# HUMIDIFICATION AND WATER TYPE

## How potable, softened, high-purity and boiler water affect humidifier operation

### Water type affects performance, maintenance, vapor quality, and efficiency

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.

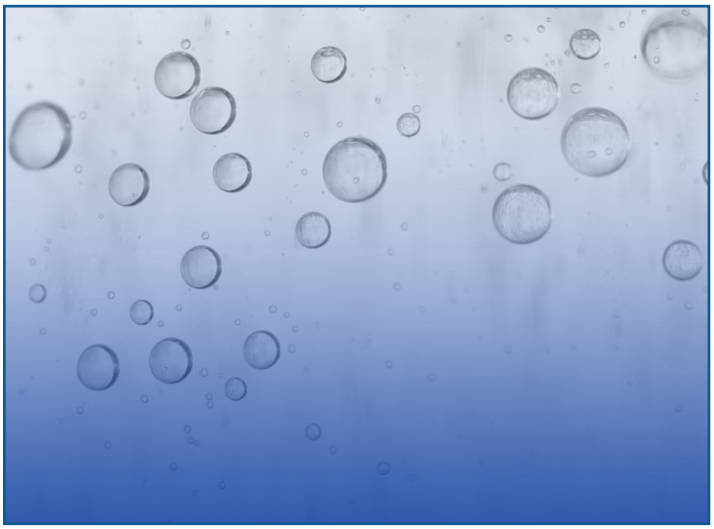
Humidification is the process of transforming water into vapor, and so it is not surprising that water type has a great impact on humidifier performance, maintenance requirements, humidification vapor quality, and efficiency of operation.

There are four types of water used in humidifiers:

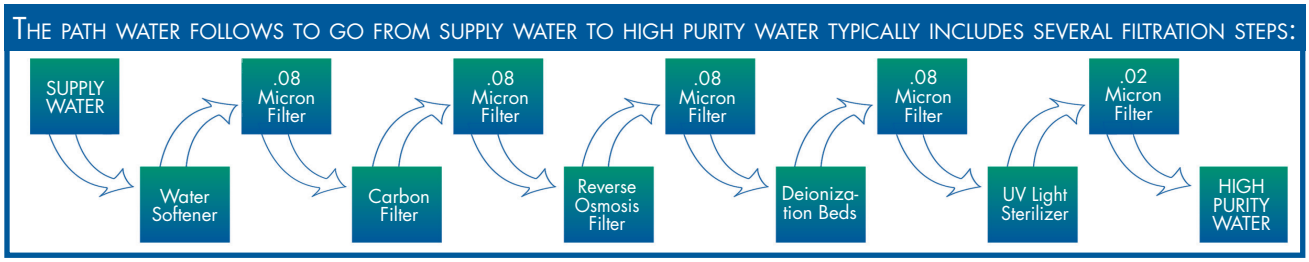
- **Potable water** (drinking, tap or well water)
- **Softened water** (hardness reduced through an ion exchange process)
- **High-purity water** (deionized and/or reverse osmosis treated water)
- **Boiler water** (typically treated with anti-corrosion chemicals)

### 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, 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, disinfection and deionization. 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); and
  - –chemical reactions that occur during water treatment processes (from disinfection by-products or pipe joint adhesives).

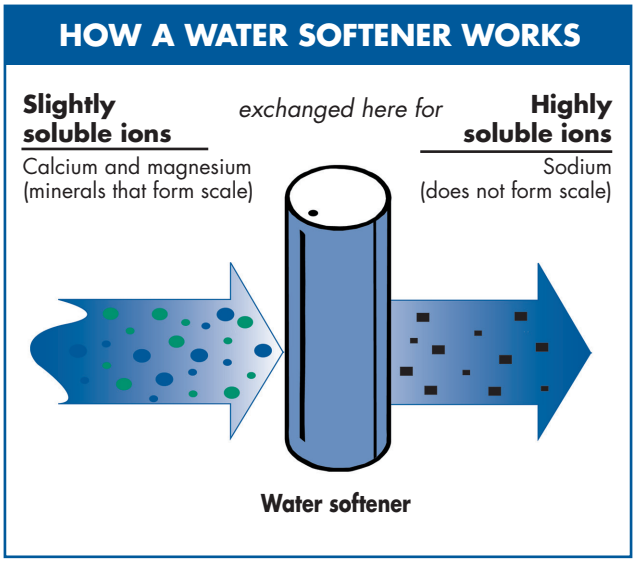
  Activated carbon and microfiltration, and reverse osmosis and deionization processes remove dissolved organic material.

