Water Treatment Application Guide

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Executive Summary

A Treatise on Water Treatment

Understanding water treatment is essential in being able to properly apply a water treatment solution for STULZ Ultrasonic Humidifier Systems. Ultrasonic Humidifiers require water treatment to prolong the life of the transducers and to prevent mineral deposits in the water from being introduced into the air stream.

Table of Contents

Understanding Water Chemistry

Water Chemistry

The most effective way to understand water treatment equipment is to have a basic knowledge of water chemistry. This allows one to understand a water quality report and make educated decisions on what water treatment is needed for the application. A water quality report will list a breakdown of what minerals are found in the water and will display the overall water quality in parts per million (PPM), grains per gallon (GPG) or total dissolved solids (TDS). These metrics are all a measure of dissolved solids and can be used to determine the conductivity/resistivity of the incoming water source.

Water Conductivity

Water conductivity is defined as the measurement of the ability of a water sample to conduct electricity. This is used as a measure of the concentration of dissolved solids which have been ionized in water.

Units of Water Conductivity

1/Ω (1/Resistance)
TDS (Total Dissolved Solids)
mg/L (milligrams/liter)
PPM (Parts Per Million)
µS/cm (microsiemens per centimeter)
GPG (grains per gallon)

Table 1 – Water Conductivities

Water Conductivities			
Solution	µS/cm	gpg	ppm or mg/l
Totally Pure Water	0.055		
Typical DI Water	0.1		
Distilled Water	0.5		
RO Water	50 - 100	1.5 - 2.9	30 – 65
Domestic "Tap" Water	500 - 800	14.6 - 23.4	320 – 510
Potable Water (Max)	1055	30.9	675
Sea Water	56,000	1,637	35,900
Brackish Water	100,000	2,924	64,100

Conductivity vs Resistivity

When the ionic concentration is very low (such as in high purity water), the measured conductivity falls below a value of one microsiemen per centimeter. In order to express this value as a whole number, as opposed to fractions, the resistivity scale are often used; conductivity and resistivity are inversely proportional. For example: the reciprocal of 0.10 µS/cm [or $1/(0.10 \times 10^6$ S/cm)] is then 10×10^6 ohms-cm (10 MΩ-cm). This is also commonly referred to as megaohms. Either unit of measurement can be used to state exactly the same value.

Commonly the conductivity scale is more versatile as it can be used for a broader range of measurements. For the STULZ Ultrasonic Ultra-Series Controller, a water resistivity of five micromhos or microsiemens will give a water quality alarm informing the need for maintenance on the water treatment system. If the water quality degrades to 20 micromhos then the STULZ Ultra Series Controller will shut down operation of the humidifier(s) in order to protect the equipment, and prevent the dissolved minerals in the water from distribution into the humidifier. This prevents powdered dissolved solids being introduced into the space.

Table 2 – Conductance, Resistance and Dissolved Solids

Conductance		Resistance		Dissolved Solids		Status
Microsiemens	Micromhos	Ohms	Megaohms	PPM	GPG	
0.0500	0.0500	20,000,000	20.0	0.032	0.002	Stainless Steel Fill Valve Required
0.0556	0.0556	18,000,000	18.0	0.036	0.002	
0.0625	0.0625	16,000,000	16.0	0.040	0.002	
0.0714	0.0714	14,000,000	14.0	0.046	0.003	
0.0833	0.0833	12,000,000	12.0	0.053	0.003	
0.100	0.100	10,000,000	10.0	0.064	0.004	Brass Fill Valve with Stainless Steel Seat Acceptable
0.125	0.125	8,000,000	8.0	0.080	0.005	
0.167	0.167	6,000,000	6.0	0.107	0.006	
0.20	0.20	5,000,000	5.0	0.128	0.007	
0.25	0.25	4,000,000	4.0	0.160	0.009	
0.50	0.50	2,000,000	2.0	0.321	0.019	
1.00	1.00	1,000,000	1.0	0.641	0.037	
2.00	2.00	500,000	0.5	1.282	0.075	
4.00	4.00	250,000	0.25	2.564	0.150	
5.00	**5.00**	**200,000**	**0.2**	**3.205**	**0.187**	**Alarm**
6.67	6.67	150,000	0.15	4.274	0.250	Water Treatment Maintenance Required
8.00	8.00	125,000	0.13	5.128	0.300	
10.00	10.00	100,000	0.10	6.410	0.375	
12.50	12.50	80,000	0.08	8.013	0.469	
14.29	14.29	70,000	0.07	9.158	0.536	
16.67	16.67	60,000	0.06	10.684	0.625	
20.00	**20.00**	**50,000**	**0.05**	**12.821**	**0.750**	**Shutdown**

Water Hardness

Water hardness is defined as the amount of calcium carbonate ($CaCO_3$) dissolved in one US gallon of water.

Table 3 – Water Hardness

Standard Water Hardness Levels		
Clarification	**mg/l or ppm**	**gpg**
Soft Water	0-17.1	0-1
Slightly Hard Water	17.1-60	1- 3.5
Moderately Hard Water	60-120	3.7-7.0
Hard Water	120-180	7.0-10.5
Very Hard	180 & Over	10.5 & Over

- *Water hardness is classified by the U.S. Department of the Interior and the Water Quality Association*

STULZ Water Treatment Solutions

Demi Cabinet

The term **demi cabinet** refers to demineralization cabinet.

