Water Group

# PRODUCT & APPLICATION TRAINING MANUAL

# WaterGroup

## Product & Application Training

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Product & Application Training

# SECTION 1

## Water Softening & Filtration

#57708Rev 03/06

Water Group

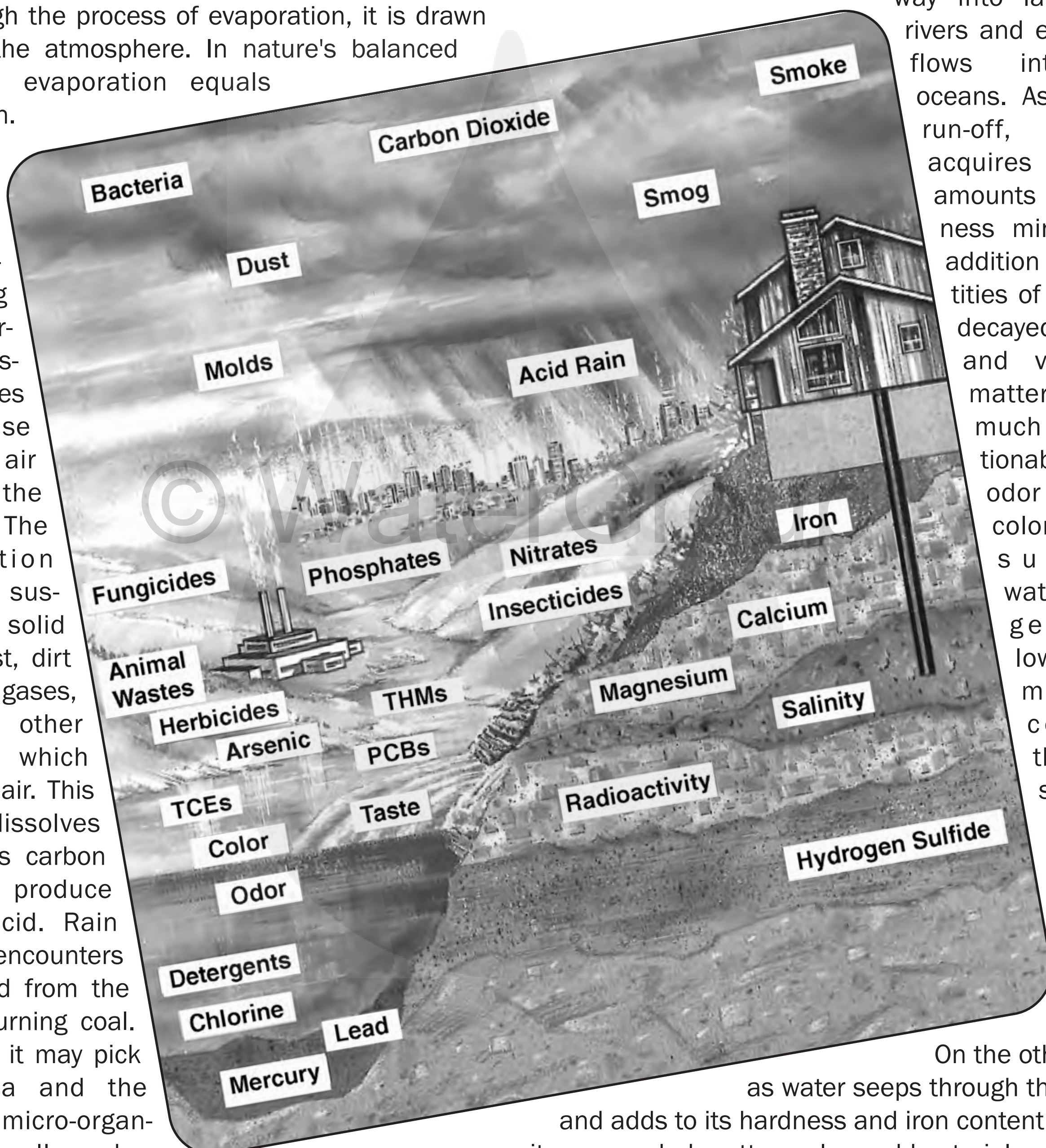
# Water, Water Everywhere

## Objectives

1. To describe the hydrologic cycle and the contamination of water.
2. To summarize various water problems and understand the benefits achieved by using water conditioning equipment.

# The Hydrological Cycle

Water begins its never-ceasing cycle as vapor in the atmosphere. When millions of vapor particles unite, they form droplets of moisture. As these increase in size, they become heavy enough to fall to earth as precipitation in such varied forms as rain, snow, sleet or hail. It is estimated that 16 million tons of precipitation in any of these forms falls earthward each second. Through the process of evaporation, it is drawn back into the atmosphere. In nature's balanced operations, evaporation equals precipitation.




As water falls to earth in this never-ceasing moisture circulating system, it serves to cleanse both the air and the ground. The precipitation absorbs suspended solid matter (dust, dirt and soot), gases, odors and other impurities which pollute the air. This moisture dissolves and collects carbon dioxide to produce carbonic acid. Rain water also encounters sulfuric acid from the gases in burning coal. In addition, it may pick up bacteria and the spores in micro-organisms. Normally, when such water reaches the earth, it is slightly acid, corrosive and relatively soft. After water reaches the ground, it may pick up additional amounts of carbon dioxide from decaying vegetable matter. Equipped with this booster action, it acquires even greater potential for dissolving minerals and other impurities on or below the surface.

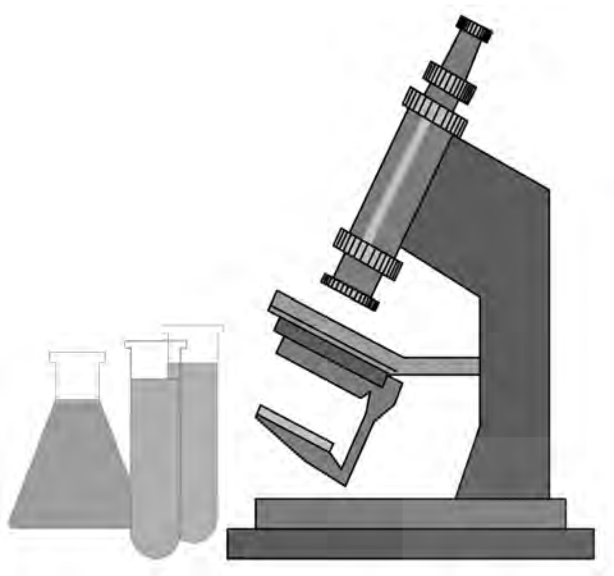
The sun causes 70% of precipitation to evaporate back into the atmosphere almost immediately. The remainder either seeps deep into the soil or finds its way into lakes and rivers and eventually flows into the oceans. As surface run-off, water acquires further amounts of hardness minerals in addition to quantities of clay, silt, decayed animal and vegetable matter and much objectionable taste, odor and color. While surface waters are generally lower in mineral content, they possess far more contamination requiring treatment. On the other hand, as water seeps through the ground and adds to its hardness and iron content, much of its suspended matter, color and bacterial content are filtered out. As water collects in lakes or oceans and as it is brought up from deep wells and exposed, it evaporates to the atmosphere to continue the hydrologic cycle.

# Guidelines for Solving Water Problems

| ***Problem*** | ***Symptom*** | ***Cause*** | ***Corrective Equipment*** |
|---|---|---|---|
| Hard Water | Spotting on dishes and glassware; scale on inside of water heater, pipes and water-using appliances; soap curd and bathtub ring; clothes look gray and dingy. | Calcium and magnesium in water, measuring 3.5 gpg or more. | Water Softener<br>(Max. Hardness 100 gpg)<br>(Max. Clear Water Iron 1.5 ppm) |
| Clear Water Iron (Ferrous) | Yellow, brown or rusty stains on plumbing fixtures, water-using appliances and fabrics; metallic taste in foods and beverages; water is clear when drawn from the faucet but oxidizes when exposed to air, then changes color ranging from yellow to brown. | Iron in the water measuring 0.3 ppm or more. | 0.3-1.5 ppm Water Softener<br>1.5-7.5 ppm Iron Guard Softener<br>1.5-30 ppm Chemical Free Iron Filter (Note 1) |
| Red Water Iron (Ferric) | Same symptoms as Clear Water Iron but iron has already oxidized and has a yellow to rust color when drawn from the faucet. | Iron in the water measuring 0.3 ppm or more. | 0.3-30 ppm Chemical Free Iron Filter ( Note 1)<br>0.3-10 ppm Iron & Sulfur Filter |
| Bacterial Iron | Same symptoms as Clear & Red Water Iron but can have clumps or balls that may foul plumbing lines and other water-using appliances; particularly noticeable as a yellow to reddish slime in toilet flush tanks. | Iron bacteria are a group of bacteria which thrive in iron-bearing water, utilizing iron as an energy source. This bacteria is not a health hazard. | Chemical Free Iron Filter (Note 1) |
| Manganese | Blackish stain on fixtures and laundry; manganese content above 0.05 ppm causes stains. | Interaction of carbon dioxide or organic matter with manganese-bearing soils. Usually found in combination with iron. | .05-1.0 ppm Chemical Free M Iron Filter (Note 1)<br>1.0-2.0 ppm Neutralizing Filter followed by Iron & Sulfur Filter (Note 2) |
| Acid Water | Blue/green or rusty stains and corrosion of plumbing fixtures and other water using appliances; pitting of porcelain and enamel fixtures and dishes. Pin holes in copper plumbing lines. | Generally associated with water with a pH value of less than the neutral 7.0. | pH 6.0-6.9 Neutralizing Filter<br>pH 4.0-6.9 Chemical Feed Pump feeding soda ash<br>Consult our Customer Service Dept. |
| Aggressive/Corrosive Water | Same symptoms as Acid Water but pH is 7.0 or higher. | Alkalinity and carbon dioxide or high dissolved oxygen in water. Electrolysis - two dissimilar metals in plumbing lines. | Consult our Customer Service Dept. |
| Hydrogen Sulfide | Rotten egg taste and/or odor. Turns copper plumbing lines black. Very corrosive. | Hydrogen sulfide is a dissolved gas found in some water supplies. | 0.1-3.0 ppm Chemical Free Iron Filter or Iron & Sulfur Filter<br>3.0-15 ppm Chemical Feed Pump feeding chlorine followed by a Multimedia Filter. (Note 3) |
| Marshy, metallic or chlorine taste and/or odors | Objectionable tastes and/or odors other than hydrogen sulfide. | Dissolved minerals or gases; organic contamination or chlorination. | Activated Carbon Filter for whole house water supply or Taste & Odor Cartridge Filter for individual faucets |
| Turbidity (Sand/Sediment) | Foreign particles, dirty or cloudy water | Tiny suspended particles that are the result of water main scale or silt. Private wells often contain sand or clay. | Multimedia Filter for whole house water supply or a Sediment Cartridge Filter for individual faucets. |
| Tannins | Yellow or brown tint or cast in water supply; tannins measuring 0.5 ppm or higher may cause staining and/or interference with various water treatment processes. | Result of decaying vegetative matter | Organic Color Removal Filter<br>Consult our Customer Service Dept. |



**Note 1** - Water must have a minimum pressure of 20 psi, pumping rate of 5 gpm and a pH of 6.5 or higher for proper operation. Most water supplies contain calcium and magnesium which are not removed by an iron filter. We recommend following an iron filter with a water softener.
**Note 2** - Oxidation of manganese is more pH dependent than iron. Therefore a pH of 8.2 or higher must be maintained. If the manganese level is >2.0 ppm or bacterial iron is present, consult our Customer Service Department.
**Note 3** - This system also requires a retention tank to allow adequate contact time (minimum 20 minutes). An optional activated carbon filter for the whole house water supply or a taste & odor cartridge filter for individual faucets may be installed to remove any objectionable taste or odor.



# Water Testing

## Objectives

***Level 1***

1. To discuss the terminology used in the testing of water
2. To be able to discuss various tests and use of a water analysis



***Level 2***

1. To be able to conduct the tests for a water analysis and complete a water analysis report completely and accurately

# Terminology

**Grains per Gallon - gpg**
1/7000 of a pound - normally used in relation to hardness.

**Parts per Million - ppm**
One part dissolved material in one million parts of water. Used as a measurement for iron, manganese, TDS, hydrogen sulfide, chlorides, sulfates and tannins.

**Milligrams per Liter - mg/l**
For our purpose, same as ppm. Normally used for a more accurate measurement or where small quantities of certain elements cause big problems in relation to iron, manganese, sulfur, nitrates and silica.

**Converting gpg to ppm or mg/l**
1 gpg = 17.1 ppm

**Total Dissolved Solids - TDS**
The weight of solids, per unit volume of water, which are in true solution. Can be determined by the evaporation of a measured volume of filtered water and determination of the residue weight. A common alternative method to determine TDS is to measure the conductivity of water.

**Hardness**
A characteristic of natural water due to the presence of dissolved calcium and magnesium. Water hardness is responsible for most scale formation in pipes and water heaters and forms insoluble "curd" when it reacts with soaps. Hardness is usually expressed in grains per gallon (gpg), parts per million (ppm) or milligrams per liter (mg/l), all as calcium carbonate equivalent.

**Ferric Iron**
Iron that is oxidized in water and is visible. Also called red water iron.

**Ferrous Iron**
Iron that is dissolved in water. Also called clear water iron.

**pH**
The *potential of hydrogen* expresses the hydrogen ion activity or concentration. pH is a measure of the intensity of the acidity or alkalinity of water on a scale from 0 to 14, with 7 being neutral. When acidity is increased, the hydrogen ion concentration increases, resulting in a lower pH value. Similarly, when alkalinity is increased, the hydrogen ion concentration decreases, resulting in higher pH. The pH value is an exponential function so that pH 10 is 10 times as alkaline as pH 9 and 100 times as alkaline as pH 8. Similarly a pH 4 is 100 times as acid as pH 6 and 1000 times as acid as pH 7.

**pH Scale**

| | | |
|---|---|---|
| | 14.0 | |
| Extremely Alkaline | 13.0 | Household Lye |
| Extremely Alkaline | 12.0 | Bleach |
| Extremely Alkaline | 11.0 | Ammonia |
| Strongly Alkaline | 10.0 | Milk of Magnesia |
| Moderately Alkaline | 9.0 | Borax |
| Slightly Alkaline | 8.0 | Baking Soda<br>Sea Water |
| Neutral | 7.0 | Blood<br>Distilled Water |
| Slightly Acid | 6.0 | Milk<br>Corn |
| Moderately Acid | 5.0 | Boric Acid |
| Strongly Acid | 4.0 | Orange Juice |
| Extremely Acid | 3.0 | Vinegar |
| Extremely Acid | 2.0 | Lemon Juice |
| Excessively Acid | 1.0 | |
| Very Extremely Acid | 0.0 | Battery Acid |

## Notes

# Water Analysis

For correct sizing and application of water conditioning equipment, a water analysis is required. A basic water analysis includes tests for the following:

- Hardness
- Iron
- Manganese
- pH
- TDS

Water samples should be taken as near the source as possible and represent the average water condition. Clean containers must be used. When performing the analysis, the test equipment must be clean and rinsed with the test water and the test water should be between 20°C and 25°C (68°F and 77°F). Use rubber stops as supplied. Do not use your fingers as contaminants and acids could affect test results.

Additional tests can be performed for tannins and hydrogen sulfide. The test for $H_2S$ must be performed on-site for accurate results. Special tests can be performed for chlorides, sulfates and alkalinity by specified laboratories. If it is suspected the water supply is contaminated with coliform bacteria or nitrates, a sample must be collected in an approved sterilized container and submitted to a government approved laboratory. Iron bacteria will not be detected with the standard iron test and can be tested for by a government approved laboratory.

If the total hardness expressed in mg/l is only 1/3 or less than 1/3 of the TDS or if the TDS is 1000 mg/l or higher, a complete water analysis should be performed to discover what other contaminants exist in the water.

If a contaminant exceeds the limits detectable by any test method, the raw water sample can be diluted with distilled water until a reading can be taken. A calculation must then be performed to determine the actual degree of contamination.

All test chemicals are subject to age and extreme temperatures. Proper storage techniques and expiry dates should be observed.

The Water Analysis Report shown on the next two pages must be completed accurately to determine the correct equipment to recommend for the water problem(s) being experienced.



## Notes

# Water Analysis Report

**NOTE:** Please answer ALL appropriate questions to ensure accurate equipment recommendations

**FOR LABORATORY USE ONLY**

Date Received ____________________

Report No. ____________________

Date Completed ____________________

## CUSTOMER

______________________________
Name

______________________________
Street

______________________________
Town State/Province

______________________________
Zip Code/P.C. Phone

## DEALER

______________________________
Name

______________________________
Street

______________________________
Town State/Province

______________________________
Zip Code/P.C. Phone

## DISTRIBUTOR

______________________________
Name

______________________________
Street

______________________________
Town State/Province

______________________________
Zip Code/P.C. Phone

**Bacterial analysis must be performed by your local health department.**

**HOW TO DRAW WATER SAMPLE**

Use outlet nearest pump (not from bottom of pressure tank). Run water for five minutes or two pump cycles, then fill clean bottle to neck and cap immediately. Never use hot water. Return bottle with this completed form.

**HOW TO MEASURE PUMPING RATE OF PUMP**

1. Make certain no water is being drawn. Open spigot nearest pressure tank. When pump starts, close tap and measure time (in seconds) to refill pressure tank. This is ***cycle time***.
2. Using a container of known volume, draw water and measure volume in gallons until pump starts again. This is ***drawdown***.
3. Divide drawdown by cycle time and multiply the result by 60 to arrive at the ***pumping rate*** in gallons per minute. Insert this figure in #3 Water System.

**1. Water Source**

❏ City or area-wide authority
❏ Community water system (small water system usually supplying 12 homes or fewer)
Water comes from:
❏ Well ❏ Lake ❏ Reservoir ❏ River ❏ Unknown
❏ New private well - Approx age ____________months
❏ Old private well - Approx age____________ months
❏ Private lake ❏ Private spring ❏ Private dugout
❏ Private cistern ❏ Other - describe ____________________
______________________________

**2. Household Information**

Do you now have water conditioning equipment?
❏ No ❏ Yes Type____________Size______________
❏ Single family ❏ Multi-family No. of units
No. persons ______________No. baths ______________
❏ Lawn irrigation on water system?
❏ Indoor pool ❏ Outdoor pool - Capacity _________ gallons
Water line size from source - _____inches

**3. Water System**

***Type of Pump***
❏ Piston ❏ Jet ❏ Submersible ❏ Unknown
Pumping rate of pump________ gpm
***Pressure Tank***
❏ Air to water ❏ Bladder Capacity ___________ gallons
Operating pressure (low/high) ________/________ psi

**4. Water Problems**

When this sample was drawn, it was:
❏ Clear ❏ Colored ❏ Cloudy
This water sample is ❏ Untreated ❏ Treated
How is it treated? ______________________________
______________________________

**PROBLEMS**

❏ Hardness (e.g. high soap usage, bathtub ring, lime deposits, etc.)
❏ Iron Deposits - if so, is iron build-up in flush tank?
❏ Greasy ❏ Gritty ❏ Stringy (iron bacteria?)
Color of Water - ❏ Red ❏ Orange ❏ Black
❏ Greenish or blue stains on sinks, tubs, etc.
❏ Pitting of fixtures and/or pipes
❏ Sand (visible particles) ❏ Sediment or silt (cloudy)
Bad Taste - ❏ Iron ❏ Bitter ❏ Salty
Other - describe ______________________________
Bad Odor - ❏ Rotten Egg ❏ Musty ❏ Iron
Odor is in - ❏ Cold Water ❏ Hot Water ❏ Both
Other Problems - describe ______________________________
______________________________
______________________________
______________________________

Return completed form to:

**5. Standard Laboratory Tests**

| | | |
|---|---|---|
| Total Hardness | ____________ | gpg |
| Iron | ____________ | mg/l |
| Manganese | ____________ | mg/l |
| pH | ____________ | |
| Total Dissolved Solids | ____________ | mg/l |

**6. Other Tests**

| | | |
|---|---|---|
| Hydrogen Sulfide | ____________ | mg/l |
| (test must be performed on-site) | | |
| Tannins | ____________ | mg/l |

**7. Special Laboratory Tests**

| | | |
|---|---|---|
| Chlorides | ____________ | mg/l |
| Sulfates | ____________ | mg/l |
| Alkalinity | ____________ | mg/l |

***If TDS is over 1000 ppm and hardness is less than 30% of the TDS, a total water analysis is required.***

**8. Explanation of Water Analysis**

A. Total Hardness
This indicates the efficiency or workability of the water for everyday household use. Water in excess of 3 gpg is generally considered hard and should be softened.

B. Iron
Over 0.3 ppm of iron will cause discoloration of water and staining. Fully automatic water conditioners will correct this problem. Some extreme water situations may require filtration.

C. Manganese
Manganese is frequently encountered in iron-bearing water but to a lesser degree. Manganese is similar to iron in that it stains and clogs pipes and valves. Concentrations as low as 0.05 mg/l of manganese can cause problems.

D. pH
A scale used to measure the acidity or alkalinity of water. A pH reading below 6.5 normally indicates highly corrosive water and neutralizing equipment should be used. A pH reading in excess of 8.5 could indicate contaminated water and generally requires bacteriological and chemical analysis.

E. Hydrogen Sulfide ($H_2S$)
Testing for hydrogen sulfide should occur on-site. Hydrogen sulfide imparts a rotten egg odor and taste that makes water all but undrinkable and also promotes corrosion. In addition, it can foul the resin bed of a water conditioner. The use of a water conditioner is not recommended unless the water is first treated for the removal of hydrogen sulfide.

F. Total Dissolved Solids (TDS)
A measure of the soluble solids present in the water.

G. Tannins
Tannic acid is formed by decaying organic matter. Tannins alone are not harmful, although they can affect the proper operation of a chemical free iron filter.

H. Chlorides
Over 500 ppm may impart a salty taste to water.

I. Sulfates
Over 500 ppm may impart a bitter taste to water and have a slight laxative effect.

J. Alkalinity
Caused by the presence of bicarbonates, carbonates and hydroxides. Over 500 ppm creates a “soda” taste and makes skin dry.



## Recommendations

Recommendations are based entirely on the information supplied and the water sample chemistry results at the time of analysis.

________________________________________

________________________________________

________________________________________

________________________________________

________________________________________

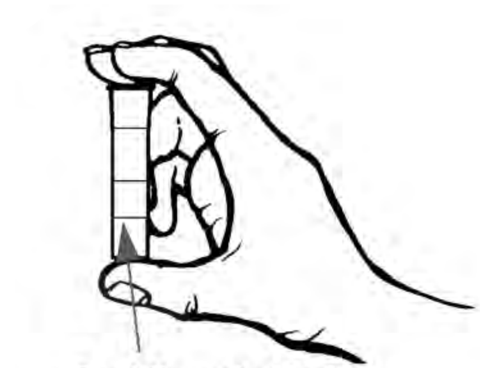
Recommended by ______________________________ Date ______________________

# Hardness Test Instructions

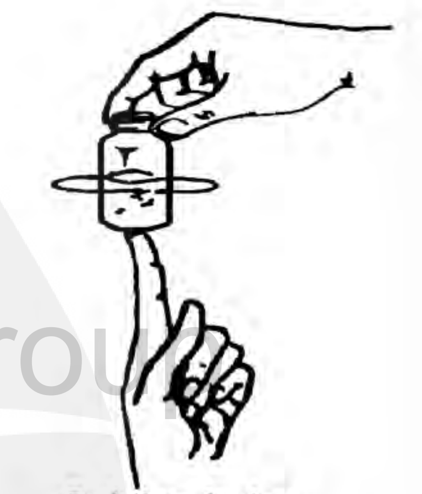
1. Using Hach Test Kit Model HA62, fill the plastic measuring tube level full with the water to be tested. Pour the contents of the tube into the mixing bottle.
2. **Option 1** - (use on up to 400 gpg) Add 3 drops of the clear buffer solution, Hardness 1, to the mixing bottle. Swirl to mix. Add 1 drop of the red ManVer2 hardness indicator to the mixing bottle. Swirl to mix.

   **Option 2** - (use on up to 30 gpg) Open one UniVer 3 hardness reagent powder pillow. Add the contents of the pillow to the mixing bottle and swirl to mix.

   - A blue color indicates soft water.
   - If a red color develops, proceed to Step 3.
3. Add titrant reagent, Hardness 3, drop by drop to the mixing bottle. Swirl the bottle constantly as the drops are added. Count each drop as it is added and continue to add reagent until the color changes from red to blue.
4. Each drop of titrant reagent, Hardness 3, used to bring about the color change is equal to 1 grain per gallon.



5 ml Sample Mark



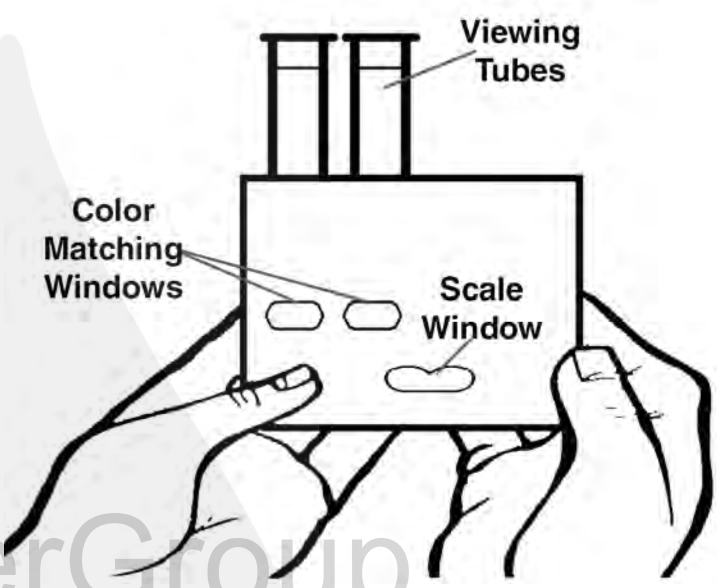
Swirling Action



## Notes

# Iron Test Instructions

1. Using Hach Test Kit Model HA62, swirl the water to be tested and rinse both color viewing tubes with it. Fill one tube to the 5 ml mark with the water sample.
2. Tear open one FerroVer iron reagent pillow. Add the contents of the pillow to the tube. Stopper and swirl to mix. Place this tube in the right top opening of the color comparator (prepared sample position). Let sit for at least one minute. An orange color will develop if iron is present.
3. If the color changes instantly and holds, it is probable that the iron is ferrous. However, if the color change is slow to develop, the iron is probably ferric.
4. Fill the other viewing tube to the 5 ml mark with clear water. Place this tube in the left top opening of the comparator (untreated sample position).
5. Hold the comparator up to a light source such as the sky, a window or lamp and view through the openings in the front. Rotate the disc to obtain a color match. Read the mg/l iron (Fe) through the scale window.
6. The reading must be taken within 10 minutes of the test.
7. When high concentrations of iron (10 mg/l or more) are suspected, a diluted sample should be used.

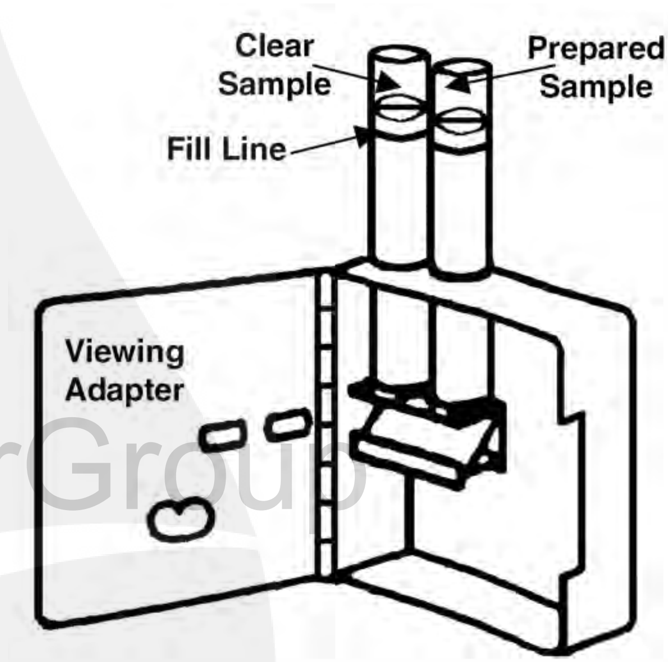





## Notes

# Manganese Test Instructions

1. Using Hach Test Kit Model MN-5 for Manganese, fill a sample mixing bottle to the shoulder with the water to be tested.
2. Use the clippers to open one buffer powder pillow for Manganese, Periodate Method. Add the contents of the pillow to the mixing bottle. Swirl to mix.
3. Use the clippers to open one sodium periodate powder pillow. Add the contents of the pillow to the mixing bottle and swirl to mix. A pink color will develop if manganese is present.
4. Allow the prepared sample to stand undisturbed for one minute to allow full color development.
5. Fill one sample tube to the line underlining "Cat. 1730-00" with the prepared sample. This will be approximately 15 ml.
6. Place the lengthwise viewing mirror adapter into the comparator.
7. Insert the tube of prepared water sample into the right comparator opening (prepared sample position).
8. Fill the other sample tube with untreated water or a reagent blank to the line underlining "Cat. 1730-00". Insert this tube into the left comparator opening (untreated sample position).
9. Hold the comparator with the tube tops pointing to a window or light source. View through the openings in the front of the comparator. When viewing, use care not to spill samples from unstopped tubes.
10. Rotate the disc to obtain a color match. Read the mg/l manganese (Mn) through the scale window.

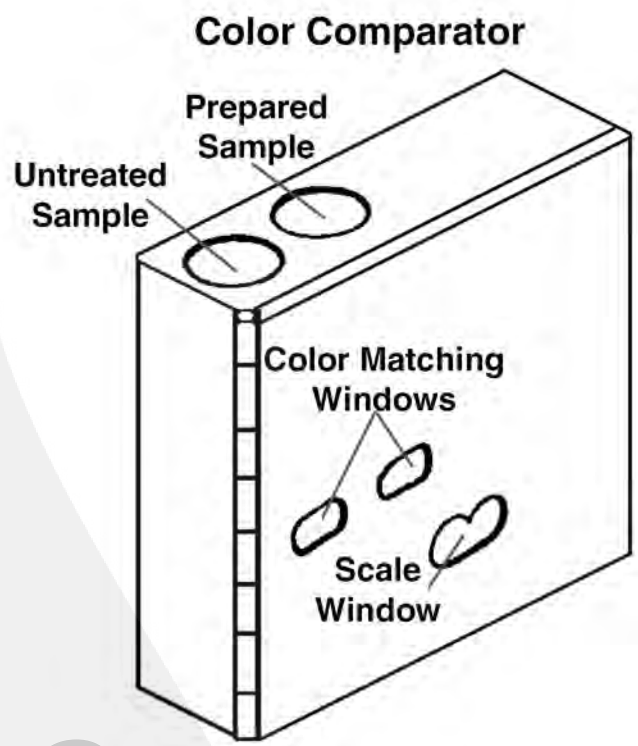





## Notes

# pH Test Instructions

1. Using the Hach Test Kit for pH, thoroughly rinse two clean viewing tubes and fill to the 5 ml mark with the water to be tested.
2. Add the contents of one Bromthymol Blue indicator powder pillow or six drops of liquid to one of the tubes and swirl to mix.
3. Insert this tube of prepared sample into the right opening in the top of the comparator.
4. Insert the tube of untreated sample into the left opening in the top of the comparator. This sample should be clear and colorless.
5. Hold the color comparator up to a light source such as the sky, a window or a lamp and view through the two openings in the front of the comparator. Rotate the color disc until a color match is obtained. Read the pH from the scale window.





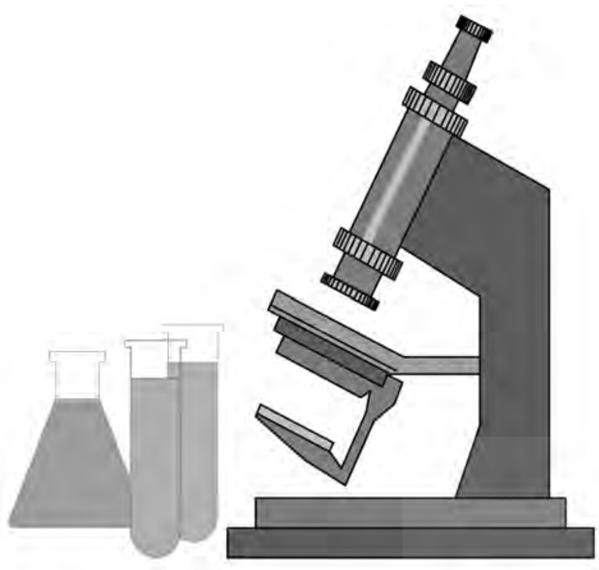

## Notes

# TDS Test Instructions

1. Using the Myron L, Model 532T1 DS Meter, follow the instructions to verify a charged battery and correct calibration.
2. Turn the Range Switch to the desired range. If you don't know which range to use, set it to 1000.
3. Rinse the cell cup three times with the sample you want to test. Never fill the cell by dipping the meter into the water.
4. Fill the cell with another sample to at least 1/4" above the upper electrode.
5. Press the black button.
6. Read the dial value indicated by the pointer. If the pointer is very low on the left or goes off the scale to the right, try the next lower or higher range.
7. Multiply the dial value by the range setting to determine parts per million (ppm) Total Dissolved Solids.




## Notes



# Water Testing

## Summary

### *Level 1*

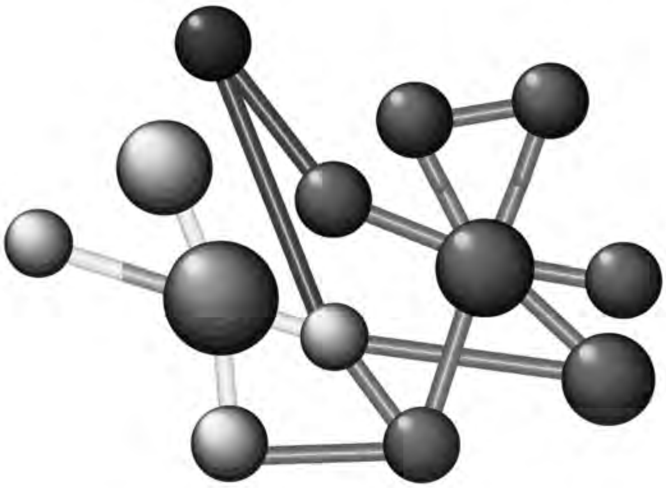
1. Water must be analyzed in order to apply the correct type and size of water conditioning equipment.



2. Contaminants are measured in milligrams per liter (mg/l) or parts per million (ppm). Hardness is measured in grains per gallon.
3. Common tests are performed for hardness, iron, manganese, pH, total dissolved solids, tannins and hydrogen sulfide.
4. Chlorides, sulfates alkalinity and bacteria must be tested for at an approved laboratory.

### *Level 2*

1. Various test kits can be used. Please verify the instructions for the test kit you are using before conducting the test. Be sure that all test equipment is clean.
2. The Water Analysis Report must be filled in completely and accurately in order for the recommendation to be correct.



# The Science of Water Softening

## Objectives

### *Level 1*



1. To be familiar with common terminology used in discussing water softening
2. To understand the characteristics of hard water and soft water
3. To be able to discuss the concept of ions and ion exchange and their significance to water softening
4. To be familiar with the various components of a water softener and how it functions
5. To be familiar with the different control methods and their respective benefits
6. To be familiar with the concept of downflow and upflow regeneration
7. To be able to discuss and understand the need for sizing a water softener relative to the existing water quality and the consumption demands

### *Level 2*

1. To know how to size a water softener relative to need
2. To be able to describe the technical differences between upflow and downflow regeneration
3. To be able to describe the technical issues and benefits of all regeneration methods.

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# Glossary

**Anion** - A negatively charged ion in solution such as bicarbonate, chloride or sulfate.

**Anion Exchange** - An ion exchange process in which anions in solution are exchanged for other anions from an ion exchanger. In demineralization, for example, bicarbonate, chloride and sulfate anions are removed from solution in exchange for a chemically equivalent number of hydroxide anions from the anion exchange resin.

**Attrition** - The process in which solids are worn down or ground down by friction, often between particles of the same material. Filter media and ion exchange materials are subject to attrition during backwashing, regeneration and service.

**Backwash** - The process in which beds of filter or ion exchange media are subjected to flow opposite to service flow direction to loosen the bed and to flush suspended matter collected during the service run to waste.

**Bed** - The ion exchange or filter media in a column or other tank or operational vessel.



Bed Depth - The height of the ion exchange or filter media in the vessel after preparation for service.

**Brine (Softening)** - A strong solution of salt(s), such as sodium chloride, and water used in the regeneration of ion exchange water softeners but also applied to the mixed sodium, calcium and magnesium chloride waste solution from regeneration.

**Calcium (Ca)** - One of the principal elements making up the earth's crust, the compounds of which when dissolved, make the water hard. The presence of calcium in water is a factor contributing to the formation of scale and insoluble soap curds which are a means of clearly identifying hard water.

**Capacity** - An expression of the quantity of an undesirable material which can be removed by a water conditioner between servicing of the media (i.e. cleaning regeneration or replacement, as determined under standard test conditions). For ion exchange water softeners, the capacity is expressed in grains of hardness removal between successive regenerations and is related to the pounds of salt used in regeneration. For filters, the capacity may be expressed in the length of time or total gallons delivered between servicing.

**Cation** - An ion with a positive electrical charge, such as calcium, magnesium and sodium.

**Cation Exchange** - Ion exchange process in which cations in solution are exchanged for other cations from an ion exchanger.

**Channelling** - The flow of water or other solution in a limited number of passages in a filter or ion exchange bed instead of distributed flow through all passages in the bed.

**Chloride (Cl)** - An anion which forms acids when combined with hydrogen and salts when combined with metal ions. Chlorides can be corrosive and impart a salty taste to water.

**Compensated Hardness** - A calculated value based on the total hardness, iron and magnesium concentration of a water. It is used to correct for the reductions in hardness removal capacity caused by these factors in cation exchange water softeners.

**Conductivity** - The quality or power to carry electrical current. In water, the conductivity is related to the concentration of ions capable of carrying electrical current.

**Corrosion** - The destructive disintegration of a metal by electrochemical means.

**Dissolved Solids** - The weight of matter in true solution in a stated volume of water. Includes both inorganic and organic matter and is usually determined by weighing the residue after evaporation of the water.

**Effluent** - The stream emerging from a unit, system or process such as the softened water from an ion exchange softener.

**Exhaustion** - The state of an ion exchange material in which it is no longer capable of effective function due to the depletion of the initial supply of exchangeable ions. The exhaustion point may be defined in terms of a limiting concentration of matter in the effluent or, in the case of demineralization, in terms of electrical conductivity.

# Glossary

**Fouling** - The process in which undesirable foreign matter accumulates in a bed of filter media or ion exchanger, clogging pores and coating surfaces and thus inhibiting or retarding the proper operation of the bed.Freeboard - The vertical distance between a bed of filter media or ion exchange material and the overflow or collector for backwash water. The height above the bed of granular media available for bed expansion during backwashing. May be expressed either as a linear distance or a percentage of bed depth.

**Grain (gr)** - A unit of weight equal to 1/7000 of a pound or 0.0648 gram.

**Grain per Gallon (gpg)** - A common basis for reporting water analysis in the United States and Canada. One grain per U.S. gallon equals 17.1 milligrams per liter (mg/l) or parts per million (ppm). One grain per British (imperial) gallon equals 14.3 mg/l or ppm.

**Hardness** - A characteristic of natural water due to the presence of dissolved calcium and magnesium. Water hardness is responsible for most scale formation in pipes and water heaters and forms insoluble "curd" when it reacts with soaps. Hardness is usually expressed in grains per gallon (gpg), parts per million (ppm) or milligrams per liter (mg/l), all as calcium carbonate equivalent.

**Hard Water** - Water with a total hardness of 1 gpg or more as calcium carbonate equivalent.

**Hydrologic Cycle** - The natural water cycle, including precipitation of water from the atmosphere as rain or snow, flow of water over or through the earth and evaporation or transpiration to water vapor in the atmosphere.

**Influent** - The stream entering a unit, stream or process, such as the hard water entering an ion exchange water softener.

**Ion** - An atom, or group of atoms, which function as a unit and have a positive or negative electrical charge due to the gain or loss of one or more electrons.

**Ion Exchange** - A reversible process in which ions are released from an insoluble permanent material in exchange for other ions in a surrounding solution; the direction of the exchange depends upon the affinities of the ion exchanger for the ions present and the concentrations of the ions in the solution.

**Magnesium (Mg)** - One of the elements making up the earth's crust, the compounds of which, when dissolved in water, make the water hard. The presence of magnesium in water is a factor contributing to the formation of scale and insoluble soap curds.

**Milligrams per Liter (mg/l)** - A unit concentration of matter used in reporting the results of water and waste water analysis. In dilute water solutions, it is practically equal to parts per million but varies from the ppm in concentrated solutions such as brine. As most analysis are performed on measured volumes of water, the mg/l is a more accurate expression of the concentration and is the preferred unit of measure.

**Mineral** - A term applied to inorganic substances such as rocks and similar matter found in the earth strata as opposed to organic substances such as plant and animal matter. Minerals normally have definite chemical composition and crystal structure. The term is also applied to matter derived from minerals such as the inorganic ions found in water. The term has been incorrectly applied to ion exchangers, even though most of the modern materials are organic ion exchange resins.

**Mineral Salts** - The form in which minerals from dissolved rock exist in water. Same as Total Dissolved Solids. This is the so-called inorganic form of minerals. In excess, they cause water to have a disagreeable taste. Some are harmful to human health.

**Parts per Million (ppm)** - A common basis for reporting the results of water and waste water analysis, indicating the number of parts by weight of a dissolved or suspended constituent, per million parts by weight of water or other solvent. In dilute water solutions, one part per million is practically equal to one milligram per liter, which is the preferred unit. 17.1 ppm equals one grain per U.S. gallon.

# Glossary

**Potassium Chloride (KCl)** - A compound consisting of potassium and chloride, becoming increasingly popular as a substitute for sodium chloride in regenerating water softeners.

**Raw Water** - Untreated water or any water before it reaches a specific water treatment device or process.

**Regenerant** - A solution of a chemical used to restore the capacity of an ion exchange or oxidation system.

**Regeneration** - In general, includes the backwash, brine and fresh water rinse steps necessary to prepare a water softener exchange bed for service after exhaustion. Specifically, the term may be applied to the "brine" step in which the sodium chloride solution is passed through the exchanger bed. The term may also be used for similar operations relating to demineralizers and certain filters.

**Resin** - Synthetic organic ion exchange material such as the high capacity cation exchange resin widely used in water softeners.

**Resistance** - The ability of a substance to resist carrying an electrical current, measured in ohms.



**Slippage** - Is used as a general term in water conditioning, referring to the amount of the problem which remains after the water passes through the process that was expected to remove that problem.

**Soap** - One of a class of chemical compounds which possesses cleaning properties, formed by the reaction of a fatty acid with a base of alkali. Sodium and potassium soaps are soluble and useful but can be converted to insoluble calcium and magnesium soaps (curd) by the presence of these hardness ions in water.

**Sodium (Na)** - An ion found in natural water supplies and introduced to water in the ion exchange water softening process. Sodium compounds are highly soluble and do not react with soaps or detergents.

**Sodium Chloride (NaCl)** - The chemical name for common salt, widely used in the regeneration of ion exchange water softeners.

**Soft Water** - Any water which contains less than 1.0 gpg (17.1 mg/l) of hardness minerals, expressed as calcium carbonate equivalent.

**Softened Water** - Any water that is treated to reduce hardness minerals, expressed as calcium carbonate equivalent.

**Tannins** - A substance resulting from the decomposition of lignins in vegetable matter. The resulting color is aesthetically undesirable but does not pose a health hazard.

**Total Dissolved Solids (TDS)** - The weight of solids per unit volume of water which are in true solution, usually determined by the evaporation of a measured volume of filtered water and determination of the residue weight.

**Total Hardness** - The sum of all hardness constituents in a water, expressed as their equivalent concentration of calcium carbonate. Primarily due to calcium and magnesium in solution but may include small amounts of metals such as iron which can act like calcium and magnesium in certain reactions (see hardness).

**Water Softening** - The removal of calcium and magnesium, the ions which are the principal cause of hardness, from water.

# Hard Water - Soft Water

### *Hard Water*

Water with a total hardness of 1.0 gpg or more as calcium carbonate equivalent.

| | |
|---|---|
| Less than 1.0 gpg | Soft |
| 1.0 - 3.5 gpg | Slightly hard |
| 3.5 - 7.0 gpg | Moderately hard |
| 7.0 - 10.5 gpg | Hard |
| More than 10.5 gpg | Very hard |

### *Hardness*

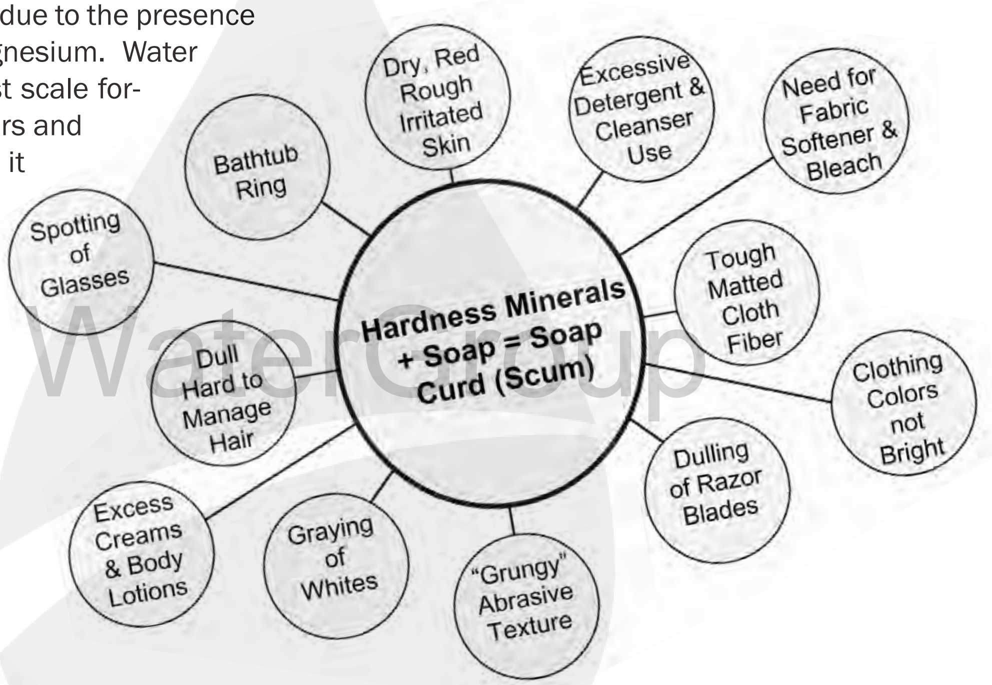
A characteristic of natural water due to the presence of dissolved calcium and magnesium. Water hardness is responsible for most scale formation in pipes and water heaters and forms insoluble "curd" when it reacts with soaps. Hardness is usually expressed in grains per gallon (gpg), parts per million (ppm) or milligrams per liter (mg/l) all as calcium carbonate equivalent.

### *Soft Water*

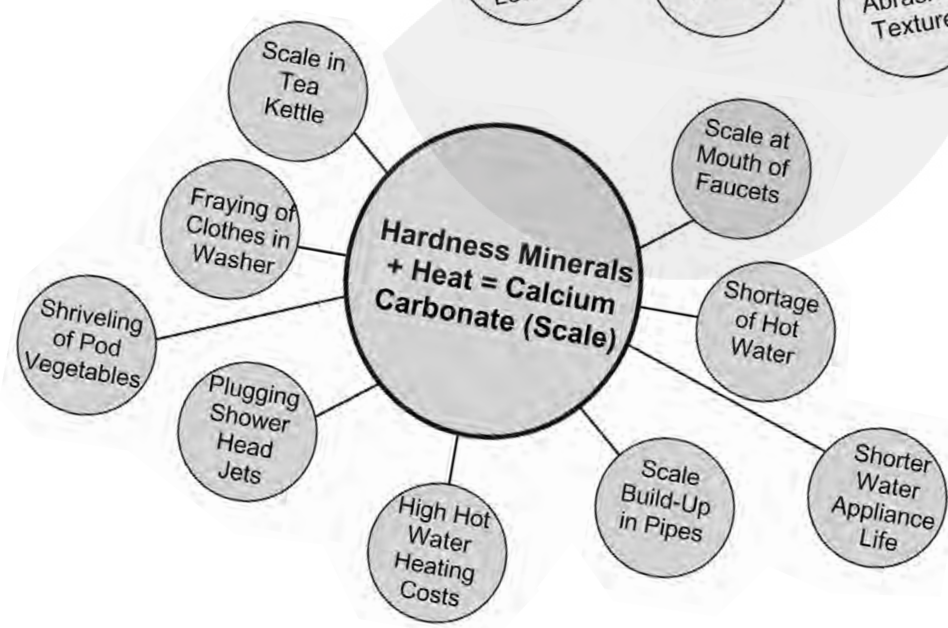
Any water which contains less than 1.0 gpg (17.1 mg/l) of hardness minerals, expressed as calcium carbonate equivalent.

### *Softened Water*

Any water that is treated to reduce hardness minerals, expressed as calcium carbonate equivalent.






**Hard Water Disadvantages**

# Ion Exchange

## *Ion*

An atom or group of atoms which function as a unit and have a positive or negative electrical charge due to the gain or loss of one or more electrons.

## *Ion Exchange*

A reversible process in which ions are released from an insoluble permanent material in exchange for other ions in a surrounding solution. The direction of the exchange depends upon the affinities of the ion exchanger for the ions present and the concentrations of the ions in the solution.

