

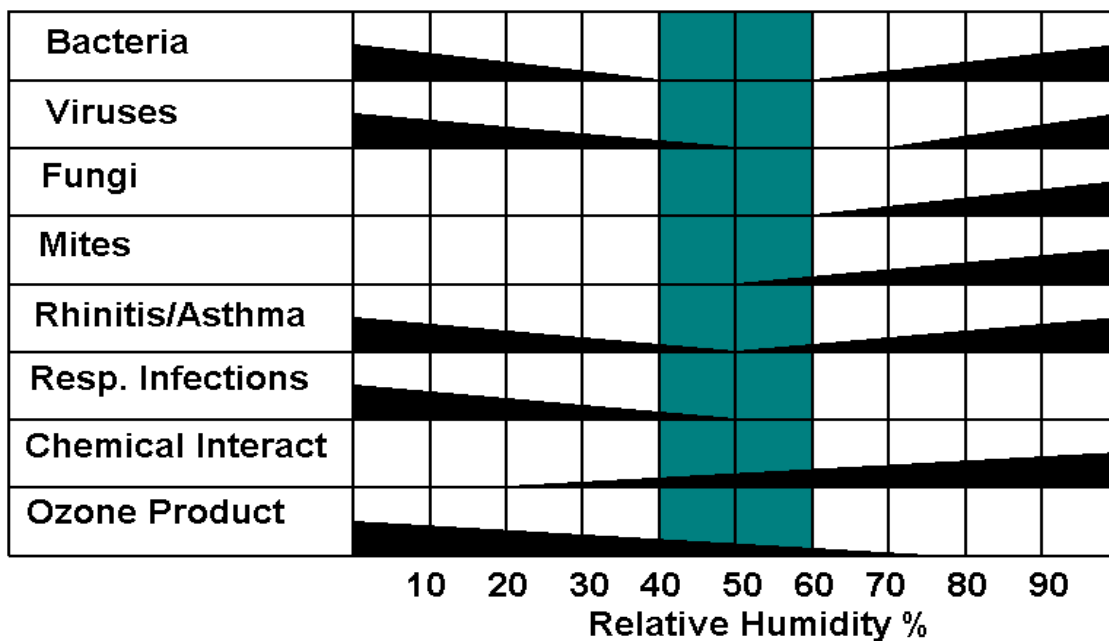
The Need For Humidity In Hospitals

It is ironic that people going to the hospital to be healed sometimes end up being exposed to dangerous and even life-threatening organisms that they wouldn't have been exposed to elsewhere. Yet this exposure is relatively easy to minimize with proper humidity control.

Dry air (below 35 %RH) causes many problems, including increased static electricity, and drying out of human mucous membranes (nose, throat, lungs). Dry mucous membranes are not only uncomfortable, but also tend to crack when they dry out (the morning dry mouth and bloody nose syndrome), making the person more susceptible to airborne infections that are breathed in. Lung surfaces dry out and lose some of their elasticity, causing further discomfort for patients with respiratory ailments.

In dry air, the dust count will also increase along with a legion of airborne opportunists such as mites, bacteria and viruses, playing havoc with any allergies. The following graph shows how these little nasties are influenced by relative humidity. NOTE that the range of 40 to 60 %RH is where the minimum quantities of nasties are able to be airborne to cause infection.

OPTIMUM HUMIDITY LEVELS FOR HEALTH



Accordingly, hospitals should be kept at recommended humidity levels as per the following chart:

Hospital Areas	Temperature	Temperature	Recommended Humidity
Operating, Cystoscopic and Fracture Rooms	72 °F	22 °C	50 %RH
Patient Rooms	75 °F	24 °C	45 %RH
Intensive Care Unit	75 °F	24 °C	40 %RH
Administrative and Service Areas	75 °F	24 °C	40 %RH

Plastic surgeons are particularly knowledgeable of the effects of dry air on exposed subcutaneous skin and organs. Dry air = dry skin = dead skin = bad suture line = scarring.

