenix, Edmonton, New York or Minnesota and evaporative humidification and cooling should be a consideration. Of course, appropriate applications do not have to be this specialized.

Large office buildings and malls often have internal cooling loads late into the winter, based on lighting, equipment, and people. As a definitive example, the Mall of America in Bloomington, Minnesota, does not even have a central heating system! In an office building, using that extra heat for evaporative humidification allows for free humidification which benefits the health and comfort of all occupants.

Woodworking and printing facilities often must humidify to optimize their process and products, and in most situations the evaporative cooling effect can allow for free humidification as well as savings on cooling. Many manufacturing facilities – such as electronics, pharmaceuticals, and metal working – can benefit equally from a high-pressure or wetted media system.

If your building actively cools late into the season, evaporative humidification and cooling should be your next upgrade.

Why humidify?

FREE COOLING

Evaporative cooling systems integrate well with existing mechanical systems and offer reduced cooling and humidification costs. Installing an evaporative humidification and cooling system can help reduce the operating costs of a building without complicating the existing controls or making changes to your existing mechanicals.

While every building is a candidate for an evaporative system, those with a high cooling demand are the easiest to justify. If a building's cooling system is operating late into the autumn, and early in the spring, then adding an evaporative system may be the most cost-effective change that can be made. This applies whether the building uses mechanical cooling, air-side economizing or water-side economizing. Evaporative cooling can reduce the cooling bill by reducing demand on mechanical cooling equipment – and effectively eliminate the humidification bill.

Using an air-side economizer, while remarkably effective for reducing cooling bills, dries out the building. In fact, the driest time for air-side economizer buildings is often in the autumn and spring. A dry building increases the risk of disease among employees, aggravates allergies, decreases the quality of many materials, and may cause disruption to manufacturing processes. Using an evaporative humidification and cooling system can extend the economizer season further into the summer, eliminate humidification costs, reduce mechanical cooling costs and can even reduce the amount of frost coil usage in the winter by reducing the amount of outdoor air needed to cool.

Evaporative humidification and cooling is a win-win-win for buildings with an extended cooling season – regardless of the climate.

"If a building's cooling system is operating late into the autumn, and early in the spring, then adding an evaporative system may be the most cost-effective change that can be made."

High-Pressure System: Features

Feature	High-Pressure System
Application versatility	Suitable for any application; commonly used in agriculture, painting, industrial manufacturing, printing facilities,and applications using air-side economizers
Advanced technology	Precision-machined atomizing nozzles fragment water droplets into ultra-fine particles (90% are ten microns or less)
	Water delivered to nozzles at up to 1200 psi (8.27 MPa) requires no pressurized air
	Integral check valve in nozzle ensures no dripping when system shuts off
Cooling effect saves energy	Every pound of atomized water absorbed in air removes approximately 1000 Btu of heat from the air (every kg absorbed removes approximately 2300 kJ of heat)
	Significant energy savings when cooling and humidifying simultaneously
	Utility rebates can offset initial costs
Low maintenance	Stainless-steel pump is cooled by purified supply water; 8000 hours before maintenance check and service
	Stainless-steel nozzles and manifolds require little maintenance (replacement as needed)
	Thorough water filtration protects stainless-steel components from corrosion and undue wear
	Final evaporation media as close as three feet (0.9 m) downstream from heating coil prevents downstream wetting
Comprehensive system control with Vapor-logic	Accurate, responsive RH control; PID control tunes system for maximum performance
	Set up, view, and adjust system functions with intuitive keypad/display or Web interface
	Integrates into any building automation system via an optional BACnet, LonTalk, or Modbus communication protocols
User controlled	Not available
Multiple zone control capability	Individual zone monitoring and modulated staging valves provide tight control in all zones with optimized absorption and minimal water waste
	One system cools and humidifies multiple zones with separate demands
Fan-assisted dispersion	Fan assisted fans have a hub style design for localized access and more efficient evaporation as it moves air more effectively. The fan-assisted dispersion unit pulls the air from above where it tends to be warmer.
Versatile	Cools and humidifies in air handlers, ducts, and open spaces
	Nozzle staging and pulsed modulation allow high turndown of system output. Additionally, a mechanical relief valve allows for internal recirculation; providing further turndown.
	Capacities up to 5500 lbs/hr (2495 kg/h), multiple systems can be combined for larger capacities
	Flexibility to accommodate the most challenging applications; extensive network of DriSteem representatives available to assist with system layout and design
Complete water treatment solution	Water treatment options available from DriSteem include RO hyperfiltration, particulate filtering, dechlorination, and duplex water softening
	Automatic back-flush technology ensures long RO membrane life
	Ultra-pure water can eliminate white dust fallout and bacteria/virus proliferation, that can occur when using potable water

High-Pressure System: Sequence of operation

A COMPLETE SYSTEM THAT INCLUDES WATER TREATMENT

1 Water enters system from municipal water supply

2 Dechlorinator (wall-mounted on smaller models)

3 Duplex water softener with brine tank

4 RO station with particulate filter and RO membranes

5 Pressurized RO holding tank

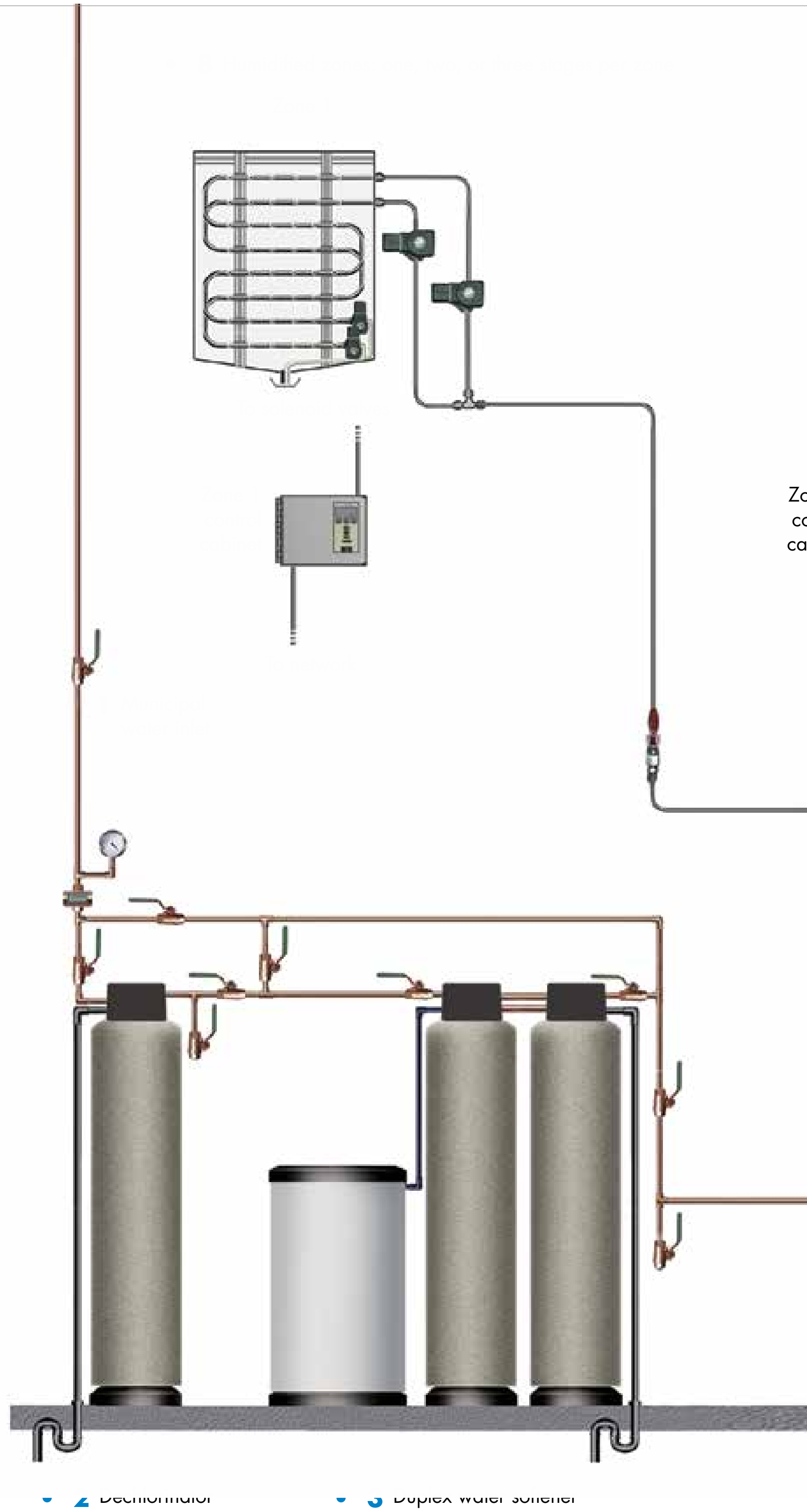
6 High-pressure pump station:

All-stainless-steel axial-piston high-pressure pump delivers purified, high-pressure water to atomizing nozzles

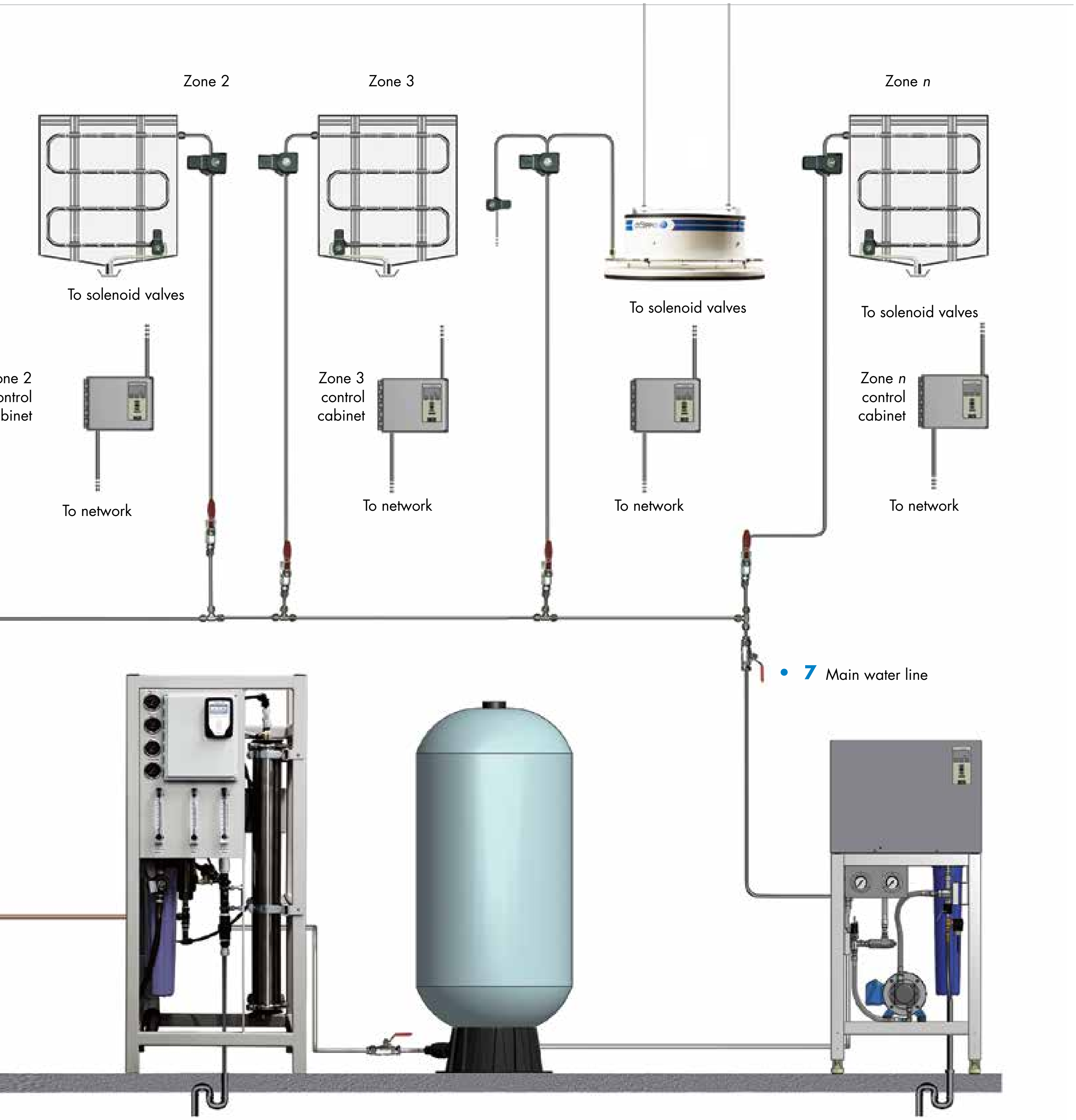
Vapor-logic controller optimizes absorption in multiple humidification zones