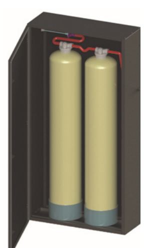


Figure 1
Demi Cabinet

Demi cabinets are used when the volume of water processed is relatively small. A demi cabinet should not be used on any water treatment opportunity which requires greater than 50 gallons per day on a design day. The advantage of demi cabinet is that it uses 100% of the supply water not wasting any water through the demineralization process.
The demi cabinets come with the following items: a pair of Di Bottles sized at 0.45 ft³, 1.0 ft³, or 2.0 ft³ which is used to purify the incoming water using ion exchange and a DI quality light resilite which will light red if water quality falls below one megaohm of resistivity.

Small RO Cabinet

Figure 2
RO Cabinet

Reverse osmosis (RO) is used for moderate flow applications normally between 40 and 200 gallons per day. The RO system allows for higher volume of water to be treated than DI bottles alone, and will substantially reduce the maintenance requirement of changing DI bottles. The disadvantage of the RO cabinet is that the system does not have an RO pump and as such the RO design recovery is only about 30%. This means that there will be a high volume of waste water. RO design recovery is the amount of process water made from the RO plant. The higher the pressure applied to the water source the higher the RO design recovery percentage.

Small RO cabinets are designed to include an RO plant, pressure tank, DI bottles and a DI quality light resilite, which will light red if water resistivity falls below one megaohm. A water softener with brine tank, and booster pump can be added to the RO cabinet as an option.

Large RO Skid

RO skids are used when a high volume of process water is required for the design. RO skids range from 500 gallons per day up to 8000 gallons per day. The RO skid has many pretreatment steps to condition the supply water before the RO plant, and a large storage tank after the RO plant to store process water for peak demand requirements. The skid mounted RO systems have an RO pump contained within the RO plant which increases the RO design recovery in the range of 50% to 75%. This is a substantial reduction in waste water when compared to the non-pump driven RO.

Figure 3 * – Large RO Skid

STULZ Water Treatment Components

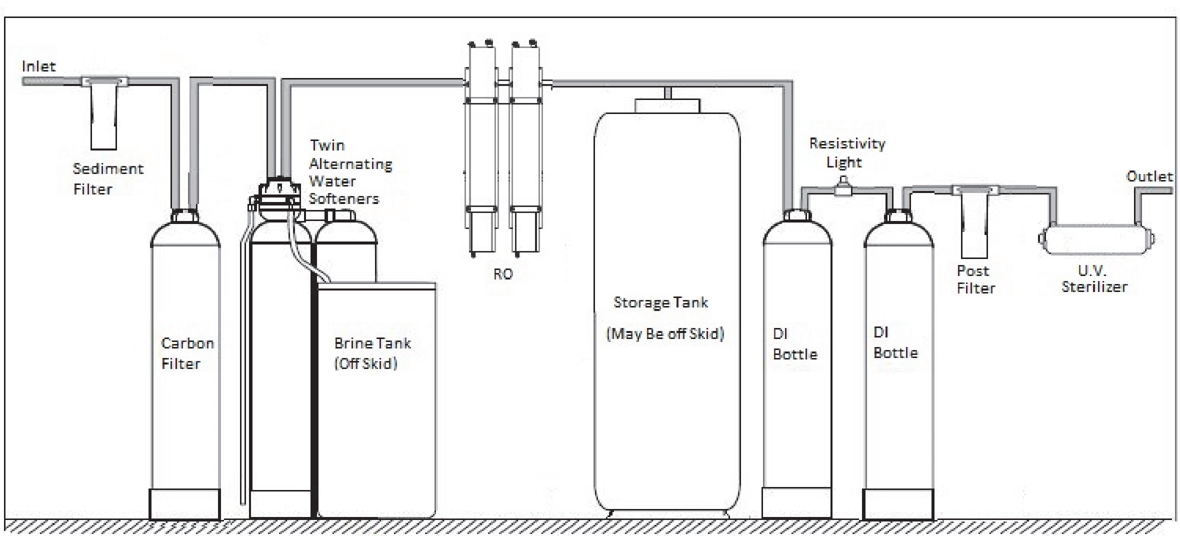


Figure 4 – RO Skid Process Diagram

Sediment Filter

The sediment filters on the RO skids are used to eliminate large particles in the water supply. The sediment filter is a cartridge constructed of pleated cellulose designed to remove any particle greater than 20 microns from the water supply.

Carbon Filter

Carbon filters are filled with a bed of activated charcoal to remove contaminates and impurities using chemical absorption. The carbon absorbs the chemicals / additives in the water, trapping these chemicals in the pore structure of the carbon granules. Activated charcoal has a high concentration of micropores allowing for the removal of particle sizes ranging from 0.5 to 50 microns. The carbon filter is used primarily to filter out chlorine before the water softener and RO, prolonging the life of both.

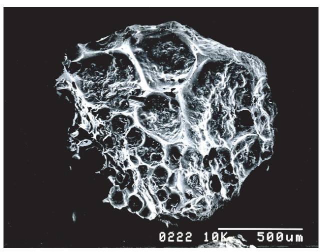


Figure 5 – Micropores of activated charcoal as seen through 10k magnification

Water Softeners

Water softeners are designed to remove hardness from the water supply through an ion exchange. This exchange is taking calcium and magnesium which have a strong positive ionic bond with sodium which has much weaker positive ionic charge. The water softener is filled with small beads known as resin or zeolite which carry a negative charge. This negative charge allows positively charged ions to cling to these beads thus removing them from the water supply. The water softener has a limited capacity of mineral removal dependent on the volume of the resin contained within. After a preset timer, which is set dependent on water hardness, the softener will regenerate. This regeneration cycle will back flush the softeners resin with a strong brine solution. During this flushing the volume of sodium ions is enough to drive the calcium and magnesium ions off the beads. This allows the sodium ions to bond with the resin and restarting the softening process. The STULZ water treatment skids all have dual softeners to allow regeneration of one tank while the other is operational.