- **Dissolved minerals** found in potable water are magnesium, calcium, iron, chloride, alkalinity, sulfate, fluoride, 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. Filtration removes some dissolved minerals, while water softening is the most common method for reducing water hardness (see discussion at right on softened water).

- **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 are typically removed by filtration.

## 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 like 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), and 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.

The process of softening water can increase water conductivity, and so some electric isothermal systems (such as plastic cylinder systems that heat water with electrodes) may not operate efficiently using softened water. Electrode systems heat by sending an electric current through water and, therefore, require water to be within a specific range of conductivity to operate. To reduce conductivity levels and to remove minerals if there is no automatic skimmer, electrode systems may need to be flushed frequently. This frequent flushing will reduce performance and increase energy usage. When purchasing a humidifier system, be sure to ask how softened water affects not only maintenance (softened water should reduce maintenance requirements), but efficiency and performance, as well. Electric systems using element heaters (not electrodes) will work in any type of water (tap, softened or DI/RO), for they do not rely on water conductivity to operate.

## High purity water yields high purity humidification for critical process environments

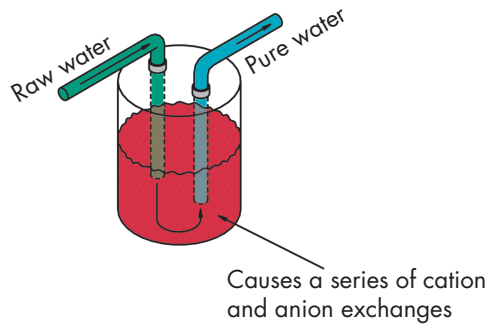
Semiconductor, pharmaceutical and electronics manufacturers, as well as laboratories, industrial clean rooms and healthcare facilities often require high purity humidification. To avoid water contaminants that can be carried into the air with water vapor, these types of environments use highly processed – 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 will degrade upon contact with the atmosphere and certain materials and should remain in a closed system contacting only chemically stable materials.

## Properly maintained DI/RO water is not corrosive

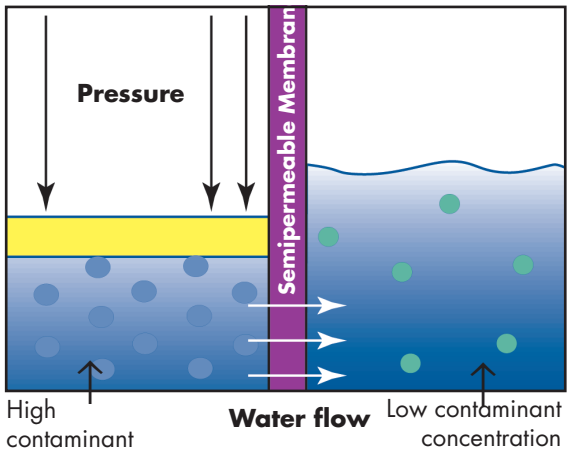
If a DI/RO system is functioning properly and well maintained, the water produced consists solely of hydrogen and hydroxides and is free of most or all total dissolved solids (TDS) including chlorides and other molecules that cause metal corrosion. Many users of high purity water have the false impression 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 anion bed) will typically become saturated or ineffective, and then the weak acid solutions generated by the second bed (the cation 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.