The Traditional Way

Traditionally, hospitals have been humidified using direct steam. Steam was considered to be clean, sterile and safe, and was available in quantity since most hospitals used the steam year-round for sterilizing instruments. Then in 1987 a white paper was presented at the International Hygiene Conference that identified the practice of using boiler treatment chemicals, containing carcinogenic amines (carcinogenic means "cancer causing"), as a possible health hazard to people exposed to humidifier steam. Up to 7% of the boiler treatment chemicals used in steam boiler systems will find their way into the air via the humidifiers. As a result of this concern, major manufacturers of the boiler treatment chemicals began to recommend NOT using this treated steam for humidification. Many hospitals now follow a safer practice of injecting boiler treatment chemicals in small, continuous amounts to reduce the concentrations possible in the air. Nevertheless, the exposure is still there.

In an effort to answer this chemical treatment concern, "steam-to-steam" humidifiers were introduced to produce "clean" steam from potable water, using the boiler steam through a heat exchanger immersed in water in a pan. As with any humidifier having a reservoir of large surface area, precautions must be taken to insure that biological growth does not occur in the stagnant pan during the non-humidification season. This extra heat exchange also reduces efficiency of the overall humidifier system.

Then hospitals began to move to gas sterilizers, eliminating the need for steam during the non-heating months, creating a desire to shut down the boilers and save on energy use. Since humidity is often required even in months when there is no heating load in the hospital, another efficient and safe method of humidifying hospitals was needed.

Enter The Atomizers

Needing a clean, efficient method of humidifying hospitals year-round, in all climates, attention began to be paid to adiabatic systems, in particular atomizing systems, which can cool the air during the Spring and Fall months and don't require the boilers to be in operation. Several important criteria for successful application of atomizing systems in hospitals began to emerge:

1. The system must be sealed and contain no open reservoirs or means for ambient air (which could be contaminated) to enter the system;
2. The system must use demineralized water (preferably from a Reverse Osmosis system, more about this later);
3. The system must create droplets no larger than 10 microns in diameter, as larger droplets fall to the bottom of the ducts or air handler and can cause accumulation of stagnant water;
4. The system must modulate capacity to avoid over-saturating the air;
5. The system must reduce droplet size into sub-micron levels as it modulates the capacity downward in response to rising duct humidity.

These criteria would eliminate media type evaporative humidifiers (open water exposure on hygroscopic surfaces), evaporative pan types (open reservoir), centrifugal humidifiers (as they contain a reservoir through which the ambient air passes), and even pressure type atomizing systems (droplet sizes are too large, don't modulate, and actually increase droplet size with any modulation).

The only type of humidifier to answer all of the 5 criteria listed above would be an air-assisted, sealed atomizing system.

Water Considerations

Atomizing systems work by creating small water droplets that are readily evaporated into the air. It must be recognized that 100% of whatever is in the water (mineral, chemicals) will go into the air as dust particles after the water droplet evaporates. Generally, a 10 micron water droplet will leave behind a 0.3 to 0.7 micron dust particle after it evaporates, which will travel through everything except a HEPA filter. This dust can collect on surfaces and be ingested by patients. Although the mineral dust is not so much of a problem by itself, its accumulation on surfaces meant to be kept clean is not desirable. If the mineral dust contains trace elements, such as Sulfur, which some people may be hypersensitive to, then allergic reactions can occur. Further, some potable waters may also contain biologicals. Therefore, it is necessary to use sterile, mineral-free water in humidifiers used in hospitals.

The best way to handle the minerals and biologicals is with a Reverse Osmosis water treatment system. A Reverse Osmosis system uses a semi-permeable membrane, which allows only water molecules to pass through under pressure, leaving the minerals and biologicals on the other side to be flushed away. The purified water is then circulated through a continuous loop with a UVC ultraviolet lamp to sterilize it before being used by an atomizing humidifier. Some systems then further polish the water by running it through chemical deionizers which results in water of up to 18 megohm purity – the same as used in Class 1 clean rooms. This same treated water should be used in personal humidifiers and respirator humidifiers used in hospitals. The MC 2000 atomizing system using this quality of water is the purest humidification system known.

