Water Improvement

Engineering Guide

"This guide provides
National drinking water regulations,
suggestions for water correction,
water softening sizing information,
filter media and resin properties,
deionization systems application
guidelines and much more."

WATTS®

SHORT GLOSSARY OF IMPORTANT TERMS

Some of the following information is reprinted here from a more extensive publication of the WQA.

Angstrom Unit: A unit of wavelength of light equal to one tenth of a millimicron or one ten-millionth of a millimeter.

Etching: The deterioration by chemical change on the surface of glassware caused by the action of high temperatures and detergents, and it is more prevalent or intensified in soft or softened water supplies. Very high water temperatures in automatic dishwashers can cause detergent phosphate compounds to change into even more aggressive forms. If enough dish soil or water hardness is available, it will react with the most aggressive of these sequestering phosphates. Otherwise, however, the excessive detergent agents can actually extract elements directly from the glassware composition. In early stages, incipient etching appears as a rainbowcolored film similar to an oil-on-water film. As etching progresses, this changes to opaqueness, which appears similar to filming except that it cannot be removed or repaired since etching is an actual eating away of the glass. It is sometimes called "soft water filming". The solution to chemical etching is to use less detergent, water temperatures below 140°F, and sufficient amounts of water during the rinse cycle. (Poor rinsing can also be caused by overloading the dishwasher.) Mechanical etching can occur when two glasses rub against each other in the dishwasher. (See also Water Spotting.)

Flux: Gallons per day of permeate passing through each square foot of membrane surface.

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.

Jackson Turbidity Unit (JTU): An arbitrary unit of turbidity originally based on a suspension of a specific type of silica with the turbidity measured in a Jackson Candle Turbidimeter. Now called a Nephelometer.

Langelier's Index: A calculated number used to predict whether or not a water will precipitate, be in equilibrium with, or dissolve calcium carbonate. It is sometimes erroneously assumed that any water which tends to dissolve calcium carbonate is automatically corrosive.

Micron: A linear measure equal to one millionth of a meter or .00003937 inch. The symbol for the micron is the Greek letter "μ".

Sequestering Agent: A chemical compound sometimes fed into water to tie up undesirable ions, keeps them in solution, and eliminates or reduces the normal effects of these ions. For example, polyphosphates can sequester hardness and prevent reactions with soap.

Uniformity Coefficient: The degree of variation in the size of the grains that constitute a granular material; the ratio of (a) the diameter of a grain size that is barely too large to pass through a sieve that allows 60 percent of the material (by weight) to pass through, to (b) the diameter of a grain of a size that is barely too large to pass through a sieve that allows 10 percent of the material (by weight) to pass through. The coefficient is unity for any material having grains all the same size, and it increases above unity with variation in size of grain.

Virus: The smallest form of life known to be capable of producing disease or infection, usually considered to be of large molecular size. They multiply by assembly of component fragments in living cells, rather than by cell division, as do most bacteria.

Water Hammer: The shock wave or series of waves caused by the resistance of inertia to an abrupt change (acceleration or deceleration) of water flow through a water piping system. Water hammer may produce an instantaneous pressure many times greater than the normal pressure. For this reason, many building codes now require the installation of a "water hammer arrestor", a device to absorb these shock waves and prevent damage to appliances such as washing machines.

Water Spotting: Cloudy milk-like film, spots, streaks, or heavy white deposits left on surfaces after water has dried from them, especially noticeable on clear glassware and cars after washing. Spotting is caused by minerals that had been dissolved in the water remaining behind after the water has evaporated. Soft water spotting can be wiped off easily with a damp cloth or rinsed off with a little fresh water. Hard water deposits, on the other hand, are comprised of the more tenacious calcium and magnesium salts. Hard water films typically require harsh abrasives or an acid cleaner to remove them. A third type of water residue film is due to silica (SiO_2) deposits. Silica spotting is rare, but it is more difficult or impractical to be removed when it does occur. If glassware films won't dissolve in acids such as vinegar or lemon juice, they may be due to silica spotting or etching. If the spot won't dissolve in acid, but can be scratched off with a razor blade or pinpoint, it's likely a silica film. (See also Etching.)

Notes

Notes

PLEASE BE ADVISED OF PUBLISHER'S DISCLAIMER:
This information is meant to be only a general guide. The data has been compiled from numerous sources without verification or guarantee of its current accuracy at the time of this printing.

Water Improvement Engineering Guide

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NATIONAL PRIMARY DRINKING WATER REGULATIONS

SAFE DRINKING WATER ACT OF 1974 & 1986 & PROPOSED PRIMARY CONTAMINANT LEVELS

INORGANIC CHEMICALS

CONTAMINANT	PROPOSED	MAX. LEVEL
Antimony		0.006 mg/L
Arsenic		0.01 mg/L
Asbestos	7 million fibers/L	
Barium		2 mg/L
Beryllium		0.004 mg/L
Cadmium		0.005 mg/L
Chromium		0.1 mg/L
Copper		1.3 mg/L TT
Cyanide		0.2 mg/L
Fluoride (depending on temperature)		4 mg/L
Lead	0.015 mg/L TT	
Mercury		0.002 mg/L
Nickle		0.1 mg/L
Nitrate (as N)		10 mg/L
Nitrite		1.0 mg/L
Selenium		0.05 mg/L
Silver		0.05 mg/L
Sulphates		250 mg/L
Thallium		0.002 mg/L

SECONDARY CONTAMINANT LEVELS

CONTAMINANT	MAX. LEVEL
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 Color units
Copper	1 mg/L
Corrosivity	Noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Hexachlorocyclopentadiene	0.05 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver (Ag^{+1})	0.1 mg/L
Sulfate	250 mg/L
TDS	500 mg/L
Zinc	5 mg/L

RADIONUCLIDES

CONTAMINANT	MCL
Beta Particle and Photon Activity	4 mrem/Year
Radium 226 and Radium 228	5 pCi/L (P)
Radon	300 pCi/L (P)
Uranium	30 pCi/L (P)

(P) = Proposed

Regulations are updated and changed continuously. Contact regional EPA, or State Health Dept. for latest or specific information.

ORGANIC CHEMICALS

CONTAMINANT	TREATMENT	MAX. LEVEL
Acrylamide	TT	0.0005 mg/L
Adipates (diethylhexyl)	2	0.4 mg/L
Alachlor	1	0.002 mg/L
Aldicarb	1	0.003 mg/L
Aldicarb Sulfone	1	0.003 mg/L
Aldicarb Sulfoxide	1	0.004 mg/L
Atrazine	1	0.003 mg/L
Benz(a)anthracene (PAH)	1	(P) 0.0001 mg/L
Benzene	2	0.005 mg/L
Benzo(a)pyrene (PAH)	1	0.0002 mg/L
Benzo(b)fluoranthene (PAH)	1	(P) 0.0002 mg/L
Benzo(k)fluoranthene (PAH)	1	(P) 0.0002 mg/L
Butyl benzyl phthalate (PAE)	1	(P) 0.1 mg/L
Carbon Tetrachloride	2	0.005 mg/L
Carbofuran	1	0.04 mg/L
Chlordane	1	0.002 mg/L
Chrysene (PAH)	1	0.0002 mg/L
Dalapon	1	0.2 mg/L
Dibenz(a,h)anthracene (PAH)	1	0.0003 mg/L
Dibromochloropropane (DBCP)	2	(P) 0.0002 mg/L
Dichlorobenzene (para-)	2	0.075 mg/L
Dichloroethylene (1,1-)	2	0.007 mg/L
Dichloromethane (Methylene chloride)	1	(P) 0.005 mg/L
Diethylhexyl phthalate (PAE)	1	0.006 mg/L
Dinoseb	1	0.007 mg/L
Diquat	1	0.02 mg/L
Endothall	1	0.1 mg/L
Endrin	1	0.002 mg/L
Epichlorohydrin	TT	0.002 mg/L
Ethylbenzene	2	0.7 mg/L
Ethylene Dibromide (EDB)	2	0.00005 mg/L
Glyphosate	1	0.7 mg/L
Heptachlor	1	0.0004 mg/L
Heptachlor Epoxide	1	0.0002 mg/L
Hexachlorobenzene	1	0.001 mg/L
Hexachlorocyclopentadiene	2	0.05 mg/L
Indeno (1,2,3-c,d) pyrene (PAH)	1	(P) 0.0004 mg/L
Lindane	1	0.0002 mg/L
Methoxychlor	1	0.04 mg/L
Monochlorobenzene	2	0.1 mg/L
Oxamyl (Vydate)	1	0.2 mg/L
PCBs	1	0.0005 mg/L
Pentachlorophenol	1	0.001 mg/L
Picloram	1	0.5 mg/L
Simazine	1	0.004 mg/L
Styrene	2	0.005 mg/L
Tetrachloroethylene	2	0.005 mg/L
Toluene	2	1.0 mg/L
Toxaphene	1	0.003 mg/L
Trichlorobenzene (1,2,4)	2	0.07 mg/L
Trichloroethane (1,1,1-)	2	0.2 mg/L
Trichloroethane (1,1,2-)	2	(P) 0.005 mg/L
Trichloroethylene	2	0.005 mg/L
Vinyl Chloride	3	0.002 mg/L
Xylenes	2	10 mg/L
o-Dichlorobenzene	2	0.6 mg/L
1,2 Dichloropropane	2	0.005 mg/L
1,2 Dichloroethane	2	0.005 mg/L
cis-1, 2-Dichloroethylene	2	0.07 mg/L
trans-1, 2-Dichloroethylene	2	0.1 mg/L
2,3,7,8 TCDD (Dioxin)	1	3×10^{-8} mg/L
2,4-D	1	0.07 mg/L
2,4,5-TP Silvex	1	0.05 mg/L
THM	2	0.10 mg/L
Turbidity		1TU-5TU
Coliform Bacteria		1/100 ml(mean)

1 = Activated Carbon; 2 = Aeration & Activated Carbon;
3 = Aeration Only (P) = Proposed
TT = treatment tested: ie,Corrosive Acid Water = Raise pH.

SOME SUGGESTIONS FOR WATER CORRECTION

Concentrations, Flow Rate, Multiple Contaminants, and Temperature can affect results.
Call for recommendations.

CONTAMINANTS	TREATMENT METHODS	
Aluminum (Al^{+3})	1) Ion Exchange (Cation)	2) Reverse Osmosis
Antimony Arsenic (As^{+3}) Arsenic (As^{+5}) Arsenic (As^{+6}) Organic Arsenic Complexes	1) Flocculation/Filtration 1) Ion Exchange (Anion) 1) Reverse Osmosis 1) Activated Carbon 1) Reverse Osmosis	2) Submicron Filtration 2) Reverse Osmosis
Asbestos	1) Flocculation/Filtration 3) Reverse Osmosis	2) Submicron Filtration 4) Ultrafiltration
Barium (Ba^{+2})	1) Ion Exchange (Cation)	2) Reverse Osmosis
Beryllium	1) Flocculation/Filtration 3) Ion Exchange (Cation)	2) Carbon Block
Cadmium (Cd^{+2})	1) Ion Exchange (Cation)	2) Reverse Osmosis
Chromium (Cr^{+3}) Chromium (Cr^{+6}) Organic Chromium Complexes	1) Ion Exchange (Cation) 1) Ion Exchange (Anion) 1) Activated Carbon	2) Reverse Osmosis 2) Reverse Osmosis
Chloramines	1) Chlorine Dioxide	2) Activated Carbon
Coliform Bacteria	1) Chlorination 3) Chlorine Dioxide 5) Iodine (as $I_2 + KI_2$) 7) Ultrafiltration (with pore size less than 0.45 micron)	2) Ozone 4) Ultraviolet Radiation 6) Microfiltration
Colloids	1) Diatomaceous Earth (DE) Filtration 3) Multimedia	2) Flocculation 4) Ion Exchange (Adsorption)
Color	1) Filtration 3) Chlorination 5) Reverse Osmosis	2) Flocculation 4) Activated Carbon 6) Acrylic Anion Resins
Copper (Cu^{+2})	1) Ion Exchange (Cation) 20-90%	2) Reverse Osmosis
Cyanide	1) Ion Exchange (Anion)	2) Reverse Osmosis
Fluoride (F^{-1})	1) Reverse Osmosis	2) Adsorption with Activated Alumina (Run Jar-Test)
Foaming Agents (MBAS) (Methyl Blue Active Substrate)	1) Chlorination 3) Activated Carbon	2) Reverse Osmosis 4) Ozonation
Iron (Fe^{+2}) (Ferrous Ion) Iron (Fe^{+3}) (Ferric Ion)	1) Aeration/Filtration 3) Chlorination - Precipitation/Filtration 1) Filtration	2) Filtration (oxidizing filters)
Lead (Pb^{+2})	1) Reverse Osmosis 3) Ion Exchange (Cation) 20-90%	2) Carbon Block
Manganese (Mn^{+2}) Manganese (Mn^{+4}) Oxidizer	1) Aeration/Filtration 3) Chlorination - Precipitation/Filtration 1) Filtration	2) Filtration (Oxidizing Filters)
Mercury (Hg^{+2}) Inorganic Organic Mercury ($HgCl_3^{-1}$)	1) Activated Carbon 1) Activated Carbon 1) Ion Exchange (Anion)	2) Reverse Osmosis 2) Reverse Osmosis
Nitrate (NO_3^{-1})	1) Anion Exchange (w/soft water)	2) Reverse Osmosis (sensitive to pressure)
Odor	1) Activated Carbon 3) Chlorination/Filtration	2) Aeration 4) Ozonation
Organics (VOC's) pH >7 pH <7 & >5.8 pH <5.8	1) Activated Carbon 1) Acid Feed 1) Neutralizing Filters 1) Caustic Feed	2) Aeration (Call AWR)
Radon	1) Aeration 3) Activated Carbon	2) Ion Exchange
Selenium (Se^{+4}) Selenium (Se^{+6})	1) Ion Exchange (Anion) 3) Activated Alumina 1) Ion Exchange (Anion)	2) Reverse Osmosis 4) Flocculation/Filtration 2) Reverse Osmosis
Silver (Ag^{+1})	1) Ion Exchange	2) Flocculation/Filtration
Sulfate (SO_4^{-2})	1) Ion Exchange (Anion) (must be zero-soft)	2) Reverse Osmosis
TDS	1) Reverse Osmosis 3) Flocculation/Filtration	2) Deionization by Ion Exchange
Thallium	1) Ion Exchange (Cation)	
Turbidity	1) Granular Dual Media Filtration 3) Flocculation/Filtration	2) Diatomaceous Earth (DE) Filtration
Zinc (Zn^{+2})	1) Ion Exchange (Cation)	2) Reverse Osmosis

Water Softener & Filter Sizing Information

NOTE: Reduce gallons of usage by 20% in these listings where water saving toilets and shower heads are being used.

WATER REQUIREMENTS for SMALL PUBLIC WATER SYSTEMS

Seek professional engineering advice. Many areas vary.

	COMMUNITY TYPE WATER SYSTEM		NON-COMMUNITY TYPE WATER SYSTEM	
TYPE OF REQUIREMENT	**GROUND** Per Connection	**SURFACE** Per Connection	**GROUND** Per Unit	**SURFACE** Per Unit
LESS THAN **50** CONNECTIONS OR LESS THAN **150** POPULATION				
Ground Storage (minimum clear water)	Not required	200 gallons[1]	Not required	35 gallons[1]
Pressure Tank Capacity (minimum)	50 gallons	50 gallons[2]	10 gallons[2]	10 gallons[2]
Well Capacity	1.5 gpm	2 @ .6 gpm	1.5 gpm	2 @ .6 gpm
Treatment Plant Capacity	N/A	0.6 gpm	N/A	0.6 gpm
Service Pumps	N/A	2 @ 2 gpm	N/A	2 @ 1 gpm
50 TO **150** CONNECTIONS OR 150 TO **450** POPULATION				
Covered Storage (min)	200 gallons	200 gallons[4]	35 gallons	
Pressure Tank capacity (or Elevated Storage)	25 gallons[3]	25 gallons[3]	10 gallons	
Well Capacity (Raw Water Trans Pumps)	0.6 gpm	2 @ .6 gpm	0.6 gpm	
Treatment Plant Capacity	N/A	0.6 gpm	N/A	
Service Pumps	2 @ 2 gpm	2 @ 2 gpm	2 @ 1 gpm	

[1] 1000 gallons minimum [2] 250 gallons minimum [3] 2500 gal minimum or 200 gal E.S per connection [4] 25% of total

A system should maintain a 20 PSI minimum residual pressure with a normal operating pressure of 35 PSI.
Non-Community are accommodations such as hotel rooms, motel rooms, travel trailer spaces, campsites, etc.

WATER REQUIREMENTS OF VARIOUS KINDS OF ESTABLISHMENTS

To be used as a guideline only.

SCHOOLS Based on 25 gallons per day per student

NUMBER OF STUDENTS	**100**	**200**	**300**	**400**	**500**	**500**	**1,000**
Total water usage	2,500	5,000	7,500	10,000	12,500	20,000	25,000
Peak flow with flush valves	60	90	120	150	180	250	300
Peak flow with flush tanks	30	50	80	90	100	130	160
Hot water only gallons per day	600	1,200	1,800	2,400	3,000	4,800	6,000
Hot water only gallons per minute	15	23	30	40	80	60	70

APARTMENTS / TRAILER PARKS Central laundry included. Based on 3 people at 60 gallons per day.

NUMBER OF UNITS	**4**	**5**	**6**	**8**	**10**	**15**	**20**	**30**	**40**	**50**	**100**
Total water usage gallons per day	720	900	1,000	1,440	1,800	2,700	3,600	5,400	7,200	9,000	18,000
Gallons per minute peak flow with flush tanks (no lawn sprinkling)	22	25	30	40	50	75	90	110	125	140	220
Hot water only gallons per day	240	300	360	480	600	900	1,200	1,800	2,400	3,000	6,000
Hot water peak flow gal per minute	12	15	20	26	30	45	55	65	75	85	110

MOTELS (Not Hotels) Based on 40 gallons per person per day. 2.5 people per unit with bath.
Figure restaurant or bar separately.

NUMBER OF UNITS	**10**	**20**	**30**	**40**	**50**	**75**	**100**	**125**	**150**
Peak gallons per minute with flush valves	65	90	109	128	145	180	210	240	270
Peak gallons per minute with flush tank	26	43	55	65	75	105	130	152	172
Hot water only gallons per day (estimate 16 gallons per person)	400	800	1,200	1,600	2,000	3,000	4,000	5,000	6,000
Hot water only flow gal per minute	17	25	36	43	48	62	73	85	96

Water Softener & Filter Sizing Information *(continued)*

ANIMALS-GPD	Each Horse -10 (add 5 in stables); Each Milking Cow -15 (add 15 with drinking cup); Each Dry Cow -10 (w/drinking cup add 10); Each Hog -3; Each Sheep -2; 100 Chickens in lighted henhouse -5; 100 Turkeys -18.
ASSEMBLY HALLS	2 gallons per seat.
BARBER SHOPS	55 gallons per chair per day.
BEAUTY SHOPS	200 gallons per day per operator.
BOILERS	To determine daily make-up in gallons: 1) Multiply boiler horsepower by 4.25. 2) Then multiply (1) by hours per day operation. 3) Then multiply by the percentage operating rating. 4) Then subtract the percentage of condensate return.
BOWLING ALLEY	175 gallons per lane.
CASINO HOTELS	450 gallons per room, per day.
CLUBS	Showers X 600 GPD. Lavatories X 150 GPD. Meals X 4 gallons.
COOLING TOWERS	To determine daily make-up in gallons: 1) Multiply the tonnage by 4 (this includes 2 gallons per ton hour evaporation and 2 gallons per ton hour bleed off). 2) Then multiply (1) by the hours per day of operation.
DEPARTMENT STORES	.215 gallons per day per square foot of sales area.
DORMITORIES	Estimate 40 gallons per person per day total water usage. Estimate 16 gallons per person per day hot water only.
GOLF CLUB/GYM/ FACTORY	Showers X 1300 GPD. Lavatories X 150 GPD. Meals X 4 gallons. Factory - 16 GPD per employee not including process.
HOTELS	350 GPD per guest room (hot and cold). Hot only 225 GPD per guest room.
HOSPITALS	250 GPD per bed for total water usage. 170 GPD per bed for hot water only.
LAUNDRY (Washateria)	Flow rate - divide capacity of machines by 2. Gallons per cycle - multiply pounds of laundry by 2-1/2. Total daily usage - gallons per cycle X 2 loads per hour X hours of operation X number of machines.
NURSING HOMES	75 GPD per bed for total water usage. 50 GPD per bed for hot water only.
OFFICE BUILDING	15 GPD per person for total water usage. 2 GPD per person for hot water only. **NOTE**: Non-medical.
OIL REFINERY	80,000 gallons per day per 100 barrels of crude processed.
PACKING HOUSE	6 GPD per Hog to 12 GPD per Steer slaughtered.
POULTRY PACKING	1 gallon per day per bird.
RESIDENCE	60 GPD inside usage per person. 100 GPD per person inside & outside.
RESTAURANTS	Estimate 10 GPD per person (total water usage) or estimate 4 GPD per person (hot only). Add 30% water usage for 24 hour restaurants, add 2 GPD per person for cocktail/bar facilities.
R.O. SOFTENING	GPD product + GPD reject X grains compensated hardness (see page 11) X 1.5 (to use minimum salt capacity) X 2 (days per regeneration or twins).
SCHOOLS	With cafeteria and showers estimate 25 GPD per student (total water usage) or estimate 10 GPD per student (hot only). With cafeteria, no showers, estimate 15 GPD per student (total water usage) or estimate 4 GPD per student (hot only). Boarding school - 80 gpd per student.
SERVICE STATION	1000 gallons - 1st bay per day; 500 each additional bay per day.
SHOPPING CENTERS	.16 gallons per day/square foot.
STOCKYARDS	160-200 gallons per acre total per day.
SUGAR REFINERY	1 gallon per pound of sugar.
TAVERN	20 gallons per seat.
THEATERS (Movie)	2 gallons per seat.

FLOW RATES IN PIPES - Normal to peak

1/2”	= 4 - 7 GPM	3”	= 120-270 GPM
3/4”	= 6 - 16 GPM	4”	= 250-500 GPM
1”	= 16-30 GPM	6”	= 500-1100 GPM
1-1/4”	= 30-35 GPM	8”	= 1000-2000 GPM
1-1/2”	= 40-70 GPM	10”	= 1500-3000 GPM
2”	= 65-120 GPM		
2-1/2”	= 80-170 GPM		

QUICK CALCULATE - FLOW RATE

Normal **Flow Rate** of a Pipe = **D^2 x 20**
(Diameter Squared x 20)

Twice the Diameter = 4 times the flow

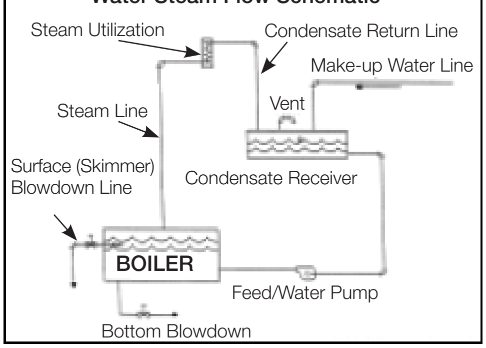
Water Softener & Filter Sizing Information *(continued)*

QUALITY WATER FOR STEAM BOILERS

STEAM PRODUCTION

Most boilers have several things in common. Usually at the bottom is a firebox or combustion chamber (furnace) where the cheapest or most available fuel is fed through a burner to form a flame. The burner is controlled automatically to pass only enough fuel to maintain a desired steam pressure. The flame or heat is directed and distributed to the heating surfaces which are usually tubes, flues or coils of fairly small diameter. In some designs the water flows through the tubes or coils and the heat is applied to the outside. These are called watertube boilers. In other boilers, the tubes or flues are immersed in the water and the heat passes through the inside of the tubes. These are fire-tube boilers. If the water is subjected to the heated gases more than once the boiler is a “two pass”, “three pass”, or “multiple pass” boiler.

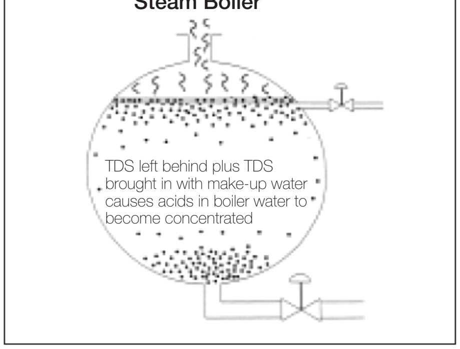
Water Steam Flow Schematic



The heated water or steam rises to the water surface, vaporizes, and is collected in one or more chambers or “drums”. The larger the drum capacity, the greater is the ability of the boiler to produce large, sudden demands of steam. At the top of the steam drum is an outlet or “steam header” from which the steam is piped to the points of use. At the top of the firebox is a metal or brick chimney or “stack” which carries away the combustion by-products and varying amounts of unused fuel. At the bottom of the boiler, and usually at the opposite end from the firebox, is an outlet valve called a “blowdown”. It is through this valve that most of the dirt, mud, sludge and other undesirable materials are purged from the boiler.