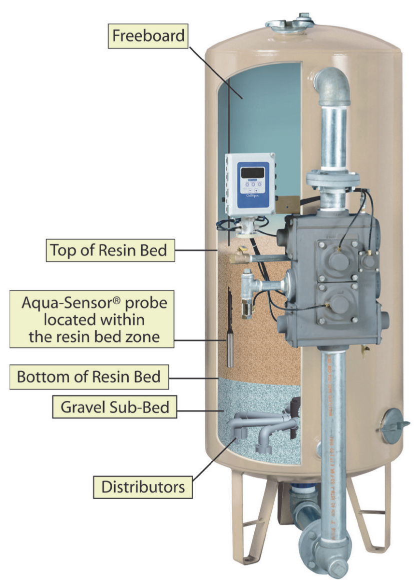
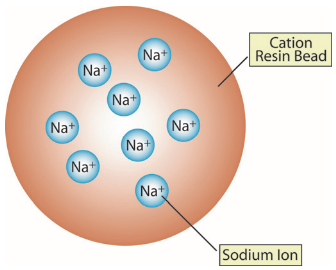
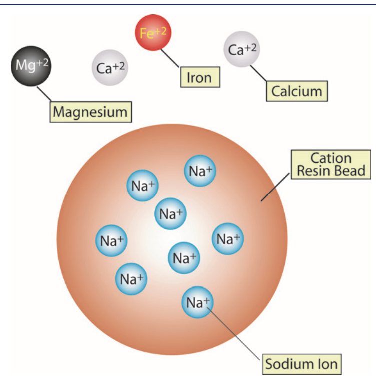


Figure 6 * – Water Softener Cutaway

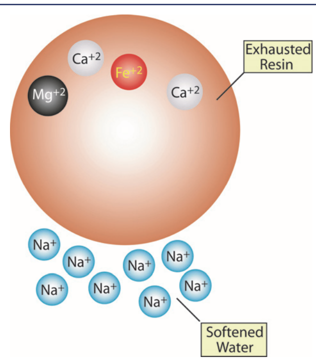
Softening Process – How it Works



Softener resin charges with sodium ions

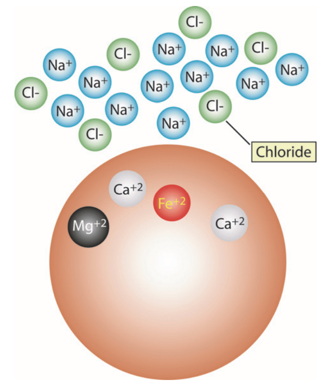


Supply water & minerals passing through resin

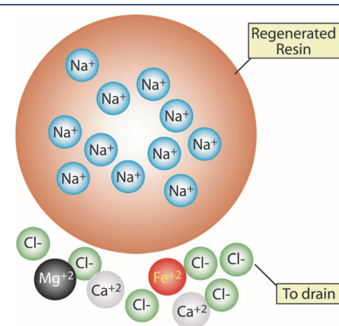


Ion exchange softening water by removal of hard minerals with sodium

Softener Regeneration Process



Back flush of salt water through resin to force ion exchange to regenerate resin



Regenerated resin with hard minerals and chloride drained away

Figure 7 * – How Water Softeners Work

RO Plant

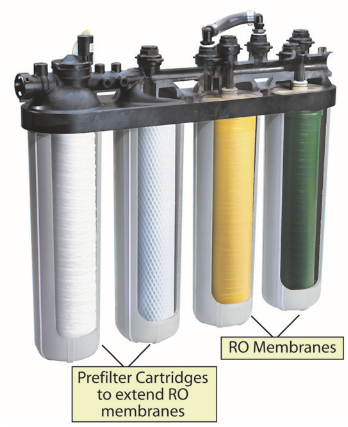
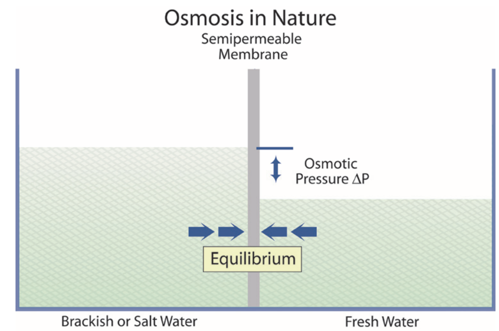
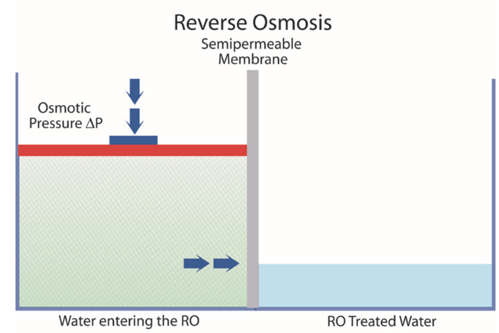