**Figure 1**

**Hardness Ions & Resin Bead**

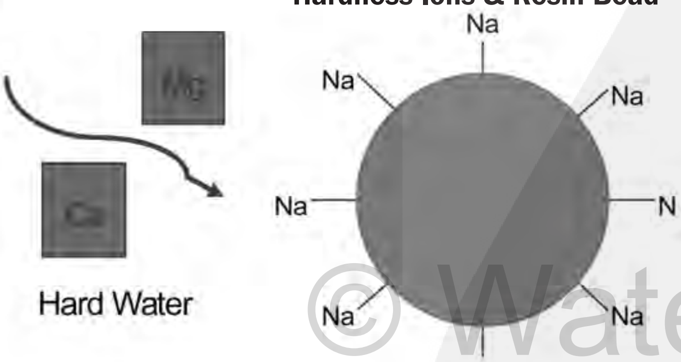



**Figure 2**

**Hardness Ions Move Into Exchange Sites**

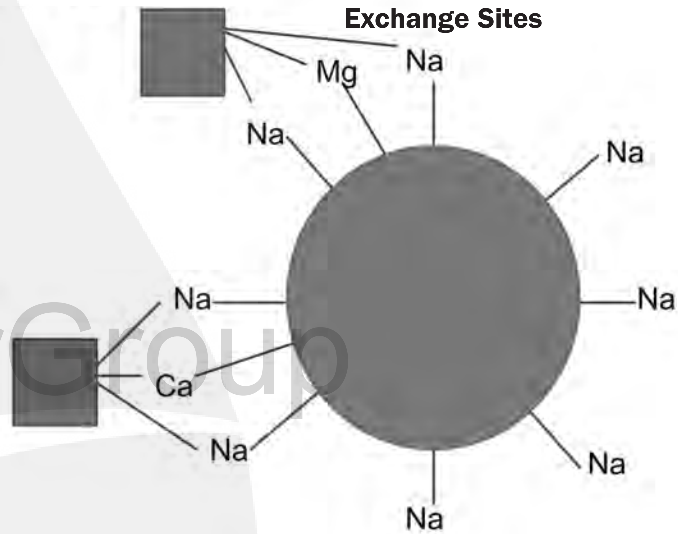
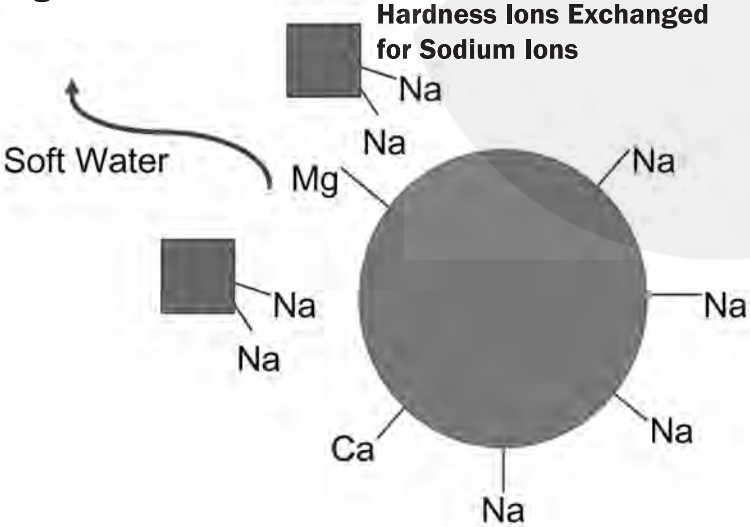



**Figure 3**

**Hardness Ions Exchanged for Sodium Ions**




***The ion exchange process in a water softener is an exchange of positively charged cations in which calcium and magnesium are exchanged for sodium.***

# Hardness Correction by Ion Exchange

Ion exchange water conditioning is the most widely used method of hardness correction. The process uses particles of man-made resin that have the ability to hold certain elements and then trade these elements with other elements that are dissolved in the water. A cation resin bead, which is about 1/32 of an inch in diameter or less, has negative magnetic spikes or bumps on its surface with positively charged sodium ions attached. While the resin is indestructible, it can be damaged by freezing, boiling or drying out and by abrasion from backwashing and metals.

The resin has an affinity for positive ions based on their molecular weight. Therefore, it will attract ions such as barium, radium and iron--which can lead to fouling--before it attracts calcium and magnesium.

When the resin is installed in the resin tank and hard water containing calcium and magnesium ions passes down through the deep column of resin beads (the resin bed), the sodium ions are exchanged for the magnesium and calcium ions. The water flowing out of the conditioner after this ion exchange has no more calcium or magnesium ions because they have been replaced by sodium ions. However, the TDS content remains the same.

The soft minerals, sodium bicarbonates, sulfates and chlorides do not form troublesome scummy compounds with soaps and detergents and they do not easily form scale on pipes, heaters, valves and faucets. Therefore, by trading sodium for dissolved calcium and magnesium ions, the hardness elements originally dissolved in the water have been removed and the water has been softened.

The softening resin can only hold so many sodium ions so there comes a time when the resin has traded back all of its initial stock of sodium ions and none are left to soften the water (exhaustion of the resin bed). The sodium ions must be replenished if the conditioner is to continue to soften the water. The restocking of the softening resin with sodium ions is called regeneration.

This is accomplished by passing a sodium chloride solution through the resin beads which reverses the ion exchange process and recharges the beads with sodium ions.



## Notes

# TDS Content Remains the Same

| | Raw Water (mg/l) | Same Water After Passing Through a Resin Bed (mg/l) |
|---|---|---|
| Hardness - Calcium Carbonate | 257 | 0 |
| - Magnesium Carbonate | 171 | 0 |
| Sodium Chloride | 171 | 171 |
| Sodium Sulfate | 171 | 171 |
| Alkalinity | 257 | 257 |
| Sodium Bicarbonate | 171 | 599 |
| Total Dissolved Solids (TDS) | 1,198 | 1,198 |

Softened water may have an increase in TDS due to imperfections in the ion exchange process. This will be affected by the degree of hardness and general make-up of the raw water.

## Sodium

The sodium content of a natural water supply can be determined by a laboratory water analysis. Sodium added by ion exchange water softening can be calculated by multiplying the hardness in the water supply (mg/l as calcium carbonate equivalent) by the factor of .46 to determine the actual sodium (Na) in milligrams added by softening. The harder the original water, the more sodium is added.



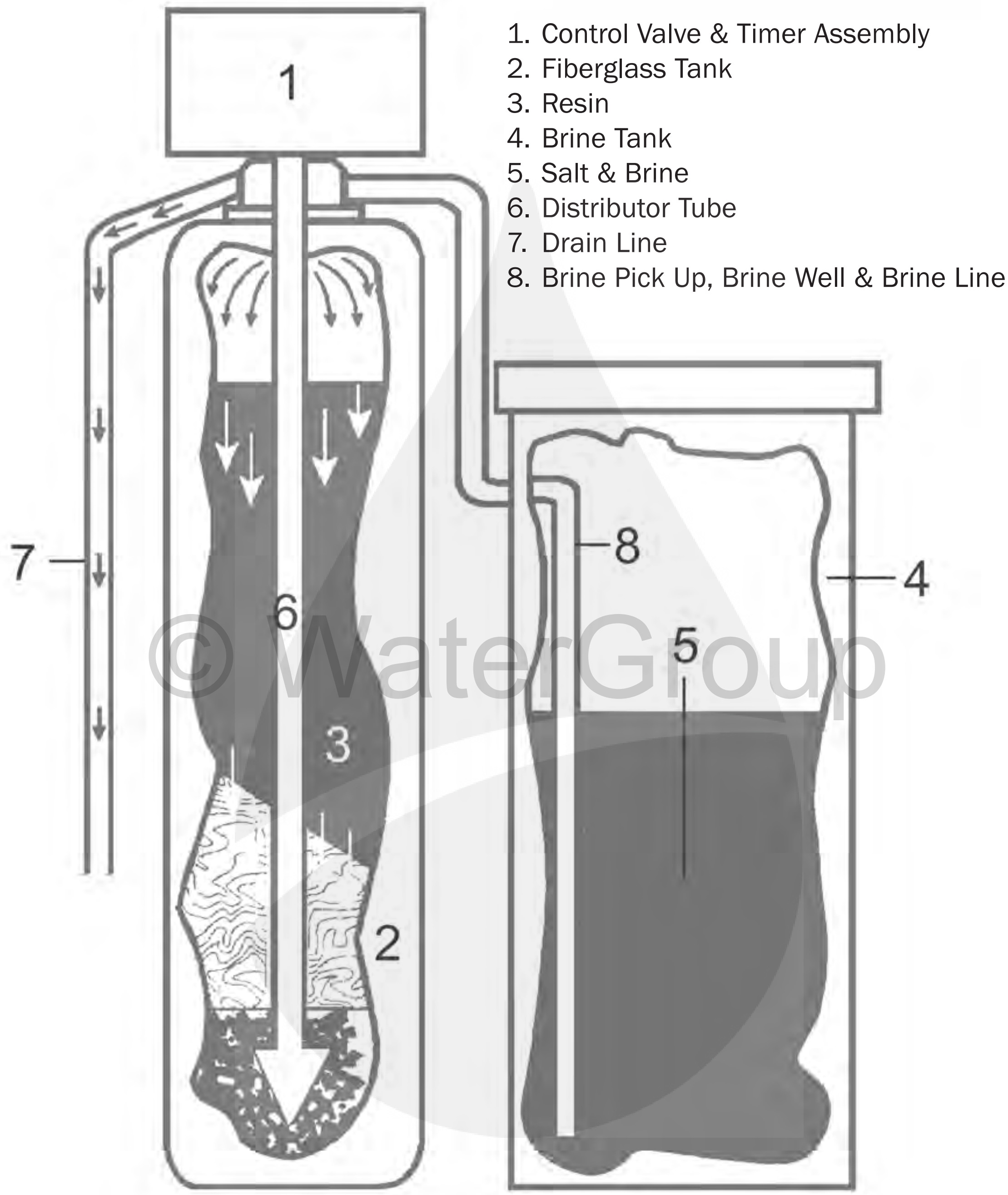
The following table illustrates the daily sodium intake from drinking 3 quarts of softened water for different hardness levels compared to daily sodium intake from food. For example, 2 slices of white bread contain 300 mg of sodium, 1 cup of milk contains 120 mg of sodium and 3 oz. of ham contains 900 mg of sodium.

People on a sodium restricted diet should consult their physician to determine proper sodium levels from food and water.

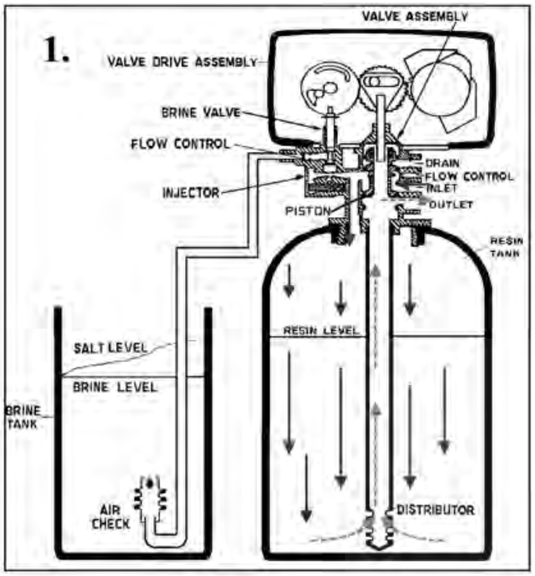
**Sodium Intake from Softened Water Compared to Total Sodium Intake**

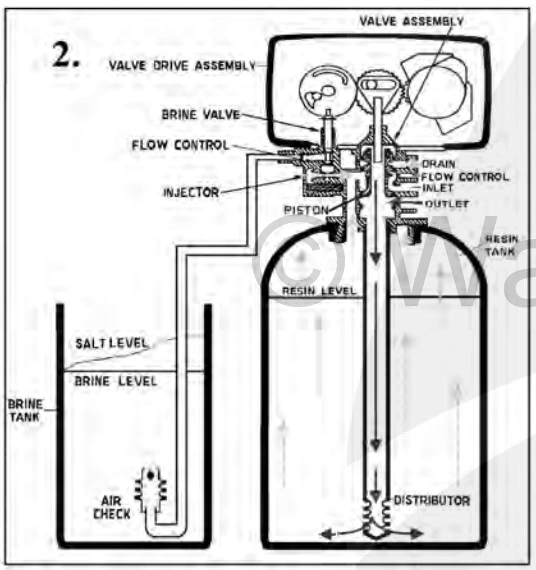
| Initial Water Hardness in gpg | Mg of Na+/ 3 Quarts Softened Water | Mg Na+ from Food | Total Mg Na+ Consumed | % of Total Na+ from Softened Water |
|---|---|---|---|---|
| 1 | 23 | 5,000 | 5,023 | 0.4% |
| 5 | 112 | 5,000 | 5,112 | 2.2% |
| 10 | 223 | 5,000 | 5,223 | 4.3% |
| 15 | 335 | 5,000 | 5,335 | 6.5% |
| 20 | 447 | 5,000 | 5,447 | 8.2% |
| 30 | 670 | 5,000 | 5,670 | 12.5% |
| 40 | 893 | 5,000 | 5,893 | 15.2% |

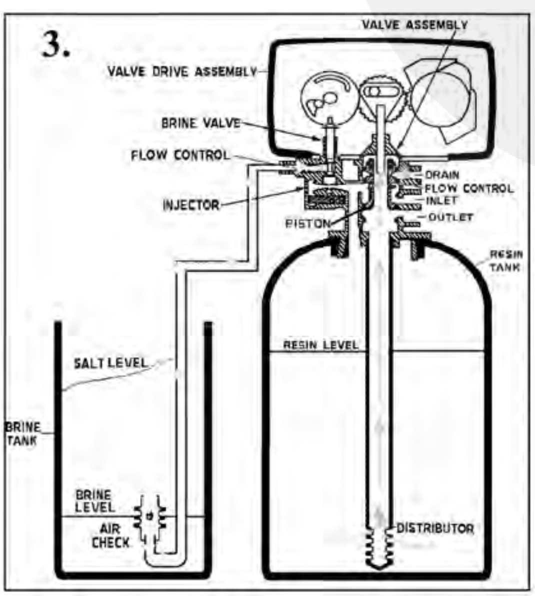
# Build a Softener

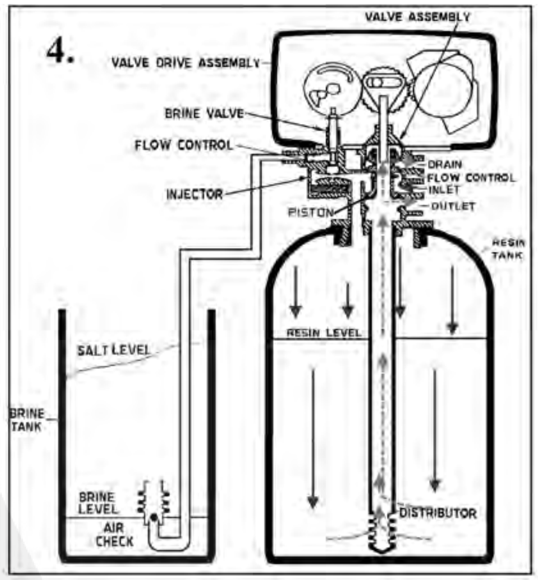


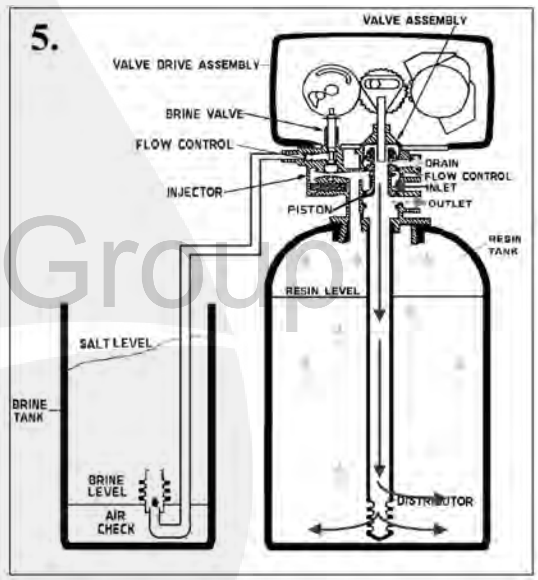
# Downflow Regeneration

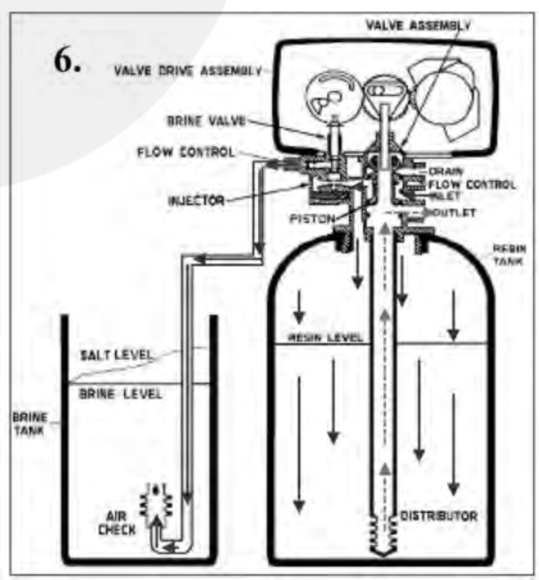


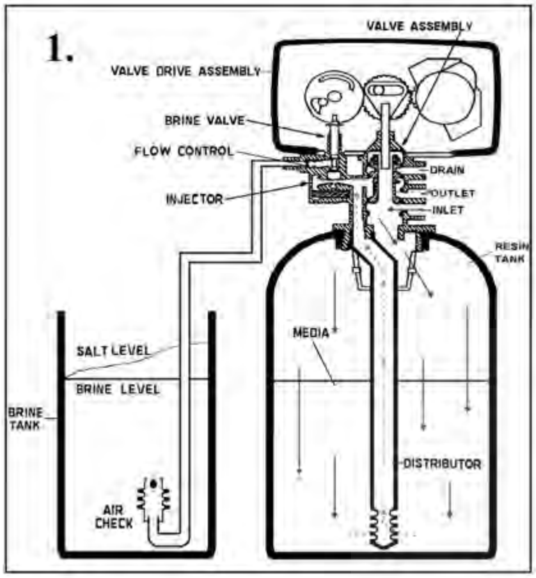
# Downflow Regeneration

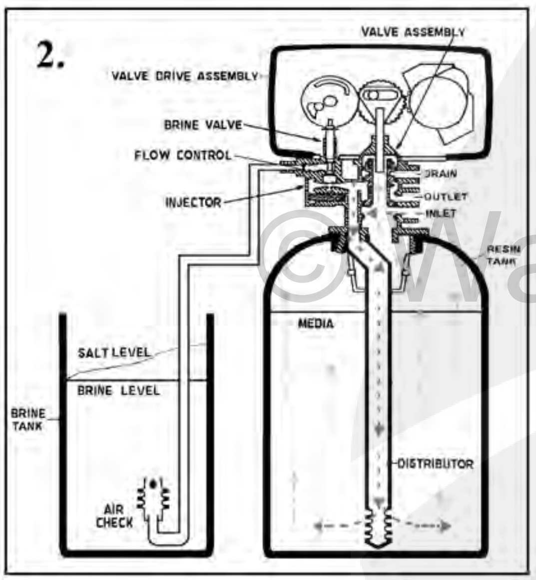
1. **Service Position** - Hard water enters at the valve inlet, flows around the lower piston groove, through the passage to the top of the tank, down through the resin and enters the distributor as conditioned water. The conditioned water flows up through the center tube to the valve outlet, providing soft water to the home.
2. **Backwash Position** - Hard water enters at the valve inlet, flows around the lower piston groove and lower piston land, down through the center tube and out the distributor, up through the resin, through the top of the tank passage, around the upper piston groove and out the drain line. Hard water is automatically bypassed for use in the home.
3. **Brine Position** - Hard water enters at the valve inlet, flows around the lower piston groove, through the injector nozzle and orifice to draw brine from the brine tank. The injector is designed as a venturi. As water passes through the nozzle, a vacuum is created on the outside of the injector which causes brine to be drawn from the brine tank. The brine flows down through the resin into the distributor, up through the center tube, through the center hole in the piston and out the drain line.
4. **Slow Rinse Position** - After all the brine has been drawn from the brine tank, hard water continues to enter through the valve inlet, flows around the lower piston groove, through the nozzle and orifice, down through the resin and into the distributor, up through the center tube, through the center hole in the piston and out the drain line.
5. **Rapid Rinse Position** - Hard water enters at the valve inlet, flows around the lower piston groove and lower piston land, down through the center tube and out the distributor, up through the resin, through the top of the tank passage, around the upper piston groove and out the drain line.
6. **Brine Tank Fill Position** - Hard water enters at the valve inlet, flows around the lower piston groove, through the injector throat, through the brine valve and flow control to fill the brine tank. Hard water also flows around the lower piston groove, through the passage to the top of the tank, down through the resin and enters the distributor as conditioned water. The conditioned water flows up through the center tube to the valve outlet.

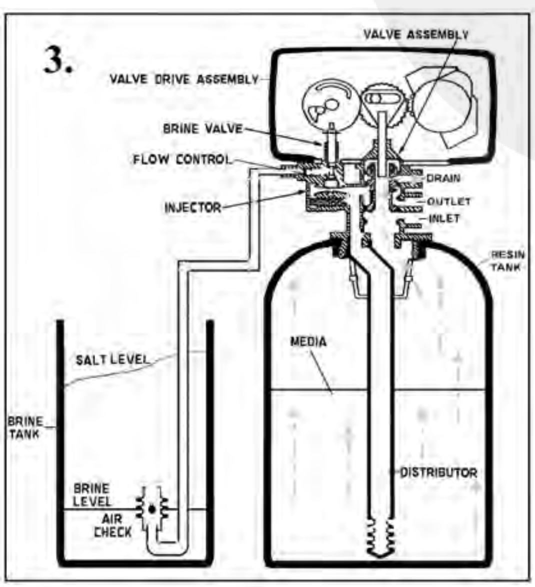


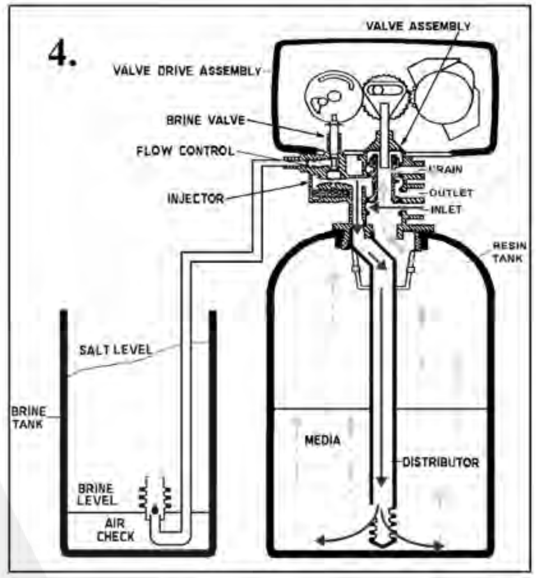
## Notes

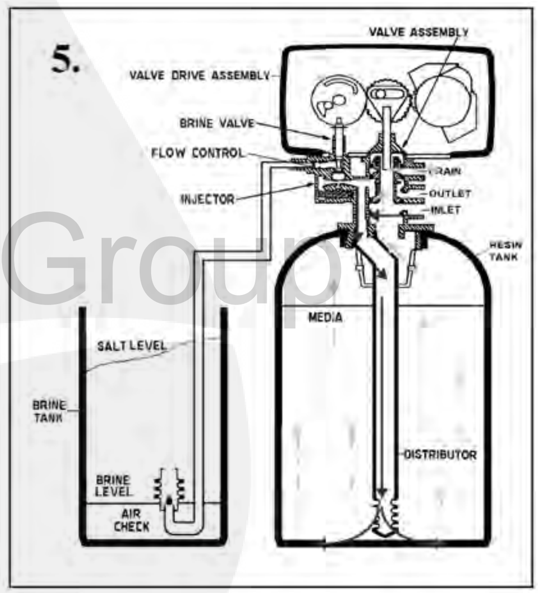
# Upflow Regeneration

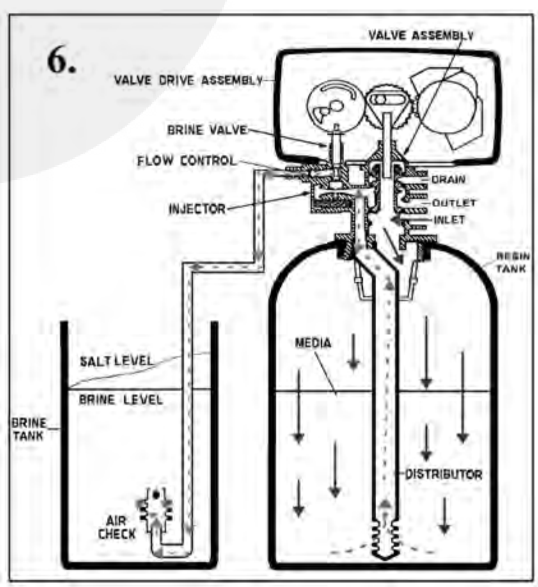


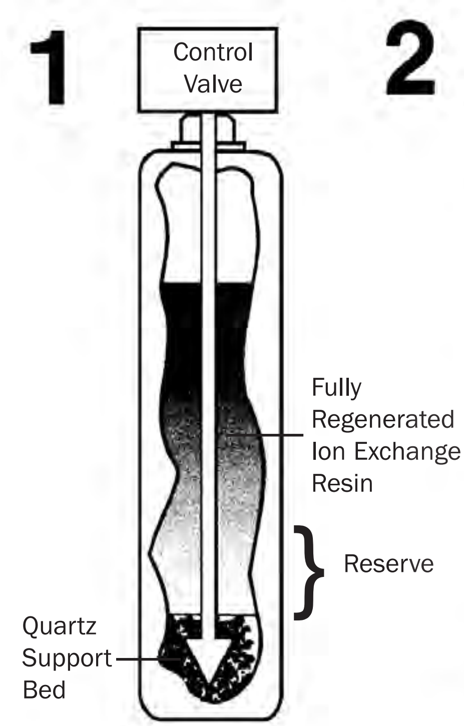
# Upflow Regeneration

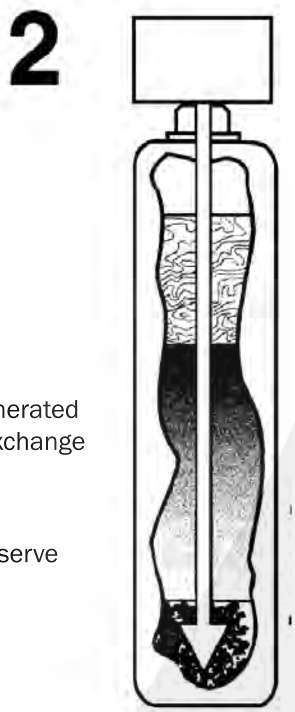
1. **Service Position** - Hard water enters at the valve inlet and flows under the piston, through the passage to the top of the tank, down through the resin and up the distributor, around the lower piston groove and to the valve outlet, providing soft water to the home.
2. **Backwash** - Hard water enters at the valve inlet, flows around the lower piston groove, down through the distributor tube, up through the resin through the top of the tank passage, through the center hole of the piston, around the upper piston groove and out the drain line. Hard water is automatically bypassed for use in the home.
3. **Brine Draw** - Hard water enters at the valve inlet, flows around the lower piston groove, through the injector nozzle and orifice to draw brine from the brine tank. The injector is designed as a venturi. As water passes through the nozzle, a vacuum is created on the outside of the injector which causes brine to be drawn from the brine tank. The brine flows down through the distributor tube, up through the resin, through the top of the tank passage, through the center hole of the piston, around the upper piston groove and out the drain. A pressure regulator limits the flow of water and brine through the bed, minimizing resin lift and ensuring optimum ion exchange.
4. **Slow Rinse** - Hard water enters at the valve inlet, flows around the lower piston, through the injector and down the distributor tube, up through the resin, through the top of the tank passage, through the center hole of the piston, around the upper piston groove and out the drain line.
5. **Rapid Rinse** - Hard water enters at the valve inlet and flows under the piston, down through the resin and up the distributor, around the lower piston groove and out to the drain line.
6. **Brine Tank Fill** - Hard water enters at the valve inlet, passes under the piston, down through the passage to the top of the tank, down through the resin, up through the distributor tube, through the injector throat and brine valve to fill the brine tank with soft water.



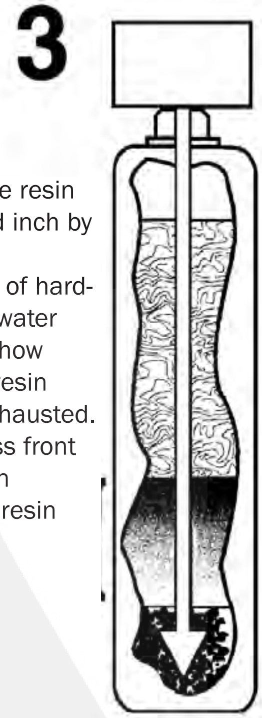
## Notes

# Downflow Depletion



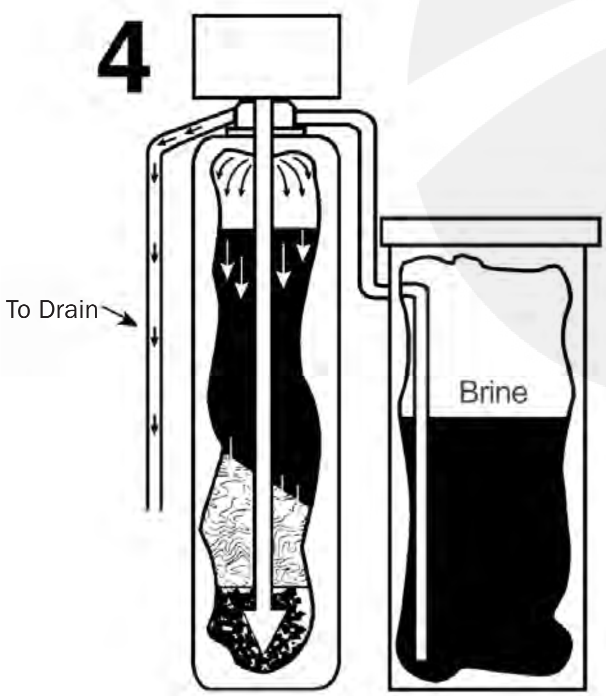




- Ion exchange resin is exhausted inch by inch
- The amount of hardness in the water determines how quickly the resin becomes exhausted.
- The hardness front passes down through the resin bed.

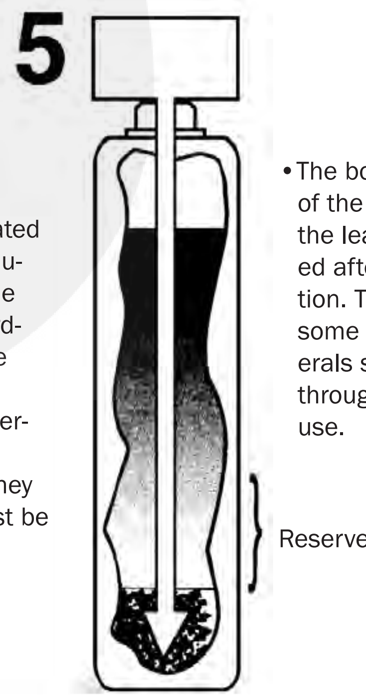



- A metered unit is programmed using maximum hardness and estimated water use as it is unable to recognize changing water conditions.
- A reserve based on these estimates plus a safety factor provides soft water until regeneration occurs.






- The resin is regenerated by rinsing a brine solution down through the resin, driving the hardness minerals off the resin beads.
- As the hardness minerals pass through the remaining reserve, they exhaust it and it must be regenerated.

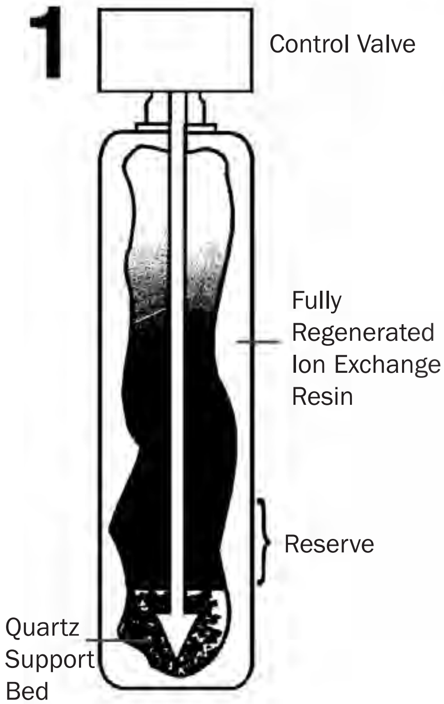



- The bottom portion of the resin bed is the least regenerated after regeneration. This results in some hardness minerals slipping through during water use.

} Indicates reserve

# Upflow Depletion

1




2

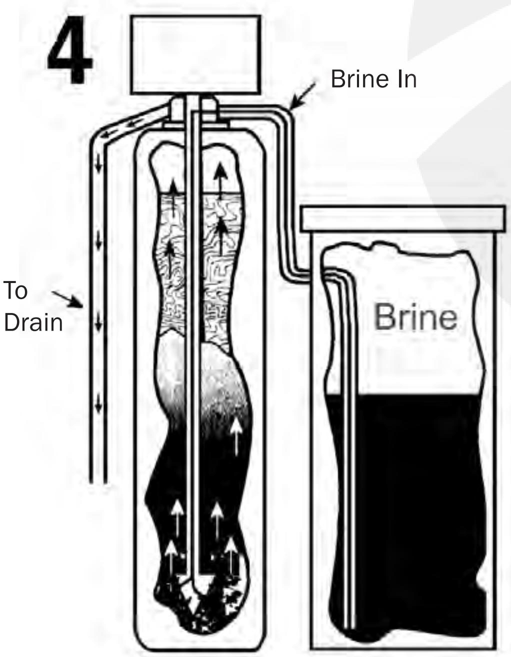
- Ion exchange resin is exhausted inch by inch
- The amount of hardness in the water determines how quickly the resin becomes exhausted.
- The hardness front passes down through the resin bed.

3

- Eventually the resin at the bottom becomes exhausted, signalling the need for regeneration.
- The reserve ensures soft water until regeneration occurs.
- The reserve is partially exhausted by the time the unit regenerates at 2:00 a.m.

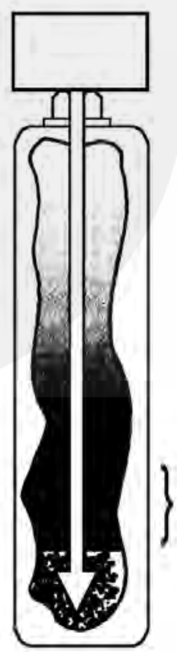


4




- A brine solution is rinsed up through the resin bed, super-regenerating the reserve and regenerating a band of the exhausted resin.

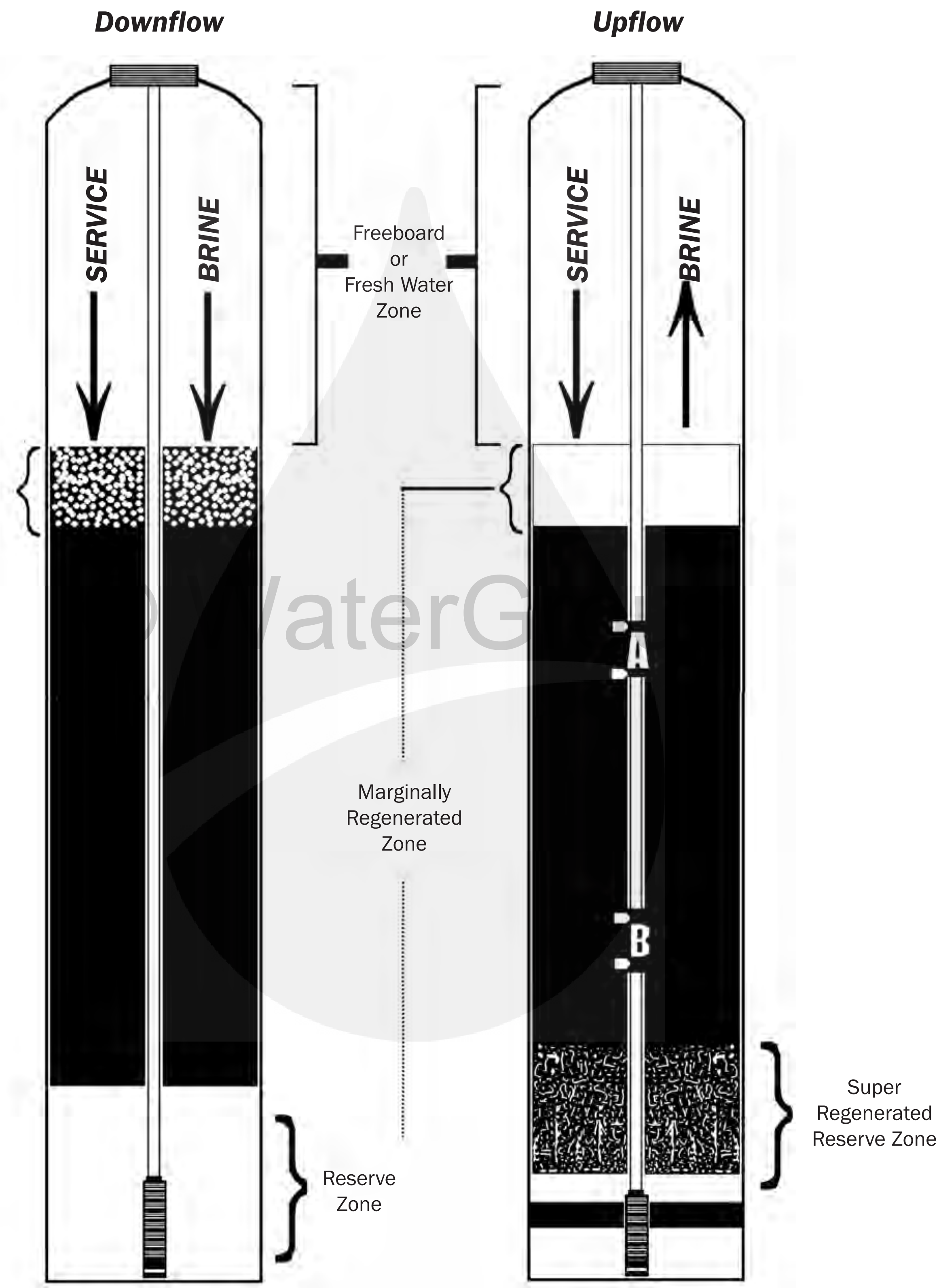
5



- Regeneration never occurs too soon or too late, only when necessary
- Because upflow regeneration does not deplete the reserve, less salt is needed to totally regenerate the resin bed.
- You get 100% salt efficiency and softer water.

} Indicates reserve

# Downflow vs Upflow Brining



# Sizing Parameters

## *Assumptions for Basic Sizing*

- Each person will use an average of 60 gallons of water per day
- The number of people in the household will remain constant
- The water hardness will not fluctuate.

## *Sizing Parameters*

**Water Softener Sizing is Based On:**

- 60 gallons per person per day - total household use
- Three day minimum between regenerations
- Capacity between regenerations at factory salt settings or K label capacity
- Number of people x 60 gallons per person x gpg of hardness x 3 days = capacity required between regenerations
- Consult your factory representative for water that is 75 gpg or harder

**Hardness Compensation**

- 1 mg/l of iron = 4 gpg
- 1 mg/l of manganese = 8 gpg
- Maximum iron is not to exceed 1.5 mg/l total iron
- Recommend the addition of a Res-up feeder when the total iron exceeds 0.5 mg/l

**Water Softener - Iron Removal Combination** Units

- This unit should only be recommended when dictated by special circumstances or the needs of the customer
- The customer should be made aware that a separate iron filter and softener is preferred because it is a more efficient way to deal with the water
- When recommending a combination unit, follow the guidelines provided in the specifications.

**Water Consumption For Regeneration**

The volume of water used during the regeneration process of a water softener will vary depending on:

- Amount and type of resin
- Salt Settings
- Cycle Time Settings
- Tank Diameter
- Flow Controllers

Generally, water usage for regeneration is based on the cubic feet of resin per water softener from a low of 30 gallons of water per cu. ft., up to a normal of 75 gallons of water per cu. ft., to a maximum of 100 gallons of water per cu. ft. Manufacturing specs and settings for each model size should be checked to verify exact amounts.



# Notes

# Three Day Sizing Method

The three day sizing method is used for the following reasons:

1. To determine the size of the water conditioner to be used
2. To allow for reserve capacity between regenerations so the customer does not run out of soft water
3. To provide the most economical operation cost:

a. Number of people in the home x 60 gallons each per day = ________

b. If iron or manganese is present, add 4 gpg to the hardness of the water for each 1.0 ppm of iron and 8 gpg to the hardness of the water for each 1.0 ppm of manganese to arrive at the total compensated hardness = ________

c. Multiply the compensated hardness from "b" x the total gallons used in "a" = ________

d. Multiply the total from "c" x 3 days = ________

e. Select the size of the unit according to the regenerated or K label capacity of the unit = ________

a. 6 people x 60 gallons each = total gallons per day = **360** gallons

b. 30 gpg hardness + 1.5 ppm of ferrous iron x 4 = compensated hardness = **36** gpg

c. 36 gpg compensated hardness x total gallons per day = hardness to be removed per day = **12,960** grains

d. 12,960 x 3 days = **x 3** days

e. Total capacity required = **38,880** capacity

Because 38,880 is more than a 32K unit and less than a 45K unit, a 45K softener should be selected.



## Notes

# Water Softener Sizing Guide

| No. of People | TOTAL HARDNESS (GRAINS/US GALLON) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 5 | 10 | 15 | 20 | 25 | 30 | 40 | 50 |
| 1 | 20,000 | 20,000 | 20,000 | 20,000 | 20,000 | 20,000 | 20,000 | 20,000 |
| 2 | 20,000 | 20,000 | 20,000 | 20,000 | 20,000 | 20,000 | 20,000 | 30,000 |
| 3 | 20,000 | 20,000 | 20,000 | 20,000 | 20,000 | 20,000 | 30,000 | 40,000 |
| 4 | 20,000 | 20,000 | 20,000 | 20,000 | 30,000 | 30,000 | 40,000 | 60,000 |
| 5 | 20,000 | 20,000 | 20,000 | 20,000 | 30,000 | 40,000 | 60,000 | 60,000 |
| 6 | 20,000 | 20,000 | 20,000 | 30,000 | 40,000 | 40,000 | 60,000 | 90,000 |
| 7 | 20,000 | 20,000 | 30,000 | 40,000 | 40,000 | 60,000 | 90,000 | 90,000 |
| 8 | 20,000 | 20,000 | 30,000 | 40,000 | 60,000 | 60,000 | 90,000 | CALL |
| 9 | 20,000 | 30,000 | 40,000 | 40,000 | 60,000 | 90,000 | 90,000 | CALL |
| 10 | 20,000 | 30,000 | 40,000 | 60,000 | 60,000 | 90,000 | CALL | CALL |

## Required Resin Volume in Cubic Feet

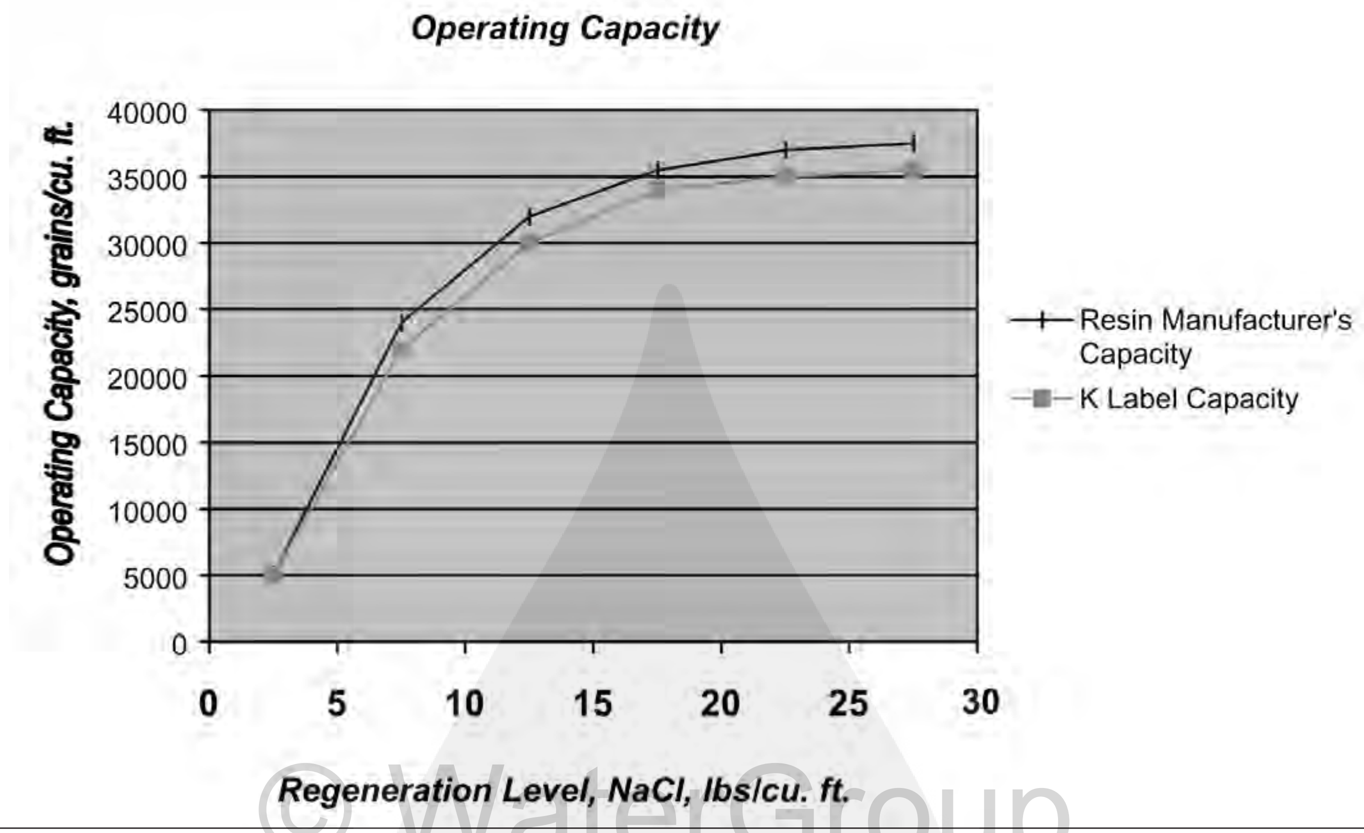


| No. of People | TOTAL HARDNESS (GRAINS/US GALLON) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 5 | 10 | 15 | 20 | 25 | 30 | 40 | 50 |
| 1 | .75 | .75 | .75 | .75 | .75 | .75 | .75 | .75 |
| 2 | .75 | .75 | .75 | .75 | .75 | .75 | .75 | .75 |
| 3 | .75 | .75 | .75 | .75 | .75 | 1.0 | 1.0 | 1.0 |
| 4 | .75 | .75 | .75 | .75 | .75 | .75 | 1.25 | 2.0 |
| 5 | .75 | .75 | .75 | .75 | 1.0 | 1.25 | 2.0 | 2.0 |
| 6 | .75 | .75 | .75 | 1.0 | 1.25 | 2.0 | 2.0 | 2.5 |
| 7 | .75 | .75 | 1.0 | 1.25 | 2.0 | 2.0 | 2.5 | 2.5 |
| 8 | .75 | .75 | 1.0 | 1.25 | 2.0 | 2.0 | 2.5 | 3.0 |
| 9 | .75 | .75 | 1.25 | 2.0 | 2.0 | 2.5 | 2.5 | 3.0 |
| 10 | .75 | .75 | 1.25 | 2.0 | 2.0 | 2.5 | 3.0 | 3.0 |



## Notes

# K-Label Capacity

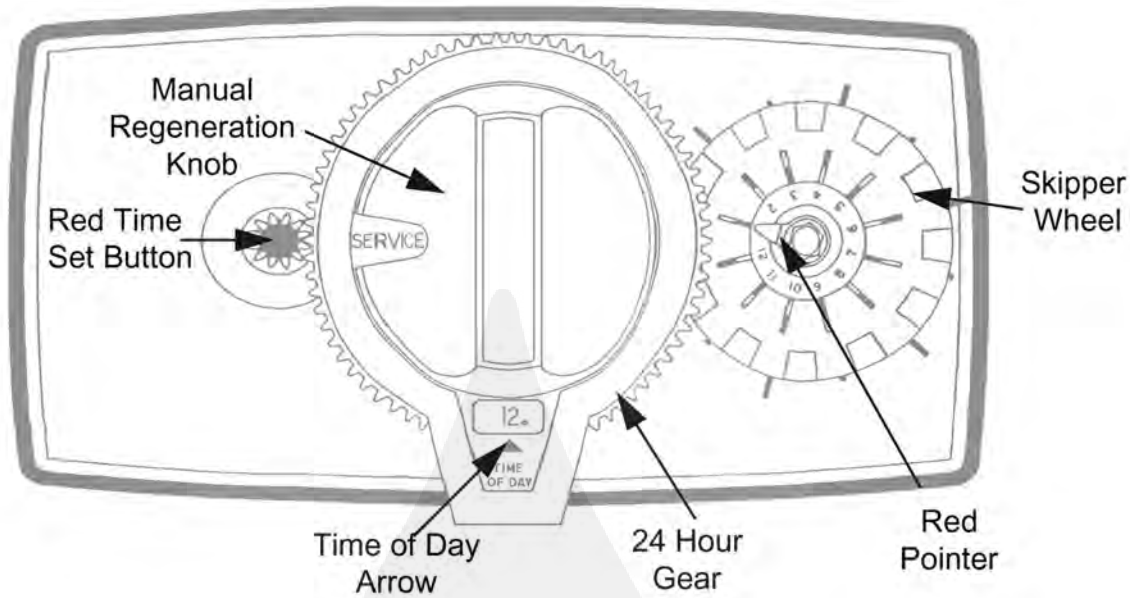





- The K Label is used as a quick and easy method for programming meter initiated softeners without having to calculate reserve capacities.
- The K Label is derived from actual capacity curves which compensate for TDS, leakage and reserve capacity versus the resin manufacturers' salt curves which are typically done under ideal conditions.
- The K Label relates to a specific amount of resin in a unit regenerated at a rate of 6 lbs. per cu. ft.

| Resin Cu. Ft. | Regenerated Capacity @ 6 lbs Salt per cu ft of Resin | Program Wheel K Label |
|---|---|---|
| .75 | 17,250 | 18 K |
| 1.00 | 23,000 | 24 K |
| 1.25 | 28,750 | 30 K |
| 2.00 | 46,000 | 45 K |
| 3.00 | 69,000 | 70 K |

# Calendar Clock Regeneration



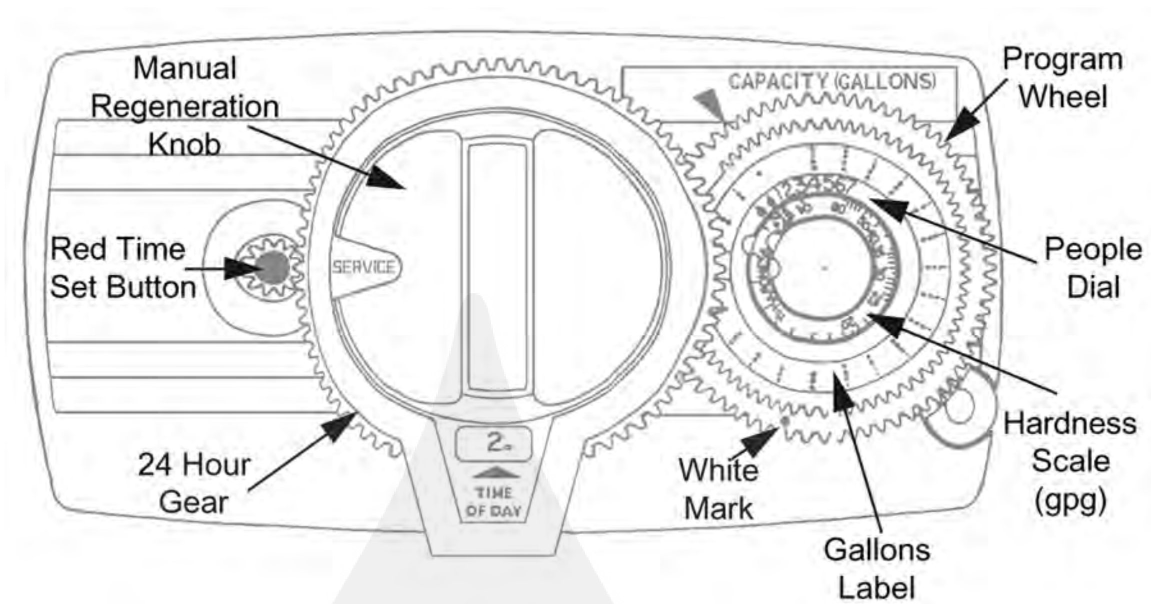

- Regeneration is programmed to occur at a specific time of day at equal intervals of between 1 to 12 days.
- To determine the number of days between regenerations, divide the actual capacity of the softener by one day's grain removal requirement as determined in the sizing calculation.
- To set the frequency of regeneration on a calendar clock, push the tabs in towards the center of the skipper wheel on the days regeneration is not desired.
- To set the correct time of day, depress the red button and turn the large gear until the present time is shown.