Attached to the boiler are a multitude of safety controls to relieve the pressure if it gets too high, to shut off the burner if the water gets too low or to automatically control the water level. A water column (sight glass) is provided so that the interior water level is visible to the operator.

Steam Boiler



EQUIVALENTS:
1 Boiler Hp hr = 4 gal of water evaporated per hr.
1 lb evaporation per hr = 0.12 gal evaporated per hr.
1 gal evaporation per hr = 8.34 lbs of water per hr.
1 Boiler Hp = 33.36 pounds of water per hr.

BOILER FEED WATER

The water for the boiler is usually stored in a “make-up” tank so that a sufficient volume of water is available for larger than usual demands. A constant level is maintained by a float valve similar in principle to the tank type toilet float control. A high pressure pump pulls the water from the make-up tank and pushes it into the boiler. Because most boilers operate at pressures higher than those of the water supply, the pump must raise the feed water pressure to somewhat above that of the boiler operating pressure.

Clean steam is pure water in the form of gas. When it is cooled and condensed, it is pure water and it is referred to as “condensate”. As it is condensed into water it contains considerable heat which can be utilized. It is nearly perfect boiler make-up or feed water since it has been stripped of dissolved minerals and foreign matter in the evaporation process.

Whenever possible, condensate is returned to the boiler and is collected in a tank called a “condensate receiver”. When condensate is recovered, the receiver may also perform the functions of the make-up tank. In some installations, condensate return may supply as much as 99% of the feed water and the higher the percentage of condensate the less water treatment is required. Other installations may use 100% make-up if, for various reasons, the condensate cannot be recovered, or if it is badly contaminated.

BOILER PRESSURES

The temperature and pressure at which a boiler operates have a definite relationship as shown in the following table:

BOILING POINT OF WATER AT VARIOUS PRESSURES

TEMPERATURE ºF	ºC	PRESSURE P.S.I
212	100	0
300	149	52
400	204	232
500	260	666
600	316	1529
700	371	3080
705	374	3200

At normal atmospheric pressure, water boils at 212º F (100º C); at higher pressures the boiling point increases, reaching a maximum of 705º F (374º C) at a pressure of 3200 pounds per square inch. Above this temperature water cannot exist as a liquid.

BOILER RATINGS

Boilers are rated by the amount of steam they can produce in a certain period of time at a certain temperature. The largest units produce 1,000,000 pounds of steam per hour. Boiler are rated at one horsepower for every 34.5 pounds of water it can evaporate per hour. Another definition is one horsepower for every 10 square feet of heating surface in a water-tube boiler or 12 square feet of heating surface in a fire-tube boiler.

SOFTENER SIZING

In the process of selecting a proper water softener for boiler feedwater treatment, several areas of sizing must be reviewed. This basically entails the need to obtain a water analysis, the boiler horsepower and information pertaining to the recovery of the steam. Each of these areas will be addressed prior to the process of actually selecting a softener. (Continued on next page)

Water Softener & Filter Sizing Information *(continued)*

QUALITY WATER FOR STEAM BOILERS (continued)

WATER HARDNESS ANALYSIS

Hardness is made up of calcium and magnesium. Hardness within natural waters will vary considerably, depending upon the source from which water is obtained. Sections of the country that have limestone formations generally have a high hardness content in the water. Since surface waters are diluted by rainfall, well water in the same area will normally have a much higher hardness than surface water since the flow is underground over rock layers.

The degree of hardness at any location should never be assumed. Every effort should be made to obtain a water analysis at the site of installation. This will assure accuracy in your selection process.

In order to determine the size of a water softener, the first procedure in the selection process is to determine the amount of hardness. Many of the water analysis reports express total hardness in parts per million (PPM). The PPM expression must be converted to grains per gallon (GPG) in order to size a softener system. To convert the hardness expressed in PPM to GPG, divide PPM by 17.1.

Example: A report of total hardness of 342 PPM is converted as follows; 342 PPM ÷ 17.1 = 20 GPG of hardness.

DETERMINING MAKE-UP VOLUME

In order to determine the amount of water used to feed a boiler, calculations are necessary to convert the rating of the boiler to the maximum amount of make-up in gallons. Boiler ratings are provided in several forms. However, all can be and should be converted to a common factor of horsepower. For each horsepower, a feed water volume of 4.25 gallons per hour is required. To convert other boiler ratings to horsepower, the following table should be referenced.

BOILER RATINGS	FACTORS USED TO CONVERT TO HORSEPOWER
Pounds of steam per hour	Divide by 34.5
BTU's	Divide by 33,475
Square foot area — water tube	Divide by 10
Square foot area — fire tube	Divide by 12

Upon determining the boiler horsepower rating, two additional factors must be known in order to obtain the net amount of make-up water required in a 24 hour period. The first of these is to determine the amount of condensate return to the boiler. The amount of the condensate returned to a boiler system is vital information in selecting a water softener. This information is generally known by the boiler operator or design engineer. The amount of condensate returned is subtracted from the maximum amount of boiler water make-up volume calculated from the horsepower rating. The net amount referred to is the variance between maximum make-up less the amount of condensate returned to the system.

A very accurate method in determining the net amount of make-up water per hour, or the percent of condensate returned, can be simply calculated on existing operations by comparing a water analysis of the water from the condensate receiver tank and the raw makeup water. In comparing these two waters one can be very accurate in the amount of condensate returned to the system.

Example: A condensate receiver tank with a water containing 300 PPM of total dissolved solids (TDS) and a known factor of 600 PPM TDS in the raw water make-up supply would indicate a 50% condensate return. As described earlier in this publication, condensate is near perfect water (zero TDS) when it enters the condensate receiver. Therefore, when the raw water supply of 600 PPM TDS is diluted with 0 PPM TDS water at a one to one ratio, the result would be 300 PPM TDS or a dilution of 50% or a condensate return of 50%.

The final step in our gathering of data for our softener selection process is to obtain the number of hours in a day the boiler is operated. This is not only important in order to determine total make-up volume, it is also information required to determine the design of our softener system. A boiler operating 24 hours per day will require soft water at all times. Therefore, the design will require the use of two units. On systems operating 16 hours per day, the use of a single softener will meet the needs of the operation. Typically the time required to recharge a softener is less than three hours.

SOFTENER SELECTION

We are now ready to proceed with a typical approach to selecting a water softener. Information is first gathered on all of the aspects of the boiler system discussed in this section. A listing of all our design factors should first be assembled. The following represents a typical boiler plant from which we can calculate the demand for a softener.

(1) DETERMINE WATER HARDNESS

Analysis received or taken is in parts per million (PPM).
Convert to grains per gallon (GPG).
342 ÷ 17.1 = 20 GPG.

(2) DETERMINE BOILER HORSEPOWER

Boiler rating is in pounds per hour of steam.
Convert to Horsepower.
3,450 pounds per hour ÷ 34.5 = 100 H.P.

(3) DETERMINE MAXIMUM GALLONS PER HOUR MAKE-UP

Boiler rating is 100 horsepower.
Convert H.P. to gallons per hour make-up.
100 H.P. x 4.25 gallons per hour make-up.

(4) DETERMINE AMOUNT OF CONDENSATE RETURNED TO SYSTEM AND CALCULATE NET MAKE-UP REQUIREMENT

Make-up per hour is 425 gallons.
Condensate returned is 50% or 213 gallons per hour.
425 - 213 = 212 net gallons make-up per hour.

(5) DETERMINE TOTAL DAILY MAKE-UP REQUIREMENTS

212 gallons net make-up per hour.
Boiler system operates 16 hours per day.
212 gallons per hr. x 16 hrs. = 3,392 gallons per operating day.

(6) DETERMINE TOTAL GRAINS OF HARDNESS TO BE REMOVED DAILY

3,392 gallons per day with a hardness of 20 grains per gallon.

3,392 gallons x 20 GPG = 67,840 grains of hardness needed to be removed daily.

The answer in our sixth step of 67,840 grains of hardness to be removed daily, brings us to our final approach in selecting a water softener. Due to the nature of the importance of obtaining soft water for the boiler feed water, we must allow for a margin of error in our sizing process. This margin is commonly 15%. Multiplication of the 67,840 grains per day by 1.15 results in a total removal demand of 78,016 grains per day needed to be removed.

Water Softener & Filter Sizing Information *(continued)*

Use this chart to determine softener model /size for a given hardness and given number of people in household, the setting required for regeneration cycle, and optional meter setting (gallons). See note below chart for KEY to reading the chart.

Number of people using softened water in household

Hardness (grains per gallon)	1	2	3	4	5	6	7	8
	75gal	150gal	225gal	300gal	375gal 450gal	525gal	600gal	
	15k	15k	15k	15k	15k	30k	30k	30k
1 - 5	12	12	6	6	4	6	4	3
	1700	1600	1500	1500	1400	3500	3400	3300
	15k	15k	15k	30k	30k	30k	30k	45k
6 - 10	12	4	3	4	4	3	3	4
	800	750	650	1500	1400	1300	1200	2100
	15k	15k	30k	30k	30k	45k	45k	45k
11 - 15	6	3	4	3	3	3	3	2
	500	400	950	900	800	1300	1200	1100
	15k	15k	30k	45k	45k	45k	60k	60k
16 - 20	4	2	3	4	3	3	3	2
	375	300	675	1100	1000	900	1200	1100
	15k	30k	30k	45k	45k	60k	60k	90k
21 - 25	4	4	3	3	2	3	2	3
	250	600	500	800	700	1000	900	1600
	30k	30k	45k	45k	60k	90k	120k	120k
24 - 30	6	3	3	2	2	3	3	3
	450	400	550	500	700	1200	1600	1500
	30k	30k	45k	60k	90k	90k	120k	120k
31 - 35	6	3	3	3	4	3	3	3
	400	350	550	700	1200	1100	1500	1400
	30k	45k	45k	60k	90k	120k	120k	-
36 - 40	4	4	2	2	3	3	3	-
	400	525	450	600	975	1350	1200	-
	45k	45k	60k	90k	90k	120k	-	-
41 - 45	6	3	3	3	3	3	-	-
	500	400	500	900	800	1000	-	-
	45k	60k	90k	90k	120k	-	-	-
46 - 50	6	4	4	3	3	-	-	-
	500	600	950	850	1100	-	-	-

KEY TO EACH HORIZONTAL SEGMENT OF CHART:
First line in row = Softener Size (THOUSANDS OF GRAINS) Model
Second line = Number of DAYS between regeneration cycle (where timer is installed)
Third line = Meter setting (GALLONS used between regeneration) where optional meter is installed.

Meter settings based on softener capacities at minimum brining (6 lbs / cu. ft.)

COMPENSATED HARDNESS:

When sizing water conditioning equipment, the hardness should be based on compensated hardness. Compensated hardness takes into consideration minerals and other factors that will reduce the softening capacity of a softener. These items cannot be picked up in a standard hardness test. To arrive at compensated hardness multiple the figure on the right by the hardness in grains per gallon.

YOUR TEST HARDNESS	MULTIPLE BY	COMPENSATED HARDNESS
1 — 20	1.1	= ______
21 — 40	1.2	= ______
41 — 70	1.3	= ______
71 — 100	1.4	= ______
101 — Plus	1.5	= ______

ALWAYS DETERMINE BOTH (1) FLOW RATE AND (2) CAPACITY TOTAL IN GRAINS

CHECKLIST: Floor space (footprint) available for system.

Width: ________ Length: _________ Height : _________

Doorway:________ Stairs width:_____ Hall width: _______.

Any obstructions in path / entry way for equipment? Yes No

Floor strength to hold weight of equipment? Yes No

Floor drain size (ability to handle backwash water)? Yes No

Water available for backwash at location? Yes No

CONTINUOUS HARDNESS LEAKAGE

in ppm as $CaCO_3$

	SALT DOSAGE PER CU. FT		
TDS*	**6 lbs**	**10 lbs**	**12 lbs**
250	1.25	.6	.2
500	5	2.5	.8
750	12	6	1.75
1000	20	10	3
1500	45	23	7
2000	-	40	13
2500	-	-	20
3000	-	-	30

*Raw Water TDS as $CaCO_3$

TERMS DEFINED:

TERM	GRAINS PER GAL
Soft	1.0 or less
Slightly Hard	1.0 to 3.5
Moderately Hard	3.5 to 7.0
Hard	7.0 to 10.5
Very Hard	10.5 or over

TERM	MILLIGRAMS PER LITER
Soft	17.0 or less
Slightly Hard	17.1 to 60
Moderately Hard	60 to 120
Hard	120 to 180
Very Hard	180 or over

Water Softener & Filter Sizing Information *(continued)*

TANK DIA. INCHES	SQ FT BED AREA	CU FT PER INCH OF HEIGHT	SIDE SHELL HEIGHT ONLY	CU FT CAPACITY WITH 50% ± FREEBOARD	BED DEPTH INCHES	FREE-BOARD INCHES	FLOW RATE		MAXIMUM SOFTENER-SALT		MINIMUM SOFTENER-SALT	
							SOFT-ENER	FILTER	CAPACITY @ 30,000 GRAINS	@ 15#/ CU FT	CAPACITY @ 20,000 GRAINS	@ 6#/ CU FT
6”	.196	.016	31”	.35	21	10	2	1	10,500	5.25	7,000	2.1
7”	.267	.022	40”	.56	26	14	2.6	1.3	18,000	9	12,000	3.6
8” 8”	.35 .35	.029 .029	31” 40”	.5 .8	18 28	13 12	3.5 3.5	1.75 1.75	16,000 24,000	7.5 12	10,500 16,000	3 4.8
9”	.44	.04	44”	1	27	17	4	2.2	30,000	15	20,000	6
10” 10”	.54 .54	.045 .045	40” 50”	1.25 1.5	28 34	12 16	5 5	2.7 2.7	40,000 45,000	18.75 22.5	25,000 30,000	7.5 9
12” 12”	.78 .78	.065 .065	42” 48”	1.8 2	28 31	14 17	7 7	4 4	54,000 60,000	27 30	36,000 40,000	10.8 12
13”	.92	.077	50”	2.5	33	17	9	4.6	75,000	37.5	50,000	15
14”	1.07	.089	54”	3	34	20	10	5	90,000	45	60,000	18
16”	1.39	.116	54”	4	35	19	14	7	120,000	60	80,000	24
18”	1.77	.147	54”	5	34	20	18	9	150,000	75	100,000	30
20”	2.18	.182	60”	7	39	21	20	11	210,000	105	140,000	42
21”	2.41	.20	54”	7	36	18	24	12	210,000	105	140,000	42
22”	2.64	.220	56”	8.0	37	19	26	13	240,000	120	160,000	48
24”	3.14	.261	60”	10	38	22	30	15	300,000	150	200,000	60
30” 30”	4.91 4.91	.409 .409	60” 72”	15 20	37 49	23 23	50 50	25 25	450,000 600,000	225 300	300,000 400,000	90 120
36”	7.07	.589	60”	20	34	26	70	35	600,000	300	400,000	120
42”	9.62	.801	60”	30	38	22	95	50	900,000	450	600,000	180
48”	12.57	1.05	60”	40	38	22	125	60	1,200,000	600	800,000	240
54” 54”	15.90 15.90	1.32 1.32	60” 72”	50 60	38 46	22 26	160 160	80 80	1,500,000 1,800,000	750 900	1,000,000 1,200,000	360 300
60” 60”	19.63 19.63	1.64 1.64	60” 72”	65 80	40 49	20 23	200 200	100 100	1,950.000 2,400,000	975 1200	1,300,000 1,600,000	390 480
66”	23.76	1.98	60”	80	40	20	240	120	2,400,000	1200	1,600,000	480
72” 72”	28.27 28.27	2.36 2.36	60” 72”	95 110	40 48	20 24	280 280	140 140	2,850,000 3,300,000	1425 1650	1,900,000 2,200,000	570 660
78”	33.18	2.76	60”	110	40	20	330	165	3,300,000	1650	2,200,000	660
84”	38.48	3.2	60”	130	40	20	380	190	3,900,000	1950	2,600,000	780
90”	44.18	3.68	60”	150	40	20	440	220	4,500,000	2250	3,000,000	900
96”	50.27	4.19	60”	170	40	20	500	250	5,100,000	2550	3,400,000	1020
102”	56.75	4.73	60”	190	40	20	560	280	5,700,000	2850	3,800,000	1140
108”	63.62	5.3	60”	215	40	20	640	320	6,450,000	3225	4,300,000	1290
114”	70.88	5.91	60”	240	40	20	700	350	7,200,000	3600	4,800,000	1440
120”	78.54	6.54	60”	260	40	20	780	390	7,800,000	3900	5,200,000	1560
126”	86.59	7.22	60”	300	41	19	860	430	9,000,000	4500	6,000,000	1800
132”	95.03	7.92	60”	315	40	20	950	475	9,450,000	4725	6,300,000	1890
138”	103.87	8.66	60”	350	40	20	1040	520	10,500,000	5250	7,000,000	2100
144”	113.10	9.42	60”	380	40	20	1130	565	11,400,000	5700	7,600,000	2280
							Filter[1] Backwash Rate	Softener[2]				

NOTE: Because of varying conditions, tables are for guideline only:

[1] Figured @ 10 gpm per square foot of bed area. FLOW RATE OF FILTER IS 50% OF BACKWASH RATE.

[2] Figured @ 5 gpm per square foot of bed area. FLOW RATE OF SOFTENER IS TWICE BACKWASH RATE.

Water Softener & Filter Sizing Information *(continued)*

WATER SOFTENER

UNDERBED SIZE FOR SINGLE TANK

TANK SIZE	UNDER BED 1/2 x 1/4	1/4 x 1/8	#20
12 x 52	–	–	30
14 x 65	–	–	60
16 x 65	–	–	80
20 x 60	–	–	100
20 x 62	–	–	100
21 x 62	–	–	100
24 x 60	–	100	100
24 x 72	–	100	100
30 x 60	–	200	100
30 x 72	–	200	200
36 x 60	–	200	200
36 x 72	–	300	200
42 x 60	–	400	300
42 x 72	–	400	300
48 x 60	–	600	300
48 x 72	–	600	300
DIAPHRAGM VALVE NEST SYSTEMS – STEELTANK			
54 x 60	500	400	400
60 x 60	700	500	500
66 x 60	800	500	500
72 x 72	1200	700	700

WATER FILTERS

UNDERBED SIZE FOR SINGLE TANK

TANK SIZE	UNDER BED 1/2 x 1/4	1/4 x 1/8	#20
FIBERGLASS TANK – AUTOMATIC – CARBON			
9 x 48	–	–	15
10 x 54	–	–	22
12 x 52	–	–	30
14 x 65	–	–	30
16 x 65	–	–	80
21 x 62	–	–	100
22 x 54	–	–	100
24 x 71	–	100	100
24 x 72	–	100	100
30 x 72	–	200	200
36 x 72	–	300	200
42 x 72	–	400	200
48 x 72	500	500	500
63 x 86	1050	500	500

FIBERGLASS TANK – AUTOMATIC – CARBON – MAGNUM VALVE

16 x 65 – – 60
21 x 62 – – 100
24 x 72 – 100 100
30 x 72 – 200 200

TANK SIZE	UNDER BED 1/2 x 1/4	1/4 x 1/8	#20
STEEL TANK – AUTOMATIC – CARBON			
20 x 60	–	–	100
24 x 60	–	100	100
30 x 60	–	200	100
36 x 60	–	300	200
42 x 60	–	400	200
54 x 60	700	700	500
FIBERGLASS TANK – MANUAL – CARBON			
6 x 18	–	–	5
7 x 35	–	–	10
7 x 44	–	–	20
8 x 18	–	–	15
8 x 35	–	–	20

(continued next column)

WATER FILTER

UNDERBED SIZE FOR SINGLE TANK

TANK SIZE	UNDER BED 1/2 x 1/4	1/4 x 1/8	#20
(continued from previous column)			
8 x 44	–	–	10
9 x 48	–	–	10
10 x 54	–	–	22
12 x 36	–	–	30
12 x 52	–	–	30
14 x 47	–	–	–
14 x 65	–	–	60
16 x 65	–	–	20
22 x 54	–	–	10
30 x 72	–	200	200
36 x 72	–	300	200
42 x 72	–	400	300
48 x 72	500	500	500
FIBERGLASS TANK – AUTOMATIC – FILTER AG			
14 x 65	–	–	60
16 x 65	–	–	80
22 x 54	100	50	60
24 x 72	100	100	100
STEEL TANK– AUTOMATIC – FILTER AG			
20 x 60	100	55	55
24 x 60	100	100	100
30 x 60	200	100	200
36 x 60	300	200	200
42 x 60	400	200	200
FIBERGLASS TANK – MANUAL – FILTER AG			
24 x 72	125	75	75
30 x 72	200	125	125
36 x 72	300	125	175
42 x 72	400	250	250
48 x 72	525	325	325
FIBERGLASS TANK– AUTOMATIC – SAND			
30 x 72	–	300	200
36 x 72	–	600	200
42 x 72	–	900	200
48 x 72	–	1300	200
FIBERGLASS TANK – AUTOMATIC – 100% NEUTRALITE			
9 x 48	–	–	10
10 x 35	–	–	10
10 x 54	–	–	10
12 x 52	–	–	15
14 x 65	–	–	60
16 x 65	–	–	90
Aeration/precipitation Units– Iron or Neutratlizer			
7 x 35	–	–	15

WATER FILTER

UNDERBED SIZE FOR SINGLE TANK

TANK SIZE	UNDER BED 1/4 x 1/8	#20	.6 -.8
FIBERGLASS TANK – AUTOMATIC – GREENSAND (w/o Feeder)			
9 x 48	14	8	–
12 x 52	–	30	15
14 x 65	–	45	22
16 x 65	–	60	25
22 x 54	100	50	50
24 x 72	125	75	75

(continued next column)

WATER FILTER

UNDERBED SIZE FOR SINGLE TANK

TANK SIZE	UNDER BED 1/4 x 1/8	#20	.6 -.8
(continued from previous column)			
30 x 72	200	125	125
36 x 72	300	175	175
42 x 72	400	250	250
48 x 72	525	325	325
FIBERGLASS TANK – AUTOMATIC – GREENSAND (w/o Feeder) – MAGNUM VALVE			
16 x 65	–	60	40
21 x 62	–	100	50
24 x 72	100	100	75
30 x 72	200	200	100
STEEL TANK – AUTOMATIC – GREENSAND (w/o Feeder)			
20 x 60	–	100	50
24 x 60	100	80	75
30 x 60	165	125	12
36 x 60	235	175	18
42 x 60	320	240	25
FIBERGLASS TANK – AUTOMATIC – GREENSAND (w/ Feeder)			
9 x 48	–	14	8
10 x 54	–	20	10
12 x 52	–	30	15
FIBERGLASS TANK – AUTOMATIC – BIRM			
9 x 48	–	–	15
12 x 52	–	–	30
14 x 65	–	–	60
16 x 65	–	–	80
20 x 62	–	100	50
24 x 72	–	125	75
30 x 72	–	200	125
36 x 72	–	300	175
42 x 72	–	400	250
48 x 72	525	325	325
FIBERGLASS TANK – AUTOMATIC – BIRM – MAGNUM VALVE			
16 x 65	–	60	–
21 x 62	–	100	–
24 x 72	100	100	–
30 x 72	200	200	–
FIBERGLASS TANK – MANUAL – BIRM			
14 x 65	–	–	60
16 x 65	–	–	90
24 x 72	–	100	100
30 x 72	–	200	100
36 x 72	–	300	200
42 x 72	–	400	200
48 x 72	500	500	500
FIBERGLASS TANK – AUTOMATIC – FILOX-R			
			GARNET
7 x 44	–	–	10
8 x 44	–	–	12
9 x 48	–	–	16
10 x 35	–	–	20
12 x 36	–	–	30
12 x 52	–	–	30
13 x 52	–	30	18
14 x 47	–	–	100
16 x 65	–	60	40
21 x 62	–	100	50
24 x 72	100	100	75

Water Softener & Filter Sizing Information *(continued)*

BRINE TANK CAPACITY AND AREA

BRINE DATA

TANK DIA. (INCHES)	TANK AREA (SQ, FT)	BRINE PER INCH OF HEIGHT (GALLONS)*	SALT PER INCH SATURATED BRINE SOLUTION (LBS)
18	1.76	1.10	2.86
20	2.16	1.33	3.48
24	3.14	1.95	5.07
30	4.90	3.04	7.90
36	7.06	4.40	11.4
42	9.62	5.97	15.5
48	12.57	7.8	20.2
54	15.90	9.9	25.2
60	19.63	12.2	31.8
66	23.76	14.7	38.2
72	28.27	17.5	45.5

* gallons without salt in tank (brine only)

NOTE:
1. Saturated brine is when salt dissolves in water to ± 26% by weight.
2. One gallon of 26% brine has 2.6 pounds of salt @80° F.
3. One gallon of 26% brine solution weighs 10 pounds.
4. One cubic foot of 26% brine has 19.5 pounds of salt.
5. One cubic foot of 26% brine solution weighs 75 pounds.
6. Specific gravity of 26% brine at 60°F is 1.2.
7. #2 Coarse rock salt is ± 46% and voids are 54% of space in a salt tank.