A typical hospital water treatment system is shown at right. The potable water first flows through a multi-media filter to remove sediment and macrobiologicals, then through a water softener to strip away the hard minerals, such as Calcium, that can damage the membranes in the R/O unit. Then the water passes through a carbon filter to strip away Chlorine, then through the R/O membranes, a UVC sterilizer, and off to the atomizing humidifier systems.

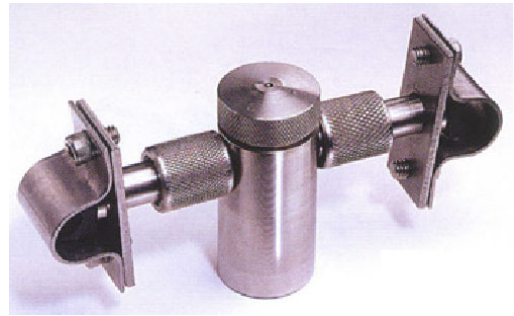


H₂O (water) is a unique molecule that has two hydrogen atoms located 105° apart, adjacent to the oxygen atom. The hydrogen side carries a positive charge while the oxygen side is negatively charged. These characteristics make the water molecule dipolar and allow the molecules to bond to each other quite easily. This ease of bonding also allows for other disassociated ions to attach to the water molecule. For example, the compound for sodium chloride (table salt) is NaCl. When separated, the atoms have specific charges; Na is positive and Cl is negative. As the compound is added to water, the negatively charged oxygen of the water molecule will attract the Na while the positively charged hydrogen of another water molecule will attract the Cl atom. It's the dipolar character that the water molecule is often described as the universal solvent.

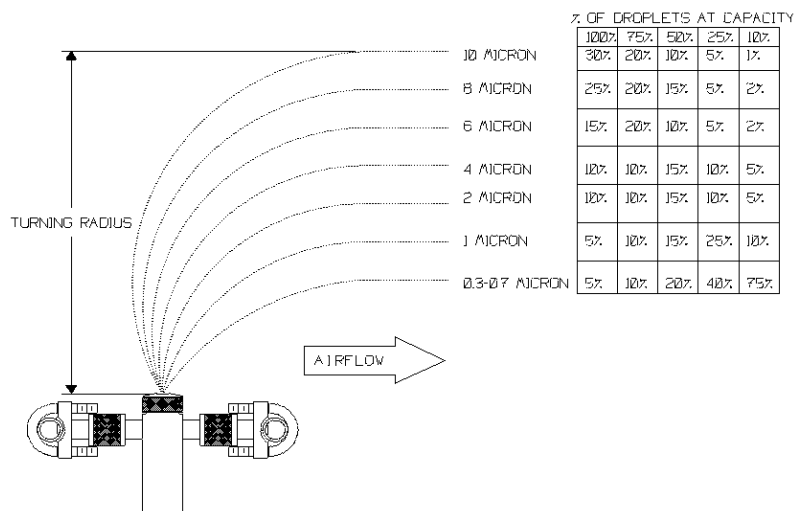
As the levels of impurities are removed from the water, the water becomes a more aggressive solvent. Pure water exists at a high-energy state and achieves energy equilibrium by its surroundings. The water becomes "ion hungry" and becomes aggressive to less noble metals (copper, aluminum, brass) and will tend to dissolve them. This is an important point – all humidification water piping systems using demineralized water should be of stainless steel, PVC or polypropylene. Water atomized onto copper or aluminum cooling coils could be dangerous, except for the MC 2000 system (explanation given in the next section).

The MC 2000 Atomizing System – King Of The Atomizers

The MC 2000 Atomizing System is based on the principle of Supersonic Vacuum Implosion (SVI). In this system, compressed air is discharged through a nozzle orifice, and around a water orifice at supersonic speed. The air flow around the water nozzle orifice creates a vacuum just ahead of the nozzle that draws water into it. As the water leaves its orifice and enters the vacuum, it is rapidly accelerated from zero to supersonic speed in 1/10,000th of a second. This literally tears the water into tiny droplets. These droplets then enter the vacuum cavity where they are stretched, followed by the implosion area where they are compressed. This rapid distortion causes the droplets to ingest air which not only aids in evaporation, but also deactivates the demineralized water so that it is not aggressive to any cooling coil surfaces. It should be noted that droplets created by atomizing systems not employing SVI technology are not distorted and therefore the water remains aggressive to metal surfaces. The MC 2000 system is the ONLY atomizer to use SVI technology.