Figure 8 *
RO Plant Cut Away

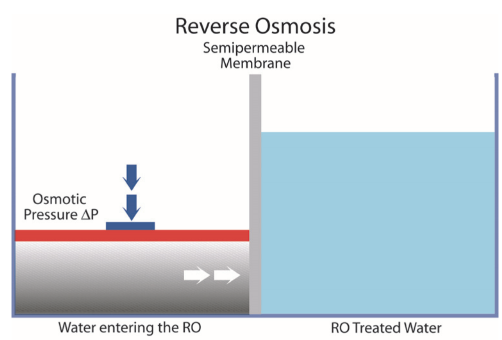
Reverse Osmosis is the process where solids are removed from supply water. This process uses pressure and a semi-permeable membrane which catches over 98% of all dissolved solids. This process is accomplished by having the multiple layers of membrane to catch dissolved minerals. A portion of the water supply is used to constantly remove the solids contained in the membrane so the RO does not become ineffective. Whenever an RO plant is in use it generates process water which is called permeate, and waste water, which is called concentrate. Permeate is supply water which has been pushed through the membranes of the RO and is 98% pure. Concentrate is the mineral rich water that is rejected as waste to flush away the minerals from the surface of the RO membranes. Rejection of concentrate is required to keep RO plant in full working efficiency. The ratio of process water to supply water is known as the design recover rate of the RO and is a measurement to determine the overall efficiency of the RO Plant.



Osmosis can occur in nature when there is a difference in fluid density, which is the osmosis pressure.



Reverse Osmosis is possible when pressure is applied to the process fluid.



As pressure of the process water is increased, the effectiveness of the RO Plant increases.

Figure 9 * – The Osmotic Process

RO Water Storage

RO storage is required for the RO plant because the RO process requires time to process supply water, as such storage is needed so there is a supply of RO water stored. This stored water will be used when water is required.

In the Smaller RO systems the CDC-200 and the CHP-500 this RO storage is a pressurized tank which is used to ensure proper water pressure is delivered from the system. In the Larger RO systems CHP-1200 and up this storage is an atmospheric tank, and is used with a re-pressurization pump.

Repressurization Pump

The repressurization pump is a 304 stainless steel pump used to pump the processed water from the RO Storage tank through the DI bottles and out of the water treatment system.

DI Bottles

DI Bottles work by an ion exchange of the supply water thus removing all ions contained within the water. Each cubic foot of DI resin is capable of removing 12,000 gains/ft³ of dissolved minerals.

There are two types of ions anions (-) and cations (+). The resin contained within the bottles has a mixture of hydrogen (H) and hydroxide (OH) ions. The hydrogen exchanges with the cations and the hydroxide with the anions thus the output is pure water H_2O. *(See Figure 10)*

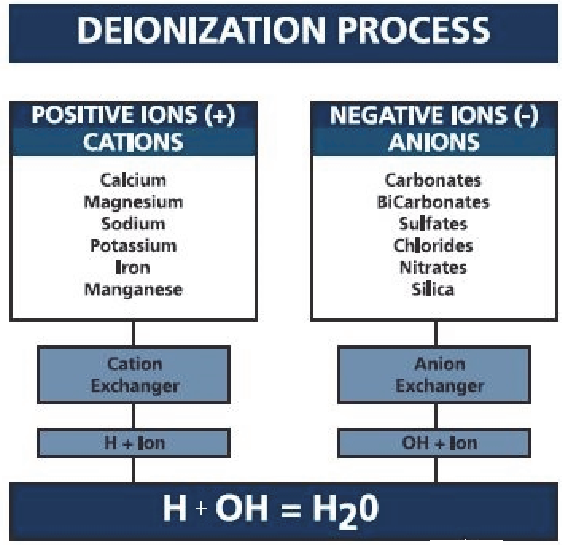


Figure 10 – Deionization Process

Anions are negatively charged ions or non-metals (examples are carbonates, bicarbonates, sulfates, chlorides, nitrates and silica). Cations are positively charged ions or metals (examples are calcium, magnesium, sodium, potassium, iron and magnesium).

Post Filter

The post filter is used to eliminate any fine particles which make it through all previous water treatment steps. The post filter is a filter cartridge that is constructed of pleated cellulose designed to remove any particle greater than five microns from the water supply.

Resilite Water Purity Monitoring

The resilite is a visual indication of the acceptability of the water quality. When the water resistance is greater than one megaohm, the resilite lamp will light green. When the resistance falls below the one megaohm the lamp will light red. This red lamp is an indication that the DI bottles would need to be serviced and that other service may be required on the system.

Ultraviolet Sterilization

The ultraviolet (UV) sterilization lamp is designed to kill bacteria, viruses and protozoa.

The UV lamp is provided to ensure indoor air quality as per ASHRAE 62.1 Ventilation for Acceptable Indoor Air Quality

Short-wave UV light has been found to be 99.9% effective as a germicide killing harmful biologicals which can be contained within supply water. Short-wave UV light is produced in a mercury vapor lamp. These low pressure mercury vapor lamps are made of quartz glass that allows 70 to 90 percent of short-wave UV rays to pass through into the water supply. Destroying all biologicals in the process water ensures that the humidifier's open pan stays cleaner and requires less maintenance.

The UV sterilization lamp consists of 304 stainless steel housing with a 37 watt UV bulb which produces light at 254nm wave length.