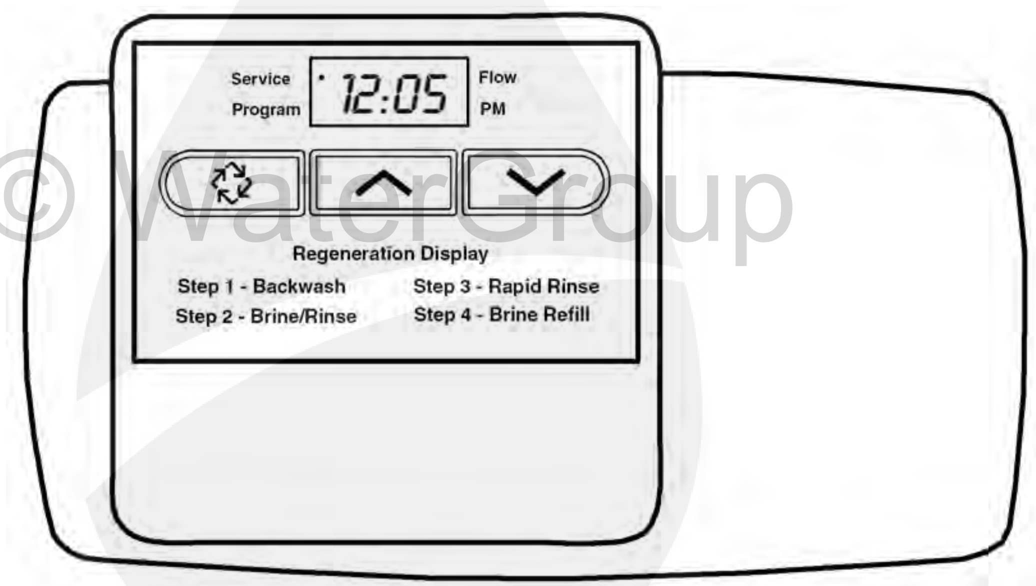
## Notes

# Meter Initiated Regeneration

**Mechanical Meter**




**Electronic Meter**






### *Mechanical Meter*

- Regeneration is programmed to occur at a specific time of day after a preset number of gallons of soft water has been used.
- The program wheel can be set by aligning the number of people with the compensated hardness in grains per gallon.
- To set the correct time of day, depress the red button and turn the large gear until the present time is shown.

### *Electronic Meter*

- Regeneration is programmed to occur at a specific time of day after a preset number of gallons of soft water has been used.
- The time of day, time of regeneration and the number of gallons used between regenerations is electronically entered into the control module.

# Meter Initiated Regeneration

Alternatively, the frequency of automatic regeneration can be set by using the gallon label and the small white mark on the program wheel. To set the program wheel, grasp it and, while pulling it towards you, turn it until the desired number of gallons is aligned with the white mark on the circumference. The number of gallons is read by multiplying the number on the label by 100. To determine the number of gallons of softened water that can be produced between regenerations, use the following formula:

| | |
|---|---|
| Capacity of your conditioner | ______ |
| Divided by the grains of compensated hardness in the water sample | ______ |
| Equals the number of gallons between regenerations | ______ |
| Minus the reserve (number of people x 75 gallons) | ______ |
| Equals the number of gallons at which to set the program wheel | ______ |

| | |
|---|---|
| Capacity of the conditioner | 30,000 |
| Divided by the grains of compensated hardness | ÷ 30 |
| Equals the number of gallons between regenerations | 1,000 |
| Minus the reserve | - 300 |
| Equals the number of gallons at which to set the program wheel | 700 |
| Round down to the nearest 50 gallon mark, if necessary, and set next to the white mark | 700 |

**GIVEN:**

Based on three day sizing, a 30K softener is decided upon with a capacity of 30,000 grains. The water hardness is 30 gpg. There are 4 people in the home.

***The program wheel must be set for either the number of people over the hardness OR for gallons. It cannot be set for both.***



## Notes

# Twin Meter Initiated (TMI) Regeneration

The Twin Alternating Meter Initiated Water Softener (TMI) is ideal to meet unusually high soft water demands in residential applications and for light commercial applications such as laundromats, restaurants, car washes and boilers in small heating plants requiring a constant supply of soft water.

The TMI consists of four major components:

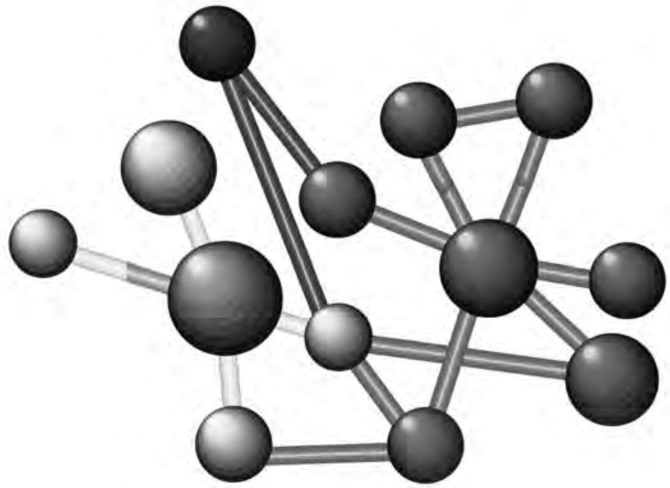
- A meter initiated control valve which governs the operation of the system
- Two identical mineral tanks, each containing a bed of ion exchange resin--one is in service, the second is in reserve
- A brine tank where salt and water combine to produce a specific volume of brine solution for each regeneration cycle

When the system is installed, the meter on the control valve is set to deliver the volume of water one mineral tank can soften before its capacity is depleted. Once the pre-set volume of water has been softened, the control valve diverts the incoming water supply from the service mineral tank to the reserve mineral tank and soft water service is maintained while the depleted tank is regenerated. Conditioned water is used in the regeneration cycle.

Sizing is based on one mineral tank being able to supply soft water for a minimum of one day. The meter initiated control valve is programmed in gallons using the same method as the single tank meter initiated softener but it is not necessary to calculate a reserve. However, the amount of water required for soft water regeneration of the alternate tank must be allowed for.



## Notes



# The Science of Water Softening

## Summary



### *Level 1*

1. Hardness minerals in water are measured in mg/l or gpg (grains per gallon) as calcium carbonate equivalent. Water with 1 gpg or more is considered hard.
2. Hard water causes soap scum and scale.
3. A water softener has a column or bed of ion exchange resin which exchanges positively charged calcium and magnesium ions for sodium ions. While TDS remains unchanged, the water now contains sodium and the hard water problems are eliminated.
4. A typical water softener consists of a control valve and timer assembly, a fiberglass tank filled with ion exchange resin, a brine tank to hold salt and brine, a distributor tube, a drain line and a brine line assembly.
5. In a softener with downflow brining, the brine travels down through the resin bed. With upflow brining, the brine travels up through the resin bed. Better salt efficiency is achieved in upflow brining because only the depleted portion of the bed needs to be regenerated. The reserve is super-regenerated ensuring soft water with no hardness slippage.
6. Calendar clock and meter initiated softeners are sized and programmed by assuming that each person will use 60 gallons of water per day, that the number of people in the household is constant and that the water hardness remains constant.

### *Level 2*

1. Upflow and downflow regeneration is accomplished by using a six cycle piston valve for service, backwash, brine, slow rinse, rapid rinse and brine tank refill.
2. Using three day sizing, a water softener can be selected by multiplying the number of people x 60 gallons x the compensated hardness x three days, rounded up to the next largest regenerated or K label capacity. As an alternative, a sizing chart can be used.
3. To determine total compensated hardness, add mg/l of iron x 4 gpg and mg/l of manganese x 8 gpg to the grains per gallons of hardness.
4. The regenerated or K label capacity is determined from the actual removal capacity in grains achieved when regenerating the resin at a rate of 6 lbs. of salt per cubic foot.
5. Upflow brining permits the use of less salt to properly regenerate a water softener.

# Basic Filtration

## Objectives



### *Level 1*

1. To be familiar with common terminology used in discussing basic filtration
2. To understand the basics of filtration systems
3. To know the basic features and processes of chlorination systems

### *Level 2*

1. To be able to identify the most efficient and effective filtration system to suit a client's needs
2. To select the appropriate type and size of system to meet the specific need
3. To know how to install in proper sequence, all aspects of a chlorination filtration system and the sizing of a chemical feeder pump to suit the system's requirements

# Glossary

**Absolute** - A term used to describe the effectiveness of a filter medium. The medium will reject all particles of a certain size or larger expressed in microns.

**Absorption** - The process in which one substance is taken into the body of another substance, termed the absorbent. An example is the absorption of water into soil.

**Activated Carbon** - A granular material usually produced by the roasting of cellulose base substances, such as wood or coconut shells, in the absence of air. It has a very porous structure and is used in water conditioning as an adsorbent of organic matter and certain dissolved gases. Sometimes called "activated charcoal".

**Adsorption** - The process in which matter adheres to the surface of the adsorbent.

**Attrition** - The process in which solids are worn down or ground down by friction, often between particles of the same material. Filter media and ion exchange materials are subject to attrition during backwashing, regeneration and service.

**Bed** - A common term referring to the media in a softener or filter.

**Caustic Soda** - The common name for sodium hydroxide.

**Channeling** - The flow of water or other solution in a limited number of passages in a filter or ion exchange bed instead of distributed flow evenly through the entire bed.

**Chloramine** - A disinfectant formed by the reaction of ammonia and chlorine. Chloramines require a longer contact time but result in the formation of fewer THMs.

**Chlorine ($Cl_2$)** - A gas widely used in the disinfection of water and an oxidizing agent for organic matter, iron, etc.

**Coagulant** - A material, such as alum, which will form a gelatinous precipitate in water and cause the agglomeration of finely divided particles into larger particles which can then be removed by settling and/or filtration.

**Colloid** - Very finely divided solid particles which will not settle out of a solution; intermediate between a true dissolved particle and a suspended solid which will settle out of solution. The removal of colloidal particles usually requires coagulation to form larger particles which may be removed by sedimentation and/or filtration.

**Dechlorination** - The removal of excess chlorine residual, often after super-chlorination.

**Disinfection** - A process in which pathogenic, disease producing bacteria are killed. May involve disinfecting agents such as chlorine or physical processes such as heating.

**E Coli Escherichia Coli** - One of the members of the coliform group of bacteria indicating fecal contamination.

**Fecal** - Matter containing or derived from animal or human wastes.

**Flocculation** - The agglomeration of finely divided suspended solids into larger, usually gelatinous, particles. The development of a "floc" after treatment with a coagulant by gentle stirring or mixing.

**Flow Control** - A device designed to limit the flow of water or regenerant to a predetermined value over a broad range of inlet water pressures.

**Free Chlorine** - A measure of chlorine residual in mg/l following the disinfection process and the reaction of chlorine with other elements in water.

**Flow Rate** - The quantity of water or regenerant which passes a given point in a specified unit of time, often expressed in gallons per minute.

**Fouling** - The process in which undesirable foreign matter accumulates in a bed of filter media or ion exchanger, clogging pores and coating surfaces and thus inhibiting or retarding the proper operation of the bed.

# Glossary

**Freeboard** - The vertical distance between a bed of filter media or ion exchange material and the overflow or collector for backwash water. The height above the bed of granular media available for bed expansion during backwashing. May be expressed either as a linear distance or as a percentage of bed depth.

**Media (singular Medium)** - The material within the filter or softener which is responsible for treating the water.

**Micron** - A unit of length, one millionth of a meter or .00004 inch. The smallest particle that can be seen by the naked eye is about 40 microns across. The smallest bacteria is about .2 microns across.

**Micron Rating** - The term applied to a filter or filter medium to indicate the particle size above which all suspended solids will be removed throughout the rated capacity. As used in industry standards, this is an "absolute" not "nominal" rating. (Refer to S-200, Recommended Industry Standards for Household & Commercial Water Filters).

**Neutralization** - In general, the addition of either an acid or a base to a solution as required to produce a neutral solution. The use of alkaline or basic materials to neutralize the acidity of some waters is common practice in water conditioning.

**Nominal** - A term used to describe the effectiveness of a filter medium. The medium will reject particles with a majority size expressed in microns.

**Particle Size** - As used in industry standards, the size of a particle suspended in water as determined by its smallest dimension, usually expressed in microns.

**Precipitate** - To cause a dissolved substance to form a solid particle which can be removed by settling or filtering such as in the removal of dissolved iron by oxidation, precipitation and filtration. The term is also used to refer to the solid formed and the condensation of water in the atmosphere to form rain or snow.

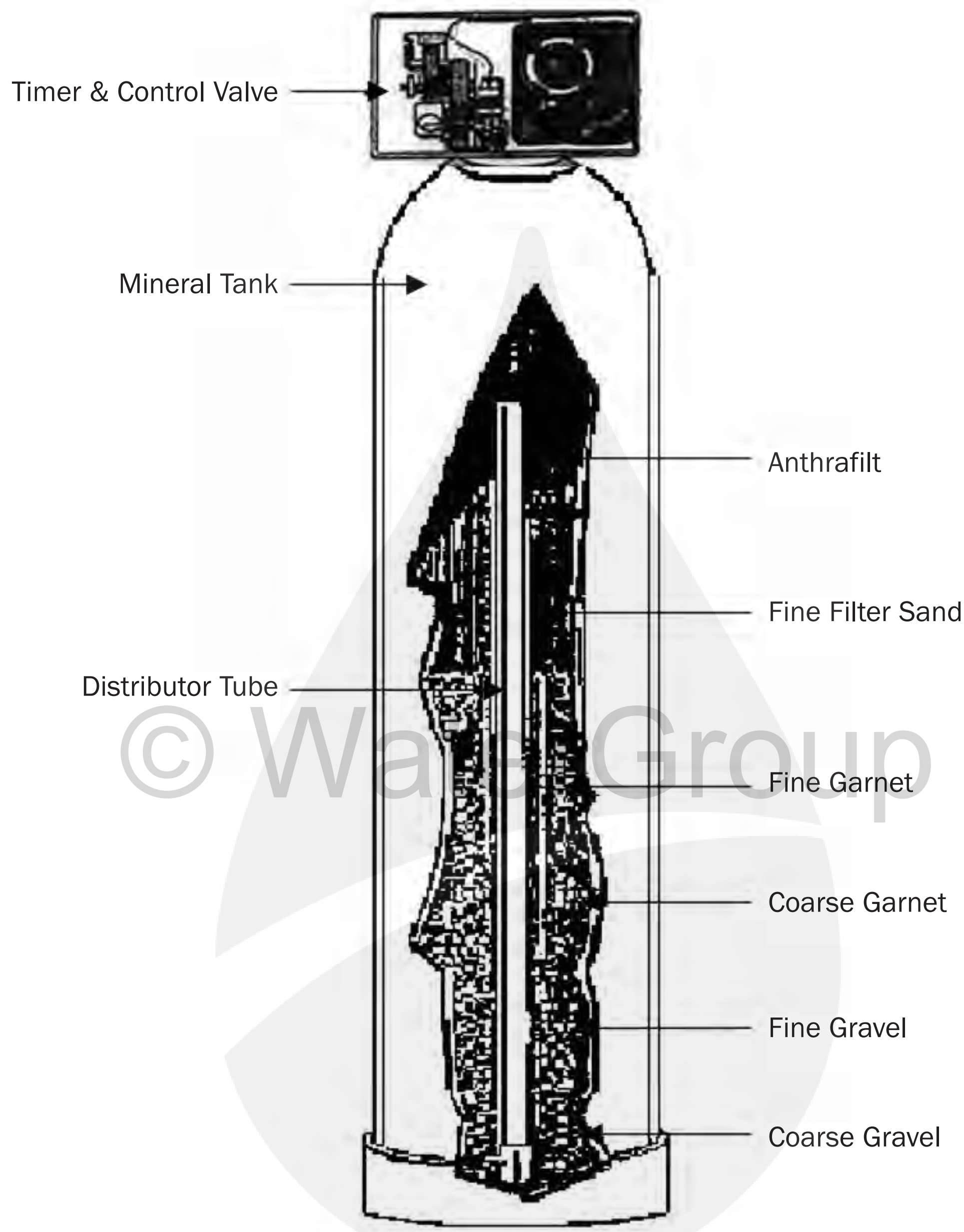
**Residual Chlorine** - Chlorine remaining in a treated water after a specified period of contact time to provide protection throughout a distribution system. The difference between the total chlorine added and that consumed by oxidizable matter.

**Sequester** - A chemical reaction in which certain ions are bound into a stable, water soluble compound, thus preventing undesirable action by the ions.

**Sodium Hypochlorite** - A chemical compound, $[Na(C10)24H_20]$, used as a bleach and a source of chlorine water treatment; specifically useful because it is stable as a dry powder and can be formed into tablets.

**Total Chlorine** - A measure of the chlorine in mg/l available as free chlorine plus the chlorine that has reacted with other elements in water.

# Multi-Media Filter



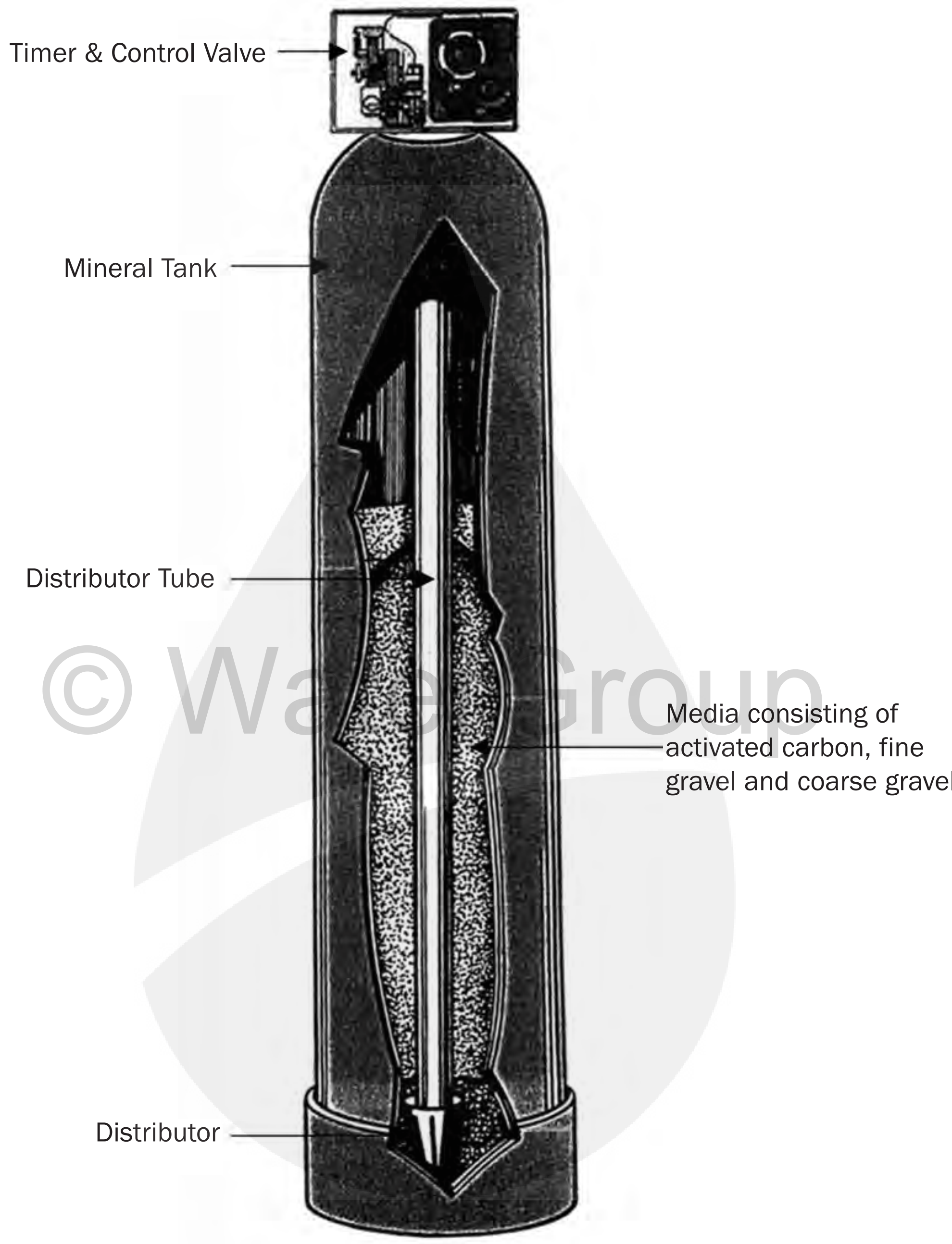
# Multi-Media Filtration

- Also referred to as a depth filter or turbidity filter.
- Suspended particulate matter, such as clay and silt, which gives water a cloudy appearance, is trapped in the filter bed to produce clean, clear water. A variety of gravels and sand facilitates more thorough backwashing and prevents channeling.
- Multi-media filters are designed for the removal of turbidity in the water caused by sand, silt, ferric iron and oxidized manganese or sulfur.
- They are used in applications such as chlorination filtration systems, general turbidity removal and prior to ultraviolet sterilizers.
- They are sized primarily on flow rate available for backwashing the filter. This ranges from 4 USGPM for .75 C.F. filters to 10 USGPM for 2.0" C.F.filters.
- They are capable of removing particles down to 15 micron in size as opposed to a conventional single media sand filter which removes 30 micron or higher.

### *Application Guidelines*

| | | | | |
|---|---|---|---|---|
| Media - Cubic Feet | .75 | 1.0 | 1.5 | 2.0 |
| Backwash Rate Required - USGPM | 4 | 5 | 7 | 10 |
| Service Flow Rate - USGPM | 4 - 5 | 5 - 7 | 7 - 10 | 10 - 12 |
| Factory Set Regeneration Time | 1:00 a.m. | 1:00 a.m. | 1:00 a.m. | 1:00 a.m. |
| Nominal Micron Filtration | 15 | 15 | 15 | 15 |

# Activated Carbon Filter



# Activated Carbon Filtration

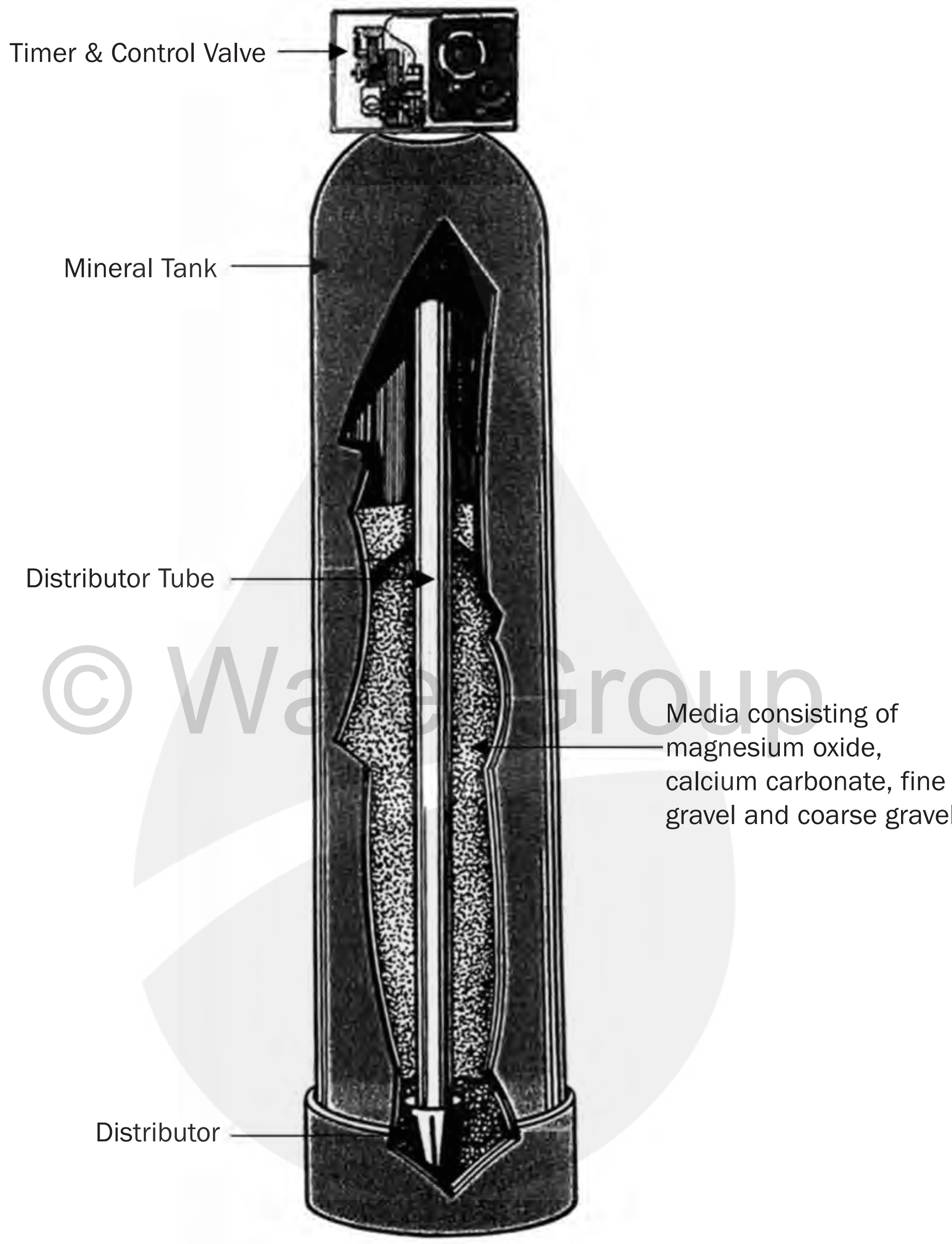
- Activated carbon is a form of elemental carbon whose particles have a large surface area with high adsorptive qualities. A variety of substances, such as coal, coconut shells, nutshells and wood, are exposed to high temperatures to produce carbon which is then activated by high pressure steam, leaving behind carbon etched with a complex pore structure.
- Adsorption is defined as the adhesion of a gas, vapor or dissolved organic compound on the surface of activated carbon. Activated carbon is effective for adsorbing dissolved organic compounds such as decayed vegetation and run-off which create unpleasant tastes and odors.
- With sufficient contact time, activated carbon will adsorb organic chemical compounds such as VOCs, THMs and chloramines.
- Granular activated carbon is the most effective and reliable technology for dechlorination. Free chlorine is removed by a catalytic reaction which occurs on the particle surface and in the macropores.
- Activated carbon filters are used in chlorination filtration systems or on municipal water supplies to remove traces of chlorine.
- Backwashing must take place at least once every three to six days to clean the bed and to prevent channeling, pressure loss and bacterial growth in the bed.
- Activated carbon filters are sized primarily on flow rates available for backwashing the filter. This ranges from 3.5 USGPM for .75 C.F. filters to 10 USGPM for 2.0 C.F. filters.
- The installation of an activated carbon filter must be preceded or followed by some form of disinfection.



### *Application Guidelines*

| | | | | |
|---|---|---|---|---|
| Media - Cubic Feet | .75 | 1.0 | 1.5 | 2.0 |
| Backwash Rate Required - USGPM | 3.5 | 5 | 7 | 10 |
| Service Flow Rate - USGPM | 4 - 5 | 5 - 7 | 7 - 10 | 10 - 12 |
| Factory Set Regeneration Time | 1:00 a.m. | 1:00 a.m. | 1:00 a.m. | 1:00 a.m. |

# Neutralizing Filter



# Neutralizing Filtration

- Neutralizing filters contain special media which raises the pH of acidic water and neutralizes its acidic characteristics. In addition to protecting pipes, plumbing fixtures and appliances, this filter also facilitates the use of other water conditioning equipment by raising the pH to required levels. Occasional backwashing cleans the bed. After one or two years, additional media may be required.
- Neutralizing filters are designed to increase the pH of an acidic water supply. Acidic water is measured as below 7.0 on a pH scale. The lower the pH value below 7.0, the greater the acidity.
- They are capable of increasing pH from 6.0 and up.
- They are sized primarily on flow rates available for backwashing the filter. This ranges from 3.5 USGPM for .75 C.F. filters to 7.0 USGPM for 2.0 C.F. filters.

### *Application Guidelines*

| | | | | |
|---|---|---|---|---|
| Media - Cubic Feet | .75 | 1.0 | 1.5 | 2.0 |
| Backwash Rate Required - USGPM | 3.5 | 4 | 5 | 7 |
| Service Flow Rate - USGPM | 2 - 3.5 | 3 - 5 | 5 - 8 | 6 - 10 |
| Factory Set Regeneration Time | 1:00 a.m. | 1:00 a.m. | 1:00 a.m. | 1:00 a.m. |
| Minimum pH Level | 6.0 | 6.0 | 6.0 | 6.0 |

# How to Select & Size a Filter

1. Measure the pumping rate of the system. This must exceed the backwash requirements of the filter.
2. Determine the user's service flow rate requirements.
3. Select the type of filter based on the contaminants in the raw water and the end usage.

**How to Measure the Pumping Rate**

1. Make certain no water is being drawn. Open spigot nearest pressure tank. When pump starts, close tap and measure time (in seconds) to refill pressure tank. This is cycle time.
2. Using a container of known volume, draw water and measure the volume in U.S. gallons until the pump starts again. This is draw down.
3. Divide the draw down by the cycle time and multiply the result by 60. This will give you the pumping rate in USGPM.

**Example:**

Draw down = 7.0 gallons

Cycle time = 80 seconds

7.0 gallons ÷ 80 seconds = 0.0875 x 60 seconds = 5.25 USGPM

**Caution:** Do not rely on the pump label, tank capacity or a well driller's report as an alternative to using the above procedure to measure actual pumping rate.



## Notes

# Chlorination Systems

Chlorine is highly effective in destroying microorganisms in water. It is also a powerful oxidizer used to precipitate various contaminants in water.

With the introduction of the chemical free iron filter and ultraviolet, the number of chlorination applications has been reduced. However, there are still cases where a full-line chlorination system is the best solution for some water problems.

Information is available concerning the alternate use of hydrogen peroxide for specialty applications.

**Application**

Following are the conditions where we recommend the installation of a full-line chlorination system:

1. Where hydrogen sulfide exceeds 3.0 ppm
2. Where combined levels of iron, manganese and sulfur exceed the limits for the chem free or the iron & sulfur filter
3. Where disinfection is required to make the water bacteriologically safe
4. For livestock application requiring chlorine residuals
5. For community wells
6. To comply with user's personal preference (type of recommendation by governments).

# Chlorination System Installation



### *Chemical Feeder/Solution Tank*

The injection point should be installed after the pressure tank and before the holding tank.

This pump is wired to the pressure switch of the water pump(s). Thus it is important that the chemical pump be the same voltage as the water pump. Specify 115V or 230V when ordering.

The injector and anti-syphon valves should be cleaned regularly according to the maintenance instructions provided with the pump.

### *Chemical Feed Solution*

Is most often a mixture of household bleach (chlorine). Do not use a powdered pool type of bleach. If you must dilute the chlorine, be sure to use clean, treated water for mixing; otherwise the mixture will be too weak to work and a sludge will build up on the bottom of your solution tank.

### *Shut-Off Valves*

Are required on both sides of the injection point in order to be able to isolate the injector for cleaning and testing purposes.

### *Flow Switch*

Optional when all water is not being treated - the flow switch is installed after the untreated water lines.

### *Retention Tank*

Water should always be fed in at the bottom and the outlet should be at the top. A bleed off valve should be installed at the lowest point of the tank.

Retention of at least 20 minutes is required as calculated by the tank size and the recommended 4-5 gpm flow rate. Chlorine must have this time for an effective bacteria kill and to oxidize contaminants. At 5 USGPM, a 100 gallon retention tank would be required.

### *Multi-Media Filter*

Installed after the retention tank to collect suspended matter such as clay, silt or ferric iron or oxidized manganese or sulfur. Pressure loss usually indicates more frequent backwash is required.

### *Activated Carbon Filter*

Will remove any residual chlorine and trace organics in the water, improving taste and odor. Pressure loss or chlorine slippage usually indicates more frequent backwashes are required. If a chlorine residual is desired after the system, eliminate this filter.

### *Water Softener*

Installed after filtration equipment. The water softener should be applied when the water tests more than 1 gpg total hardness. Sizing of the correct model of softener should be done according to the normal three day sizing formula.

### *Test Cocks*

Should be installed after each piece of equipment in order to analyze operating performance.

### *Plumbing*

Should be in good order and all taps indicated should be installed. All plumbing, including pressure tank fittings should be a minimum of 3/4" for good flow rates and healthy backwash flows. A minimum of 20 psi should be maintained throughout the system.

Bypass valves are recommended on every filter and softener. PVC plumbing is recommended over galvanized steel.

Do not use polybutylene pipe with total chlorine levels over 2 ppm.

### *pH*

If the pH is below 6.5, it must be increased to allow for efficient oxidation by the chlorine. This can be accomplished with the addition of soda ash by a separate feed system.

### *Regeneration Time*

All filters and the softener should regenerate/backwash every three days. The time of regeneration/backwash must be staggered to avoid having more than one unit backwashing at one time.

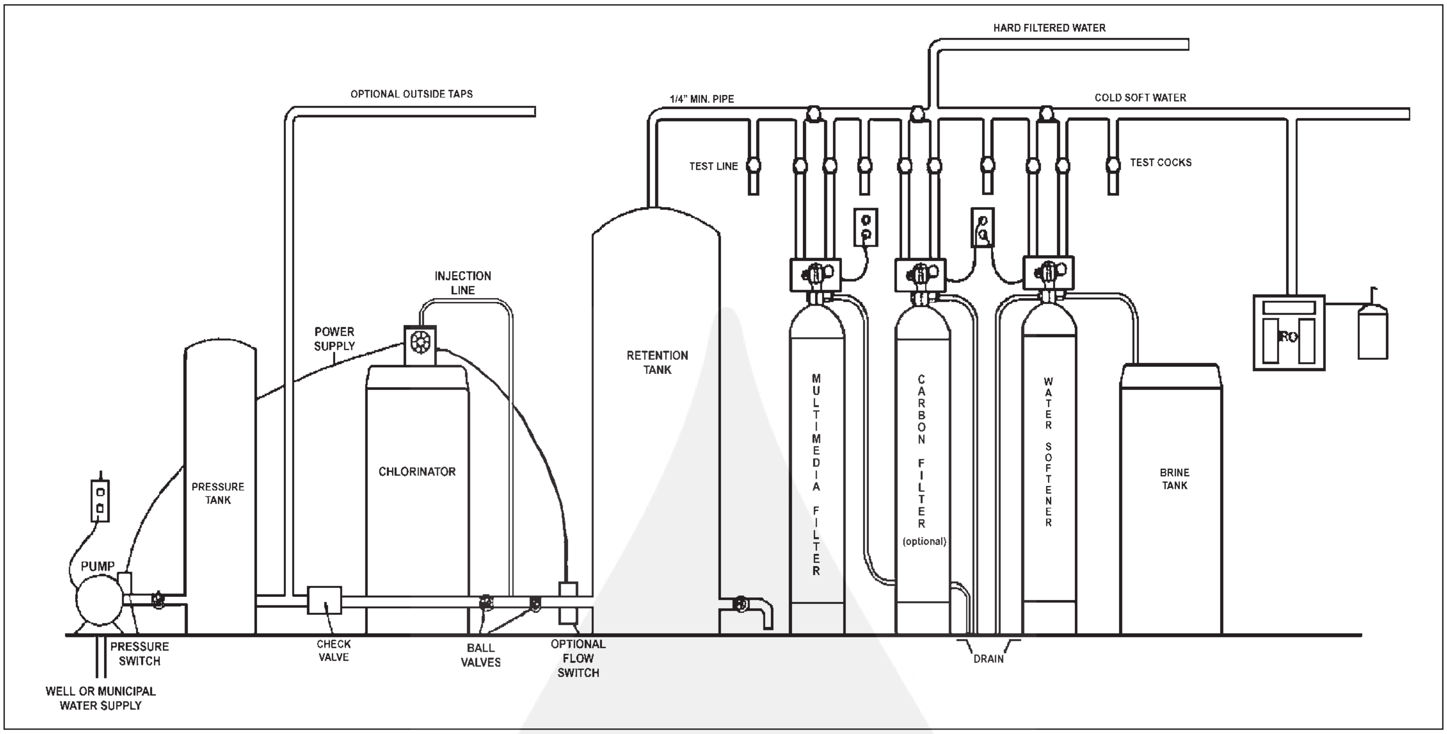
### *User Involvement*

A problem water system requires testing and monitoring. The user must be aware of the chemical mixing procedure and how to test for residual chlorine at the test tap between the multi-media and carbon filters, etc. The chlorine tank must not run dry and loose the prime of the feed pump. (Chlorine test kits are available at most hardware stores, swimming pool supply stores and the manufacturer.)



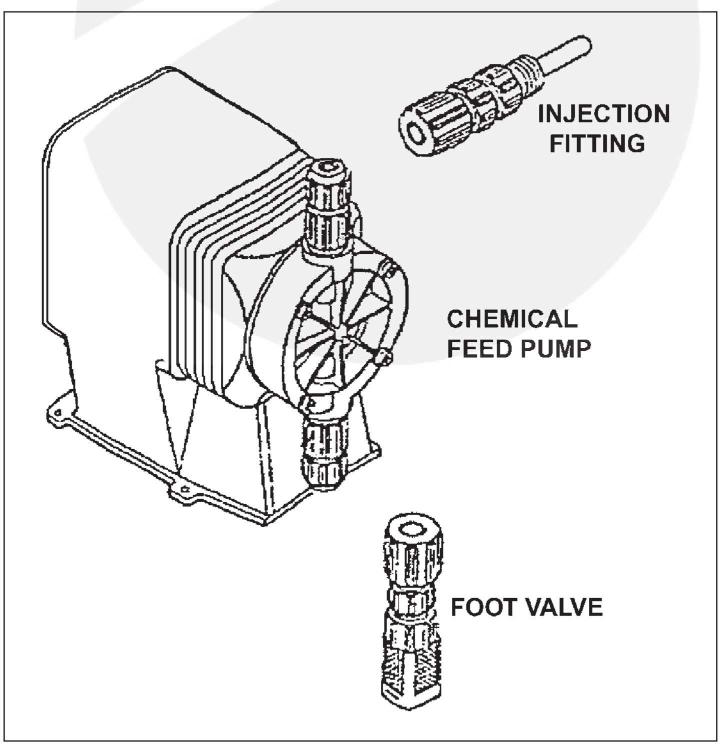
## Notes

# Chlorination System Installation (cont'd)




- The chlorinator is wired to the pump or flow switch
- The retention tank is sized for a minimum of 20 minutes retention
- Optional flow switch is to be used when outside unchlorinated water service is required
- Backwash and regeneration times must be staggered to ensure adequate water supply for proper regeneration.





### *Sizing the Filters*

When sizing the filtration components in a full line chlorination system, the basic rule for filtration applies - match the pumping flow rates to the backwash rates and service flow rates. Remember "Bigger is not better and smaller is not right either".

### *Sizing the Chemical Feeder Pump*

Need to know:

Chlorine demand for water treatment

To do a chlorine demand test (should be performed on-site):

- 1 gallon of fresh raw water
- Sample of chlorine which will be used in the system
- Chlorine test kit

**Goal:**

- To achieve a residual chlorine level of 1.0 - 1.5 ppm (free chlorine test)
- If used to precipitate hydrogen sulfide, a residual of 3 ppm should be obtained

**Procedure:**

- Add 3 drops chlorine to the gallon of raw water
- Allow to stand for 5 minutes
- Test water with the chlorine test kit
- If no chlorine residual is indicated, add more drops in sets of 3 until a chlorine residual of 1.0 - 1.5 ppm is obtained
- Measure the pumping rate of the pump system
- Multiply the pumping rate by the number of drops of chlorine required. This will equal the number of drops of chlorine required per minute.

**Example:**

| | | |
|---|---|---|
| | 26 | drops required |
| x | 6 | gpm pumping rate |
| = | 156 | drops per minute |
| x | 60 | minutes per hour |
| = | 9,360 | drops per hour |
| ÷ | 75,000 | drops per gallon |
| = | 0.125 | gallons of chlorine per hour |

### *Sizing the Chlorinator*

Select a chlorinator which will run at approximately 30-80% injection

Most chlorinators will inject more than required. Therefore, dilute the chlorine with "clean" treated soft water to obtain the quantity required versus the pump's efficient setting.

**Example:**

.125 gallons of chlorine required per hour

The pump selected will inject 1.0 gallons per hour

| | | |
|---|---|---|
| | 1.0 | max output of chemical feed pump |
| ÷ | 50% | optimum pump setting |
| = | .5 | gallons per hour |
| ÷ | .125 | gallons per hour required |
| = | 4 | This is your dilution ratio - 4:1 |

# Advantages & Disadvantages

### *Advantages*

- Chlorine kills bacteria
- Chlorine acts as an oxidizer handling sulfur, iron and manganese
- Chlorine is detectable and can be measured. By measuring the residual after treatment, we know sufficient chlorine has been used to remedy the problem(s).
- Chlorine is economical to purchase
- Chlorine is readily available to the user
- Chlorine is easily diluted

### *Disadvantages*

- Chlorine requires a minimum of 20 minutes contact time
- Chlorination systems require a larger capital expenditure
- Chlorination systems require testing and cleaning on a regular basis
- Chlorine is corrosive
- Chlorine has an objectionable taste and odor
- Chlorination systems require multiple units (more installation space)



## Notes

# Color in Water - Tannins

- Tannins are organic colorations of the water. Infinitely small microscopic particles add color to water.
- Colloidal suspensions and non-colloidal organic acids as well as neutral salts also affect the color of water. The color in water is primarily of vegetable origin and is extracted from leaves and aquatic plants. Naturally, water draining from swamps has the most intense coloring. The bleaching action of sunlight plus the aging of water gradually dissipates this color. All surface waters possess some degree of color.
- Likewise, some shallow wells, springs and the occasional deep well can contain noticeable coloring.
- In general, however, water from deep wells is practically colorless.
- Excessive color lacks appeal from an aesthetic standpoint in potable water. Further, it can cause staining.
- In general, color is reduced or removed from water through the use of coagulation, settling and filtration techniques. Aluminum sulfate and polyaluminum chloride are widely used coagulants for this purpose. Super-chlorination, activated carbon filters, ozone and potassium permanganate have been used with varying degrees of success in removing color.
- There are several ion exchange resins available that effectively remove tannins. For proper recommendation, a complete water analysis would be required, as well as a minimum one gallon sample of raw water.



## Notes

# Basic Filtration

## Summary

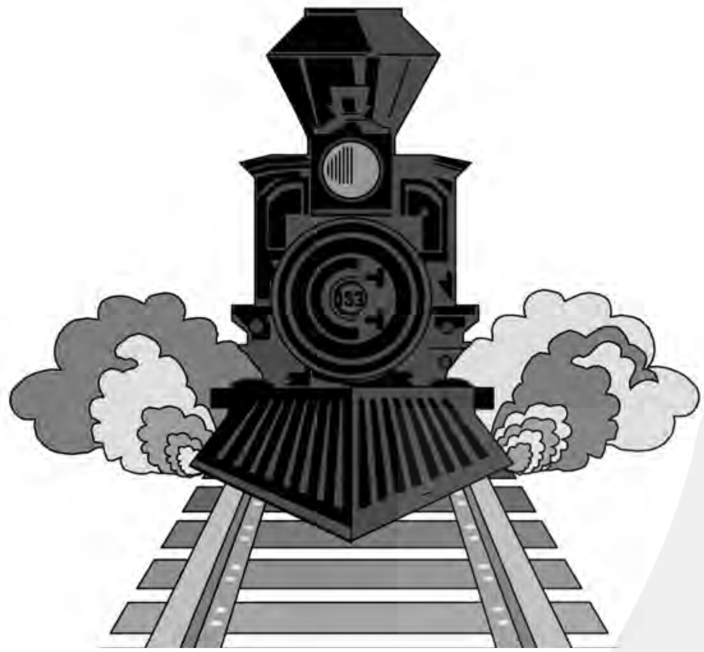


### *Level 1*

1. All filters are composed of a media bed in a fiberglass mineral tank. A control valve controls the flow of water through the bed and periodically reverses the flow to backwash and cleanse the media of captured contaminants.
2. · Multi-media filters capture suspended particles to a nominal size of 15 microns.
   · Activated carbon filters eliminate tastes and odors by removing chlorine and adsorbing harmful compounds.
   · Neutralizing filters raise the pH of water, preventing corrosion and facilitating the use of other water conditioning equipment.
3. A chemical feed system can be installed to feed chlorine into a water supply for disinfection and to oxidize iron, manganese and hydrogen sulfide for removal by filtration.

### *Level 2*

1. A filter is selected and sized by determining the contaminants to be removed, the service flow rates required and the pumping rate available to match the service and backwash flow rates of the filter.
2. A chlorination filtration system consists of a chemical feed pump, a solution tank, a chemical solution, an injection point, a retention tank, a multi-media filter (if required), an activated carbon filter and a water softener (if required).
3. The amount of chlorine to be injected and the dilution ratio is obtained by matching the amount of chlorine needed to be effective and to leave a residual with the chemical feed pump.



# The Iron Horse of Iron Filters

## Objectives

### *Level 1*

1. To become familiar with the terminology commonly used in discussing iron filtration
2. To know the principal effects of iron, manganese and hydrogen sulfide in water and the process of filtration
3. To know the principles of chemical free filtration
4. To know the principles of greensand filtration

### *Level 2*

1. To know the features, benefits and limitations of chemical free iron filtration and of manganese greensand filtration and the sizing of equipment for efficient system functioning
2. To know the importance of pH in oxidation and the application of guide charts and tables for analyzing needs and installation of properly sized equipment
3. To know the proper sequencing and arrangement of filters and pressure system components.

# Glossary

**Acid** - A substance which releases hydrogen ions when dissolved in water. Most acids will dissolve the common metals and will react with a base to form a neutral salt and water.

**Aeration** - The process in which air is brought into intimate contact with water, often by spraying water through air, or by bubbling air through water. Aeration may be used to add oxygen to the water for oxidation of matter, such as iron, or to cause the release of dissolved gases, such as carbon dioxide or hydrogen sulfide, from the water.

**Alkalinity** - The quantitative capacity of a water or water solution to neutralize an acid. It is usually measured by titration with a standard acid solution of sulfuric acid and expressed in terms of its calcium carbonate equivalent.

**Attrition** - The process in which solids are worn down or ground down by friction, often between particles of the same material. Filter media and ion exchange materials are subject to attrition during backwashing, regeneration and service.



**Backwash** - The process in which beds of filter or ion exchange media are subjected to flow opposite to service flow direction to loosen the bed and to flush suspended matter collected during the service run to waste.

**Base** - A substance which releases hydroxyl ions when dissolved in water. Bases react with acids to form a neutral salt and water.

**Bed** - The ion exchange or filter media in a column or other tank or operational vessel.

**Bed Depth** - The height of the ion exchange or filter media in the vessel after preparation for service.

**Capacity** - An expression of the quantity of an undesirable material which can be removed by a water conditioner between servicing of the media (i.e. cleaning, regeneration or replacement, as determined under standard test conditions). For ion exchange water softeners, the capacity is expressed in grains of hardness removal between successive regenerations and is related to the pounds of salt used in regeneration. For filters, the capacity may be expressed in the length of time or total gallons delivered between servicing.

**Channelling** - The flow of water or other solution in a limited number of passages in a filter or ion exchange bed instead of distributed flow through all passages in the bed.

**Chlorine** ($Cl_2$) - A gas widely used in the disinfection of water and an oxidizing agent for organic matter, iron, etc.

**Colloid** - Very finely divided solid particles which will not settle out of a solution; intermediate between a true dissolved particle and a suspended solid that will settle out of solution.

**Cycle Time** - The amount of time in seconds elapsed between pump start and pump shut-down.

**Drawdown** - The amount of water delivered by the storage tank between pump shut-down and pump start.

**Flow Control** - A device designed to limit the flow of water or regenerant to a predetermined value over a broad range of inlet water pressures.

**Flow Rate** - The quantity of water or regenerant which passes a given point in a specified unit of time, often expressed in gallons per minute.

**Fouling** - The process in which undesirable foreign matter accumulates in a bed of filter media or ion exchanger, clogging pores and coating surfaces and thus inhibiting or retarding the proper operation of the bed.

**Grain per Gallon (gpg)** - A common basis for reporting water analysis in the United States and Canada. One grain per U.S. gallon equals 17.12 milligrams per litter (mg/l) or parts per million (ppm). One grain per British (Imperial) gallon equals 14.3 mg/l or ppm.

**Greensand** - A natural mineral, primarily composed of complex silicates, which can be coated with manganese oxide to form a catalytic adsorptive surface. This surface is used to attract ferrous iron and manganese as well as to adsorb dissolved oxygen which is used to oxidize iron, manganese or hydrogen sulfide.

# Glossary

**Hydrogen Sulfide ($H_2S$)** - A gas characterized by an offensive odor, commonly referred to as "rotten egg". Flammable and poisonous in high concentrations, corrosive to most metals and can even tarnish silver. Detectable by most people in concentrations as low as 0.5 ppm.

**Hydrocharger** - Trade name of a particular type of air inducting or injector valve.

**Iron** - An element often found dissolved in ground water (in the form of ferrous iron) in concentrations usually ranging from 0-10 ppm (mg/l). It is objectionable in water supplies because of the staining caused after oxidation and precipitation (as ferric hydroxide); because of the tastes; and because of unsightly colors produced when iron reacts with tannins in beverages such as coffee and tea.

**Iron Bacteria** - Organisms which are capable of utilizing ferrous iron, either from the water or from steel pipe in their metabolism and precipitating ferric hydroxide in their sheaths and gelatinous deposits. These organisms tend to collect in pipelines and tanks during periods of low flow and to break loose in slugs of turbid water to create staining, taste and odor problems.

**Manganese (Mn)** - An element sometimes found dissolved in ground water, usually with dissolved iron but in lower concentrations. Causes black stains and other problems similar to iron.

**Media** - The selected materials in a filter that form the barrier to the passage of certain suspended solids or dissolved molecules. (Singular of media is medium)

**Milligrams per Liter (mg/l)** - A unit concentration of matter used in reporting the results of water and waste water analysis. In dilute water solutions, it is practically equal to the part per million but varies from the ppm in concentrated solutions such as brine. As most analysis are performed on measured volumes of water, the mg/l is a more accurate expression of the concentration and is the preferred unit of measure.

**Mineral** - A term applied to inorganic substances such as rocks and similar matter found in the earth strata as opposed to organic substances such as plant and animal matter. Minerals normally have definite chemical composition and crystal structure. The term is also applied to matter derived from minerals such as the inorganic ions found in water. The term has been incorrectly applied to ion exchangers, even though most of the modern materials are organic ion exchange resins.

**Organic Iron** - A ferrous iron molecule which is enveloped in an organically complex molecule that resists oxidation. May be present in water that contains a great deal of colored colloidal turbidity.

**Oxidization** - A chemical process in which electrons are removed from an atom, ion or compound. The addition of oxygen is a specific form of oxidation. Combustion is an extremely rapid form of oxidation while the rusting of iron is a slow form.

**Oxidizing Agents** - Any substance that oxidizes another substance and is itself reduced in the process. Common examples include: oxygen, chlorine, potassium permanganate, hydrogen peroxide, iodine and ozone.

**Ozone ($O_3$)** - An unstable form of oxygen occurring naturally in the upper atmosphere or artificially produced because of its strong oxidizing or disinfection characteristics.

**Parts per Million (ppm)** - A common basis for reporting the results of water and wastewater analysis, indicating the number of parts by weight of a dissolved or suspended constituent, per million parts by weight of water or other solvent. In dilute water solutions, one part per million is practically equal to one milligram per liter, which is the preferred unit. 17.12 ppm equals one grain per U.S. gallon.