Droplets generated by the MC 2000 nozzle are generally a mix of sizes from 0.3 to 10 microns. The percentage of small to large droplets in this mix changes, depending on modulation. Due to the dual-modulation design of the MC 2000 atomizing head, the air/water ratio increases as the system modulates down, increasing the percentage of small droplets and enhancing evaporation. In fact, at the lowest end of modulation (1/100th of full capacity), the droplets produced are below the visible range.



Another VERY important feature of the MC 2000 is its ability to modulate at a 100:1 turn down (special systems achieve 500:1 modulating turn down and track as close as +0.5%RH). This extreme turn down allows more precise control than is possible with any other humidifier and insures good control as the air approaches saturation.

As a rule of thumb, installation in a duct requires 20 feet of straight duct run without elbows or obstructions in order to evaporate the mist to non-wetting vapor. In an air handler, the ideal location is upstream of the cooling coil, with 3 feet of space being the optimum. Generally installation in the air handler is preferred since the surface area is larger, the air velocity is low and more laminar. One frequently asked question is “how do you evaporate moisture ahead of an active cooling coil. This question is best answered by the following paragraph on control technique.

Control is accomplished by sensing the room or return air humidity as well as the downstream humidity after the MC 2000 system and any cooling coils. As the humidity approaches either the room set point or the high-limit set point, the system is modulated down, reducing capacity AND reducing droplet size. It is desirable to have the temperature sensor for the cooling coil (or economizer), located after the coil so that, as the MC 2000 system begins to cool and humidify the air, the control system will begin to reduce the mechanical cooling and let the atomizing system do it. Even with the cooling coil active, sub-micron droplets will find their way through the coil, emerging on the downstream side as 1-2 micron droplets that appear as smoke. Evaporation of this “smoke” then lowers the temperature and raises the humidity – something steam cannot do. During spring and fall months, the MC 2000 can do the humidification AND cooling by itself.

So, let's look again at the 5 criteria mentioned above, for a successful atomizing system in a hospital:

1. *The system must be sealed and contain no open reservoirs or means for ambient air (which could be contaminated) to enter the system;*

MC 2000 answers this with not only a sealed system, but an atomizing head that has a positive shut-off seat, clean-out needle and dries itself on every shutdown.

2. *The system must use demineralized water (preferably from a Reverse Osmosis system);*

MC 2000 answers this by being entirely constructed of stainless steel.

3. *The system must create droplets no larger than 10 microns in diameter, as larger droplets fall to the bottom of the ducts or air handler and can cause accumulation of stagnant water;*

MC 2000 answers this by creating a maximum 10 micron droplet as well as modulating down to produce droplets as small as 0.3 micron. The no-drip, no-spit design further insures no puddling.

4. *The system must modulate capacity to avoid over-saturating the air;*

MC 2000 answers this by modulating at an incredible 100:1 turn down ratio. NO other humidifier system is capable of even approaching this precision.

5. *The system must reduce droplet size into sub-micron levels as it modulates the capacity downward in response to rising duct humidity.*

MC 2000 answers this by reducing capacity and droplet size through dual-modulation.

But, it gets even better: Special lubricant and Viton O-rings are used to insure that the MC 2000 head produces no ions in operation. It is so pure that with 18 megohm deionized water it can be used in a Class 1 clean room. The MC 2000 head actually produces a vacuum in the nozzle that negates the effects of air bubbles in the water lines. Other nozzles that operate under higher pressures can drip or spit when air bubbles cause pulsing in the pressurized water lines. Using SVI technology, the MC 2000 atomizing head produces 10 micron droplets with only 0.10 SCFM of compressed air per pound of water atomized – the most efficient atomizer ever made.

Why use the MC 2000 instead of steam?