RESIN EXCHANGE CAPACITY

20,000 grain approx. per cu. ft.
6 lbs. salt-sodium chloride

25,000 grain approx. per cu. ft.
8 lbs. salt-sodium chloride

30,000 grain approx. per cu. ft.
15 lbs. salt-sodium chloride

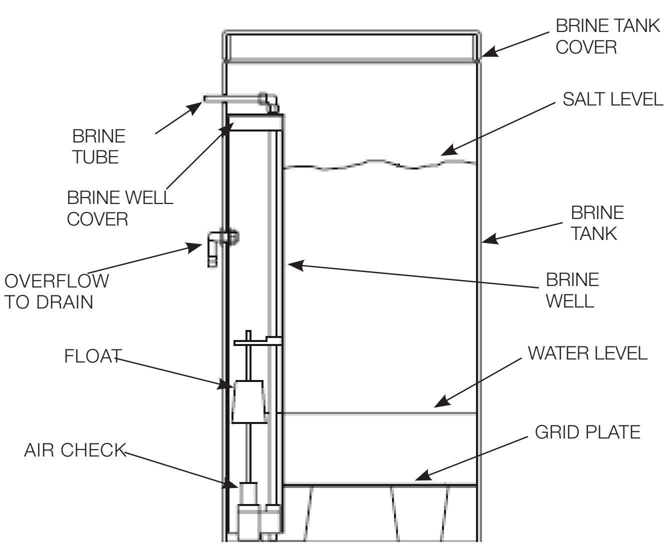
Note: To convert parts per million (ppm) or milligrams per liter (mgl) to grains **divide by 17.1**.

Example:
Water Hardness of **250 ppm**
(250 ppm ÷ 17.1 ppm/gr)
= 14.6 gr.

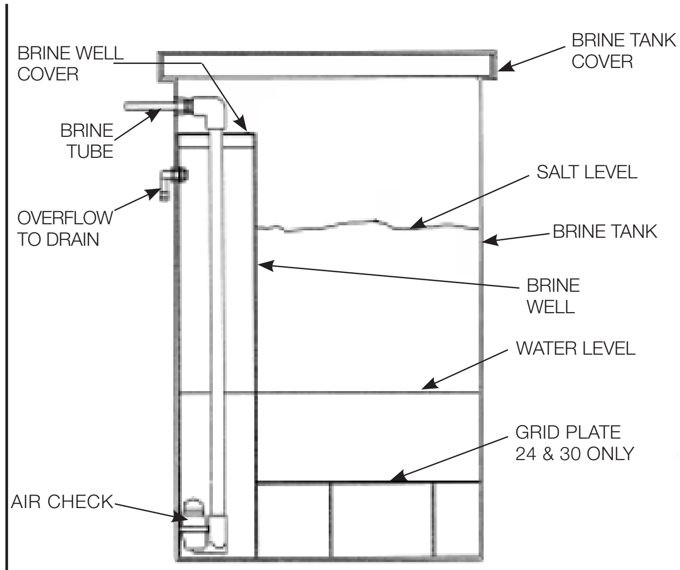
HANDY CONVERSION FACTORS

GPG (grains per gallon) = **PPM ÷ 17.1**
PPM (part per million) = **MG/L** (milligrams/liter)
PSI = Rise in Feet X .434
i.e.: 5 story building = 50' x .434
= 22 PSI loss on 5th Floor
Square Foot of Bed Area = D^2 x .785

TYPICAL ASSEMBLY DRAWINGS



TYPICAL INSTALLATION
18" DIA. BRINE TANK ASSEMBLY



TYPICAL INSTALLATION
24" DIA. AND LARGER BRINE TANK ASSEMBLY

ALSO SEE BRINE ASSEMBLY,
REPLACEMENT PARTS SECTION OF CATALOG.

FILTER MEDIA Properties and Conditions for Operation

General reference only; conditions may vary. Ask about your application.

ACTIVATED CARBON

Description	LB/CF	Equipment Use
Highly activated carbon. Absorbs chlorine, phenois, detergents, pesticides, etc.	28	Carbon Filters
Granular activated carbon. Absorbs larger molecular particles. Good organic trap ahead of deionizers.	28	Carbon Filters
Highly active acid washed carbon. Used in high purity applications such as pharmceutical and medical.	27	R.O. Pretreatment Special Applications
Highly active carbon manufactured to develop catalytic functionality. Used for hydrogen sulfide and chloramine reduction. Primarily used in medical, aquatic, and bottling applications.	36	R.O. Pretreatment Special Applications
Fine mesh nut-shell activated carbon. Extremely hard, high chlorine capacity.	51	Special Filtration Products
FILTER MEDIA		
Crushed and graded limestone (Neutralizer™). Neutralizes water with low pH and high CO_2 on sacrificial basis.	100	Neutralizer Filters
Manganese treated zeolite. Removes iron and manganese. Removes turbidity and hydrogen sulfide on special applications. Requires chemical feed pretreatment.	90	Iron Filter
Granular non-hydrous aluminum silicate for removal of suspended organic matter and turbidity (Filter-Ag)	80	Single Media Turbidity Filters
Regular birm used for iron removal when the oxygen content of the water is at least 15% of the total iron and manganese in the water.	50	Single Media Filters
Washed and graded flint gravel used as underbedding in softeners, filters and some deionizers. Iron and lime free.	100	All Units Except Mixed Bed Deionizers
Washed and graded anthracite filter media.	52	Multi-Media Depth Filters
Filter sand, specially screened.	100	Multi-Media Depth Filters
Garnet filter media, specially sized.	125	Multi-Media Depth Filters

ACTIVATED CARBON

A porous solid, in powder, extrudate or granular form, produced from any base material which has a high percentage of carboncous content, i.e.: wood, nut pits or shell, animal bone, hydrocarbon sludge, peat, lignite, bituminous coal and anthracite coal.

Advantages: The porosity of activated carbon offers an extremely high surface area to volume mass ratio: 2.2 pounds at 1,000 square meters per gram. A good typical carbon, has about the same surface as 100 miles of two lane highway. Carbon adsorbs organic compounds which produce taste, odor, color or toxicity. Reduces free chlorine.

Principle of Adsorption: Adsorption is the concentration of compounds on the surface of a solid without changing the structure of the compound or the solid. Desorption is the deconcentration of these compounds from the surface of the solid. Adsorption/desorption may occur in either the liquid phase or vapor phase; however, the speed involved in this compound movement are very different. Therefore, the pore size, structure and distribution will add or detract from the process.

Conditions for Operation:

Native Carbon/water pH .... 6.6 to 8.4
pH operating range .... Full scale*
(Low pH liquids will leach inorganics from the carbon.)
Service flows .... 2 to 14 gpm/ft^2
Bed depth .... 4 to 30 minute EBCT*

**Note:* Empty Bed Contact Time (EBCT) formula:
flow/gpm divided by 7.481 = flow/cfm
cubic feet of media divided by flow/cfm = EBCT

Backwash bed expansion 40%
Backwash flows .... 10 to 17 gpm/ft^2 @ 55°F

ANTHRACITE

Anthracite has low ash and friability. The coal is cleaned (reduction in ash content), screened and classified to the proper sizes for water filtration purposes.

Advantages: Advantages of use versus silica and quartz sands and gravels are: longer runs between backwashes, higher flow rates without headloss, lower backwash water pressures and/or quantities, a greater utilization of the bed mass for filtration, and a volumetrically higher surface area.

Meets AWWA 100-89 Specifications.

Physical Characteristics:

Acid Solubility (AWWA B100-89) .... <1.0%
Caustic Solubility (1% NaOH @ 190 °F) .... <1.0%
Apparent Specific Gravity ....1.65 +/- 0.05
Hardness (Mohs Scale) .... 3.0 to 3.8
Attrition Loss (annually) 0.2%
Sphericity ....(Loose Pack) 0.61
.... (Tight Pack) 0.60
Ignition Point .... 950 °F

Chemically neutral, does not react with alkaline or acid waters.

Typical analysis (Moisture & Ash-Free Basis)

BTU.. 14,828
Carbon 94.7%
Nitrogen 0.8%
Oxygen 1.6%
Hydrogen 2.1%
Sulphur 0.89%

ION-EXCHANGE RESIN Properties & Conditions for Operation

General reference only; conditions may vary. Ask about your application.

CATION EXCHANGE RESIN

Description	Form	LB/CF	Equipment Use
Strong acid cation resin, sodium form, 8% cross-linked. Removes hardness, soluble iron and other heavy metals. Standard deionizer cation resin.	Na	52	Standard Softeners Deionizers and Strong Acid Dealkalizers
Specially graded large bead, strong acid cation resin. High service flow rates with low pressure drop. Use on low hardness feedwater.	Na	52	High-Flow Softeners
Strong acid cation resin, 10% cross-linked. Tough, durable resin resistant to chlorine and oxidants. Heavy, for good separation in mixed bed deionizers.	Na	55	Chlorine/Oxidation Resistant Softening Mixed Bed DI
Hydrogen Form FM-1	H	50	PEDI and H+ Cation Units
Macroporous strong acid cation resin, 22% cross-linked. Used in special applications requiring resin resistant to attrition and deterioration caused by chlorine and other oxidants.	Na	52	Two-Bed Deionizer and Single Cation Units
Weak acid carboxylic cation.	H	48	Weak acid dealkalization

ANION EXCHANGE RESINS

Strong base Type II used in deionizers and dealkalizers. Provides high operating capacity and efficiency.	Cl	44	Standard Two-Bed Demineralizers and Dealkalizers
Type I gel strong base anion resin. High silica removal. Tolerates higher water temperature	Cl	44	Deionizers Esp. Mix. Bed
Standard Type I porous gel strong base anion resin. High silica removal. Resistant to organic fouling.	Cl	44	Deionizers
Type I macroporous strong base anion resin. High silica removal. Excellent resistance to organic fouling. Good color and tannin removal.	Cl	42	Two-Bed Deionizer Special Applications
Weak base macroporous anion resin. Used where silica and CO2 removal not required. Excellent capacity. Resistant to organic fouling.	FB	40	Standard Two-Bed Deionizers
Regenerated Type II strong base anion resin (FM-12). Regenerated Type II strong base anion resin (FM-58).	OH	43	Deionizers Esp. Portable Exchange

PEDI MIXED BED RESINS

Premixed regenerated mixed bed deionizer resin (1.4 parts anion to 1 part cation). Uses Type II anion.	H/OH	43	Portable Exchange DI
Premixed regenerated mixed bed deionizer resin (2 parts anion to 1 part cation). Uses Type I anion.	H/OH	44	Portable Exchange DI
Premixed regenerated mixed bed deionizer resin (1.55 parts anion to 1 part cation). Uses Type I anion	H/OH		Portable Exchange DI Ultra High Quality

AUTOMATIC MIXED BED RESINS

Strong acid, premium quality, 10% cross-linked, gel cation resin. Excellent durability. Specially screened.	Na	52	Mixed Bed Deionizers
Inert polymer resin for cation/anion resin separation.		44	Mixed Bed Deionizers
Strongly basic, premium quality, Type I, porous anion resin, specially screened.	Cl	42	Mixed Bed Deionizers

DEIONIZATION & ION EXCHANGE RESINS

Deionization is the process of removing ionizable solids from water using the principles of ion exchange. It involves the removal of virtually all ionizable particles from water. The deionizer requires two resins because it exchanges both cations and anions. A cation exchange resin is chemically formulated to attract positive ions; an anion exchange resin is formulated to attract negative ions. The simplest deionizer is a two-column unit in which the cation exchange resin is held in one pressure vessel and the anion exchange resin in another. Water first passes through the cation tank, then the anion tank.

ION-EXCHANGE RESIN Properties & Conditions for Operation

General reference only; conditions may vary. Ask about your application.

CATION EXCHANGE PROCESS

As water passes down through the cation tank, it encounters millions of resin beads, each of which contains a large number of negatively charged exchange sites in the pores and microscopic paths of its structure. As the positively charged cations in the water contact the beads, they are attracted to the negative exchange sites. They drive off the hydrogen ions and attach to the exchange sites. The displaced hydrogen ions (H^+) pass down through the resin bed and are discharged from the tank. There are two kinds of cation resin – strong acid and weak acid.

Weak Acid Cation (WAC) resins are not used as widely as Strong Acid Cation (SAC) resins because they will work only under certain chemical conditions.

WEAK ACID

Is effective in removing alkalinity. Weak acid resins will only remove cations associated with alkalinity.

Physical Characteristics:

Polymer structure .... Styrene-Divinylbenzene
Physical form .... Moist Spherical Beads
Reversible Swelling % approx .... 60 H→Na
Screen Mesh Size .... Standard 16/40
Ionic form as shipped .... Hydrogen
Maximum operating temperature .... 250 °F

STRONG ACID

"Workhorse" ion exchange resins. SAC resins capable of removing essentially all of the unwanted positive ions. A strong acid when in the hydrogen form.

Physical Characteristics:

Polymer structure Crosslinked Styrene-Divinylbenzene
Physical form .... Moist Spherical Beads
Reversible Swelling % .... approx 5 Na→H

Screen Mesh Size:

Standard 16/50
Ionic form as shipped .... Sodium
Maximum operating temperature .... 280 °F
Coarse 16/40
Ionic form as shipped .... Hydrogen
Maximum operating temperature .... 265 °F

ANION EXCHANGE PROCESS

The anion exchange process is similar to the cation exchange process. There are two kinds of anion resin –strong base and weak base. A strong base anion resin is made of beads which have positive exchange sites, which in the regenerated state are occupied by negative hydroxide ions (OH^-). As the negatively charged nonmetallic anions contact the beads, the negative hydroxide ions are dislodged and replaced by the stronger negative non-metallic anions.

The hydroxide ions (OH^-)pass down through the anion resin and are discharged from the tank. At the same time, the hydrogen ion (H^+) from the cation tank has passed unchanged through anion resin and they join the hydroxide to form H_2O (water).

A weak base resin will neutralize mineral acid but does not use ion exchange. Strong base and weak base resins are used for different purposes.

WEAK BASE

Employed when removing chlorides and sulfates. Weak base resins are generally higher in acid-removing capacity than strong base resins and are thermally stable.

Physical Characteristics:

Basicity .... Weak
Polymer structure .... Styrene-Divinylbenzene
Physical form .... Moist Spherical Beads
Reversible Swelling % approx. .... 15 FB→Cl
Screen Mesh Size .... Standard 16/50
Ionic form as shipped .... Free base
Maximum operating temperature .... 140°F

STRONG BASE, TYPE I

Removes mineral acids most completely, including silica as silicic acid and CO_2 as carbonic acid. Is stable at temperatures to 140 °F.

Physical Characteristics:

Polymer structure .... Styrene-Divinylbenzene
Physical form .... Moist Spherical Beads
Reversible Swelling % approx. .... 20 Cl→OH

Screen Mesh Size:

Standard 16/50
Ionic form as shipped .... Chloride
Maximum operating temperature .... 212 °F
Coarse 16/40
Ionic form as shipped .... Hydroxide
Maximum operating temperature .... 120-140 °F

STRONG BASE, TYPE II

Removes mineral acids efficiently, but does not remove silica as completely as Type I. Is stable at temperatures to 105 °F. Is higher in capacity than Type I.

Physical Characteristics:

Polymer structure .... Styrene-Divinylbenzene
Physical form .... Moist Spherical Beads
Reversible Swelling % approx. .... 15 Cl→OH

Screen Mesh Size:

Standard 16/50
Ionic form as shipped .... Chloride
Maximum operating temperature .... 160°F
Coarse 16/40
Ionic form as shipped .... Hydroxide
Maximum operating temperature ....95°F

Media Loading or Replacement Procedure

Media loading or replacement for water softeners or filters is sometimes required for units in the field. Replacement of media is relatively simple, if the following procedure is followed:

Replacement of Media

Simplex Unit - Open bypass valve and close inlet/outlet isolation valves.

Duplex Unit - Close inlet/outlet isolation valve of unit to be rebedded.

Manually turn timer dial to backwash position (Manual Regeneration) to relieve vessel pressure.

Unplug electrical connection of unit. Disconnect inlet, outlet, drain, and brine lines. Unscrew valve head from tank. Remove distribution tube from tank and visually inspect for any damage or wear — replace if necessary.

Empty media into a vessel with resin trap/strainer, to retain the resin/gravel and allowing water to drain. Dispose of used media. Relocate softener tank in original location.

Loading of Media

Install distribution tube in mineral tank. Place a cap or tape over the open end of distributor to prevent any media from entering.

Fill tank approximately one-third with water to act as a buffer.

Slowly pour the required amount of media in each vessel: Gravel to be loaded first. Resin to be loaded second.

Clean top of tank and tank threads of any resin or gravel. Remove cap or tape from distribution tube and clean. Visually check and clean valve and distribution "O" Ring of any foreign matter and lubricate with silicone or soap.

NOTE: Do <u>not</u> use Vaseline or grease.

Locate control valve on tank making certain riser tube is centered. Tighten valve to tank.

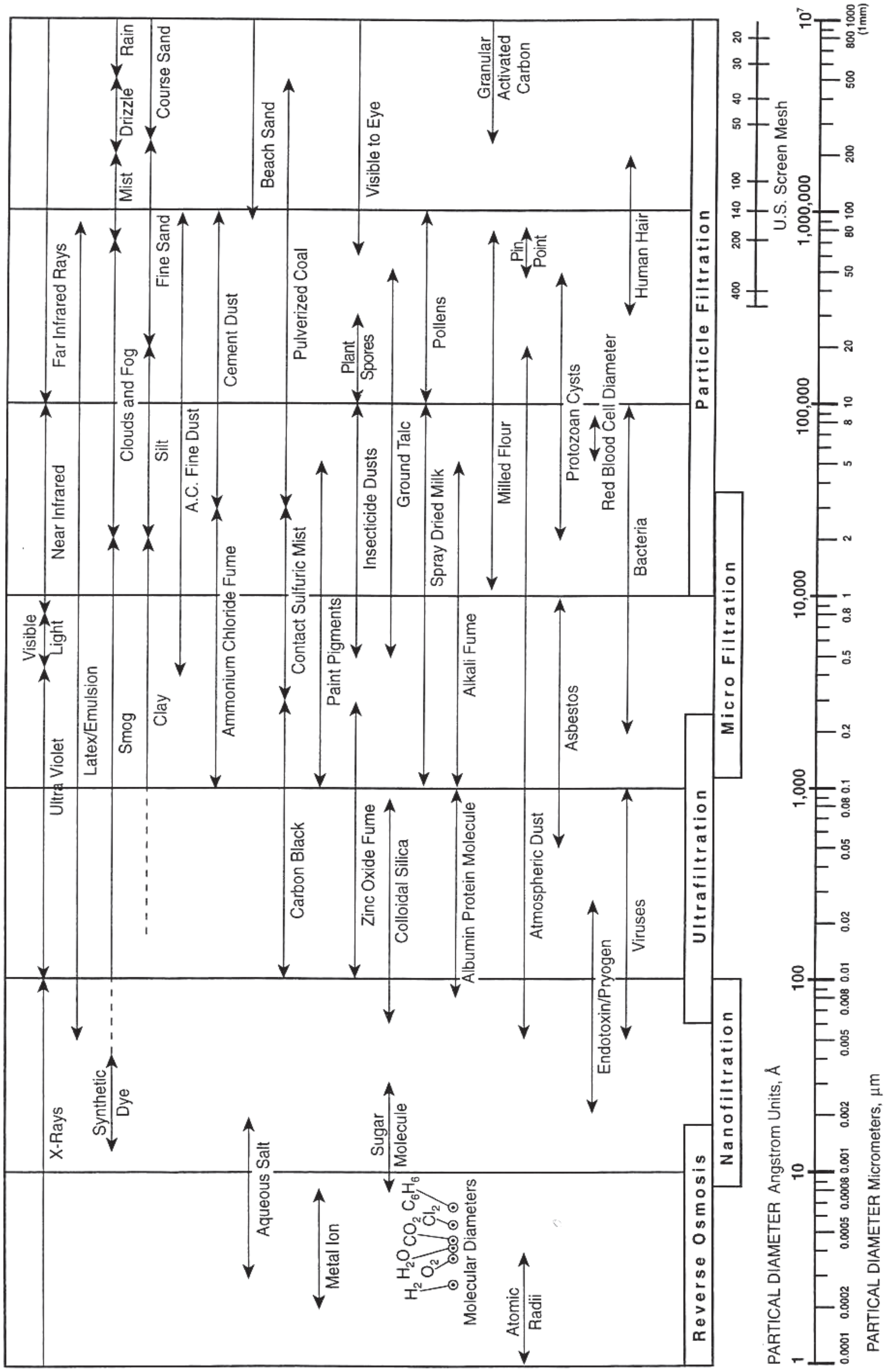
Reposition and level tank if necessary to assure proper alignment.

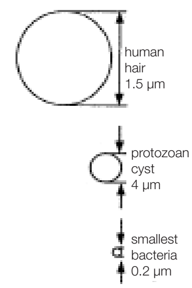
Connect inlet, outlet, drain, and brine connections.

NOTE: Disposal of used media must meet local and state regulations.

Particle Size Removal Range by Filtration

Information below appears in “Water Filtration”, a publication, prepared & distributed by the Water Quality Association





NOT TO SCALE

RELATIVE SIZE OF COMMON MATERIAL

EQUIVALENTS

MESH OPENING

U.S.	mm	inch	micron
4	4.70	.185	4654.98
6	3.33	.131	3277.55
8	2.36	.094	2322.83
12	1.65	.065	1624.01
14	1.40	.056	1377.95
16	1.17	.047	1151.57
18	0.991	.039	975.39
20	.833	.033	819.88
25	.701	.028	689.96
30	.589	.023	579.72
35	.495	.020	487.20
40	.417	.016	410.43
45	.351	.014	345.47
50	.295	.012	290.35
60	.246	.0097	242.13
70	.200	.008	210.00
80	.175	.0069	172.24
100	.147	.0058	144.68
140	.104	.004l	102.36
200	.074	.0029	72.83
230	.061	.0024	60.04
325	.043	.0017	42.32
400	.038	.0015	35.43

High Purity Water Information

Because of varying conditions, information is to be used as a guideline only.

LABORATORY WATER REQUIREMENT STANDARDS

(ACS) American Chemical Society

Specific resistance .... Not less than 0.5 megohm/cm
Silicate (as SiO_2) .... Not more than 0.01 ppm
Heavy metals (e.g. Pb) .... Not more than 0.01 ppm

(NCCLS) National Committee for Clinical Laboratory Standards

Characteristics	Type I	Type IIA	Type IIB	Type III
CFU/ml	< 10.00	10.0	1000	N/A
Resistivity megohms/cm	10.00	1.0	1.0	0.1
Particulate matter	0.22	N/A	N/A	N/A
Organics	Act. Carbon	N/A	N/A	N/A

(ASTM) American Society for Testing and Materials

Laboratory Grade Water

Type	Type I	Type II	Type III	Type IV
Max. Conductivity Micromhos-cm	0.06	1.0	1.0	5.0
Minimum Resistivity Megohm/cm	16.66	1.0	1.0	0.2
pH	—	—	6.2–7.5	5. - 8.

