## Formula/Conversion Table

 for Water Treatment and Water Distribution| Measurement Conversion |
| :--- |
| 1 ft. Measurement Conversion 12 in.$$ Measurement Conversion  Measurement Conversion |
| 1 yd. $=3 \mathrm{ft}$. |

$\mathrm{L}=$ Length $\quad \mathrm{B}=\mathrm{Base} \quad \mathrm{W}=$ Width $\quad \mathrm{H}=$ Height $\quad \mathrm{R}=$ Radius $\quad \mathrm{D}=$ Diameter $\quad \pi=3.14$

## Alkalinity

Phenolphthalein Alkalinity, as $\mathrm{mg} \mathrm{CaCO}^{3} / \mathrm{L}=\quad$ (Titrant Volume A, ml)(Acid Normality)(50,000)

Total Alkalinity, as $\mathrm{mg} \mathrm{CaCO} 3 / \mathrm{L}=$
(Titrant Volume B, ml)(Acid Normality)(50,000)
Sample Volume, ml
Alkalinity Relationships: Alkalinity, mg/l as $\mathrm{CaCO}^{3}$

| Result of <br> Titration | Hydroxide <br> Alkalinity <br> as CaCO | Carbonate <br> Alkalinity <br> as $\mathrm{CaCO}_{3}$ | Bicarbonate <br> Concentration <br> as $\mathrm{CaCO}_{3}$ |
| :--- | :--- | :--- | :--- |
| $\mathrm{P}=0$ | 0 | 0 | T |
| $\mathrm{P}<1 / 2 \mathrm{~T}$ | 0 | 2 P | $\mathrm{T}-2 \mathrm{P}$ |
| $\mathrm{P}=1 / 2 \mathrm{~T}$ | 0 | 2 P | 0 |
| $\mathrm{P}>1 / 2 \mathrm{~T}$ | $2 \mathrm{P}-\mathrm{T}$ | $2(\mathrm{~T}-\mathrm{P})$ | 0 |
| $\mathrm{P}=\mathrm{T}$ | T | 0 | 0 |

Key: P - phenolphthalein alkalinity; T - total alkalinity

## Area, Circumference and Volume

## Area, sq ft

Circle: $\mathrm{A}=\pi \mathrm{x}^{2}$ or $\mathrm{A}=0.785 \mathrm{xD}^{2}$
Cylinder (total outside surface area): $A=\left(2 \times \pi \times R^{2}\right)+\pi \times D \times H \quad$ or $\quad A=\left(2 \times 0.785 \times D^{2}\right)+(\pi \times D \times H)$
Rectangle: A = L x W
Triangle: A =1/2 $\times$ B x H
Circumference, ft
Circle, $\mathrm{ft}=\pi \times \mathrm{D}$
Rectangle, $\mathrm{ft}=2 \times \mathrm{L}+2 \times \mathrm{W}$
Volume, cu ft:
Cone: $V=1 / 3 \times 0.785 \times D^{2} \times H$ or $V=1 / 3 \times \pi \times R^{2} \times H$ Cylinder: $\mathrm{V}=\pi \times \mathrm{R}^{2} \times \mathrm{H}$ or $\mathrm{V}=0.785 \times \mathrm{D}^{2} \times \mathrm{H}$
Rectangle: V $=\mathrm{L} \times \mathrm{W} \times \mathrm{H}$
Average $($ arithmetic mean $)=$
Sum of All Terms or Measurements
Number of Terms or Measurements
Annual Running Average =