Example

Selecting the proper sizing for water treatment - a comparison of operating costs:

Table 4 - Sample Water Quality Report

Total Dissolved Solids	ppm	873.6
Conductance	uS/cm	560
pH		7.83
Total Hardness as $CaCO_3$	ppm	127
Calcium as $CaCO_3$	ppm	90
Magnesium as $CaCO_3$	ppm	37
P-Alkalinity as $CaCO_3$	ppm	0
M-Alkalinity as $CaCO_3$	ppm	86
Chloride as Cl	ppm	91
Silica as SiO_2	ppm	3.9
Molybdenum as Mo	ppm	1.04
Orthophosphate as PO_4	ppm	0.5
Tolyltriazole as TTA	ppm	BDL
Mono Sodium Nitrite as $NaNO_2$	ppm	ND
Iron - Dissolved as Fe *	ppm	0.59
Iron – Suspended as Fe *	ppm	1.21
Copper - Dissolved as Cu *	ppm	0.15
Copper – Suspended as Cu *	ppm	0.19
Nitrate as NO_3	ppm	4.9

Total Dissolved Solids (TDS)

When reviewing water reports, the most important information to look for is the total dissolved solids or TDS. The TDS is the sum of all ions dissolved in the raw water. As seen in Table 4, the TDS is greater than the sum of all recorded minerals on the report. The conductance is also a good indicator of water quality 1.56 uS/cm (conductance) = TDS. Other ions can be present in water which are not shown on the report such as aluminum, boron, manganese, potassium, and many others.

Conductance

A convenient way to estimate the total amount of dissolved salts in water is to measure its electrical conductivity. A conductivity measurement can't distinguish between salts. Dissolved ions like sodium and chloride tend to have higher conductivities than other ions like calcium, magnesium and sulphate. Water with a higher proportion of sodium and chloride tends to have higher conductivity than water with the same amount of calcium, magnesium and sulphates.

pH

pH is an approximate indication of the acidity or alkalinity of water. pH is a logarithmic expression of the inverse of the number of hydrogen ions (H^+) present in a solution. Low pH water often indicates increased corrosion potential or acidity in the sample. For drinking water pH should ideally be between 6.8 and 8.5.

Total Hardness

Hardness is the amount of calcium and magnesium in the sample water. By convention hardness is given as amount of calcium carbonate ($CaCO_3$) although it actually measures magnesium as well.

Calcium

Calcium (Ca) is the measure of calcium carbonate ($CaCO_3$) contained in the sample. Calcium carbonate is commonly found in ground water. Total water hardness is normally expressed as $CaCO_3$ on water quality reports.

Magnesium

Magnesium (Mg) is expressed on most water hardness reports as $CaCO_3$. This expression is to normalize magnesium atomic number (12) to calcium atomic number (20), this is to express the total water hardness as parts per million of $CaCO_3$.

Alkalinity

Alkalinity is a measure of the bicarbonates (HCO_3) and hydroxides (OH) that make water alkaline. The alkalinity in water comes partly from carbon dioxide dissolving in the water to form bicarbonate and H^+ ions. There is no acceptable or unacceptable level of alkalinity. Alkalinity gives an indication of the resistance the water has to changes in pH. It is also used along with carbon dioxide levels to calculate a theoretical pH.

Chlorine and Chlorination

Chlorine gas (Cl_2) is widely used as a cheap and effective sanitizer for water. Bacteriological contamination is unlikely to occur if free chlorine levels are kept around 0.4 – 0.5 ppm. If used to treat drinking water, chlorine helps to offset the harmful effects of iron, manganese, sulphides and ammonia.

Silica

Silica (SiO_2) can be present in water as silicic acid or silicate ions. This is known as reactive silica. It can also be present as insoluble or suspended particles in a polymeric or colloidal state. In general reactive silica levels are 20 ppm, and significantly higher in well water. The main problem with reactive silica is that it supports greater growth of algae in water.

Molybdenum

Molybdenum (MoO_4) is soluble in water and is a naturally occurring mineral. It is normally found in surface water supplies, such as water systems pulling water from rivers and reservoirs.

Orthophosphate

In natural waters orthophosphate (PO_4) ranges from about 0.005 – 0.02 ppm. Algae may become a problem in water with more than 0.05 to 0.09 ppm phosphate, depending on other conditions. Around 0.27 ppm phosphate is excessive in natural waters and may lead to over production of plants including algae. If water report is given as phosphorus, then multiply by 4.58 to get phosphate.

Tolyltriazole

Tolyltrazole ($C_7H_6N_3$) or TTA is a rust and corrosion inhibitor. TTA is only found in a water systems where it has been added. TTA should only be found in closed loop systems. It is an irritant, to skin, eyes and is harmful if ingested.

Mono Sodium Nitrite

Sodium nitrite ($NaNO_2$) concentrations are rarely over 0.1 ppm in natural water. Formation of nitrites is an intermediate step in the process that converts ammonium to nitrate. Normally nitrites are oxidized to less harmful nitrates in water if there is an adequate amount of oxygen. If there is too much nitrogenous waste to break down, the process may not have enough oxygen and nitrites will accumulate. Nitrite binds with sodium in a water system that contains insuficent oxygen to make nitrates. Sodium nitrite is used to prevent growth of bacteria; however in high amounts it is toxic to animals and humans.

