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WATER CHEMISTRY AND TREATMENT

Water is a natural solvent.
Rain water is acidic due to carbon dioxide picked up in the atmosphere.
Water and CO2 make carbonic acid (acid rain).

Water hardness is primarily calcium and magnesium.
Calcium is limestone - common throughout Midwest.
Acid water dissolves limestone, iron, and other minerals in soil.
All pure water has an affinity for metals.

Surface water supplies are generally low in dissolved minerals.
Well supplies vary in dissolved minerals with depth and location.

pH is the measure of acidity of a water supply based on the hydrogen ion.
Water with a pH below 7.0 is corrosive. Above is considered alkaline water which is not a problem except in industry.

IONIZATION

Minerals dissolved in water are present as ions. Ions have an electrical charge; either positive or negative. Ion exchange resins take advantage of this charge.

Water Softeners are cation exchangers meaning they will exchange, or pick up all positive ions. Positive ions are calcium, magnesium, iron, copper, lead, sodium, zinc, manganese, mercury, and other metals.

Negative ions are not exchanged, or removed, by a water softener and negative ions are called anions. Negative ions are nitrate, sulfate, chloride, bicarbonate, and other similar minerals.

Minerals are measured by grains per gallon (gpg) or parts per million (ppm). The metric equivalent of ppm is milligrams per liter (mg/l).

A grain is a unit of weight (7,000 grains = one pound) parts per million is a finer measurement (17.1 ppm = one grain) one ppm = 8.33 pounds of mineral in one million gallons of water. More common minerals such as hardness are measured in gpg. Minerals such as iron are present in lesser quantities and are measured in ppm (or mg/l).

An analysis usually reports minerals as calcium carbonate equivalents to base results on a common denominator. Calcium and magnesium reported separately are reported as individual ions and must be converted to calcium carbonate equivalents to arrive at total hardness.

TOTAL DISSOLVED SOLIDS (TDS)

Total dissolved solids as reported on an analysis are the total of all minerals dissolved in the water. TDS levels below 900 ppm do not present a problem in residential or commercial applications. TDS levels above 900 ppm will affect the performance of water softeners in the form of hardness and iron “leakage”. All waters contain some natural sodium, and the higher the TDS, usually the higher the sodium level.

Sodium is used to regenerate a water softener and high levels of natural occurring sodium, plus that used to remove the hardness, will combine to a level high enough to partially regenerate the softener. Thus, water with a TDS of 1500 ppm and 40 grains of hardness will cause hardness and iron leakage.

TDS is also a factor in performance of Reverse Osmosis Systems. The R.O. membrane has limitations on TDS due to its ability or inability to carry away solids which might plug the membrane.

ALKALINITY

Sometimes confused with pH, has nothing to do with pH level. Alkalinity is due to the presence of bicarbonate, carbonate, and hydrate ions. For our purposes alkalinity consists of calcium and magnesium bicarbonate. This alkalinity will produce CO_2 when water is heated; therefore, it can cause corrosion even though the pH is neutral. Usually alkalinity as high as 300 ppm is not a problem unless the hardness is below 10 gpg. An index called the saturation index is used to determine if a specific water will cause corrosion.

WATER PROBLEMS AND TREATMENT

Frequently several minerals are involved in a given water problem.

HARDNESS

Water hardness above 5 grains is considered for treatment. Hardness is calcium and magnesium which tends to revert back to the solid state when water is heated. This solid material will form scale and will also combine with chemicals added to water such as detergents. The higher the hardness, the faster scale will form or the "harder" it is to produce suds for good cleaning action.

High hardness (10 grains and above) will shorten the life of water heaters, electric heating elements, and water using appliances.

A water softener removes the hardness minerals from water and replaces it with sodium which is an inert mineral. Sodium readily dissolves in water; it has a high solubility which means it will stay in solution unlike the hardness minerals. The source of sodium for regeneration of a softener is (sodium chloride). A softener's capacity is based on how much sodium the resin will retain and what that represents in grains of hardness removed by ion exchange.