Electronic Grade Water

Type	E-I	E-II	E-III	E-IV
Resistivity, minimum, Megohm @ 25°C	17	10.0	1	0.1
Copper*	0.002	0.01	0.1	1.0
Chloride*	0.020	0.20	2.0	20.0
Dissolved gases*	0.010	0.10	0.5	0.5
Potassium*	0.001	0.01	0.1	1.0
SiO_2 (total)*	0.001	0.01	0.1	1.0
Sodium*	0.001	0.01	0.1	1.0
Total solids*	0.050	0.50	5.0	50.0
Fixed solids (inorganic)*	0.010	0.10	1.0	10.0
Volatile solids (organic)*	0.04	0.40	4.0	40.0
Zinc*	0.001	0.01	0.1	1.0

Note: *mg/l

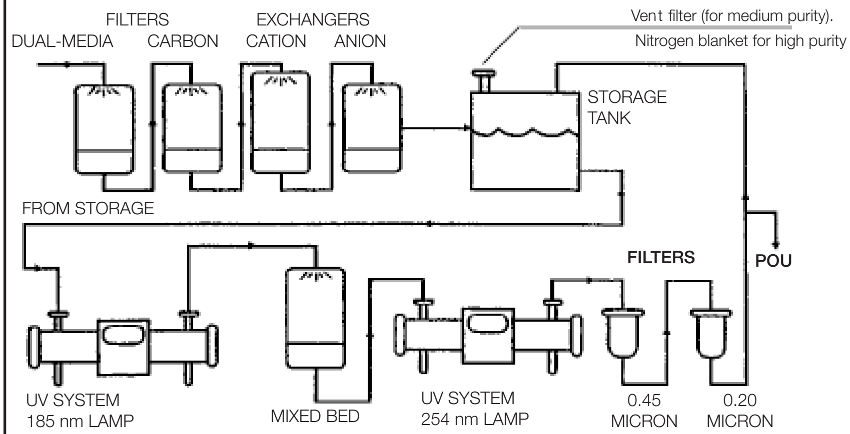
Particle count (>1 micron), Maximum/ml	2	10	100	500
Micro-organisms, Maximum/ 100ml	1	10	100	100
Total organic carbon*	0.075	0.50	1.0	2.0

Note: *mg/l

(USP) United States Pharmacopoeia XXI Standards

Type	USP Purified	Water for Injection
Chloride, mg/l	2.0	2.0
Total solids, mg/l	10	10
Micro-organisms	—	—
	Maximum per 100 ml	
pH	5 –7	5 -7
Sulfates, mg/l as SO_4	5.0	4.0
Ammonia, mg/l as NH_3	0.3	0.3
Calcium, mg/l	4.0	4.0
CO2 mg/l @ 25°C	5.0	5.0
Heavy Metals, mg/l as Cu	1.0	1.0
Oxidizable substances as O_2	0.8	0.8
Pyrogens Test	—-	Absent by Rabbit

HIGH PURITY WATER LOOP



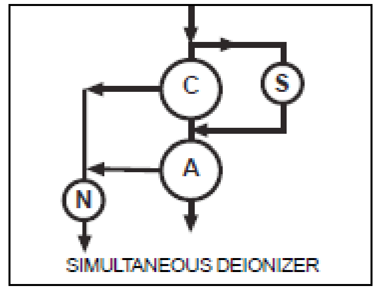
CONDUCTIVITY - RESISTIVITY CHART

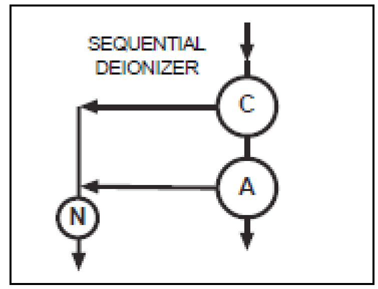
CONDUCTIVITY MICROMHOS/cm @25°C	RESISTIVITY OHMS-cm @25°C	DISSOLVED SOLIDS PARTS/MILLION (PPM)	APPROXIMATE GRAINS/GALLON (GPG) AS $CaCO_3$
0.056	18,000,000	0.0277	0.00164
0.059	17,000,000	0.0294	0.00170
0.063	16,000,000	0.0313	0.00181
0.067	15,000,000	0.0333	0.00193
0.072	14,000,000	0.0357	0.00211
0.077	13,000,000	0.0384	0.00222
0.084	12,000,000	0.0417	0.00240
0.091	11,000,000	0.0455	0.00263
0.100	10,000,000	0.0500	0.00292
0.111	9,000,000	0.0556	0.00322
0.125	8,000,000	0.0625	0.00368
0.143	7,000,000	0.0714	0.00415
0.161	6,000,000	0.0833	0.00485
0.200	5,000,000	0.100	0.00585
0.250	4,000,000	0.125	0.00731
0.333	3,000,000	0.167	0.00971
0.500	2,000,000	0.250	0.0146
1.00	1,000,000	0.500	0.0292
1.11	900,000	0.556	0.0322
1.25	800,000	0.625	0.0368
1.43	700,000	0.714	0.0415
1.67	600,000	0.833	0.0485
2.00	500,000	1.00	0.0585
2.50	400,000	1.25	0.0731
3.33	300,000	1.67	0.0971
5.00	200,000	2.50	0.146
10.00	100,000	5.00	0.292
11.1	90,000	5.56	0.322
12.5	80,000	6.25	0.368
14.3	70,000	7.14	0.415
16.7	60,000	8.33	0.485
20.0	50,000	10.0	0.585
25.0	40,000	12.5	0.731
33.3	30,000	16.7	0.971
50.0	20,000	25.0	1.46
100.0	10,000	50.0	2.92
111	9,000	55.6	3.22
125	8,000	62.5	3.68
143	7,000	71.4	4.15
167	6,000	83.3	4.85
200	5,000	100	5.85
250	4,000	125	7.31
333	3,000	167	9.71
500	2,000	250	14.6
1,000	1,000	500	29.2
1,110	900	556	32.2
1,250	800	625	36.8
1,430	700	714	41.5

Deionization Systems Information

Because of varying conditions, information is to be used as a guideline only.

SIMULTANEOUS Vs. SEQUENTIAL SYSTEMS





Simultaneous – Both the cation and anion vessels will regenerate at the same time. It is not uncommon to blend the wastewater from the two in order to neutralize the stream and reduce the size and expense of the neutralization system. A source of softened water must be provided for the regeneration of the anion bed, as hardness will tend to precipitate and foul the media.

Sequential – The cation bed regenerates first in this configuration and supplies decationized water to the anion bed for regeneration. A separate source of soft water is not needed; however, the waste stream will require some consideration. In most applications, the low pH waste from the cation bed as well as the high pH waste from the anion bed will both need neutralization in order to be fed straight to the drain. The use of a storage tank with a chemical neutralization system is recommended.

INFLUENT WATER LIMITS

To achieve long resin and equipment life and deliver the highest quality of water obtainable from deionizers, the following limits are specified:

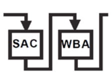
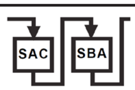
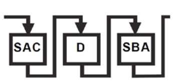
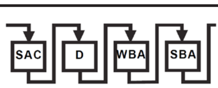
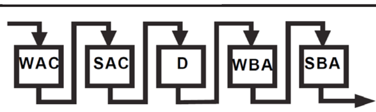
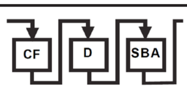
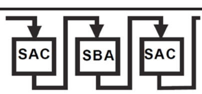
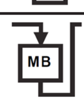
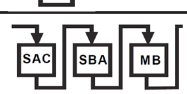
Temperature – 45°F – 105°F (7°C – 40°C) cold water tends to inhibit ion exchange and high temperature degrades the anion resin.

Pressure – 40 psi minimum to ensure proper eduction of regenerants.

Water Quality Limits without Pretreatment

TDS	35 gpg (600ppm)
Hydrogen Sulfide	0.01 ppm
Manganese	5.0 ppm
Organics-COD	1.0 ppm
Oil	0 ppm
Free Chlorine	0.2 ppm
Iron	1.0 ppm
Turbidity	5 JTU
Color	5 units

If any of the above substances are present and exceed the suggested parameters, pretreatment for their removal or reduction prior to deionization is recommended.

TYPICAL DEIONIZATION SYSTEMS	APPLICATION	TYPICAL	ADVANTAGES & LIMITATIONS
	Silica and CO2 are Not Objectionable	Conductance: 10-40 µS/cm Silica Unchanged	Low Equipment Costs Low Anion Regenerant Costs
	Lower Alkalinity Raw Water, Silica and CO_2 Removal Required	Conductance: 10-40 µS/cm Silica: removal	Low Equipment Costs Medium Regenerant Cost
	High Alkalinity Water, Silica and CO_2 Removal Required	Conductance: 10-40 µS/cm Silica: removal	Low Anion Regenerant Costs Repumping Required
	High Alkalinity Chloride and Sulfate Raw Water, Silica and CO_2 Removal Required	Conductance: 10-40 µS/cm Silica: removal	Higher Equipment Cost Lowest Regenerant Cost Repumping Required
	High Hardness Alkalinity, Chloride and Sulfate Raw Water, Silica and CO_2 Removal Required	Conductance: 10-40 µS/cm Silica: removal	Higher Equipment Cost Lowest Regenerant Cost Repumping Required
	High Sodium Raw Water, Low Leakage Required	Conductance: 10-40 µS/cm Silica: removal	Medium Equipment Cost Lower Acid Cost for Leakage Obtained
	High Sodium Raw Water, Existing 2-Bed System Low Leakage Required	Conductance: 10-40 µS/cm Silica: removal	Easy To Retrofit System Danger of Acidic Water on Anion Breakthrough
	Low Solids Raw Water, High Purity Required	Conductance: 1-10 µS/cm Silica: removal	Low Equipment Costs High Chemical Costs Higher Attention Required
	Low Solids Raw Water, High Purity Required	Conductance: 0.06-1 µS/cm Silica: removal	Medium Equipment Costs High Chemical Costs Higher Attention Required

D	CF	MB	SAC	SBA	WAC	WBA
Degasifier	Counter Flow Cation	Mixed Bed	Strong Acid Cation Exchanger	Strong Base Anion Exchanger	Weak Acid Cation Exchanger	Weak Base Anion Exchanger

Dealkalizer Information

Applications for Chloride Anion Dealkalizers :

Softened water is passed through the dealkalizer reducing free carbon dioxide, bicarbonate alkalinity, and sulfates, and replacing these with an equivalent amount of chlorides. The resulting water keeps boiler and process equipment clean and scale free and also solves the problems of excessive boiler alkalinity and corrosive condensate. Savings are obtained by lowering boiler blowdown requirement and virtually eliminating condensate line corrosion due to carbon dioxide.

Companion Equipment:

It is advisable to feed a dealkalizer with **softened water**. The hardness ions in the feed water can combine with the sulfate ions attracted to the anion resin and form an insoluble calcium sulfate precipitate. This scale will tend to foul the dealkalizer over time as it accumulates on the resin bed. If this occurs, an acid regeneration may help to dissolve the scale and clean the bed.

Complete these calculations to determine size:

1. Determine Total Anion Loading:

Anions	Symbol	as ions	factor	as $CaCO_3$
Hydroxide Alkalinity	OH	_______	x 2.94 =	________
Carbonate Alkalinity	CO_3	_______	x 1.67 =	________
Bicarbonate Alkalinity	HCO_3	_______	x 0.82 =	________
Sulfates	SO_4	_______	x 1.04 =	________
Nitrates	NO_3	_______	x 0.81 =	________
Carbon Dioxide	CO_2	_______	x 1.14 =	________
Chlorides	Cl	_______	x 1.41 =	________

Total Exchangable Anions = + _________

/ 17.1

Anions as grains per gallon = ________

2. Determine Resin Capacity (Percent Alkalinity)=
   Total Alkalinty (OH + CO_3 + HCO_3) Divided by Total Exchangeable Anions

____

____

Notes

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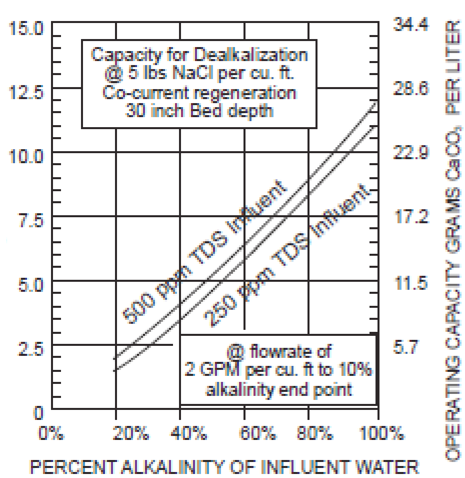
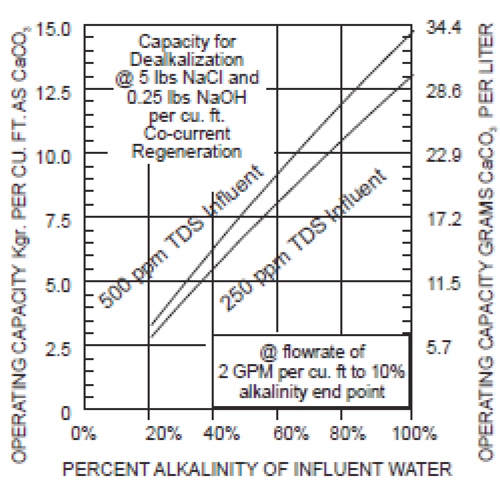
These charts illustrate the operating capacity of the anion exchange resin when regenerated with 5 lbs. of sodium chloride (salt) per cubic foot and approximately 0.25 lbs. per cubic foot of rayon grade sodium hydroxide (caustic). Addition of caustic to the regenerant solution will increase the resin capacity for alkalinity and CO_2 due to a more efficient exchange with hydroxide ions as compared to chloride ions.





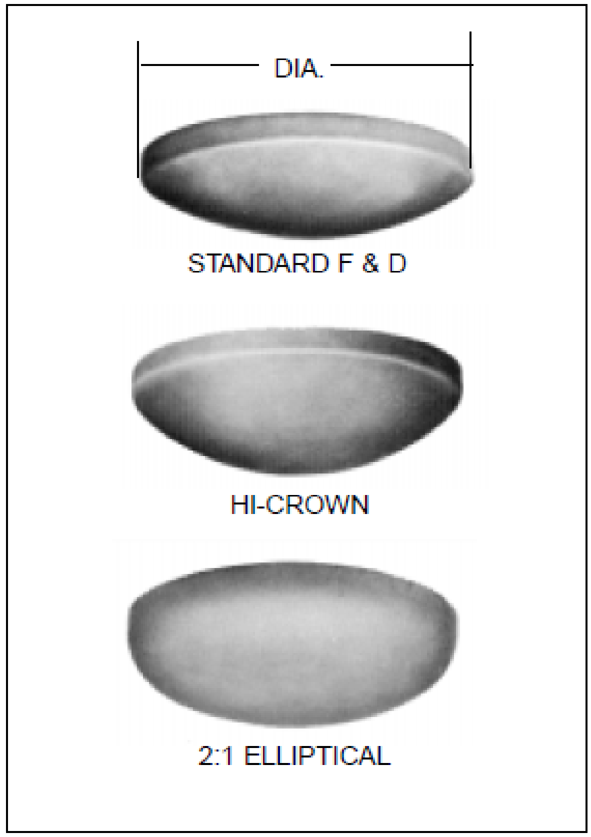
Tank Sizing Information

Because of varying conditions, information is to be used as a guideline only.

CONTENTS OF STANDARD DISHED HEADS without straight flange.

Contents in cubic feet for one head only. This table is only approximate but close enough for estimating. Head thickness affects the volume.

DIA OF HEAD IN INCHES	STANDARD F & D	HI-CROWN F & D	ELLIPTICAL 2:1
	NON-CODE	ASME	ASME
16”	0.14	—	0.29
20”	0.26	—	0.57
24”	0.45	0.74	0.99
30”	1.33	1.38	1.95
36”	2.13	2.4	3.39
42”	3.2	3.8	5.36
48”	4.6	5.7	8.1
54”	6.3	8.1	11.5
60”	8.5	11.2	15.8
66”	11.1	14.9	21.1
72”	14	19.4	27.2
78”	17.6	24.5	34.7
84”	21.6	30.6	43.40
90”	26.1	37.40	53.20
96”	31.5	45.6	64.9
102”	37.5	54.8	78.0
108”	44.2	64.8	92.8
114”	51.7	76.4	109.2
120”	59.7	89.3	126.4
132”	77.9	119.3	169.7
144”	101.2	154.2	220.9

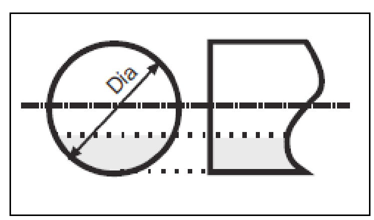


TANK CAPACITIES, HORIZONTAL CYLINDRICAL

Contents of tanks with flat ends when filled to various depths.
Contents in cubic feet per one foot of length.

DEPTH OF LIQUID, IN INCHES

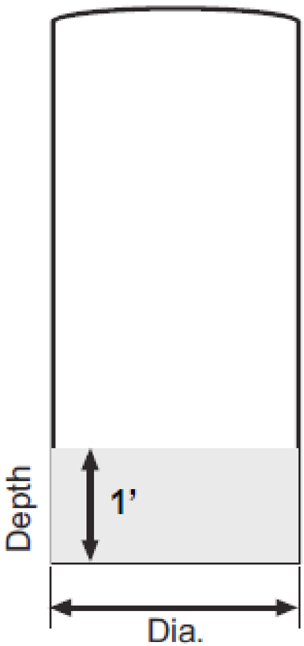
TANK DIA.	FULL TANK	3”	6”	9”	12”	15”	18”	21”	24”	27”	30”	33”	36”	39”	42”	45”	48”	51”	54”	57”	60”
12”	.79	0.15	0.39	—	—																
18”	1.77	0.19	0.52	.89	—																
24”	3.15	0.23	0.62	1.08	1.58																
30”	4.92	0.26	0.70	1.24	1.84	2.46	—	—													
36”	7.09	0.28	0.78	1.39	2.07	2.79	3.54	—													
42”	9.65	0.31	0.85	1.52	2.27	3.09	3.95	4.82													
48”	12.60	0.33	0.91	1.64	2.46	3.37	4.32	5.30	6.30	—	—										
54”	15.95	0.35	0.97	1.75	2.64	3.61	4.65	5.74	6.85	7.97	—										
60”	19.69	0.37	1.02	1.85	2.80	3.85	4.97	6.14	7.36	8.59	9.84										
64”	23.82	0.39	1.08	1.95	2.96	4.07	5.27	6.52	7.83	9.17	10.5	11.9	—	—							
72”	28.35	0.41	1.13	2.05	3.11	4.28	5.54	6.88	8.27	9.71	11.2	12.8	14.2	—							
78”	33.28	0.42	1.18	2.14	3.45	4.48	5.81	7.22	8.70	10.2	11.8	13.8	15.0	16.6							
84”	38.59	0.44	1.22	2.22	3.38	4.67	6.06	7.55	9.10	10.7	12.4	14.1	15.8	17.5	19.3	—	—				
90”	44.30	0.46	1.27	2.31	3.51	4.85	6.31	7.86	9.48	11.1	12.9	14.5	16.5	18.4	20.3	22.2	—				
96”	50.40	0.47	1.31	2.39	3.64	5.03	6.54	8.15	9.86	11.6	13.5	15.3	17.3	19.2	21.2	23.2	25.2				
102”	56.90	0.48	1.35	2.46	3.75	5.23	6.77	8.44	10.2	12.0	14.0	15.9	18.0	20.0	22.1	24.2	26.3	28.5	—	—	—
108”	63.80	0.50	1.39	2.54	3.87	5.37	6.99	8.73	10.6	12.5	14.5	16.5	18.6	20.8	33.0	25.2	27.4	29.0	31.91	—	—
114”	71.10	0.51	1.44	2.61	3.99	5.53	7.20	8.99	10.9	12.9	14.9	17.1	19.3	21.5	23.8	26.1	28.4	30.8	33.16	35.5	—
120”	78.80	0.52	1.47	2.68	4.10	5.68	7.41	9.26	11.2	13.3	15.4	17.6	19.9	22.2	24.6	27.0	29.4	31.9	34.37	36.9	39.4



Tank Sizing Information *(continued)*

TANK CAPACITIES, VERTICAL CYLINDRICAL

Contents of tanks with flat ends when filled to various depths.



DIAMETER		U.S. GALLONS DIAMETER PER 1' OF DEPTH	DIAMETER		U.S. GALLONS DIAMETER PER 1' OF DEPTH	DIAMETER		U.S. GALLONS DIAMETER PER 1' OF DEPTH
1'		5.87	3'	4"	65.28	7'		287.9
1'	1"	6.89	3'	5"	68.58	7'	3"	308.8
1'	2"	8.00	3'	6"	71.97	7'	6"	330.5
1'	3"	9.18	3'	7"	75.44	7'	9"	352.9
1'	4"	10.44	3'	8"	78.99	8'		376.0
1'	5"	11.79	3'	9"	82.62	8'	3"	399.9
1'	6"	13.22	3'	10"	86.33	8'	6"	424.5
1'	7"	14.73	3'	11"	90.13	8'	9"	449.8
1'	8"	16.32	4'		94.00	9'		475.9
1'	9"	17.99	4'	1"	97.96	9'	3"	502.7
1'	10"	19.75	4'	2"	102.0	9'	6"	530.2
1'	11"	21.58	4'	3"	106.1	9'	9"	558.5
2'		23.50	4'	4"	110.3	10'		587.5
2'	1"	25.50	4'	5"	114.6	10'	6"	647.7
2'	2"	27.58	4'	6"	119.0	11'		710.9
2'	3"	29.74	4'	7"	123.4	11'	6"	777.0
2'	4"	31.99	4'	8"	128.0	12'		846.0
2'	5"	34.31	4'	9"	132.6	12'	6"	918.0
2'	6"	36.72	4'	10"	137.3	13'		992.9
2'	7"	39.21	4'	11"	142.0	13'	6"	1071.0
2'	8"	41.78	5'		146.9	14'		1152.0
2'	9"	44.43	5'	3"	161.9	14'	6"	1235.0
2'	10"	47.16	5'	6"	177.7	15'		1322.0
2'	11"	49.98	5'	9"	194.3	15'	6"	1412.0
3'		52.88	6'		211.5	16'		1504.0
3'	1"	55.86	6'	3"	229.5	16'	6"	1600.0
3'	2"	58.92	6'	6"	248.2	17'		1698.0
3'	3"	62.06	6'	9"	267.7	17'	6"	1799.0

NEMA STANDARDS FOR ELECTRICAL ENCLOSURES

NEMA 1 GENERAL PURPOSE ENCLOSURE:
These have sheet metal enclosures and serve as protection against dirt and against light, indirect splashing. They are not dust tight or splash proof.
NEMA 2 DRIP TIGHT ENCLOSURE: Used for severe condensation, cooling rooms, laundries, tunnels.
NEMA 3 WEATHER RESISTANT (Weather Proof):
Used outdoors for splashing rain, snow, sleet. Ship docks, subways, tunnels.
NEMA 4 WATER TIGHT: Used in dairies, breweries, etc. Must pass hose test, using one inch nozzle, delivering 65 gallons per minute at 10 foot distance for 5 minutes.
NEMA 5 DUST TIGHT: Gasketed enclosure to exclude nonhazardous dust in cement mills, steel mills, etc. Do not use for grain or coal dust atmosphere.
NEMA 6 SUBMERSIBLE: Used in quarries, mines, and manholes. To operate while submerged in water under conditions of pressure and time.
NEMA 7 HAZARDOUS LOCATIONS (Class I Group C & D): Explosion proof. Atmospheres of ethylether, ethylene, cyclopropane, gasoline, petroleum, naptha, benzene, propane, alcohol, acetone, benzol, lacquer solvent, vapor, natural gas.
NEMA 8 HAZARDOUS LOCATIONS (Class I Oil Immersed): Oil circuit breakers.
NEMA 9 HAZARDOUS LOCATIONS (Class II Group E, F, G): Combustible dust such as metal dust, carbon black, coal dust, coke dust, grain dust.
NEMA 10 BUREAU OF MINES (Explosion Proof): Used in gassy coal mines.
NEMA 11 ACID & FUME RESISTANT (Oil immersed- Used Indoors): Equipment submerged in oil when subjected to acid or other corrosive fumes, as in chemical plants, plating rooms, sewage plants, etc.
NEMA 12 INDUSTRIAL USE: To exclude dust, lint fibers, filings, oil seepage.
NEMA 13 DUST PROOF: Special design required for each application.

Material Selection Guide

The following pages describe some characteristics of materials used in piping, fittings, and valves.

Material Designations & ASTM Standards for Listed Valve Metals

Aluminum	ASTM D-85 Die Cast	3% Ni-Iron	ASTM A-126-Class B Modified
Copper	ASTM B-75 Wrot & ASTM B-88	Ni-Plated	
Bronze	ASTM B-61 Cast	Ductile Iron	ASTM B-320 Plating
....	ASTM B-62 Cast	400 Series	
....	ASTM B-584, Alloy 844	Stainless Steel	ASTM B-582 Type 416 Wrot
Silicon Bronze	ASTM B-98 Alloy B	....	ASTM A-217-Grade CA-15
....	ASTM B-371 Wrot	....	ASTM A-276 Type 410 Wrot
Aluminum Bronze	ASTM B-148 Cast	316 Stainless	ASTM 276 Type 316
....	ASTM B-150 Rod	....	ASTM A-351-Grade CF-8M
Brass	ASTM B-16 Wrot	17-4 PH	
....	ASTM B-124 Forged	Stainless Steel	ASTM A-564 Type 630
Gray Iron	ASTM A-126 Class B	Alloy 20	ASTM A-351-Grade CN-7M
Ductile Iron	ASTM A-395 Heat Treated	....	ASTM B-473 20Cb-3
....	ASTM A-536 As Cast	Monel	ASTM B-164
Carbon Steel	ASTM A-216-Grade WCB Cast	....	ASTM B-494 Grade M-35-1
....	ASTM A-105 Forged	Stellite	AWS 5.13 Hard Face
....	ASTM A-352-Grade LCB Cast	Hastelloy C	ASTM B-574
		....	ASTM B-494 Grade CW-12 MW

METALS USED IN VALVES & FITTINGS

ALUMINUM — A non-ferrous metal, very lightweight, approximately one-third as much as steel. Aluminum exhibits excellent atmospheric corrosion resistance, but can be very reactive with other metals. In valves, aluminum is mainly used as an exterior trim component such as a handwheel or identification tag.