7 Main water line feeds network of high-pressure, stainless-steel piping

8 Humidified zones: purified, ultra-fine water droplets exit nozzles and disperse in AHUs, ducts, and/or open spaces



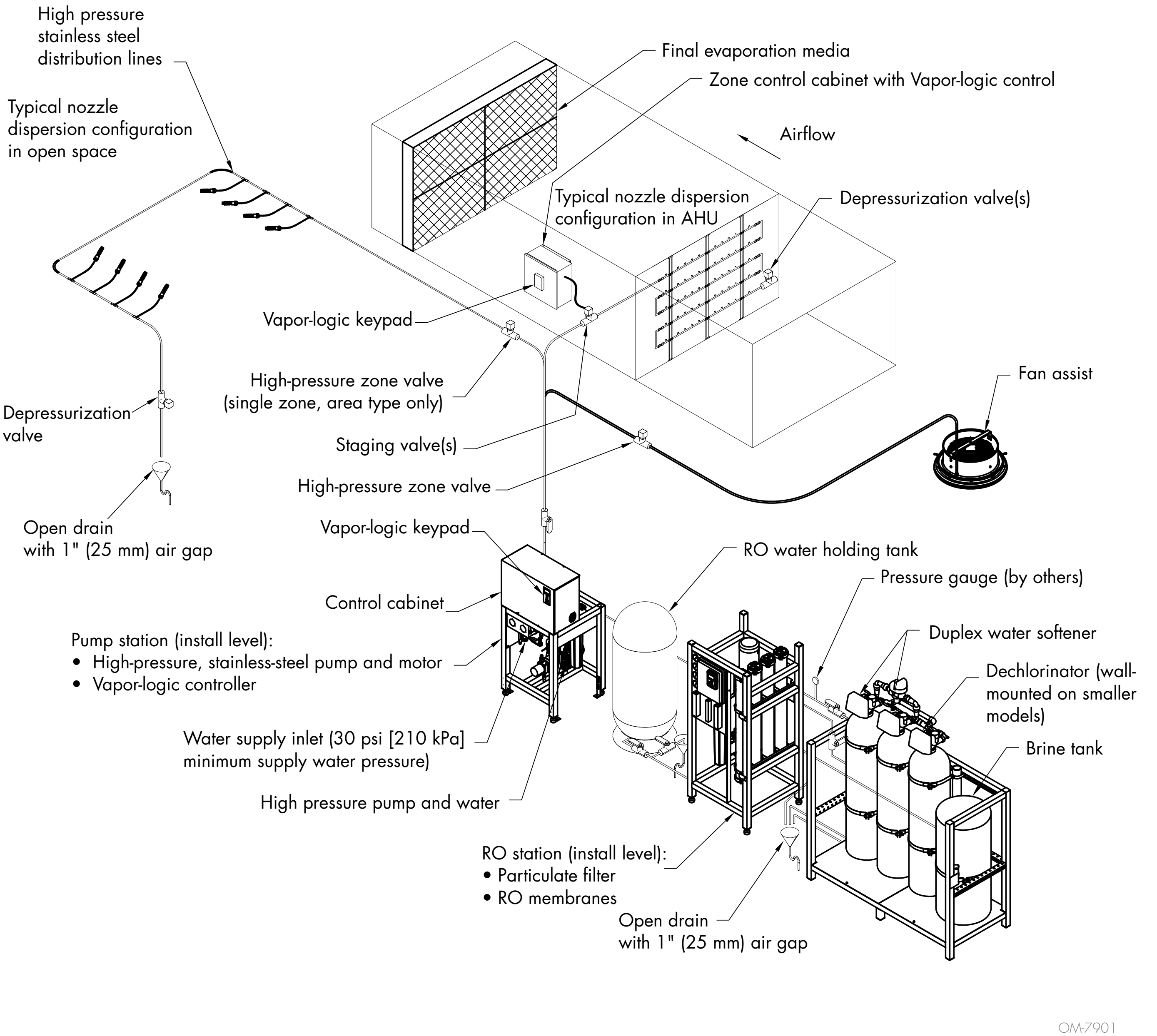
High-Pressure System: Sequence of operation



- **4** RO station:
  - Particulate filter
  - RO membranes
- **5** Pressurized RO holding tank
- **6** High-pressure pump station:
  - High-pressure stainless steel pump
  - Vapor-logic controller

High-Pressure System: Components overview

FIGURE 16-1: DRISTEEM HIGH-PRESSURE SYSTEM OVERVIEW



Note:

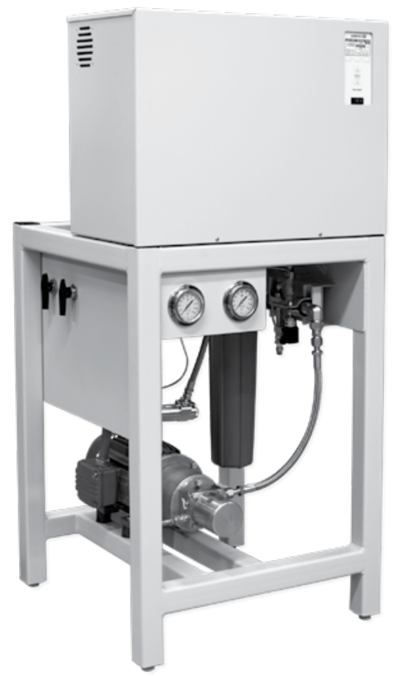
- System components and configuration may vary to meet application requirements.
- A water treatment system must be used with the DriSteem High-pressure system. See the Pre-treatment Installation, Operation, and Maintenance manual for skid mounted options.

High-Pressure System: Components overview

Your system may include all or some of the following components.

- Pretreatment equipment
  - Dechlorinator
  - Softener
- RO system components
  - Water pump
  - Vapor-logic controller
  - Gauges, valves
  - Control cabinet
  - Storage tank
- Pumping station components
  - High-pressure water pumping components
  - Vapor-logic controller
  - Gauges, valves
  - Control cabinet
- Atomization piping, manifolds, nozzles, valves
- Fan-assist dispersion with nozzles, tubing, valves
- Final evaporation media
- RH transmitters and airflow switches

FIGURE 17-1: PUMPING STATION



PUMPING STATION

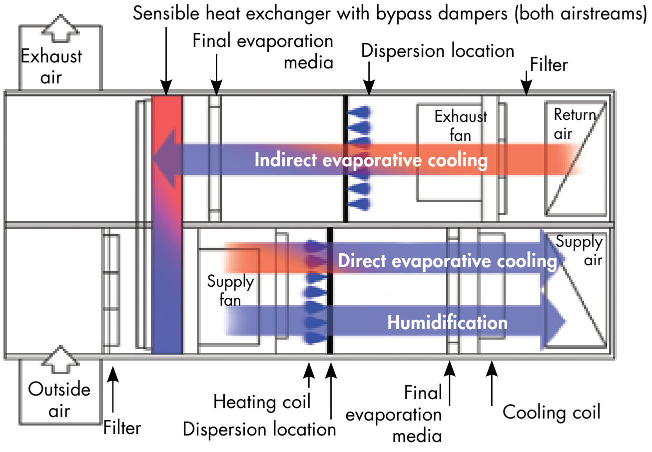
The pumping station arrives at the job site ready for single-point connection to power and water. Contained within the rugged, painted-steel frame are the high-pressure water pumping components, gauges, valves, and a control cabinet.

DIRECT OR INDIRECT EVAPORATIVE COOLING

Direct evaporative cooling adds moisture to the supply air while humidifying and cooling the space at the same time.

Indirect evaporative cooling occurs in the heat exchanger without adding moisture. Cooling air before it enters the space without adding moisture to the space.

A High-Pressure System is shown here.



Fan-assisted dispersion

DriSteem's high-pressure fan-assisted dispersion Model FA is a component of a high-pressure atomization system. The fan is designed to throw small water droplets and increase air movement. The Model FA-2 is designed for low ceiling heights. Models FA-3 and FA-4 are designed to pull air from above the fan (typically the hottest air), which promotes better absorption, and throws moisture horizontally. The Model FA can be used for cooling and/or humidification applications.

- Pulls air from above the system rather than below, using the warmest air and minimizing the chance for condensation forming from fog return.
- Utilizes flexible tubing to increase installation speed.
- The hub style system allows for easier access to service all nozzles on the unit.
- Promotes better air movement.
- The stainless steel design provides quality and longevity of the dispersion system.
- Fan powered dispersion allows for installation in lower ceiling applications.

APPLICATION VERSATILITY

- Greenhouses
- Germination chambers
- Printing
- Paper products
- Wood working
- Warehouses
- Electronics
- Textiles
- Clean rooms
- Cigar manufacturing
- Plastic fabrication

Evaporative cooling and humidification

HIGH-PRESSURE WATER ATOMIZED, REDUCES COOLING LOAD AND ENERGY COSTS

Evaporative high-pressure systems are used to cool and humidify air for processes, products, preservation, and comfort. These flexible systems can be installed in airstreams or directly in the space to be conditioned. They use very little electrical energy to operate and can be located long distances from the air being conditioned. A single system can condition multiple zones and cool supply air directly and/or indirectly through a heat exchanger.

The following characteristics are typical of evaporative high-pressure systems:

Reduced cooling load: The evaporative cooling effect can draw enough heat from the air to produce a 20 °F or more temperature drop. One pound of water evaporated into the air removes approximately 1000 Btu of heat; 12 pounds of water equals about a ton of cooling.

Energy savings: Evaporative high-pressure systems require very little energy to deliver water droplets into the air — about one percent of the energy used by an electric humidifier per pound of water.

Minimal maintenance: Systems using reverse-osmosis (RO) or deionized (DI) water require very little maintenance, particularly if the pump and atomizing nozzles are low- or no-maintenance stainless steel.

Pure, particulate-free cooling and humidification: When using RO or DI water, systems with high-grade stainless steel parts can disperse atomized water particles without dispersing bacteria, viruses, or minerals.

High capacity: In air handlers and ducts, capacity is limited only by duct or air handler size and evaporation capability. In open spaces, very large capacities can be met with a single system or with multiple smaller systems.

Twelve pounds of water evaporated into the air equals about a ton of cooling. Evaporative high-pressure systems provide significant energy savings compared to other evaporative technologies.

Evaporative cooling and humidification psychrometrics

Table 20-1 presents how an evaporative high-pressure system can be configured for regional outside conditions and reconfigured for seasonal changes. Operating conditions for each scenario are charted in Figure 21-1.

Table 20-1: Seasonal/regional scenarios and evaporative high-pressure system design factors

<table>
<tr><th rowspan="2">Scenario</th><th colspan="4">Outside air operating conditions</th><th colspan="5">Design factors</th></tr>
<tr><th>Wet bulb (°F)</th><th>Dry bulb* (°F)</th><th>Dew point (°F)</th><th>RH %</th><th>Outside air %</th><th>Evaporative high-pressure system status**</th><th>Supply air dry bulb (°F)</th><th>Supply air dew point (°F)</th><th>Room dew point (°F)</th></tr>
<tr><td>A</td><td>< 53</td><td>—</td><td>< 42</td><td>—</td><td>Minimal to 100</td><td>Staging / Modulating</td><td>64</td><td>42</td><td>—</td></tr>
<tr><td>B</td><td>> 53</td><td>—</td><td>< 42</td><td>—</td><td>Minimal to 100</td><td>Staging / Modulating</td><td>64 to 81</td><td>42</td><td>—</td></tr>
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< 76</td><td>> 81</td><td>> 42</td><td>—</td><td>Minimal to 100</td><td>Staging / Modulating</td><td>81</td><td>42 to 59</td><td>—</td></tr>
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<tr><td>H</td><td>—</td><td>> 64</td><td>< 59</td><td>> 60</td></tr>
</table>

* Dry bulb temperature includes heat gain from the supply fan.
** When evaporative cooling cannot meet the cooling requirement, supplemental cooling is required.

Evaporative cooling and humidification psychrometrics

FIGURE 21-1: OUTSIDE AIR OPERATING CONDITIONS ON THE PSYCHROMETRIC CHART

Scenarios from Table 20-1 are defined by the red borders in this chart, which characterize year-round, seasonal differences for a specific application.

Table 20-1 design factors are based on the required supply conditions (Scenario C in the table, and region C in this chart).

Note: Region C in this chart is the design range for supply air.