Iron

Iron (Fe) is normally measured as dissolved and suspended. Dissolved iron levels for drinking water should not exceed 0.2 – 0.3 ppm, Iron in excess can foul pipes and fitting. Suspended iron occurs when water from wells and deeper dams is brought to the surface and mixes with air the iron becomes less soluble and suspends as reddish iron compounds. The iron becomes less soluble due to two factors; the water becomes more oxygenated and the pH usually rises because carbon dioxide dissipates.

Copper

Normally copper (Cu) levels are around 0.03 ppm in natural waters but may rise to 1 ppm if copper contamination is present.
Levels are commonly around 0.05 ppm in reticulated supplies. Copper levels of 1.3 ppm or greater may cause staining and water may have a bitter taste. Water which is acidic normally contains higher copper levels due to dissolved copper from plumbing.

Nitrate

The amount of nitrate (NO_3) in water is an important issue in many parts of the world due to nitrates entering groundwater and streams due to runoff of agricultural fertilizers or through organic pollution. High concentrations of nitrates may be a health problem. In unpolluted water nitrate is rarely above 1 ppm so higher levels may indicate contamination. If measurements are given as Nitrate-N this means the nitrogen contained in the nitrate compound is free nitrogen. Free nitrogen is unbound nitrogen which can form harmful nitires. To convert nitrate to nitrite, multiply by 4.4, so 1 ppm Nitrate-N (NO_3-N) is the same as 4.4 ppm nitrite (NO_2).

System Operating Cost Calculation

The Opportunity

A humidification system requires two DRH-16's, which is a max load of 35.2 lbs./hr. Due to the location we would have a humidification season of 3,500 hours/year. Referencing the above water quality report we know we have water with a TDS of 873.6 ppm.

Water Requirement

Taking the humidification load of 35.2lbs./hr. we can determine the maximum water treatment load by dividing by the weight of a gallon of water and multiplying by 24 hours in a day.

35.2lbs/hr * 1 gallon/ 8.35 lbs.* 24 hours/ 1 day = 101.2 gallons/day

Looking at the water quality report we determine that the total dissolved solids (TDS) is 873.6 ppm
Referencing the Appendix A (standard water quality conversions) 1 grain/gallon (gpg) = 17.1 ppm of TDS so in our case 873.6/17.1 = 51.08 grains/gallon.

DI Cabinet Maintenance Determination

We will be calculating the service interval for a 2.0 ft³ DI cabinet which contains two 2.0 ft³ DI bottles, or 4.0 ft³ of DI resin.

Known: Each cubic foot of Culligan DI resin is capable of removing 12,000 gains/ft³ of dissolved minerals.
4.0 ft³ of DI resin
101.2 gallons/day of water
3500 hours per year of humidification
51.08 grains/gallon
Water/Sewer Rate $8.20 / 1,000 gallons
430.00 Maintenance $/service for two 2.0 ft³ DI bottle exchange
Power Consumption= 0.2 kWh
Electrical Cost = 0.10 $/kWh

Solve: DI Bottles have a Design Recovery of 100% and is 100% effective at removal of minerals.

Yearly Process Water = Volume per hour * Operational hours per year
Yearly Process Water = 101.2 gallons/day * 1day/24 hours* 3500 hours/year = 14,758 gallons/year

Yearly Supply Water = Yearly Process Water/ Design Recovery
Yearly Supply Water = 14,758 gallons/year / 1.00 = 14,758 gallons per year

Removal Capacity per service = 12,000 grains/ft³ * Bottle Volume
Removal Capacity per service = 12,000 grains/ft³ * 4.0 ft³= 48,000 grains/service

Services per Year = Yearly Process Water * Water Quality / Removal Capacity per Service
Services per Year = 14,758 gallons/year * 51.08 grains/gallon / 48,000 grains/service = 15.7 services/year

Looking at this selection at 15.7 services/year we would strongly discourage using DI bottles due to the maintenance requirement, and would instead recommend a small RO cabinet.

Power Cost = Operating Hours * Power Consumption * Electrical Cost
Power Cost = 3500 hr/yr * 0.2 kWh * 0.10 $/kWh
Power Cost = 70.00 $/yr

Water Cost = Yearly Supply Water * Water Rate
Water Cost = 14,758 gallons/year * $8.20 /1000 gallons
Water Cost = 121.02 $/yr

Maintenance Cost = Services per Year * Maintenance cost
Maintenance Cost = 15.7 * $430.00
Maintenance Cost = 6,751.00 $/yr

Operating Cost = Maintenance Cost + Water Cost + Power Cost
Operating Cost = 6,751.00 $/yr + 121.02 $/yr + 70.00 $/yr
Operating Cost = 6,942.02 $/yr

Small RO Cabinet Maintenance Determination

We will be calculating the service interval for a CDC-200 cabinet which contains an LP-200 RO and two 0.45 ft^3 DI bottles, or 0.9ft^3 of DI resin.

LP-200 RO has a design recovery of 30% and a mineral removal effectiveness of 98%.