COPPER — Among the most important properties of wrot copper materials are their thermal and electrical conductivity, corrosion resistance, wear resistance, and ductility. Wrot copper performs well in high temperature applications and is easily joined by soldering or brazing. Wrot copper is exclusively used for fittings.

BRONZE — One of the first alloys developed in the bronze age is generally accepted as the industry standard for pressure rated bronze valves and fittings. Bronze has a higher strength than pure copper, is easily cast, has improved machinability, and is very easily joined by soldering or brazing. Bronze is very resistant to pitting corrosion, with general resistance to most chemicals less than that of pure copper.

SILICON BRONZE — Has the ductility of copper but much more strength. Silicon bronze corrosion resistance is equal to or greater than that of copper. Commonly used as stem material in pressure-rated valves, silicon bronze has greater resistance to stress corrosion cracking than common brasses.

ALUMINUM BRONZE — The most widely accepted disc material used in butterfly valves, aluminum bronze is heat treatable and has the strength of steel. Formation of an aluminum oxide layer on exposed surfaces makes this metal very corrosion resistant. Not recommended for high pH wet systems.

BRASS — Generally good corrosion resistance. Susceptible to de-zincification in specific applications; excellent machinability. Primary uses for wrot brass are for ball valve stems and balls, and iron valve stems. A forging grade of brass is used in ball valve bodies and end pieces.

GRAY IRON — An alloy of iron, carbon and silicon; easily cast; good pressure tightness in the as-cast condition. Gray iron has excellent dampening properties and is easily machined. It is standard material for bodies and bonnets of Class 125 and 250 iron body valves. Gray iron has corrosion resistance that is improved over steel in certain environments.

DUCTILE IRON — Has composition similar to gray iron. Special treatment modifies metallurgical structure which yields higher mechanical properties; some grades are heat treated to improve ductility. Ductile iron has the strength properties of steel using casting techniques similar to those of gray iron.

CARBON STEEL — Very good mechanical properties; good resistance to stress corrosion and sulfides. Carbon steel has high and low temperature strength; is very tough and has excellent fatigue strength. Mainly used in gate, globe and check valves for applications up to 850° F, and in one-, two-, and three-piece ball valves.

3% NICKEL IRON — Improved corrosion resistance over gray and ductile iron. Higher temperature corrosion resistance and mechanical properties. Very resistant to oxidizing atmospheres.

NICKEL PLATED DUCTILE IRON — Nickel coatings have received wide acceptance for use in chemical processing. These coatings have very high tensile strength, 50 to 225 ksi. To some extent, the hardness of a material is indicative of its resistance to abrasion and wear characteristics. Nickel plating is widely specified as a disc coating for butterfly valves.

400 SERIES STAINLESS STEEL— An alloy of iron, carbon, and chromium. This stainless is normally magnetic due to its martensitic structure and iron content. 400 Series Stainless Steel is resistant to high temperature oxidation and has improved physical and mechanical properties over carbon steel. Most 400 Series Stainless Steels are heat-treatable. The most common applications in valves are for stem material in butterfly valves, backseat bushings, and wedges in cast steel valves.

316 STAINLESS STEEL — An alloy of iron, carbon, nickel and chromium. A non-magnetic Stainless Steel with more ductility than 400SS. Austinetic in structure, 316 Stainless Steel has very good corrosion resistance to a wide range of environments, is not susceptible to stress corrosion cracking and is not affected by heat treatment. Most common uses in valves are for stem, body, and ball materials.

17-4 PH STAINLESS STEEL® — Is a martenistic precipitation/ age hardening stainless steel offering high strength and hardness. 17-4 PH withstands corrosive attack better than any of the 400 series stainless steels and in most conditions its corrosion resistance closely approaches that of 300 series stainless steel. 17-4 PH is primarily used as a stem material for butterfly and ball valves.

ALLOY 20Cb-3® — This alloy has higher amounts of nickel and chromium than 300 series stainless steel and with the addition of columbium, this alloy retards stress corrosion cracking and has improved resistance to sulfuric acid. Alloy 20 finds wide use in all phases of chemical processing. Commonly used as interior trim on butterfly valves.

Material Selection Guide *(continued)*

The following pages describe some characteristics of materials used in piping, fittings, and valves.

Material Designations & ASTM Standards for Listed Valve Metals

MONEL® — Is a nickel-copper alloy used primarily as interior trim on butterfly and ball valves. One of the most specified materials for corrosion resistance to sea and salt water. Monel is also very resistant to strong caustic solutions.

STELLITE® — Cobalt based alloy, one of the best allpurpose hard facing alloys. Very resistant to heat, abrasion, corrosion, impact, galling, oxidation, thermal shock and erosion. Stellite takes a high polish and is used in steel valve seat rings. Normally applied with transfer plasma-arc, Stellite hardness is not affected by heat treatment.

HASTELLOY C® — A high nickel-chromium molybdenum alloy which has outstanding resistance to a wide variety of chemical process environments including strong oxidizers such as wet chlorine, chlorine gas, and ferric chloride. Hastelloy C is also resistant to nitric, hydrochloric, and sulfuric acids at moderate temperatures.

NOTES:
17-4 PH Stainless Steel is a registered trademark of Armco Steel Co.
Alloy 20Cb-3 is a registered trademark of Carpenter Technology.
Hastelloy C is a registered trademark of Cabot Corporation.
Monel is a registered trademark of International Nickel.
Stellite is a registered trademark of Cabot Corporation.

ENGAGEMENT CHART

SIZE	O.D.	STD THREAD	S.S. THREAD	PVC SCH 80/40 SOCKET
1/8	0.405	1/4	–	–
1/4	0.540	3/8	–	5/8
3/8	0.675	3/8	–	3/4
1/2	0.840	1/2	–	7/8
3/4	1.050	9/16	1/2	1
1	1.315	11/16	9/16	1-1/8
1-1/4	1.660	11/16	5/8	1-1/4
1-1/2	1.900	11/16	5/8	1-3/8 / 1-5/16
2	2.375	3/4	9/16	1-1/2 / 1-3/8
2-1/2	2.875	15/16	7/8	1-3/4 / 2
3	3.500	1	7/8	1-7/8 / 2
4	4.500	1-1/8	15/16	2-1/4 / 2
6	6.625	1-5/16	–	3-1/2
8	8.625	1-7/16	–	4-1/2

NUMBER AND SIZE OF BOLTS FOR FLANGED JOINTS

PRIMARY SERVICE PRESSURE RATING	150 POUNDS					300 POUNDS				
BOLTING	NUMBER OF BOLT HOLES	DIAMETER OF BOLT HOLES	LENGTH OF STUD BOLTS		LENGTH OF MACH. BOLTS	NUMBER OF BOLT HOLES	DIAMETER OF BOLT HOLES	LENGTH OF STUD BOLTS		LENGTH OF MACH. BOLTS
FLANGE FACING			1/16" RF	RTJ	1/16" RF			1/16" RF	RTJ	1/16" RF
1/2	4	1/2	2-1/4	–	1-3/4	4	1/2	2-1/2	3	2
3/4	4	1/2	2-1/4	–	2	4	5/8	2-3/4	3-1/4	2-1/2
1	4	1/2	2-1/2	3	2	4	5/8	3	3-1/2	2-1/2
1-1/4	4	1/2	2-1/2	3	2-1/4	4	5/8	3	3-1/2	2-3/4
1-1/2	4	1/2	2-3/4	3-1/4	2-1/4	4	3/4	3-1/2	4	3
2	4	5/8	3	3-1/2	2-3/4	8	5/8	3-1/4	4	3
2-1/2	4	5/8	3-1/4	3-3/4	3	8	3/4	3-3/4	4-1/2	3-1/4
3	4	5/8	3-1/2	4	3	8	3/4	4	4-3/4	3-1/2
3-1/2	8	5/8	3-1/2	4	3	8	3/4	4-1/4	5	3-3/4
4	8	5/8	3-1/2	4	3	8	3/4	4-1/4	5	3-3/4
5	8	3/4	3-3/4	4-1/4	3-1/4	8	3/4	4-1/2	5-1/4	4
6	8	3/4	3-3/4	4-1/4	3-1/4	12	3/4	4-3/4	5-1/2	4-1/4
8	8	3/4	4	4-1/2	3-1/2	12	7/8	5-1/4	6	4-3/4
10	12	7/8	4-1/2	5	3-3/4	16	1	6	6-3/4	5-1/4
12	12	7/8	4-1/2	5	4	16	1-1/8	6-1/2	7-1/4	5-3/4
14	12	1	5	5-1/2	4-1/4	20	1-1/8	6-3/4	7-1/2	6
16	16	1	5-1/4	5-3/4	4-1/2	20	1-1/4	7-1/4	8	6-1/2
18	16	1-1/8	5-3/4	6-1/4	4-3/4	24	1-1/4	7-1/2	8-1/4	6-3/4
20	20	1-1/8	6	6-1/2	5-1/4	24	1-1/4	8	8-3/4	7
24	20	1-1/4	6-3/4	7-1/4	5-3/4	24	1-1/2	9	10	7-3/4

Material Selection Guide *(continued)*

The following pages describe some characteristics of materials used in piping, fittings, and valves.

THERMOPLASTIC & ELASTOMER MATERIALS

Thermoplastics are not recommended for compressed air or gas service.

ABS — (Acrylonitrile-Butadiene-Styrene) Class 4-2-2 conforming to ASTM D1788 is a time-proven material. The smooth inner surface and superior resistance to deposit formation makes ABS drain, waste, and vent material ideal for residential and commercial sanitary systems. The residential DWV system can be exposed in service to a wide temperature span. ABS-DWV has proven satisfactory for use from -40° to 180°F. These temperature variations can occur due to ambient temperature or the discharge of hot liquids into the system. ABS-DWV is very resistant to a wide variety of materials ranging from sewage to commercial household chemical formulations. ABS-DWV is joined by solvent cementing or threading and can easily be connected to steel, copper, or cast iron through the use of transition fittings.

CPVC — (Chlorinated Polyvinyl Chloride) Class 23447- B, formerly designated Type IV, Grade 1 conforming to ASTM D-1784 has physical properties at 73°F similar to those of PVC, and its chemical resistance is similar to or generally better than that of PVC. CPVC, with a design stress of 2000 psi and maximum service temperature of 210°F, has proven to be an excellent material for hot corrosive liquids, hot and cold water distribution, and similar applications above the temperature range of PVC. CPVC is joined by solvent cementing, threading or flanging.

P.P. (Polypropylene) — (PP) Type 1 Polypropylene is a polyolefin which is lightweight and generally high inchemical resistance. Although Type 1 polypropylene conforming to ASTM D-2146 is slightly lower in physical properties compared to PVC, it is chemically resistant to organic solvents as well as acids and alkalis. Generally, polypropylene should not be used in contact with strong oxidizing acids, chlorinated hydrocarbons, and aromatics. With a design stress of 1000 psi at 73°F, polypropylene has gained wide acceptance where its resistance to sulfur-bearing compounds is particularly useful in salt water disposal lines, crude oil piping, and low-pressure gas-gathering systems. Polypropylene has also proven to be an excellent material for laboratory and industrial drainage where mixtures of acids, bases, and solvents are involved. Polypropylene is joined by the thermo-seal fusion process, threading or flanging. At 180°F, or when threaded, P.P. should be used for drainage only at a pressure not exceeding 20 psi.

PVC — (Polyvinyl Chloride) Class 12454-B, formerly designated Type 1, Grade 1. PVC is the most frequently specified of all thermoplastic materials. It has been used successfully for over 30 years in such areas as chemical processing, industrial plating, chilled water distribution, deionized water lines, chemical drainage, and irrigation systems. PVC is characterized by high physical properties and resistance to corrosion and chemical attack by acids, alkalis, salt solutions, and many other chemicals. It is attacked, however, by polar solvents such as ketones, some chlorinated hydrocarbons and aromatics. The maximum service temperature of PVC is 140°F. With a design stress of 2000 psi, PVC has the highest long-term hydrostatic strength at 73°F of any of the major thermoplastics being used for piping systems. PVC is joined by solvent cementing, threading, or flanging.

PVDF — (SYGEF®) (KYNAR®) (Polyvinylidene Fluoride) is a strong, tough and abrasion-resistant fluorocarbon material. It resists distortion and retains most of its strength to 280°F. It is chemically resistant to most acids, bases and organic solvents and is ideally suited for handling wet or dry chlorine, bromine and other halogens. No other solid thermoplastic piping components can approach the combination of strength, chemical resistance and working temperatures of PVDF. PVDF is joined by the thermo-seal fusion process, threading or flanging.

EPDM — **EPDM** is a terpolymer elastomer made from ethylene-propylene diene monomer. EPDM has good abrasion and tear resistance and offers excellent chemical resistance to a variety of acids and alkalines. It is susceptible to attack by oils and is not recommended for applications involving petroleum oils, strong acids, or strong alkalines. It has exceptionally good weather aging and ozone resistance. It is fairly good with ketones and alcohols and has an excellent temperature range from -20°F to 250°F.

HYPALON® (CSM) — Hypalon has very good resistance to oxidation, ozone, and good flame resistance. It is similar to neoprene except with improved acid resistance where it will resist such oxidizing acids as nitric, hydrofluoric, and sulfuric acid. Abrasion resistance of Hypalon is excellent, about the equivalent of the nitriles. Oil and solvent resistance is somewhat between that of neoprene and nitride. Salts have little if any effect on Hypalon. Hypalon is not recommended for exposure to concentrated oxidizing acids, esters, ketones, chlorinated, aromatic and nitro hydrocarbons. Hypalon has a normal temperature range of -20°F to 160°F.

NEOPRENE (CR) — Neoprenes were one of the first synthetic rubbers developed. Neoprene is an all-purpose polymer with many desirable characteristics and features high resiliency with low compression set, flame resistance, and is animal and vegetable oil resistant. Neoprene is principally recommended for food and beverage service. Generally, neoprene is not affected by moderate chemicals, fats, greases, and many oils and solvents. Neoprene is attacked by strong oxidizing acids, most chlorinated solvents, esters, ketones, aromatic hydrocarbons, and hydraulic fluids. Neoprene has a moderate temperature range of -20°F to 160°F.

NITRILE (NBR) — **(BUNA-N)** is a general-purpose oil-resistant polymer known as nitrile rubber. Nitrile is a copolymer of butadiene and acrylonitrile and has a moderate temperature range of -20°F to 180°F. Nitrile has good solvent, oil, water, and hydraulic fluid resistance. It displays good compression set, abrasion resistance and tensile strength. Nitrile should not be used in highly polar solvents such as acetone and methyl ethyl ketone, nor should it be used in chlorinated hydrocarbons, ozone or nitro hydrocarbons.

FLUOROCARBON (FKM) (Viton®) (Fluorel®) — Fluorocarbon elastomers are inherently compatible with a broad spectrum of chemicals. Because of this extensive chemical compatibility, which spans considerable concentrations and temperature ranges, fluorocarbon elastomers have gained wide acceptance as a material of construction for butterfly valve o-rings and seats. Fluorocarbon elastomers can be used in most applications involving mineral acids, salt solutions, chlorinated hydrocarbons, and petroleum oils. They are particularly good in hydrocarbon service. Fluorocarbon elastomers have one of the broadest temperature ranges of any of the elastomers, -20°F to 300°F, however, are not suitable for steam service.

TEFLON® (PTFE) — Polytetrafluoroethylene has outstanding resistance to chemical attack by most chemicals and solvents. PTFE has a temperature rating of -20°F to 400°F in valve applications. PTFE, a selflubricating compound, is used as a seat material in ball valves.

NOTES:

Fluorel is a registered trademark of the 3M Company.
Hypalon is a registered trademark of the DuPont Company.
Kynar is a registered trademark of the Pennwalt Company.
Teflon is a registered trademark of the DuPont Company.
Viton is a registered trademark of the DuPont Company.

Material Selection Guide *(continued)*

The following pages describe some characteristics of materials used in piping, fittings, and valves.

WATER HAMMER EFFECTS & FORMULA

A formula, which closely predicts Water Hammer effects is:

$$p = v\left(\frac{SG - 1}{2}\, C + C\right)$$

p = maximum surge pressure, psi
v = fluid velocity in feet per second
(See Flow Capacity and Friction Loss for Sch. 40 & 80)
C = surge wave constant for water at 73°F
SG = specific gravity of liquid
*If SG is 1, then p = vC

EXAMPLE:
A 2” PVC schedule 80 pipe carries a fluid with a specific gravity of 1.2 at a rate of 30 gpm and at a line pressure of 160 psi. What would the surge pressure be if a valve were suddenly closed?

C = 24.2 (See:C-Surge Wave Constant Table)

$$p = (3.35)\left(\frac{1.2-1}{2}\right) 24.2 + 24.2)$$

$$p = (3.35)\,(26.6) = 90 \text{ psi}$$

Total line pressure = 90 + 160 = 250 psi

Schedule 80 2” PVC from the chart on Pressure Ratings: Pipe and Fittings has a pressure rating of 400 psi at room temperature. Therefore, 2” schedule 80 PVC pipe is acceptable for this application.

RECOMMENDATIONS TO HELP ELIMINATE WATER HAMMER EFFECTS:

The following suggestions will help in avoiding problems:

1. In a plastic piping system, a fluid velocity not exceeding 5 ft./sec. will minimize water hammer effects, even with quickly closing valves, such as solenoid valves.
2. Using actuated valves which have a specific closing time will eliminate the possibility of someone inadvertently slamming a valve open or closed too quickly. With pneumatic and air-spring actuators, it may be necessary to place a valve in the air line to slow down the valve operation cycle.
3. If possible, when starting a pump, partially close the valve in the discharge line to minimize the volume of liquid, which is rapidly accelerating through the system. Once the pump is up to speed and the line completely full, the valve may be opened.
4. A check valve installed near a pump in the discharge line will keep the line full and help prevent excessive water hammer during pump start-up. Ref.:“NIBCO Chemtrol Plastic Piping Handbook”, NIBCO Inc., Elkhart, IN

C-SURGE WAVE CONSTANT

PIPE SIZE	PVC SCH 40	PVC SCH 80	CPVC SCH 40	CPVC SCH 80	POLYPRO SCH 80	PVDF SCH 80
1/4"	31.3	34.7	33.2	37.3	–	–
3/8"	29.3	32.7	31.0	34.7	–	–
1/2"	28.7	31.7	30.3	33.7	25.9	28.3
3/4"	26.3	29.8	27.8	31.6	23.1	25.2
1"	25.7	29.2	27.0	30.7	21.7	24.0
1-1/4"	23.2	27.0	24.5	28.6	19.8	–
1-1/2"	22.0	25.8	23.2	27.3	18.8	20.6
2"	20.2	24.2	21.3	25.3	17.3	19.0
2-1/2"	21.1	24.7	22.2	26.0	–	–
3"	19.5	23.2	20.6	24.5	16.6	–
4"	17.8	21.8	18.8	22.9	15.4	–
6"	15.7	20.2	16.8	21.3	–	–
8"	14.8	18.8	15.8	19.8	–	–
10"	14.0	18.3	15.1	19.3	–	–
12"	13.7	18.0	14.7	19.2	–	–
14"	13.4	17.9	14.4	19.2	–	–

PRESSURE RATINGS: PIPE & FITTINGS
Maximum Operating Pressure (PSI) at 75°F

	SCHEDULE 40	SCHEDULE 80				
Nominal Pipe Size	CPVC/PVC Socket End	CPVC/PVC Socket End	CPVC/PVC Threaded End	Polypropylene Thermo-Seal Joint [2]	PVDF Thermo-Seal Joint	PVDF Threaded end
1/2	600	850	420	410	580	290
3/4	480	690	340	330	470	235
1	450	630	320	310	430	215
1-1/4	370	520	260	-	-	-
1-1/2	330	471	240	230	320	160
2	280	400	200	200	275	135
2-1/2	300	425	210 [3]	185	-	-
3	260	375	190 [3]	185	-	-
4	220	324	160 [3]	160	-	-
6	180	280	N.R.	N.R.	-	-
8	160	250	N.R.	-	-	-
1 0	140	230	N.R.	-	-	-
1 2	130	230	N.R.	-	-	-

[1] Based on water service. For more severe service, an additional correction factor may be required.
[2] Threaded Polypropylene is not recommended for pressure service.
[3] For threaded and backwelded joints.
N.R.= Not recommended.
Plastic pipe is not recommended for air or compressed gas service.

TEMPERATURE CORRECTION FACTORS

Operating Temp (°F)	FACTORS PVC	CPVC	PP	PVDF
7 0	1.00	1.00	1.00	1.00
8 0	0.90	0.96	0.97	0.95
9 0	0.75	0.92	0.91	0.87
100	0.62	0.85	0.85	0.80
110	0.50	0.77	0.80	0.75
115	0.45	0.74	0.77	0.71
120	0.40	0.70	0.75	0.68
125	0.35	0.66	0.71	0.66
130	0.30	0.55	0.68	0.62
140	0.22	0.52	0.65	0.56
150	N.R.	0.47	0.57	0.52
160	N.R.	0.40	0.50	0.49
170	N.R.	0.32	0.26	0.45
180	N.R.	0.25	N.R.	0.42
200	N.R.	0.18	N.R.	0.36
210	N.R.	0.15	N.R.	0.33
240	N.R.	N R.	N.R.	0.25

N.R.= Not recommended.
*Recommended for continuous drainage pressure only.