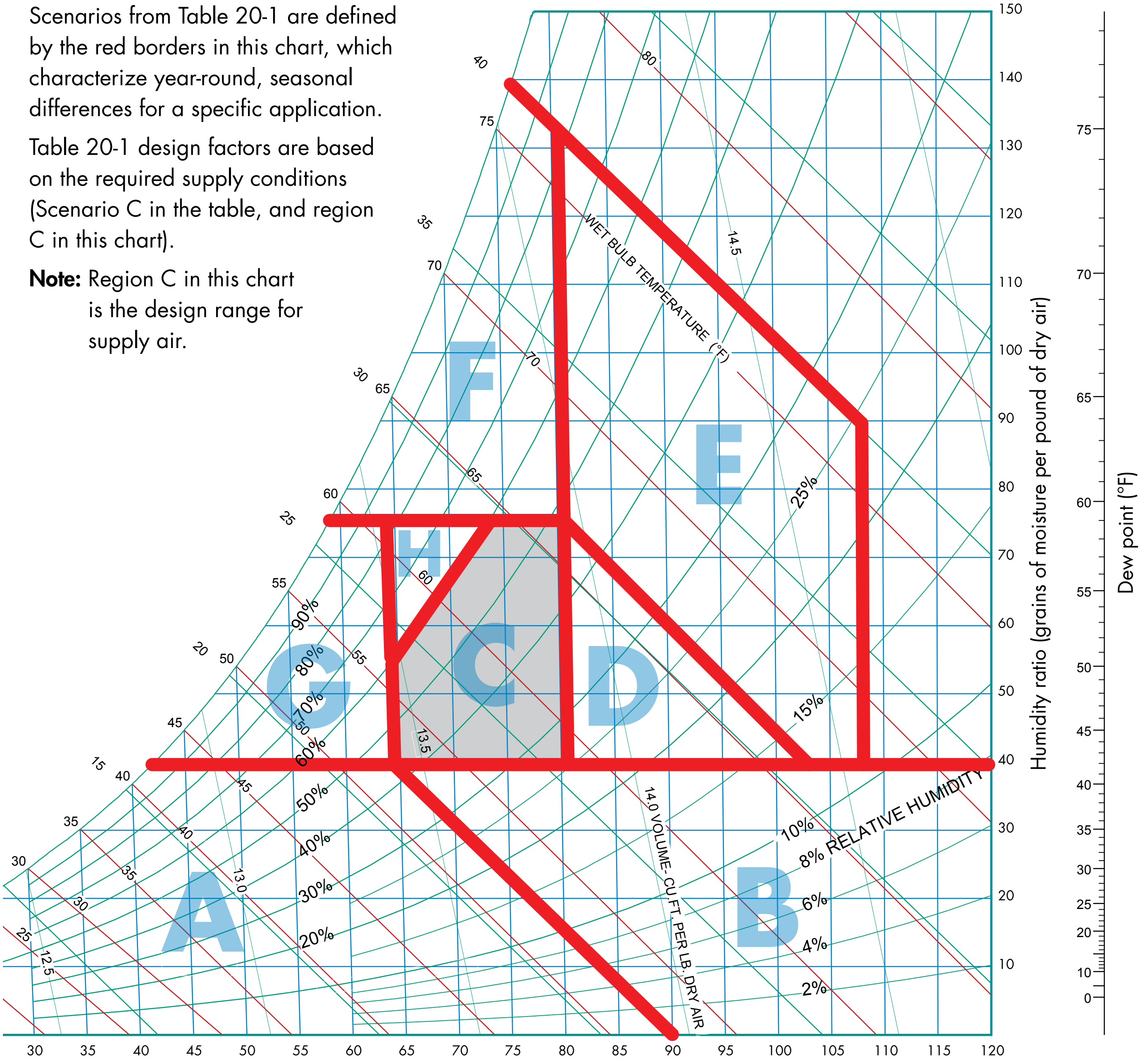


Chart courtesy of Hands Down Software, www.handsdownsoftware.com

Evaporation efficiency in air handlers and ducts

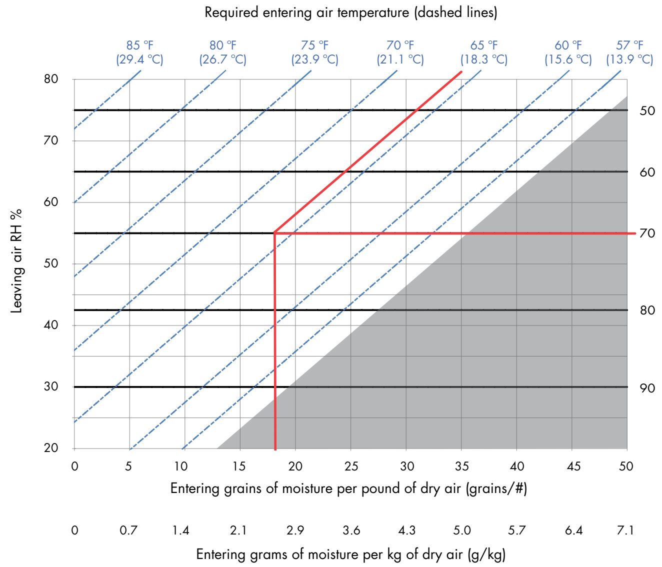
FACTORS AFFECTING EVAPORATION EFFICIENCY

Once water is dispersed into a moving airstream, many factors affect evaporation efficiency, or how much of that water will evaporate.

The main factors are leaving RH, leaving air temperature, and available evaporation distance.

Other factors include humidification load, air velocity and velocity profile, entering air dew point temperature, and duct or air handler design and components.

FIGURE 22-1: EVAPORATION EFFICIENCY CHART



Benefits

BENEFITS OF ADIABATIC HUMIDIFICATION

Reduces cooling load. Perhaps the most touted benefit of adiabatic humidification is air cooling. Because adiabatic humidifiers draw heat from air for evaporation, they can produce a 20 °F or more temperature drop. In fact, every pound of adiabatic humidification added to air removes approximately 1000 Btu of heat. Twelve pounds of water added as humidification equals about one ton of cooling. This is a significant benefit in climates where air is consistently warm and dry, or in spaces where there is an additional heat load such as from equipment in a computer room.

Energy efficient. Unlike humidification systems that boil water into steam, adiabatic humidification systems do not have a dedicated energy source to change water into vapor for humidification. Because adiabatic humidifiers use heat present in air to convert water to vapor, they consume relatively small amounts of energy to operate when compared to isothermal (steam) humidifiers. Adiabatic humidification systems require energy to operate compressors, pumps, or oscillators; and some adiabatic humidifier applications with low entering air temperatures require air preheating, which can decrease energy savings.

Adiabatic humidifiers cause relative humidity (RH) levels to increase and air temperature (dry bulb) to decrease.

FOCUS ON PSYCHROMETRICS

“Evaporation is a cooling process.” This mantra, used by junior high school science teachers, rings in many of our heads to this day. While a true statement, it only scrapes the surface of understanding adiabatic humidification.

“Evaporation is a constant enthalpy process” would be a better phrase. For as water is absorbed by warm air it follows a constant enthalpy line up and to the left on the psychrometric chart (see Figure 24-1).

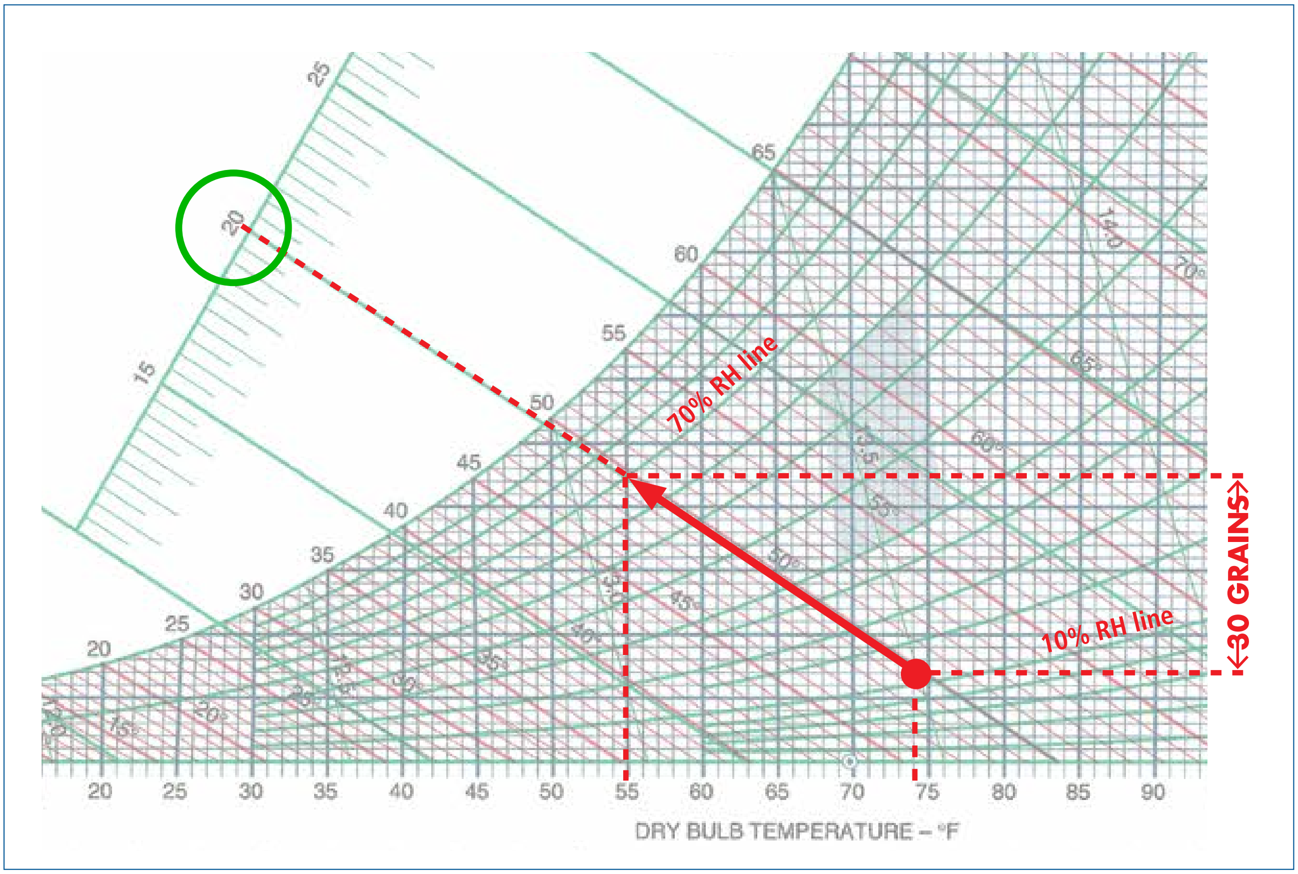
The solid red process line in the chart at right describes the addition of 30 grains of moisture per pound of dry air with an adiabatic humidifier. Note that the temperature goes from 74 °F to 55 °F, but the total energy of the air remains the same, following the line for 20 Btu per pound of dry air. The only way to do this is to raise the relative humidity from 12% to 70%. Evaporative coolers follow the same theory when cooling air, so the main benefit of adiabatic humidification is obvious: When the process calls for both cooling and humidification, total system energy is the lowest. Adiabatic humidifiers can still be used when entering air conditions are cool, but additional heat may be needed to ensure that set point is met.

Psychrometric (adjective): Relating to the measurement or determination of atmospheric conditions, particularly the moisture in air.

Benefits

EVAPORATION IS A CONSTANT ENTHALPY PROCESS.

FIGURE 24-1: PSYCHROMETRIC CHART



Enthalpy (noun): The total energy in dry air and water vapor per pound of dry air.

Benefits

Minimal maintenance. Adiabatic humidifiers using reverse-osmosis-treated water (RO) or deionized water (DI) require the least maintenance. Adiabatic systems that use tap water require cleaning or component replacement to remove deposited minerals. Systems with moving parts (humidifiers with rotating disks and atomizers with movable nozzle pins) require periodic parts replacement.

High capacity potential. In open spaces, very large capacities can be met with a single adiabatic humidifier such as an atomizer, or with multiple smaller-capacity humidifiers. In ducts or air handlers, capacity is limited only by duct/AHU size and evaporation capability.

Pure, particulate-free humidity. When using DI or RO water, adiabatic systems with high-grade stainless steel parts can produce humidification as pure as the supply water.

FIGURE 25-1: PRESSURIZED WATER HUMIDIFIER

Twelve pounds of water added as humidification equals about one ton of cooling.

Applications

APPLICATION CONSIDERATIONS

Warm, dry air. The evaporation rate of dispersed water or water from within a wetted media is affected by temperature, air velocity, and water droplet size. Because adiabatic humidifiers rely on warm air temperature to evaporate water, the most efficient systems will be in areas where the entering air temperatures are consistently warm and dry, or where there is an existing heat load such as from equipment or an industrial process. If the installation is in a climate with cool or cold seasons, air may have to be preheated, adding an extra energy expense.

Supply water type. Humidifier performance, humidification vapor quality, indoor air quality, and maintenance requirements are significantly affected by humidifier supply water type. Most adiabatic technologies can operate using either treated or untreated water; however, most contaminants in supply water pass through a humidifier system. Especially when misted or sprayed, supply water with minerals produces white dust, which along with other water contaminants can be an inhalation hazard. Settling white dust can also contaminate processes and accumulate in ducts and on furnishings. See Page 11 for more information about supply water.

The most efficient adiabatic systems are installed in areas where entering air is warm and dry, or where there is an existing heat load such as from equipment or an industrial process.

Applications

EVAPORATION EFFICIENCY IN AIR HANDLERS AND DUCTS

Once water is dispersed into a moving airstream, many factors affect how much of that water becomes actual humidification. Factors that affect the evaporation rate are described in the example bullet points and are illustrated in the chart below. This chart is one method for calculating evaporation efficiency.