# Glossary

**pH** - Or the "potential of hydrogen" expresses the hydrogen ion activity or concentration. pH is a measure of the intensity of the acidity or alkalinity of water on a scale from 0 to 14, with 7 being neutral. When acidity is increased, the hydrogen ion concentration increases, resulting in a lower pH value. Similarly, when alkalinity is increased, the hydrogen ion concentration decreases, resulting in higher pH. The pH value is an exponential function so that pH 10 is 10 times as alkaline as pH 9 and 100 times as alkaline as pH 8. Similarly a pH 4 is 100 times as acid as pH 6 and 1000 times as acid as pH 7.

**Potassium Permanganate** - A powerful oxidizing agent consisting of dark purple crystals with blue metallic sheen. Explosive in contact with sulfuric acid or hydrogen peroxide. Increases flammability of combustible materials. Used to renew the black manganese oxide coating on greensand media.

**Precipitate** - To cause a dissolved substance to form a solid particle which can be removed by settling or filtering such as in the removal of dissolved iron by oxidation, precipitation and filtration. The term is also used to refer to the solid formed and the condensation of water in the atmosphere to form rain or snow.

**Pumping Rate** - The amount of actual water that can be drawn from a pressure system expressed in U.S. gallons per minute, obtained by dividing the drawdown (gallons) by the cycle time (seconds) and multiplying the result by 60 (seconds).

**Regenerant** - A solution of chemical used to restore the capacity of an ion exchange or oxidation system.

**Service (Peak) Flow Rate** - The greatest amount of water (expressed in gallons per minute) that a particular filter can effectively process, based on short pump runs of less than 10 to 15 minutes maximum.

**Soda Ash** - The common name for sodium carbonate, a chemical compound used as an alkaline builder in some soap and detergent formulations to neutralize acid water and in the lime soda ash water treatment process.

**Sulfate-Reducing Bacteria** - A group of bacteria which are capable of reducing sulfates in water to hydrogen sulfate gas, thus producing obnoxious tastes and odors. These bacteria have no sanitary significance and are classed as nuisance organisms.

**TDS** - The abbreviation for "total dissolved solids"



# Notes

# Iron, Manganese & Hydrogen Sulfide ($H_2S$)

A brief explanation of the different types of iron, manganese and hydrogen sulfide found in water supplies:

### *Ferric Iron*

- Troublesome in concentrations as low as 0.3 mg/l
- Also known as "red water iron"
- Present in water in its oxidized state and is visible to the naked eye

### *Ferrous Iron*

- Troublesome in concentrations as low as 0.3 mg/l
- Also known as "clear water iron"
- A dissolved-in-solution iron molecule

### *Bacterial Iron*

- A harmless bacteria which consumes iron
- A slimy, stringy growth of iron which can be found in the water closet of a toilet and may break loose from piping, etc. to cause sporadic staining of laundry and fixtures

### *Organic Iron*

- A ferrous iron molecule which is enveloped in an organic compound
- Extremely difficult to remove
- Research is being conducted to discover an economical method to deal with this type of iron

### *Manganese*

- Troublesome in concentrations as low as 0.05 mg/l
- Normally present in water in the dissolved-in-solution state
- Causes a dark black stain

### *Hydrogen Sulfide*

- Is a dissolved gas which imparts a rotten egg taste and odor to the water
- Is troublesome in concentrations as low as 0.1 mg/l
- Can be corrosive and cause a blackish stain



# Iron, Manganese & $H_2S$ in Water

Concentrations of more than 0.3 ppm of iron and 0.05 ppm of manganese stain plumbing fixtures and laundry. Although the discoloration from the iron and manganese is the most serious problem, water containing excess iron and manganese causes foul tastes and offensive odors which are produced by the growth of iron bacteria.

Dissolved iron and manganese are often found in groundwater from wells located in shale, sandstone and alluvial deposits. Surface water supplies may also contain iron and manganese if they are oxygen deficient.

Hydrogen sulfide will exist as a gas in underground water sources and can be detected by its rotten egg smell.

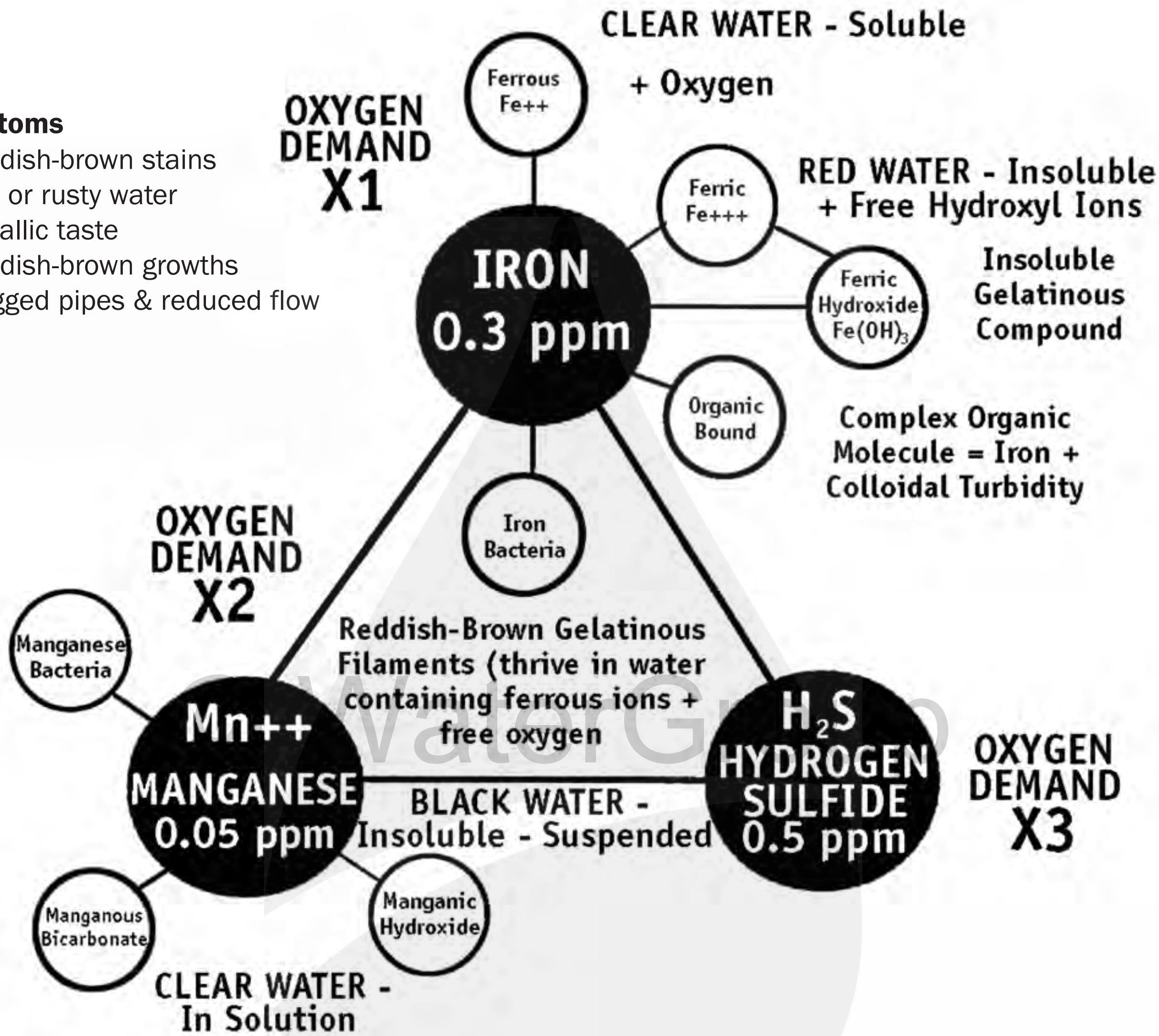
Soluble forms of iron (Fe2+) and manganese (Mn2+) exist in an environment that is deprived of dissolved oxygen and has a low pH. When the water is exposed to air, the iron and manganese start oxidizing to insoluble forms Fe3+ and Mn4+.

The rate of oxidation depends primarily on the type and concentration of the oxidizing agent and the pH. Alkalinity, organic content and presence of catalysts also have an effect.

The most common oxidizing agents are oxygen, chlorine and potassium permanganate. For oxidation of iron, the pH should be 7.0 or higher, but manganese requires a pH of 8.5 or higher to oxidize. Once oxidized, iron, manganese and hydrogen sulfide can be removed by mechanical filtration.

# Troublesome Trio - Iron, Manganese & $H_2S$

**Symptoms**
- Reddish-brown stains
- Red or rusty water
- Metallic taste
- Reddish-brown growths
- Clogged pipes & reduced flow




**Symptoms**
- Dark brown or black stains
- Black sediment & turbidity
- Deposits collect in pipes
- Usually present in conjunction with dissolved iron

**Symptoms**
- Offensive gas with a "rotten egg" odor
- Promotes corrosion as a weak acid
- Tarnishes silver
- Flammable & poisonous
- Capable of causing nausea & illness
- Capable of fouling resin bed
- Turns whiskey black
- Oxidizes into insoluble yellow sulfur powder

# Iron, Manganese & $H_2S$ Solutions

### *Aeration*

Plain aeration is the simplest form of treatment. The water is aerated (oxidized) by exposing it to air. This is performed by having the water flowing over steps or obstacles or by spraying the water so that it mixes with air. The manganese is not oxidized as effectively as the iron, so the pH must be raised to 8.0 or higher with lime, soda ash or caustic soda. When oxidized the contaminants can be removed by mechanical filtration.

Aeration can be used to eliminate methane when proper guidelines are used.

### *Manganese Greensand Filtration*

Manganese zeolite is made by coating natural greensand zeolite with oxides. The greensand (Mn02) oxidizes and filters soluble iron and manganese until it becomes exhausted. The filter is then rinsed clean and regenerated by using potassium permanganate.

A common method is to supply a continuous feed of potassium permanganate solution ahead of a dual media filter (anthracite and greensand). The anthracite removes most solubles thereby reducing plugging of the greensand. The frequency of regeneration is reduced by supplying a continuous feed of potassium permanganate. As well, excess iron and manganese are oxidized by the greensand when the permanganate feed is less than the iron and manganese in the water. If a surplus is applied, it regenerates the greensand.

### *Chemical Free Iron Filtration*

Air is injected into the water stream prior to the filter to initiate oxidation. The oxidation process and filtration is completed by the media in the filter.

### *Chlorination*

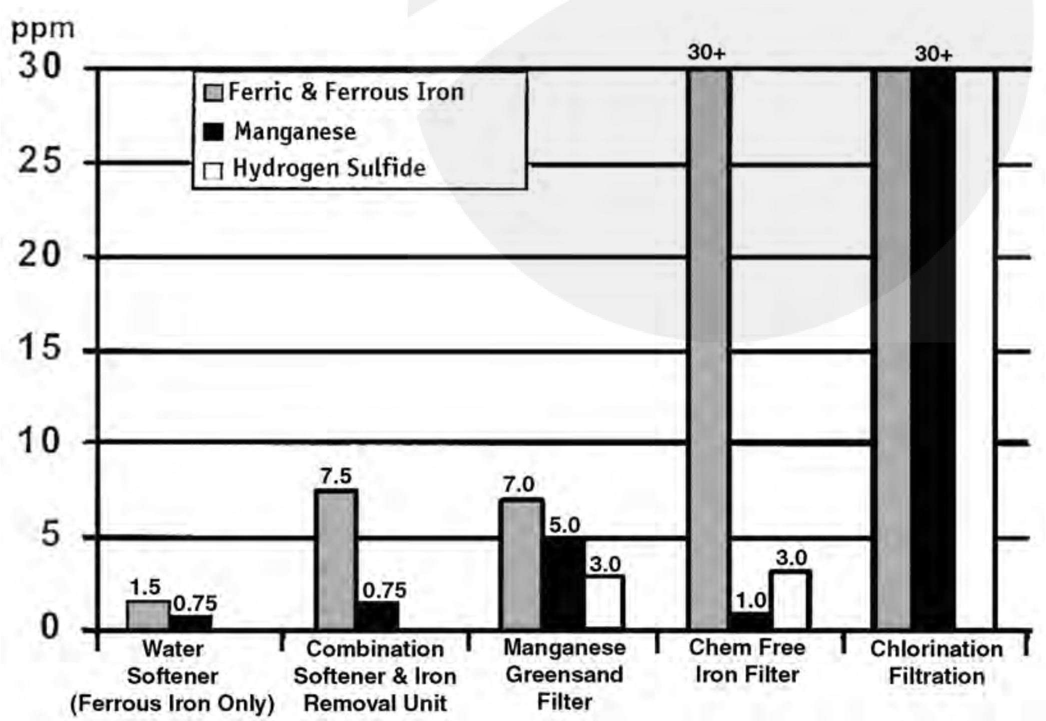
Chlorine is introduced into the water to chemically oxidize iron, manganese, iron bacteria and hydrogen sulfide. A sufficient retention time must be provided. The precipitated contaminants must then be removed by mechanical filtration.

### *Combination Softener - Iron Removal*

A fine mesh ion exchange resin is used to both soften the water and remove clear and red water iron. Regeneration with a salt brine solution replenishes the resin. The use of a resin cleaner is essential with this system.



# Iron, Manganese & $H_2S$ Removal




Manganese and hydrogen sulfide removal levels indicated are for that contaminant only.

If concentrations of more than one of these contaminants are present in the water supply, consult specific application guidelines for the equipment selected.

- Iron will readily oxidize when the pH of the water is 7.0 or higher
- Manganese will not readily oxidize unless the pH is 8.0.

### *pH or the "Potential of Hydrogen"*

Expresses the hydrogen ion activity or concentration. pH is a measure of the intensity of the acidity or alkalinity of water on a scale from 0 to 14, with 7 being neutral. When acidity is increased, the hydrogen ion concentration increases, resulting in a lower pH value. Similarly, when alkalinity is increased, the hydrogen ion concentration decreases, resulting in higher pH. The pH value is an exponential function so that pH 10 is 10 times as alkaline as pH 9 and 100 times as alkaline as pH 8. Similarly a pH 4 is 100 times as acid as pH 6 and 1000 times as acid as pH 7.

### *Acid*

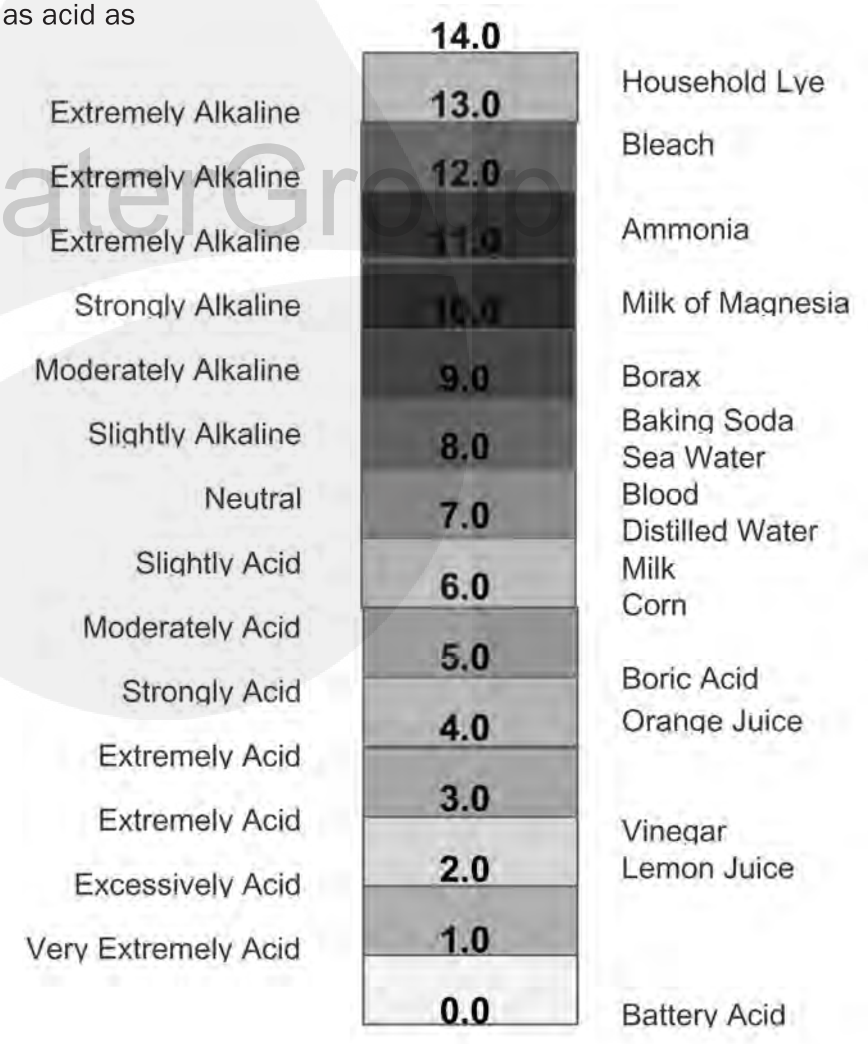
A substance which releases hydrogen ions when dissolved in water. Most acids will dissolve the common metals and will react with a base to form a neutral salt and water.

### *Alkalinity*

The quantitative capacity of a water or water solution to neutralize an acid. It is usually measured by titration with a standard acid solution of sulfuric acid and expressed in terms of its calcium carbonate equivalent.

### *Low pH Correction*

When water has a pH below 6.5, consult your manufacturer's representative because it may be necessary to install a chemical feeder (feeding soda ash) ahead of the filter. This is more likely to be necessary when you have a combination of lower than 6.5 pH, high iron (over 15 ppm) and manganese present.



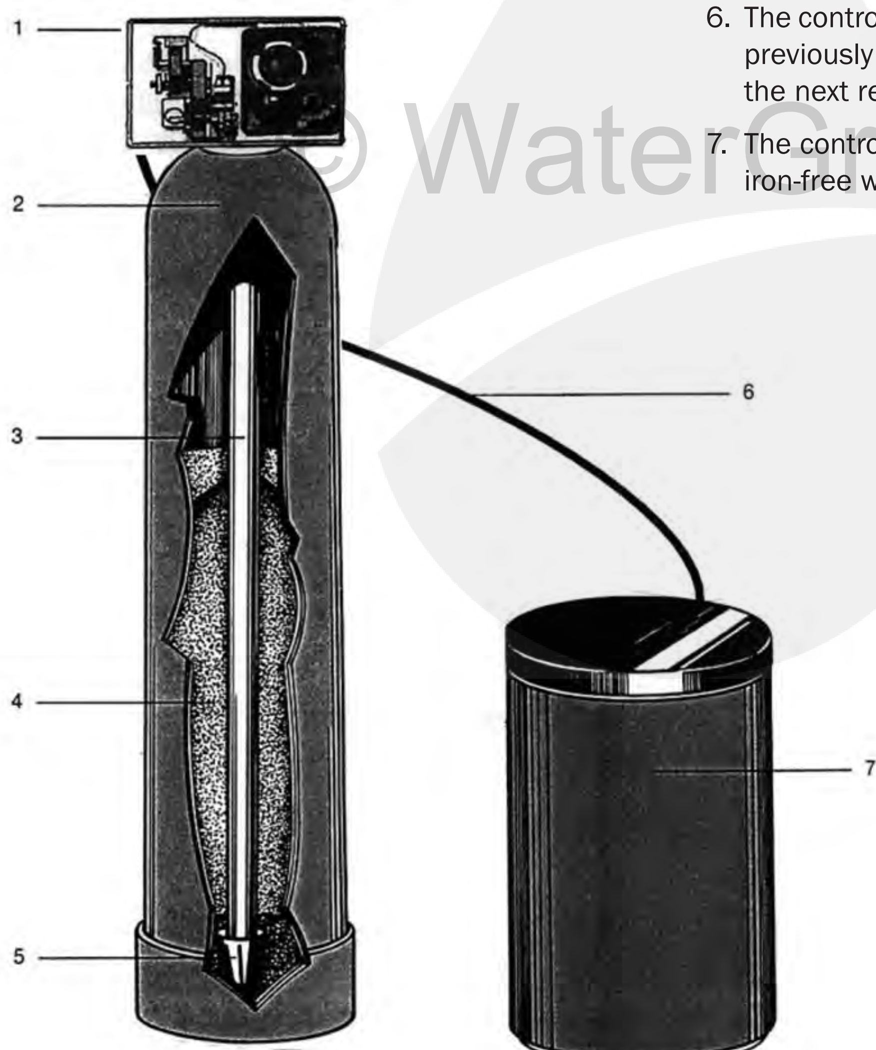
# Manganese Greensand Filtration

The automatic manganese greensand filter consists of a bed of filter media contained in a fiberglass tank, a container with potassium permanganate for the regeneration of the filter and an automatic control valve.

Raw water enters your home through the main supply line, enters your iron filter and passes down through the filter media. Any iron, manganese or hydrogen sulfide present in your water supply is exposed to oxygen stored in the filter media. The oxygen causes precipitation of the minerals and they are trapped in the filter media. Only clean, filtered water flows to your household water line. The filter media is periodically regenerated automatically, backwashing the trapped minerals to the drain and regenerated by replacing the oxygen. This is done by introducing potassium permanganate to the media.

1. In the service position, filtered water is supplied for household use.
2. The automatic control reverses the flow of the water through the filter, backwashing minerals trapped in the filter to the drain. Untreated water is automatically bypassed for household use.
3. The control pulls a vacuum on the potassium permanganate container, drawing an exact volume of saturated potassium permanganate solution into the filter tank.
4. The control slowly rinses the chemical through the media tank. The potassium permanganate supplies oxygen to the filter media.
5. The control fast rinses the media bed to settle it and to ensure that all the chemical and mineral precipitate is removed.
6. The control adds the correct amount of water to the previously evacuated container in preparation for the next regeneration.
7. The control puts the system into service, supplying iron-free water to the household.






1. Control Valve
2. Fiberglass Pressure Vessel
3. Distribution Tube
4. Media consisting of manganese greensand, fine gravel and coarse gravel
5. Distributor
6. Potassium Supply Line
7. Potassium Permanganate Solution Container

# Sizing a Greensand Filter

### Determine Size of Filter

a. Verify the pumping rate

b. In most cases the pumping rate and service flow rate will be similar

c. Choose the size of filter with a backwash rate equal to or slightly less than the pumping rate.

(In some cases, such as agricultural applications, the pumping rate may exceed the required domestic service flow rate. In this situation, determine the size of the filter based on the required service flow rate.)

### How to Measure the Pumping Rate

1. Make certain no water is being drawn. Open spigot nearest pressure tank. When pump starts, close tap and measure time (in seconds) to refill pressure tank. This is cycle time.
2. Using a container of known volume, draw water and measure the volume in U.S. gallons until the pump starts again. This is draw down.
3. Divide the draw down by the cycle time and multiply the result by 60. This will give you the pumping rate in U.S. gallons per minute.

*Example:*

Draw down = 7.0 gallons

Cycle time = 80 seconds

7.0 gallons ÷ 80 seconds = 0.0875 x 60 seconds

= 5.25 U.S.gpm

*Caution:*

Do not rely on the pump label tank capacity or a well driller's report as an alternative to using the above procedure to measure actual pumping rate. This procedure should be repeated to confirm accuracy.

### Compensated Iron

Manganese and hydrogen sulfide have a higher oxygen demand and are more difficult to oxidize than iron. Therefore you must calculate iron x 1, manganese x 2 and hydrogen sulfide x 3.

### Calculate Loading Factor

a. Determine the iron content in mg/l and multiply this figure by 1 ______________

b. Determine the manganese content in mg/l and multiply this figure by 2 ______________

c. Determine the sulfur content in mg/l and multiply this figure by 3 ______________

d. Total compensated loading factor (a + b + c should not exceed 10 mg/l) ______________

### Determine the Size of Filter Required

a. Number of people in the home x 60 gallons per person ______________

b. Multiply this figure by the total compensated loading factor (above) ______________

c. This equals the daily removal capacity requirement

d. Multiply this figure by 3 days. ______________

Referring to the Greensand Filter spec sheets, select the model of Filter that will provide this capacity while keeping in mind the pumping rate available to backwash the filter ______________

### Determine the Frequency of Regeneration

a. Capacity between regenerations ______________

b. Divide by the total compensated loading factor in mg/l ______________

c. This equals the number of gallons supplied between regenerations ______________

d. Subtract reserve capacity (number of people x 75 gallons) ______________

e. This equals the number of gallons for setting the control ______________

(If applicable, the water usage should be increased to include the water necessary to regenerate a 60,000 grain or larger water softener, if installed.)

# How Long Will the Potassium Permanganate Last? LEVEL 2

- Potassium permanganate will be delivered in 2 oz or 4 oz doses each time the filter cycles.
- It is important to not run out of potassium permanganate as the filter bed will be stripped and manganese will be released into the water supply, causing staining.
- The temperature or area in which the filter is installed affects the amount of chemical delivered. At higher than usual temperatures, a little more chemical will be dissolved and fed; and at lower temperatures, a little less will be fed.
- Determine frequency of regeneration using the following formula:

  ppm capacity between regenerations
  ÷ by ppm of compensated iron in water sample
  = number of gallons
  \- reserve capacity (no. of people x 70 gallons)
  = no. of gallons of filtered water between regenerations
  ÷ 60 gallons of water per person per day
  ÷ no. of people
  = approximate no. of days between regenerations

*Example -*
Based on using a 10" filter:

6000 ppm capacity
÷ 8 ppm
= 750 gallons
\- 240 gallons
= 510 gallons
÷ 60 gallons per person per day
÷ 4 people
= 2.125 days between regenerations

Use 2 days between regenerations

- Determine how long the potassium permanganate will last by using the following formula:

  Weight of the potassium permanganate
  ÷ weight of each regeneration dose (2 oz or 4 oz)
  = number of regenerations available
  x number of days between regenerations
  = number of days to consume all the potassium permanganate

*Example -*

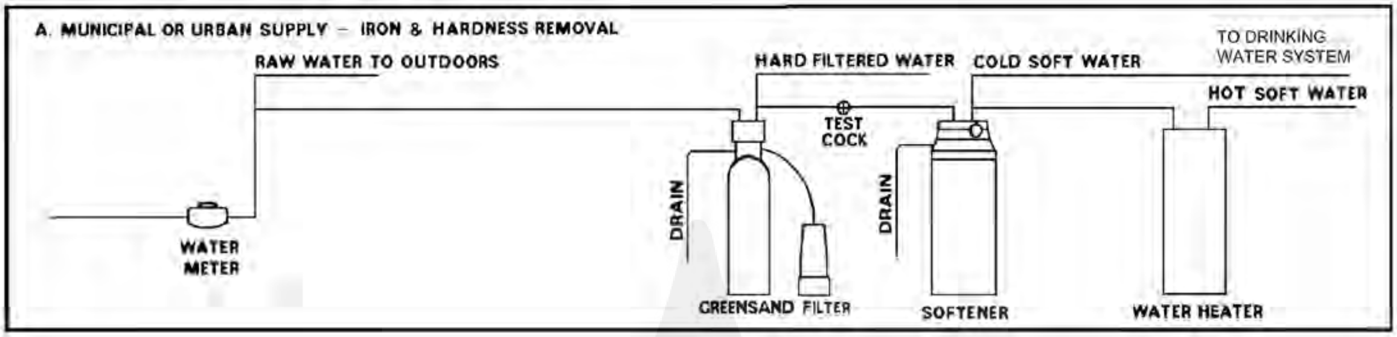
10 lbs (160 oz) potassium permanganate
÷ 4 oz per regeneration
= 40 regenerations
x 2 days between regenerations
= 80 days to consume 10 lbs of potassium permanganate



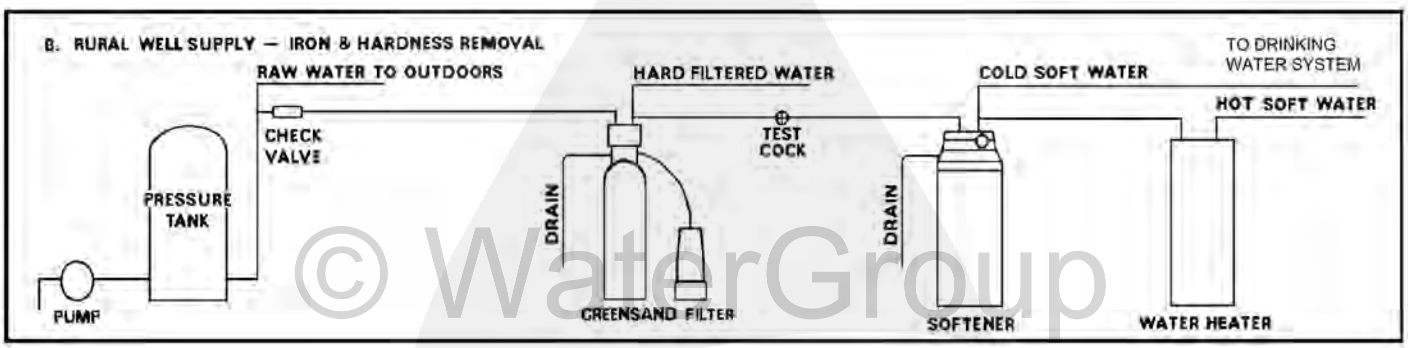
- Or refer to the following chart to determine how long the chemical will last. Determine the expiry date and record it.

| FREQUENCY OF REGENERATION | 2 OUNCE FEED COLD 35-50°F (1-10°C) | 2 OUNCE FEED NORMAL 55-70°F (12-21°C) | 2 OUNCE FEED WARM 75-90°F (24-32°C) | 4 OUNCE FEED COLD 35-50°F (1-10°C) | 4 OUNCE FEED NORMAL 55-70°F (12-21°C) | 4 OUNCE FEED WARM 75-90°F (24-32°C) |
|---|---|---|---|---|---|---|
| Every day | 3 Mos. | 2 Mos. | 1.5 Mos. | 1.5 Mos. | 1 Mos. | 0.5 Mos. |
| Every 2 days | 6 Mos. | 4 Mos. | 3 Mos. | 3 Mos. | 2 Mos. | 1 Mos. |
| Every 3 days | 9 Mos. | 6 Mos. | 4.5 Mos. | 4.5 Mos. | 3 Mos. | 1.5 Mos. |
| Every 4 days | 12 Mos. | 8 Mos. | 6 Mos. | 6 Mos. | 4 Mos. | 3 Mos. |
| Every 6 days | 18 Mos. | 12 Mos. | 9 mos. | 9 Mos. | 6 Mos. | 3 Mos. |

### *Municipal or Urban Supply*




### *Rural Well Supply*






## Notes

# Advantages & Disadvantages

### *Advantages*

1. Effective oxidizer for hydrogen sulfide
2. Fully automatic

### *Disadvantages*

1. Does not remove bacterial iron
2. Limited capacity for removal of iron, manganese and hydrogen sulfide
3. Requires the use and replenishment of potassium permanganate

## Manganese Greensand Application Guidelines

| | | | | |
|---|---|---|---|---|
| Media Cubic Feet | .75 | 1.0 | 1.5 | 2.0 |
| Total Rated Capacity - mg/l gallons | 6,000 | 9,000 | 12,000 | 16,000 |
| Compensated Iron Removal Capacity Between Regenerations - mg/l gallons | 4,500 | 6,000 | 9,000 | 12,000 |
| Maximum Combination of Iron x 1, Manganese x 2, H2S x 3 - mg/l | 10 | 10 | 10 | 10 |
| *Ferrous Iron Only - mg/l | 7 | 7 | 7 | 7 |
| Manganese Only - mg/l | 5 | 5 | 5 | 5 |
| Hydrogen Sulfide Only - mg/l | 3 | 3 | 3 | 3 |
| Bacterial Iron - mg/l | 0 | 0 | 0 | 0 |
| Organic Iron - mg/l | 0 | 0 | 0 | 0 |
| Tannins - mg/l | 0 | 0 | 0 | 0 |
| Minimum pH | 7.0 | 7.0 | 7.0 | 7.0 |
| Backwash Rate Required - USGPM | 3.5 | 5 | 7 | 10 |
| Minimum Pressure Required - psi | 20 | 20 | 20 | 20 |
| Continuous Service Flow Rate - USGPM | 4 | 5 | 8 | 10 |
| Factory Set Regeneration Time - p.m. | 11:00 | 11:00 | 11:00 | 11:00 |
| Potassium Permanganate per Regeneration - ounces | 2 | 4 | 4 | 8 |

# Chemical Free Iron Filtration

## *Chemical Free Iron Filter Concept*

This filter facilitates the removal of iron by the introduction of a small amount of air into a system, sufficient to start oxidation of the iron but not sufficient to complete the oxidation prior to the water passing through the special filter media. Here, the media causes the pH to rise to approximately 8.5. The oxidation process is completed and the iron is attracted by the media, thus removing all iron from the water. The chemical free iron filter removes ferric (red water) iron, ferrous (clear water) iron and bacterial iron.

## *How is a Controlled Amount of Air Introduced into the System?*

The air injector is installed ahead of the pressure tank and is set to aspirate air for a minimum of 20 seconds whenever the well pump runs. Use the adjuster on the air injector to increase or decrease the time of aspiration.

## *Pumping Rate*

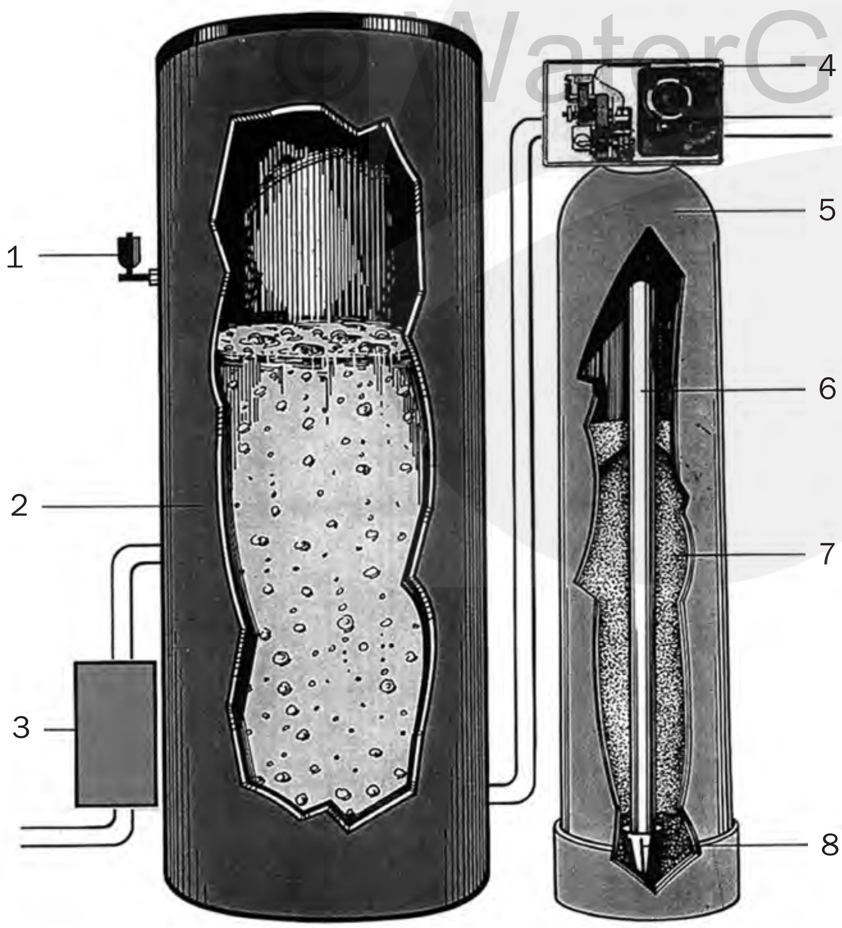
Having sufficient pumping rate is critical. The air injector simply will not aspirate with less than 3.5 gpm pumping rate.

## *Filter*

A backwashing type filter containing a special media causes the iron in the water to precipitate throughout the filter bed. The media requires no chemical regenerant for oxygen enrichment.

The clean, filtered water then flows into your household water line. Depending on water use and the concentration of iron in your water, periodic backwashing is required to flush the entrapped iron from the system. During backwash, untreated water is automatically bypassed for household use.






1. Air Vent Assembly
2. Pressure Tank
3. Air Injector
4. Control Valve
5. Fiberglass Pressure Vessel
6. Distributor Tube
7. Filter media consisting of mag oxide, calcium carbonate, fine filter sand and support gravel
8. Distributor

## *Sizing*

Sizing chem free iron filters should be based on the following:

1. The measured pumping rate of the system must exceed the backwash requirements of the filter selected plus an additional 0.5 USGPM to compensate for any loss through the air injector
2. The user's service flow rate requirements
3. The levels of iron, manganese, hydrogen sulfide and the pH of the water shown on the water analysis will determine whether you require an "A" model or an "M" model.

## *How to Measure the Pumping Rate*

1. Make certain no water is being drawn. Open spigot nearest pressure tank. When pump starts, close tap and measure time (in seconds) to refill pressure tank. This is cycle time.
2. Using a container of known volume, draw water and measure the volume in U.S. gallons until the pump starts again. This is draw down.
3. Divide the draw down by the cycle time and multiply the result by 60. This will give you the pumping rate in U.S. gallons per minute.

*Example* -

Draw down = 7.0 gallons

Cycle time = 80 seconds

7.0 gallons ÷ 80 seconds = 0.0875 x 60 seconds = 5.25 U.S.gpm

*Caution* - Do not rely on the pump label tank capacity or a well driller's report as an alternative to using the above procedure to measure actual pumping rate. This procedure should be repeated to confirm accuracy.

## *Iron Content*

For purposes of the chemical free iron filter, concentrations of manganese and hydrogen sulfide are considered equivalent to iron.

## *pH*

- There must be a minimum pH of 6.5 and the water must be less than one grain hard for a standard "A" model to achieve good pH correction from 6.5 to 8.5. Iron will readily oxidize when the pH is 7.0 or higher. With pH below 7.0, the magnesium oxide in the filter becomes sacrificial as it raises the pH. Water hardness will increase.
- With a pH of 6.5, it will be necessary to add 1 jar of MPH adder twice a year to the filter bed. With a pH of 7.0 or higher and no manganese, MPH adder will not have to be added.
- When the pH is below 7.0 and hardness is above 1 gpg or the water has up to 1.0 mg/l of manganese, an "M" model must be used which contains a higher percentage of magnesium oxide to raise the pH.
- Do not use an "M" model when there is no manganese in the water as it may raise the pH too high.
- When manganese is present and an "M" model is used, add MPH adder twice a year for every full measurement below 8.5
- If the TDS of the water is above 1500 ppm and the pH of the water is above 7.0, good pH correction will not be achieved. Therefore, if you require a pH boost to 8.0 for manganese removal, the media will not be able to do it. The water does not readily dissolve the pH additive portion of the media at normal flow rates once the TDS is over 1500 ppm. In this case, pump soda ash.

### *Determine the Frequency of Backwash (Normal Applications)*

a. For households with average water, this table can be used. Locate the box intersected by the number of people in your family and the parts per million (ppm) of iron in your water (or next higher).

b. The number in the box represents how many times your filter has to backwash in a twelve day schedule.

| People in Family | Iron Content (ppm) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| 3 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| 4 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 4 | 4 | 4 |
| 5 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 6 | 6 |
| 6 | 1 | 2 | 2 | 3 | 3 | 4 | 6 | 6 | 6 | 6 |

### *Determine the Frequency of Backwash (Higher Iron Content or High Demand)*

a. Number of people in the home x 60 gallons per person ________________

b. Multiply this figure by the total ppm of iron, manganese and $H_2S$ ________________

c. This equals the daily removal requirement ________________

d. Divide the iron removal capacity between backwashes by 'c' ________________

e. Round down to obtain the number of days between regenerations ________________



## Notes

# Installation Guidelines

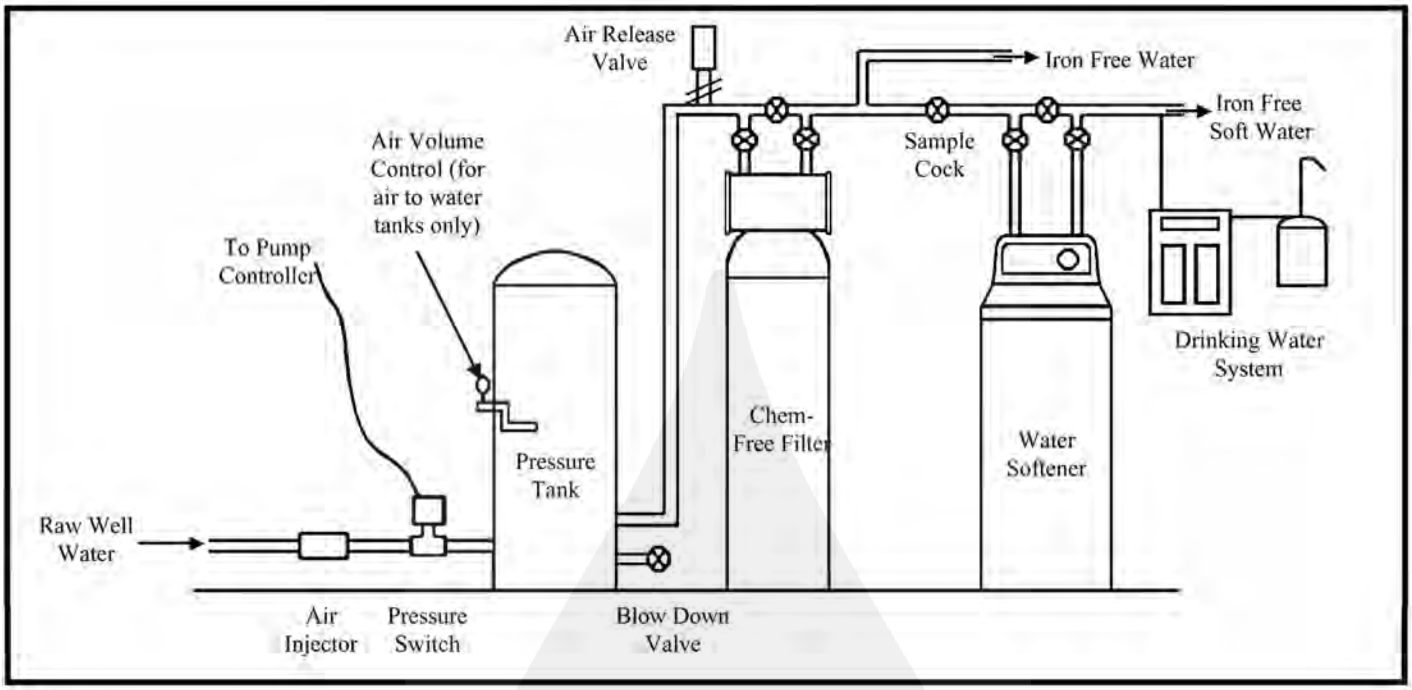
It is imperative that the equipment be installed in the following order:

1. Air Injector
2. Pressure Switch
3. Pressure Tank
4. Auxiliary Pressure Tank or Mixing Tank (optional - based on application)
5. Air Release Valve or Air Volume Control
6. Maximum 3/4" Plumbing from the Pressure Tank to the Filter
7. Chem Free Iron Filter

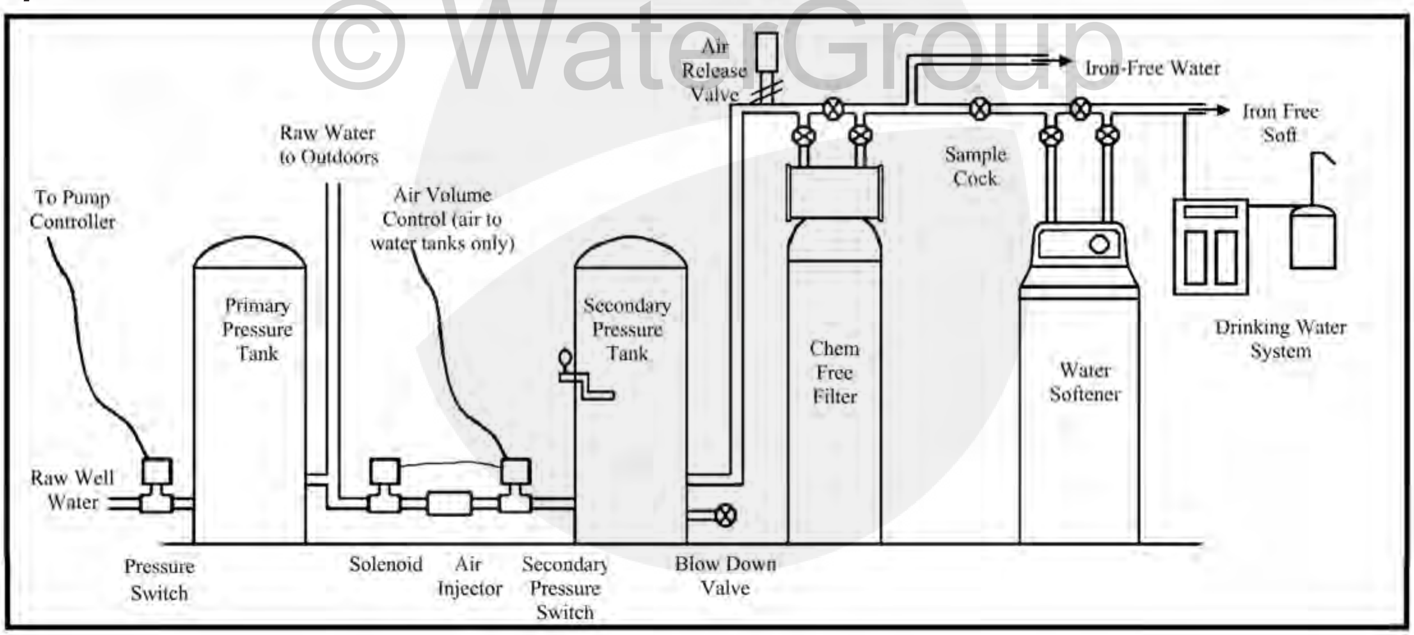
- It is necessary to have a minimum 6" of uninterrupted straight line on the inlet and outlet of the air injector.
- A minimum pump cycle time of 60 seconds is recommended. Rapid pump cycling may occur if the pressure switch precedes the air injector. This can be remedied by plumbing the pressure reading line into the line or tank after the air injector.
- The air injector should be adjusted to aspirate or draw air for 1/3 of the pump cycle time. If the cycle time is only 40 seconds, set the air injector to aspirate approximately 1/2 the cycle time (minimum 20 seconds) to ensure sufficient air to start the oxidation process.
- The unit should be backwashed right after installation so the media bed can be totally mixed to prevent it from cementing. Backwash until the water runs free of fines.
- It is also important to backwash the unit after MPH has been added until the water runs free of fines.
- The freeboard above the media must be at least 15".
- During the first day or two after installation, some iron will slip through the system. Depending on the application, the unit should totally remove the iron after two days.
- This filter, unlike conventional filters, works better when the media becomes somewhat dirty or iron-fouled. Therefore, we suggest following the regeneration frequency chart in the manual. It can be detrimental to backwash a chem free system too often.
- The backwash water at the end of the backwash cycle should not be clear. The filter works better when the media is slightly coated with iron.
- The air injector can be installed vertically or horizontally but you must remain aware of the proper direction of the flow water indicated by the arrow and the 6 " of uninterrupted line on the inlet and the outlet.
- Although there are advantages to using an air to water pressure tank, captive air and bladder tanks can be and are most commonly used with an air release valve at a high point in the plumbing prior to the filter. However, if any hydrogen sulfide is present, an air to water pressure tank should be installed. If an air to water pressure tank is used, an air volume control or air release valve would be installed on the side of this tank.
- In remote pumping systems, a split-stream installation should be followed with the air injector installed prior to the secondary pressure tank. This will prevent iron fouling of the plumbing from the pump if the air injector is installed near the pump.
- Locate the filter as closely as possible to the pressure tank to eliminate fouling of the connecting plumbing.
- ***Contact the manufacturer when water analysis show extreme conditions - high iron, low pH, high TDS, etc.***

# Typical Installations

### *Standard Installation*




### *Split Stream Installation*






*An air release valve must be used with bladder tanks.

# Advantages & Disadvantages



### *Advantages*

1. Unlike conventional filters, it removes bacterial iron
2. It has no upper limit for iron removal
3. Not affected by hardness
4. No chemicals (potassium permanganate, chlorine, etc.) are required for regeneration
5. Because it regenerates less often than other iron filters and uses as little as 50 gallons for total backwash, this equates to less than 10% of the water used by other types of iron filters
6. The fully automatic control valve features adjustable backwash times, time of day settings and frequency of backwash. As a result, a short cycle can be set which allows the user to have filtered water at all times except for the 22 minutes required for periodic backwashing.

### *Disadvantages*

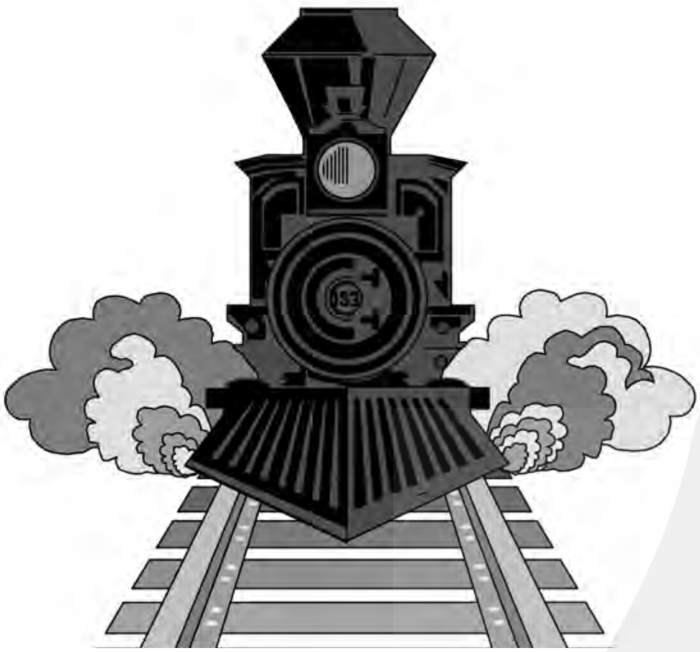
1. Limited capacity for removal of manganese and hydrogen sulfide
2. A portion of the media may be sacrificial and may need to be replenished
3. Installation requires an air injector and an air release valve
4. May increase the hardness of the water being treated

* Ferrous & Ferric Iron
** With the installation of an air to water pressure tank and the proper ventilation, the chemical free iron filter can remove up to 3.0 mg/l of H2S.
† If above these limits, consult your dealer or the manufacturer.