Material Selection Guide *(continued)*

FLOW CAPACITY AND FRICTION LOSS FOR SCHEDULE 40 THERMOPLASTIC PIPE PER 100 FEET

GALLONS Per Minute	1/2 in. VELOCITY Feet Per Second	1/2 in. FRICTION HEAD Feet	1/2 in. FRICTION LOSS Pounds Per Sq. Ft.	3/4 in VELOCITY Feet Per Second	3/4 in FRICTION HEAD Feet	3/4 in FRICTION LOSS Pounds Per Sq. Ft.	1 in VELOCITY Feet Per Second	1 in FRICTION HEAD Feet	1 in FRICTION LOSS Pounds Per Sq. Ft.	11/4 in VELOCITY Feet Per Second	11/4 in FRICTION HEAD Feet	11/4 in FRICTION LOSS Pounds Per Sq. Ft.	11/2 in VELOCITY Feet Per Second	11/2 in FRICTION HEAD Feet	11/2 in FRICTION LOSS Pounds Per Sq. Ft.	2 in VELOCITY Feet Per Second	2 in FRICTION HEAD Feet	2 in FRICTION LOSS Pounds Per Sq. Ft.	21/2 in VELOCITY Feet Per Second	21/2 in FRICTION HEAD Feet	21/2 in FRICTION LOSS Pounds Per Sq. Ft.	3 in VELOCITY Feet Per Second	3 in FRICTION HEAD Feet	3 in FRICTION LOSS Pounds Per Sq. Ft
1	1.13	2.08	0.90	0.63	0.51	0.22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	2.26	4.16	1.80	1.26	1.02	0.44	0.77	0.55	0.24	0.44	0.14	0.06	0.33	0.07	0.03	-	-	-	-	-	-	-	-	-
5	5.64	23.44	10.15	3.16	5.73	2.48	1.93	1.72	0.75	1.11	0.44	0.19	0.81	0.22	0.09	0.49	0.066	0.029	0.30	0.038	0.016	0.22	0.015	0.007
7	7.90	43.06	18.64	4.43	10.52	4.56	2.72	3.17	1.37	1.55	0.81	0.35	1.13	0.38	0.17	0.69	0.11	0.048	0.49	0.051	0.023	0.31	0.021	0.009
10	11.28	82.02	35.51	6.32	20.04	8.68	3.86	6.02	2.61	2.21	1.55	0.67	1.62	0.72	0.31	0.98	0.21	0.091	0.68	0.09	0.039	0.44	0.03	0.013
15	-	**4 in**	-	9.48	42.46	18.39	5.79	12.77	5.53	3.31	3.28	1.42	2.42	1.53	0.66	1.46	0.45	0.19	1.03	0.19	0.082	0.66	0.07	0.030
20	0.51	0.03	0.013	12.65	72.34	31.32	7.72	21.75	9.42	4.42	5.59	2.42	3.23	2.61	1.13	1.95	0.76	0.33	1.37	0.32	0.14	0.88	0.11	0.048
25	0.64	0.04	0.017	-	-	-	9.65	32.88	14.22	5.52	8.45	3.66	4.04	3.95	1.71	2.44	1.15	0.50	1.71	0.49	0.21	1.10	0.17	0.074
30	0.77	0.06	0.026	-	-	-	11.58	46.08	19.95	6.63	11.85	5.13	4.85	5.53	2.39	2.93	1.62	0.70	2.05	0.68	0.29	1.33	0.23	0.10
35	0.89	0.08	0.035	-	-	-	-	-	-	7.73	15.76	6.82	5.66	7.36	3.19	3.41	2.15	0.93	2.39	0.91	0.39	1.55	0.31	0.13
40	1.02	0.11	0.048	-	-	-	-	-	-	8.84	20.18	8.74	6.47	9.43	4.08	3.90	2.75	1.19	2.73	1.16	0.50	1.77	0.40	0.17
45	1.15	0.13	0.056	-	-	-	-	**6 in**	-	9.94	25.10	10.87	7.27	11.73	5.08	4.39	3.43	1.49	3.08	1.44	0.62	1.99	0.50	0.22
50	1.28	0.16	0.069	-	-	-	0.56	0.07	0.009	11.05	30.51	13.21	8.08	14.25	6.17	4.88	4.16	1.80	3.42	1.75	0.76	2.21	0.60	0.26
60	1.53	0.22	0.095	-	-	-	0.67	0.03	0.013	-	-	-	9.70	19.98	8.65	5.85	5.84	2.53	4.10	2.46	1.07	2.65	0.85	0.37
70	1.79	0.30	0.13	-	-	-	0.79	0.04	0.017	-	-	-	-	-	-	6.83	7.76	3.36	4.79	3.27	1.42	3.09	1.13	0.49
75	1.92	0.34	0.15	-	-	-	0.84	0.05	0.022	-	-	-	-	-	-	7.32	8.82	3.82	5.13	3.71	1.51	3.31	1.28	0.55
80	2.05	0.38	0.16	-	-	-	0.90	0.05	0.022	-	**8 in**	-	-	-	-	7.80	9.94	4.30	5.47	4.19	1.81	3.53	1.44	0.62
90	2.30	0.47	0.20	-	-	-	1.01	0.06	0.026	-	-	-	-	-	-	8.78	12.37	5.36	6.15	5.21	2.26	3.98	1.80	0.78
100	2.56	0.58	0.25	-	-	-	1.12	0.08	0.035	0.65	0.03	0.012	-	-	-	9.75	15.03	6.51	6.84	6.33	2.74	4.42	2.18	0.94
125	3.20	0.88	0.38	-	-	-	1.41	0.17	0.052	0.81	0.035	0.015	-	**10 in**	-	-	-	-	8.55	9.58	4.15	5.52	3.31	1.43
150	3.84	1.22	0.53	-	-	-	1.69	0.16	0.069	0.97	0.04	0.017	-	-	-	-	-	-	10.26	13.41	5.81	6.63	4.63	2.00
175	4.48	1.63	0.71	-	-	-	1.97	0.22	0.096	1.14	0.055	0.024	-	-	-	-	-	-	-	-	-	7.73	6.16	2.67
200	5.11	2.08	0.90	-	-	-	2.25	0.28	0.12	1.30	0.07	0.030	0.82	0.027	0.012	-	**12 in**	-	-	-	-	8.63	7.88	3.41
250	6.40	3.15	1.36	-	-	-	2.81	0.43	0.19	1.63	0.11	0.048	1.03	0.035	0.015	-	-	-	-	-	-	11.04	11.93	5.17
300	7.67	4.41	1.91	-	-	-	3.37	0.60	0.26	1.94	0.16	0.069	1.23	0.05	0.022	-	-	-	-	-	-	-	-	-
350	8.95	5.87	2.55	-	-	-	3.94	0.79	0.34	2.27	0.21	0.091	1.44	0.065	0.028	1.01	0.027	0.012	-	-	-	-	-	-
400	10.23	7.52	3.26	-	-	-	4.49	1.01	0.44	2.59	0.27	0.12	1.64	0.09	0.039	1.16	0.04	0.017	-	-	-	-	-	-
450	-	-	-	-	-	-	5.06	1.26	0.55	2.92	0.33	0.14	1.85	0.11	0.048	1.30	0.05	0.022	-	-	-	-	-	-
500	-	-	-	-	-	-	5.62	1.53	0.56	3.24	0.40	0.17	2.05	0.13	0.056	1.45	0.06	0.026	-	-	-	-	-	-
750	-	-	-	-	-	-	8.43	3.25	1.41	4.86	0.85	0.37	3.08	0.28	0.12	2.17	0.12	0.052	-	-	-	-	-	-
1000	-	-	-	-	-	-	11.24	5.54	2.40	6.48	1.45	0.63	4.11	0.48	0.21	2.89	0.20	0.087	-	-	-	-	-	-
1250	-	-	-	-	-	-	-	-	-	8.11	2.20	0.95	5.14	0.73	0.32	3.62	0.31	0.13	-	-	-	-	-	-
1500	-	-	-	-	-	-	-	-	-	9.72	3.07	1.33	6.16	1.01	0.44	4.34	0.43	0.19	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-	-	-	8.21	1.72	0.74	5.78	0.73	0.32	-	-	-	-	-	-
2500	-	-	-	-	-	-	-	-	-	-	-	-	10.27	2.61	1.13	7.23	1.11	0.49	-	-	-	-	-	-
3000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.68	1.55	0.67	-	-	-	-	-	-
3500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10.12	2.07	0.90	-	-	-	-	-	-
4000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.07	2.66	1.15	-	-	-	-	-	-

Material Selection Guide *(continued)*

FLOW CAPACITY AND FRICTION LOSS FOR SCHEDULE 80 THERMOPLASTIC PIPE PER 100 FEET

GALLONS Per Minute	1/2 in. **VELOCITY** Feet Per Second	1/2 in. **FRICTION HEAD** Feet	1/2 in. **FRICTION LOSS** Pounds Per Sq. Ft.	3/4 in **VELOCITY** Feet Per Second	3/4 in **FRICTION HEAD** Feet	3/4 in **FRICTION LOSS** Pounds Per Sq. Ft.	1 in **VELOCITY** Feet Per Second	1 in **FRICTION HEAD** Feet	1 in **FRICTION LOSS** Pounds Per Sq. Ft.	11/4 in **VELOCITY** Feet Per Second	11/4 in **FRICTION HEAD** Feet	11/4 in **FRICTION LOSS** Pounds Per Sq. Ft.
1	1.48	4.02	1.74	0.74	0.86	0.37-	-	-	-	-	-	-
2	2.95	8.03	3.48	1.57	1.72	0.74	0.94	0.88	0.38	0.52	0.21	0.09
5	7.39	45.23	19.59	3.92	9.67	4.19	2.34	2.75	1.19	1.30	0.66	0.29
7	10.34	83.07	35.97	5.49	17.76	7.69	3028	5.04	2.19	1.82	1.21	0.53
10	-	-	-	7.84	33.64	14.65	4.68	9.61	4.16	2.60	2.30	1.00
15	-	**4 in**	-	11.75	71.70	31.05	7.01	20.36	8.82	3.90	4.87	2.11
20	0.57	0.04	0.017	-	-	-	9.35	34.68	15.02	5.20	8.30	3.59
25	0.72	0.06	0.025	-	-	-	11.69	52.43	22.70	6.50	12.55	5.43
30	0.86	0.08	0.035	-	-	-	14.03	73.48	31.82	7.80	17.59	7.62
35	1.00	0.11	0.048	-	-	-	-	-	-	9.10	23.40	10.13
40	1.15	0.14	0.061	-	-	-	-	-	-	10.40	29.97	12.98
45	1.29	0.17	0.074	-	-	-	-	**6 in**	-	11.70	37.27	16.14
50	1.43	0.21	0.091	-	-	-	0.63	0.03	0.013	13.00	45.30	19.61
60	1.72	0.30	0.13	-	-	-	0.75	0.04	0.017	-	-	-
70	2.01	0.39	0.17	-	-	-	0.88	0.05	0.022	-	-	-
75	2.15	0.45	0.19	-	-	-	0.94	0.06	0.026	-	-	-
80	2.29	0.50	0.22	-	-	-	1.00	0.07	0.030	-	-	-
90	2.58	0.63	0.27	-	-	-	1.13	0.08	0.035	-	**8 in**	-
100	2.87	0.76	0.33	-	-	-	1.25	0.10	0.043	-	-	-
125	3.59	1.16	0.50	-	-	-	1.57	0.16	0.068	0.90	0.045	0.019
150	4.30	1.61	0.70	-	-	-	1.88	0.22	0.095	1.07	0.05	0.022
175	5.02	2.15	0.93	-	-	-	2.20	0.29	0.12	1.25	0.075	0.033
200	5.73	2.75	1.19	-	-	-	2.51	0.37	0.16	1.43	0.09	0.039
250	7.16	4.16	1.81	-	-	-	3.14	0.56	0.24	1.79	0.14	0.61
300	8.80	5.83	2.52	-	-	-	3.76	0.78	0.34	2.14	0.20	0.087
350	10.03	7.76	3.36	-	-	-	4.39	1.04	0.45	2.50	0.27	0.12
400	11.47	9.93	4.30	-	-	-	5.02	1.33	0.58	2.86	0.34	0.15
450	-	-	-	-	-	-	5.64	1.65	0.71	3.21	0.42	0.18
500	-	-	-	-	-	-	6.27	2.00	0.87	3.57	0.51	0.22
750	-	-	-	-	-	-	9.40	4.25	1.84	5.36	1.08	0.47
1000	-	-	-	-	-	-	12.54	7.23	3.13	7.14	1.84	0.80
1250	-	-	-	-	-	-	-	-	-	8.93	2.78	1.20
1500	-	-	-	-	-	-	-	-	-	10.71	3.89	1.68
2000	-	-	-	-	-	-	-	-	-	-	-	-
2500	-	-	-	-	-	-	-	-	-	-	-	-
3000	-	-	-	-	-	-	-	-	-	-	-	-
3500	-	-	-	-	-	-	-	-	-	-	-	-
4000	-	-	-	-	-	-	-	-	-	-	-	-

GALLONS Per Minute	11/2 in **VELOCITY** Feet Per Second	11/2 in **FRICTION HEAD** Feet	11/2 in **FRICTION LOSS** Pounds Per Sq. Ft.	2 in **VELOCITY** Feet Per Second.	2 in **FRICTION HEAD** Feet	2 in **FRICTION LOSS** Pounds Per Sq. Ft.	21/2 in **VELOCITY** Feet Per Second	21/2 in **FRICTION HEAD** Feet	21/2 in **FRICTION LOSS** Pounds Per Sq. Ft.	3 in **VELOCITY** Feet Per Second	3 in **FRICTION HEAD** Feet	3 in **FRICTION LOSS** Pounds Per Sq. Ft.
1	-	-	-	-	-	-	-	-	-	-	-	
2	0.38	0.10	0.041	-	-	-	-	-	-	-	-	-
5	0.94	0.30	0.126	0.56	0.10	0.040	0.39	0.05	0.022	0.25	0.02	0.009
7	1.32	0.55	0.24	0.78	0.15	0.065	0.54	0.07	0.032	0.35	0.028	0.012
10	1.88	1.04	0.45	1.12	0.29	0.130	0.78	0.12	0.052	0.50	0.04	0.017
15	2.81	2.70	0.95	1.68	0.62	0.27	1.17	0.26	0.11	0.75	0.09	0.039
20	3.75	3.75	1.62	2.23	1.06	0.46	1.56	0.44	0.19	1.00	0.15	0.065
25	4.69	5.67	2.46	2.79	1.60	0.69	1.95	0.67	0.29	1.25	0.22	0.095
30	5.63	7.95	3.44	3.35	2.25	0.97	2.34	0.94	0.41	1.49	0.31	0.13
35	6.57	10.58	4.58	3.91	2.99	1.29	2.73	1.25	0.54	1.74	0.42	0.18
40	7.50	13.55	5.87	4.47	3.83	1.66	3.12	1.6	0.69	1.99	0.54	0.23
45	8.44	16.85	7.30	5.03	4.76	2.07	3.51	1.99	0.86	2.24	0.67	0.29
50	9.38	20.48	8.87	5.58	5.79	2.51	3.90	2.42	1.05	2.49	0.81	0.35
60	11.26	28.70	12.43	6.70	8.12	3.52	4.68	3.39	1.47	2.99	1.14	0.49
70	-	-	-	7.82	10.80	4.68	5.46	4.51	1.95	3.49	1.51	0.65
75	-	-	-	8.38	12.27	5.31	5.85	5.12	2.72	2.74	1.72	0.74
80	-	-	-	8.93	13.83	5.99	6.24	5.77	2.50	3.99	1.94	0.84
90	-	-	-	10.05	17.20	7.45	7.02	7.16	3.11	4.48	2.41	1.04
100	-	-	-	11.17	20.90	9.05	7.80	8.72	3.78	4.98	2.03	1.27
125	-	**10 in**	-	-	-	-	9.75	13.21	5.72	6.23	4.43	1.92
150	-	-	-	-	-	-	11.70	18.48	8.00	7.47	6.20	2.68
175	-	-	-	-	-	-	-	-	-	8.72	8.26	3.58
200	0.09	0.036	0.015	-	-	-	-	-	-	9.97	10.57	4.58
250	1.14	0.045	0.02	-	**12 in**	-	-	-	-	12.46	16.00	6.93
300	1.36	0.07	0.03	-	-	-	-	-	-	-	-	-
350	1.59	0.085	0.037	1.12	0.037	0.016	-	-	-	-	-	-
400	1.81	0.11	0.048	1.28	0.05	0.022	-	-	-	-	-	-
450	2.04	0.14	0.061	1.44	0.06	0.026	-	-	-	-	-	-
500	2.27	0.17	0.074	1.60	0.07	0.030	-	-	-	-	-	-
750	3.40	0.36	0.16	2.40	0.15	0.065	-	-	-	-	-	-
1000	4.54	0.61	0.26	3.20	0.26	0.110	-	-	-	-	-	-
1250	5.67	0.92	0.40	4.01	0.4	0.17	-	-	-	-	-	-
1500	6.80	1.29	0.56	4.81	0.55	0.24	-	-	-	-	-	-
2000	9.07	2.19	0.95	6.41	0.94	0.41	-	-	-	-	-	-
2500	11.34	3.33	1.44	8.01	1.42	0.62	-	-	-	-	-	-
3000	-	-	-	9.61	1.99	0.86	-	-	-	-	-	-
3500	-	-	-	11.21	2.65	1.15	-	-	-	-	-	-
4000	-	-	-	12.82	3.41	1.48	-	-	-	-	-	-

Material Selection Guide *(continued)*

The following pages describe some characteristics of materials used in piping, fittings, and valves.

PVC Recommended Pipe Support Spacing (in feet)

PIPE SIZE	SCHEDULE 40 20ft	40ft	60ft	80ft	100ft	120ft	140ft	160ft	PIPE SIZE	SCHEDULE 80 20ft	40ft	60ft	80ft	100ft	120ft	140ft	160ft
1/4	5-1/2	5	5	4-1/2	4-1/2	3-1/2	3	1-1/2	1/4	6	5	5-1/2	5-1/2	5	4	3	2
3/8	5-1/2	5	5	4-1/2	4-1/2	3-1/2	3	1-1/2	3/8	6-1/2	6-1/2	6	5-1/2	5-1/2	4-1/2	3-1/2	2
1/2	6	5-1/2	5-1/2	5	4-1/2	4	3	1-1/2	1/2	7	6-1/2	6	6	5-1/2	4-1/2	3-1/2	2
3/4	6	5-1/2	5-1/2	5	4-1/2	4	3	1-1/2	3/4	7	7	6-1/2	6	5-1/2	5	3-1/2	2
1	6-1/2	6-1/2	6	5-1/2	5-1/2	4-1/2	3-1/2	2	1	7-1/2	7	7	6-1/2	6	5	4	2
1-1/4	6-1/2	6-1/2	6	5-1/2	5-1/2	3-1/2	2	2	1-1/4	8	7-1/2	7	6-1/2	6-1/2	5-1/2	4	2-1/2
1-1/2	7	6-1/2	6	6	5-1/2	4-1/2	3-1/2	2	1-1/2	8	7-1/2	7-1/2	7	6-1/2	5-1/2	4	2-1/2
2	7	7	6-1/2	6	5-1/2	5	3-1/2	2	2	8	8	7-1/2	7	6-1/2	5-1/2	4-1/2	2-1/2
2-1/2	8	7-1/2	7-1/2	7	6-1/2	5-1/2	4	2-1/2	2-1/2	9-1/2	9	8-1/2	8	7-1/2	6-1/2	5	3
3	8	8	7-1/2	7	6-1/2	5-1/2	4-1/2	2-1/2	3	10	9-1/2	9	8-1/2	8	6-1/2	5	3
4	9	8-1/2	8	7-1/2	7	6	4-1/2	2-1/2	4	10-1/2	10	9-1/2	9	8-1/2	7	5-1/2	3
5	9	8-1/2	8-1/2	8	7-1/2	6	4-1/2	2-1/2	5	11	10-1/2	10	9	8-1/2	7	5-172	3
6	9-1/2	9	8-1/2	8	7-1/2	6-1/2	5	3	6	12-1/2	11-1/2	10	9-1/2	8	7	5-1/2	3
8	0-1/2	1 0	9-1/2	9	8-1/2	7	5-1/2	3	8	12-1/2	12-1/2	11	10	8-1/2	6-1/2	6-1/2	4
10	11	10-1/2	10	9	8-1/2	7	5-1/2	3	10	14	13-1/2	12-1/2	12	11	9-1/2	7	4
12	1-1/2	11	0-1/2	10	9	8	6	3-1/2	12	15	14-1/2	13-1/2	13	12	10	8	4-1/2

Notes:
The necessary support spacing indicated in the above table assumes:
- Uniform placement of supports
- No Concentrated loads

Maximum fluid weight of 85 lb/cu ft (1.35 gravity).
Axial movement should be permitted by not fastening support clamps too tightly. Suppor t spacing may be doubled for ver tical runs. Valves and heavy fittings should be individually suppor ted. Examine the economies of continuous support at higher tempera- tures. Standard pipe support, free of burrs or sharp edges, may be used.

SOLVENT CEMENTING for Schedule 80 PVC Pipe & Fittings

CARE AND CAUTION:

Cements and primer are flammable, care should be taken to avoid sparks, heat or open flame in both work and storage areas. Contact with eyes and skin should be avoided. Proper ventilation is mandatory.
Temperature extremes adversely affect solvent cementing. Do not cement with temperatures above 110°F or below 40°F.

Appropriate cement and primer, cutting and deburring tools, daubers (applicators) with minimum surface of one-half the pipe diameter, and pipe joiners for large-diameter pipe and fittings are available. Supplement tools with natural fiber rags, gloves resistant to cement and primer, and natural fiber brushes for larger-diameter pipe and fittings.

CURE TIME for 3875 & 3675 cements for PVC Schedule 80 Pipe & Fitting Joints

Temp Range During Cur	Test Pressure 1/2 to 1-1/4" pipe: Up to 180 psi	Up to 370 psi	Test Pressure 1-1/2 to 3" pipe: Up to 180 psi	Up to 370 psi	Test Pressure 3-1/2 to 8" pipe: Up to 180 psi	Up to 370 psi
60-100°F	1hr	6 hr	2 hr	12hr	6 hr	24 hr
40-60°F	2hr	12hr	4hr	24hr	12hr	48hr
20-40°F	8hr	48hr	18 hr	96hr	24hr	8days

CEMENT USAGE FOR PVC and CPVC

Allowing two joints for each coupling, three joints for each tee, etc.

Joints / in*	1/4	3/8	1/2	3/4	1	1-1/4	1-1/2	2
PINT	150	150	130	80	70	50	35	20
QUART	300	300	260	160	140	100	70	40
GALLON	1200	1200	1040	640	560	400	280	160

*Each joint represents one socket in a fitting.

Joints / in*	2-1/2	3	4	5	6	8	10	12
PINT	17	15	10	8	-	-	-	-
QUART	34	30	20	16	8	3	-	-
GALLON	136	120	80	64	32	12	10	6

*Each joint represents one socket in a fitting.

PROCEDURE:

1. Inspect pipe for a square, deburred cut and a 10°-15° beveled end. With a dry, clean rag, remove all foreign matter from the pipe and fitting surface to be welded.Check the dry fit for 1/4-3/4 of the socket.
2. Dissolve the inside socket of the fitting with appropriate primer by repeated strokes of a well- wetted applicator.
3. Dissolve the surface area of pipe in a similar manner.
4. Apply a second application of primer to the inside socket of the fitting; then immediately apply a generous amount of cement to the outside of the pipe. Cement applications to both pipe and fitting should be made while the primer is still wet.
5. Apply cement to the inside of the fitting. Here caution should be taken on the amount applied, since any excess will puddle inside the system and may cause a weakness. Immediately apply a second application of cement to the pipe, and while both surfaces are still liquid, bottom the pipe into the fitting, rotating the pipe 90°, if possible, and hold until the pipe will not "push out," normally less than 30 seconds.
6. Wipe any excess cement from the pipe and observe the set time and cure time charts below. Never test the system with air pressure. PVC and CPVC systems are not recommended for gaseous systems under pressure.

SET TIME FOR 3875 & 3675 CEMENTS FOR PVC SCHEDULE 80 PIPE & FITTING JOINTS
30 minutes minimum .... at 60-100°F
60 minutes minimum ...... at 40-60°F
2 hours minimum .... at 20-40°F
4 hours minimum .... at 0-20°F

Chemical Resistance Guide

The following tables show degree of resistance of certain materials to (a list of) various chemicals.

PIPE, FITTING, VALVES, etc.	PVC	GFPPL	POLY	SAN	TEFLON	316SS	EPDM	CERAMIC	HYPALON	VITON
ACETALDEHYDE	E	C	X	E	A	A	A	A	E	A
ACETIC ACID, 20%	B	A	A	A	A	A	A	A	A	E
ACETIC ACID, 80%	E	C	B	E	A	A	B	A	B	E
ACETIC ACID, GLACIAL	E	C	B	E	A	A	B	A	E	E
ACETIC ANHYDRIDE	E	A	X	E	A	D	B	A	A	E
ACETONE	E	B	D	E	A	A	A	A	D	E
ALUMINUM CHLORIDE	A	A	A	A	A	D	A	A	A	A
ALUMINUM FLUORIDE	A	A	X	A	A	C	A	X	A	A
ALUMINUM SULFATE	A	A	A	A	A	D	A	A	A	A
AMMONIA, 10%	A	A	B	A	A	A	B	A	A	A
AMMONIUM CHLORIDE	A	A	A	A	A	D	A	A	A	A
AMMONIUM NITRATE	A	A	X	A	A	A	A	A	A	A
AMMONIUM PERSULFATE	A	A	X	A	A	C	A	A	A	A
AMMONIUM PHOSPHATE	A	A	X	A	A	A	A	A	A	A
AMMONIUM SULFATE	A	A	A	A	A	B	A	A	B	B
AMYLACETATE	E	E	E	E	A	A	A	A	E	E
AMYLALCOHOL	B	X	X	E	A	A	B	A	B	B
AMYLCHLORIDE	E	X	X	E	A	C	A	A	E	A
ANILINE	E	C	D	E	A	A	A	A	B	A
AGUA REGIA	E	X	D	E	A	E	D	A	B	A
ARSENIC ACID	A	A	X	A	A	X	A	A	X	A
BARIUM CHLORIDE	A	A	X	A	A	C	A	A	B	B
BARIUM SULFATE	A	A	X	A	A	B	A	A	A	A
BEER	A	A	B	A	A	A	A	A	A	A
BENZALDEHYDE	E	C	X	E	A	A	A	A	E	E
BENZENE (BENZOL)	E	C	E	E	A	A	E	A	E	D
BENZOIC ACID	A	A	A	C	A	B	X	A	E	A
BORAX (SODIUM BORATE)	A	A	D	X	A	A	A	A	B	B
BORIC ACID	A	A	A	A	A	A	A	A	B	B
BROMINE WATER	C	E	X	X	A	E	D	A	E	A
BUTYL ACETATE	E	E	X	X	A	B	C	A	E	E
BUTYRIC ACID	D	A	X	D	A	B	B	A	E	D
CALCIUM BISULFITE	A	A	A	X	A	B	E	A	A	A
CALCIUM CHLORIDE	A	A	A	A	A	C	A	A	A	A
CALCIUM HYPOCHLORITE	A	A	A	A	A	D	B	A	A	D
CALCIUM SULFATE	A	A	X	A	A	B	B	A	A	A
CARBON TETRACHLORIDE	C	C	E	X	A	B	X	A	E	A
CARBONIC ACID	A	A	X	A	A	B	X	A	B	B
CHLOROACETIC ACID	A	D	X	E	A	E	E	A	A	A
CHLORINE WATER	A	E	B	X	A	E	B	A	B	A
CHLOROBENZENE	E	C	X	E	A	A	E	A	E	A
CHLOROFORM	E	E	E	E	A	D	E	A	X	E
CHROMIC ACID, 10% OR 30%	A	A	A	A	A	B	E	A	A	A
CHROMIC ACID, 50%	E	A	B	D	A	C	E	A	A	A
CITRIC ACID	A	A	A	A	A	B	A	A	A	A
COPPER CHLORIDE	A	A	B	A	A	B	B	A	B	B
COPPER CYANIDE	A	A	X	A	A	A	B	A	X	B
COPPER NITRATE	A	A	X	A	A	A	B	A	B	B
COPPER SULFATE	A	A	A	A	A	B	B	A	B	B
CRESYLIC ACID	B	X	X	X	A	A	E	A	X	A
ETHYL ACETATE	E	C	X	E	A	B	D	A	E	E
ETHYL CHLORIDE	E	E	X	E	A	A	B	A	D	A
ETHYLENE GLYCOL	A	A	X	A	A	B	B	A	B	B
FATTY ACIDS	A	A	E	D	A	A	X	A	X	B
FERRIC CHLORIDE	A	A	A	A	A	E	A	A	B	B