In this example, the following are known:

- Humidification load = 385 lbs/hr
- Available evaporation distance = 4 ft
- Leaving air temperature = 55 °F
- Air velocity = 500 fpm
- Entering air grains of moisture per pound of dry air = 15
  Entering air dew point temperature = 20 °F
- Leaving air RH = 55%

From these values, the evaporation efficiency chart below identifies:

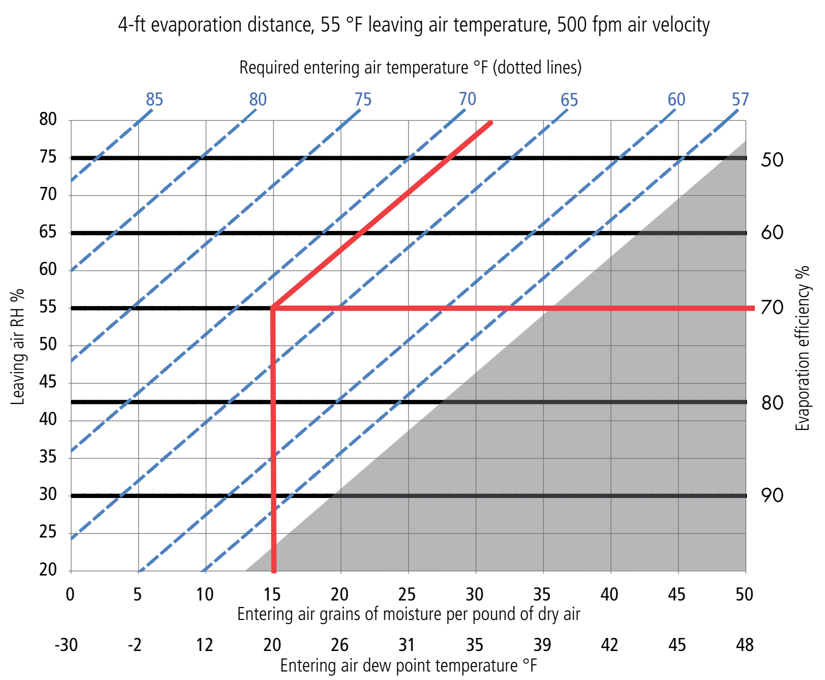
- Required entering air temperature = 68 °F
- Evaporation efficiency = 70%

Now required system capacity can be calculated:

- Load ÷ evaporation efficiency = required system capacity
  385 lbs/hr ÷ 70% = 550 lbs/hr

To accurately size an adiabatic humidification system, make sure that you can define all the values above. This will ensure a system that maximizes efficiency while consistently meeting set point.

EVAPORATION EFFICIENCY EXAMPLE CHART



Application

EXAMPLE 1: OPEN SPACE APPLICATION

Entering air condition:
Dry bulb = 0 °F; RH = 50%; 2 air changes per hour

Desired space condition: Dry bulb = 75 °F; RH = 35%

Building dimensions: 200' W × 240' L × 25′ H; volume = 1,200,000 ft3

Step 1: Locate and mark entering air condition (A) and desired space condition (B) on the psychrometric chart.

Step 2: Calculate grains of moisture to add.

Draw horizontal lines from (A) and (B) all the way to the right edge of the chart. Entering air has 3 grains of moisture per pound of dry air and space air will have 45 grains of moisture per pound of dry air.
45 – 3 = 42 grains of moisture per pound of dry air

Step 3: Determine required space air temperature.

Find the constant enthalpy line that intersects (B). In this example it is the 25 Btu per pound of dry air line. Draw a line along the enthalpy line from (B) until you intersect the entering air humidity ratio line, which is at 102 °F (C). This is the temperature outside air must be raised to by either the space load or by drop heaters in the space. This enthalpy line also describes the path the humidification process will take, dropping dry bulb temperature from 102 °F to 75 °F.

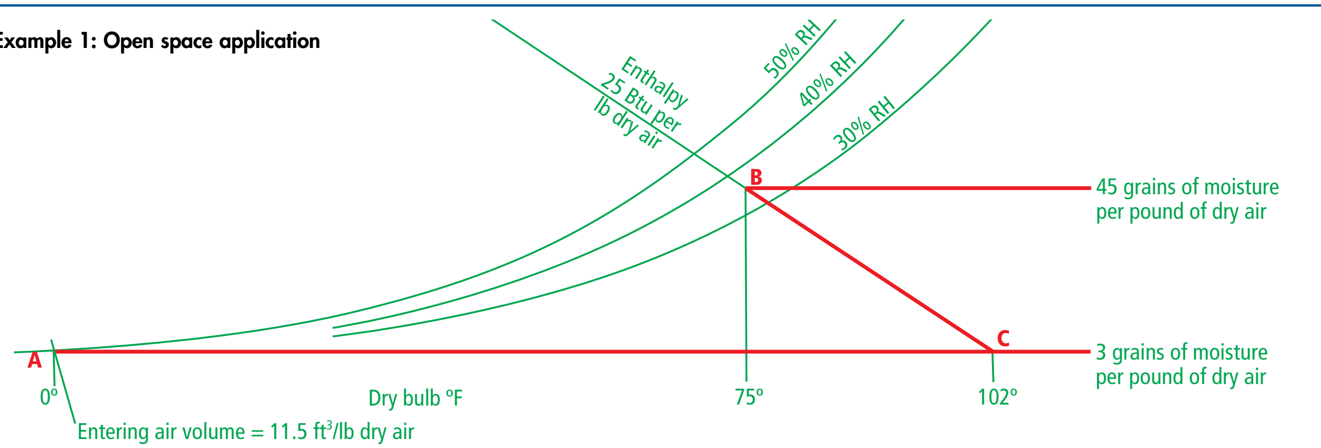
Step 4: Determine entering air volume.

Find point (A) from Step 1 above. Locate the entering air volume of (A) by finding the series of almost vertical lines going from approximately the 11 o'clock position to the 5 o'clock position. They range from about 11 cubic feet per pound of dry air in the negative dry bulb temperature region to 15 cubic feet per pound of dry air in the 100+ dry bulb temperature region. Point (A) is at about 11.5 cubic feet per pound of dry air.

Step 5: Calculate pounds of dry air per hour.
2 air changes per hour × 1,200,000 ft3
= 2,400,000 cfh ÷ 11.5 cubic feet per lb dry air
= 208,695 pounds of dry air per hour

Step 6: Calculate load.
208,695 pounds of dry air per hour × 42 grains of moisture per pound of dry air
= 8,765,190 grains per hour ÷ 7,000 grains per pound of water
= 1,252 pounds of water per hour

Example 1: Open space application



Applications

EXAMPLE 2: AHU/DUCT APPLICATION, YEAR-ROUND COOLING REQUIREMENT

Entering air condition:
Dry bulb = 85 °F; RH = 8%; air flow = 20,000 cfm; outside air = 100%

Desired space condition: Dry bulb = 75 °F; RH = 35%

AHU dimensions: 60" H × 96" W; available evaporation distance = 4 feet

Step 1: Ensure that air velocity is in the recommended range of 250-750 fpm.
20,000 cfm ÷ [(60" × 96") ÷ 144 in2/ft2] = 500 feet per minute

Step 2: Locate and mark entering air condition (A) and desired space condition (B) on the psychrometric chart.

Step 3: Calculate grains of moisture to add.

Draw horizontal lines from (A) and (B) all the way to the right edge of the chart. Entering air has 14 grains of moisture per pound of dry air and space air will have 45 grains of moisture per pound of dry air.
45 – 14 = 31 grains of moisture per pound of dry air

Step 4: Find the maximum recommended leaving RH%

Draw a horizontal line from (B) until you reach the 75% RH curve (C), which is the maximum recommended AHU RH% before excessive water fallout occurs. The horizontal lines crosses the 75% RH curve at approximately 53 °F, which is the lowest temperature when humidifying without excessive water fallout.

Step 5: Determine leaving air condition after the humidifier.

Starting at the entering air condition point (A), draw a line up and to the left along the constant enthalpy line, 22.5 Btu per pound of dry air in this example, until it intersects the line drawn in Step 4. These two lines meet at the 50% RH curve (D). This temperature is 65 °F, but will rise to the desired space condition of 75 °F in the humidified space due to additional heat from computers, lights, people, etc.

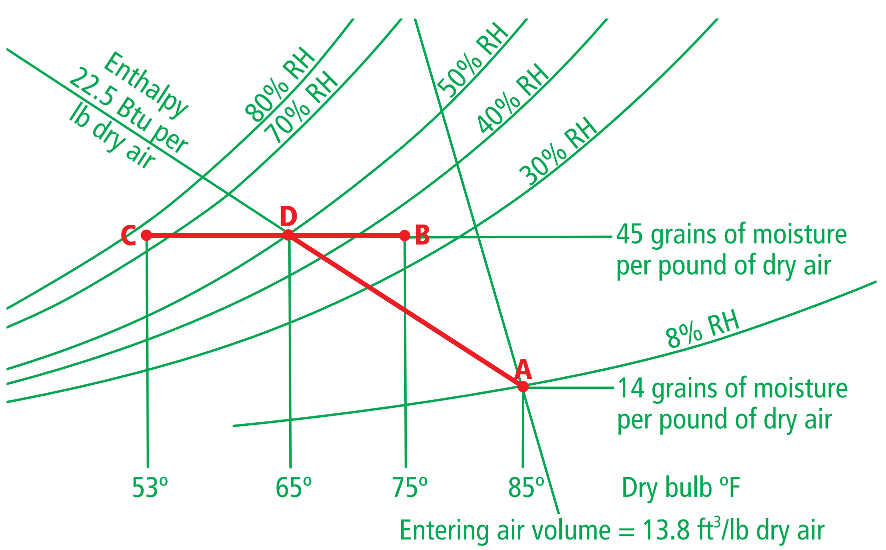
Step 6: Determine entering air volume.

Point (A) is at about 13.8 cubic feet per pound of dry air. See Example 1 for guidance on finding entering air volume.

Step 7: Calculate pounds of dry air per hour.
20,000 cfm ÷ 13.8 cubic feet per lb dry air
= 1450 pounds of dry air per minute × 60 minutes per hour
= 87,000 pounds of dry air per hour

Step 8: Calculate system load.
87,000 pounds of dry air per hour × 31 grains per pound of dry air
= 2,697,000 grains per hour ÷ 7,000 grains per pound of water
= 385 pounds of water per hour

EXAMPLE 2: AHU/DUCT APPLICATION, YEAR-ROUND COOLING REQUIREMENT



Applications

EXAMPLE 3: AHU/DUCT APPLICATION WITH HEATING REQUIREMENT

Entering air condition:
Dry bulb = 55 °F; RH = 30%; air flow = 20,000 cfm; outside air = 100%

Desired space condition: Dry bulb = 70 °F; RH = 40%

AHU dimensions: 60" H × 96" W; available evaporation distance = 4 feet

Step 1: Ensure that air velocity is in the recommended range of 250-750 fpm.
20,000 cfm ÷ [(60" × 96") ÷ 144 in2/ft2] = 500 feet per minute

Step 2: Locate and mark entering air condition (A) and desired space condition (B) on the psychrometric chart.

Step 3: Calculate grains of moisture to add.

Draw horizontal lines from (A) and (B) all the way to the right edge of the chart. Entering air has 19 grains of moisture per pound of dry air and space air will have 43 grains of moisture per pound of dry air.
43– 19 = 24 grains of moisture per pound of dry air

Step 4: Find the maximum recommended leaving RH%

Draw a horizontal line from (B) until you reach the 75% RH curve (C), which is the maximum recommended AHU RH% before excessive water fallout occurs. The horizontal lines crosses the 75% RH curve at approximately 52 °F, which is the lowest leaving air temperature when humidifying without excessive water fallout.

Step 5: Determine leaving air condition after the humidifier.

a)Starting at entering air condition (A), draw a line along the constant enthalpy line, in this example 16 Btu per pound of dry air, with intent to intersect the line drawn in Step 4. But because these two lines do not intersect, additional energy will need to be added in order to evaporate enough water to reach set point. Adjust the economizer set point or use a heating coil to add energy.

b)For this example let's assume a heating coil is used to heat the air to the same enthalpy as the 75% RH point on the line drawn in Step 4. This is on the 19 Btu per pound of dry air line.

c) Draw a line starting at 52 °F and 75% RH (C) down to where the 19 Btu per pound of dry air line crosses 19 grains per pound of dry air (the original entering air conditions). This is at about 68°F (D). This indicates the requirement to add 3 Btu per pound of dry air to reach desired set point. This temperature will rise to the desired space condition of 70 °F in the humidified space due to additional heat from computers, lights, people, etc.

Applications

Step 6: Determine entering air volume.

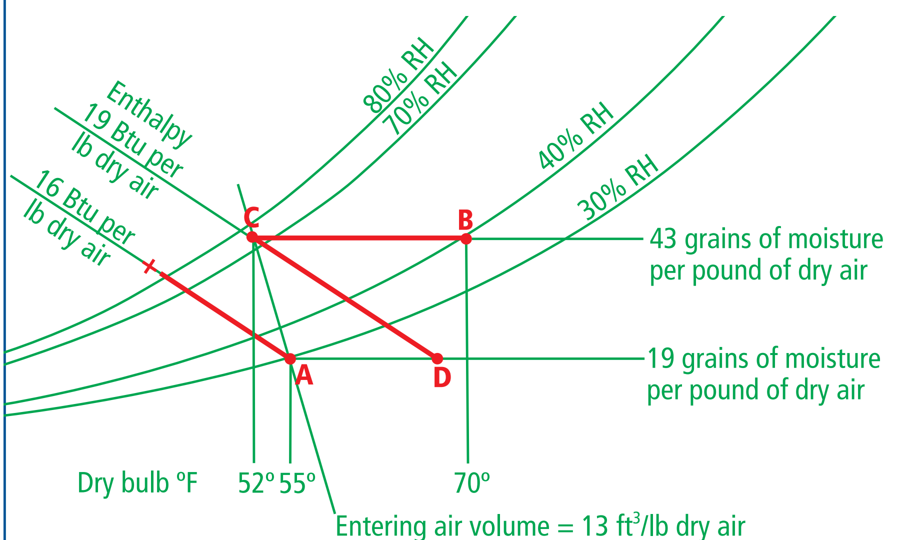
Point (A) is at about 13.0 cubic feet per pound of dry air. See Example 1 for guidance on finding entering air volume.