## Chemical Free Application Guidelines



| Media Cubic Feet | .75 | .75M | 1.0 | 1.0M | 1.5 | 1.5M | 2.0 | 2.0M |
|---|---|---|---|---|---|---|---|---|
| Total Rated Capacity - mg/l gallons | 22,500 | | 30,000 | | 60,000 | | 90,000 | |
| Total Iron Removal Capacity Between Regenerations - mg/l gallons | 11,250 | | 15,000 | | 30,000 | | 45,000 | |
| Maximum Combination of Iron, Manganese & H2S - mg/l | 30+ | 30+ | 30+ | 30+ | 30+ | 30+ | 30+ | 30+ |
| Maximum Iron* - mg/l† | 30+ | 30+ | 30+ | 30+ | 30+ | 30+ | 30+ | 30+ |
| Maximum Manganese - mg/l† | 0 | 1.0 | 0 | 1.0 | 0 | 1.0 | 0 | 1.0 |
| Maximum $H_2S$** - mg/l† | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Bacterial Iron - mg/l | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Organic Iron - mg/l | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tannins | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Minimum pH | 7.0 | 6.5 | 7.0 | 6.5 | 7.0 | 6.5 | 7.0 | 6.5 |
| Backwash Rate Required - USGPM | 3.5 | 3.5 | 4 | 4 | 5 | 5 | 7 | 7 |
| Minimum Pressure Required - psi | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Peak Service Flow Rate - USGPM | 4 | 4 | 6 | 6 | 10 | 10 | 15 | 15 |
| Continuous Service Flow Rate - USGPM | 2 | 2 | 3 | 3 | 4 | 4 | 5 | 5 |
| Factory Set Regeneration Time - a.m. | 1:00 | 1:00 | 1:00 | 1:00 | 1:00 | 1:00 | 1:00 | 1:00 |



# The Iron Horse of Iron Filters

## Summary

*Level 1*

1. Iron, manganese and hydrogen sulfide in water can cause staining and scaling as well as taste and odor problems.
2. Iron is found as ferrous iron (in solution), ferric iron (oxidized), bacterial iron and organic iron.
3. Iron, manganese and hydrogen sulfide must be oxidized before removal by filtration. Common processes used are aeration, manganese greensand filtration, chemical free iron filtration and chlorination. Ion exchange can also be used to remove iron.
4. A manganese greensand filter oxidizes and captures the iron in the filter media. The oxygen in the media must be occasionally replenished by regenerating with potassium permanganate.
5. A chemical free iron filter uses an air injector to inject oxygen into the water supply, causing the iron to oxidize and precipitate in the filter media. The bed must be cleaned by periodic backwashing.

*Level 2*

1. Manganese greensand filters and chemical free iron filters must be sized by matching the backwash rate and the peak service flow rate to the pumping rate.
2. The frequency of regeneration is determined by multiplying the water usage times the loading factor, divided into the capacity of the unit. When using a manganese greensand filter, the manganese and hydrogen sulfide content must be compensated times 2 and 3 respectively to obtain the total compensated loading factor.
3. The life of the potassium permanganate supply can be determined by multiplying the number of regenerations available from the supply times the days between regenerations.
4. Chemical free iron filters require a minimum pH of 6.5. Manganese greensand filters require a minimum pH of 7.0.
5. A chemical free iron filter contains magnesium oxide which is sacrificial as it can increase the pH from 6.5 to 8.5 to facilitate the removal of iron and manganese.



WaterGroup

Product & Application Training

# SECTION 2

## Drinking Water



WaterGroup

#57709Rev 3/09

# Reverse Osmosis

## Objectives

### *Level 1*

1. To be familiar with the common terminology regarding reverse osmosis
2. To be familiar with the concept of reverse osmosis and cross-flow filtration
3. To be familiar with the benefits of reverse osmosis
4. To be familiar with the factors affecting the performance of reverse osmosis systems

### *Level 2*

1. To be able to select an appropriate reverse osmosis system to meet specific needs, including the completion of a work-sheet necessary to size a system.

# Glossary

**Activated Carbon** - A form of elemental carbon whose particles have a large surface area with high adsorptive qualities, primarily used to remove chlorine, objectionable tastes and odors and numerous toxic organic compounds from water.

**Adsorption** - The process by which particles and molecular impurities adhere to the surface of activated carbon. It is an electro-chemical attraction.

**Air Gap** - a clear, vertical space designed to prevent a cross connection between potable and waste (non-potable) water in the event of backflow or siphonage.

**Bacteria** - primitive single cell structures called prokaryotes. Bacteria cells range in size from less than 1 to 10 microns in length and from 0.2 to 1 micron in width and can be helpful to man (decomposing organic waste material or fermentation) or harmful (disease producing).

**Bactericide** - an agent capable of destroying bacteria

**Bacteriostatic** - A feature of a filter that is designed to inhibit the growth of bacteria within the filter, usually by the addition of silver.



**Brackish Water** - Water containing between 1000 and 1500 mg/l of dissolved solids is generally considered to be brackish.

**Brine** - a common term for reject water which carries the impurities to the drain.

**Carcinogen** - a substance or agent capable of producing or inciting cancer.

**Cellulose Acetate (CA) and Cellulose Triacetate (CTA)** - A family of synthetic materials based on cellulose used to make Reverse Osmosis membranes. While CTA is superior to CA, under adverse water conditioning both are effective in removing a wide spectrum of impurities from water. The disadvantage of cellulose-type membranes is that they are subject to bacterial attack, particularly in unchlorinated water supplies.

**Chloramines** - Chemical complexes formed from the reaction between ammonia and chlorine. They are presently being used to disinfect municipal water supplies because, unlike chlorine, they do not combine with organics in the water to form potentially dangerous carcinogens such as trihalomethanes (THMs). Chloramines can exist in three forms, the proportions of which depend on the physical and chemical properties of the water. Water containing chloramines may not be used for fish and kidney dialysis equipment.

**Chlorine ($Cl_2$)** - A chemical in the form of a liquid or gas used to disinfect water. It is known to react with organic matter in the water to form trihalomethanes (THMs), a suspected carcinogen.

**Concentrate (same as reject)** - that portion of the feed water that does not pass through the R.O. membrane and which carries the remaining impurities to the drain.

**Conductivity** - A measure of the ability of a substance to transmit an electrical current. The conductivity imparted to water by dissolved solids is a function of both the amount and composition of the salts and of the temperature of the water.

**Contact Time** - The length of time water is in direct contact with activated carbon. This is a major factor in determining how effectively organic impurities will be removed.

**Cross Connection** - a direct link between a potable water system and a non-potable or waste system which could result in undesirable substances being drawn into potable water.

**Cryptosporidium** - a protozoan parasite that produces an environmentally stable cyst, that is highly resistant to disinfection but can be removed by fine filtration or distillation. In humans, this waterborne parasite causes acute gastro-intestinal illness (AGI). Symptoms of AGI may include severe dehydration, weight loss and fatigue.

**Cyst (same as spore)** - A unicellular reproductive body of an organism that is capable of germinating directly without an embryo to form a new individual. In water most cysts resist adverse conditions that would readily kill the parent organism. Sometimes considered the resting stage of an organism.

**Feed Pressure** - The pressure at which water is supplied to the R.O. module.

**Feed Water** - A term which refers to the water supply that is put into a water treatment system for processing (removal of impurities).

**Flux** - The flow rate of water through reverse osmosis membranes, per square foot of surface.

# Glossary

**Fouling** - The process of depositing impurities on the membrane surface, thus impeding normal function. Can be due to the presence of suspended solids, precipitated salts or biological growth. Causes a decrease in both the amount of water produced and the quality of water.

**Giardia Lambia** - a small, protozoan parasite that inhabits the intestines of a variety of animals. Often referred to as "beaver fever". Responsible for acute gastro-intestinal illness (AGI) in humans.

**Heavy Metals** - metals having a high density or specific gravity of 5.0 or higher. A generic term used to describe contaminants such as cadmium, lead and mercury. Most are toxic to humans in low concentrations.

**Hydrolysis** - The chemical degradation of an R.O. membrane in water due to certain conditions such as high pH. Cellulose based membranes are quite susceptible to hydrolysis while the TFC type are virtually immune.

**Mechanical Filtration** - The process of removing suspended particles form water by a straining action. The finest mechanical filters can remove bacteria as small as .2 microns.

**Micron** - A unit of length, one millionth of a meter. The smallest particle that can be seen by the naked eye is about 40 microns across. The smallest bacteria is about .2 microns across. 1 micron = .00004 in.

**Mineral Salts** - The form in which minerals from dissolved rock exist in water. Same as Total Dissolved Solids. This is the so-called inorganic form of minerals. In excess, they cause water to have a disagreeable taste. Some are harmful to human health.

**Module** - A membrane element combined with the membrane element housing.

**Molecule** - the smallest physical unit of a substance, composed of one or more atoms, that retains the properties of that substance.

**Molecular Weight** - The sum of the atomic weights of the individual atoms (from a periodic chart) that make up a molecule of a particular substance (e.g. H201 H = 1 atomic weight, 0 = 16 atomic weight, therefore, molecular weight = 2 + 16 = 18.) Cellulose based membranes can remove substances as light as MW of 300, while TFC type membranes remove substances as light as MW of 200.

**Organics** - Any of the compounds whose chemical structure is based on carbon (e.g. carbon dioxide, wood, sugar, protein, plastics, methane, THM, TCE, etc.)

**Osmosis** - The natural tendency for water molecules to pass through a semi-permeable membrane from the side low in dissolved impurities to the side high in dissolved impurities.

**Osmotic Pressure** - The pressure created by the tendency of water to flow in osmosis. Every 100 ppm of TDS generates about 1 pound per square inch (psi) of osmotic pressure. This osmotic pressure must first be overcome by the water pressure for the Reverse Osmosis membrane to be effective.

**Parasite** - an organism that lives on or in the body of another from which it obtains its nutrients.

**Parts per Million (ppm)** - The measure of TDS. The parts of Total Dissolved Solids per one million parts of water (e.g. one pound of mineral salts dissolved in one million pounds of water will give one part per million of TDS or ppm).

**PCB - Polychlorinated Biphenyls** - A highly toxic organic contaminant found in water supplies which is suspected of causing cancer in humans.

**Permeate (same as product water)** - that portion of the feed stream that passes through a membrane.

**pH** - The acidity or alkalinity of water due to dissolved solids and measured on a scale of 1 to 14; 7 being neutral, 1 being most acid and 14 being most alkaline.

**Polyphosphate -** a group of molecularly dehydrated phosphates commonly referred to as "glasses". Used in water treatment to sequester hardness or "tie up" ferrous iron or manganese to inhibit normal oxidation or to control corrosion by depositing a thin, glass-like film on water lines, etc.

**Polyphosphate Feeder** - a vessel or cartridge containing polyphosphate through which water is allowed to flow prior to entering a membrane.

**Pore** - an opening in a membrane or filter matrix.

**Potable** - water which is safe and suitable for human consumption.

**Pretreatment** - Whatever alterations of the raw feed water are required to prevent damage to the membrane.

# Glossary

**Product Water** - The pure water that has been separated from the feed water stream by the reverse osmosis membrane.

**Pyrogens** - any substance capable of producing a fever in mammals. Often an organic substance shed by bacteria during cell growth. Chemically and physically stable, not necessarily destroyed by conditions that kill bacteria.

**Recovery** - The amount of product water as compared with the total amount of feed water. This will give a measure of the efficiency of operation. For example, starting with 10 gallons of feed water, if we separate 6 gallons into product water and reject 4 gallons, the recovery is 60%.

**Rejection** - The percentage of TDS removed from the feed water. Typically greater than 90% rejection is achieved with reverse osmosis.

Reject Water - That portion of the fed water that does not pass through the R.O. membrane and which carries the remaining impurities to the drain.

**Reverse Osmosis (R.O.)** - A reversal of the natural phenomenon of osmosis brought about by application of hydraulic pressure greater than the osmotic pressure water (containing dissolved solids to cause the water molecules to flow through the membrane away from the dissolved substances.

**Sediment** - The sum of particles of dirt, clay, silt and vegetation which float or are suspended in water and can be removed by mechanical filtration. See Turbidity.

**Semi-permeable** - A term which applies to special materials both natural and synthetic which allow certain substances such as water to pass through (permeate) while blocking or rejecting the passage of other substances such as dissolved solids and organics.

**Sequester** - literally, to isolate or seclude by forming a complex molecule with an ion to prevent its normal chemical reaction.

**Spiral Wound** - The most common practical configuration for a Reverse Osmosis membrane in which sheets with large surface area are wrapped in a spiral fashion to fit in a small space.

**Spore** - a unicellular reproductive body of an organism that is capable of germinating directly without an embryo to form a new individual. In water, most spores resist adverse conditions that would readily kill the parent organism. Sometimes considered the resting stage of an organism.

**TCE (Trichloroethylene)** - One of the more common toxic organic contaminants found in water. It is a constituent of numerous home, industrial and dry cleaning solvents.

**(TFC) Thin Film Composite** - The most advanced membrane made with a polyamide based polymer. It exhibits superior performance, immunity to adverse water conditions and is the only membrane material that is truly bacteria proof.

**THMs (Trihalomethanes)** - A group of suspected carcinogenic organic chemicals formed in water when chlorine (used as a disinfectant) reacts with naturally occurring organic matter such as by-products of decayed vegetation (e.g. humic acid). One of the most common THMs is chloroform.

**Total Dissolved Solids** - Generally, the total amount of mineral salts and metals which are dissolved in water.

**Toxic Metals** - Elemental metals that find their way into water supplies from natural and industrial sources and which are detrimental to human health (e.g. lead, cadmium, mercury, arsenic).

**Toxic Organics** - Carbon-based chemicals which are frequently found in our water supplies and are harmful to human health. They are usually from agricultural and industrial effluents and hazardous waste dumps (e.g. TCE, PCB, DCBP, pesticides, etc.)

**Turbidity** - Suspended biological, inorganic and organic particles in water which may be in sufficient amount to make the water seem cloudy. See Sediment.

**Virus** - any of a large group of sub-microscopic infective agents that usually cause disease and are capable of growth and multiplication only in the living cells of a host.

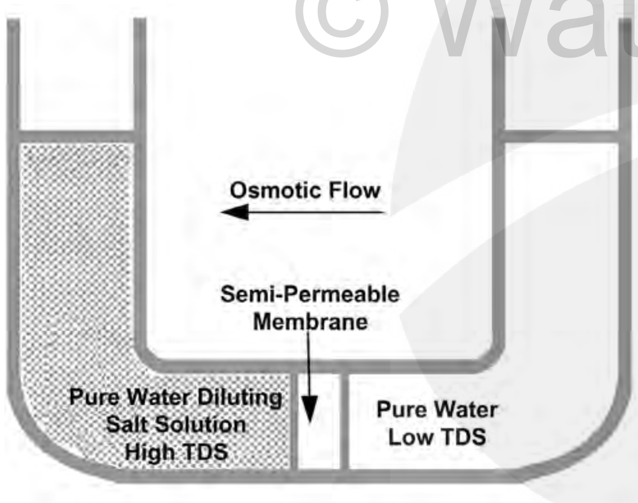
**Volatile Organic Compound (VOC)** - synthetic organic compounds that readily pass off by evaporation. Many are suspected carcinogens.

# Osmotic Flow

## *Natural Osmotic Flow*

The term "reverse osmosis" is derived from "osmosis", the natural phenomenon that provides water to all animal and vegetable cells to support life.

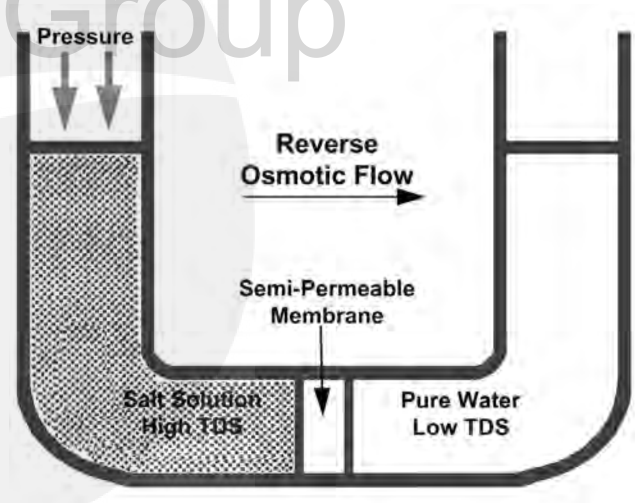
- Osmosis occurs when water passes from a less concentrated solution to a more concentrated solution through a semi-permeable membrane.
- The more concentrated solution possesses a greater potential energy.
- A fundamental scientific principle dictates that dissimilar solutions or liquids will try to reach the same concentration on both sides of the membrane.
- The only way for that to happen is for pure water to pass through the membrane to the "salt" water side in an attempt to dilute the "salt" solution.
- This attempt to reach equilibrium is call the process of osmosis.




## *Pressure is Applied*

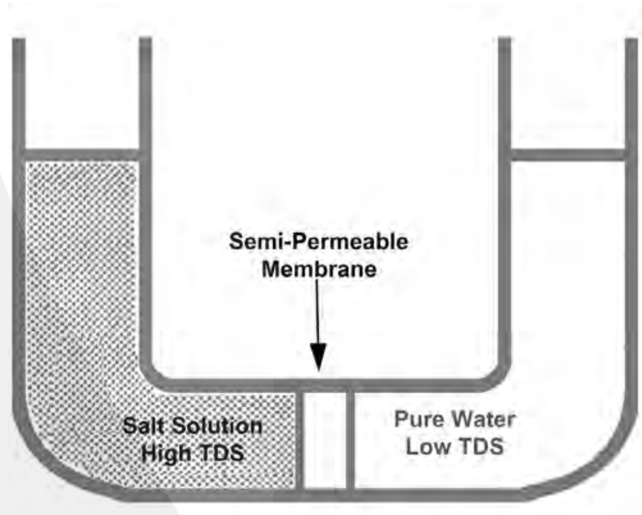
Learning from the naturally occurring process of osmosis, a method has been developed to purify water by removing salt or dissolved solids.

- The solution requires that the water be forced through the membrane in the opposite direction to reverse the natural osmotic flow leaving the dissolved solids in the more highly concentrated solution.
- This is accomplished by applying pressure to the salt water as it is fed into the system, creating the condition known as reverse osmosis.
- Osmotic pressure measures the amount of force binding water molecules to dissolved ions or more complex molecular structures.
- In order for reverse osmosis to occur, the amount of force or pressure applied must exceed the osmotic pressure.



Semi-Permeable Membranes are at the Heart of RO Systems

- The process of reverse osmosis (R.O.) is the finest level of liquid filtration available today.
- Reverse osmosis works through a technique called membrane separation. Raw water enters a module housing the membrane system. Normal water pressure or boosted pressure forces the water against the semi-permeable membrane and only clean water molecules pass through the pores in the membrane. Impurities are rejected and flushed away.
- The membrane will be permeable to water molecules but not to molecules of dissolved salt.
- If the membrane is placed between two compartments in a container with a salt solution in one half of the container and pure water in the other, water, under pressure, passes through the membrane while the salt cannot.






## Notes

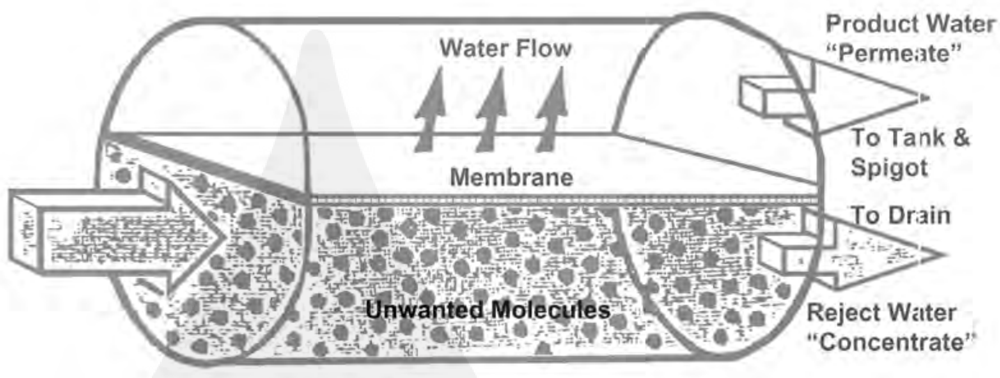
## Crossflow Filtration

While the principles of reverse osmosis are simple, in practical terms the R.O. process cannot go on indefinitely unless steps are taken to ensure that the membrane doesn't become clogged by precipitated salts and other impurities forced against it by the pressurized stream of feed water.

In crossflow filtration, two exit streams are generated--a "concentrate" stream (reject water) containing those materials which are rejected or do not pass through the membrane, and the "permeate" stream (product water) which has been pumped through the membrane.

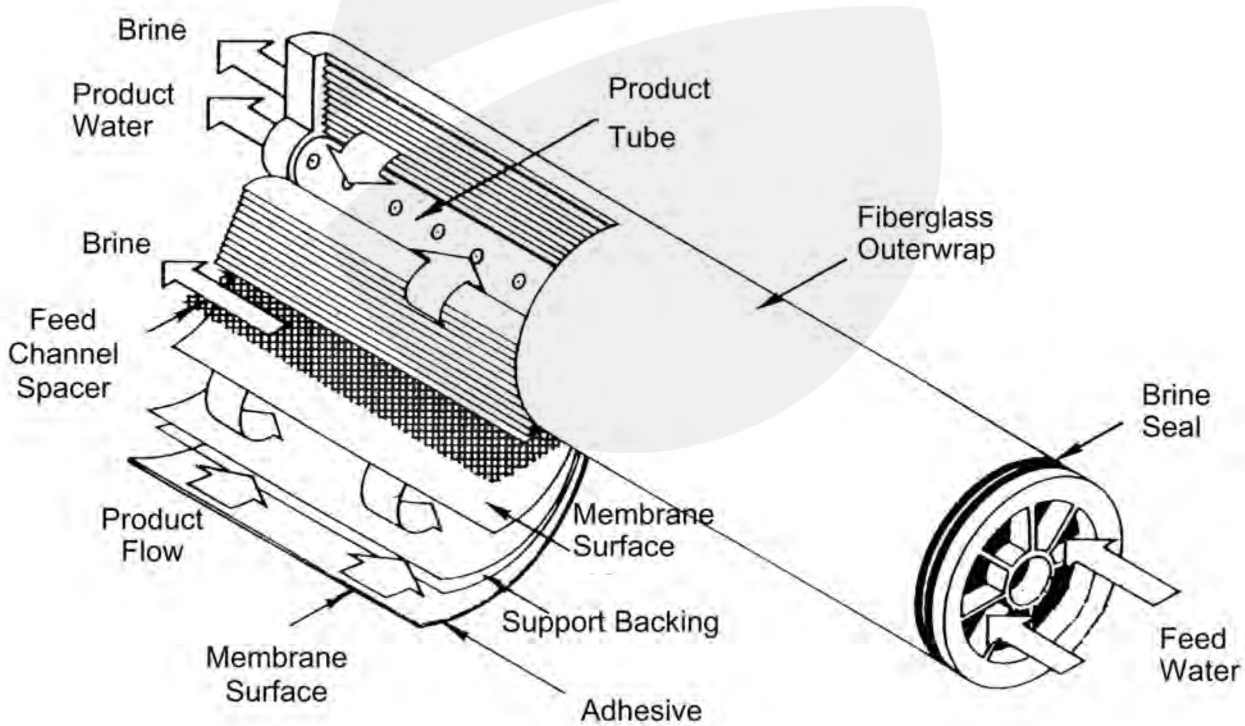
To significantly reduce the rate of membrane fouling, R.O. systems employ crossflow filtration.

In conventional filtration, the entire water solution to be filtered is pumped through the filter media and all contaminants too large to pass through the pores of the membrane are trapped or retained on the surface.




## Spiral Wound Membrane





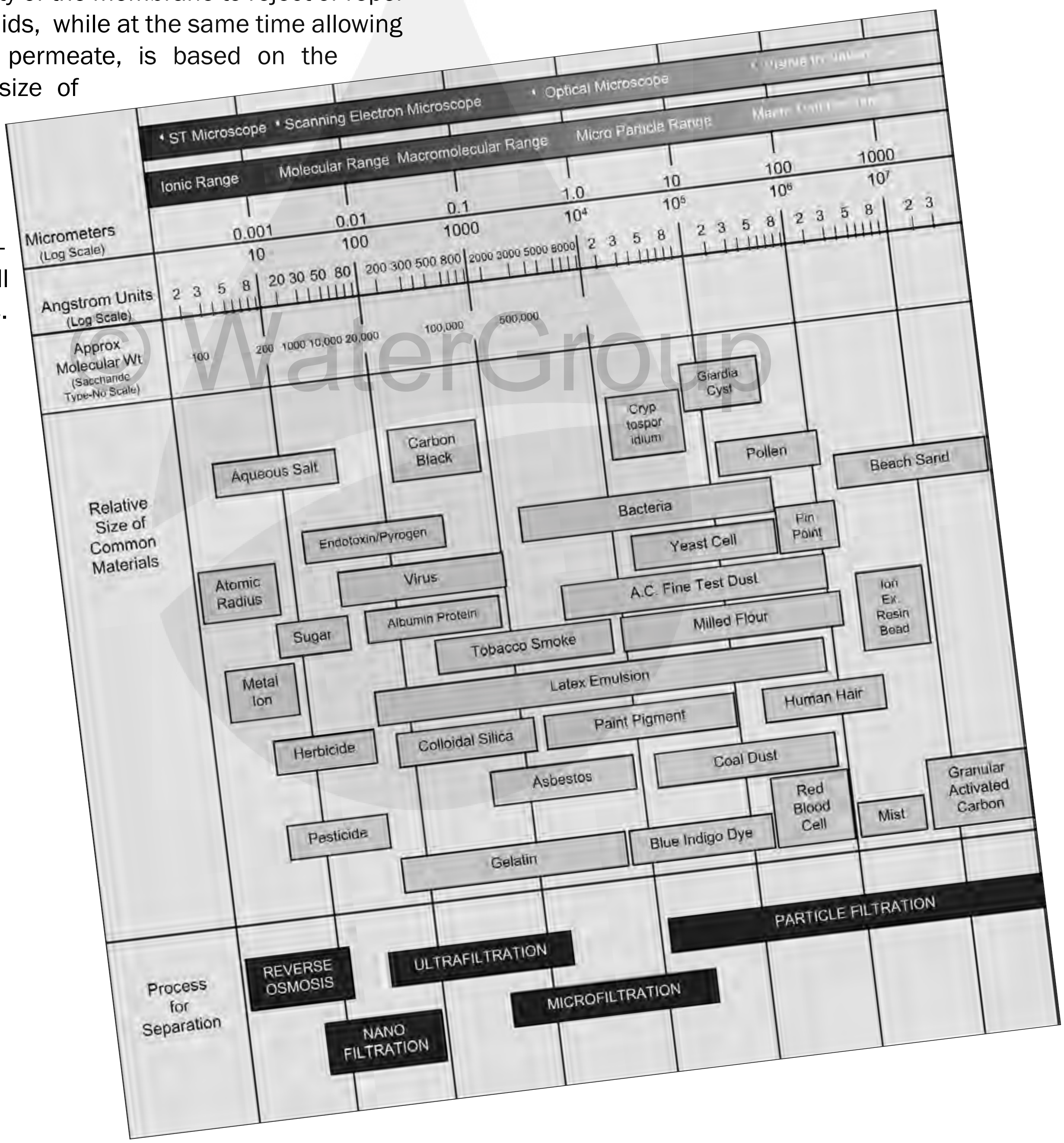
# Comparative Size of Particles

The process of purifying water by means of reverse osmosis is dependent on the ability of a semi-permeable membrane to allow the passage of water molecules while blocking other dissolved or suspended molecules. Various mineral salts, heavy metals, particulate matter, some organic molecules, bacteria and even viruses are rejected or repelled by the membrane surface based on their molecular or atomic weight. However, reverse osmosis should be applied only on bacteriologically safe water supplies.

However, the ability of the membrane to reject or repel total dissolved solids, while at the same time allowing water to readily permeate, is based on the incredibly small size of the multitude of pores that penetrate its surface. Such pores are able to reject substances as small as .0005 microns.

A micron is a metric unit of length equal to a millionth of a meter, or .00003937 inch. The symbol for the micron is the Greek letter "m". A human hair is approximately 75 m in diameter. The smallest particle that can be seen by the naked eye is 40 m across. The smallest bacteria is about .22 m while a virus is even smaller at .01 m.

The following Filtration Spectrum Chart shows the relative size of a number of common materials.



# R.O. Process Removes or Reduces

### *Mineral Salts*

- calcium, magnesium, sodium, bicarbonate, sulfate, chloride

### *Inorganic Contaminants*

- barium, mercury, arsenic

### *Particulate Matter*

- silt, sand, scale, rust

### *Organic Molecules**

- fructose, lactose, protein, dyes, formaldehyde

### *Colloidal Matter*

- extremely fine suspended solids

* Includes some larger molecules with a combined molecular weight over 200

Water to be treated must be potable.

### *Nominal Membrane Rejection Performances**

* Based on reverse osmosis membranes producing to atmosphere with 60 psi net pressure and 77°F

| Inorganic Contaminant | CTA Rejection | TFC Rejection | Inorganic Contaminant | CTA Rejection | TFC Rejection |
|---|---|---|---|---|---|
| Aluminum | 90-95% | 93-98% | Magnesium | 90-95% | 93-98% |
| Arsenic | 90-95% | 93-98% | Manganese 2 | 90-95% | 93-98% |
| Barium | 90-95% | 93-98% | Mercury | 90-95% | 93-98% |
| Bicarbonate | 85-90% | 90-95% | Nickel | 90-95% | 93-98% |
| Boron | 30-40% | 55-60% | Nitrate3 | 40-50% | 85-90% |
| Cadmium | 90-95% | 93-98% | Phosphate | 90-95% | 93-98% |
| Calcium | 90-95% | 93-98% | Potassium | 85-90% | 90-95% |
| Chloride | 85-90% | 90-95% | Radioactivity | 90-95% | 93-98% |
| Chromate | 85-90% | 90-95% | Selenium | 90-95% | 93-98% |
| Chromium | 90-95% | 93-98% | Silver | 90-95% | 93-98% |
| Copper | 90-95% | 93-98% | Sodium | 85-90% | 90-95% |
| Cyanide | 85-90% | 90-95% | Strontium | 90-95% | 93-98% |
| Fluoride | 85-90% | 90-95% | Sulfate | 90-95% | 93-98% |
| Iron2 | 90-95% | 93-98% | Zinc | 90-95% | 93-98% |
| Lead | 90-95% | 93-98% | | | |

# Basic R.O. Components

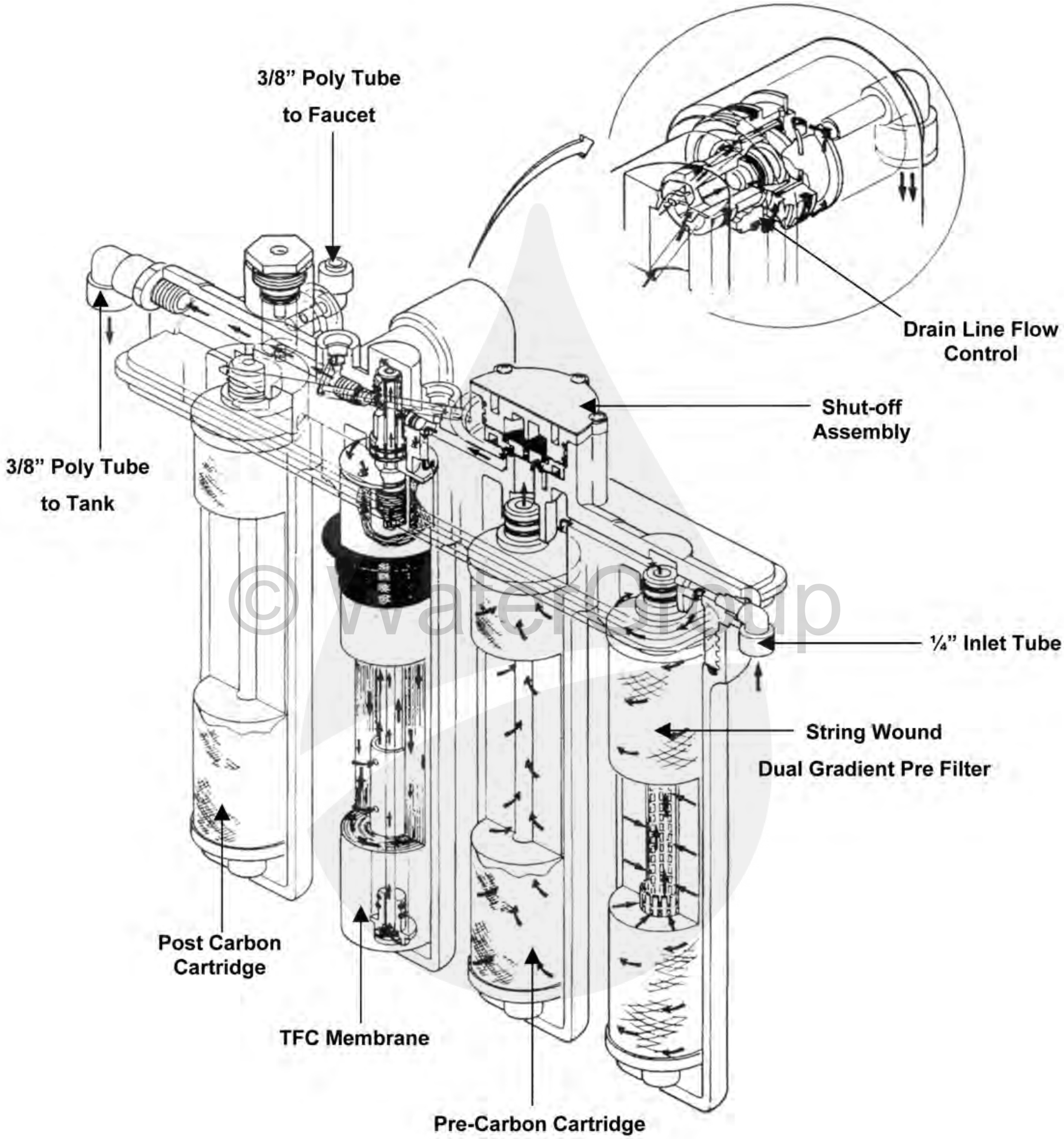
Each component of a drinking water system serves a special purpose. We begin with a basic reverse osmosis unit:

- The first component is a 5 micron Pre-Filter. Its function is to remove suspended particles from the feed water, thus reducing the possibility of clogging the reverse osmosis membrane. The prefilter should be replaced every 12 months or earlier, depending on the quality of the feed water. In case of cryptosporodium, a 1 micron pre-filter is recommended. A Carbon Pre-Filter is installed on all R.O.s using a TFC membrane. This is essential for removal of chlorine in the water supply.
- After the pre-filter, the water flows to the Reverse Osmosis Module which contains a semi-permeable membrane. Its function is to separate water molecules from dissolved impurities in the feed water. This is accomplished by application of hydraulic pressure greater than the osmotic pressure in water containing dissolved solids. The good parts of the water pass through the membrane and the impurities are sent to the drain. The membrane should provide two to five years of service and should be checked periodically by measuring the percent rejection.
- The filtered water then goes into the Storage Tank which holds up to three gallons of purified water.
- The flow of water to the R.O. is shut off when the storage tank pressure reaches approximately 2/3 of the inlet pressure. This is accomplished by the Shut-Off Valve.
- When you call for water at the tap, the good water travels from the storage tank through the Post Filter which contains granular activated carbon. Its function is to remove any taste and odor from the water prior to delivering it to the spigot. The post-filter cartridge should be replaced every 24 months.
- The basic R.O. unit is compact enough to fit under a kitchen sink or in the basement below the kitchen, if you prefer. An easy to use long-reach 1/4" Faucet is mounted right at your kitchen sink for maximum convenience.
- A Flow Restrictor is installed on the reject water line sized to allow the correct amount of back pressure to be applied on the membrane surface.



## Notes

# Build An R.O. Drinking Water System



# Carbon Adsorption

Carbon plays an integral role in a complete drinking water system.

- Activated carbon is a form of elemental carbon whose particles have a large surface area with high adsorptive qualities, primarily used to remove objectionable tastes and odors and numerous toxic organic compounds from water. Chlorine is removed by a catalytic reaction which occurs on the surface of the carbon particles and in the macropores. A variety of substances such as coal, coconut shells, nutshells, peat, wood and fruit pits can be used to produce carbon. Such substances are heated at high temperatures in a low oxygen atmosphere to reduce everything to carbon and ash that is then activated by high pressure steam, leaving behind carbon etched with a complex pore structure. Several media types exist including powdered, granular and block carbon.
- Adsorption is defined as the adhesion of a gas, vapor or dissolved organic compound on the surface of activated carbon. A particle of carbon has an extremely large surface area owing to its structure of pores similar to those found in a sponge. Due to this texture, a single teaspoon of activated carbon will have a surface area equal to a football field.
- Unlike a sponge that will absorb water containing taste and odor and then, when squeezed, release water with these constituents still present, activated carbon adsorbs or engulfs such constituents, causing them to adhere to the surface of the carbon thus effectively removing them from the water.
- The ability of activated carbon to adsorb organic chemical contaminants, like VOCs, THMs and chloramines, is dependent on the amount of contact time as determined by the flow rate as well as the porosity of the carbon involved. By way of an example, water travels through a post-carbon filter at the rate it is dispensed, approximately 0.5 gpm. At this flow rate, carbon is only able to remove any tastes or odors imparted from the storage tank or tubing.
- In order to maximize the potential of activated carbon to remove toxic chemical contaminants, the following three conditions must exist when the water flows through the carbon: (1) TDS substantially reduced, (2) prolonged contact time and (3) slow flow rate to prevent channelling.

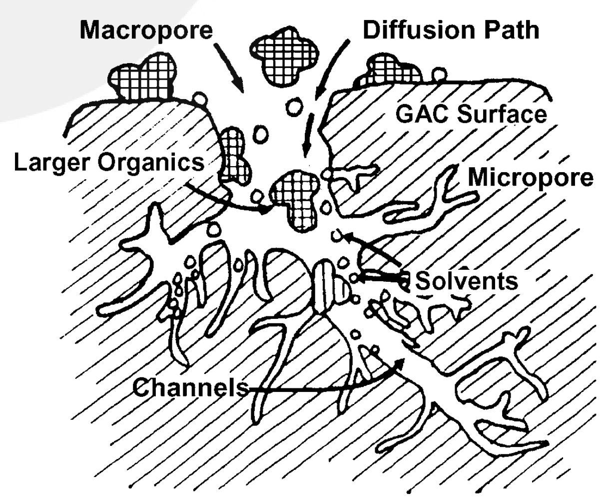
### *Carbon Adsorption Removes*

It is critical to differentiate between the individual process of reverse osmosis and carbon adsorption and the unique synergy represented by a complete Drinking Water System which integrates the two mutually beneficial technologies--membrane separation and activated carbon filtration.

- The ability of carbon to remove a host of toxic chemical contaminants must therefore be viewed in relation to a complete Drinking Water System rather than independently. On this basis, a few examples of such contaminants removed by carbon follow:

| | |
|---|---|
| • Benzene | • PCBs |
| • Chloramines | • Pesticides |
| • Chlorine | • Toluene |
| • Dichlorobenzene | • Trichlorethylene (TCE) |
| • Dioxin | • Trihalomethane (THM) |
| • Herbicides | • Vinyl Chloride |
| • Monochlorobenzene | • Xylene |

### *Enlarged Activated Carbon Granule Showing Pores, Surfaces & Structure*



# Selection Criteria

The following factors must be considered when selecting an R.O. system:

### *Is the Water Supply Potable?*

- An R.O. system can only be applied on water that is already deemed bacteriologically safe for human consumption or is adequately disinfected or sterilized on a continuous basis.

### *Is the Feed Water Supply Chlorinated or Unchlorinated?*

- If the water is unchlorinated, a TFC membrane should be chosen due to its greater resistance to bacterial attack.
- If the water is chlorinated, a TFC membrane that is sensitive to chlorine may be used with the addition of a carbon pre-filter.

### *What is the Daily Requirement of R.O. Water?*

- For a residential application involving the use of R.O. water for drinking and cooking, a system should be capable of producing in excess of a minimum 1/2 gallon of water per person per day.

### *Is the Water Supply Adequately Pre-Treated?*

- If present, any contaminant such as iron, manganese or hydrogen sulfide must be adequately reduced or removed by pre-treatment in accordance with membrane tolerances.
- If necessary, the feed water should be treated to reduce hardness to a maximum of 20 gpg to prevent premature fouling of the membrane.

### *What is the Level of TDS?*

- A major factor in determining the product water quality, since membranes reject a percentage of feed water TDS.
- An important factor in determining the quantity of R.O. water produced daily
- An important factor in determining the type of membrane to use.

### *What is the pH of the Feed Water?*

- An important factor in determining the type of membrane chosen: CTA maximum pH is 9.0, TFC maximum pH is 11.0.
- A major factor in determining the rejection of many types of TDS impurities.

### *Is a Booster Pump Required?*

- A careful consideration of performance factors such as water pressure, temperature and TDS is required to determine whether or not a booster pump is required.



## Notes

# Factors Affecting Performance

There are many interrelated factors and design considerations that affect actual R.O. performance. Outlined below are three of the primary factors that have the greatest potential impact on the quality and quantity of R.O. water that an individual system will produce:

### TDS of Feed Water

- Osmotic pressure is the force binding water molecules to dissolved ions or solids. The higher the TDS, the higher the molecular forces. Before water molecules can start to separate and pass through the membrane, these forces must be broken with the application of pressure.
- Every 100 mg/l of TDS requires 1 psi just to overcome osmotic pressure.

### Water Pressure or Feed Pressure

- Net pressure across the membrane is a major factor in determining how much water is produced. Generally speaking, as the pressure increases, so does the rate of water production.

**NET MEMBRANE PRESSURE = FEED PRESSURE - OSMOTIC PRESSURE - BACK PRESSURE**

- The rejection of TDS depends on net pressure. Generally speaking, the higher the net pressure, the greater the percent rejection.
- The higher the TDS, the higher the osmotic pressure.
- Back pressure is the pressure generated by the captive storage tank on the product water side of the membrane.
- If the net membrane pressure is too low to produce the required amount of product water, a booster pump can be used to increase the feed water pressure to 80 psi.

### Temperature of Feed Water

- Water temperature greatly affects the actual rate of production. Membranes are rated in terms of production in gallons per day (gpd) at 77°F. Generally speaking, the colder the water, the lower the rate of production.
- Water production increases or decreases for CTA membranes - 1.5% per °F and for TFC membranes 2.0% per °F above or below 77°F.



## Notes

### Product Water Quality and Percent Rejection

To test for quality and percent rejection, you must have a TDS or conductivity meter. The R.O. system should be running for 20-30 minutes to obtain an accurate TDS reading. Test the TDS of the water going into the R.O. system (feed water) and the TDS of the water coming from the R.O. system (product water). Subtract the product water TDS from the feed water TDS and divide the answer by the feed water TDS.

*Example -*

| | | |
|---|---|---|
| Feed Water TDS | 450 | ppm |
| Product Water TDS | - 22 | ppm |
| = | 428 | ppm |
| 428 ÷ 450 = | 95% | Rejection |

### Determining Osmotic Pressure

Osmotic pressure equals one (1) pound for every 100 ppm of TDS. The osmotic pressure must be subtracted from the existing pressure to arrive at the actual pressure.

*Example -*

| | |
|---|---|
| 1000 | ppm TDS |
| ÷ 100 | ppm |
| 10 | psi osmotic pressure |

### Determining Back Pressure

Back pressure is the pressure generated by the captive storage tank on the product water side of the membrane. It follows that a higher quantity of production and a higher quality or greater percent rejection occurs when an R.O. system is producing water against a nearly empty tank (7 psi) rather than an almost full tank (38 psi). To simplify the effect of back pressure on the quantity of production, consider the average tank back pressure to be 20 psi.

### The Effect of Decreased Pressure on Production

Reverse osmosis is a direct function of pressure. A typical home R.O. system rated at 24 gpd is tested at 60 psi. Upon installation, the actual pressure of the feed water must be considered less the osmotic pressure and the back pressure of the storage tank.

*Example -*

Rural Well Pressure 30-50 psi

| | |
|---|---|
| 40 | psi average |
| -10 | psi osmotic pressure |
| - 20 | average back pressure |
| 10 | psi net effective pressure |

So, at 10 psi net effective pressure, the water production is reduced to one-sixth. The 24 gpd system now makes 4 gpd.

### Temperature Effect on Reverse Osmosis

Most membrane manufacturers measure the water production rate at 77°F. Membrane production rate will rise or fall approximately 1.5% for CTA membranes and approximately 2% for TFC membranes for each degree Fahrenheit above or below 77°F. The resultant percentage is the amount of increase or decrease in the adjusted product water rate.

*Example -*

| | |
|---|---|
| Manufacturer's temperature | 77°F |
| Feed temperature | 60°F |
| Difference | 17°F |
| CTA - 17 x 1.5% = | 25% |
| TFC - 17 x 2% = | 34% |

Thus, the product water will decrease 25% for CTA membranes and 34% for TFC membranes.

# Case Study

John and Leslie Brown, along with their three young children, have recently moved into their new home in the country. Although unaccustomed to using a private well, they have had the foresight to have the water re-tested for potability after moving in last December. The government test indicates - 0 fecal and 0 coliform bacteria. They are still apprehensive about the general quality of their drinking water and are counting on your expertise to recommend a suitable Drinking Water System. At present there is no water treatment equipment in place.

Your initial water analysis and site observations are as follows:

Pressure Setting..................30-50 psi
Hardness ................................ 28 gpg
Iron ..................................... 1.0 ppm
Manganese ..............................0 ppm
Hydrogen Sulfide ....................0 ppm
TDS .....................................800 ppm
Water Temperature ..................45°F
Water Clarity ..............................Clear
Nitrates .................................10 ppm
pH ..................................................7.2

1. Based on the above information, what type of pretreatment will be necessary before a Drinking Water System can be installed?
2. Why are you making this recommendation?
3. Using the accompanying worksheets, calculate how much water you might expect a Drinking Water System to produce per day.
4. Based on the above answer, what should be done to ensure the drinking water needs of the Brown family are properly provided for?



### *Worksheet*

Follow the steps below to determine the actual product water rate:

1. Determine the effective feed water pressure:

__________ ppm ÷ 100 ppm = __________ psi
(feed water TDS) (osmotic pressure)

__________ psi — __________ psi = __________ psi
(avg feed water pressure) (osmotic pressure) (f.w. pressure to atmosphere)

— __________ psi = __________ psi
(back pressure) (net membrane pressure)

2. Using the net membrane pressure from Step 1, determine the adjusted product water rate.

__________ gpd x __________ psi ÷ 60 psi = __________ gpd
(product water rate standard) (net membrane pressure) (adjusted product water rate)

3. Using the adjusted product water rate from Step 2, determine the actual product water rate.

77°F — __________ °F = __________ °F
(average feed water temp.) (temp. difference)

__________ °F x 1.5% (CTA) or 2% (TFC) = __________ %
(temp. difference) (adjustment)

__________ gpd ± __________ % = __________ gpd
(adj product water rate) (adjustment) (actual product water rate)

## Nominal Membrane Characteristics

| Specification | TFC Membrane |
|---|---|
| Product Water Rate (to atmosphere @ 60 psi, 77°F) | 24 gpd, 50 gpd, 75 gpd |
| Maximum Feed Water TDS (with sufficient line pressure) | 2000 mg/l |
| Maximum Feed Water Hardness | 20 gpg |
| Rejection of TDS | 95% to 99% |
| Feed Water Temperature | 40°F to 113°F or 4°C to 45°C |
| Feed Water pH | 2.0 to 11.0 |
| Maximum Feed Pressure (in suitable pressure vessel) | 50 to 100 psi |
| Booster Pump Pressure | 80 psi |

| | TFC Membrane |
|---|---|
| Bacteria Resistance | Bacteria resistant, operates on non-chlorinated feed water. |
| Chlorine Tolerance | Sensitive to chlorine and other oxidizers. Use on non-chlorinated water or protect with a carbon filter. |

**Other Precautions** - Feed water must be microbiologically safe with the following limits:
Iron - 0.1 mg/l    Manganese - 0.05 mg/l    Hydrogen Sulfide - 0 mg/l    Tannins - 0 mg/l

# Reverse Osmosis Production

| Line Pressure | Membrane Rating | TDS - ppm or mg/l | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 |
| 35 psi | 25 | 2.5 | 2.3 | 2.1 | 1.9 | 1.7 | 1.5 | 1.3 | 1.0 | 0.6 | 0.2 | 0.0 | 0.0 | 0.0 |
| | 45 | 4.5 | 4.1 | 3.8 | 3.4 | 3.0 | 2.6 | 2.3 | 1.9 | 1.1 | 0.4 | 0.0 | 0.0 | 0.0 |
| | 50 | 5.0 | 4.6 | 4.2 | 3.8 | 3.3 | 2.9 | 2.5 | 2.1 | 1.3 | 0.4 | 0.0 | 0.0 | 0.0 |
| | 75 | 7.5 | 6.9 | 6.3 | 5.6 | 5.0 | 4.4 | 3.8 | 3.1 | 1.9 | 0.6 | 0.0 | 0.0 | 0.0 |
| 40 psi | 25 | 3.5 | 3.3 | 3.1 | 2.9 | 2.7 | 2.5 | 2.3 | 2.1 | 1.7 | 1.3 | 0.8 | 0.4 | 0.0 |
| | 45 | 6.4 | 6.0 | 5.6 | 5.3 | 4.9 | 4.5 | 4.1 | 3.8 | 3.0 | 2.3 | 1.5 | 0.8 | 0.0 |
| | 50 | 7.1 | 6.7 | 6.3 | 5.8 | 5.4 | 5.0 | 4.6 | 4.2 | 3.3 | 2.5 | 1.7 | 0.8 | 0.0 |
| | 75 | 10.6 | 10.0 | 9.4 | 8.8 | 8.1 | 7.5 | 6.9 | 6.3 | 5.0 | 3.8 | 2.5 | 1.3 | 0.0 |
| 50 psi | 25 | 5.6 | 5.4 | 5.2 | 5.0 | 4.8 | 4.6 | 4.4 | 4.2 | 3.8 | 3.3 | 2.9 | 2.5 | 2.1 |
| | 45 | 10.1 | 9.8 | 9.4 | 9.0 | 8.6 | 8.3 | 7.9 | 7.5 | 6.8 | 6.0 | 5.3 | 4.5 | 3.8 |
| | 50 | 11.3 | 10.8 | 10.4 | 10.0 | 9.6 | 9.2 | 8.8 | 8.3 | 7.5 | 6.7 | 5.8 | 5.0 | 4.2 |
| | 75 | 16.9 | 16.3 | 15.6 | 15.0 | 14.4 | 13.8 | 13.1 | 12.5 | 11.3 | 10.0 | 8.8 | 7.5 | 6.3 |
| 60 psi | 25 | 7.7 | 7.5 | 7.3 | 7.1 | 6.9 | 6.7 | 6.5 | 6.3 | 5.8 | 5.4 | 5.0 | 4.6 | 4.2 |
| | 45 | 13.9 | 13.5 | 13.1 | 12.8 | 12.4 | 12.0 | 11.6 | 11.3 | 10.5 | 9.8 | 9.0 | 8.3 | 7.5 |
| | 50 | 15.4 | 15.0 | 14.6 | 14.2 | 13.8 | 13.3 | 12.9 | 12.5 | 11.7 | 10.8 | 10.0 | 9.2 | 8.3 |
| | 75 | 23.1 | 22.5 | 21.9 | 21.3 | 20.6 | 20.0 | 19.4 | 18.8 | 17.5 | 16.3 | 15.0 | 13.8 | 12.5 |
| 70 psi | 25 | 9.8 | 9.6 | 9.4 | 9.2 | 9.0 | 8.8 | 8.5 | 8.3 | 7.9 | 7.5 | 7.1 | 6.7 | 6.3 |
| | 45 | 17.6 | 17.3 | 16.9 | 16.5 | 16.1 | 15.8 | 15.4 | 15.0 | 14.3 | 13.5 | 12.8 | 12.0 | 11.3 |
| | 50 | 19.6 | 19.2 | 18.8 | 18.3 | 17.9 | 17.5 | 17.1 | 16.7 | 15.8 | 15.0 | 14.2 | 13.3 | 12.5 |
| | 75 | 29.4 | 28.8 | 28.1 | 27.5 | 26.9 | 26.3 | 25.6 | 25.0 | 23.8 | 22.5 | 21.3 | 20.0 | 18.8 |
| 80 psi | 25 | 11.9 | 11.7 | 11.5 | 11.3 | 11.0 | 10.8 | 10.6 | 10.4 | 10.0 | 9.6 | 9.2 | 8.8 | 8.3 |
| | 45 | 21.4 | 21.0 | 20.6 | 20.3 | 19.9 | 19.5 | 19.1 | 18.8 | 18.0 | 17.3 | 16.5 | 15.8 | 15.0 |
| | 50 | 23.8 | 23.3 | 22.9 | 22.5 | 22.1 | 21.7 | 21.3 | 20.8 | 20.0 | 19.2 | 18.3 | 17.5 | 16.7 |
| | 75 | 35.6 | 35.0 | 34.4 | 33.8 | 33.1 | 32.5 | 31.9 | 31.3 | 30.0 | 28.8 | 27.5 | 26.3 | 25.0 |

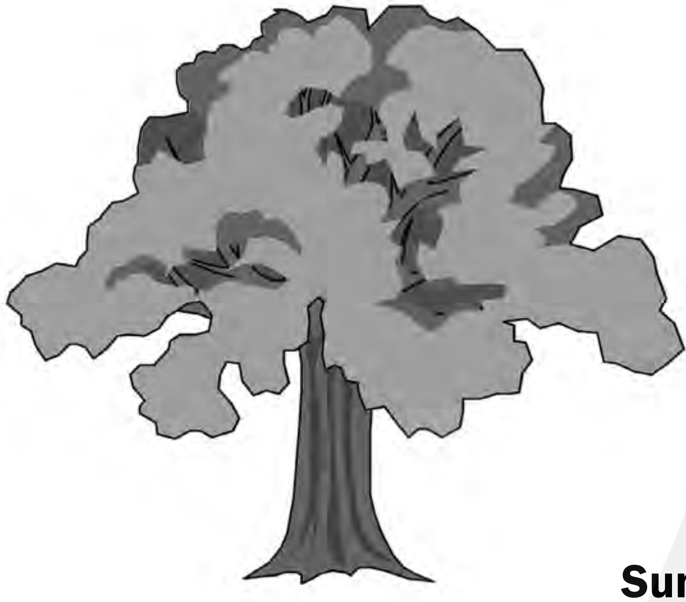


Factors affecting production and the standards used to rate membrane capacity per day are:
Pressure ............................60 psi
Temperature ....................77°F
Total Dissolved Solids ......350 mg/l
Producing the water to atmosphere

**Production rates** shown are based on feed water temperature of 52°F and producing the water into a pre-charged storage tank.