A water softener will also exchange (remove) other metallic ions in solution such as iron, manganese, copper, etc. These ions must be dissolved in the water for complete removal. Oxidized iron will pass directly through the softener.

IRON (0.3 ppm Will Stain)

Stains fixtures and clothing red/brown. Unstable in water when water is exposed to oxygen. Yellow water indicates that part, or all of the iron, has oxidized and will precipitate out of the water.

Dissolved Iron is indicated when water drawn at tap is clear but turns yellow upon standing. A water softener will remove this "clear water" iron.

Oxidized Iron is indicated by yellow color as soon as water is drawn from tap. A sediment filter will remove this iron, but should be followed by a softener to remove iron still in solution. If iron removal only is desired, a manganese greensand (ML-FFE) filter will remove both oxidized and dissolved iron.

CAUTION: Greensand should not be used on waters where pH is below 6.8.

Iron Bacteria is indicated when water pressure diminishes and iron stains are present. Lift toilet tank cover to confirm; slimy, stringy, brown growth is iron bacteria. This is most difficult form of iron and is caused by harmless bacterial that live in the absence of oxygen and feed on iron in water. It will eventually plug plumbing lines to reduce flow. Chlorinating well periodically may control growth. Best treatment is continuous chlorination. followed by activated carbon filtration (ML-ACF). Optional treatment for lesser cases is the installation of a large diameter manual sediment filter (18KF-AG) to provide a "home" for them to grow.

MANGANESE (0.2 ppm Will Stain)

Similar to iron but difficult to oxidize; causes dark brown to black stains. Is frequently present with iron, but in lesser amounts. Best removal method is with water softener.

HYDROGEN SULFIDE (Rotten Egg Odor)

Caused by decayed vegetation; is most troublesome due to bad odor and will cause corrosion; hydrogen lowers pH.

Hydrogen sulfide is sometimes present with iron and/or manganese. It will then cause black sticky precipitate which stains everything. Removal can be accomplished with a manganese greensand filter (up to 2 ppm H2S) or chlorination using a chemical pump, retention tank, and followed by an activated carbon filter. The latter method is used when the H2S is above 2 ppm or is accompanied by iron and low pH. A combination of chlorine and acid neutralizer is fed to adjust pH, oxidize the sulphur and iron in one operation.

Hydrogen sulfide is a gas and must be tested for at the job site to determine total H_2S level.

LOW pH

Acidic condition (6.8 down to 5.0 pH) will corrode plumbing, erode porcelain, and put copper or iron in water depending upon type of plumbing. Stains will be blue/green for copper and red/brown for iron. Adjustment of pH from 6.9 down to 6.5 can be done with an acid neutralizer filter (ML-ANF) which contains calcium carbonate (marble chips) media which slowly dissolves. Requires addition of more media about every two years depending upon pH level. Lower pH must be adjusted by feeding MAN-607 to the water with a chemical feed pump.

NITRATES, SULFATES, CHLORIDES (Anions)

EPA or U.S. Public Health Service limits on the nitrate level permissible is 44 ppm as nitrate or 10 ppm as the nitrogen ion. Nitrate causes what is known as "blue babies" due to oxygen starvation (this can occur at 25 ppm nitrate). Nitrate presence is also an indicator of organic contamination.

Sulfates cause an astringent taste in the water. Concentrations of 30 gpg can have a laxative effect due to calcium sulfate.

Chlorides can combine with natural sodium or sodium produced by softening and result in salty tasting water. Both sulfates and chlorides, as well as nitrates, are most economically removed by reverse osmosis.

REVERSE OSMOSIS

R.O. is a process of forcing water, by pressure, through a membrane (plastic) with microscopic pores which will separate the dissolved solids from the water. The water produced is equal in quality to distilled water.