Known: Each cubic foot of Culligan DI resin is capable of removing 12,000 gains/ft^3 of dissolved minerals.
RO Design Recovery 30%
RO Effectiveness 98%
0.9 ft^3 of DI resin
101.2 gallons/day of water
3500 hours per year of humidification
51.08 grains/gallon
Water/Sewer Rate $8.20 /1,000 gallons
150.00 Maintenance $/service for two 0.45 ft^3 DI bottle exchange, pre-filter, and RO filter
Power Consumption= 1.7 kWh
Electrical Cost = 0.10 $/kWh

Solve: Yearly Process Water = Volume per hour * Operational hours per year
Yearly Process Water = 101.2 gallons/day * 1day/24 hours* 3500 hours/year = 14,758 gallons/year

Yearly Supply Water = Yearly Process Water/ Design Recovery
Yearly Supply Water = 14,758 gallons/year / 0.30 = 49,193 gallons per year

Removal Capacity per service = 12,000 grains/ft^3 * Bottle Volume
Removal Capacity per service = 12,000 grains/ft^3 * 0.9 ft^3= 10,800 grains/service

RO Supply Quality = Water Quality *(1.0 - RO Effectiveness)
RO Supply Quality = 51.08 grains/gallon * (1.0-0.98) = 1.02 grains/gallon

Services per Year = Yearly Process Water * Water Quality / Removal Capacity per Service
Services per Year = 14,758 gallons/year * 1.02 grains/gallon / 10,800 gains/service = 1.4 services/year

Looking at this selection; at 1.4 services/year the small RO would save substantially on maintenance but there is the cost of the 49,193 gallon/year of supply water to provide the needed water to the humidifiers.

Power Cost = Operating Hours * Power Consumption * Electrical Cost
Power Cost = 3500 hr/yr * 1.7 kWh * 0.10 $/kWh
Power Cost = 595.00 $/yr

Water Cost = Yearly Supply Water * Water Rate
Water Cost = 49,193 gallons/year * $8.20 /1000 gallons
Water Cost = 403.38 $/yr

Maintenance Cost = Services per Year * Maintenance cost
Maintenance Cost = 1.4 * $150.00
Maintenance Cost = 210.00 $/yr

Operating Cost = Maintenance Cost + Water Cost + Power Cost
Operating Cost = 210.00 $/yr + 403.38 $/yr + 595.00 $/yr
Operating Cost = 1,208.38 $/yr

Large RO Cabinet Maintenance Determination

We will be calculating the service interval for a CHP-500 Skid which contains an E1-2S RO and two 0.6 ft^3 DI bottles, or 1.2 ft^3 of DI resin.

E1-2S RO has a design recovery of 50% and a mineral removal effectiveness of 98%.

Known: Each cubic foot of Culligan DI resin is capable of removing 12,000 gains/ft^3 of dissolved minerals.
RO Design Recovery 50%
RO Effectiveness 98%
1.2 ft^3 of DI resin
101.2 gallons/day of water
3500 hours per year of humidification
51.08 grains/gallon
Water/Sewer Rate = $8.20 /1,000 gallons
350.00 Maintenance $/service for two 0.6 ft^3 DI bottle exchange, Carbon filter and particulate filter replacement
Power Consumption= 3.6 kWh
Electrical Cost = 0.10 $/kWh

Solve: Yearly Process Water = Volume per hour * Operational hours per year
Yearly Process Water = 101.2 gallons/day * 1day/24 hours* 3500 hours/year = 14,758 gallons/year

Yearly Supply Water = Yearly Process Water/ Design Recovery
Yearly Supply Water = 14,758 gallons/year / 0.50 = 29,516 gallons per year

Removal Capacity per service = 12,000 grains/ft^3 * Bottle Volume
Removal Capacity per service = 12,000 grains/ft^3 * 1.2 ft^3= 14,400 grains/service

RO Supply Quality = Water Quality * (1.0 - RO Effectiveness)
RO Supply Quality = 51.08 grains/gallon * (1.0-0.98) = 1.02 grains/gallon

Services per Year = Yearly Process Water * Water Quality / Removal Capacity per Service
Services per Year = 14,758 gallons/year * 1.02 grains/gallon / 14,400 gains/service = 1.05 services/year

Looking at this selection; at 1.05 services/year the RO Skid would require 29,516 gallons/year of supply water to provide the needed water to the humidifiers.

Power Cost = Operating Hours * Power Consumption * Electrical Cost
Power Cost = 3500 hr/yr * 3.6 kWh * 0.10 $/kWh
Power Cost = 1,260.00 $/yr

Water Cost = Yearly Supply Water * Water Rate
Water Cost = 29,516 gallons/year * $8.20 /1000 gallons
Water Cost = 242.03 $/yr

Maintenance Cost = Services per Year * Maintenance cost
Maintenance Cost = 1.05 * $350.00
Maintenance Cost = 367.50 $/yr

Operating Cost = Maintenance Cost + Water Cost + Power Cost
Operating Cost = 367.50 $/yr + 242.03 $/yr + 1,260.00 $/yr
Operating Cost = 1,869.53 $/yr

Conclusion:

Each type of water treatment system has a role, depending on the application. When considering purchase price vs maintenance cost, the general guidelines would be as follows: for small quanitites of humidification less than 10 lbs/hr a DI cabinet should be used. If the humidification load is greater than 10 lbs/hr but less than 70 lbs/hr then the RO DI cabinet is the best solution to use. When the required humidifier maximum load is 70 lbs/hr or greater, an RO DI skid solution would be required.

Selecting the correct water treatment system is a balance of evaluating the humidifier load and examining the first cost vs maintenance cost of the water treatment solution.

Appendix A: Standard Water Quality Conversions

Water Hardness Unit Conversions

Input conversion to obtain PPM

1 gpg =17.1 PPM
1 mg/l (milligrams/liter) = 1 PPM
1.56 µS/cm (micro-Siemens/centimeter) = 1 PPM

The TDS scale uses 2 µS/cm = 1 ppm (part per million as $CaCO_3$, Calcium Carbonate).
It is also expressed as 1 mg/l TDS.