**Water Chemistry**
Hardness ..........................<10 gpg (171 mg/l)
Iron ...................................0.1 mg/l
Manganese........................0.05 mg/l
Hydrogen Sulfide ..............0 mg/l
Tannins ..............................0 mg/l

Water must be **microbiologically safe.**



# Reverse Osmosis

## Summary

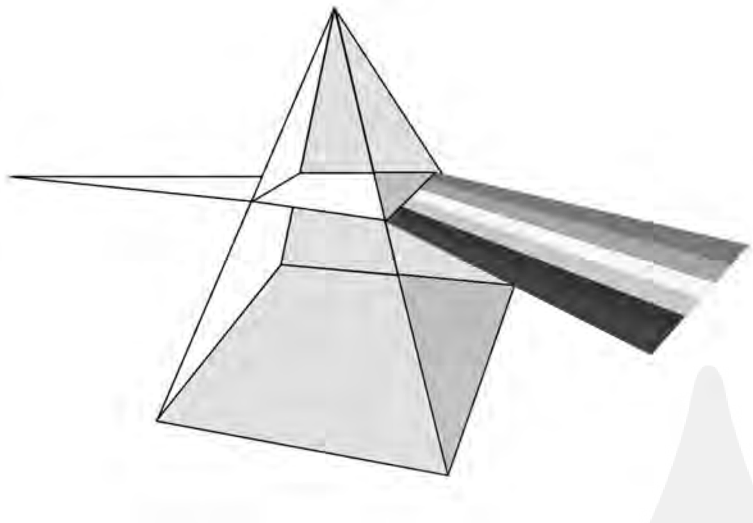


### *Level 1*

1. Osmosis is the natural flow of water molecules from a less concentrated solution through a membrane to a more concentrated solution.
2. When pressure is applied to the more concentrated solution, the flow of water molecules can be reversed through the membrane to the less concentrated or pure water solution.
3. In a reverse osmosis unit, the membrane is able to reject substances as small as .0005 micron.
4. Crossflow filtration or the flow of feed water across the membrane surface keeps the membrane clean by carrying rejected contaminants to the drain.
5. While reverse osmosis will reject bacteria and viruses, it must be applied on potable water supplies which are less than 10 gpg hard. Reverse osmosis is recommended primarily for the reduction of total dissolved solids.
6. The basic R.O. unit is comprised of a 5 micron pre-filter, a carbon pre-filter, a membrane module, a storage tank, a shut-off valve, a carbon post-filter, a faucet and a flow restrictor. A thin film composite (TFC) membrane is recommended for higher TDS waters and for non-chlorinated supplies because it is bacteria resistant, and chlorinated supplies if protected by a pre-carbon filter.
7. The performance of an R.O. unit is affected by the TDS of the feed water, the water pressure and the water temperature.

### *Level 2*

1. The performance quality of an R.O. unit can be determined by taking conductivity tests to obtain the feed water TDS and the product water TDS. The difference is then divided by the feed water TDS to obtain the percent rejection.
2. The quantity of product water produced is determined by pressure and temperature. The osmotic pressure, which is 1 psi for every 100 TDS, and a storage tank back pressure of 20 psi, must be subtracted from the feed water pressure to obtain the net membrane pressure. This pressure divided by the standard of 60 psi times the standard product water rate will equal the adjusted product water rate.
3. The adjusted product water rate is further decreased (or increased) by 1.5% (CTA membranes) or 2% (TFC membranes) for every degree of temperature difference from the standard of 77°F.



# Ultraviolet Disinfection

## Objectives

### *Level 1*

1. To be familiar with the common terminology used in ultraviolet disinfection.
2. To know the general concepts and process of ultraviolet disinfection.
3. To know about the benefits and features of ultraviolet disinfection as they relate to water quality

### *Level 2*

1. To know how ultraviolet disinfection systems operate to achieve water purity
2. To know how to select and size ultraviolet disinfection equipment
3. To be able to distinguish the various major groups of microorganisms and their disease-causing impact and the benefits achieved with ultraviolet disinfection systems.



WaterGroup

# Glossary

**Activated Carbon** - A form of elemental carbon whose particles have a large surface area with high adsorptive qualities, primarily used to remove chlorine, objectionable tastes and odors and numerous toxic organic compounds from water.

**Angstrom (A)** - A unit of length equal to 1/10,000 of a micrometer or 1/10 of a millimicron.

**Bacteria** - Primitive cell structures called prokaryotes. Bacteria cells range in size from less than 1 to 10 microns in length and from 0.2 to 1 micron in width and can be helpful to man (decomposing organic waste matter) or harmful (disease-producing).

**Coliform Bacteria** - An organism of the bacteria family, harmless in itself, but since E Coli, a member of this group exists and grows as part of the normal microbe population in the digestive tract of warm blooded animals, it serves as a strong indicator of sewage contamination.

**DNA - Deoxyribonucleic Acid** - The genetic material within a cell which controls reproduction and the characteristics thereof.

**Fecal Coliform** - Matter containing or derived from animal or human waste containing one or more of the coliform groups of bacteria.

**Nanometer** - A measure of a wavelength in the electromagnetic spectrum. One nanometer equals 10-9 meter.

**Nitrate** - When found in water, owes its origin to several possible sources, including the atmosphere, legume plants, plant debris, animal excrement and sewage as well as nitrogenous fertilizers and some industrial wastes. Most is generated by the decay of organic matter and from industrial and agricultural chemicals. No visible color, taste or odor in water. Usually a Public Health matter. Nitrates above 10.0 ppm as N are considered a health hazard for infants (cyanosis).

**Potable** - Water which is safe and suitable for human consumption.

**Quartz** - A high grade of glass made using quartz sand.

**Total Dissolved Solids (TDS)** - The total amount of minerals salts and metals which are dissolved in water.

**Trihalomethanes (THMs)** - A group of suspected carcinogenic organic chemicals formed in water when chlorine reacts with naturally occurring organic matter such as by-products of decayed vegetation. One of the most common THMs is chloroform.

**Ultraviolet Radiation (UV)** - Light waves shorter than visible blue-violet waves of the spectrum having wave lengths of less than 9,300 D Angstroms.

**Virus** - Any of a large group of sub-microscopic infectious agents that usually cause disease and are capable of growth and multiplication only in the living cells of a host.

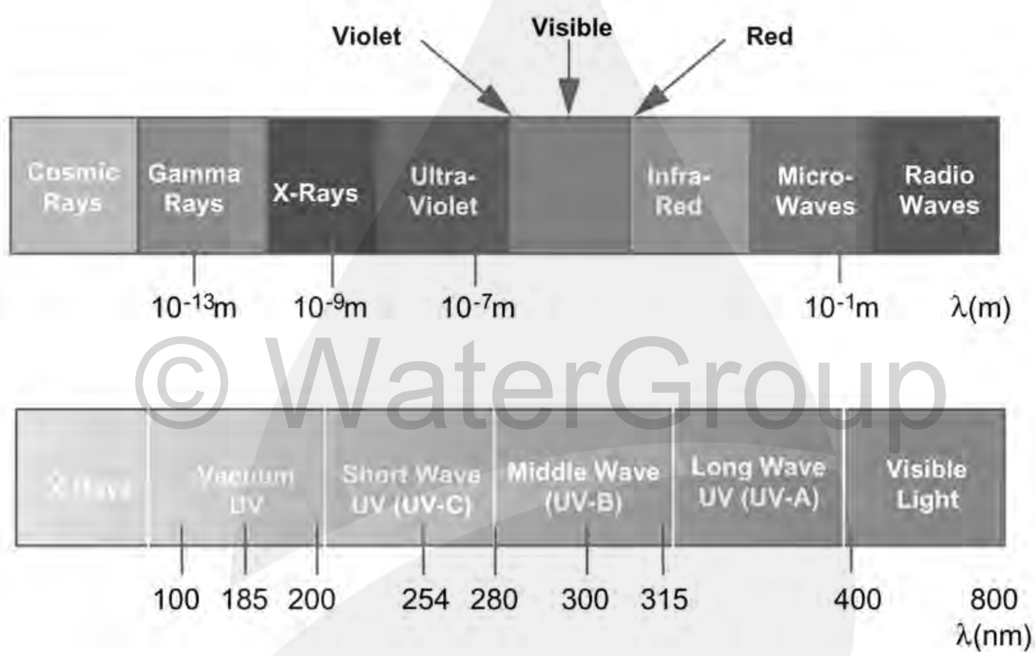
**Volatile Organic Chemical (VOC)** - Chemicals or compounds with boiling points below 212°F, facilitating their evaporation before water.

# Ultraviolet Light

Ultraviolet light, better known as UV, is one energy region of the electromagnetic spectrum. In this spectrum, UV lies between visible light and x-rays. The shorter the wavelength, the greater the energy produced. Therefore, UV has less energy than the x-ray region and more than visible light. The UV region is made of four areas--vacuum UV, UV-C, UV-B and UV-A.

The UV-A region (315 - 400 nm) is used for suntanning lamps. UV-B (280 - 315 nm) and UV-C (200 - 280 nm) are the regions that contain the wavelengths most effective for germicidal action.

***Electromagnetic Spectrum With Expanded Scale of Ultraviolet Radiation (1 Nanometer = $10^{-9}$ Meter)***






## Notes

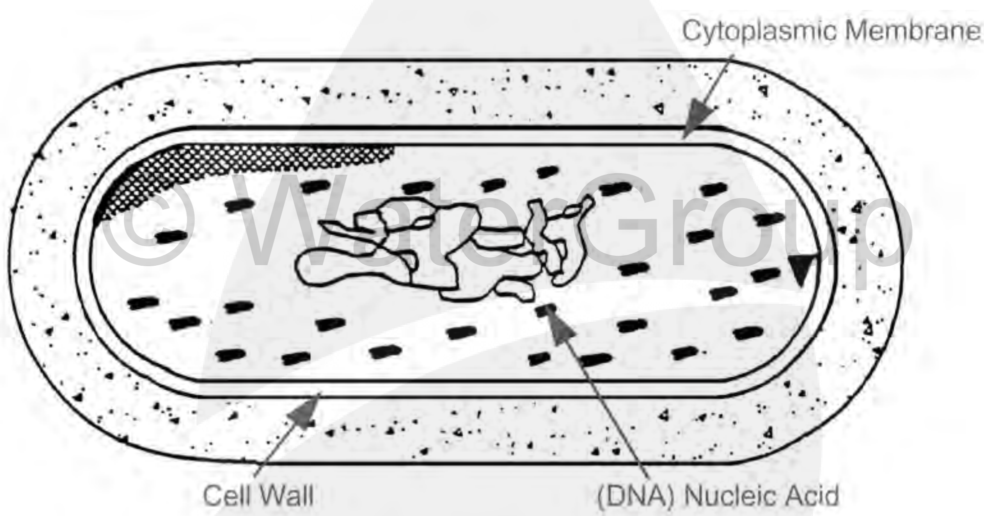
# Water Disinfection Using Ultraviolet Technology

Disinfection of water using ultraviolet light is a proven technology. This safe and effective physical disinfectant is suitable for both large and small applications.

UV units contain one or more powerful UV lamps protected inside a quartz sleeve from the water which passes through the chamber. UV light is emitted as a result of current flow through the mercury vapor between the electrodes of the lamp. The most commonly used UV lamps (low pressure mercury vapor) produce the majority of their UV output at 253.7 nm, a wavelength which is very close to the 260 to 265 nm wavelengths which are most effective in killing microbes.

The UV light damages the DNA part of the bacteria and viruses in such a way that they are unable to replicate. A cell that cannot reproduce is considered dead since it is unable to multiply to infectious numbers within a host. This is a highly effective way of destroying bacteria in water and, in a correctly designed installation, 99.999% reduction is achievable.

UV is strictly a disinfection process like chlorination in the sense that numbers of microorganisms are reduced to a very low level but not necessarily to zero. Complete removal of microorganisms is called sterilization and can realistically be achieved only by high temperatures. UV units are often called sterilizers for historical reasons.






## Notes

# Ultraviolet Disinfection

## *Ultraviolet Lamp*

UV equipment uses modern technology low pressure lamps which run cool. They are warranted for 7500 hours (almost 1 year). The main difference between germicidal and fluorescent lamps is the germicidal lamp is constructed of UV transmitting quartz, whereas the fluorescent lamp has soft glass with an inside coating of phosphor which converts UV to visible light. The quartz tube transmits 93% of the lamp's UV energy whereas the soft glass emits very little. UV bulbs should not be touched by hand as oils and other contaminants will inhibit UV transmission and shorten bulb life.

## *Warning Devices*

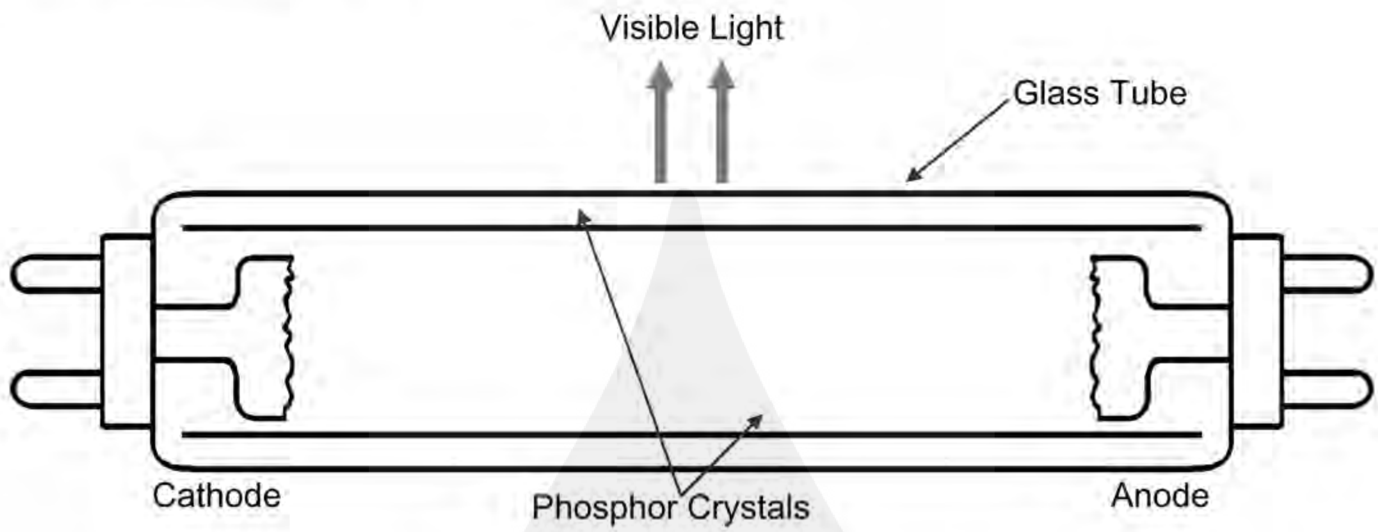
It is important to know that the UV unit is providing the UV dose required at all times. The UV units have a light which indicates whether the lamp is operating, coupled with an audible alarm. In addition, certain models continuously monitor the UV intensity through the water. If the intensity drops due to the lamp or coating of the quartz sleeve, warning lights and an audible alarm will be triggered as well as a signal to close the inlet solenoid valve, if installed. On good quality, high transmission waters UV monitors are less important but they will still give reassurance that the unit is working as it should.

## *Stainless Steel Cell*

In older models the UV chamber was made of plastic. Unfortunately, ultraviolet light degrades plastic and will weaken it with time. This may cause taste problems. Modern generation UV equipment has stainless steel chambers with easy to remove lamps and quartz sleeves for cleaning.

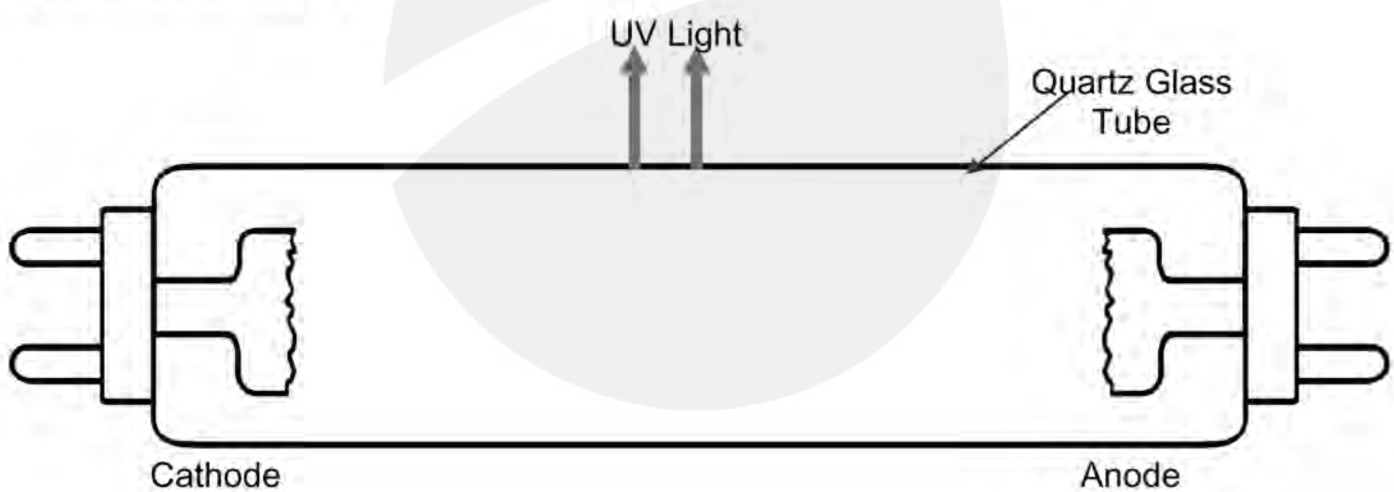
# Comparison of Fluorescent & Germicidal Lamps

*Fluorescent Lamp*






*Germicidal Lamp*



Microorganisms include several distinct groups of disease-causing germs, differing widely in form and life cycle, but resembling one another in their small size and relatively simple structure. Microorganisms encompass five major groups:

1. Viruses
2. Bacteria
3. Fungi
4. Algae
5. Protozoa

UV is effective in destroying the following organisms:

| Organisms | Disease |
|---|---|
| **Bacteria** | |
| Salmonella Species | Typhoid Fever |
| Shigellae (4 species) | Shigellosis |
| Escherichia Coli (Enteropathogenic types) | Gastroenteritis |
| Vibrio Comma | Cholera |
| **Enteric Viruses** | |
| Enteroviruses | Gastroenteritis, Heart Anomalies, Meningitis |
| Polioviruses | Polio |
| Coxsackie viruses | Other |
| EchovirusesRotavirus (Reovirus) | Gastroenteritis |
| Parvovirus-Like Agents | Gastroenteritis |
| (Norwalk) | Gastroenteritis |
| Hepatitis A Virus | Infectious Hepatitis |
| Adenoviruses | Respiratory Disease, Conjuntivitis, Other |
| **Protozoa** | |
| Entamoeba Histolytica | Amebiasis |



## Notes

## *Water Quality*

The quality of water to be treated can have a large influence on the performance of an ultraviolet unit. There are three main influences:

**Suspended Solids** - can shield bacteria from ultraviolet light and should be removed by 5 micron pre-filtration. Total removal of suspended solids is very difficult and this partly accounts for low levels of bacteria which can remain after disinfection. Chemical disinfectants, such as chlorine, are also affected this way. Waters which are optically clear or which have received simple cartridge filtration are easily disinfected by ultraviolet to achieve drinking water standards.

**Chemicals Present in the Water** - can affect ultraviolet disinfection. Substances such as iron, manganese and sulfides or excessive temporary hardness can lead to coating of the quartz sleeve and thereby block the UV light. Iron at levels of 0.2 mg/l will start to cause problems. Calcium hardness may be a problem when long "no flow" situations are encountered where the lamp can cause the water in the UV chamber to heat up and deposit hardness scale. If coating does occur it can easily be removed by cleaning the quartz sleeve and, if it is likely to occur, it is advisable to install a UV monitor to give warning of low UV dose situations.

**Optical Clarity** - to light at 254 nm is very important since it affects the depth of penetration of UV light. This can be affected by organic substances such as humic acids. If there is a faint yellow color in the water when viewed through a reasonable depth, such as in a white bucket, then UV absorbing substances are likely to be present. The more UV that is absorbed by a given depth of water, the less that is transmitted to further depths and hence penetration is reduced. The standard test is to measure the UV transmission in a 1 cm cell at 254 nm in a laboratory spectrophotometer using distilled water as the reference. Distilled water has a UV transmission of almost 100% which means that all the incident light will pass through the 1 cm depth. Surface waters can have a transmission as low as 70% which means that only 70% of the incident light will pass through a 1 cm depth.

## *Water Flow Rate*

In sizing a UV unit, the most important factor is the peak water flow rate which can pass through the unit because UV dose is a combination of lamp intensity and flow rate/residence time in the UV chamber. If the correct UV dose is not applied, then bacteria may pass through the UV unit unharmed. The flow rate in USGPM can be measured at the faucet in a single point-of-use application or at an entry faucet or the pump in a point-of-entry application. A flow control set at the unit's maximum flow rate can be installed on the effluent line to ensure adequate residence time for disinfection.

UV overdosing does not matter since nothing is added to the water. UV units may be left on indefinitely and the heating will not damage the equipment.

### *How to Measure the Pumping Rate*

1. Make certain no water is being drawn. Open spigot nearest pressure tank. When pump starts, close tap and measure time (in seconds) to refill pressure tank. This is cycle time.
2. Using a container of known volume, draw water and measure the volume in U.S. gallons until the pump starts again. This is draw down.
3. Divide the draw down by the cycle time and multiply the result by 60. This will give you the pumping rate in U.S. gallons per minute.

*Example -*

Draw down = 7.0 gallons

Cycle time = 80 seconds

7.0 gallons ÷ 80 seconds =

0.0875 x 60 seconds = 5.25 USGPM

*Caution -*

Do not rely on the pump label, tank capacity or a well driller's report as an alternative to using the above procedure to measure actual pumping rate. This procedure should be repeated to confirm accuracy.

## *Ultraviolet Dose*

The UV dose is calculated by multiplying the UV intensity given out by the lamp by the residence time of the water in the UV chamber. Intensity is the amount of UV energy per unit area measured in microwatts/cm2. The residence time is the amount of time the solution is exposed to UV (measured in seconds). Therefore, UV dose is expressed in microwatt seconds per square centimeter.

Microorganisms differ in their sensitivity to UV light. This variation may be due to cell wall structure, thickness and composition; to the presence of UV absorbing proteins or to differences in the structure of the nucleic acids themselves. Waterborne diseases may be caused by a wide variety of pathogenic microorganisms. Disinfection of the drinking water with UV must ensure a maximum dose to cover this wide variation of UV sensitivities.

To kill the common disease-causing microorganisms and indicators of water pollution, such as salmonella, polio virus, legionella, E. coli, etc., requires a dose of around 6000 to 10,000 microwatt seconds/cm2. Most of the simple bacteria and viruses are susceptible to this order of UV dose. UV units are sized to give a UV dose of 20,000 or more microwatt seconds/cm2. This assumes 85% transmission or better at the rated flow. The dose can be increased if the water quality is worse or if more than the rated flow is used. Larger organisms, such as protozoa, fungi and algae, are susceptible to UV but require larger doses because the organism cell walls are more difficult to penetrate with ultraviolet light. In specialized applications such as brewing or the food industry it is advisable to find out which organisms are of concern. In this way the dose can be increased by correct design.



### Ultraviolet Energy Levels at 254 Nanometer Units Wavelength Required for 99.9% Destruction of Varions Microorganisms UV Energy in Microwatt Seconds per Square Centimeter

| | |
|---|---|
| **BACTERIA** | |
| Agrobacterium tumefaciens | 8500 |
| Bacilus anthracis | 8700 |
| Bacillus megaterium (vegetative) | 2500 |
| Bacillus megaterium (spores) | 52000 |
| Bacillus Subtilis (vegetative) | 11000 |
| Bacillus subtilis (spores) | 58000 |
| Clostridium tetani | 22000 |
| Corynebacterium diphtheriae | 6500 |
| Escherichia coli | 7000 |
| Legionella bozemanii | 3500 |
| Legionella dumoffii | 5500 |
| Legionella gormanii | 4900 |
| Legionella micdadei | 3100 |
| Legionella longbeachae | 2900 |
| Legionella pneumophila | 3800 |
| Leptospira interrogans (infectious jaundice) | 6000 |
| Mycobacterium tuberculosis | 10000 |
| Neisseria catarrhalis | 8500 |
| Proteus vulgaris | 6600 |
| Pseudomonas aeruginosa (laboratory strain) | 3900 |
| Pseudomonas aeruginosa (environmental strain) | 10500 |
| Rhodospirilium rubrum | 6200 |
| Salmonella enteritidis | 7600 |
| Salmonella paratyphi (enteric fever) | 6100 |
| Salmonella typhimurium | 15200 |
| Salmonella typhosa (typhoid fever) | 6000 |
| Sarcina lutea | 26400 |
| Serratia marcescens | 6200 |
| Shigella dysenteriae (dysentery) | 4200 |
| Shigella flexneri (dysentery) | 3400 |
| Shigella sonnei | 7000 |
| Staphylococcus epidermis | 5800 |
| Staphylococcus aureus | 7000 |
| Streptococcus faecalis | 10000 |
| Streptococcus hemolyticus | 5500 |
| Streptococcus factis | 8800 |
| Viridans streptococci | 3800 |
| Vibrio cholerae | 6500 |
| **MOLD SPORES** | |
| Asperfillus flavus (yellowish green) | 99000 |
| Aspergillus glaucus (bluish green) | 88000 |
| Aspergillus niger (black) | 330000 |
| Mucor ramosissmus (white gray) | 35200 |
| Penicillum digitatum (olive) | 88000 |
| Penicillum expensum (olive) | 22000 |
| Penicillum roqueforti (green) | 26500 |
| Rhizopus nigricans (black) | 220000 |
| **ALGAE** | |
| Chlorella vulgaris (algae) | 22000 |
| **PROTOZOA** | |
| Nematode eggs | 92000 |
| Paramecium | 200000 |
| **VIRUSES** | |
| Bacteriophage (E. coli.) | 6600 |
| Hepatitis virus | 8000 |
| Influenza virus | 6600 |
| Poliovirum (poliomyelitis) | 21000 |
| Rotavirus | 24000 |
| Tobacco mosaic virus | 440000 |
| **YEAST** | |
| Baker's yeast | 8800 |
| Brewer's yeast | 6600 |
| Common yeast cake | 13200 |
| Saccharomyces var. ellipsoideus | 13200 |
| Saccharomyces sp | 17600 |

### Point-of-Use

A POU system is usually installed on the cold water line. The disinfected water should be dispensed from a separate faucet to ensure that the water does not become recontaminated by using the same faucet that is used for untreated water.

### Point-of-Entry

POE equipment for home applications is installed prior to the line split for hot and cold water.

### Industrial

Most industrial applications are site specific depending on their application, what microbes they are concerned with, the water quality and effluent discharge regulations.

### Installation

- When you install a UV system ensure that you leave enough clearance so that lamp replacement and maintenance can be done without having to remove the system. A bypass should be installed to facilitate easy removal of the system if necessary.
- The installation of a softener to remove hardness and a 5 micron pre-filter to remove suspended particles is recommended. The pre-filter provides a convenient location for adding a disinfectant. The system should be disinfected with chlorine when the unit is installed or serviced or after a power failure.
- Since UV is a physical process (nothing is added to the water), it does not leave a residual disinfectant in the distribution system.
- Microbial testing is the only direct way to verify that a UV system is providing proper disinfection. However, safety features to monitor UV intensity are available to ensure that adequate disinfection conditions are present. The UV detectors will activate audio and visual lamp alarms and activate solenoids which stop water flow.
- UV sterilizers can be applied on water flow rates from 0.5 to 100 USGPM.

  Other features available to enhance UV system performance, maintenance and testing include flow controllers, solenoid valves, sample ports, cleaning mechanisms, thermistors and running time meters.



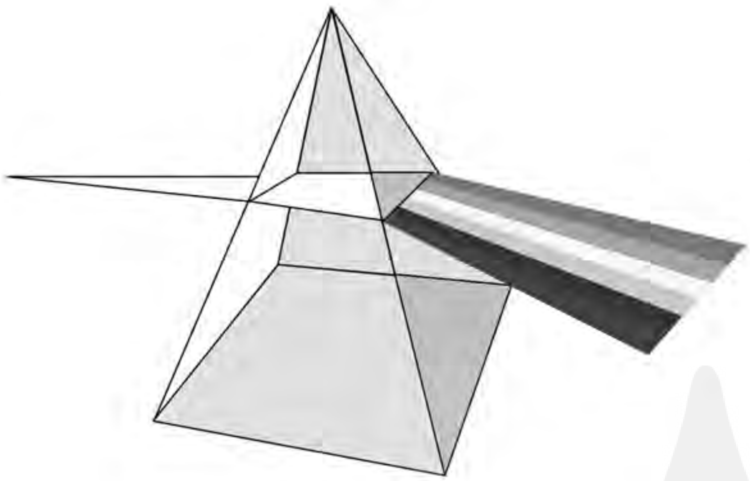
## Advantages & Disadvantages

### Advantages

- Disinfection without adding chemicals
- No production of any trihalomethanes (THMs)
- No change to the taste
- Minimal maintenance
- Immediate treatment without the need for holding tanks
- Ideal compatibility with other technologies for complete solutions: carbon filtration, water softeners, reverse osmosis
- Low power consumption
- Effectively disinfects giardia lambia and cryptosporidium

### Disadvantages

- No chemical residual to test effectiveness
- Must be chemically disinfected after power failures, brown-outs or servicing



# Ultraviolet Disinfection

## Summary

### *Level 1*

1. Ultraviolet light units producing a wavelength of 254 nanometers, disinfect water by damaging the DNA in bacteria and viruses.
2. Ultraviolet disinfection systems consist of an ultraviolet lamp protected by a quartz sleeve housed in a stainless steel chamber.



3. Warning devices are available to indicate if the lamp is working, to indicate if there is enough UV intensity and to stop water flow.
4. UV has the advantage of disinfection without adding chemicals. However, since there is no residual chemical for testing, the water must be tested in a lab to measure the effectiveness of the UV.

### *Level 2*

1. UV is effective in destroying microorganisms which include viruses, bacteria, fungi, algae and protozoa, as well as, cryptosporidium or giardia lambia.
2. UV intensity can be affected by suspended solids and chemicals in the water and by the optical clarity of the water.
3. Sufficient UV dose is determined by the intensity of the lamp and by the residence time (flow rate). Units must be sized to meet peak flow rates.
4. UV can be applied at point-of-use or point-of-entry on residential water or tailored for industrial uses.

# Distillation

## Objectives

### *Level 1*

1. To be familiar with the common terminology used in distillation
2. To know the general concepts and process of water distillation
3. To know about the benefits and features of distillation as it relates to water quality



### *Level 2*

1. To know how distillers are constructed, their specific operating principles and their features and benefits
2. To know how to maintain the operating efficiency of a distiller
3. To be able to distinguish the various contaminants removed by distillation

# Glossary

**Activated Carbon** - A form of elemental carbon whose particles have a large surface area with high adsorptive qualities, primarily used to remove chlorine, objectionable tastes and odors and numerous toxic organic compounds from water.

**Bacteria** - Primitive cell structures called prokaryotes. Bacteria cells range in size from less than 1 to 10 microns in length and from 0.2 to 1 micron in width and can be helpful to man (decomposing organic waste matter) or harmful (disease-producing).

**Boiling Point** - The temperature at which a substance will change from a liquid state to a gaseous or vapor state.

**Coliform Bacteria** - An organism of the bacteria family, harmless in itself, but since E Coli, a member of this group exists and grows as part of the normal microbe population in the digestive tract of warm blooded animals, it serves as a strong indicator of sewage contamination.

**Condensation** - The process by which a substance changes from the vapor to the liquid state

**Evaporation** - The process by which a substance changes from the liquid to the vapor state.

**Fecal Coliform** - Matter containing or derived from animal or human waste containing one or more of the coliform groups of bacteria.

**Nitrate** - When found in water, owes its origin to several possible sources, including the atmosphere, legume plants, plant debris, animal excrement and sewage as well as nitrogenous fertilizers and some industrial wastes. Most is generated by the decay of organic matter and from industrial and agricultural chemicals. No visible color, taste or odor in water. Usually a Public Health matter. Nitrates above 10.0 ppm as N are considered a health hazard for infants (cyanosis).

**Potable** - Water which is safe and suitable for human consumption.

**Total Dissolved Solids (TDS)** - The total amount of minerals salts and metals which are dissolved in water.

**Trihalomethanes (THMs)** - A group of suspected carcinogenic organic chemicals formed in water when chlorine reacts with naturally occurring organic matter such as by-products of decayed vegetation. One of the most common THMs is chloroform.

**Virus** - Any of a large group of sub-microscopic infectious agents that usually cause disease and are capable of growth and multiplication only in the living cells of a host.

**Volatile Organic Chemical (VOC)** - Chemicals or compounds with boiling points below 212°F, facilitating their evaporation before water.



## Notes

# How a Distiller Operates

Using nature's own design for recycling water, distillation reduces impurities through the process of evaporation and condensation.

- As the water is heated, it turns into vapor which rises leaving most impurities behind in the boiling chamber or discharged through the volatile gas vent
- As the water vapor cools, it again condenses into a liquid state. A final polishing takes place as the water passes through the carbon filter.
- The result - water quality that's naturally dependable for you and your family
- The distiller is a self-contained unit with a water inlet and a spigot for dispensing distilled water.
- When connected to the cold water supply line, the water will feed into the boiling chamber. A float will maintain the proper water level in the boiling chamber.
- When there is enough water in the chamber to fully immerse the heating element, a concealed microswitch activates the power to the heating element and cooling fan circuit.
- When the chamber is full, a microswitch causes the power to close the water inlet solenoid valve. As the water is boiled off, the solenoid valve will open to add raw water to the boiling chamber.
- When the reservoir of distilled water reaches its full level, the reservoir float overrides power to the inlet solenoid valve, shutting off the heating element and cooling fan.
- The dual float design in the reservoir allows you to use two gallons of distilled water before the unit automatically restarts, providing a continuous supply of pure water in an economical, energy-efficient method.



# Application & Construction

### *Application*

- Simultaneous removal of bacteria and total dissolved solids
- No limit on TDS removal
- Removal of cysts, chemicals, color

### *Construction*

**Stage 1** - Activated Carbon Pre-Filtration

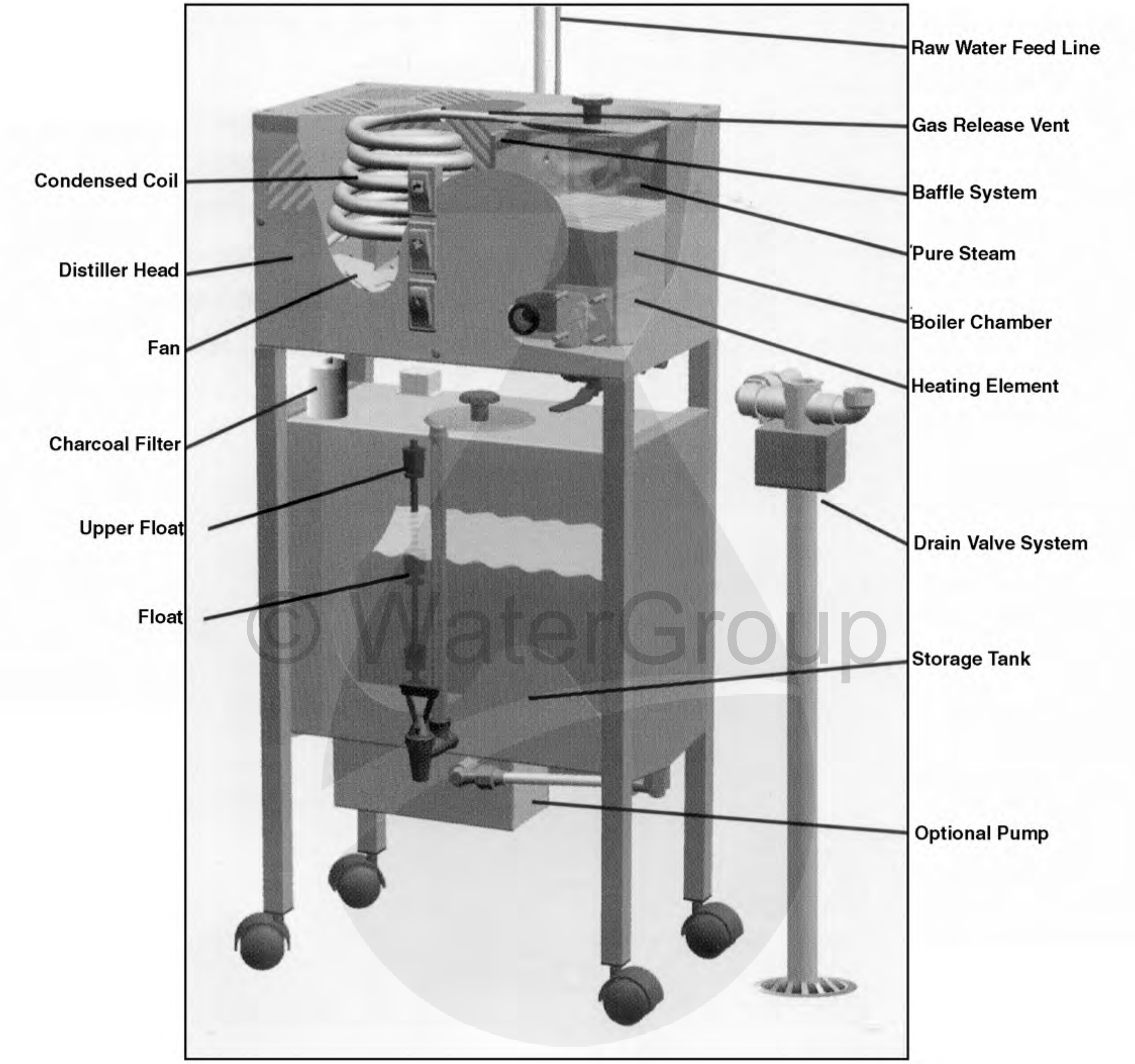
**Stage 2** - Distillation

- Boiling Chamber
- Heating Element
- Condensing Fan
- Condensing Coil
- Reservoir

**Stage 3** - Volatile Organic Chemical Venting

**Stage 4** - Activated Carbon Post-Filtration

# Distiller Cross-Section



# Advantages & Disadvantages

### *Advantages*

1. Removes both organics and inorganics
2. Can be used on contaminated water including removal of cryptosporidium and giardia lambia cysts and high nitrates
3. Removes up to 99% TDS
4. Activated carbon filters remove volatile organic chemicals (VOCs)
5. Optional pump system for remote installation
6. Increased coil size and fan speed for faster production
7. Dual float system in reservoir to increase energy efficiency by allowing 2 gallons of water to be drawn off without activating the boiling process
8. Separate fan and heating element switches can be used manually to allow heating only for sterilization of the complete system with steam.
9. Consistent product water quality
10. Exterior surface is not too hot to touch

### *Disadvantages*

1. Excessive build-up caused by chlorides, sodium and acidic water.
2. Does not remove glycol.
3. Maintenance intensive.
4. Quality deteriorates if distiller is not maintained properly.



## Notes

# Performance Analysis

| Removed by Distillation | | | Removed by Activated Carbon | |
|---|---|---|---|---|
| Boiling Point Above 212°F (100°C) | | | Boiling Point Above 212°F (100°C) | Boiling Point Below 212°F (100°C) |
| 2-4-D | Endrin | Radon | 2-4-D | Benzene |
| Aluminum | Fluoride | Selenium | Silvex | Chlorine |
| Arsenic | Giardia Lambia | Silvex | | Endrin |
| Asbestos | Hardness | Sodium | | Lindane |
| Bicarbonate | Iron | Sulfate | | Methoxychlor |
| Calcium | Lead | TDS | | Toxapene |
| Chloride | Magnesium | Tetrachloroethylene | | TCE |
| Coliform Bacteria | Mercury | Toluene | | THMs |
| Color | Nitrate | Uranium | | |
| Copper | O-Dichlorobenzene | Viruses | | |
| Cryptosporidium | PCBs | Xylene | | |
| Cyanide | Radionuclides | | | |



## Maintenance

The exterior of the distiller and reservoir tank may be cleaned with hot soapy water and a sponge or soft cloth. A commercial window cleaner may be used to maintain the luster of the exterior. Care should be taken that no cleaners used on the exterior can find their way into the reservoir tank.

Pre-treatment by softening or filtration may be necessary, depending on the water quality and to minimize cleaning of the boiling chamber. Periodic cleaning of the boiling chamber is essential to the efficient operation of your distiller. Because water quality varies from place to place, your cleaning schedule may vary from once or twice per month to once every three months. It is suggested that you check the boiling chamber after the first week of use and once per week thereafter until you determine the cleaning schedule that's right for you. The boiling chamber should be cleaned when you see accumulated mineral deposits and debris collect in the chamber - visible proof that your distiller is removing unwanted water contaminants.

The carbon pre-filter has an effective life of 800 gallons or six months at which time it should be replaced.

The carbon post filter should be replaced every two months.

# Distillation

## Summary

### *Level 1*

1. A distiller is a reproduction of nature's hydrologic cycle, using evaporation and condensation to purify water.
2. In a distiller, contaminants with a boiling point above 212°F are left behind in the boiling chamber as the water evaporates.
3. Contaminants, which boil before water, are vented prior to the condensing coil.

### *Level 2*

1. A distiller consists of activated carbon pre-filtration, distillation, volatile organic chemical venting and activated carbon post-filtration.
2. The distillation stage consists of a boiling chamber, a heating element, a condensing coil, a condensing fan and a reservoir.
3. A distiller will remove bacteria, minerals, toxic compounds, pesticides as well as cryptosporidium and giardia lambia.
4. Maintenance of a distiller is critical. Frequency of cleaning is determined by observation.

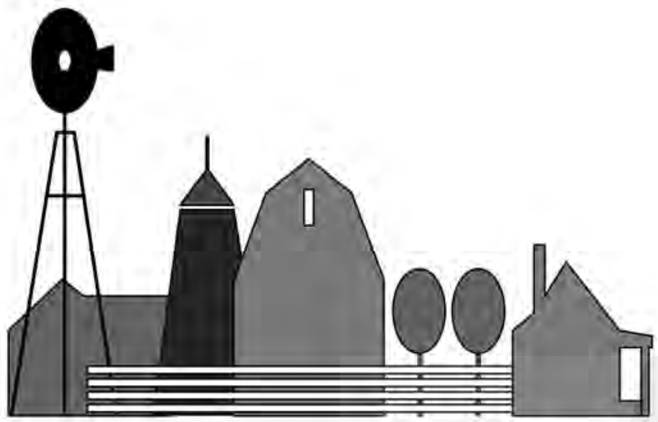
Product & Application Training

# SECTION 3

## Pumps



Water Group



# Pumps

## Objectives

***Level 1***

1. To become familiar with common terminology used in describing pumps and the pumping process.
2. To be able to identify water supply sources and variety of needs.
3. To understand the concept of atmospheric pressure and its application to pumping water.
4. To know the basic principles and application of centrifugal pumps.

***Level 2***

1. To be able to read pump curves and charts and apply client information in sizing and selecting a pump with appropriate capacity to meet system requirements.
2. To understand the application of pressure tanks and their selection relative to system needs.
3. To know the features, benefits and specific use of various accessories to complete an efficient functioning water system.
4. To understand all issues relating to the installation and operation of a well system.

# Terms & Facts

**ft. hd.** - feet of head

**gph** - gallons per hour

**gpm** - gallons per minute

**psi** - pounds per square inch

- 1 psi will raise a column of water 2.31 feet (whether the column of water is 2 inches or 2 feet in diameter)
- Atmospheric pressure at sea level is 14.7 psi (14.7 psi x 2.31 = 33.95 ft hd)
- A general rule for sizing a pump for a standard residence would be to use 1 gpm for each fixture.
- Pressure in pounds per square inch of a column of water = head in feet x .432
- Head in feet of a column of water = pressure in pounds per square inch x 2.31

**T.D.H. Total Dynamic Head** - total head from drawdown to point of use including suction head, discharge head and all friction loss in both suction and discharge pipes.

**Shallow Well** - 25 foot depth or less

**Deep Well** - more than 25 foot depth

**Volumes of Wells**

- 4" diameter contains .654 US gallons per foot
- 5" diameter contains 1.02 US gallons per foot
- 6" diameter contains 1.47 US gallons per foot
- 3 ft. bored well contains 53.02 gallons per foot

**Friction Loss** - lack of free movement of liquid due to resistance in pipe, meaning extra work for a pump or system and therefore adding to the total head of the system.

**Suction Head** - the vertical distance from the level of the water supply to the level of the pump.

**Discharge Head** - the vertical distance from the level of the pump to the level of the discharge outlet where the water is delivered + required service pressure + friction loss.

- A shallow well jet - pumps from the static or drawdown level and the jet is located in or on the pump.
- A deep well jet - pumps from the depth at which the pump injector is located. The minimum well diameter for our deep well jets or submersibles is 4 inches.
- Generally speaking, our deep well jets can be used to depths of 100 feet and our deep well submersibles perform best at below 50 feet but can be applied to both shallow and deep wells.
- An Imperial gallon of fresh water weighs 10 lbs.
- A cubic foot of water contains 7.48 U.S. gallons or 6.24 Imperial gallons and weighs 62.4 pounds
- A cubic meter of water contains 265 U.S. gallons or 220 Imperial gallons.
- Doubling the pipe diameter quadruples the capacity
- Atmospheric pressure at sea level is usually estimated at 14.7 pounds per square inch. This pressure will maintain a column of water 33.9 feet high when the normal pressure in the column is relieved by the creation of a vacuum. This is the theoretical distance that water may be drawn by suction. In practice, however, pumps should not be placed over 20 to 25 feet above the water supply and nearer, if possible.

# Water Supply Sources

### The Water Cycle

The water cycle is a continuous process of evaporation and precipitation. Water falls as rain or snow, some collecting as surface water--ponds, lakes, rivers and streams--while the remainder seeps into the earth as groundwater and continues to move until it emerges again as surface water. The water we use comes from two main sources:

### Surface Water

- Lakes, ponds, streams, rivers, etc.
- Surface waters are susceptible to toxic contamination from pesticides, industrial waste and farm animals, etc.

### Groundwater

- Wells
- Groundwater sources are usually safer from toxic contaminants than surface water sources.

# Types of Wells

There are basically four types of wells which are divided into two groups:

- Deep Wells - wells that require a total suction lift of more than 25 feet
- Shallow Wells - wells that require a total suction lift of 25 feet or less



### Dug Wells

New wells of this type are rare. This type of well is usually about 3 feet in diameter and less than 30 feet deep. To create a dug well, the digger works down, lining the well with 3-4 foot diameter concrete pipe in sections which fit together to create a sort of chimney. He may be assisted by power tools but the going is slow and the loosened earth has to be hauled up continuously. For obvious reasons, dug wells are practical only where the water table is near the surface.

They have the nasty habit of going dry when the water table drops during prolonged heat and drought -- at the very time when water is most needed. They are also the most liable to contamination.

### Bored Wells

Some historians claim that wells were bored in China as long ago as 2640 B.C. Today, wells to 100 feet in depth and up to 30 inches in diameter can be bored with an earth auger. This implement is turned by hand or power and additional lengths of shank can be added to achieve the required depth. When the auger is pulled up carefully, it leaves a fairly clean hole which must be lined with pipe made of concrete, clay or steel. In ideal conditions, this method is fast and satisfactory. However, it will not work well in loose soils and, for that reason, a bored well can go only a few feet below the water table. Boring is hard in boulder-laden soil and the auger-type tool will not penetrate solid rock.