- Higher precision of control
- Ability to shut off steam boilers in the spring and fall months
- Evaporative cooling savings in the spring and fall months (On average, a 100 lbs/hr atomizing system costs \$1,200 less per year to operate than a comparable electric steam humidifier, \$368 less per year than a gas-fired steam boiler.)
- Lower maintenance
- Elimination of boiler treatment chemicals
- Reduction of fossil fuel use

The MC 2000 in Hospitals: A humidifier whose time has come !

Hutchinson Hospital A Case Study

In 1993, the Director of Plant Operations of the Hutchinson Hospital in Hutchinson, Kansas received an order to humidify parts of the hospital. Faced with all the considerations outlined above, and tired of the maintenance required with steam humidifier systems, he decided to blaze a new path and solve the problem with an MC 2000 atomizing humidifier system from Carel LLC (then DGH Systems).



The first system was installed in a custom built-up 34,100 cfm air handler, just upstream of the cooling coils. The atomizing system consists of 14 - MCHA15DA atomizing heads (210 lbs/hr capacity) on factory supplied, pre-built stainless steel manifolds. Mist eliminators were installed downstream of the atomizing manifold to protect the cooling coils from the aggressive R/O water (it was not known at the time that the SVI technology used in the MC 2000 system would deactivate the water). The control panel supplied by Carel accepts a modulating control signal from the building's DDC control system.

At right is a photo of the atomizing manifolds inside the air handler. The top right insert shows a typical system in operation (with the air flow off). The atomizing heads are arranged on a single manifold at the bottom of the air handler, pointing up. They are placed upstream of the cooling coils, as far as possible to allow for evaporation distance. They discharge their mist at 90° to the air flow, which is then turned by the air flow and carried into the cooling coils or mist eliminator. No dripping or spitting occurs and in nine years there has never been a case of any type of contamination or even suspect growth. This is not always the case with steam humidifiers.



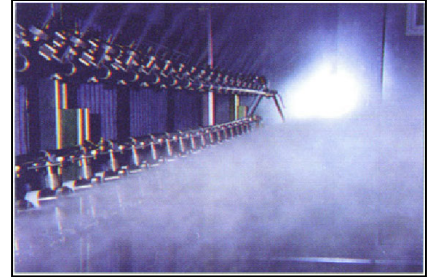
Control of the system is from the building's control system by sending a modulating signal to the MC 2000 control cabinet, which then activates the compressed air and water flow to the atomizing heads and modulates their output to match demand. Return air and room sensors provide input for the control set point, and high-limit sensors placed downstream of the MC 2000 system provide input to modulate the system as it approaches saturation in the duct. MC 2000 control cabinet also provides for automatic activation of the self-cleaning mechanism in the atomizing heads.



Carel is careful to note that the MC 2000 system is NOT a fogger – it is an atomizer, designed not to produce excessive wetting in the ducts or air handler.

A state-of the art Reverse Osmosis system is used to provide pure water to the humidifier system and consists of a 5 micron water filter, followed by a water softener, carbon filter, R/O membranes and UVC lamp.

The system serves the Front Lobby, Conference Rooms, Psychiatric Ward, Outpatient Dialysis, and some patient rooms. The Director of Plant Operations stated during the interview: "The system has been very reliable, and has not required any preventative maintenance or service since installed". He is very satisfied with the performance of the system and would recommend it to anyone. Shutting down boilers and reducing mechanical cooling has probably paid for the system in under 12 months.



Sales Rep: Doug Lane, Jorban-Riscoe Assoc., Wichita, Kansas

Other Medical Facilities Humidified With The MC 2000 Atomizing System

Blue Cross / Blue Shield of Michigan, MI

Broome Developmental Center, Binghamton, NY

Eagle Ridge Hospital, Vancouver, BC

Franklin Correctional, Malone, NY

Logansport Hospital, Logansport, IN

South East Medical Center, AL

Southern New England Regional Medical Center, Nashua, NH

University of Medicine & Dentistry, Stratford, NJ

We have also humidified animal veterinary facilities too numerous to mention.



White Paper / Case Study
MC 2000 Atomizing Humidifiers In Hospitals

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