## Chemical Feed, Mixing and Solution Strengths

| Chemical Feed, lbs/day = <br> (Dry Chemical Collected, gm )( $60 \mathrm{~min} / \mathrm{hr}$ )(24 hr/day) <br> (Dry Chemical Feeder) <br> ( $454 \mathrm{gm} / \mathrm{lb}$ )(Time, min) |
| :---: |
| $\text { Chemical Feed, lbs/day }=\quad \frac{(\text { Polymer Feeder) Polymer Conc, mg/l)(Volume Pumped, } \mathrm{ml})(60 \mathrm{~min} / \mathrm{hr})(24 \mathrm{hr} / \mathrm{day})}{(\text { Time Pumped, } \mathrm{min})(1,000 \mathrm{mg} / \mathrm{l})(1,000 \mathrm{mg} / \mathrm{gm})(454 \mathrm{gm} / \mathrm{lb})}$ |
| Chemical Feed Pump Setting, \% Stroke $=\quad \frac{(\text { Desired Flow })(100 \%)}{\text { Maximum Flow }}$ |
| Chemical Feed Pump Setting, mL/minute $=\quad \frac{(\text { Flow, MGD) }(\text { Dose }, \mathrm{mg} / \mathrm{L})(3.785 \mathrm{~L} / \mathrm{gal})(1,000,000 \mathrm{gal} / \mathrm{MG})}{(\mathrm{Liquid}, \mathrm{mg} / \mathrm{ml})(24 \mathrm{hr} / \mathrm{day})(60 \mathrm{~min} / \mathrm{hr})}$ |
| $\text { Chemical Flow, gpm }=\quad \begin{gathered} \text { Volume Pumped, gal } \\ (\text { Pumping Time, hr)(60 min/hr) } \end{gathered}$ |
| Dry Polymer, lbs = $($ Water, lbs $) /((100 /$ polymer \% $)-1)$ |
| Feeder Setting, \% = (Desired Feed Rate, lbs/day)(100\%)/(Maximum Feed Rate, lbs/day) or Feeder Setting, \% = (Desired Feed Rate,gph(100\%)/(Maximum Feed Rate, gph) |
| Hypochlorite Strength, \% = $\quad$(Chlorine Required, lbs)(100\%) <br> (Hypochlorite Solution Needed, gal)(8.34lbs/gal) |
| Liquid Polymer, gal $=\quad \frac{(\text { Polymer Solution, \%)(gal of solution) }}{\text { Liquid Polymer, } \%}$ |
| Mixture Strength, \% = |
| Polymer Strength, \% = (Dry Polymer, lbs)(100\%)/(Dry Polymer, lbs + Water, lbs) or Polymer Strength, \% = (Weight of Solute, lbs)(100\%)/Weight of Solution |
| $\text { Water, lbs }=\frac{(\text { Dry Polymer, lbs)(100\%) }- \text { Dry polymer, lbs }}{\text { Polymer } \%}$ |
| $\text { Water added, gal }=\quad \frac{(\text { hypo, gal)(hypo, \%) }-(\text { hypo, gal)(desired hypo, \%) }}{\text { Desired hypo, \% }}$ |

## Demineralization

Membrane Area, sq $\mathrm{ft}=($ Number of Vessels)(Number of Elements/Vessel)(Surface Area/Element)
Average Flux Rate, GFD = $\quad$ Permeate Flow, gpd
(flow through membranes) Membrane Area, sq ft

Mineral Rejection, \% =
Product Concentration (TDS), mg/l
[1- Feedwater Concentration (TDS), mg/l ] x 100\%
Recovery, \% = (Product Flow, mgd)(100\%)
(Feed Flow, mgd)

## Detention Time

Detention Time (days)= Volume, gallons Note: For detention time in hours multiply by 24hr/day andfor Flow, gpd detention time in minutes multiply by $1440 \mathrm{~min} /$ day

## Disinfection

Chlorine Demand, mg/L = Chlorine Dosage, mg/L - Chlorine Residual, mg/L
Chlorine Dosage, mg/L = Chlorine Demand, mg/L + Chlorine Residual, mg/L
Chlorine Residual, mg/L = Chlorine Dosage, mg/L - Chlorine Demand, mg/L
CT calculation, time $=($ Disinfectant Residual Concentration, $\mathrm{mg} / \mathrm{L})($ Time $) \quad$ Units must be compatible

## Electrical



Power Requirements, kW-hr = $\quad($ Power, kilowatts)(Time, hours)

## Feed Rate

Feed Rate, lbs/day = (Dosage, mg/L)(Flow, MGD)(8.34 lbs/gal)
(Purity, as a decimal)


## Filtration

Davidson Pie Chart

- To find the quantity above the horizontal line: multiply the pie wedges below the line together and divide by thepurity, as a decimal (i.e., $65 \%=0.65$ ).
- To solve for one of the pie wedges below the horizontal line: cover that pie wedge then divide the remaining pie wedges into the quantity above the horizontal line and multiply by the purity, as a decimal (i.e., $65 \%=0.65$ ).
- The given units must match the units shown in the pie wheel.

Backwash Rise Rate, in $/ \mathrm{min}=\quad($ Backwash Rate, $\mathrm{gpm} / \mathrm{sq} . \mathrm{ft}).(12 \mathrm{in} / \mathrm{ft})$ ( $7.48 \mathrm{gal} / \mathrm{cu} . \mathrm{ft}$.)