Step 7: Calculate pounds of dry air per hour:
20,000 cfm ÷ 13.0 cubic feet per lb dry air
= 1538 pounds of dry air per minute × 60 minutes per hour
= 92,280 pounds of dry air per hour

Step 8: Calculate system load.
92,280 pounds of dry air per hour × 24 grains per pound of dry air
= 2,214,720 grains per hour ÷ 7,000 grains per pound of water
= 316 pounds of water per hour

Step 9: Calculate energy added to incoming air.
3 Btu per pound of dry air × 92,280 pounds of dry air per hour = 276,840 Btu per hour

EXAMPLE 3: AHU/DUCT INSTALLATION WITH HEATING REQUIREMENT



Applications

SYSTEM DESIGN CONSIDERATIONS

Keep in mind the following when designing adiabatic humidification systems:

- Because no energy is added or lost in the system, and the liquid water added to the airstream must be evaporated, energy must transfer from air to water. Assuming 75 °F supply water in Example 3, the air gives up 19% of its energy to evaporate the water:

  Total air energy
  = 90,240 lbs of dry air/hr × 19 Btu/lb of dry air
  = 1,714,560 Btu

  Energy to evaporate water
  = 1,050 Btu/lb of water × 309 lbs of water/hr
  = 324,450 Btu
  = 19% of total air energy

- The two most important things to determine are the desired space condition and the maximum load condition. The maximum load condition will occur at some combination of the driest entering condition and economizer maximum outside air condition.
- When preheat is required to ensure adequate energy for evaporation, it is critical that the system controller can anticipate this need and react appropriately. Reacting too fast to space changes, or increasing humidifier demand too quickly can cause control issues. In AHU applications, utilizing dew point sensors both up- and downstream of the humidifier will allow the system to anticipate the available energy in the entering air and humidify appropriately. Additional heat will need to be added to the entering air if set point is not met.
- In addition to understanding system psychrometrics, it's important to understand the application and installation requirements of your chosen humidifier technology. Variables such as air stratification; pressure drop; and nozzle quantity, size and placement affect evaporation efficiency and system operation. To ensure optimal operation, choose an experienced manufacturer who can guide you through the specifics of your system.

Technologies

ADIABATIC TECHNOLOGIES

The five most common types of adiabatic humidifiers include:

- Pressurized water humidifiers.
- Wetted media humidifiers
- Ultrasonic humidifiers
- Pressurized air and water humidifiers
- Centrifugal humidifiers

Pressurized water humidifiers. Pressurized water systems are often used where high-quality humidification is required. Construction is typically all stainless steel. A high-pressure pump propels treated water through dispersion nozzles, fragmenting water droplets into fine particles that quickly evaporate in air-handler airstreams or open spaces. Water under pressure (800 to 1200 psi) is delivered to dispersion nozzles; no pressurized air is required, making the system simpler than air/water systems thereby reducing operating and maintenance costs. AHU systems typically have a mist eliminator installed downstream of the humidifier.

Wetted media humidifiers. Wetted media humidifiers have a water-absorbing mesh placed in a duct or AHU airstream. Water flows over the media or is wicked from a basin as the water evaporates into the airstream. A humidistat or building management system turns supply water on and off.

It is more difficult to achieve tight RH control with wetted media humidifiers, compared to other adiabatic humidifiers. Once water is pumped onto the media it remains until evaporated. This results in a lag between a call for humidity and delivery, and also for continued humidification delivery after demand is satisfied (the wetted media continues to evaporate until it is dry). However, while a wetted media humidifier may overshoot RH set point, it cannot oversaturate airstreams.

If untreated water is supplied to a wetted media humidifier dissolved solids will be left on the media after the water evaporates. This will foul the media and increase duct static pressure, requiring media replacement. The basin of water for media wicking or to catch overflow can be a breeding ground for harmful bacteria and mold.

Ultrasonic humidifiers. Ultrasonic humidifiers have a submerged vibrating disk that creates a high-frequency oscillation, expelling small water droplets into air. Many of these systems use DI or RO water and are used in applications where particulate-free humidity is essential but where a large capacity is not required. The disks require replacement after approximately 10,000 operating hours, which can be a concern for applications that cannot tolerate off-line time or the expense of disk replacement. Water droplets are generally small and maximum capacity is approximately 80 lbs/hr per unit. Multiple, rack-mounted units can meet higher capacities.

FIGURE 33-1: PRESSURIZED WATER HUMIDIFIER

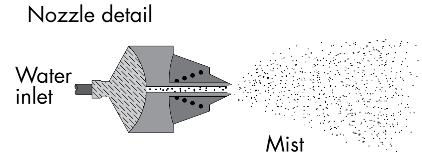


FIGURE 33-2: WETTED MEDIA HUMIDIFIER

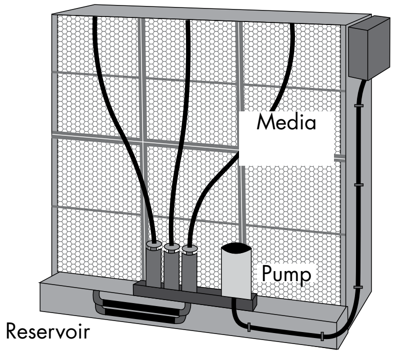
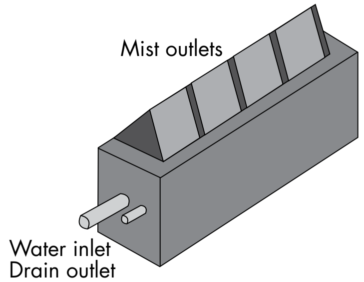


FIGURE 33-3: ULTRASONIC HUMIDIFIER



Technologies

Pressurized air and water humidifiers. Many misters, sprayers, and atomizers combine compressed air with water to emit water droplets into open spaces, ducts or AHUs. Most systems use untreated water and are typically installed in industrial environments, such as woolen and carpet mills, where air cleanliness is not a critical issue. Some pressurized air and water systems have automatic nozzle-pin shutoffs that prevent dripping and also provide some nozzle cleaning. Mineral buildup and nozzle-pin failure can create additional maintenance. Pressurized air and water humidifiers are the noisiest; and require piping runs for both the air and water lines to all nozzles. Some systems installed in AHUs have mist eliminators installed downstream from the heating coil to prevent wetting farther downstream and to improve evaporation efficiency.

Centrifugal humidifiers. Centrifugal humidifiers deliver supply water to a fast-spinning disk that fractures water into small drops. Most operate using tap water and disperse only in open spaces and where mineral dust fallout is not an issue. Dispersed water droplets are large, requiring very warm air and/or high ceilings to achieve evaporation, and the systems tend to be noisy. Centrifugal humidifiers are easy and inexpensive to install.

FIGURE 34-1: PRESSURIZED AIR AND WATER HUMIDIFIER

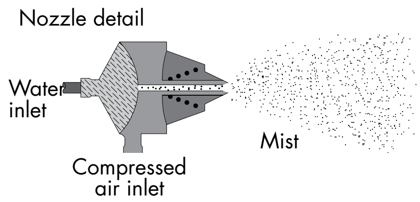
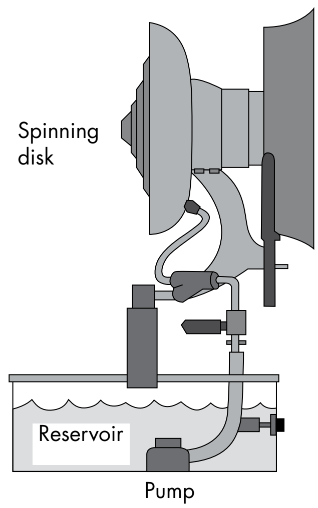


FIGURE 34-2: CENTRIFUGAL HUMIDIFIER



Water quality

WATER QUALITY AFFECTS PERFORMANCE, AIR QUALITY, AND MAINTENANCE REQUIREMENTS

Water is often called the universal solvent because almost everything is soluble to some degree in water. This property causes water to become contaminated by virtually any material it contacts, with the mix of contaminants varying greatly from one location to another.

There are three types of water used in adiabatic humidifiers:

- Tap or well water
- Softened water (hardness reduced through an ion exchange process)
- High-purity water (reverse osmosis and/or deionized treated water)

Tap or well water can contain living microorganisms, dissolved organic material, dissolved minerals, and suspended materials. While all of these substances can affect humidification vapor quality, humidifier maintenance and performance are significantly affected by dissolved minerals and suspended materials.

Living microorganisms (bacteria). Care should be taken to ensure that all harmful microorganisms are removed from water sources feeding adiabatic humidifiers.

In addition, even though a water supply may be free of harmful bacteria, contaminants from the air can still cause microbial growth in wetted-media or wick systems. Water treatment for bacteria includes filtration, reverse osmosis, chemical oxidation, and disinfection.

- Dissolved organic material comes from three major sources:
- The breakdown of naturally occurring organic materials (plant and animal matter);
- Domestic and commercial chemical wastes (agricultural and urban runoff, or leaching from contaminated soils); and
- Chemical reactions that occur during water treatment processes (from disinfection by-products or pipe joint adhesives).

Activated carbon and microfiltration, and reverse osmosis processes remove dissolved organic material.

Water quality

High-purity water. High-purity water yields high-purity humidification for critical-process environments. Semiconductor, pharmaceutical and electronics manufacturers, as well as laboratories and industrial clean rooms often require high-purity humidification. To avoid water contaminants that can be carried into air with water vapor, these types of environments use highly processed — and very pure — water in their humidification systems. For these environments, water is cycled through several prefilters, a dechlorinator, a water softener, reverse osmosis permeable membranes and, sometimes, also through a chemical deionization process.

Water softeners remove calcium, magnesium and iron. Water softeners remove dissolved minerals from supply water using an ion-exchange process. For applications where high-purity humidification is not a requirement, water softening can significantly reduce humidifier maintenance requirements. Systems requiring high-purity humidification typically soften water before it enters other processes. For example, water not properly softened damages reverse osmosis membranes and also causes atomizing nozzles to clog.

Dechlorinators remove chlorine. Use a dechlorinator to remove chlorine from supply water before it enters reverse osmosis membranes. Dechlorinators have charcoal sieves that neutralize chlorine. Some dechlorinators automatically backflush whenever a programmed calendar date or water meter usage is met. During automatic backflushing, clean water flows through the dechlorinator to rinse the charcoal, and then flows to drain.

Reverse osmosis filtration provides ultra-pure humidification. Some adiabatic systems require most minerals removed from water in order to keep components operating properly. Before entering a reverse-osmosis system, potable water passes through a dechlorinator and water softener. This water is then pressurized and forced through reverse-osmosis membranes, which remove most dissolved minerals. The water is now purified and contains minerals at less than 10 parts per million.

Deionizing removes remaining minerals. Deionization removes all mineral ions from water, producing water similar to distilled water. Like reverse-osmosis filtration, water is pretreated before entering the deionizing process.

Silver ionization. Silver ionization technology adds silver to the water and attaches to microorganism cells disrupting cellular function and destroying the viruses or bacteria.

Summary

CHOOSE HUMIDIFICATION SYSTEM TO MEET REQUIREMENTS

While adiabatic humidification systems offer many advantages, it's important to choose the right system based on application, performance and economic requirements. Questions to consider when making an adiabatic system choice include:

- Will the humidifier be installed in a new facility or is it a retrofit? Retrofit applications limit technology choices. New facility air handler designs can be optimized to meet application requirements. For example, the more area available in an AHU for evaporation, the higher the evaporation efficiency.
- What are your energy- and water-efficiency requirements? Adiabatic humidification systems are very energy-efficient. Water efficiency varies by application, technology and manufacturer. When operating correctly, open-space adiabatic humidifiers can convert 100% of supply water to vapor. Sprayers and atomizers in AHU applications can send a large percentage of supply water to drain, depending on air temperatures and area available for evaporation.
- What are your operating cost and capital expenditure requirements? Adiabatic humidification systems can have extremely low operating costs. Low energy costs can produce utility rebates for adiabatic humidification systems, which can offset capital costs.
- How often can the system go off-line for maintenance? High-pressure atomizing systems using reverse-osmosis or deionized-treated water have the highest ability to stay on-line. This is a critical issue for some environments, like semiconductor manufacturing, which are seriously affected by changes in humidity.
- How clean does your humidity need to be? If particulate-free humidity is required for process or health reasons, then water treatment will also be required.

Finally, when choosing a humidification system, consider all costs. Cost analysis of a humidification system should be based on lifetime costs, and include equipment, installation and operating — especially energy — costs.