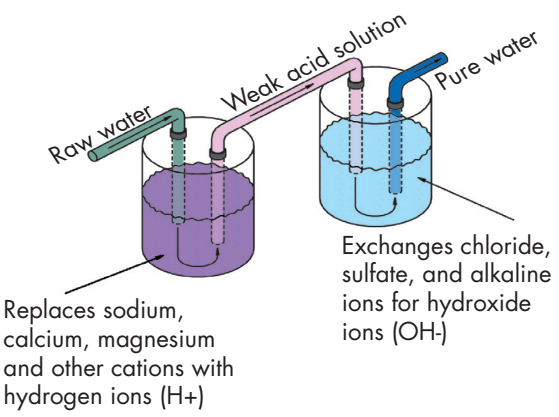
### SINGLE TANK (MIXED BED) DI SYSTEM




### HOW REVERSE OSMOSIS FILTRATION WORKS



## TWO-TANK DI SYSTEM




### 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.

Key to delivering a responsive energy source is a control system that quickly adapts to changing and often unique environmental conditions. But given the same controller, a system with a modulating valve, such as a boiler-steam heat exchanger system, will have a bit of an edge over electric and gas isothermal systems because of the infinite variability of a modulating steam valve — it truly provides energy to heat water on demand. Gas and electric systems however, come very close to achieving this capability, making the comparison mostly academic.

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 will cause 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 (over about an eight minute time period) and then typically flush the tank with cold water for eight minutes. In this situation, not only is the humidifier off-line for about 16 minutes, 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.

### 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 get plugged. In systems that use plastic cylinders, the cylinders may require replacement. 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 systems will 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.

## Direct injection of boiler steam affects indoor air quality

Boiler steam is often directly injected into the air through steam dispersion units to provide humidification. Owners of existing boiler systems have found this a cost-effective, energy efficient, and easily controllable way to add humidity without adding additional equipment to make steam. However, boiler water is typically treated with anticorrosion chemicals which, when directly injected into the air as steam, negatively impact indoor air quality. Concerned owners wishing to make use of an existing boiler for humidification should consider a closed loop system such as a steam-to-steam system that provides chemical-free steam for humidification by running boiler steam through a heat exchanger (see illustration at right).

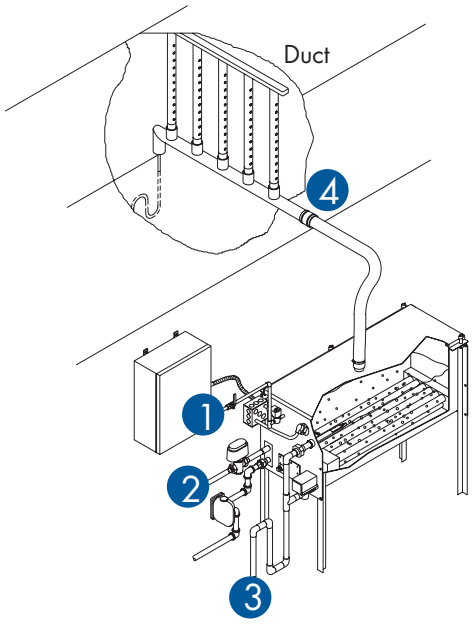
## Humidification vapor as pure as the fill water

In general, the quality of humidification vapor will be only as good as the humidifier tank's fill water. High purity water (DI/RO) provides the purest humidification. Humidification produced through an isothermal process (boiling) will be a bit more pure than humidification produced through an adiabatic process (unheated water turned into vapor by evaporation, pressure and/or compressed air). Some adiabatic systems using potable or softened water leave a fine dust on area surfaces; and wetted-media or wick systems may contaminate humidification vapor. Process-critical environments, such as surgical suites, clean rooms, semiconductor manufacturing, or museums requiring artifact preservation, will use high purity water to ensure very clean humidification vapor. Potable hard and softened water in isothermal systems typically provide humidification vapor that is adequately clean for comfort applications such as office or residential buildings.

## Hard water reduces energy efficiency

How water type affects energy efficiency is closely related to how water type affects performance. Simply stated, the harder the water, the more water wasted down the drain to remove minerals and, therefore, the more water that will need to be replaced and reheated, resulting in increased energy costs.