PIPE, FITTING, VALVES, etc.	PVC	GFPPL	POLY	SAN	TEFLON	316SS	EPDM	CERAMIC	HYPALON	VITON
FERRIC NITRATE	A	A	E	A	A	B	A	A	B	B
FERRIC SULFATE	A	A	E	A	A	A	A	A	B	B
FERROUS CHLORIDE	A	A	A	A	A	E	B	A	B	B
FERROUS SULFATE	A	A	B	A	A	D	B	A	B	B
FLUOBORIC ACID	A	A	E	B	A	B	B	E	B	X
FLUOSILICIC ACID	A	A	A	B	A	B	X	E	X	B
FORMALDEHYDE, 40%	B	A	B	A	A	A	A	A	B	E
FORMIC ACID	C	A	B	E	A	B	B	A	B	E
FREON 12 (WET)	C	A	X	X	A	E	D	A	E	A
FUEL OILS	A	C	X	X	A	A	E	A	B	B
FURFURAL	E	E	X	X	A	B	D	A	X	E
GASOLINE	C	E	X	E	A	A	E	A	E	A
GLYCERINE (GLYCEROL)	A	A	X	A	A	A	A	A	B	B
HEPTANE	A	C	X	X	A	A	X	A	B	B
HEXANE	C	C	X	X	A	A	E	A	B	B
HYDROBROMIC ACID, 20%	A	A	B	X	A	E	B	C	A	A
HYDROCHLORIC ACID, 0-25%	A	A	B	A	A	E	C	C	A	B
HYDROCHLORIC ACID, 25-37%	A	A	B	B	A	E	C	C	A	A
HYDROCYANIC ACID	A	A	B	B	A	A	B	C	X	A
HYDROFLUORIC ACID, 10%	C	A	A	B	A	C	B	E	A	A
HYDROFLUORIC ACID, 30%	C	B	D	E	A	C	C	E	A	A
HYDROFLUORIC ACID, 60%	D	B	E	E	A	C	D	E	D	A
HYDROFLUOSILICIC ACID, 20%	A	A	A	D	A	B	A	E	X	B
HYDROGEN PEROXIDE, 30%	A	A	B	B	A	B	D	X	A	A
HYDROGEN PEROXIDE, 50%	C	X	B	X	A	B	E	X	A	A
HYDROGEN PEROXIDE, 90%	E	X	D	E	A	B	E	X	D	A
HYDROGEN SULFIDE, AQ SOL	C	A	X	B	A	B	A	X	B	B
IODINE (IN ALCOHOL), 10%	A	C	X	X	A	A	E	A	E	A
KETONES	E	E	X	E	A	A	X	A	E	E
LACQUER THINNERS	D	C	X	E	A	A	E	A	X	X
LACTIC ACID	B	A	A	E	A	B	A	A	B	B
LEAD ACETATE	A	A	X	A	A	A	A	A	E	A
LUBRICATING OIL	C	C	D	A	A	A	E	A	D	A
MAGNESIUM CHLORIDE	A	A	A	A	A	B	A	A	A	A
MAGNESIUM NITRATE	A	A	X	A	A	A	B	A	A	A
MAGNESIUM SULFATE	A	A	A	A	A	A	A	A	A	A
MALEIC ACID	A	A	X	E	A	B	E	A	A	A
METHYL ALCOHOL	C	A	E	E	A	A	B	A	B	D
METHYL CHLORIDE	E	E	X	E	A	A	D	A	E	A
METHYL ETHYL KETONE	E	C	X	E	A	A	B	A	E	E
METHYL ISOBUTYL KETONE	E	C	X	E	A	A	D	A	E	E
METHYLENE CHLORIDE	E	E	X	E	A	A	E	A	E	D
NAPTHA	B	C	X	E	A	A	E	A	E	A
NAPTHALENE	E	C	X	E	A	A	E	A	E	D
NICKEL CHLORIDE	A	A	A	A	A	B	A	A	B	B
NICKEL SULFATE	A	A	A	A	A	B	A	A	B	B
NITRIC ACID, 10%	A	A	A	C	A	C	D	A	A	A
NITRIC ACID, 20%	A	A	B	E	A	B	E	A	A	A
NITRIC ACID, 50%	A	C	C	E	A	C	E	A	D	A
NITRIC ACID, ANHYDROUS	E	E	E	E	A	B	X	A	E	B
NITRO BENZENE	E	C	X	E	A	B	E	A	E	A
OILS AND FATS	A	A	X	X	A	A	E	A	X	A
OLEIC ACID	A	C	E	E	A	B	D	A	D	D
OLEUM, 25%	E	X	E	E	A	X	X	A	E	A
OXALIC ACID	A	A	B	D	A	C	B	A	A	A

A - Excellent
B - Good
C - Good to 80°F
D - Moderate effect
(Use under limited conditions)
E - Not Recommended
F - Autocatalytic
X - Unknown

CODE:
PVC = Polyvinyl Chloride
SAN = Styrene Acrylonitrile
EPDM = Ethylene Propylene Dimonome
GFPPL = Glass-Filled Polypropylene

Chemical Resistance Guide *(continued)*

The following tables show degree of resistance of certain materials to (a list of) various chemicals.

PIPE, FITTING, VALVES, etc.

	PVC	GFPPL	POLY	SAN	TEFLON	316SS	EPDM	CERAMIC	HYPALON	VITON
PHENOL	C	B	C	A	A	B	D	A	E	A
PHOSPHORIC ACID, 0-50%	A	A	A	B	A	B	D	A	A	B
PHOSPHORIC ACID, 50-100%	B	B	B	D	A	B	E	A	A	B
POTASSIUM BICARBONATE	A	A	B	A	A	B	A	A	B	B
POTASSIUM BROMIDE	A	A	B	A	A	B	A	A	B	B
POTASSIUM CARBONATE	A	A	B	A	A	B	A	A	B	B
POTASSIUM CHLORATE	A	A	B	A	A	A	B	A	B	B
POTASSIUM CHLORIDE	A	A	A	A	A	D	A	A	B	B
POTASSIUM CYANIDE	A	A	X	A	A	A	B	A	B	B
POTASSIUM DICHROMATE	A	A	B	A	A	A	B	A	B	B
POTASSIUM HYDROXIDE	A	A	A	E	A	B	D	E	B	B
POTASSIUM NITRATE	A	A	A	A	A	B	B	A	B	B
POTASSIUM PERMANGANATE	A	A	A	A	A	B	B	A	B	B
POTASSIUM SULFATE	A	A	A	A	A	B	A	A	A	E
SODIUM BICARBONATE	A	A	A	A	A	B	A	A	B	B
SODIUM BISULFATE	A	A	A	A	A	A	A	A	B	B
SODIUM BISULFITE	A	A	A	A	A	B	A	A	B	B
SODIUM CARBONATE	A	A	A	A	A	B	B	A	B	B
SODIUM CHLORATE	A	A	A	A	A	B	B	A	B	B
SODIUM CHLORIDE	A	A	A	A	A	B	B	A	B	B
SODIUM CYANIDE	A	A	X	A	A	A	B	A	B	B
SODIUM HYDROXIDE, 20%	A	A	A	B	A	A	B	B	B	E
SODIUM HYDROXIDE, 50%	A	A	B	B	A	A	C	B	B	E
SODIUM HYPOCHLORITE	A	A	A	A	A	D	B	A	A	D
SODIUM NITRATE	A	A	A	A	A	A	A	A	B	B
SODIUM SILICATE	A	A	A	A	A	B	A	A	A	A
SODIUM SULFATE	A	A	A	A	A	A	A	A	B	B
SODIUM SULFIDE	A	A	A	A	A	B	B	A	B	B
STANNIC CHLORIDE	A	A	A	A	A	E	D	A	D	B
STEARIC ACID	A	C	E	E	A	A	D	A	D	A
STODDARDS SOLVENT	E	X	X	X	A	A	E	X	X	A
SULFURIC ACID, 0-10%	A	A	A	E	A	E	D	A	D	A
SULFURIC ACID, 10-75%	A	A	C	E	A	E	E	A	D	A
SULFURIC ACID, 75-95%	C	C	C	E	A	E	E	A	D	A
SULFURIC ACID, 95-100%	D	C	C	E	A	B	E	A	D	A
TANNIC ACID	A	A	B	X	A	B	B	A	B	B
TANNING LIQUORS	A	A	A	X	A	A	E	A	X	A
TARTARIC ACID	A	A	X	E	A	B	D	A	B	B
TETRAHYDROFURANE	E	C	X	E	A	A	D	A	X	X
TOLUENE (TOLUOL)	E	C	E	E	A	A	E	A	E	E
TRICHLOROETHYLENE	E	C	E	X	A	B	E	A	E	A
TRICRESYLPHOSPHATE	E	X	X	X	A	A	B	A	E	A
TURPENTINE	B	C	X	X	A	A	E	A	E	A
UREA	A	A	X	X	A	B	X	A	A	E
VINEGAR	A	A	A	A	A	A	A	A	B	B
WHITE LIQUOR (ACID)	A	X	X	E	A	A	X	A	X	A
XYLENE (XYLOL)	E	E	E	E	A	A	E	A	E	A
ZINC CHLORIDE	A	A	A	A	A	B	A	A	B	B
ZINC SULFATE	A	A	A	A	A	A	A	A	A	A

A - Excellent
B - Good
C - Good to 80°F
D - Moderate effect
(Use under limited conditions)
E - Not Recommended
F - Autocatalytic
X - Unknown

CODE:
PVC = Polyvinyl Chloride
SAN = Styrene Acrylonitrile
EPDM = Ethylene Propylene Dimonome
GFPPL = Glass-Filled Polypropylene

COATINGS: IMMERSION SERVICE (Room Temperature)

R - Recommended
L - Limited recommendation
N - Not recommended

Source : NACE TPC-2, Coatings and Linings for Immersion Service, Courtesy of National Association of Corrosion Engineers.

	ACIDS							WATER		ALKALIES				GASES			ORGANICS							MAX. F°	
	Sulfuric, 10%	Sulfuric, 80%	Hydrochloric, 10%	Hydrochloric, 35%	Nitric, 10%	Nitric, 50%	Acetic, 100%	Distilled	Salt Water	Sodium hydroxide, 10%	Sodium hydroxide, 70%	Ammonium hydroxide, 10%	Sodium carbonate, 5%	Chlorine	Ammonia	Hydrogen sulfide	Alcohols	Aliphatic hydrocarbons	Aromatic hydrocarbons	Ketones	Ethers	Esters	Chlorinated hydrocarbons	Dry conditions	Wet conditions
CHLORINATED RUBBER	R	R	R	R	R	N	N	R	R	R	R	R	R	R	N	R	L	L	N	N	N	N	N	160	140
VINYLIDENE CHLORIDE	R	L	R	R	R	L	N		R	L	N	N	R	L	N	R	R	R	L	N	N	N	L		150
URETHANES (Baked)	L	L	L	L	L	N	N	L	L	L	L	R	R	R	R	R	R	R	R	R	R	R	R		
URETHANES (Air Dried)	L	N	L	L	L	N	N	L	L	L	L	L	R	L	L	R	N	R	R	N	R	N	L		
VINYL ester	R	R	R	R	R		L	R	R	R	R	R	R	R	R	R	R	R	L	N	N	L	L	350	210
POLYVINYL chloracetates	R	N	R	L	R	N	N	R	R	R	L	R	R	L	L	L	R	R	N	N	N	N	L	160	150
POLYESTERS (unsaturated)	R	R	R	R	R	N	N	R	R	R	N	R		R	N		R	R	R	N		L	N		250
PHENOLIC baked	R	N	R	R	N	N	L	R	R	N	N	N		N	N	R	R	R	R	R	R	R	R	250-300	160-250
FURFURYL ALCOHOL	R	L	R	R	N	N	L	R	R	R	L	R		N	R	R	R	R	R	L	L	R	L	300	190
EPOXY ester	L	N	L	N	N	N	N	R	R	N	N	L		L	R		L	R	R	N	N	N	N	250	150
EPOXY amine cured	R	N	R	N	N	N	N	R	R	R	R	L		L	L	R	R	R	R	L	L	L	L	250	150
EPOXY phenolic baked	R	N	R	N	L	N	N	R	R	R	R	R	R	L	L	R	R	R	R	L	L	L	L	250	150
COAL TAR URETHANES	R	N	L				N	L	L	R	L	R		N	N		N	L	L	N		N	L	200	150
COAL TAR EPOXY	R		L				N	R	R	R		R		L	N	R	N	L	N	N		N	N	200	150
COAL TAR (cold applied)	N	N	N	N	N	N	N	R	R	L	N	L	R	N	L	R	L	L	N	N	N	N	N		120
COAL TAR (hot applied)	L	N	L	N	L	N	N	R	R	R	N	R	R	N	L	R	L	L	N	N	N	N	N		120
ASPHALT (unmodified)	R		R	R	N	N		R	R	R		R	R	R			R	N	N	N	N	N	N	150	

NOTE: This data is for coatings only. Thin coatings generally are not suitable for substrates such as carbon steel which are coroded significantly (e.g.>20 mils/yr) in the test environment

Feeder Chemicals Information

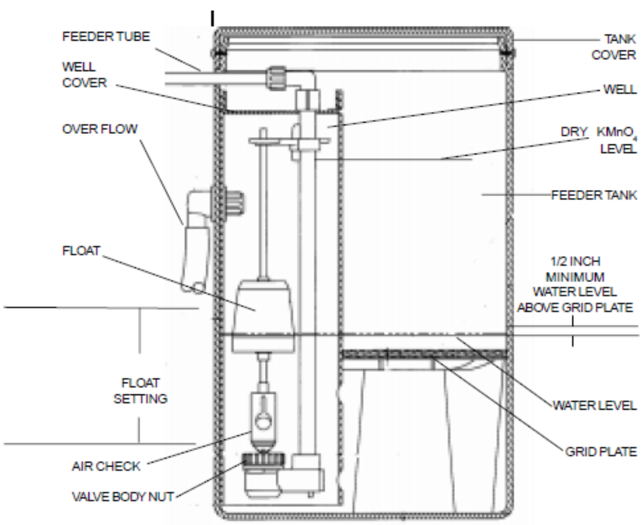
Because of varying conditions, information is to be used as a guideline only.

MANGANESE GREENSAND CONTINUOUS REGENERATION (CR)

The CR method of operation is recommended for well waters where iron removal is the main objective with or without the presence of manganese. This method involves the feeding of a predetermined amount of potassium permanganate ($KMnO_4$), usually in combination with chlorine (Cl_2), directly to the raw water prior to the unit containing manganese greensand. The chlorine should be fed upstream of the $KMnO_4$ with a contact time of 10 to 20 seconds, if possible, using sufficient chlorine to produce the desired residual in the filter effluent. A quantity of $KMnO_4$ should be fed to produce a “just pink” color in the filter inlet. This will maintain the manganese greensand in a continuously regenerated condition.

The concentration of Cl_2 and $KMnO_4$ to be fed may be estimated as follows:
mg/L Cl_2 = mg/L Fe
mg/L $KMnO_4$ = (0.2 x mg/L Fe) + (2 x mg/L Mn)

Without Cl_2 the $KMnO_4$ demand may be estimated by:
mg/L $KMnO_4$ = (1 x mg/L Fe) + (2 x mg/L Mn)



MANGANESE GREENSAND INTERMITTENT REGENERATION (IR)

The IR method of operation is recommended for well water where only manganese or manganese with small amounts of iron is to be removed. Briefly, it involves the regeneration of manganese greensand with a predetermined amount of $KMnO_4$ after a specified quantity of water has been treated. With this method, pressure drop is minimized as manganese is removed by contact oxidation on the grain of manganese greensand. This results in a larger manganese greensand grain size and eventual bed growth.

SUGGESTED OPERATING CONDITIONS

Backwash Rate: Sufficient rate to produce approximately 40% bed expansion.
Regeneration:
$KMnO_4$ Dosage .... 1.5-2.0 oz/cu. ft.
$KMnO_4$ Stock Solution Strength .... .2-4 oz/gallons
$KMnO_4$ Regeneration Volume .... 7.5 gal/cu. ft.*
$KMnO_4$ Regeneration Rate .... 0.25gpm/cu. ft.
$KMnO_4$ Regeneration Time .... 30 minutes optimum
Rinse Rate (Raw Water) .... 1 gpm/cu. ft.
Rinse Volume .... 40-50 gal/cu. ft. or until all traces of $KMnO_4$ are gone.
*Using 0.5-1.0 gallons of dilution water.

The run length between backwashes can be estimated as follows:
Example: What is the run length on a water containing 1.7 mg/L iron and 0.3 mg/L manganese at a 4gpm/sq. ft. operating rate?
$KMnO_4$ demand = (1 x mg/L Fe) + (2 x mg/L Mn)
= (1 x 1.7) + (2 x 0.3)
= 2.3 mg/L or 2.3/17.1 = 0.13 grains/gal (gpg)

At 700 grains/sq. ft. loading: 700/0.13gpg = 5385 gal/sq. ft.
At 4gpm/sq.ft. service rate: 5385/4 = 1350 min.
Therefore, the backwash frequency is approximately every 20 to 24 hours of operation.

FORMULA FOR SIZING FEED PUMPS

Use the formula below to size the feed pump for iron and hydrogen sulfide removal using chlorine bleach or potassium permanganate. Size the pump so that the maximum capacity of pump is double the required feeding.

Well Pump		Required				Solution		Required
FLOW RATE	**X**	**DOSAGE**	**X**	1440	**÷**	**STRENGTH**	**=**	**FEED RATE**
(gpm)		(ppm)				(ppm)		(gpd)

TYPICAL ($KMnO_4$) FEEDER FLOAT SETTINGS AND DOSAGE INFORMATION

WARNING: Potassium Permanganate is a very strong oxidizing agent used in water and waste water treatment **(avoid contact with eyes, mucus membrane and skin)**. It converts dissolved iron and/or manganese to corresponding insoluble oxides, which are removed during filter system operation. Also see further description and recommended float settings below.

TYPICAL ($KMnO_4$) FEEDER FLOAT SETTINGS & DOSAGE
(Required on Greensand Filter)

OZ. OF ($KMnO_4$)	POLY TUBE ELBOW	GALLONS OF SOLUTION	FLOAT SETTING*	RISER PIPE LENGTH
2 Oz.	3/8”	3/4 gal	2-1/2”	11”
4 Oz.	3/8”	1 gal	4”	12-1/2”
6 Oz.	3/8”	1-1/2 gal	5-5/8”	12-1/2”

FLOAT SETTING is based on distance between the top of the valve body nut and the bottom of the float with the valve closed (float up) position. All dimensions are to the nearest 1/4 inch.

Correct water temperature is important in obtaining proper dissolving of $KMnO_4$. Table is based on solubility of 4 oz/gal at 50° F.

*Grid-height for 6 ounce feeder is 7-5/8”.
Grid height for others is 5-3/4”. Maintain 1/2” minimum water level above grid plate.

Feeder Chemicals Information *(continued)*

Because of varying conditions, information is to be used as a guideline only.

CALCIUM HYPOCHLORITE MEASUREMENT EQUIVALENTS	
Dry Weight	**Household Measurement***
1/6 ounce	1 level teaspoon
1/2 ounce	1 level tablespoon
1 ounce	2 level tablespoons
8 ounces	16 level tablespoons 1 cup)

*These household measurement equivalents are only approximate values given for the user's convenience.

HELPFUL EQUIVALENTS:

ACIDS: 1 gallon of muratic acid (20 Baume) equals approximately:

- 3.2 lbs. Hydrochloric acid
- 8.4 lbs. Sulphamic acid
- 12.0 lbs Sodium bisulphate (monohydrate)
- 10.3 lbs. Sodium bisulphate (anhydrous)

BASES: 1 lb. Sodium hydroxide equals approximately:

- 1.3 lbs. Sodium carbonate, technical grade
- 2.3 lbs. Sodium carbonate (soda ash 58%)
- 3.1 lbs. Trisodium phosphate, commercial grade

Polyphosphate
1 lb/10 gal .... = 12,000 ppm
Bleach 5.25% .... = 52,500 ppm
Bleach 12.5% .... = 125,000 ppm
Potassium Permanganate
0.25 lb/gal .... = 30,000 ppm
Chlorine 3 ppm ... /1 ppm hydrogen sulfide
Chlorine 1 ppm .... /1 ppm iron
Potassium Permanganate
0.7 ppm .. /1 ppm hydrogen sulfide
Maximum solubility of $KMnO_4$
.... = 0.25 lbs/gal strength
Do not neglect the residual required for chlorine applications.

PREPARING CALCIUM HYPOCHLORITE SOLUTIONS

For applications that require specific concentrations measured in ppm or percent available chlorine.

Follow these simple directions:
As a safety precaution, prepare only the amount of solution needed.
Never store a calcium hypochlorite solution.

1. Use a clean, nonmetallic container free of grease, oil or residue.
2. Add granular calcium hypochlorite to lukewarm water.
3. Stir for three to five minutes.
4. Use immediately.

The table below indicates the amount of calcium hypochlorite needed to make various quantities of solution containing from 5 to 10,000 ppm available chlorine.

Weight of Calcium Hypochlorite Required to Make A Solution

Available Chlorine (PPM)*	1 gallon		10 gallon		50 gallon		100 gallon	
	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.
5	0	0.001	0	0.01	0	0.05	0	0.10
10	0	0.002	0	0.02	0	0.10	0	0.21
25	0	0.005	0	0.05	0	0.26	0	0.51
50	0	0.01	0	0.10	0	0.51	0	1.03
100	0	0.02	0	0.21	0	1. 03	0	2.05
150	0	0.03	0	0.31	0	1.54	0	3.08
200	0	0.04	0	0.41	0	2.05	0	4.11
300	0	0.06	0	0.62	0	3.08	0	6.16
500	0	0.11	0	l.03	0	5.13	0	10.27
600	0	0.12	0	1.23	0	6.16	0	12.32
1,000	0	0.21	0	2.05	0	10.26	1	4.53
2,500 (.25%)	0	0.51	0	5.13	1	9.66	3	3.32
5,000(.5%)	0	1.03	0	10.26	3	3.32	6	6.65
10,000 (1%)	0	2.05	1	4.53	6	6.65	12	13.29

*Parts available = chlorine per million parts of water.

POLYPHOSPHATE FEED PUMP SIZING:

To size a feed pump for polyphosphate feeding it is necessary to know or calculate the following: **a.** the polyphosphate residual (ppm), and **b.** the well pump rate (gpm).
RULE 1: One pound of polyphosphate per 10 gallons water = 12,000 ppm (solution strength).
RULE 2: One pound of polyphosphate typically treats 40,000 gal of water at a 2 ppm concentration (residual).
FORMULA: [Well pump rate (gpm) x polyphosphate residual (ppm) x 1440 (conversion factor)] ÷ solution strength = required feed output (gpd).

Example: Well pump rate = 10 gpm
Polyphosphate residual = 4 ppm
(10 x 4 x 1440) ÷12,000 = 57,600÷12,000 = 4.8 gpd (pump output)

It is advisable to slug the system initially at 10 ppm for approximately 30 days to clean out the lines at a faster rate.

NOTICE:
The statements and methods presented about the products mentioned herein are based upon the best available information and practices known to Watts Water Refiners, Inc. at the present time, but are not representations of performance, results, or comprehensiveness of such data.

The products mentioned herein, if not used properly, can be hazardous. Watts Water recommends that anyone using and/or handling the products mentioned herein thoroughly read and understand the directions and precautionary information appearing on the product label before using the product.

The products mentioned herein, as all potentially hazardous materials, must be kept out of the reach of children.