### Driven Wells (often referred to as a Sandpoint)

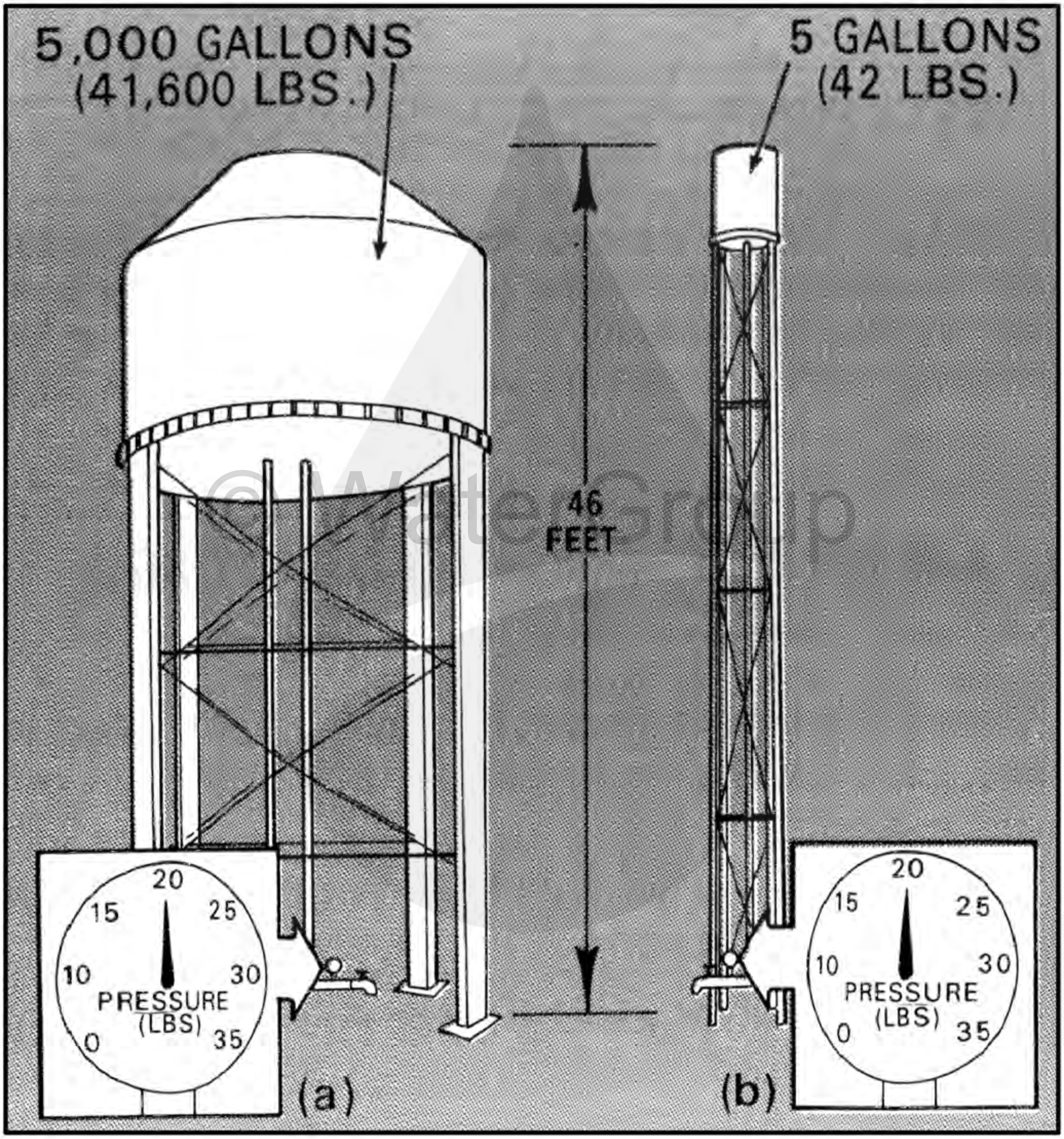
Driving a well simply means hammering a metal pipe into the ground like a hollow nail. This pipe is tipped with a point of hard steel. Openings in the pipe just behind the tip are screened by a mesh sleeve which acts as a filter. One man holds the pipe upright while one or more men drive it downwards with hammer blows. 1-1/4" to 2" pipe is normally used in lengths of 4' to 6' with threaded ends for joining the sections until the necessary depth is reached. The pipe is then left in place and the upper end is linked to the pump and distribution system. This is a quick and low cost way to get water if the water table is within 25 feet of the surface and there are no rocks to prevent the driving of the pipe. The maximum practical depth of a driven well is about 50 feet.

### Drilled Wells

This is the most common type of well used today. Wells from 4" to 24" in diameter can be drilled to depths of 1000 feet. Development of present equipment and methods owes a great deal to oil drilling specialists. This method can pulverize even consolidated rock, mixing the particles with fluid and bailing them to the surface as mud.

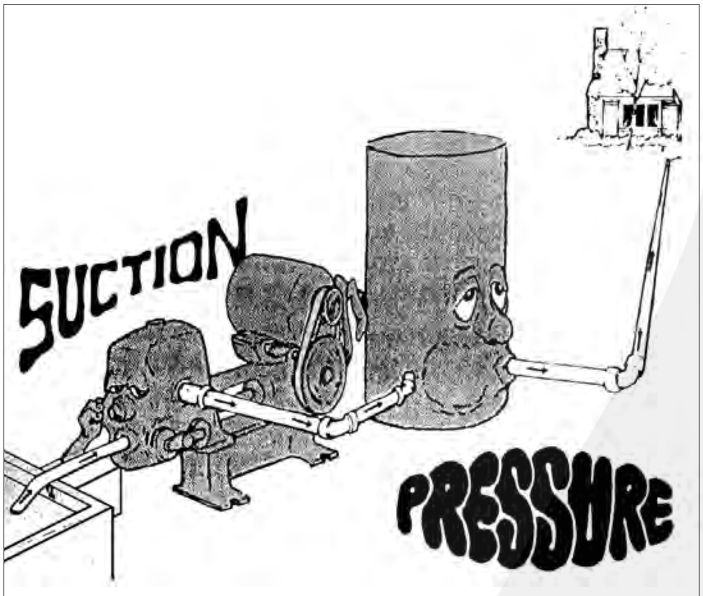
# PSI

***1 psi = 2.31 feet***
***1 ft. hd. = .432 psi***



# Principles Involved in Pumping

There is a wide assortment of pumps for home and farm use but, no matter how they are made, they do a certain amount of pulling water by suction and a lot of pushing water by pressure.



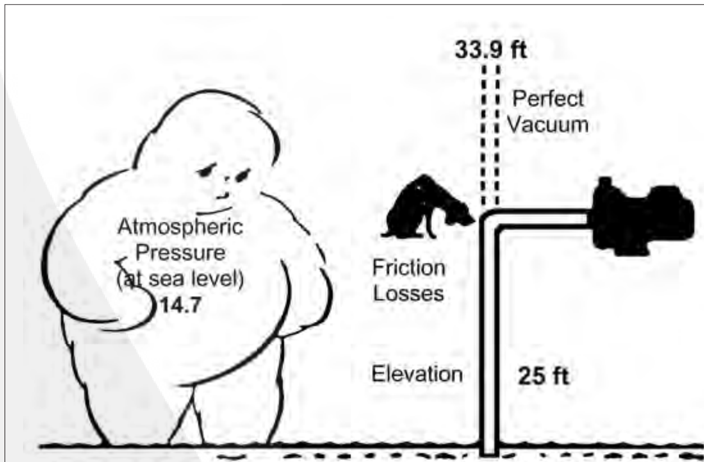

The job of a pump is to lift water by suction into its mechanism, then deliver the water to a storage or pressure tank.

The suction comes when your pump draws water into its working mechanism from your water source. The pump puts the water under pressure as it forces the water into the pressure tank. From the tank, it flows under pressure through your piping system.

When the pump starts, it removes more and more water from the suction pipe. This gradually reduces the pressure inside the pipe while the atmospheric pressure on the outside remains the same.

This allows atmospheric pressure to force water up the suction line and into the pump, where the impeller and centrifugal force take over.

| | |
|---|---|
| 14.7 | lbs. per square inch - atmospheric pressure |
| x 2.31 | feet - amount of water lifted by 1 psi pressure |
| 33.95 | ft. hd. |




Atmospheric pressure overcomes elevation or suction lift but its effectiveness is lessened by friction loss.

Pumps that lift water by suction from limited depths (less than 25 feet) are called shallow well pumps.

Pumps that lift water from greater depths are called deep well pumps. Pumps of this type provide for lowering part or all of the pumping mechanism down into the well to a point where little or no suction is needed. The "no suction" condition is when the pumping mechanism is submerged in the water.

# Centrifugal Pumps

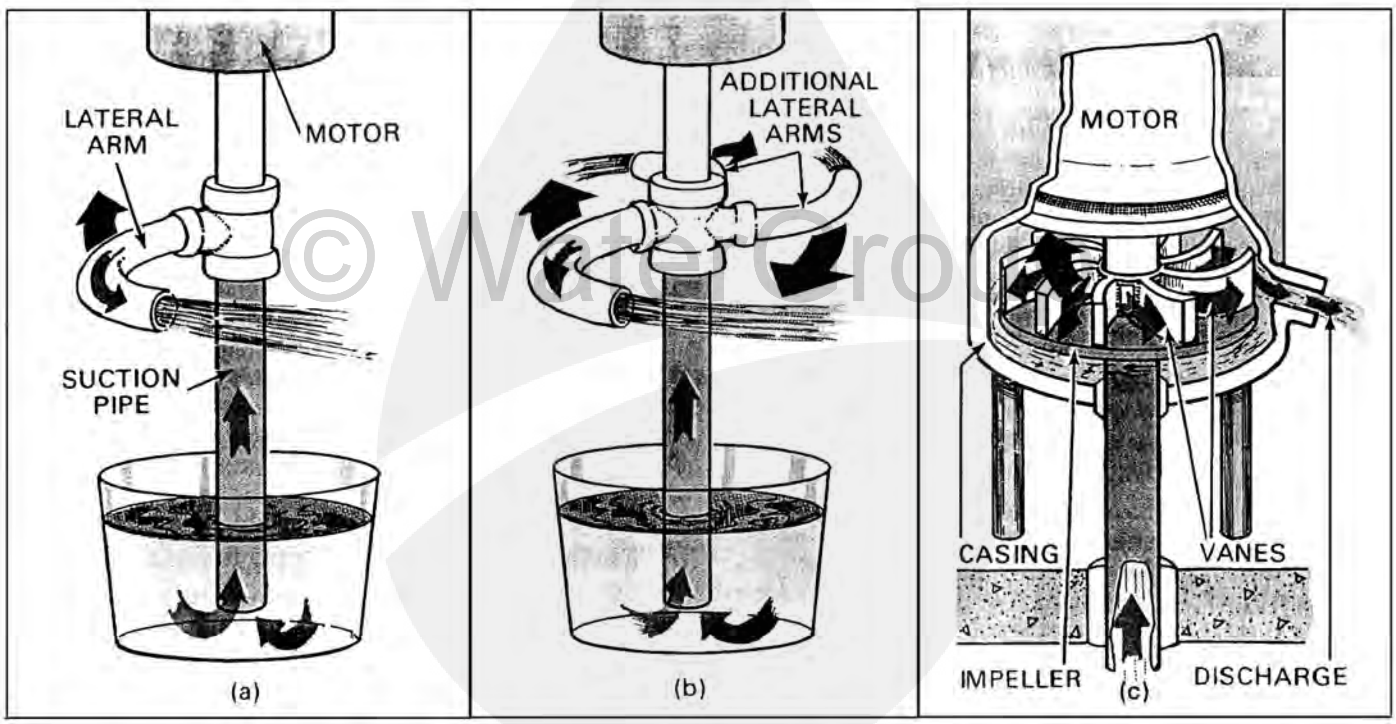
### *Centrifugal -*

**centri - from the center, fugere - to fly away**

Take a bucket with some water in it and swing it around and around by the handle at arm's length in a full circle. Swing it fast enough and the water won't spill out, even when you swing it upside-down over your head. The water seems to fly away from the center of the circle which is your shoulder. If there's a hole in the bucket, the water will shoot out through the hole with increasing force, the faster you swing it.

A centrifugal pump has an impeller which spins inside a circular casing. The blades of the impeller whirl the water around in a circle, so it tries to fly away from the center. In fact, it tries to fly out through the side walls of the casing but it can only get out at one point--the discharge point.

As the water is flung out, a low pressure area is created at the inlet port at the center of the impeller. This draws more water into the pump.




(a) An L-shaped pipe, completely filled with water and rotated rapidly will pump water out of a bucket. Water thrown out of a lateral arm by centrifugal force creates suction, causing water to rise from the bucket.

(b) By adding more lateral arms, more water is pumped.

(c) With a manufactured pump, the lateral arms are replaced with an impeller mounted inside a casing. The impeller vanes are mounted with a plate on one side (as shown) or with a plate on each side. These vanes act in the same way as the lateral arms in (b).

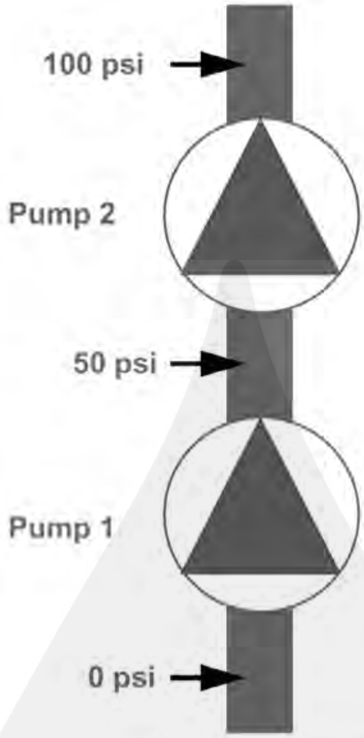
When viewed from the motor end, the impeller turns in a clockwise direction.

### *Single Stage Centrifugal Pumps*

Centrifugal pumps can have one impeller (single stage) or several impellers (multi-stage). The single stage centrifugal pump can lift water a vertical distance of about 15 feet with an absolute maximum of 20 feet. Since it can lift water such a limited distance, it makes an ideal booster pump.

### *Multi-Stage Centrifugal Pumps*

One way to increase the pressure output of a centrifugal pump is to increase the number of impellers. Each impeller in a multi-stage pump adds its own pressure capability to the one before it. The vertical height to which a centrifugal pump can push water is increased every time another impeller is added. This makes multi-stage pumps suitable for deep wells.




Stacking Pumps to Increase Pressure

For example a 4" submersible pump with a single 3½" diameter impeller that produces 9 psi of discharge pressure at a flow rate of 5 gpm will develop 21 feet of head.

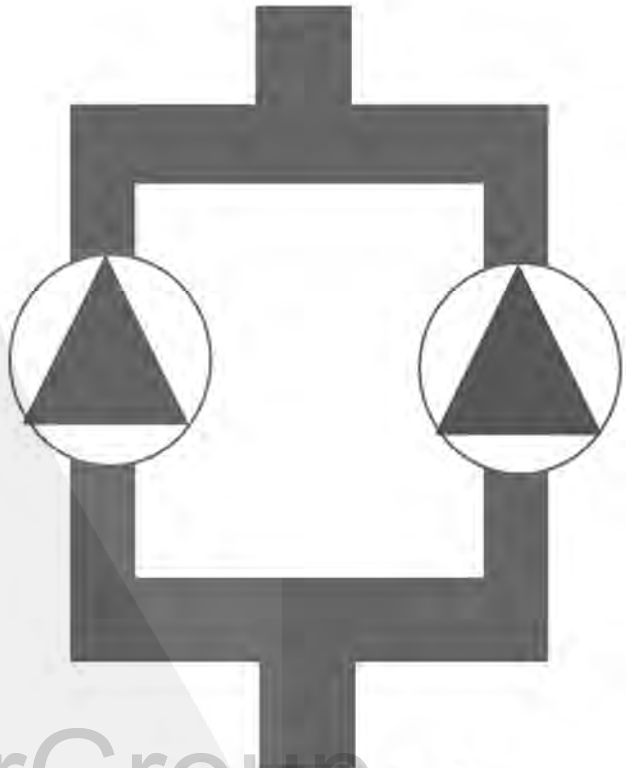
Adding two more impeller stages will increase the pressure capability of this pump to 27 psi, or 62 feet of head.

A simple way to increase pressure is to stack pumps (see diagram), hooking them in a series with the outlet of the first connected to the inlet of the second. This was a common practice before multi-stage centrifugal pumps were more readily available and may still be the most economical alternative in some situations. The more conventional practice today is to use a multi-stage centrifugal with enough pressure capability to do the job.



## Notes

# Flow Capacity



Connecting Pumps in Parallel to Increase Flow

The amount of water pumped by a centrifugal pump is determined by the rpm of the motor and width of the impeller. The only major difference between the impellers in a 5 gpm, 4" submersible and those of a 75 gpm, 4" submersible is the width of the impellers. Of course, the 75 gpm sub will require a much larger motor to do the additional work of pumping more water.

The concept of using multiple pumps can also be used to increase the flow capacity of a system but, instead of connecting the pumps in series as we did to increase pressure, we would connect them in parallel which will result in a flow capacity equal to the sum of the two pumps with no pressure increase (see diagram).

With the abundance of pumps on the market today, it is seldom necessary to resort to this practice to achieve the desired flow but the concept does have particular merit when your application requires a reduced flow rate some of the time and more flow at other times. A back-up fire fighting system would be one example of such a system. Parallel pumps are also used as an alternating mode in applications where having a back-up pump is desirable. Of course, check valves in series with each pump are necessary to run them independently.



## Notes

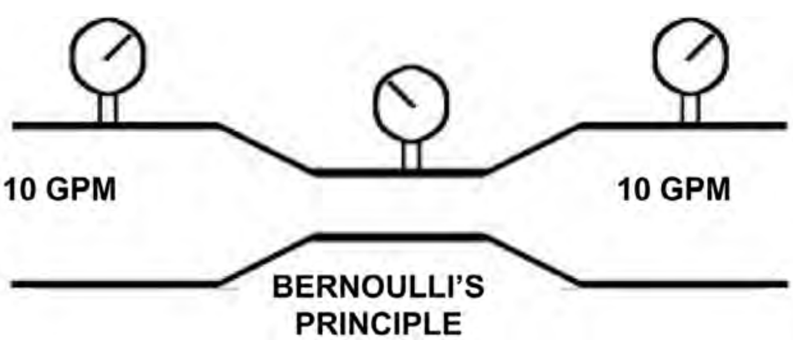
# Jet Pumps

In a pump, the impeller with vanes directly connected to the motor takes the place of the lateral arms. Because a shallow well centrifugal pump will lift water only 15 to 18 feet, a jet assembly is added to the pump. Instead of all the water being directed to discharge, some is directed back through the jet where it creates the area of low pressure, drawing more water into the pump. For the jet to be more effective, it is used with a cone shaped diffuser or venturi to create a better vacuum. The jet and diffuser assembly, known as the ejector, are simple in appearance but, in fact, are carefully engineered and matched for efficiency.

A shallow well jet is located on the pump while a deep well jet is located in the well below the water. The ejector is at the motor of a shallow-well jet pump but is down in the well for a deep well jet pump, requiring both a suction and a return or pressure line. The impeller is motor driven to draw water into the inlet and force it out the high pressure outlet side. A shallow well jet pump will generate less pressure but higher flow, while a deep well jet pump will produce less flow but higher pressure.

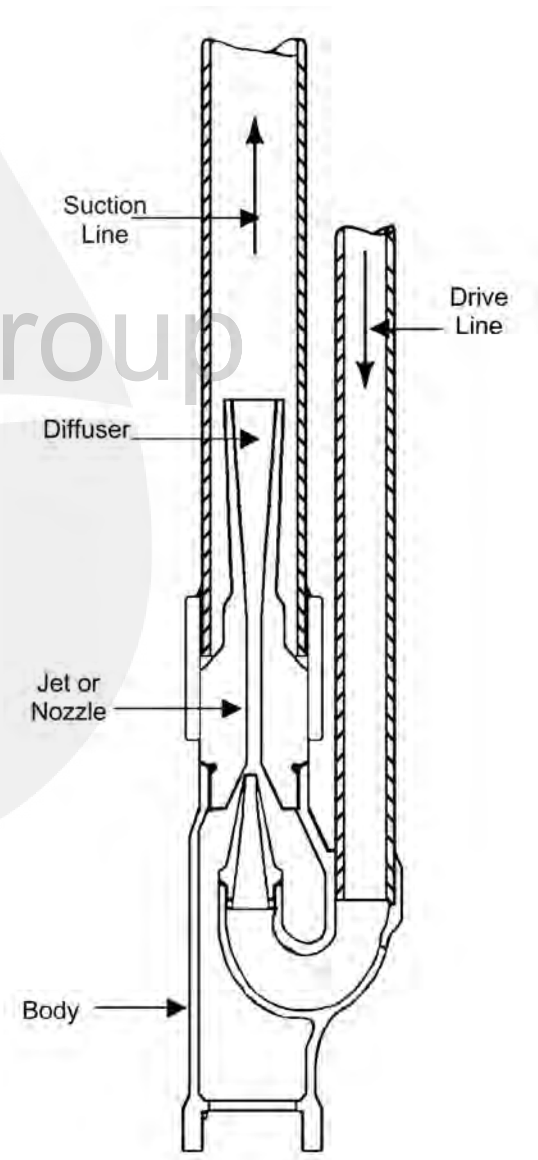
### Advantages

- Because jet pumps have only one moving part--the impeller, (which is directly connected to the motor) they are quite easy to handle and very reliable.
- Operate with very little noise or vibration
- Produce good volumes (particularly shallow well jets)
- Require very little maintenance and have a reasonable life considering the workload
- Shallow well jet pumps can be used to lift water up to 25 ft. Deep well jet pumps can be used for lifts up to 100 ft.




### Disadvantages

- Will not tolerate air (causes loss of prime)
- As the vertical distance between the pump and water increases, the pressure and/or flow decreases.
- Limited depths of operation and discharge pressures available
- A control valve is needed on the outlet of the pump to provide a minimum back pressure of 20 psi for efficient jet operation.



# Deep Well Submersibles

Deep well submersible pumps are so named because the whole unit -- pump and motor -- is designed to be operated under water. The pump end is made up of a number of individual stages (multi-stage) of cups, impellers and caps. They are stacked one on top of another in a stainless steel shell and capped at the top with a discharge head and at the bottom with a suction bowl. This pump assembly is then mounted on top of the submersible motor. The shafts are joined through a splice coupling. The suction area is then covered with a screen to prevent solids from gaining entry.

There is only one pipe connection, the discharge port, located at the top. A check valve is located here to prevent water from running back into the well when the pump is not running. The volume of these pumps is governed by the impeller design while the pressure they can produce is governed by the number of stages. The motors are carefully selected to match the needs of each model.

Several impellers (small centrifugal pumps) act in series to force water up the drop pipe. A nylon rope permits pulling the pump if the drop pipe breaks. An electric cable provides electricity to the pump motor.

### *Advantages*

- Can be installed in wells up to 1000 feet deep and 4" or larger in diameter
- More efficient than any other type of pump--high volumes and high pressure with minimum horsepower
- Silent running and maintenance free
- Control box with electrical components located in basement
- Simple installation (only one line)

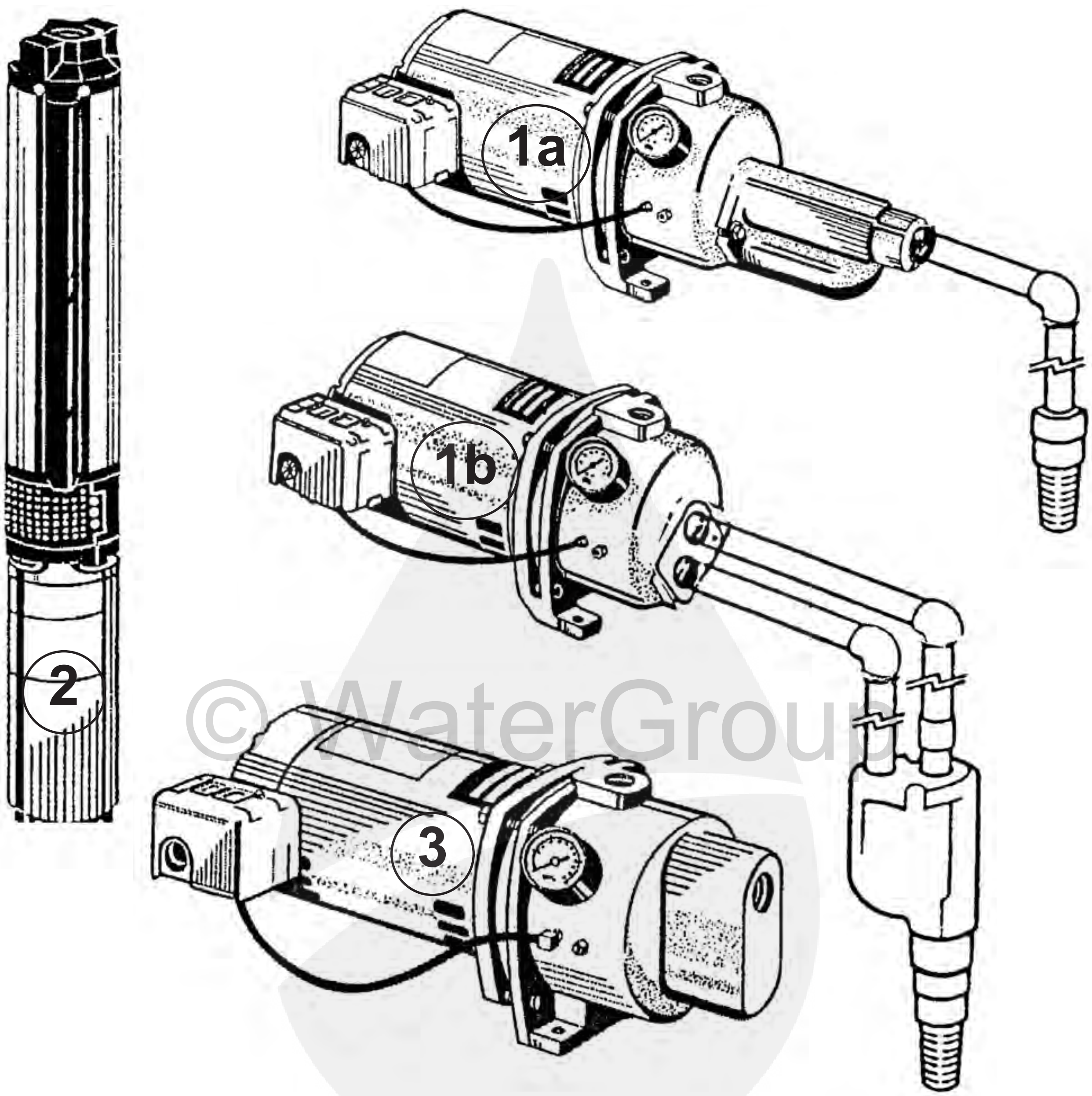
### *Disadvantages*

- Higher installation cost and initial investment



## Notes

# Types of Pumps






1. Convertible Jet Pumps can be installed as either:
   a. Shallow Well Jet Pump (ejector on pump)
   b. Deep Well Jet Pump (ejector in well)

2. Deep Well Submersible Pump (multi-stage pumps with multi-impellers mounted on a submersible motor)

3. Shallow Well Jet Pump (ejector on pump)

# Pump Capacity

There is no way of knowing what capacity pump to purchase unless you determine the peak demand for the conditions under which it will be used.

In determining what pumping capacity will be used, there are three factors to consider:

- Capacity needed to meet peak demands
- Capacity needed for fire protection
- Recovery rate of water supply limits the size of the pump

### *How To Calculate Water Needs*

A general rule for sizing a pump for a standard residence is to use 1 gpm for each plumbing fixture in the house.

The chart on the following page is intended as a handy calculator of daily water needs of humans and livestock. The figures are reliable averages but they do not attempt to make allowances for increased needs of the future, nor for emergency needs such as farm fire fighting.

Here are a few tips to bear in mind:

- Flushing toilets accounts for one third of all the domestic water used by an average family.
- Livestock need considerably more water in summer than in winter.
- A water system should not be designed for average hourly water consumption but for maximum peak loads. For safety, a water system should be able to deliver the full daily requirement in a two hour period.
- Fire can destroy a lifetime of work in minutes. Fire fighting equipment demands a capacity of 500 USGPH. If the pump is going to be used for fire protection, we recommend it has a capacity of 500 gph or more.



## Notes

# Planning Guide for Water Consumption

**Apartments - Based on 3 persons/apartment**
- Hot and cold ............................... 180 gal/unit/day
- Hot only ....................................... 60 gal/unit/day

**Assembly Hall** .......................................... 2 gal/seat
**Barber Shops** ................................. 55 gal/day/chair
**Beauty Salons** .......................... 270 gal/day/station
**Boilers**
To determine daily makeup in gallons:
1. Multiply boiler hp by 4.25
2. Then multiply by hours/day of operation
3. Then multiply by the % operating rating
4. Then subtract the % condensate returns

When ratings are given in pounds of steam per hour, divide by 500 to obtain gpm requirement.
When ratings are given in BTUs, divide by 12,000. For every 12,000 BTUs, there is an equivalent of 1 hp

**Bowling Alley** ....................................... 175 gal/lane
**Camps**
- Day - no meals ........................ 15 gal/day/person
- Resorts ................................... 50 gal/day/person
- Tourist ..................................... 35 gal/day/person

**Cooling Tower**
To determine daily makeup in gallons:
1. Multiply the tonnage by 4 (this includes 2 gal/day/hr/ton bleed off.
2. Then multiply by the number of hours per day of operation

**Dentist** ................................. 4,000 gal/month/chair
**Department Stores** .................. 0.215 gal/day/sq ft
**Dormitories**
- Hot and cold ............................ 40 gal/person/day
- Hot only ................................. 20 gal/person/day

**Golf Club/Gym**
- ................................ # of showers x 1300 gal/day
- ................................ # of lavatories x 150 gal/day
- .......................................... # of meals x 4 gal/day

**Hotels**
- Hot and cold .................. 350 gal/day/guest room
- Hot only ......................... 225 gal/day/guest room

**Hospitals**
- Hot and cold ............................. 250 gal/bed/day
- Hot only ..................................... 170 gal/bed/day

**Homes** ......................................... 60 gal/person/day
**Lawns** ...................................... 25 gal/sq ft/season
**Laundromat** ............................. 2.5 x lb. capacity is equivalent to gallons per cycle
**Livestock and Poultry**
- Cow, beef ............................... 12 gal/animal/day
- Cow, dairy ............................... 20 gal/animal/day
- Goat, sheep .............................. 2 gal/animal/day
- Hog, horse, mule .................... 12 gal/animal/day
- Chickens ............................. 10 gal/each100/day
- Turkeys ............................... 18 gal/each 100/day

**Meat Packing Facility**
- ........................................................ 1 gal/bird/day
- ........................................................ 6 gal/hog/day
- ..................................................... 12 gal/cow/day

**Motels**
- Hot and cold ............................ 100 gal/unit/day
- Hot only......................................... 40 gal/unit/day

**Movie Theater** .................................. 2 gal/seat/day
**Nursing Homes**
- Hot and cold ............................ 100 gal/bed/day
- Hot only ....................................... 50 gal/bed/day

**Office Buildings**
- Hot and cold ........................... 20 gal/person/day
- Hot only .................................... 3 gal/person/day

**Restaurants**
- Hot and cold ............................. 15 gal/meal/day
- Hot only ......................................... 7 gal/meal day
- Cocktail Lounge add on ........... 2 gal/patron/day

**Elementary Schools**
- Hot and cold .......................... 13 gal/student/day
- Hot Only .................................. 5 gal/student/day

**High Schools with Showers**
- Hot and cold .......................... 25 gal/student/day
- Hot only .................................. 6 gal/student/day

**High Schools with Showers & Cafeteria**
- Hot and cold .......................... 35 gal/student/day
- Hot only ................................. 15 gal/student/day

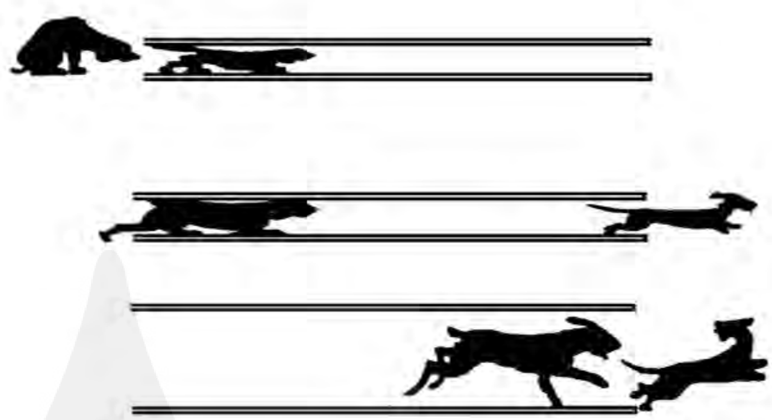
**Service Stations** ................ 700 gal/day/service bay
**Shopping Centers** .............. 300 gal/day/1000 sq ft
**Stockyard** ..................................... 200 gal/day/acre
**Tavern** ............................................ 20 gal/day/seat
**Trailer Parks** ............................... 150 gal/day/trailer

# Friction Loss

When water flows through pipe, the inner wall of that pipe resists the flow. This resistance is called pipe friction.

Friction in turn means more work for a pump, so it is desirable to keep the friction losses as low as is practical.

Friction loss is very important when selecting a pump as it could make the difference as to whether the unit works or not. For instance, if a shallow well pump had a vertical lift of 15 feet as well as 15 feet of friction loss, it would be beyond the acceptable limit for a shallow well of 25 feet.



Friction loss increases when capacity or pipe length increases and when diameter decreases



## Notes

# Plastic Pipe Friction Loss

## 1" PIPE

| FLOW | | VELOCITY | | HEAD LOSS | |
|---|---|---|---|---|---|
| US Gal per Min | Liters per Min | Feet per Sec | Meters per Sec | Feet per 100 Feet | Meters per 30 Meters |
| 2 | 8 | 0.74 | 0.23 | 0.31 | 0.09 |
| 3 | 11 | 1.11 | 0.34 | 0.67 | 0.20 |
| 4 | 15 | 1.49 | 0.45 | 1.16 | 0.35 |
| 5 | 19 | 1.86 | 0.57 | 1.74 | 0.53 |
| 6 | 23 | 2.23 | 0.68 | 2.43 | 0.74 |
| 8 | 30 | 2.97 | 0.91 | 4.15 | 1.26 |
| 10 | 38 | 3.71 | 1.13 | 6.30 | 1.92 |
| 12 | 45 | 4.46 | 1.36 | 8.80 | 2.68 |
| 14 | 53 | 5.20 | 1.58 | 11.70 | 3.57 |
| 16 | 61 | 5.94 | 1.81 | 15.00 | 4.57 |
| 18 | 68 | 6.68 | 2.04 | 18.60 | 5.67 |
| 20 | 76 | 7.43 | 2.26 | 22.50 | 6.86 |

## 1¼" PIPE

| FLOW | | VELOCITY | | HEAD LOSS | |
|---|---|---|---|---|---|
| US Gal per Min | Liters per Min | Feet per Sec | Meters per Sec | Feet per 100 Feet | Meters per 30 Meters |
| 4 | 15 | 0.86 | 0.26 | 0.30 | 0.09 |
| 5 | 19 | 1.07 | 0.33 | 0.46 | 0.14 |
| 6 | 23 | 1.29 | 0.39 | 0.64 | 0.20 |
| 7 | 27 | 1.50 | 0.46 | 0.86 | 0.26 |
| 8 | 30 | 1.72 | 0.52 | 1.10 | 0.34 |
| 10 | 38 | 2.15 | 0.66 | 1.65 | 0.50 |
| 12 | 45 | 2.57 | 0.78 | 2.31 | 0.70 |
| 13 | 53 | 3.00 | 0.91 | 3.06 | 0.93 |
| 14 | 61 | 3.43 | 1.05 | 3.95 | 1.20 |
| 16 | 68 | 3.86 | 1.18 | 4.90 | 1.49 |
| 20 | 76 | 4.29 | 1.31 | 5.90 | 1.80 |
| 25 | 95 | 5.36 | 1.63 | 9.10 | 2.77 |
| 30 | 114 | 6.43 | 1.95 | 12.60 | 3.84 |
| 35 | 132 | 7.51 | 2.29 | 16.40 | 5.00 |
| 40 | 151 | 8.58 | 2.62 | 21.40 | 6.52 |

## 3" PIPE

| FLOW | | VELOCITY | | HEAD LOSS | |
|---|---|---|---|---|---|
| US Gal per Min | Liters per Min | Feet per Sec | Meters per Sec | Feet per 100 Feet | Meters per 30 Meters |
| 10 | 38 | 0.43 | 0.13 | 0.034 | 0.010 |
| 15 | 57 | 0.65 | 0.20 | 0.072 | 0.022 |
| 20 | 76 | 0.87 | 0.27 | 0.122 | 0.037 |
| 25 | 95 | 1.19 | 0.33 | 0.186 | 0.057 |
| 30 | 114 | 1.30 | 0.40 | 0.257 | 0.078 |
| 35 | 132 | 1.52 | 0.46 | 0.342 | 0.104 |
| 40 | 151 | 1.74 | 0.53 | 0.440 | 0.134 |
| 45 | 170 | 1.95 | 0.59 | 0.550 | 0.168 |
| 50 | 189 | 2.17 | 0.66 | 0.665 | 0.203 |
| 55 | 208 | 2.39 | 0.73 | 0.790 | 0.216 |
| 60 | 227 | 2.60 | 0.79 | 0.940 | 0.287 |
| 65 | 246 | 2.82 | 0.86 | 1.08 | 0.329 |
| 70 | 265 | 3.04 | 0.93 | 1.24 | 0.378 |
| 75 | 284 | 3.25 | 0.99 | 1.41 | 0.430 |
| 80 | 303 | 3.47 | 1.06 | 1.58 | 0.482 |
| 85 | 322 | 3.69 | 1.12 | 1.78 | 0.543 |
| 90 | 341 | 3.91 | 1.19 | 1.96 | 0.597 |
| 95 | 360 | 4.12 | 1.26 | 2.18 | 0.665 |
| 100 | 379 | 4.34 | 1.32 | 2.40 | 0.732 |
| 110 | 416 | 4.77 | 1.45 | 2.86 | 0.872 |
| 120 | 454 | 5.21 | 1.59 | 3.36 | 1.02 |
| 130 | 492 | 5.64 | 1.72 | 3.91 | 1.19 |
| 140 | 530 | 6.08 | 1.85 | 4.56 | 1.39 |
| 150 | 568 | 6.51 | 1.98 | 5.10 | 1.55 |
| 160 | 606 | 6.94 | 2.12 | 5.76 | 1.76 |
| 180 | 681 | 7.81 | 2.38 | 7.10 | 2.16 |
| 200 | 757 | 8.68 | 2.65 | 8.60 | 2.62 |
| 220 | 833 | 9.55 | 2.91 | 10.10 | 3.08 |
| 240 | 908 | 10.40 | 3.17 | 12.10 | 3.69 |
| 260 | 984 | 11.30 | 3.44 | 14.40 | 4.39 |
| 280 | 1060 | 12.20 | 3.72 | 16.10 | 4.90 |
| 300 | 1136 | 13.00 | 3.96 | 18.20 | 5.55 |
| 320 | 1211 | 13.90 | 4.24 | 20.70 | 6.31 |
| 340 | 1287 | 14.80 | 4.51 | 24.00 | 7.32 |
| 360 | 1363 | 15.60 | 4.75 | 25.60 | 7.80 |

## 1½ PIPE

| | | | | | |
|---|---|---|---|---|---|
| 4 | 15 | 0.63 | 0.19 | 0.14 | 0.04 |
| 5 | 19 | 0.79 | 0.24 | 0.21 | 0.06 |
| 6 | 23 | 0.95 | 0.29 | 0.31 | 0.09 |
| 7 | 27 | 1.10 | 0.34 | 0.41 | 0.13 |
| 8 | 30 | 1.26 | 0.38 | 0.51 | 0.16 |
| 9 | 34 | 1.42 | 0.43 | 0.64 | 0.20 |
| 10 | 38 | 1.58 | 0.48 | 0.78 | 0.24 |
| 12 | 45 | 1.89 | 0.58 | 1.11 | 0.34 |
| 14 | 53 | 2.21 | 0.67 | 1.45 | 0.44 |
| 16 | 61 | 2.52 | 0.77 | 1.86 | 0.57 |
| 18 | 68 | 2.84 | 0.87 | 2.31 | 0.70 |
| 20 | 76 | 3.15 | 0.96 | 2.81 | 0.86 |
| 22 | 83 | 3.47 | 1.05 | 3.35 | 1.02 |
| 24 | 91 | 3.78 | 1.15 | 3.94 | 1.20 |
| 26 | 98 | 4.10 | 1.24 | 4.50 | 1.37 |
| 28 | 106 | 4.41 | 1.34 | 5.18 | 1.58 |
| 30 | 114 | 4.73 | 1.44 | 5.95 | 1.81 |
| 32 | 121 | 5.04 | 1.54 | 6.70 | 2.04 |
| 34 | 128 | 5.36 | 1.63 | 7.50 | 2.29 |
| 36 | 136 | 5.67 | 1.73 | 8.30 | 2.53 |
| 38 | 143 | 5.99 | 1.82 | 9.20 | 2.80 |
| 40 | 151 | 6.30 | 1.92 | 10.10 | 3.08 |
| 42 | 159 | 6.62 | 2.02 | 11.20 | 3.41 |
| 44 | 167 | 6.93 | 2.11 | 12.10 | 3.69 |
| 46 | 174 | 7.25 | 2.21 | 13.20 | 4.02 |
| 48 | 182 | 7.57 | 2.31 | 14.60 | 4.45 |
| 50 | 189 | 7.88 | 2.40 | 16.30 | 4.66 |
| 55 | 208 | 8.67 | 2.64 | 18.30 | 5.58 |
| 60 | 227 | 9.46 | 2.88 | 21.50 | 6.55 |
| 65 | 246 | 10.20 | 3.11 | 25.00 | 7.62 |

## 2" PIPE

| | | | | | |
|---|---|---|---|---|---|
| 5 | 19 | 0.48 | 0.15 | 0.064 | 0.020 |
| 6 | 23 | 0.57 | 0.17 | 0.091 | 0.028 |
| 7 | 27 | 0.67 | 0.20 | 0.119 | 0.036 |
| 8 | 30 | 0.77 | 0.23 | 0.152 | 0.046 |
| 9 | 34 | 0.86 | 0.26 | O.190 | 0.058 |
| 10 | 38 | 0.96 | 0.29 | 0.231 | 0.070 |
| 12 | 45 | 1.15 | 0.35 | 0.322 | 0.098 |
| 14 | 53 | 1.34 | 0.40 | 0.432 | 0.131 |
| 16 | 61 | 1.53 | 0.47 | 0.550 | 0.168 |
| 18 | 68 | 1.72 | 0.52 | 0.690 | O.210 |
| 20 | 76 | 1.91 | 0.58 | 0.83 | 0.253 |
| 22 | 83 | 2.10 | 0.69 | 1.00 | 0.304 |
| 24 | 91 | 2.29 | 0.70 | 1.17 | 0.357 |
| 26 | 98 | 2.49 | 0.76 | 1.34 | 0.408 |
| 28 | 106 | 2.68 | 0.82 | 1.55 | 0.472 |
| 30 | 114 | 2.87 | 0.87 | 1.75 | 0.536 |
| 35 | 132 | 3.35 | 1.02 | 2.35 | 0.716 |
| 40 | 151 | 3.82 | 1.16 | 3.00 | 0.914 |
| 45 | 170 | 4.30 | 1.31 | 3.75 | 1.140 |
| 50 | 189 | 4.78 | 1.46 | 4.55 | 1.390 |
| 55 | 208 | 5.26 | 1.60 | 5.50 | 1.68 |
| 60 | 227 | 5.74 | 1.75 | 6.40 | 1.95 |
| 65 | 246 | 6.21 | 1.89 | 7.35 | 2.24 |
| 70 | 265 | 6.69 | 2.04 | 8.50 | 2.59 |
| 75 | 284 | 7.17 | 2.19 | 9.10 | 2.77 |
| 80 | 303 | 7.65 | 2.33 | 10.80 | 3.29 |
| 85 | 322 | 8.13 | 2.48 | 12.10 | 3.69 |
| 90 | 341 | 8.61 | 2.62 | 13.40 | 4.08 |
| 95 | 360 | 9.06 | 2.76 | 14.80 | 4.51 |
| 100 | 378 | 9.56 | 2.91 | 16.30 | 4.97 |

**Friction Head Loss for Insert Adapters and Insert Couplings**

For every 10 insert adapters used, add the number offset (meters) indicated in Column A to total length of pipe.

For every 10 insert couplings used, add the number of feet (meters) indicated in Column B to the total length of pipe.

| Pipe Sizes | A | | B | |
|---|---|---|---|---|
| | Feet | Meters | Feet | Meters |
| 1" | 20 | 6 | 10 | 3 |
| 1¼ | 27 | 8 | 13 | 4 |
| 1½ | 34 | 10 | 16 | 5 |
| 2" | 44 | 13 | 20 | 6 |
| 3" | 62 | 19 | 29 | 9 |

- By design, deep well submersible pumps require more cable than pumps that are located in a building near a service panel.
- Submersibles can be hundreds of feet from the residence and hundreds more down the well.
- Just as friction loss occurs in a water pipe, the same thing is true of electrical current through cable.
- Undersized cable could cause overloading and premature failure of a submersible motor.
- The manufacturers of submersible motors, therefore, provide tables by which we can tell beforehand which size cable to use to supply adequate amperage.
- These tables specify:
- Phase - single to three
- Volts - 115 volt, 230 volt, 460 volt, 575 volt and more
- Horsepower - from 1/4 hp to 40 hp
- Maximum length or size to be used

***Always check for proper cable selection. Single phasemotors require two wire cable plus ground wire.***

***Three phase motors require three wire cable plus ground wire.***



| Motor Rating | | | 60° C Insulation - AWG Cooper Wire Size | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volts | HP | KW | 14 | 12 | 10 | 8 | 6 | 4 | 3 | 2 | 1 | 0 | 00 | 000 | 0000 |
| 115 | 1/3 | .25 | 130 | 210 | 340 | 540 | 840 | 1300 | 1610 | 1960 | 2390 | 2910 | 3540 | 4210 | 5060 |
| | 1/2 | .37 | 100 | 160 | 250 | 390 | 620 | 960 | 1190 | 1460 | 1780 | 2160 | 2630 | 3140 | 3770 |
| 230 | 1/3 | .25 | 550 | 880 | 1390 | 2190 | 3400 | 5250 | 6520 | 7960 | 9690 | 11770 | | | |
| | 1/2 | .37 | 400 | 650 | 1020 | 1610 | 2510 | 3880 | 4810 | 5880 | 7170 | 8720 | | | |
| | 3/4 | .55 | 300 | 480 | 760 | 1200 | 1870 | 2890 | 3580 | 4370 | 5330 | 6470 | 7870 | | |
| | 1 | .75 | 250 | 400 | 630 | 990 | 1540 | 2380 | 2960 | 3610 | 4410 | 5360 | 6520 | | |
| | 1 1/2 | 1.1 | 190 | 310 | 480 | 770 | 1200 | 1870 | 2320 | 2850 | 3500 | 4280 | 5240 | | |
| | 2 | 1.5 | 150 | 250 | 390 | 620 | 970 | 1530 | 1910 | 2360 | 2930 | 3620 | 4480 | | |
| | 3 | 2.2 | 120 | 190 | 300 | 470 | 750 | 1190 | 1490 | 1850 | 2320 | 2890 | 3610 | | |
| | 5 | 3.7 | 0 | 0 | 180 | 280 | 450 | 710 | 890 | 1110 | 1390 | 1740 | 2170 | 2680 | |
| | 7 1/2 | 5.5 | 0 | 0 | 0 | 200 | 310 | 490 | 610 | 750 | 930 | 1140 | 1410 | 1720 | |
| | 10 | 7.5 | 0 | 0 | 0 | 0 | 250 | 390 | 490 | 600 | 750 | 930 | 1160 | 1430 | 1760 |
| | 15 | 11 | 0 | 0 | 0 | 0 | 170 | 270 | 340 | 430 | 530 | 660 | 820 | 1020 | 1260 |

- If aluminum conductor is used, multiply lengths by 0.5. Maximum allowable length of aluminum is considerable shorter than copper wire of the same sizes.
- The portion of the total cable, which is between the service entrance and a 3 Ø motor starter, should not exceed 25% of the total maximum length to assure reliable starter operation. Single-phase control boxes may be connected at any point of the total cable length.

# Pump Curves

Simply stated, a curve is a normally curved line drawn over a grid of vertical and horizontal lines to form a graph. The curved line represents the performance of a specific pump, while the gridlines provide units by which performance can be measured.

Let's suppose we wish to use water from a well located at a level lower than the house. Since gravity will not allow the water to flow uphill, we use a pump. The pump is used to deliver a volume of water a given distance under pressure. The volume is measured over a period of time and is expressed in gallons per minute (gpm) or gallons per hour (gph).

The pump develops energy which we call discharge pressure or total dynamic head. This pressure is expressed in a unit of measure called pounds per square inch (psi) or feet of head (ft hd).

NOTE: One pound of pressure per square inch (1 psi) will raise a column of water 2.31 feet.

When measuring a pump's performance, a curve can be used to select the best pump for a given job.

Here we will show a grid with the unit of measure in feet on the left side. It begins at "0" at the bottom and the numbers increase along the vertical axis, expressing the pump's ability to produce pressure which is expressed in feet. It can be converted to psi by multiplying the number of feet by .432 (e.g. 150 feet x .432 = 64.8 psi)

Another unit of measure is shown along the bottom of the grid, beginning with "0" at the left and increasing to the right, expressing the volume in U.S. gallons per minute (USGPM).

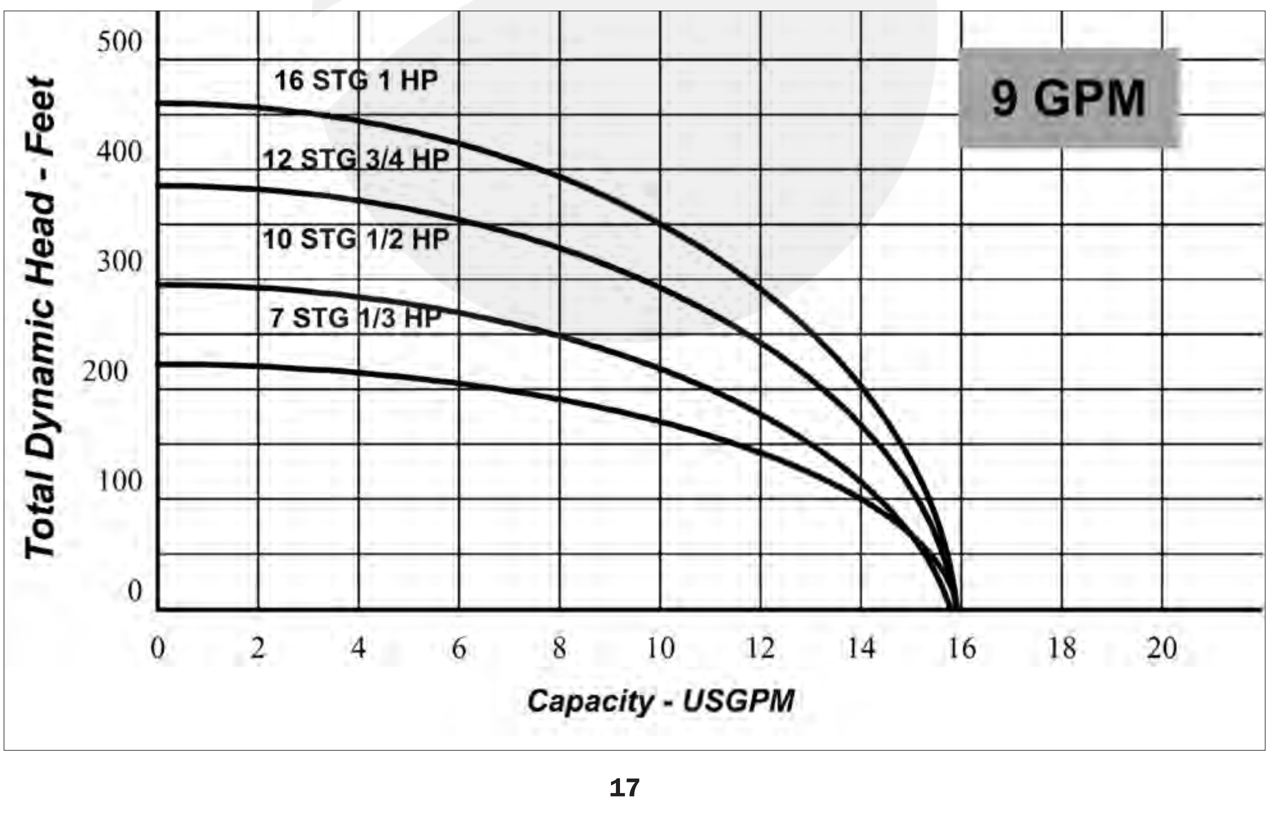
To establish a pump curve, the pump is operated using a gauge, a valve and a flow meter on the discharge side of the pump. The pump is first run with the valve closed to establish the maximum head in feet the pump can produce at "0" capacity. This point is marked on the grid. Then the valve is opened until the flow meter indicates 5 gpm and this point is marked on the grid. This is continued until the valve has been fully opened and all points have been recorded on the grid. Now all the points on the grid must be connected to form the pump curve.