Isothermal to adiabatic energy source

CHOOSE ENERGY SOURCE WISELY

A pound of water requires approximately 1,000 BTUs to vaporize. Given that proper humidification typically requires vaporizing two to three pounds of water for every 100 cfm of outside air introduced into the system, humidification energy use ranges from 2,000 to 3,000 BTUs per 100 cfm of outside air.

A kilogram of water requires approximately 2.4 kJ to vaporize. Given that proper humidification typically requires vaporizing 1.5 to 2.5 kilograms of water for every 100 m^3/h of outside air introduced into the system, humidification energy use ranges from 3.5 kJ to 5.8 kJ per 100 m^3/h of outside air.

TWO MAJOR TYPES OF HUMIDIFIERS

- Isothermal systems use heat from an external source to create humidity. Electricity, natural gas, hot water, and boiler steam are isothermal heat sources used to boil water into steam for humidification.
- Adiabatic systems use heat from the surrounding air to change water into vapor for humidification (evaporation). Atomizing, ultrasonic, and pezio disk humidifiers are typical adiabatic systems.

WHY CHOOSE ISOTHERMAL HUMIDIFICATION?

- Choose isothermal humidification if you require predictable, controllable, and short absorption distances. Adiabatic systems require long absorption distances and often do not provide complete absorption in typical HVAC applications.
- Choose isothermal humidification if you have low air temperatures in your ducts. Adiabatic humidification requires very warm or preheated air for absorption to occur.
- Choose isothermal humidification if there is an on-site boiler or hot water source. Direct steam injection or a heat-exchanger type isothermal system may be most appropriate. Consider DriSteem's:
    - Steam injection humidifiers: Ultra-sorb, Maxi-bank, Multiple-tube, Mini-bank, Single-tube, or Area-type
    - STS Steam-to-Steam (with heat exchanger) evaporative steam humidifier
    - See also the text at left for more detail about choices when using on-site steam.

Isothermal to adiabatic energy source

- **Electric**: choose isothermal electric humidification for application flexibility. Electric element humidification systems easily integrate into existing systems. They are available in a wide range of sizes, capacities and options, allowing them to meet the humidification demands of virtually any environment. Consider Dri-Steem's:
  - Vaporstream humidifier
  - Vapormist humidifier
  - RTS humidifier
  - CRUV humidifier
  - Humidi-tech humidifier (available only in Europe)
  - XT series humidifier
- **Gas**: Choose isothermal humidification to gain the economic benefits of natural gas. Gas-fired humidification systems offer substantial energy cost savings over electric systems. Consider DriSteem's:
  - GTS Gas-to-Steam humidifier LX series

WHEN IS ADIABATIC APPROPRIATE?

Choose adiabatic humidification when the application requires humidification and cooling. Adiabatic systems use sensible heat in the air for its energy source. In the right environment, these systems can be very economical due to the cooling effect they provide.

- An adiabatic High-Pressure Atomizing System uses heat already present in the air to evaporate evenly-distributed water droplets.
- There are no energy costs associated with heating water for humidification.
- The evaporative process causes a drop in air temperature, reducing the cooling load.

Design

Proper relative humidity also has an affect on manufacturing processes, materials and furnishings, and comfort. When thinking about humidification and any product that is offered, it is important to consider the water types that feed humidifiers. The type of water you use greatly affects the performance and maintenance of any humidifier. In this section, we will look at the different water types commonly available for humidification use, and illustrate the affects each supply water type has on different technologies offered. Once we know the affect that supply water has on different humidification technologies, we will consider how control can vary when maintaining a consistent relative humidity.

Introducing humidification to a room or building ultimately improves indoor air quality. Improving indoor air quality by maintaining a relative humidity (RH) between 40 and 60 percent not only decreases bacteria and viruses in the air, but hinders the development of fungi, mites, chemical interactions, and ozone production.

Water type: Potable

POTABLE WATER: USUALLY SAFE FOR DRINKING BUT CAN BE HARD ON HUMIDIFIERS

Potable water, commonly referred to as drinking, tap, or well water, can contain any number of living microorganisms, dissolved organic material, dissolved minerals, and suspended materials. While all of these substances can affect humidification vapor quality, humidifier maintenance, performance, and efficiency are significantly affected by dissolved minerals and suspended materials.

- Living microorganisms (bacteria) are killed when water is heated to 180 °F (83 °C), and so bacteria are not a concern when using isothermal humidifiers where water is boiled to make steam (vapor). However, care should be taken to ensure that all harmful microorganisms are removed from water sources feeding nonboiling (adiabatic) humidifiers such as air washers, foggers, atomizers, or pezio disk systems. In addition, even though a water supply may be free of harmful bacteria, contaminants from the air can still cause microbial growth in wetted-media or wick systems. Water treatment for bacteria includes filtration, reverse osmosis, chemical oxidation, and disinfection. The most common treatment for bacteria is chemical oxidation by either ozonation or by adding chlorine.
- Dissolved organic material comes from three major sources:
    - The breakdown of naturally occurring organic materials (plant and animal matter)
    - Domestic and commercial chemical wastes (agricultural and urban runoff, or leaching from contaminated soils)
    - Chemical reactions that occur during water treatment processes (from disinfection by-products or pipe joint adhesives)
    - Activated carbon and microfiltration, and reverse osmosis and deionization processes remove dissolved organic material.
- Dissolved minerals found in potable water are magnesium, calcium, iron, and silicon, with calcium and magnesium the primary elements causing "hard" water. Water hardness is commonly measured in grains per gallon (gpg). As water hardness increases, so does the need for humidifier cleaning to remove scale buildup. Downtime for cleaning, as well as time required to heat fresh water that replaces frequently skimmed or drained water (to remove minerals), can significantly affect humidifier performance and efficiency. Water softening is the most common method for reducing water hardness.
- Suspended materials, typically clay or silt, give water a cloudy appearance. These particles should be removed from humidifier makeup water as they will settle out and collect in humidifier water reservoirs. These particles typically are removed by filtration.

Water type: Well

DIFFERENT WATER TYPES

Water is often called the universal solvent because almost everything is soluble to some degree in water. This property causes water to become contaminated by virtually any material it contacts, with the mix of contaminants varying greatly from one location to another.

There are four types of water used in humidifiers:

A. High-purity water (DI/RO - deionized and/or reverse osmosis treated water)
B. Potable water (drinking, tap, or well water)
C. Softened water (hardness reduced through an ion exchange process)
D. Boiler water (typically treated with anti-corrosion chemicals)

HIGH PURITY WATER YIELDS HIGH PURITY HUMIDIFICATION FOR CRITICAL PROCESS ENVIRONMENTS

Semiconductor, pharmaceutical, and electronics manufacturers, as well as laboratories, industrial clean rooms, and healthcare facilities often require high purity humidification. To avoid water contaminants that can be carried into the air with water vapor, these types of environments use highly processed – and very pure – water in their humidification systems. For these environments, water is cycled through several prefilters, through a reverse osmosis permeable membrane and, frequently, through a chemical deionization process. This type of high purity water is often called “DI/RO” water (deionized, reverse osmosis water) and, depending on the quality of process, can be free of minerals and other contaminants. The purity of this water degrades upon contact with the atmosphere and certain materials, and should remain in a closed system contacting only chemically stable materials.

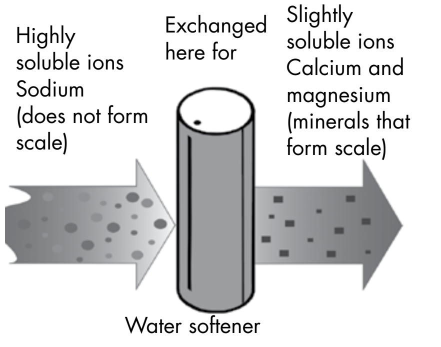
Water type: Softened

SOFTENED WATER SIGNIFICANTLY REDUCES CLEANING REQUIREMENTS

Water softening is an ion exchange process where slightly soluble magnesium and calcium ions are replaced by very soluble sodium ions. The exchanged sodium ions stay in solution when in water and do not attach to humidifier tank walls and elements as scale in the way magnesium and calcium will.

Softening water can dramatically improve humidifier performance, maintenance requirements, and efficiency. It is not unusual for systems using softened water to go several seasons without cleaning. However, water softeners need their brine tanks regularly replenished with sodium (so that there are sodium ions available to exchange with the magnesium and calcium ions). For this reason, owners should regularly inspect their humidifiers using softened water to verify softener operation. To lessen maintenance requirements, we recommend softening water for humidifier use where water hardness is greater than 12 gpg.

FIGURE 43-1: HOW A WATER SOFTENER WORKS



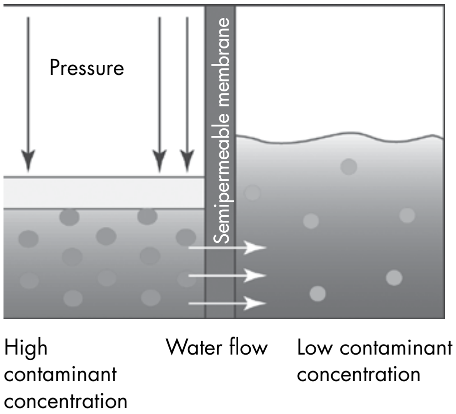
HOW WATER TYPE AFFECTS HUMIDIFIER PERFORMANCE

Isothermal systems — systems that boil water to make steam (vapor) — typically maintain relative humidity (RH) levels within 1%-5% of an established set point, with the ability to maintain a specific level of control directly dependent on the system's ability to respond to changing environmental conditions. Responsiveness is affected by two things: delivery of the energy source and the amount of water discarded (through skim, drain, and flush cycles) to remove minerals.

In combination with a programmable controller, using high quality valves or substituting electronic heater controllers such as SSRs for mechanical contactors allow responsive steam production.

Water hardness, however, plays a critical part in an isothermal humidifier's ability to maintain RH set point. As water hardness increases, so does the need for skimming, draining, and flushing. Skimming removes precipitated minerals before they attach to humidifier tank walls and elements as scale. As water is skimmed off, cold water is introduced into the tank. In some cases, this introduction of cold water causes a delay in steam output until the cold water is heated to boiling. Drain and flush cycles, automated on most systems, completely drain the humidifier and then typically flush the tank with cold water. In this situation, not only is the humidifier off-line for a period of time, but the tank needs to be filled and heated to boiling before it can produce steam. In the meantime, the RH level can drop 5% or more until the humidifier is producing steam again. In certain applications, such as office buildings or other environments humidified to improve comfort, RH fluctuation is not a major issue. In process-critical environments, however, a 5% RH fluctuation can affect processes. Humidifiers in these environments typically use softened or DI/RO water, depending on the level of control required. The fewer the minerals in the water, the better the control capability.

FIGURE 43-2: HOW REVERSE OSMOSIS FILTRATION WORKS



Water type: RO permeate

LOW MINERAL CONTENT MEANS LOW MAINTENANCE

From a maintenance point of view, the lower the mineral content in the water, the less maintenance required. Mineral buildup in improperly-maintained isothermal systems can cause humidifiers to malfunction: heater coils can fail prematurely, heat exchanger output is reduced by scale buildup, conductivity probe systems that measure water levels quit working, and drain valves become plugged. DI/RO water has the lowest mineral content, but its use is cost-prohibitive unless needed for high purity humidification or to meet very strict performance requirements (such as in semiconductor manufacturing). Hard water can be used in isothermal humidifiers with the understanding that these systems require regular inspection and cleaning and that RH performance will fluctuate. But the easiest and most cost-effective way to reduce maintenance requirements is to soften the fill water.

Water type: Deionized (DI)

PROPERLY MAINTAINED DI/RO WATER IS NOT CORROSIVE

A well-maintained DI/RO system produces water that consists solely of hydrogen and hydroxides and is free of most or all total dissolved solids (TDS) including chlorides and other molecules that cause metal corrosion.

Many users of high purity water have the false impression that it is highly corrosive to metals. This may be due, in part, to the water quality found in systems that have not been properly maintained or operated. If, for example, DI beds are not properly maintained, or the flow rate through them exceeds their capacity, the first of the two DI beds (the cation bed) typically becomes saturated or ineffective, and then the weak acid solutions generated by the second bed (the anion bed) cannot be neutralized and flow into the water system. If this happens, chlorides and other electrolytes are introduced into the system in large quantities, with the ability to cause substantial corrosion.

Another misconception about DI/RO water is that its ion-hungry nature causes metal corrosion, but while properly maintained high-purity water will take some ions from the metal it contacts, this exchange process causes, at worst, only minimal corrosion.