500 TDS = 500 mg/L = 500 PPM = 780 µS/cm

Conversion of TDS (PPM) to grains/gallon =TDS(PPM) x 0.0584 = 1 grains/gallon

Grain/gallon (gpg) is a unit of water hardness defined as 1 grain of calcium carbonate dissolved in 1 US gallon of water. It translates into 1 part in about 58,000 parts of water or 17.1 parts per million (ppm).

Appendix B: STULZ Water Treatment Systems

STULZ Water Treatment Systems by Culligan		
	Components	Connections
DI – 0.5	• (2) 0.45 ft³ DI bottles • Resolite quality monitor light	Inlet ½”, Outlet ½” 120/1/60 MFS 15
DI – 1.0	• (2) 1.0 ft³ DI bottles • Resolite quality monitor light	Inlet ½”, Outlet ¼” 120/1/60 MFS 15
DI – 2.0	• (2) 1.0 ft³ DI bottles • Resolite quality monitor light	Inlet ½”, Outlet ¼” 120/1/60 MFS 15
CDC - 200	• RO 200 GPD • Pressure tank 9 gallon • (2) 0.45 ft³ DI bottles • Resolite quality monitor light • Water softener (optional) • Booster pump (optional)	Inlet ¾”, Outlet ½” Drain ¼” 120/1/60 (Resolite only) FLA 0.5, MFS 0.63, MFS 15 120/1/60 (Softener) FLA 2.5, MCA 3.0, MFS 15 120/1/60 (Booster Pump) FLA 2.5, MCA 3.0, MFS 1.5 120/1/60 (All Options) FLA 5.0, MCA 1.5, MFS 4.5
CHP-500 P	• Sedimate filter 20 micron • Carbon filter • (2) Water Softener • RO • Pressure tank 40 gallon • Post filter 5 micron • UV Sterlizer Lamp • (2) 1.46 Ft³ DI bottles	Inlet 1” FNPT, Outlet 1” FNPT Drain 1” FNPT 120/1/60 FLA 12.2, MCA 14.5, MFS 20
CHP-500 A	• Sedimate filter 20 micron • Carbon filter • (2) Water Softener • RO • 100 Gallon Storage Tank • 1 HP Repressureization Pump • Post filter 5 micron • UV Sterlizer Lamp • (2) 1.46 Ft³ DI bottles	Inlet 1” FNPT, Outlet 1” FNPT, Drain 1” FNPT 120/1/60 FLA 28.2, MCA 32.2, MFS 50

STULZ Water Treatment Systems - Continued		
	Components	Connections
CHP-1200 A	• A Sedimate filter 20 micron • Carbon filter • (2) Water Softener • RO • 100 Gallon Storage Tank • 1 HP Repressureization Pump • Post filter 5 micron • UV Sterlizer Lamp • (2) 1.46 Ft³ DI bottles	Inlet 1" FNPT, Outlet 1" FNPT, Drain 1" FNPT 120/1/60 FLA 28.2, MCA 32.2, MFS 50
CHP-2000 A	• Sedimate filter 20 micron • Carbon filter • (2) Water Softener • RO • 300 Gallon Storage Tank • 1 HP Repressureization Pump • Post filter 5 micron • UV Sterlizer Lamp • (2) 2.55 Ft³ DI bottles	Inlet 1" FNPT, Outlet 1" FNPT, Drain 1" FNPT 120/1/60 FLA 34.8, MCA 38.8, MFS 50
CHP-4000 A	• Sedimate filter 20 micron • Carbon filter • (2) Water Softener • RO, 300 Gallon Storage Tank • 1 HP Repressureization Pump • Post filter 5 micron • UV Sterlizer Lamp • (2) 2.55 Ft³ DI bottles	Inlet 1" FNPT, Outlet 1" FNPT, Drain 1" FNPT 120/1/60 FLA 34.8, MCA 38.8, MFS 50
CHP-6000 A	• Sedimate filter 20 micron • Carbon filter • (2) Water Softener • RO • 300 Gallon Storage Tank • 1 HP Repressureization Pump • Post filter 5 micron • UV Sterlizer Lamp • (2) 2.55 Ft³ DI bottles	Inlet 1" FNPT, Outlet 1" FNPT, Drain 1" FNPT 230/1/60 FLA 20.6, MCA 22.8, MFS 30
CHP-8000 A	• Sedimate filter 20 micron • Carbon filter • (2) Water Softener • RO • 300 Gallon Storage Tank • 1 HP Repressureization Pump • Post filter 5 micron • UV Sterlizer Lamp • (2) 2.55 Ft³ DI bottles	Inlet 1" FNPT, Outlet 1" FNPT, Drain 1" FNPT 230/1/60 FLA 20.6, MCA 22.8, MFS 30

Author Bio

Jason Derrick is a licensed professional engineer who has worked in multiple engineering disciplines. Jason has been employed as a senior applications engineer at STULZ Air Technology Systems since February of 2007. He is an expert in all aspects of precision air conditioning and data center cooling, with a specialty concentration in ultrasonic humidification and water-side economization.

Prior to joining the STULZ team, Jason worked as a consulting engineer in the petrochemical industry. Jason holds a Bachelors of Science degree in Mechanical Engineering from West Virginia University.

* Images Courtesy of Culligan

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