Backwash Pumping Rate, gal/min $=\quad$ (Backwash Rate, gpm/sq. ft.)(Filter Surface Area, sq. ft.)
Backwash Water Required, gal =
(Backwash Flow, gpm)(Backwash Time, min)
Backwash Water Used, \% = (Backwash Water, gal)(100\%) Water Filtered, gal.

Drop Velocity (V), ft/min $=\quad$ Water Drop in Filter, ft
Time to Drop, min
Filtration Rate or Backwash Rate, GPM/sq. ft. =
Flow, GPM
Filter Surface Area, sq. ft.

Hydraulic or Surface Loading Rate, gpd/sq $\mathrm{ft}=\quad \underline{\text { Total Flow Applied, gpd }}$ Surface Area, sq ft

Unit Filter Run Volume, gal/sq. ft. =
Volume Filtered, gal
Filter Surface Area, sq. ft.
Unit Filter Run Volume, gal/sq. ft. = (Filtration Rate, GPM/sq. ft.)(Filter Run, hr)(60 min/hr)

## Flow Rates and Velocity (pipe line, channel or stream)

Flow Rate, cfs $=($ Area, sq. ft. $)($ Velocity, $\mathrm{ft} / \mathrm{sec})$ or $\mathrm{Q}=\mathrm{V} \times \mathrm{A}$


## Where:

$\mathrm{Q}=$ flow rate, cfs
$\mathrm{V}=$ velocity, fps
$\mathrm{A}=$ area, $\mathrm{ft}^{2}$

Flow Rate, $\mathrm{gpm}=($ Area, $\mathrm{sq} . \mathrm{ft}).($ Velocity, $\mathrm{ft} / \mathrm{sec})(7.48 \mathrm{gal} / \mathrm{cu} \mathrm{ft})(60 \mathrm{sec} / \mathrm{min})$ or $\mathrm{Q}=\mathrm{V} \times \mathrm{A} \times 7.48 \times 60$
Velocity, fps = Flow rate, cfs/Area, sq. ft or Distance, ft/Time, seconds
Reduction in Flow, \% $=\frac{(\text { Original Flow }- \text { Reduced Flow })(100 \%)}{\text { Original Flow }}$
Original Flow

## Fluoridation

| Feed Rate, lbs/day = <br> (Fl | (Dosage, mg/L)(Flow, MGD)(8.34 lbs/gal) <br> (Fluoride solution, as a decimal)(Purity, as adecimal) |
| :---: | :---: |
| Feed Rate, gpd = | Feed Rate, lbs/day |
|  | Chemical solution, lbs/gal |
| Feed Rate, lbs/day = | Fluoride, lbs/day |
|  | Fluoride, lbs / lb of commercial chemical |
| Fluoride ion purity, \% = | \% $=\quad($ Molecular Weight of Fluoride) $(100 \%)$ |
|  | Molecular Weight of Compound |
| Portion of Fluoride $=$ | (Commercial Chemical Purity, \%)(Fluoride ion, \%) |
|  | (100\%) (100\%) |

## Flushing Time

Flushing Time, sec = Volume, cu ft/Flow, cfs or (Length of Pipeline, ft )(Number of Flushing Volumes)/(Velocity, ft/sec)

## Laboratory

Dilute to $\mathrm{ml}=\quad($ Actual Weight, gm$)(1,000 \mathrm{ml})$ (desired Weight, gm)

Langelier Index (L.I.) = pH -pHs

## Leakage and Pressure Testing Pipelines

Leakage, gpd =
$\frac{\text { Volume, gal }}{\text { Time, days }}$
AC or Ductile Iron Pipe, gpd/mi-in = Leak Rate, gpd (length, mi)(Diameter, in)

Plastic pipe, gph/100 joints $=\quad$ Leak Rate, gph
(Number of Joints) / ( 100 Joints)
Test Pressure, psi $=$ Normal Pressure $+50 \%$ or 150psi whichever is greater

## Loading

Weir Overflow Rate, gpd/ft =
Total Flow, gpd Length of Weir, ft

## Parts per million

$$
\mathrm{ppm}=\mathrm{mg} / \mathrm{l}=\quad \frac{\text { Pounds of Chemical, lbs }}{(8.34 \mathrm{lbs} / \text { gal) }(\text { gallons, } \mathrm{MG})}
$$