FIGURE 45-1: SINGLE TANK (MIXED BED) DI SYSTEM

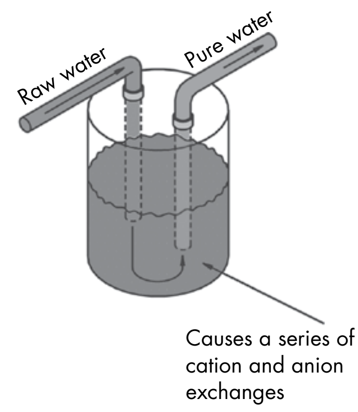
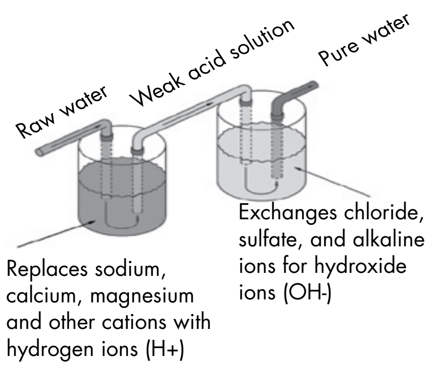


FIGURE 45-2: TWO-TANK DI SYSTEM



Water treatment systems

DECHLORINATION, WATER SOFTENING, AND REVERSE OSMOSIS EQUIPMENT

Water quality is integral to the operation and longevity of humidification and evaporative cooling equipment. Required maintenance, system performance, and water/energy usage are all affected by water quality. Operating with treated water reduces or eliminates hard water scale on equipment surfaces, thereby reducing maintenance requirements. Performance improves in systems using treated water with benefits such as reduced downtime, higher energy transfer, and the elimination of clogged nozzles.

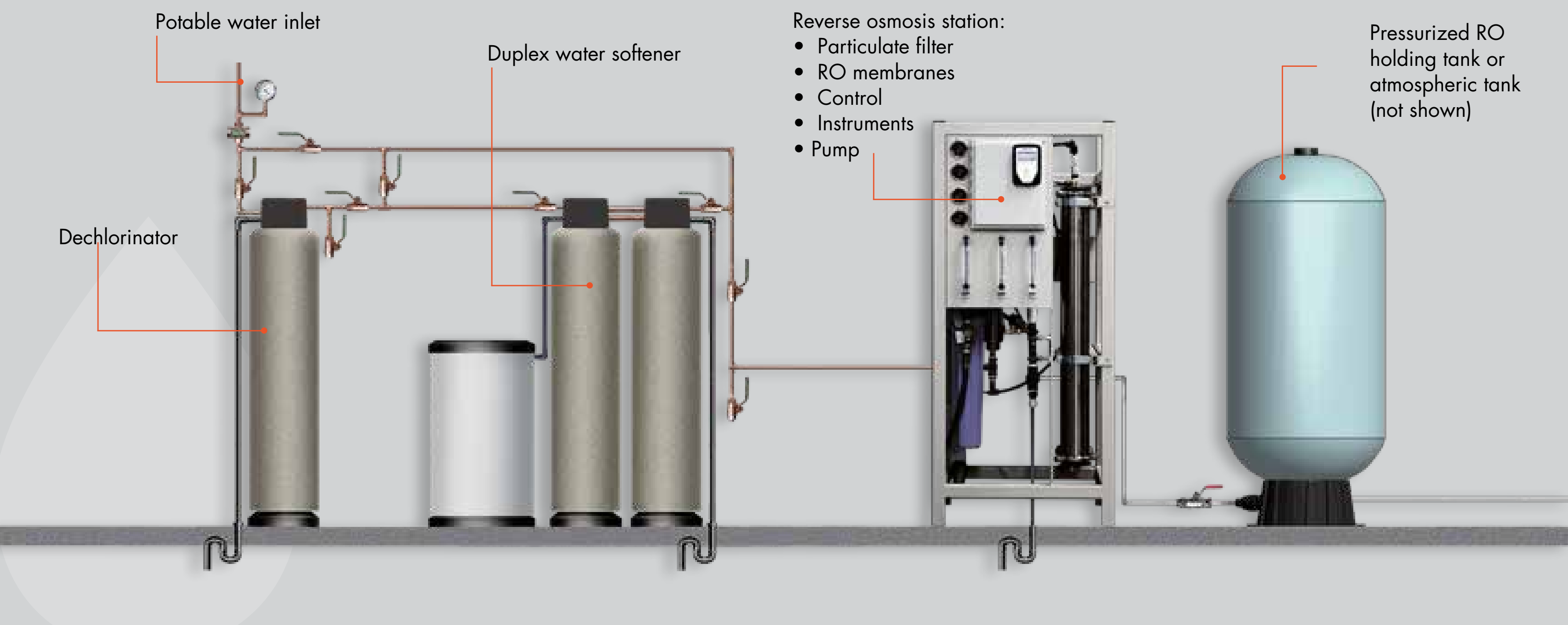
Water quality is equally important for other processes. DriSteem Hydrotrue water treatment systems can be used where softened or RO permeate is desired. Such applications include: brewery ingredients, make-up, controlled environment agriculture, car washes, pressurized steam boilers, and digital printers.

DRISTEEM'S HYDROTRUE WATER TREATMENT SYSTEMS OFFER

- Complete suite of products available for all applications — dechlorination, water softening, and reverse osmosis systems.
- Designed for use with all DriSteem humidification and evaporative cooling systems, or as a stand-alone system for other processes requiring water treatment.
- Single point supply, drain, and electrical connections and system skidding available.
- Supply multiple evaporative cooling or humidification systems with a single water treatment system.
- Components can be used individually or as a complete water treatment solution with DriSteem humidification.

Capacity: 288–15840 gallons per day (100–5500 lbs/hr; 45–2495 kg/hr)

TYPICAL PLUMBED WATER TREATMENT SYSTEM



Water treatment systems

Removes over 98% of dissolved solids

HYDROTRUE® RO 200 WATER TREATMENT SYSTEM

Significantly reduces or eliminates maintenance on downstream equipment by removing over 98% of dissolved solids from supply water.

Capacity: 100-300 pph or 12-36 gph permeate flow rate

Integrated 4.4 gallon bladder tank (option to upgrade size of tank off side)

- Vapor-logic control with top end control communication/alarms
- Heavy duty frame, rotary pump, brass inlet solenoid valve, stainless steel membrane housings
- Hygienic design with inactivity flushes

Interoperability available on DriSteem RO systems

HYDROTRUE® RO 400 WATER TREATMENT SYSTEM

Maintenance is easy with innovative front-only maintenance access to the system. Quickly replace membranes and sediment filters without wrestling within tight spaces or working around other equipment.

Capacity: 250-300 pph or 0.5-12 gpm permeate flow rate

- Storage tank options provided, pressurized or atmospheric with pump
- Vapor-logic control with top end control communication/alarms
- Heavy duty frame, centrifugal pump, brass inlet solenoid valve, stainless steel membrane housings
- Hygienic design with inactivity flushes
- Ease of maintenance with slide out racks for membrane replacement
- Multiple voltage options to fit the need of the end user

Water treatment systems

DRISTEEM SOFTENER SYSTEM

Single or twin alternating softener system with a Clack commercial multi-port valve. The system comes with all necessary equipment including support gravel, cationic resin, FRP vessel, control valve, and brine tank.

Capacity:13,500 grains to 337,500 grains. Flow rate servicing humidifiers up to 5,500 pph. Flow rates for non-humidification applications: 0 gpm-50 gpm. Operating up to 125psi inlet water pressure

Options: Water meter option included, for regeneration. Skid mounted available.

Sized to site water conditions

DRISTEEM DECHLORINATOR SYSTEM

Single dechlorinator system with a Clack commercial multiport valve. The system comes with all necessary equipment including support gravel, activated carbon, FRP vessel, control valve.

Capacity: 0-16 gpm upstream of an RO system or in terms of humidification application up to 5500 pph

Options: Skid mounted available.

Sized based on contact time

DRISTEEM FILTER HOUSING SYSTEM

Filter housing option available to either utilize a sediment filter upstream of a device or as a dechlorinator cartridge for low flow applications (<500 pph). Options to get mounting bracket and PVC ball valves installed.

Capacity: 0-2 gpm (dechlorinator/activated carbon filter), 0-5 gpm (sediment filter, 5 microns)

Removes chlorine/chloramine

Humidification system components placement

DETERMINE HUMIDIFIER PLACEMENT

A humidification system generally consists of a vapor or steam generator and a dispersion assembly. The proper placement of these two components is crucial for successful system operation. Usually, there is no single correct placement for a humidifier. Much depends on system design and application. However, the following paragraphs and dispersion assembly placement examples are presented as guidelines for common situations.

FIRST, CHECK AVAILABLE ABSORPTION DISTANCE

Available absorption distance affects system choice. Dispersed steam must be absorbed into the airflow before it comes in contact with any duct elbows, fans, vanes, filters, or any object that can cause condensation and dripping. Not all humidification systems guarantee absorption within a short distance, so it is important to be aware of the available absorption distance early in your design process.

Placing a dispersion assembly in an AHU (see Figure 52-1)

- Location A is the best choice. Installing downstream of heating and cooling coils provides laminar flow through the dispersion unit; plus, the heated air provides an environment for best absorption. Use a multiple tube dispersion unit to ensure complete absorption of steam vapor before fan entry.
- Location B is the second-best choice. However, in change-over periods, the cooling coil will eliminate some moisture for humidification.
- Location C is the third-best choice. Air leaving a fan is usually very turbulent and may cause vapor to not absorb at the expected absorption distance. Allow for more absorption distance if installing downstream of a fan.
- Location D is the poorest choice. The cooler air at this location requires an increased absorption distance.

Humidification system components placement

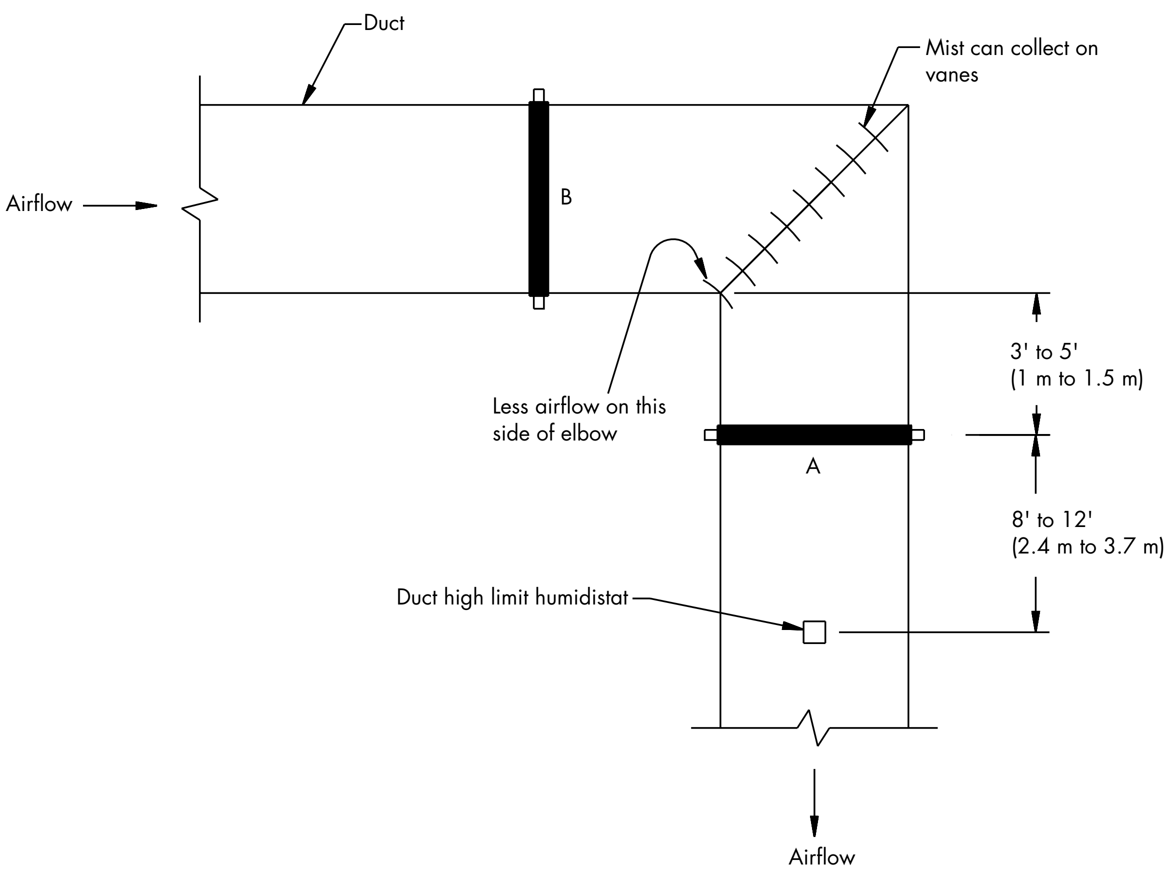
PLACING A DISPERSION ASSEMBLY NEAR AN ELBOW (SEE FIGURE 50-1)

A. Location A is the best choice. Better absorption occurs on the downstream side of an elbow than on the upstream side.

B. Location B is the second-best choice. Installing upstream of an elbow can cause wetting at the turning vanes. In cases where it is structurally impossible to avoid Location B, use a multiple tube dispersion unit to ensure complete absorption. Also, since more air flows along the outside of a turn, better absorption occurs if the humidifier discharges proportionately more steam in that part of the airstream.

C. At both locations, discharging steam against or perpendicular to the airstream gives slightly better mixing and absorption than discharging with the airstream.