### HOW AN ISOTHERMAL HEAT EXCHANGER HUMIDIFIER WORKS




1. Tap, softened, or DI/RO water fills the evaporating chamber through the fill valve. This is the water that will be converted into steam for humidification.
2. Responding to a call for humidity, boiler steam piped from an on-site steam boiler passes through the steam control valve into the heat exchanger, causing the water in the evaporating chamber to boil. The makeup water valve opens and closes as needed to maintain the proper makeup water level.
3. During refill, a portion of the surface water is skimmed off and drained, carrying away precipitated minerals.
4. Steam created in the evaporating chamber flows through the steam hose or piping into a dispersion assembly, where it is discharged into the airstream as humidity.

Table 6-1:
How fill water type affects performance, maintenance, steam quality and efficiency in isothermal humidification systems

| Fill water type | Skimming required (Y/N) | Drain and flush frequency | Hardness (gpg) | RH performance | Maintenance requirements | Humidification steam quality | Water and energy efficiency |
|---|---|---|---|---|---|---|---|
| Potable | Y | System with a manual drain: Humidifier typically drains one time per season, but may need to increase drain and flush frequency based on quarterly inspections, especially with water over 12 gpg. | 2 - 35 | Fifth-best control capability | If water is harder than 12 gpg, scale buildup will occur quickly. Increasing skim and drain/flush cycles will help reduce scale, as will regular cleaning. The key is to skim or flush minerals while they are still in solution and before they attach to humidifier components as scale. | As pure as the fill water. Contaminants in the makeup water supply will likely transfer to the airstream with the humidity vapor. | As water hardness increases, so does the need for skimming and draining, thus increasing water and energy usage, for water replacing water lost to skim and fill cycles must be heated.<br><br>In addition, performance degradation can occur in heat exchanger-based systems if the heat exchanger becomes coated with mineral. |
| Potable | Y | System with auto drain and flush: Several times per season | 2 - 35 | Sixth-best control capability | | | |
| Softened | Y | System with a manual drain: Humidifier typically drains one time per season, but may need to increase drain and flush frequency based on quarterly inspections. | 2 - 12 | Third-best control capability | Can go up to two years without cleaning, but quarterly inspections are encouraged to verify softener operation. Drain, flush and skim frequency/ duration affect maintenance requirements. | As pure as the fill water. Contaminants in the makeup water supply will likely transfer to the air-stream with the humidity vapor. | As water hardness increases, so does the need for skimming and draining, thus increasing water and energy usage, for water replacing water lost to skim and fill cycles must be heated. |
| Softened | Y | System with auto drain and flush: Several times per season. | 2 - 12 | Fourth-best control capability | | | |
| High purity (DI/RO) | N | Typically only need to drain one time per season | 0 - 2 | Second-best control capability | Cleaning typically not required, but quarterly inspections are encouraged to verify filtration operation. | Very pure humidification steam. Steam generated by an isothermal process will be a bit more pure than humidification produced by an adiabatic process, such as by a fogger. | Very efficient because there is no water used for skimming or drain/flush cycles. However, a very small amount of water will regularly overflow to keep the P-trap filled. |
| Boiler steam (direct injection) | N/A | N/A | N/A | Best control capability | Yearly inspection. Typically, no other regular maintenance is required. | Boiler anti-corrosion chemicals are directly injected into the air. | This process is very efficient because an existing boiler can often be used. |

## DriSteem humidifiers accommodate any water type

DriSteem designs and manufactures humidifiers to work with any water type. Standard humidifier models use potable or softened water for makeup water. DI models use high purity (DI/RO) water for makeup water. Both model types offer microprocessor control and numerous dispersion options.