There are many different curves or block charts in our catalogues. On the composite performance curve (more than one curve) shown below, you will see there is a different curve for each horsepower.

The 1/2 hp unit has 10 stages and, at 9 gpm, it will produce 230 ft hd. The 1 hp unit has 16 stages and, at 9 gpm, it will produce 340 ft hd. As stages are added, more pressure is developed for deeper applications but more horsepower is required to maintain the correct rpm.

Composite curves are used to locate the models you can select from for a specific application. The curve indicates the peak performance.





The pump block chart shown below provides the same information as the pump curve on the previous page but in a different format.

Pumping depths in feet are indicated across the top of the chart. Pressure settings appear down the left hand side.

Intersect the pump depth setting with the required pressure setting to arrive at the performance in gallons per hour.

The pump should be selected at the mid-range between cut-in and cut-out (e.g. for a 30/50 range, select the pump that delivers the required amount at 40 psi).

## 9 GPM, 1/3 - 3/4 hp, 3 Wire,
### Minimum Well Size 4" I.D., 1" Discharge

| H.P. | Voltage Phase | No. of Stages | Discharge Pressure psi | Pumping Depth - Feet | | | | | | | | | | | Shut Off Head Feet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 240 | |
| | | | | Capacity in U.S. Gallons per Hour | | | | | | | | | | | |
| | 115/1 | | 20 | 798 | 744 | 684 | 624 | 558 | 480 | 372 | | | | | |
| 1/3 | | 7 | 30 | 732 | 672 | 612 | 546 | 468 | 336 | | | | | | 203 |
| | 230/1 | | 40 | 672 | 600 | 528 | 444 | 324 | | | | | | | |
| | | | 50 | 594 | 522 | 438 | 294 | | | | | | | | |
| | 115/1 | | 20 | 846 | 810 | 768 | 726 | 684 | 636 | 582 | 522 | 462 | 384 | | |
| 1/2 | 230/1 | 10 | 30 | 798 | 762 | 820 | 672 | 624 | 570 | 510 | 444 | 372 | 264 | | 289 |
| | | | 40 | 765 | 714 | 672 | 618 | 564 | 504 | 432 | 360 | 240 | | | |
| | | | 50 | 708 | 660 | 606 | 564 | 492 | 432 | 348 | 204 | | | | |
| | | | 20 | 876 | 852 | 822 | 798 | 768 | 738 | 702 | 666 | 630 | 588 | 504 | |
| | | | 30 | 846 | 822 | 792 | 762 | 732 | 696 | 660 | 618 | 582 | 540 | 444 | |
| 3/4 | 230/1 | 13 | 40 | 816 | 786 | 756 | 726 | 690 | 654 | 618 | 576 | 534 | 486 | 360 | 379 |
| | | | 50 | 780 | 756 | 720 | 684 | 648 | 612 | 570 | 522 | 480 | 420 | 234 | |
| | | | 60 | 850 | 714 | 678 | 642 | 606 | 564 | 516 | 468 | 408 | 330 | | |

# Selection Factors

When in the process of selecting a pump to do a specific job, there are several factors to consider:

- Volume of water required and volume of water available
- Source and location of the water
- Diameter of the well
- Static and drawdown levels of the water
- Distance from the source to the location - both horizontal and vertical
- Electrical requirements (e.g. 115 volt or 230 volt, single or three phase)

When selecting a pump, always select it at the required volume but at the mid to high side of the pressure setting (e.g. if pressure will be set at 30-50 psi, the selection should be based on 40 psi or better).

Select the most practical and efficient pump to provide a volume as close as possible to that required (or available) at a pressure satisfactory to meet the needs.

1. Check the friction losses at the volume required. Increase the pipe size to lower the loss if practical.
2. Add the friction loss to the vertical suction lift to determine if this will be a shallow or deep well application.
3. Use this information with the curve or the chart to select a pump that will most closely match your requirements for volume and pressure.

Where installation will allow, a submersible pump should be considered before a jet pump. If you have selected a jet pump, you may wish to compare its performance to a submersible and offer your customer the option.

# Selecting a Water System



Your pumping installation is the heart of your water service system. If your pumping installation is not properly planned, you will not receive satisfactory water service.

In selecting a water system, the main factors to be considered are: the amount of water needed, the capacity of the source, the cost and the total head of the system.

### *How much water is needed?*

The information on Pages 17 and 18 is useful for figuring the total gallons of water needed in a particular installation. Attention should be paid to the requirements for backwash rates of water conditioning equipment.

### *How much water can the well provide?*

In order to choose the right pump, the capacity and drawdown of the well and the amount of water needed must be known. The capacity and draw-down distance are usually contained in the well driller's report. If your customer does not have the report, you can get a copy from your provincial water regulatory department.

### *Not enough?*

If your source of water cannot supply the needed flow rate and no suitable alternative can be found, an intermediate storage tank can be used. Sometimes an oversized pressure tank can solve this problem but usually a large storage tank or cistern is used.

### *How much will it cost?*

Advise your customer against false economy. Recommend a pump system which will provide for growing future needs. Offer him a well engineered pump which will give him a lifetime of good service to protect his investment and avoid expensive trouble.

# Sizing Information

***A. Well Size Diameter*** - The inside diameter of the casing is important to determine the type and size of pump that can be used.

***B. Static Water Level*** -The vertical distance from the top of the well to the water level in the well when the pump is not operating is called the static water level.

***C. Drawdown*** - If the water source is not an artesian (free flowing) well, the static water level will begin to drop as soon as the pump is turned on. This is because water is being pumped out faster than it is flowing into the well. The drawdown distance is the drop in water level during a pumping cycle.

If water is pumped faster than the well can provide, the pump will begin to draw silt and sand. If it doesn't seize up, it will run dry so there must be a limit to the safe drawdown of any well. This maximum figure will be given in the well driller's report.

***D. Elevation*** - The distance between the ground level at the home and the ground level at the top of the well. There is no elevation when the pump is installed right at the well.

***E. Suction Head*** - The suction head consists of the static water level, the drawdown distance and the friction loss in the piping between the foot valve and the pump.

***F. Service Pressure*** - Pressure desired for household needs. Does not include friction losses (normal average household pressure 40 - 50 lbs).

***G. Friction Loss*** - Water flows fastest where it has least resistance. In a stream, the water following the center line is unobstructed, while the water along the banks and bottom creates whirlpools and eddy currents as it stumbles against rocks and obstacles. It is the same with water coming through a pipe. Even though the pipe looks and feels smooth, there are minor imperfections in the surface which resist the water flow and slow it down. This effect is called friction loss and is expressed as the number of theoretical feet of head added to the pumping system. Normally this is considered in the pump's capacity to elevate the water to the well head but must be calculated for the horizontal or offset line from the well head to the home.

***H. Discharge Head*** - The discharge head consists of the pressure required to elevate the water to the highest fixture, the maximum service pressure needed by any outlet and the pressure needed to overcome friction loss in the piping system.

***I. Total Dynamic Head*** - The head on the suction side of the pump plus the head on the discharge side and all friction loss in both suction and discharge pipes.

***J. Setting*** - The location of the submersible or ejector in the well.

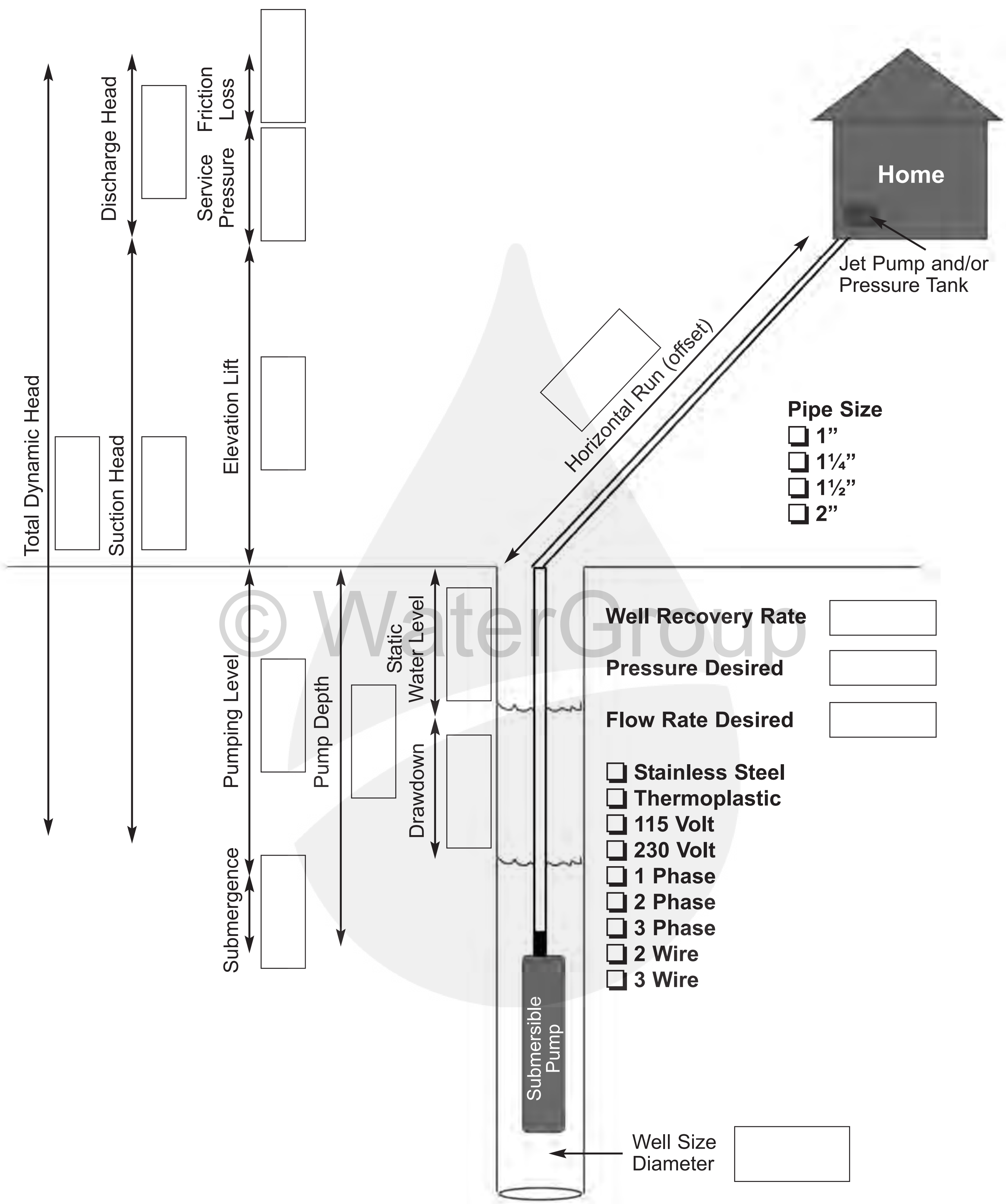
***K. Submergence*** - The vertical distance from the pumping water level to the submersible intake or ejector.

***L. Horizontal Pipe Run (Offset)*** - The distance the pump is installed away from the well.

***NOTE: Both static water level and elevation lift are vertical measurements which should be as accurate as possible and not guessed at. The exact measurements are frequently difficult to get and you may need the help of a surveyor, a theodolite level (if you can use one) or a contour map of the area (if one exists).***

# Pump Sizing Template

LEVEL 2



A. Pressure Desired

[ ] x 2.31 = [ ] ft A

(i.e. 30-50 cut in/cut out is 40 psi)

B. Pumping Level + Elevation

[ ] ft + [ ] ft = [ ] ft B

C. Horizontal Run (offset) + Vertical Pump Depth

[ ] ft + [ ] ft =

Friction Loss/100'

[ ] ft x [ ] /100 = [ ] ft C

D. Total Dynamic Head (in feet) = A + B + C [ ] ft D



## Practical Sizing Exercises

1. A cottage at a lake contains:
   - kitchen sink
   - 3 piece bath and shower
   - outside faucet

   The pump will be located in the cottage
   - Lift of 10 to 15 feet
   - Cottage is 50 feet from the lake

   What pump and line size are required?

2. A rural home contains:
   - kitchen sink
   - two 3 piece bath and showers
   - 3 outside faucets
   - automatic dishwasher
   - water softener
   - automatic clothes washer

   The well driller's report indicates:
   - 6 ft diameter well
   - 10 USGPM
   - 195 feet pumping water level
   - The well is 50 feet from the house
   - The house is 40 feet above well elevation

   What pump, tank and line size are required?

A private water system usually includes a pressure tank. This tank provides a buffer stock of water between the well and, say, the kitchen sink. It also prevents the need for the pump to run every instant a tap is turned on.

The upper half of the tank should always be full of air. As water is pumped in at the bottom, it compresses the air. When the pressure reaches a pre-set level (usually 40-50 psi) a pressure switch stops the pump.

As water is drawn off for use, the air pressure falls to a pre-set minimum (usually 20-30 psi) and the pump is automatically switched on again. On bladder style tanks, the precharge should be 2 psi lower than the cut-in pressure of the pump.

### Tank Size

Usable water in a tank is the number of gallons which can be used before the pump cuts in.

A normal domestic or farm water system should have a tank with a draw-off capacity (in gallons) of about twice the pump capacity in gpm.

### Types of Tanks

Basically there are two types of tanks in use today:

1. ***Air to Water*** - The conventional galvanized tank which will supply only about 10.2% of its total volume between switch settings (e.g. a 42 gallon tank will deliver about 4.3 gallons of at 30-50 psi).
2. ***Bladder or Diaphragm*** - The more popular tank is the precharged tank, available in many styles and sizes. This type can provide more usable capacity by super-charging the tank with captive air. In a bladder tank, the water is stored inside the bladder. In a diaphragm tank, the air is separated from the water by an expandable, fixed-in-place diaphragm.

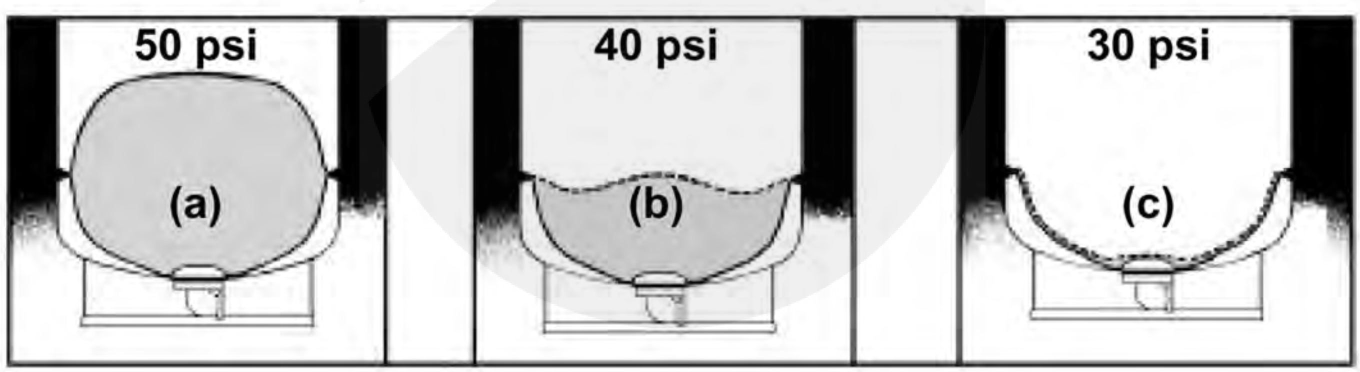
### Advantages of Bladder/Diaphragm Tanks

- Air - water separation
- Reduced oxidation of iron
- Larger drawdown with a smaller tank

### Tank Selection

The tank should have a minimum usable capacity equal to or greater than 1 minute of the pump's capacity in gpm. The optimum is a tank with usable capacity equal to 2 minutes of the pump capacity.






a. Pump is off - ready to provide drawdown water under pressure.

b. Pump still off - providing drawdown water through pressure range.

c. System reaches cut-in pressure (30 psi in this case). Pump starts and runs until cut-out pressure is reached.

### *Air Volume Controls*

In the conventional galvanized tank system where air and water mix, some of the air under pressure is absorbed and lost as water is drawn. This reduces the amount of air left to compress for the next cycle which, of course, reduces the volume of water that can be drawn. Eventually, the tank is almost void of air and the pump starts to short cycle (on-off-on) every time the tap is opened. This is known as a "water-logged" tank and is very hard on the pump and motor.

To prevent waterlogging, an air volume control is used. There are three common types of air volume controls:

1. Used with jets - vacuum operated
2. Used with jets - vacuum operated with diaphragm assist
3. Most commonly used with piston pumps - float operated.

If the water in the tank is higher than the air volume control when the pump starts, the control will add some air. If the water is lower than the control, it will not.

***Disadvantages:***

- Require large tanks for adequate volume
- Affected by iron - tend to clog
- Require a minimum 6 feet lift

### *Low Water Cut-Off Switch*

This is similar to other pressure switches except it has a level arm on the side. While the setting adjustments are the same as other pressure switches, this one will automatically break contact and shut the pump down if the pressure reaches a low of 10 psi. It is an excellent feature to use with any pump and, particularly, those where the water source is slow or low. It eliminates the loss of prime in jets and prevents serious damage in deep well subs.

To set in operation, hold the arm part way up, keeping the contacts closed until the system pressure is above the "low" setting.

### *Pitless Adapter*

The pitless adapter has eliminated the need for a pit at the well head. While available for both jet and submersible pumps, they are most often used with submersibles.

The second major advantage of these adapters is they provide ease of installation and removal of pumps or lines from the well.

Those used on 5" casing and larger fit easily through the side of the casing, while strap-on adapters must be used on 4" casings.

### *Pressure Switch*

Pressure switches are used to control the start-stop pressure levels of the system. Most switches have two adjustable settings:

1. The range of operation (e.g. 20/40, 30/50, 40/60, etc)
2. The differential - the spread between start and stop (e.g. 20/40 = 20 psi differential, 20/50 = 30 psi differential.

The adjustable settings may be screws (Furnas) or more commonly, spring loaded nuts (Square D). The Sq-D employs two posts with springs:

- The taller of these controls the range, moving both the cut-in and cut-out, without changing the differential. Turning the nut clockwise increases the range, while counter-clockwise decreases the range. One complete turn will adjust approximately 2 psi (e.g. 20/40, 22/42, 24/44, etc.)
- The shorter post controls the cut-out and adjusts only the differential. Again, clockwise increases, counter-clockwise decreases approximately 2 psi per turn (e.g. 20/40, 20/42, 20/44, etc.). It should be noted that 20 psi is most acceptable.

If an adjustment to the switch is necessary, it is essential that the range be set first as this is the only way to set the cut-in. The differential can then be adjusted with the cut-out setting, if necessary.

Sq-D also makes a switch with one adjustment. The range can be changed but the differential is fixed. This switch employs only one post.

### *Pump-Tec, Subtrol-Plus and Load-Tec*

These are all sensing devices designed to shut down the system in the event of overheating, rapid cycling, overloading or slow producing wells.

- Pump-Tec is for 2 or 3 wire submersibles, 1/3 to 1-1/2 hp, 115/230 volt, single phase
- Subtrol-Plus is for 3 phase deep well submersibles, 5 to 30 hp, 200/230 volts and 5 to 150 hp, 380/460 volts
- Load-Tec is for jet and centrifugal pump motors, 1/3 to 1 hp, 115 volts and 1/3 to 2 hp, 230 volts.

### *Splice Kit*

Splice kits are used to splice the motor cable lead to the length of cable leading back to the power source. They are a heat shrink product that forms a water-tight seal at the connection. Each connection should be staggered to prevent a large bulky ball at one location in the cable.

### *Tank Tee*

Tank tees are used for mounting the pressure switch and gauge to the tank.

### *Torque Arrester*

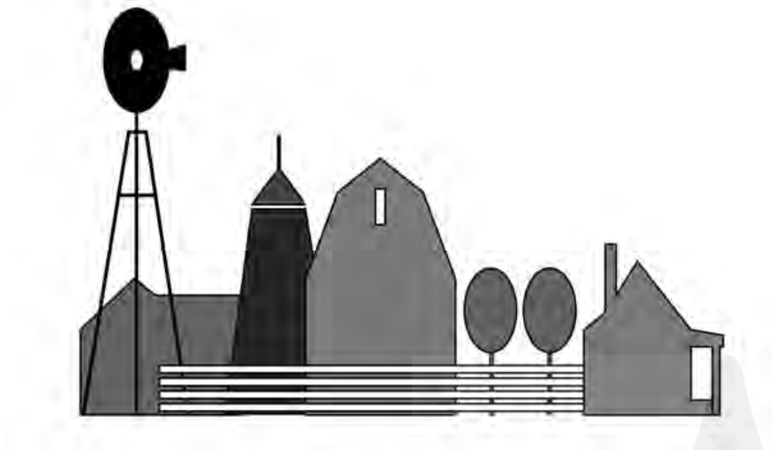
This is a rubber device clamped on to the discharge pipe of a deep well submersible pump to arrest the starting torque on the pipe connections.

### *Well Cap*

Well caps are not well seals. These caps are used with deep well subs and provide venting for the well and an area for a conduit to house the cable.



## Notes



# Pumps

## Summary



***Level 1***

1. Water can be found as surface water or as ground water in wells which are dug, bored, driven or drilled.
2. Atmospheric pressure plays a key role in pump operation. At sea level, atmospheric pressure is equal to 14.7 psi or 33.95 feet of head.
3. In a centrifugal pump, a spinning impeller creates a low pressure area at its center allowing atmospheric pressure to force water into the center. As the impeller spins, the water is flung to the outside with centrifugal force.
4. If pumps or impellers are mounted in series, a higher outlet pressure is created.
5. If pumps are mounted in parallel, an increase in flow results.
6. Jet pumps incorporate an ejector consisting of a jet or nozzle and a diffuser. This assembly can be used on shallow well applications (on the pump) or deep well applications (in the well) to assist the centrifugal pump in drawing water from greater depths.
7. Deep well submersible pumps consist of multi-stage impellers capable of drawing water from 1000 foot depths.
8. Pumps are generally sized to provide 1 gpm for each plumbing fixture in the house.

***Level 2***

1. Friction loss in pipe will affect the size of line chosen.
2. The distance a submersible pump is located from the electrical source will determine the cable size.
3. Pump curves and charts have been calculated by the manufacturer to indicate the pump capacity in USGPM at different pressures or feet of head.
4. Various factors affect the selection of a jet pump or deep well submersible pump and the subsequent sizing. These include:
   - Well size diameter
   - Drawdown
   - Suction head
   - Friction loss
   - Total dynamic head
   - Submergence
   - Horizontal pipe run (offset)
   - Static water level
   - Elevation
   - Service pressure
   - Discharge head
   - Setting
5. Both air to water and bladder or diaphragm pressure tanks are available.
6. Several accessories are necessary for a pressure system installation. These include an air volume control, a pitless adapter, a well cap, a splice kit, a tank tee, a pressure switch or low water cut-off switch, a shut-down device and a torque arrester.

WaterGroup

Product & Application Training

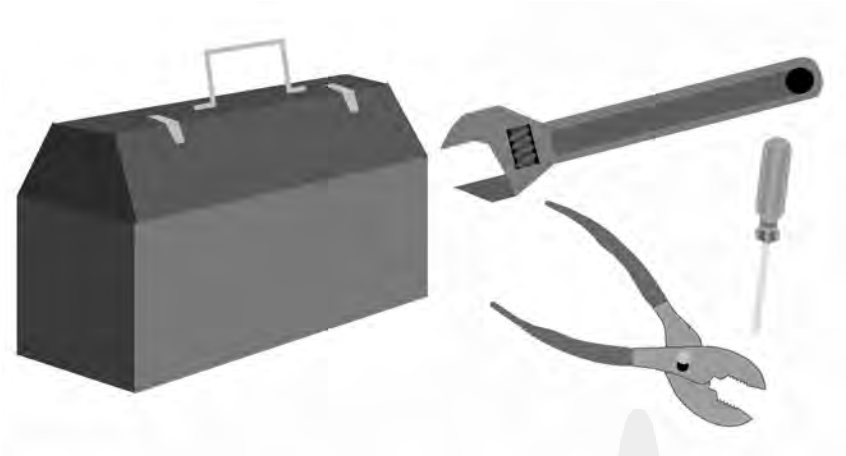
# SECTION 4

## Product Service



WaterGroup

#57711 Rev 03/06



# Product Service

## Objectives

### *Level 1*

1. To be able to identify common service problems in a conversation with a customer.



### *Level 2*

1. To be able to identify the cause of a service problem and recommend or perform the correct repair procedure.
2. To be able to verify correct sizing and application of a product or system.
3. To follow a service call procedure to isolate and correct malfunctioning systems and control mechanisms; to correctly program and start up a unit.

*The Trouble Shooting Guides on the following pages list problems that can be identified over the phone or in a service call.*

WaterGroup

# Trouble Shooting - Water Softeners & Filters

## *Unit Delivers Untreated Water*

| Cause | Correction |
|---|---|
| 1. Bypass valve is open | 1. Close bypass valve |
| 2. No regenerant in the brine tank | 2. Add regenerant to brine tank and maintain regenerant level above water. |
| 3. Injector or screen plugged | 3. Replace injector and screen |
| 4. Excessive water usage - clock models | 4. Increase frequency of regeneration and/or salt setting. Make sure that there are no leaking valves on the toilets or sinks |
| 5. Insufficient water flowing into brine tank | 5. Check tank fill time and clean brine line flow control if plugged |
| 6. Electrical service to unit has been interrupted | 6. Assure permanent electrical service (check fuse, plug or switch) |
| 7. Salt bridged | 7. Break salt bridging. Put less salt in brine tank. |
| 8. Loose brine line | 8. Tighten connections at control valve and at brine valve |
| 9. Plugged injector assembly | 9. Clean injector assembly |
| 10. Tabs on skipper wheel not out - clock models | 10. Push as many tabs to the outside of the skipper wheel as necessary to provide adequate frequency of regeneration |
| 11. Reserve capacity has been exceeded - demand regeneration models | 11. Check salt dosage requirements and reset program wheel to provide additional reserve |
| 12. Program wheel is not rotating with meter output - demand regeneration models only | 12. Pull cable out of meter cover and rotate manually. Program wheel must move without binding and clutch must give positive "clicks" when program wheel strickes regeneration stop. If it does not, replace timer. |
| 13. Meter is not measuring flow - demand regeneration models only | 13. Check output but observing rotation of small gear on front of timer (program wheel must not be against regeneration stop for this check). Each tooth to tooth is approximatley 30 gallons. If not performing properly, replace meter. |

## *Unit Fails to Regenerate or Regenerates at the Wrong Time*

| Cause | Correction |
|---|---|
| 1. Electrical service to unit has been interrupted | 1. Assure permanent electrical service (check fuse, plug, pull chain or switch). Reset time of day. |
| 2. Timer is defective | 2. Replace timer |
| 3. Power failure | 3. Reset time of day |

## *Unit Regenerates Every Day*

| Cause | Correction |
|---|---|
| 1. Tabs on skipper wheel all out - clock models | 1. Push tabs toward the center of the skipper wheel on days regeneration is not required. |
| 2. Faulty gear train | 2. Check the mechanical linkage on the timer control to eliminate possible binding in the gear train. |

# Trouble Shooting - Water Softeners & Filters

| Cause | Correction |
|---|---|
| ***Unit Delivers Intermittent Treated Water*** | |
| 1. Tabs on skipper wheel all out - clock models | 1. Push as many tabs to the outside of the skipper wheel as necessary to provide adequate frequency of regeneration. |
| 2. Control will not draw brine properly | 2. Maintain water pressure at 20 psi minimum. Check for restrictions in drain line. Clean or replac einjector assembly. Check for air leaks between control valve and air check valve and tighten connections. |
| 3. Using hot water during regeneration cycle | 3. Avoid using hot water at this time as the water heater will fill with hard or untreated water. |
| 4. Loose wiring or connections | 4. Unplug softener and check that all wires are securely connected |
| 5. Leaky faucet | 5. Check and repair plumbing leaks that can cause you to run out of soft water. |
| 6. Water quality has deteriorated | 6. Have samples of your water analysed to determine any change |
| 7. Unit capacity too small | 7. Increase capacity by replacing with a larger unit. |
| ***Unit Uses Too Much Salt/Regenerant*** | |
| 1. Improper salt setting | 1. Check salt usage and salt setting |
| 2. Excessive water in brine tank | 2. See "Excessive Water in Brine Tank" section |
| ***Loss of Water Pressure*** | |
| 1. Inlet to control blocked with iron build-up or foreign material | 1. Clean line to water conditioner. Remove piston and clean control |
| 2. Iron build-up in water softener | 2. Clean control and add resin cleaner to resin bed\ |
| ***Loss of Media Through Drain Line*** | |
| 1. Air in water system | 1. Assure that well system has proper air-eliminating control. Check for dry well condition. |
| ***Iron in Conditioned Water*** | |
| 1. Fouled resin bed | 1a. Check backwash, brine draw and brine tank fill<br>1b. Increase frequency of regeneration<br>1c. Clean control and add resin cleaner to resin bed<br>1d. Install res-up feeder<br>1e. Install iron filter |
| ***Control Cycles Continuously*** | |
| 1. Faulty timer mechanism | 1. Replace timer |

# Trouble Shooting - Water Softeners & Filters

| Cause | Correction |
|---|---|
| ***Excessive Water In Brine Tank*** | |
| 1. Plugged drain line flow control | 1. Clean flow control |
| 2. Plugged injector system | 2. Clean injector and replace screen |
| 3. Foreign material in brine valve | 3. Clean or replace brine valve |
| 4. Foreign material in brine line flow control | 4. Clean brine flow control |
| ***Unit Fails to Draw Regenerant*** | |
| 1. Drain line flow control is plugged | 1. Clean drain line flow control |
| 2. Injector is plugged | 2. Clean or replace injector |
| 3. Injector screen is plugged | 3. Clean or replace screen |
| 4. Line pressure is too low | 4. Increase line pressure (line pressure must be at least 20 psi (139.9 KPa) at all times |
| 5. Internal control leak | 5. Change seal and spacers and/or piston assembly |
| ***Drain Flows Continuously*** | |
| 1. Foreign material in control | 1. Remove piston assembly and inspect bore, remove foreign material and check control in various regeneration positions |
| 2. Internal control leak | 2. Replace seals and spacers and/or piston assembly |
| 3. Control valve jammed in brine or backwash position | 3. Replace piston and seals and spacers |
| 4. Timer motor stopped or jammed | 4. Replace timer motor |



## Notes

Slippage in a water softener happens when the ion exchange process does not trade 100% of the hardness minerals. Slippage can be caused by:

### *High Service Flows*

The water flows through the resin faster than thte resin can complete the ion exchange.

### *Channelling*

A situation when, in low flows or improperly maintained beds, flow patterns develop that allow water to consistently follow the line of least resistance so a path becomes  exhausted and allows water to flow through exhausted resin.

### *High Sodium Waters*

Resin beads exchange hardness minerals for dosium unti exhausted. When exhausted, they are recharged or regenerated by bombarding the beads with a saturated sodium chloride brine solution. If the influent water is already high in sodium content, the resin beads may slip as the ihgh sodium will recude the exchange process. Slippage from high sodium can also occur in extrememly hard water. As the hardness minerals are exchanged for sodium, the sodium levels rise and, in extremem situations, the exchanged sodium can cause reduced exchange efficiencies.

### *Depth of the Softening Bed*

In most cases it takes very little bed depth of charged resin to exchange all the hardness minerals out (usually 1" or less). The higher the heardness, thedeeper the resin band gets from ecompletely hard to completely soft water. In cases where the water is very hard and the softener resin bed is nearly exhausted, even though the resin beads are charged, slippage may occur just before a unit needs to regenerate as the band is not deep enough to allow total exchange.

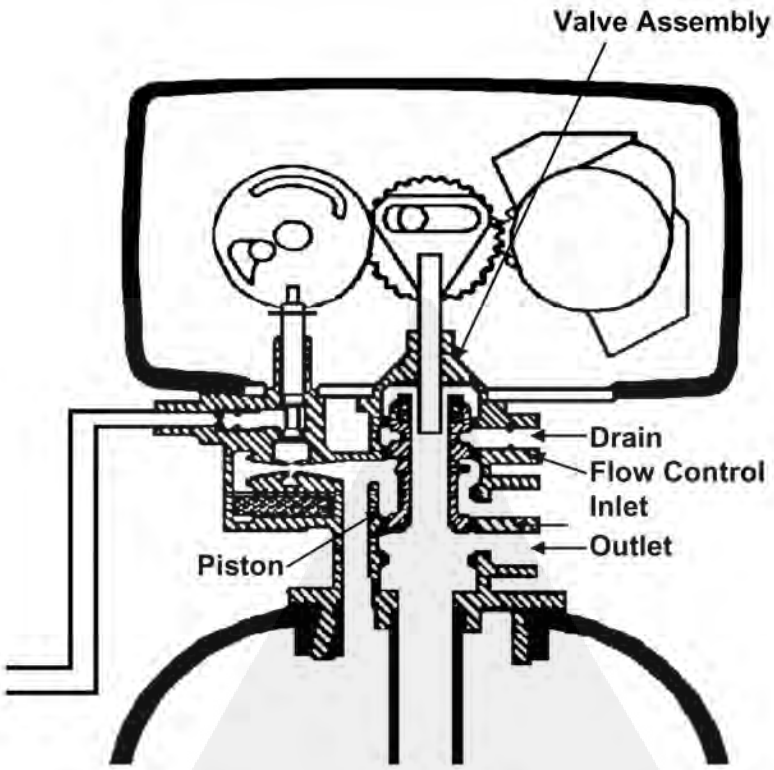
The usual corrections for these problems are:

- Larger or duplex units to provide proper flow rates
- TDS reduction systems as well as or in place of softening
- Regenerating before normal regeneration time so the bed doesn't get close to being exhausted
- Using a second or polishing unit



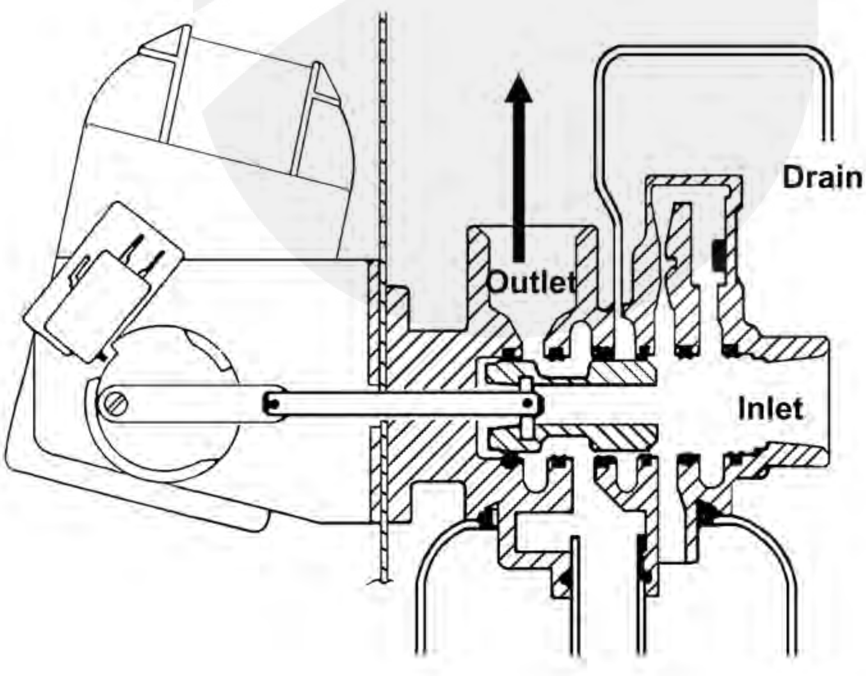
## Notes

## Water Softener/Filter Control Valve






## Chemical Free Iron Filter/Filter Control Valve



# Trouble Shooting - Chemical Free Iron Filters

| Cause | Correction |
|---|---|
| ***Water is Clean When Drawn but Turns Red Upon Standing*** | |
| 1. Insufficient air drawn by air injector | 1. Check air injector adjustment. If unable to adjust for long enough draw, check pumping rate |
| 2. Bypass open or leaking | 2. Close bypass valve and/or repair as necessary |
| 3. Filter bed backwashed too often | 3. Decrease frequency of backwash. Media should be somewhat iron-fouled for best performance |
| 4. Presence of manganese or tannins | 4. Recheck water analysis |
| 5. The check valve, loated between the air injector and pressure tank, is disrupting water flow | 5. Relocate the check valve |
| 6. Pumping cycle is too short. pH of treated water too low (should be 7.0 or higher; with manganese should be 8.5) | 6. Lengthen pump cycle time. Replenish MpH component in media (contact dealer). |
| ***Water is Red When Drawn from the Tap*** | |
| 1. Filter bed overloaded with precipitated iron due to insufficient backwash flow rate | 1a. Recheck well pumping rate and repair or replace as required<br>1b. Check for obstruction sor kink in drain line, or<br>1c. For improper drain line flow controller (see specs), upon correction of this problem, if manually backwashing does not clear bed of iron, filter bed may need chemical cleaning (contact dealer) |
| 2. Filter bed overloaded with precipitated iron due to insufficient backwash | 2. Upon correction of problem (increase backwash frequency if problem determined to be insufficient frequency), manually backwash until backwash water starts to clear (in more severe iron-fouling cases, filter bed may need chemical cleaning - contact dealer) |
| 3. Solenoid valve malfunction or inadequate supply system pressure/flow rate | 3. Replace solenoid valve, check for proper pressure flow rates |
| ***Excessive Pressure Loss Through Filter*** | |
| 1. Filter bed overloaded with precipitated iron | 1. See “Water is Red When Drawn From the Tap” |
| 2. Control inlet/outlet valve(s) not fully open | 2. Open valves |
| 3. Sand, silt or mud collecting in filter bed | 3. Check well for these conditions |
| 4. Filter bed not properly “classified” | 4. Manually backwash to reclassify |
| 5. “Cementing” or “channelling” of filter media | 5. Prod (stir) filter bed to break up hardened layer. Increase backwash frequency to prevent reccurence |
| ***Milky or Bubbly Water (appears to contain small bubbles)*** | |
| 1. Excess air draw | 1. Check adjustment for duration of draw in excess of 1/3 of the pumping rate |
| 2. Excess gases in water (carbon dioxide, hydrogen sulfide, methane) | 2. May require cleaning or installation of air-relief control (contact dealer) |

# Trouble Shooting - Reverse Osmosis Drinking Water Systems

| Cause | Correction |
|---|---|
| ***No Water or Not Enough Water*** | |
| 1. Feed water is shut off | 1. Turn on feed water |
| 2. Storage tank valve is shut off | 2. Open tank valve |
| 3. Plugged or crimped lines | 3. Remove blockage or crimp in lines |
| 4. Pre-filter cartridge is clogged | 4. Replace pre-filter cartridge |
| 5. Low feed water pressure | 5. Feed water pressure in membrane must be at least 50 psi |
| ***Low Flow Rate from Spigot*** | |
| 1. Low air pressure in storage tank | 1. Increase air pressure to 7 psi in storage tank with product water drained |
| 2. Storage tank valve partially closed | 2. Open tank valve completely |
| ***High Product Water TDS*** | |
| 1. Insufficiently flushed filters | 1. 5 gallons (approximately 2 full tanks) must be drawn from spigot to sufficiently flush filters |
| 2. Increase in feed water TDS | 2. Contact dealer for revised product water TDS |
| 3. Membrane life expired | 3. Replace membrane |
| ***Bad Tasting Water*** | |
| 1. Taste from glass or plastic containers | 1. Replace carbon filter. Replace containers |
| 2. Post carbon filter cartridge exhausted | 2. Replace post carbon filter cartridge |
| 3. Storage tank and /or system contaminated | 3. Disinfect tank. Replace carbon filter |
| 4. Membrane life expired | 4. Replace membrane |
| ***Cloudy Water - Cloudy Ice Cubes*** | |
| 1. Dissolved air in feed water gets concentrated in product water | 1. Condition will usually clear up as feed water changes. Letting water stand will allow dissolved air to dissipate |
| 2. Certain ice cube shapes trap dissolved air more readily than others. The larger, more squared off cubes are clearest, smaller rounded surface ice cubes are cloudier | 2. Change ice cube mold shape. Make cubes manually if using automatic ice cube maker. Let stand to release dissolved air before freezing. |
| ***Air Gap Overflows*** | |
| 1. Crimp or loop in reject line | 1. Straighten - there must be no sag in the reject line |
| 2. Misalignment of drain saddle | 2. Realign drain saddle |
| 3. Reject line clogged | 3. Remove restriction |

# R.O. Performance Equations

### *Product Water Flow Rate - Gallons per Day (gpd)*

To measure the product water flow rate or the gallons of water being produced each day, isolate the storage tank and open the product water sample valve. Use a 0-100 ml graduated cylinder or eequvalent. Measure the product water for 60 seconds. If the cylinder is too small, use a larger container or measure for a shorter period of time. Multiply the amount of product water in the cylinder by .38. This will equal the gallons per day the R.O. is producing.

**Example -**
You collect 10.6 ml of product water in 60 seconds. 10.6 ml x .38 = 4.0 gallons per day ***product water flow rate***

### *Reject Water Flow Rate*

To measure reject water flow rate, use a 0-100 ml or larger graduated cylinder. Measure the reject flow rate for 60 seconds. If the container is too small for a 60 second test, measure for a shorter period of time. Multiply the amount of product water in the cylinder by .38. This will equal the gallons of reject water per day the R.O. is producing.

**Example -**
You collect 7 ml of reject water in 10 seconds
= 42 ml in 60 seconds.
42 ml x .38 = 15.96 gallons per day ***reject water flow rate***

### *Reject Water to Product Water Ratio*

To find reject water to product water ratio, divide the reject water gpd by the product water gpd.

**Example -**
Product water = 4.0 gpd
Reject water = 15.96 gpd
***Ratio*** = 15.96 ÷ 4.0 = 3.99 (rounds to 4) or 4:1

### *Feed Water Rate*

Feed Water Rate = Product Water Rate + Reject Water Flow Rate

**Example -**
Product water rate = 4.0 gpd
Reject water flow rate = 15.96 gpd
***Feed water rate*** = 4.0 + 15.96 = 19.96 gpd

### *Recovery Rate*

Percentage Recovery = Product Water Rate ÷ Feed Water Rate x 100%

**Example -**
Product water rate = 4.0 gpd
÷ Feed water rate = 19.96 gpd
***Recovery rate*** = 4/0 ÷ 19.96 = 0.2 x 100% = 20%

## Notes

# Trouble Shooting - Jet Pumps

LEVEL 2

| Problem | How to Check and Correct |
|---|---|
| ***Jet Pumps - Won't Start or Run*** | |
| 1. Tubing to switch is plugged | 1. Remove and inspect - clean or replace as required. |
| 2. Impeller is jammed or damaged | 2. Turn power off and turn motor shaft. In unable to turn, remove pump case to examine |
| 3. Motor is defective | 3. If all else appears to be OK or if fuses continue to blow, repair or replace motor. Check wiring for correct voltage. |
| 4. Fuse is blown | 4. Check fuse panel. Replace with fuse of proper size. |
| 5. Line voltage is low | 5. Use voltmeter to check at the pump. If low voltage, check wire size. If OK, call power company. |
| 6. Wire is loose or broken | 6. Check wiring. Replace wire or tighten connections. |
| 7. Check switch setting and contacts | 7. Check switch setting and contacts. Adjust or replace switch. |
| ***Jet Pumps - Won't Shut Off*** | |
| 1. Pressure switch is the wrong one | 1. Lower switch setting. If pump shuts off, this was the cause. Properly adjust the settings. |
| 2. Pressure switch is defective | 2. Arcing may have welded contacts closed. Replace switch. |
| 3. Tubing to switch is plugged | 3. Remove and examine. Clean or replace as required. |
| 4. Loss of prime or low water level | 4. Check the prime of the pump, well level and piping. Reprime - wait for well to recover |
| 5. Plugged jet nozzle or suction screen | 5. Remove jet or foot valve and inspect. Clean or replace as required. |
| ***Jet Pumps - Deliver Little or No Water*** | |
| 1. Low or incorrect line voltage | 1. Check for correct voltage and wiring. If voltage is low and wiring is correct, call power company. |
| 2. Improperly primed or loss of prime | 2. Check pump for prime. Reprime if necessary |
| 3. Control valve setting incorrect or stuck | 3. (Deep Well Pumps Only) Examine control valve. Clean and reset or replace as required |
| 4. Low well level | 4. Check water levels in the well. Wait for well to recover. Recommend alternative systems |
| 5. Plugged jet assembly | 5. Remove and inspect. Clean or replace as required |
| 6. Defective or plugged foot valve/strainer | 6. Remove and inspect. Clean and repair or replace as required |
| 7. Worn, plugged or damaged impeller | 7. Disassemble and inspect. Clean or replace as required. |
| 8. Leak on suction side of system | 8. If no visual leak exists, pressurize the lines to check. Locate the leak. Double clamp connections and tees. |

| Problem | How to Check and Correct |
|---|---|
| ***Deep Well Submersibles - Deliver Little or No Water*** | |
| 1. Water in well too low; low water cut-off has shut pump down | 1. Check the position of the arm on the pressure switch. Check well level, reset switch when recovered. |
| 2. Check valve held down by discharge pipe | 2. Raise pipe and examine threads. Replace check valve or adjust pipe. |
| 3. Pump intake screen plugged | 3. Examine screen. Clean or replace as required. Take preventative measures if possible. |
| 4. Motor and pump shaft loose or damaged | 4. Examine and repair or replace as required. |
| ***Deep Well Submersibles - Blow Fuse, Trip Breaker*** | |
| 1. Incorrect or low voltage | 1. Check voltage at control box or switch (2 wire). I focrrectly wired and proper size, call power company. |
| 2. Defective control box component | 2. Follow testing instructions in box or take to service depot. Repair or replace component or control box as required. |
| 3. Defective pressure switch | 3. Check contacts, make sure both points make contact. Replace switch. |
| 4. Defective motor ro cable (splice) | 4. Follow testing instructions. Replace motor or cable. |



## Notes

# Service Call Procedure

1. Test customer's raw water and hot and cold soft water and record results.

   Raw ____ gpg  Cold ____ gpg  Hot____ gpg

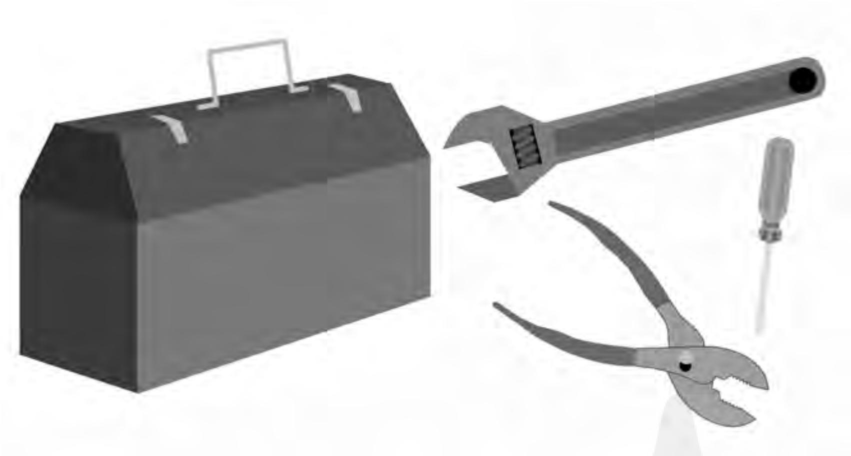
2. Compare complaint, water test and observations to see if unit size, frequency of regeneration or plumbing are the problem. Misapplication (wrong or not enough equipment) and changes in water supply must be considered.
3. Determine that the unit is displaying the correct time of day and the correct valve position.
4. a. Determine that the unit is securely plugged into a constant source of power.
   b. Check that all bypasses are open
   c. Check that the unit is not plumbed in backwards.
5. Check the salt setting and level of regenerant.
6. Check to see if the water level in the brine tank or the postassium solution in the container are correct. If the levels are incorrect, check the brine flow control and note the size.
7. Advise the customer not to draw water. Place the unit in brine draw and, after 3 or 4 minutes:
   a. Remove brine line and confirm there is suction at the fitting on the valve. Upflow brining has considerably less suction than conventional downflow brining but there should be consistent suction. If not, check that the injector screen and injector are clean and that they are the correct size.
   b. Reconnect the brine line and allow the unit to draw brine for an additional 5 minutes. Make sure brine is being drawn from the tank and that there is no premature checking of the air-check.
   c. Return the unit to service
   d. Rinse the unit through the cold soft water tap at full flow. Taste to confirm brine. When the brine taste disappears, test the water. Continue to rinse until the water tests 1 gpg of hardness or less.
8. If the unit does not deliver 1 gpg hardness or less, check the following:
   a. Check seals and spacers in valve (failed seals can cause hard water ty bypass).
   b. Check O-ring in the pilot (O-ring failures can cause hard water to bypass)
   c. Check that the riser tube is long enough (a short riser tube can cause hard water to bypass).
9. Check the wiring and circuitry.
10. Initiate a manual regeneration. Explain to the customer that, in order to have soft water, the hot water tank must be drained. Ask the customer to run the hot water until it runs cold after the regeneration is complete.

# Special Tips

- At the beginning of the backwash position (preliminary rinse is downflow), all water running to the drain has been cycled through the unit only. Therefore, you can determine if slippage is happening in the unit by testing water at the drain. If the drain water is OK, the problem is in the plumbing, not in the unit.
- If the above check shows slippage in the unit, draw brine to see how quicly it reaches the drain. Anything less than 45 to 60 seconds could indicate valve or standpipe O-ring failure.
- To verify if the system has a slow or hidden leak, turn off the main supply line and wait a few minutes before turning it back on. If water flows when the main valve is reopened, the system has lost pressure because of a leak. Check for dripping taps, overflowing toilet tank, discharges to humidifier, etc. A meter initiated unit will not detect water usage under 1/4 USGPM.
- On domestic units, the timer motor will run warm. A cool motor indicates an intermittent power source.
- If you have cloudy or colored water and you aren't sure of the cause, add some mild acid or a bed cleaner. Acids dissolve metals and minerals. If the color disappears, you know that it the cause is a metal or a mineral. If the water doesn't change color, an organic source is likely.
- Run backwash water into a pail and observe the color of the effluent. If the water runs clear, the filter is working. However, backwash water from a chemical free iron filter should not be clear.
- After breaking a salt bridge, pass water through the brine well to the loosened bridge. Loosen salt again in 2 or 3 days so the problem won't recur.
- If the brine tank is full of water and the household water is soft, check for a brine refill problem. It the water is hard, check for a brine draw problem.
- A service technician should have the following items: a pressure guage equipped with a garden hose fitting, a thermometer and 5 U.S. gallon pail.



## Notes



# Product Service

## Summary

### *Level 1*



1. Common reasons for untreated water are an open bypass valve or electrical supply interruption.
2. Common complaints may be hard or untreated water, excessive salt usage, brine tank overflow and regenerating at the wrong time.

### *Level 2*

1. All control valves feature a motor-driven piston which controls the flow of water to perform the rengeration function. The timer, the condition of the piston and the brine draw assembly determine if the regeneration is performed satisfactorily.
2. A service technician must be able to test the water, verify the problem, verify the application and visually inspect the plumbing and the unit prior to performing any mechanical work.
3. After performing any service work, program the unit to return to the service position and inform the customer of the work performed.

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