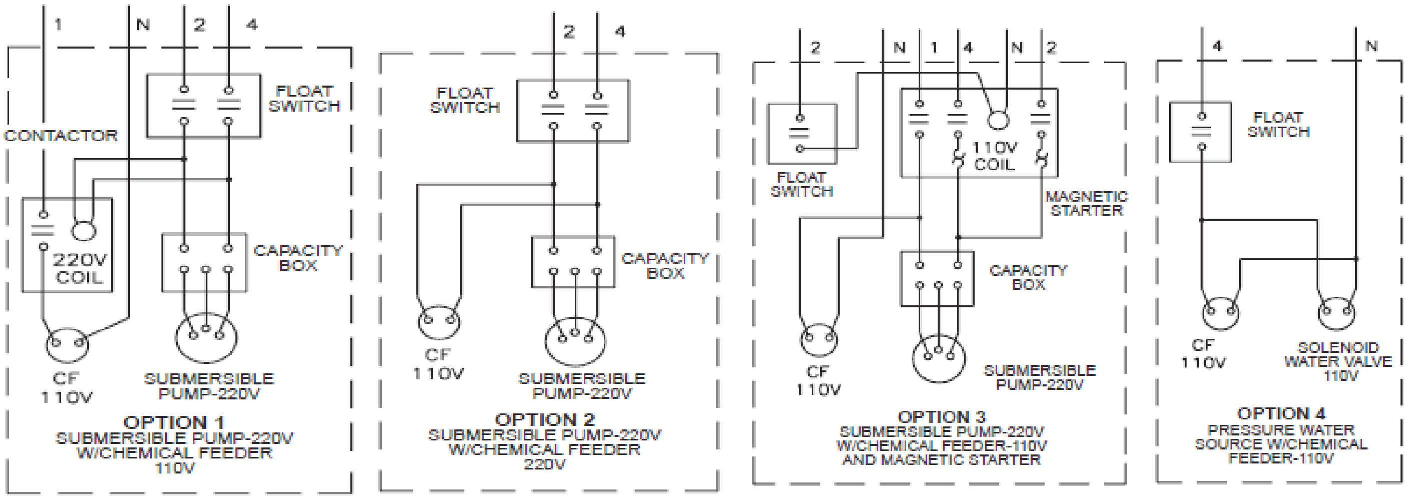
DOSAGES (VARIOUS OXIDIZING CHEMICALS)

	FAVORABLE pH RANGE	CHLORINE AS Cl_2	POTASSIUM PERMANGANATE	IODINE AS I_3	OZONE AS O_3
Iron (Fe) Retention	6.5 – 7.5	.6 – 1.0 ppm 20 minutes	.75 – 1.0 ppm 25 minutes	2.2 – 3.6 ppm 25 minutes	.1 – .7 ppm 20 minutes
Manganese (Mn) Retention	8.0 – 9.5	1.7 – 2.0 ppm 20 minutes	2.0 – 2.7 ppm 30 minutes	6.1 – 7.2 ppm 30 minutes	1.0 – 1.6 ppm 20 minutes
Hyd. Sulfide (H_2S) Retention	8.5 – 10.0	2.0 – 3.0 ppm 30 minutes	4.0 – 6.0 ppm 45 minutes	7.2 – 10.8 ppm 45 minutes	1.3 – 2.0 ppm 30 minutes

Typical Residential Aerator/Storage Tank, Piping & Electrical

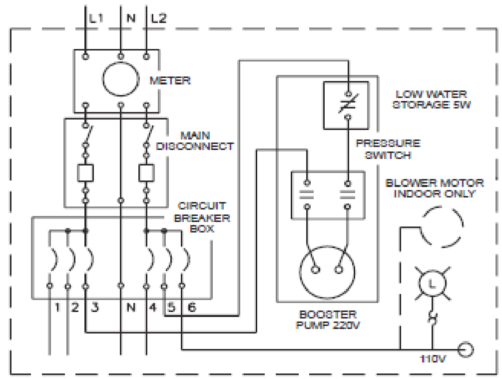
Also see next page for aerator order and sizing information.

NOTE: Select one of the option drawings (in top row) which will attach at 1, 2, 3, N, 4, and complete the Electrical Schematic.

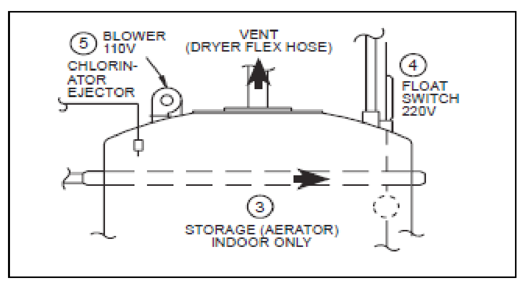


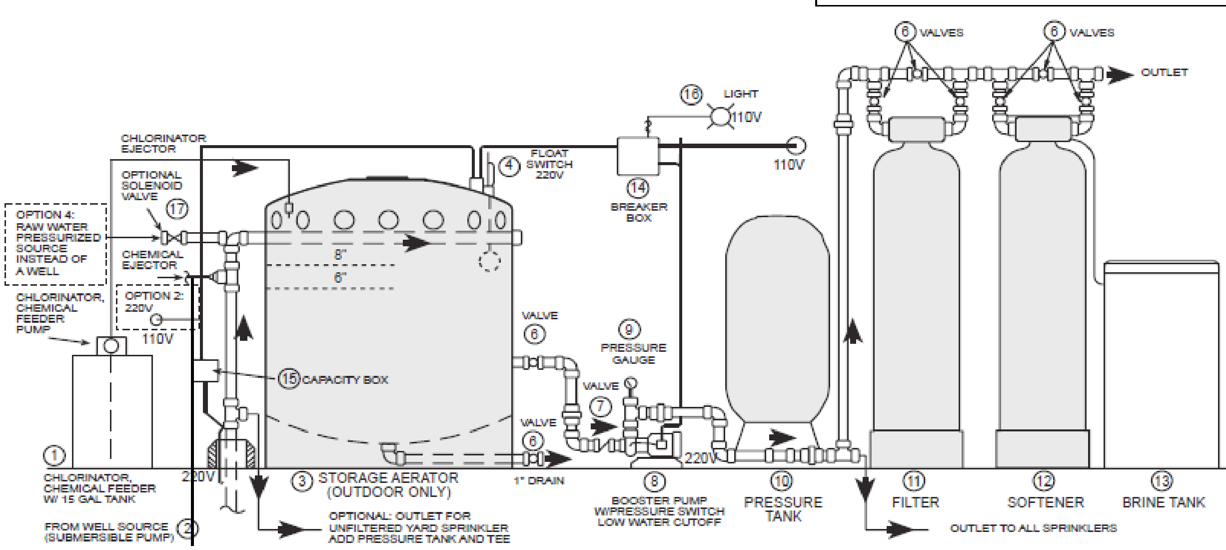
SELECT ONE OPTION FROM ABOVE: # ____________

1. CHLORINATOR/FEEDER	A: PUMP	B: DAY TANK	
2. PUMP	A: TYPE	B: H.P.	
3. STORAGE (AERATOR)	A: TYPE	B: CAPACITY	
4. FLOAT ASSEMBLY	A: SWITCH	B: BALL & ROD	C: GUIDE
5. BLOWER (INDOOR ONLY)	A: TYPE	B: SCFM	C: H.P.
6. ISOLATING VALVE	A: BALL	B: CA	
7. CHECK VALVE	A: TYPE		
8. BOOSTER PUMP	A: TYPE	B: H.P.	C: PRESSURE SWITCH
9. PRESSURE GAUGE	A: SIZE	B: PSI	
10. PRESSURE TANK	A: TYPE	B: CAPACITY	
11. FILTER	A: TYPE	B: SIZE	
12. SOFTENER	A: TYPE	B: CAPACITY	
13. BRINE TANK	A: TYPE	B: SIZE	
14. BREAKER BOX	A: TYPE	B: COMPONENTS	
15. CAPACITY BOX	A: TYPE	B: COMPONENTS	
16. LIGHT	A: TYPE		
17. SOLENOID VALVE	A: TYPE	B: SIZE	



ELECTRICAL SCHEMATIC





Reverse Osmosis Information

HOW TO CALCULATE (PERCENT) REJECTION RATE:

$$\textbf{\% REJECTION} = \frac{\text{(Feed water T.D.S. - Product water T.D.S.) x 100}}{\text{Feed water T.D.S}} \qquad \frac{\text{(FW - PW) x 100}}{\text{FW}}$$

SUGGESTED R.O. DESIGN LIMITS:

Feed Water	SDI*	FLUX	% FLUX DECLINE/YR.
Surface Water	3 - < 5	8-14 gfd [1]	7.3 - 9.9
Well Water	< 3	14-18 gfd [1]	4.4 - 7.3
R/O Water	0	20-30 gfd [1]	2.3 - 4.4

(These are general guidelines. Water analysis and total application should always be considered.)

AWRI SDI* TEST KIT
PART # T3031

*__SDI__ = Silt Density Index. Measurement of suspended solids in feed water.

[1] **FLUX** = Flow Rate of product water through cross flow filtration usually given in terms of units per time and filtration membrane area, i.e. GPD per square foot of membrane surface area = GFD.

TDS Compensation: For each 1,000 ppm, 11 psi of osmotic pressure must be overcome.

Example: An 1,800 GPD R.O. is operating at 150 psi on a TDS of 500 ppm. If the TDS increases to 1,500 ppm, the increase in pressure to maintain the same output would be approximately 161 psi.

Temperature Compensation: As temperature decreases, water becomes dense or its viscosity increases and flux rates decline. A decrease of one degree means about 3% decline in Flux Rate. Pump pressure increases at about 1.2 psi per degree down from 77° F.

Considerations: Feed Water: Analysis, gpm and pipe size. **Pretreatment:** Filters, softeners, chemical or mechanical. **High Pressure Pumps:** Voltage, stainless steel, cast iron or brass. **Instrumentation and Controls:** Manual/automatic, flow meters, pressure level & sensing, etc. **Permeate Storage:** Fiberglass, poly, pressure, atmospheric. **Cleaning Unit:** Clean in place, cleaning skid or send out for cleaning.

FLOWMETER CONVERSION FOR LIQUIDS WITH SPECIFIC GRAVITIES OTHER THAN 1.00

	0	1	2	3	4	5	6	7	8	9
SG					**CONVERSION FACTOR**					
0.4	1.647	1.626	1.605	1.585	1.565	1.548	1.529	1.513	1.495	1.479
0.5	1.462	1.447	1.433	1.418	1.404	1.391	1.377	1.364	1.351	1.339
0.6	1.326	1.316	1.304	1.292	1.282	1.271	1259	1.250	1.239	1.229
0.7	1.220	1.211	1.202	1.192	1.183	1.175	1.167	1.157	1.149	1.142
0.8	1.134	1.125	1.117	1.111	1.104	1.096	1.089	1.082	1.075	1.068
0.9	1.062	1.055	1.048	1.042	1.035	1.030	1.024	1.017	1.011	1.005
1.0	1.000	0.994	0.988	0.982	0.978	0.972	0.967	0.962	0.956	0.951
1.1	0.947	0.943	0.936	0.932	0.927	0.923	0.917	0.913	0.909	0.904
1.2	0.900	0.895	0.891	0.887	0.883	0.878	0.871	0.870	0.866	0.862
1.3	0.858	0.854	0.850	0.846	0.842	0.838	0.835	0.831	0.827	0.824
1.4	0.820	0.818	0.814	0.810	0.806	0.803	0.800	0.797	0.794	0.791
1.5	0.787	0.784	0.781	0.778	0.776	0.773	0.770	0.767	0.764	0.759
1.6	0.756	0.754	0.751	0.748	0.745	0.742	0.740	0.737	0.734	0.730
1.7	0.728	0.726	0.723	0.720	0.717	0.714	0.712	0.709	0.706	0.704
1.8	0.701	0.699	0.696	0.694	0.691	0.689	0.686	0.684	0.682	0.679
1.9	0.677	0.674	0.672	0.669	0.657	0.565	0.563	0.561	0.558	0.557
2.0	0.654	0.652	0.650	0.648	0.646	0.644	0.641	0.640	0.637	0.636

Example: SG (Specific Gravity) of 1.54; use Factor of 0.776

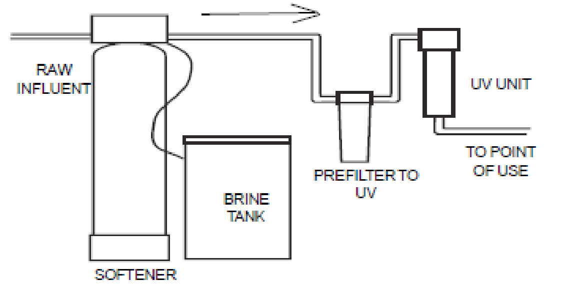
Ultraviolet & Ozone Disinfection Information

ULTRAVIOLET LAMP SELECTION

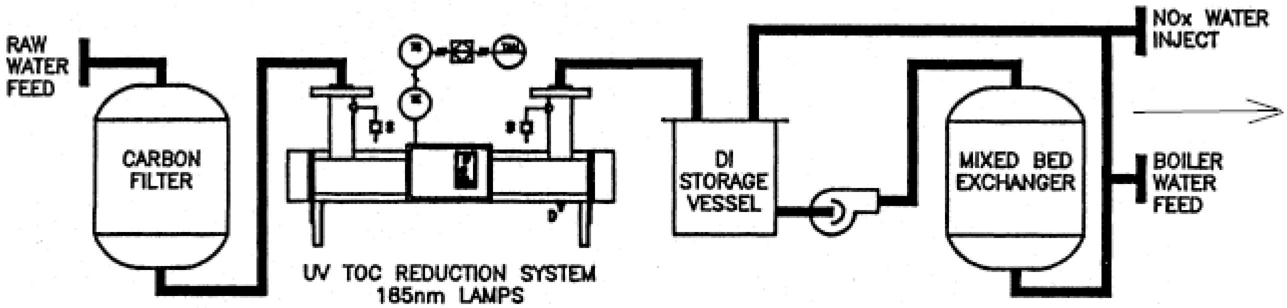
185 Nanometer Wave-length Lamps: Allow 185 nm as well as 254 nm wave length light to be transmitted. This lamp is typically used for the control of TOC (total organic compounds) and it is ozone producing.

254 Nanometer Wave-length Lamps: Prevent 185 nm wave length transmission by using a special glass or coating on the lamp. This lamp is typically used for disinfection or control of bacteria. 254 nm is also used for Ozone destruction.

NOTE: When sizing a UV System for TOC reduction or O_3 destruction, it should be sized 4-8 times larger than for bacteria reduction.



TYPICAL RESIDENTIAL ULTRAVIOLET/SOFTENER COMBINATION INSTALLATION



TYPICAL COMMERCIAL ULTRAVIOLET TREATMENT SYSTEM WITH COMPANION EQUIPMENT

OZONE PREOXIDATION for Iron, Manganese and Sulfide Treatment:

Equipment Sizing is based on the amount of ozone generation required to completely react with iron, manganese and sulfide in solution.

To (typically) treat:		THEORETICAL	PRACTICAL
1 ppm Iron (Fe++)	requires	0.43 ppm Ozone	0.50 - 14 ppm Ozone
1 ppm Manganese (Mn++)	requires	0.88 ppm Ozone	1.50 - 0.6 ppm Ozone
1 ppm Sulfide (S_2)	requires	0.60 ppm Ozone	1.50 - 0.5 ppm Ozone

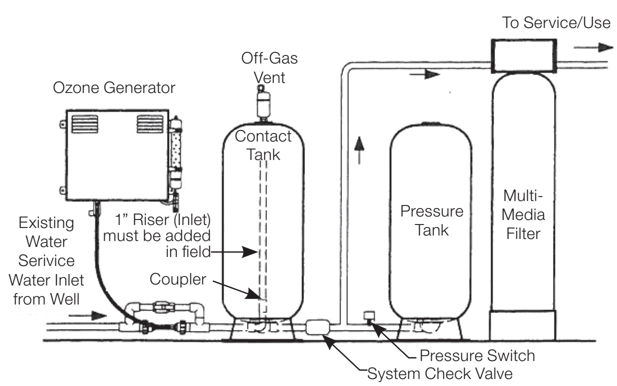
Calculation: Water Flow at 10 gpm with 1.3 ppm iron and 0.22 ppm Manganese

Ozone Dosage Required	=	1.3 (Fe)	x	0.43 (O_3)	=	0.56 ppm
		0.22 (Mn)	x	0.88 (O_3)	=	0.19 ppm
				Ozone Required	**=**	**0.75 ppm**
Dosage Added for Unknown Demand					=	0.75 ppm
Recommendeed Total Ozone Dosage					**=**	**1.50 ppm**

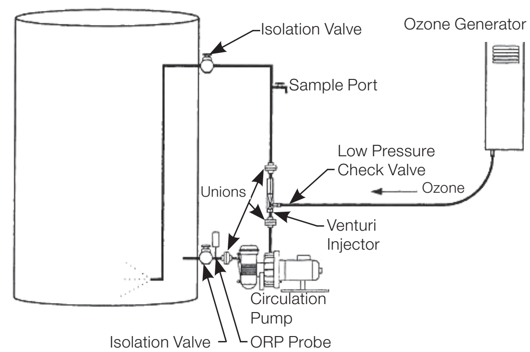
1.50 (dosage) x 10 gpm x 0.012* x 19* = **3.42 g/h**

*0.012 is the constant for conversion from gallons per minute (gpm) to pounds per day (ppd) while **19** is the number of **grams per hour** in pounds per day. In this example, **3.42 g/h** is the output of the generator required.

OZONE IN-LINE SYSTEM



OZONE RECIRCULATING SYSTEM



General Measures and Conversion Factors

WATER (LIQUID)	Multiply by	= Measure
GALLONS	128	= FL OZ
GALLONS	3.785	= LITERS
LITERS	0.2642	= GALLONS
OUNCES	29.57	= MILLILITERS
CUBIC METERS	264	= GALLONS
MILLILITERS	0.0338	= OUNCES
MILLILITERS/MIN	0.0158	= GPH
FEET OF WATER	0.4335	= PSI
GALLONS	8.337	= POUNDS
CU FT (WATER)	62.3554	= POUNDS
KILOGRAMS	2.2	= POUNDS
GALLONS	0.1337	= CUBIC FEET
GALLONS/DAY	2.628	= MILLILITERS in 1 MIN

AIR

GPM (WATER)	4.1	= SCFM (147 PSI at 70°F)
SCFM	4.115	= GPM (14.7 PSI at 70°F)
SCFM	0.4720	= LITERS/SEC

MISCELLANEOUS

PSI	0.0703	= KGS/SQ. CM
KGS/SQ. CM	14.22	= PSI
INCHES	25.4	= MILLIMETERS
DEGREES F.	0.555 (°F -32)	= DEGREES C.
DEGEES C.	(1.8 X °C) + 32	= DEGREES F.
M^3/HR	4.405	= GPM
ML/MIN	0.016	= GPM

FACTORS:

PSI CORRECTION FACTOR = V14.7 + W/PSI ÷ 14.7
INDICATED FLOW RATE
X CORRECTION FACTOR = ACTUAL FLOW RATE
TEMP CORRECTION FACTOR = V530 ÷ W/TEMP
(All SCFM for air only)

ELECTRICAL

WATTS ÷ AMPERES	= VOLTS
CURRENT X RESISTANCE	= VOLTS
WATTS ÷ VOLTS	= AMPERES
VOLTS ÷ RESISTANCE	= AMPERES
VOLTS X AMPERES	= WATTS
AMPERES X RESIST. X AMPERES	= WATTS
VOLTS X RESIST. X VOLTS	= WATTS
VOLTS ÷ AMPERES	= RESISTANCE
HORSEPOWER WATTS X .001341	= HORSEPOWER
WATTS HORSEPOWER X 745.7	= WATTS

POWER

HORSEPOWER = $\frac{\text{GPM X TOTAL HEAD (FT)}}{\text{3960 X PUMP EFFICIENCY}}$

PUMP EFFICIENCY= $\frac{\text{GPM X TOTAL HEAD (FT)}}{\text{3960 X BHP TO PUMP}}$

SOME FIELD EXAMPLES:

CAPACITY IN GALLONS OF A RESERVOIR: Multiply length by the width by the depth in feet = total cubic feet. Multiply that times 7.4805 (approx 7.5 gallons per cubic foot).

CAPACITY OF PIPE OR CYLINDER IN GALLONS:
Multiply the square of the diameter in inches by length in inches and by .0034.

CAPACITY OF PIPE OR CYLINDER IN CUBIC INCHES:
Multiply the square of the diameter in inches by length in inches and by .7854.

CAPACITY OF TANK OR CISTERN IN GALLONS:
Square the diameter in feet and multiply by .7854. Multiply that by the height in feet and multiply that by 7.48

SOME ENGINEERING RECOMMENDATIONS:

FLUID VELOCITY IN PIPE SHOULD NOT EXCEED FIVE (5) FEET PER SECOND.

SYSTEM PRESSURE, INCLUDING SURGE OF WATER HAMMER, SHOULD NOT EXCEED 100% OF RATED PRESSURE OF PIPE IN SYSTEM.

To Eliminate Water Hammer (in gallons):
Maximum GPM ÷ 60 seconds x 2 seconds x 10 = Size of Pressure Tank.

VOLUME MEASURE

1 CU INCH	= 16.387 CU CENTIMETERS
1,728 CU INCHES	= 1 CU FT = 0.0283 CU METER
27 CU FT	= 1 CU YRD = 0.7646 CU METER
16 CU FT	= 1 CORD FT
8 CORD FT	= 1 CORD = 3.625 CU METERS
40 CU FT	= 1 TON (SHIPPING)
1 GALLON	= 231 CU INCHES
1 GALLON	= 3.785 LITERS
1 GALLON	=.00379 CU METERS
1 GALLON	= .833 IMPERIAL GALLONS
7.48052 GALLONS	= 1 CU FT
202 GALLONS	= 1 CU YARD
27,154 GALLONS	= 1 ACRE INCH
1 CU YARD	= 27 CU FT
1 ACRE FOOT	= 43,560 CU FT
1 ACRE FOOT	= 325,851 GALLONS

GEOMETRIC FORMULAS

CIRCLE CIRCUMFERENCE	= DIA X 3.1416
CYLINDER AREA	= (End Areas + Length) X Circum.
CYLINDER CAPACITY	= DIA^2 X Length X .785
CONE AREA	= Base Circ x 1/2 Slant Hgt + BaseArea
CONE CAPACITY	= 1/3 Altitude X Base Area

AREA FORMULAS

43,560 SQ FT	= 1 ACRE
CIRCLE	= $RADIUS^2$ X 3.1416
SQUARE	= $SIDE^2$
TRIANGLE	= HALF BASE X ALTITUDE
RECTANGLE	= LENGTH X WIDTH
PARALLELOGRAM	= BASE X ALTITUDE

LINEAR MEASURE

MILLIMETER	= .03937 INCHES
1 CENTIMETER	= .3937 INCHES
1 METER	= 39.37 INCHES

PRESSURE @ 62°F

1 ATMOSPHERE	= 14.6963 POUNDS/SQ INCH
1 POUND/SQ IN	= 2.31 FEET OF HEAD
1 FOOT OF HEAD	= .433 POUNDS/SQ IN
1 BAR	= 1 PSI X 14.5

FRACTION • DECIMAL• MILLIMETER • EQUIVALENTS

1/64	0.015625	0.397	33/64	0.515625	13.10
1/32	0.03125	0.794	17/32	0.53125	13.49
3/64	0.046875	1.191	35/64	0.546875	13.89
1/16	0.0625	1.588	9/16	0.5625	14.29
5/64	0.078125	1.984	37/64	0.578125	14.68
3/32	0.09375	2.381	19/32	0.59375	15.08
7/64	0.109375	2.778	39/64	0.609375	15.48
1/8	**0.125**	**3.175**	**5/8**	**0.625**	**15.88**
9/64	0.140625	3.572	41/64	0.640625	16.27
5/32	0.15625	3.969	21/32	0.65625	16.67
11/64	0.171875	4.366	43/64	0.671875	17.07
3/16	0.1875	4.763	11/16	0.6875	17.46
13/64	0.203125	5.159	45/64	0.703125	17.86
7/32	0.21875	5.556	23/32	0.71875	18.26
15/64	0.234375	5.953	47/64	0.734375	18.65
1/4	**0.25**	**6.350**	**3/4**	**0.75**	**19.05**
17/64	0.265625	6.747	49/64	0.765625	19.45
9/32	0.28125	7.144	25/32	0.78125	19.84
19/64	0.296875	7.541	51/64	0.796875	20.24
5/16	0.3125	7.938	13/16	0.8125	20.64
21/64	0.328125	8.334	53/64	0.828125	21.03
11/32	0.34375	8.731	27/32	0.84375	21.43
23/64	0.359375	9.128	55/64	0.859375	21.83
3/8	**0.375**	**9.525**	**7/8**	**0.875**	**22.23**
25/64	0.390625	9.922	57/64	0.890625	22.62
13/32	0.40625	10.32	29/32	0.90625	23.02
27/64	0.421875	10.72	59/64	0.921875	23.42
7/16	0.4375	11.11	15/16	0.9374	23.81
29/64	0.453125	11.51	61/64	0.953125	24.21
15/32	0.46875	11.91	31/32	0.96875	24.61
31/64	0.484375 1	2.30	63/64	0.984375	25.00
1/2	**0.5**	**12.70**	**1**	**1.0**	**25.40**

TIP:

@ 460 volts, a 3 phase motor, draws, 1.25 amps per HP

@ 230 volts, a 3 phase motor draws 2.5 amps per HP

For more information about Water hammer and its effects see Page 27.

Notes:

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