Because water type has such a significant effect on humidifier performance, maintenance, vapor quality and energy efficiency, DriSteem humidifiers have several key design features to accommodate a variety of water types:

- **High-quality stainless steel construction**
  Standard water models use 304 stainless steel. DI models use 304 or 316 stainless steel. High quality, cleanable stainless steel allows DriSteem to give an industry-leading two-year warranty.
- **Automated skim, drain and flush cycles**
  Standard water isothermal models (Vaporstream® humidifier Vapormist® humidifier, CRUV® humidifier, GTS® humidifier, and STS® humidifier) use microprocessor controlled skimming and drain/flush sequences to remove precipitated minerals from their evaporating chambers at regular intervals. Each time an evaporating chamber refills, the water's surface is drained off through the skimmer, carrying away the mineral residue formed during the previous evaporating cycle. This can significantly reduce maintenance requirements, while allowing the use of economical potable or softened makeup water.

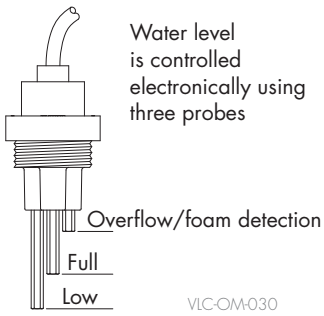
**FIGURE 7-1: DRISTEEM'S GAS-FIRED GTS SYSTEM IS ECONOMICAL TO OPERATE AND RUNS ON ANY TYPE OF WATER**

- **User-adjustable microprocessor control**
  Because water type has such a great effect on humidifier performance, maintenance, vapor quality and energy efficiency, and because water type varies from location to location, a user-adjustable control system is essential. While factory manuals suggest standards for skim, drain and flush frequencies, the microprocessor controller allows a high degree of adaptability for any water type.

**FIGURE 7-2: DRISTEEM'S VAPOR-LOGIC CONTROLLER PROVIDES PRECISE, USER-ADJUSTABLE CONTROL FROM EASY-TO-USE DISPLAYS**


- **Conductivity probe measures potable and soft water levels**
  DriSteem's standard-water isothermal systems use a three-probe conductivity sensor that cycles a solenoid-operated fill valve to maintain proper water levels. For the probe to sense water levels, the water in the tank must have a conductivity of at least 100 µS/cm (water with hardness of at least 2 grains/gallon).

**FIGURE 7-3: WATER LEVEL CONTROL**




- **Float valve measures water in DI systems**
  Because high purity water has few or no minerals, DI humidifier models (VL-DI, VM-DI, CRUV-DI, GTS-DI, and STS-DI) use a float valve to measure water levels, and do not require regular skimming, draining, flushing or cleaning to remove minerals.

# Glossary of water and humidity terms

### Adiabatic humidifier
Uses heat from the surrounding air to change water into vapor for humidification. Common types include misters, sprayers, atomizers, foggers and pezio disk systems.

### DI water
Deionized water; purified through an ion exchange process to remove contaminants and minerals

### gpg
Grains per gallon of hardness, measured with a water testing kit

### Isothermal humidifier
Uses heat from an external source, such as electricity, natural gas, or boiler steam, to boil water into steam for humidity

### pH
Measured from 0-14; 7 is neutral; above 7 is alkaline; below 7 is acidic. If a humidifier's pH water test shows acidity, send a sample of the water to a lab for further testing, specifically for chlorides, which can cause metal corrosion.

### Potable water
Drinking, well or tap water with hardness ranging from 2-35 gpg

### RH
Relative humidity: the amount of moisture present in air at a given temperature compared to what air could hold at that temperature if it were saturated. Expressed as a percentage.

### RO water
Reverse osmosis water created by pressurized filtering of water through a membrane

### Softened water
Water that has had its slightly soluble magnesium and calcium ions replaced by very soluble sodium ions. Water softened to 12 gpg or less significantly reduces scale buildup in humidifiers.

### TDS
Total dissolved solids; indicates the salts and minerals in water, determined by measuring conductance

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Check out our web site to learn more about properly applying humidification systems, types of humidifiers on the market today, and current humidification issues.

You'll also find information on **DriCalc®** — DriSteem's exclusive software that sizes loads, selects equipment, writes specifications, and creates equipment schedules for DriSteem products.

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