FIGURE 50-1: PLACING A DISPERSION ASSEMBLY NEAR AN ELBOW



Humidification system components placement

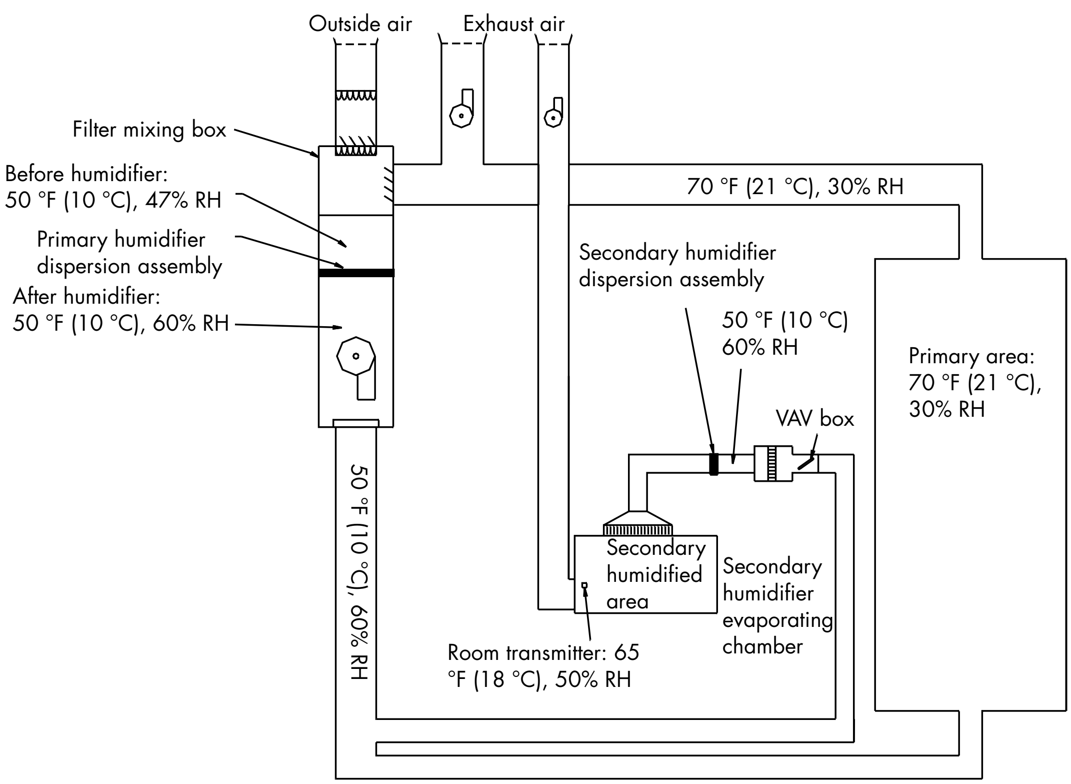
PLACING A DISPERSION ASSEMBLY IN A PRIMARY/SECONDARY SYSTEM (SEE FIGURE 51-1)

This type of system is commonly applied to facilities where most of the building requires one level of humidity (typically to meet comfort requirements) and part of the building requires additional humidity. In Figure 61-1, the primary humidification system is within the main air handling unit. The secondary humidification system is located close to the point of steam discharge into the secondary area.

SENSOR AND TRANSMITTER LOCATIONS ARE CRITICAL (SEE FIGURE 52-1 ON NEXT PAGE)

Sensor or transmitter location has a significant impact on humidifier performance. In most cases, we recommend that you do not interchange duct and room humidity devices. Room humidity devices are calibrated with zero or little airflow; whereas duct humidity devices require air passing across them. Recommended sensor locations (next page):

FIGURE 51-1: PLACING A DISPERSION ASSEMBLY IN A PRIMARY/SECONDARY SYSTEM



Humidification system components placement

A. This is the ideal sensing location because this placement ensures the best uniform mix of dry and moist air with stable temperature control.

B. This location is acceptable, but the room environment may affect controllability such as when the sensor is too close to air grilles, registers, or heat radiation from room lighting.

C. This location is acceptable because it provides a good uniform mixture of dry and moist air, but if an extended time lag exists between moisture generation and sensing, make sure the control contractor extends the sampling time.

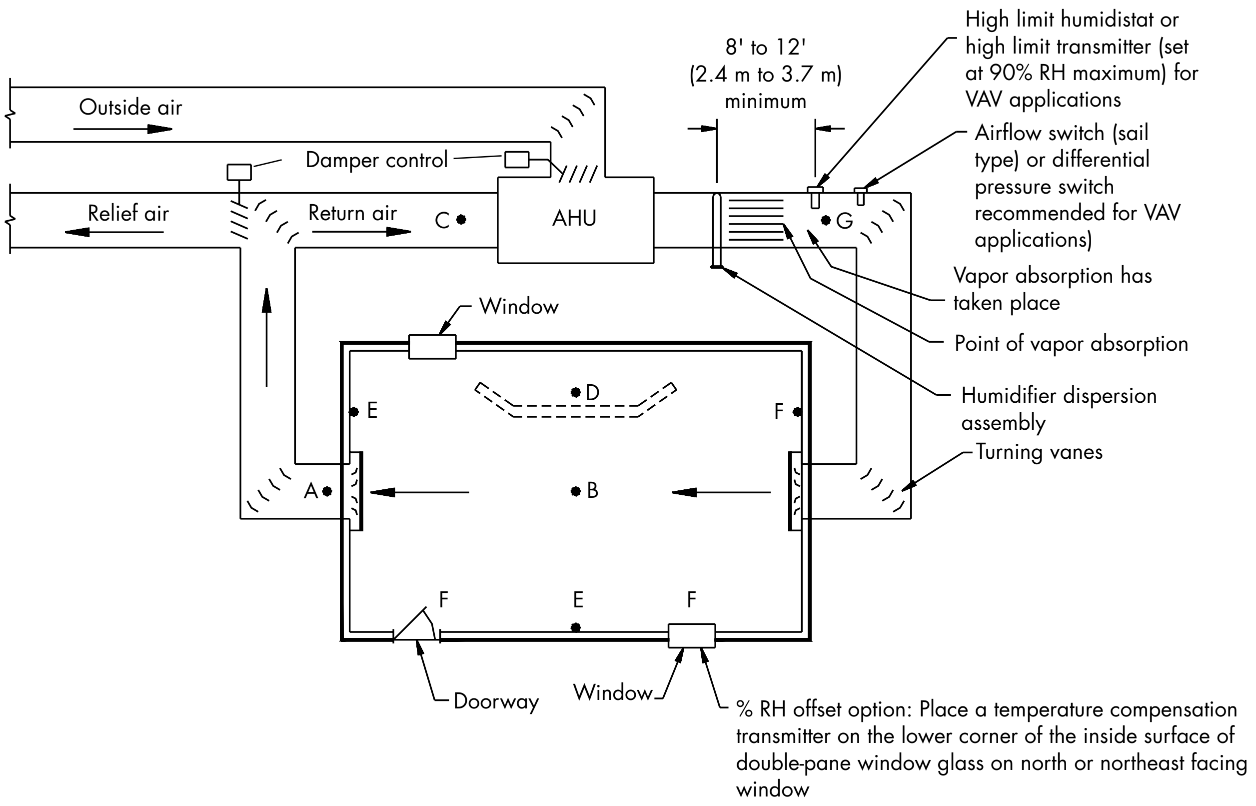
D. This location behind a wall or partition is acceptable for sampling the entire room if the sensor is near an air exhaust return outlet. This location is also typical of sensor placement for sampling a critical area.

E. These locations are not acceptable because they may not represent actual overall conditions in the space.

F. These locations are not acceptable. Do not place sensors near windows, door passageways, or areas of stagnant airflow.

G. This is the best location for a duct high limit humidistat or humidity sensor.

FIGURE 52-1: RECOMMENDED SENSOR LOCATIONS



Glossary of humidification terms

NUMBERS AND SYMBOLS

3PDT — three-pole, double throw

µS/cm — microSiemens per centimeter, a measure of conductivity

A

A — ampere, amps, amp

ac — alternating current

adiabatic humidifier — uses heat from air to convert water into vapor

AGA — American Gas Association

AHU — air-handling unit

ANSI — American National Standards Institute

aquastat — thermostat designed for use in water

ASCII — American Standard Code for Information Interchange

ASHRAE — American Society of Heating, Refrigerating, and Air-Conditioning Engineers

ASTM — American Society for Testing and Materials

atomizer — device that creates a fine spray from a liquid

B

ball valve — valve consisting of a ball resting on a spherical seat

BOM — bill of material

BSP — British standard pipe

BSPT — British standard pipe tapered

Btu — British thermal unit

C

°C — degrees Celsius

CE — Conformité Européen — required marking for selling our products in Europe

C-ETL — Electrical Testing Laboratory, Canada

cfh — cubic feet per hour

cfm — cubic feet per minute

cfs — cubic feet per second

check valve — a valve allowing fluid flow in one direction only

cold-snap offset RH transmitter — during periods of very cold weather, this window-mounted temperature transmitter lowers the RH control point to permit maximum room RH without condensation on windows

Glossary of humidification terms

condensate — in humidification, water condensed from steam

condensation — change of state of a vapor into a liquid by extracting heat from vapor

conductivity — ability to carry electrical current

contactor — electromagnetic switching device

controller — device that regulates the humidification system

CPVC — chlorinated polyvinyl chloride

CSA — Canadian Standards Association

CSI — Construction Specifications Institute

C-UL — Certified by UL in both Canada and the U.S.

Cv — valve flow coefficient

D

dB — decibel

dBA — decibel, weighted

dc — direct current

DEAE — diethylamino ethanol

dia. — diameter

DIN standard — Deutsches Institut für Normung (German Institute for Standardization)

DI/RO — deionized/reverse osmosis (water)

DK — Drane-kooler water tempering device

DN — diameter nominal — used to describe pipe sizes in metric literature

DPDT — double pole, double throw

E

EEPROM — electrically erasable programmable read-only memory

EMI — electromagnetic interference

entrained condensate — water droplets transported by steam flow

EOS — end of season

EPDM — ethylene propylene dienemonomer

ETL — Electrical Testing Laboratory

Glossary of humidification terms

F

°F — degrees Fahrenheit

F&T trap — float and thermostatic trap

flue piping —

- Type B: Double-wall construction with aluminum inner wall and galvanized steel outer wall
- Type B-W: Same as Type B except fabricated in an oval shape
- Type L: Same as Type B except inner wall is stainless steel

ft — foot, feet

ft2 — square foot, feet

fpm — feet per minute

fps — feet per second

G

gpg — grains per gallon

gph — gallons per hour

gpm — gallons per minute

GTS humidifier — Gas-to-Steam humidifier

H

heat exchanger — a device specifically designed to transfer heat between physically separated fluids or gasses

HEPA — high-efficiency particle arrestor

hp — horsepower

hr — hour, hours

humidistat — a regulatory device, actuated by changes in humidity; used for automatic control of relative humidity

humidity transmitter — a monitoring device that senses humidity level and provides an output signal based on humidity level

HVAC — heating, ventilation, air conditioning

hygrometer — an instrument responsive to humidity conditions of the atmosphere

Hz — hertz

Glossary of humidification terms

I

IAQ — indoor air quality

ID — inside diameter

in — inch, inches

in_2 — square inch(es)

in_3 — cubic inch(es)

IOM — Installation, Operation and Maintenance manual

I-P units — inch-pound units

J

J — joule

JIC — Joint Industrial Council

K

kW — kilowatt

kWh — kilowatt-hour

K_{VS} — valve flow coefficient, Europe

L

L — litre

lb — pound

lbs/hr — pounds per hour

lbs/hr/ft — pounds per hour per foot (as in vapor hose capacity)

lbs/hr/ft^2 — pounds per hour per square foot

LON — local operating network

LP — liquefied petroleum

Glossary of humidification terms

M

mA — milliampere

max — maximum

MB — megabyte

mb — millibar

MBh — one thousand Btu per hour

micromho — one-millionth of a mho. The micromho is the practical unit of measurement for conductivity, and is used to approximate the total dissolved solids content of water. The preferred term for conductivity is μS/cm

microSiemens/cm — microSiemens per centimeter (abbreviated μS/cm); a measure of conductance; see also micromho

N

NEMA — National Electrical Manufacturing Association

NIST — National Institute of Standards and Technology

No. — number

NOx — nitrogen oxide

NPT — National Pipe Thread

O

oc — on center

OD — outside diameter

P

PID — proportional, integral, derivative

ppm — parts per million

psi — pounds per square inch

PVC — polyvinyl chloride

R

RFI — radio frequency interference

RH — relative humidity

Glossary of humidification terms

S

SCR — silicon-controlled rectifier

SDU — space distribution unit

SI — Système International D'unités (International system of units based on the meter, kilogram, second, ampere, Kelvin, candela, and mole)

SSR — solid state relay

SST — stainless steel

STS humidifier — Steam-to-Steam humidifier

T

T — temperature

TDS — total dissolved solids

TP — time-proportioning

U

UL — Underwriters' Laboratories

V

VA — volt-ampere

Vac — volts alternating current

Vdc — volts direct current

W

W — watt

wc — water column

wt — weight

Notes

Expect quality from the industry leader

For more than 45 years, DriSteem has been leading the industry with creative and reliable humidification solutions. Our focus on quality is evident in the construction of the XT Series humidifier. DriSteem also leads the industry with a Two-year Limited Warranty and optional extended warranty.

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For the most recent product information visit our Web site: www.dristeem.com

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