R.O. removes up to 90-98 % of minerals, organics, bacteria, and viruses from water. dissolved gases such as chlorine or hydrogen sulfide are not removed. Many of today's chemical contaminants are also removed.

R.O. requires water which does not exceed 8 grains of hardness and all iron must be removed prior to the R.O. unit. A 5 micron cartridge filter is required ahead of the R.O. to eliminate sediment plugging of the membrane.

A water sample should be submitted to Marlo for analysis before installing an R.O. unit to ensure that the TDS does not exceed the limits. If nitrate removal is the purpose of the R.O. installation, we must have analysis to determine actual % of removal based on TDS.

SIZING CONVENTIONAL WATER SOFTENERS

Assume 60 gallons of water per day per person (natural average) if iron is present: multiply ppm x 2 and add hardness to arrive at compensated hardness. Iron is more readily exchanged than hardness and this method compensates the softener capacity.

Example: Number of Persons x 60 x Comp. Hardness = Grains Capacity Used Per Day.

Multiply: Grains per Day x 3 Days = Approximate Capacity of Softener Required. The number of days may be extended to arrive at a catalog unit which will not exhaust before regeneration.

i.e. 4 persons in household
18 grains hardness
1.5 ppm iron (clear water)

Compensated Hardness = 1.5 x 2 + 18 = 21 grains

4 x 60 x 21 = 5040 grains/day x 3 days = 15,120 grains capacity
ML-15S (15,000 grain capacity) is too small.
Timer can only be set for: Once/6 days, Twice/6 days, Three times/6days.
(Cannot be set for every 4th or 5th day.)

ML-22D (22,000 gr.) = 4.36 Days (too large)
ML-25S (25,000 gr.) = 4.96 Days (too large)
ML-30D (30,000 gr.) = 5.95 Days (too small)

Due to limitation of time clock there is not an efficient choice.
The closest time clock unit would be a ML-22D.
Consider metered (MP) unit: MP-25S (4.96 days average) *or* MP-36D (7.143 days average).

REDUCED SALT SETTING CONVENTIONAL SOFTENERS

Reduced salt dosage, 6 pounds per cubic foot of resin versus maximum salt dosage, 15 pounds per cubic foot of resin may be used to gain salt efficiency. Marlo softeners are set up to take advantage of this savings wherever it is possible to use it.

The reduced salt dosage, minimum salt setting, may not be used if iron is present in the water. With reduced salt the resin is not fully regenerated which means the resin bed retains some hardness and iron would also be retained. The iron will eventually oxidize within the resin bed and iron fouling will result in lost capacity.

Minimum salt setting can be used to obtain a more exact sizing of a unit based on 20,000 grains per cubic foot of resin versus 30,000 grains at maximum salting. This results in a smaller, less costly unit plus salt savings can be 30% or more.

Example: 3 persons, 15 grains hardness, no iron
3 x 60 x 15 - 3240 grains per day

15,000 grain unit at minimum salt = 10,500 gr. cap. ÷ 3240 = 3.24 days
(25,000 grain unit at maximum salt = 25,000 gr. cap. ÷ 3240 = 7.70 days)
(25,000 grain unit at minimum salt = 16,500 gr. cap. ÷ 3240 = 5.09 days)

ML-15S is best sizing.

COMMON SYMBOLS USED IN WATER TREATMENT

CATIONS	ANIONS
Calcium - Ca^{++}	Nitrate - NO_3^-
Magnesium - mg^{++}	Chloride - CL–
Iron - FE^{++}	Sulfate - SO_4^-
Manganese - Mn^{++}	Bicarbonate - HCO_3^- (Alkalinity)
Sodium - Na^{+}	Calcium Carbonate - $CaCO_3^-$ (Alkalinity)
Copper - Cu^{++}	
Hydrogen Sulfide - H_2S	Hydroxide - OH–
Carbon Dioxide - CO_2	
Oxygen - 0_2	