## Pressure and Head

Head (Height of Water), $\mathrm{ft}=($ Pressure, psi$)(2.31 \mathrm{ft} / \mathrm{psi})$
or Head (Height of Water) $=\underline{\text { Pressure, } \mathrm{psi}}$ $0.433 \mathrm{psi} / \mathrm{ft}$

Pressure, $\mathrm{psi}=\underline{\text { Height, } \mathrm{ft}} \quad$ or $\quad$ Pressure, $\mathrm{psi}=$ Height, $\mathrm{ft} \times 0.433 \mathrm{psi} / \mathrm{ft}$

## Pumps and Motors



Cost, $\$ /$ day $=\quad$ Kilowatt-hr/day x cost, $\$ / \mathrm{kWh}$

## Softening Processes

## Hardness

Total Hardness, $\mathrm{mg} / \mathrm{l}$ as $\mathrm{CaCO}_{3}=\quad$ Calcium Hardness, $\mathrm{mg} / \mathrm{l}$ as $\mathrm{CaCO}_{3}+$ Magnesium Hardness, $\mathrm{mg} / \mathrm{l}$ as $\mathrm{CaCO}_{3}$ $=\quad(2.5)(\mathrm{Ca}, \mathrm{mg} / \mathrm{l})+(4.12)(\mathrm{Mg}, \mathrm{mg} / \mathrm{l})$

If alkalinity is greater than total hardness:
Carbonate Hardness, $\mathrm{mg} / \mathrm{l}$ as $\mathrm{CaCO}_{3}=$ Total Hardness, $\mathrm{mg} / \mathrm{l}$ as CaCO 3 and Noncarbonate Hardness, $\mathrm{mg} / \mathrm{l}$ as $\mathrm{CaCO}_{3}=0$

If alkalinity is less than total hardness:
Carbonate Hardness, $\mathrm{mg} / \mathrm{l}$ as $\mathrm{CaCO}_{3}=$ Alkalinity, $\mathrm{mg} / \mathrm{l}$ as $\mathrm{CaCO}_{3}$ and
Noncarbonate Hardness, $\mathrm{mg} / \mathrm{l}$ as $\mathrm{CaCO}_{3}=$ Total Hardness Removed, $\mathrm{mg} / \mathrm{l}$ as $\mathrm{CaCO}_{3}-$ Alkalinity removed, $\mathrm{mg} / \mathrm{l}$ as
$\mathrm{CaCO}_{3}$
Lime Softening - If hydrated lime $\left(\mathrm{Ca}(\mathrm{OH})_{2}\right)$ is used instead of quicklime $(\mathrm{CaO})$, substitute 74 for 56 in equations below.
Lime Feed, $\mathrm{mg} / \mathrm{l}=\quad(\mathrm{A}+\mathrm{B}+\mathrm{C}+\mathrm{D}) \times 1.15$
Purity of Lime, as a decimal
$\mathrm{A}=$ Carbon dioxide $\left(\mathrm{CO}_{2}\right)$ in source water: $\quad \mathrm{mg} / \mathrm{l}$ as $\mathrm{CO}_{2}$
$\mathrm{B}=$ Bicarbonate alkalinity removed in softening: $\quad$ source water, $\mathrm{mg} / \mathrm{l}$ as $\mathrm{CaCO}_{3}-$ softened water, $\mathrm{mg} / \mathrm{l}$ as $\mathrm{CaCO}_{3} \mathrm{x}(56 / 100)$
C = Hydroxide alkalinity in softener effluent:
$\mathrm{D}=$ Magnesium removed in softening:
$\mathrm{mg} / \mathrm{l}$ as $\mathrm{CaCO}_{3} \quad \mathrm{x}(56 / 100)$
source water, $\mathrm{mg} / \mathrm{l}$ as $\mathrm{Mg}^{2}+-$ softened water, $\mathrm{mg} / \mathrm{l}$ as $\mathrm{Mg}^{2}+\quad \mathrm{x}(56 / 24.3)$

Excess Lime, mg/l $=(\mathrm{A}+\mathrm{B}+\mathrm{C}+\mathrm{D})(0.15)$
Soda Ash: dosage to remove noncarbonated hardness
Soda Ash $\left(\mathrm{Na}_{2} \mathrm{CO}_{3}\right)$ Feed, $\mathrm{mg} / \mathrm{l}=\left(\right.$ Noncarbonate Hardness, $\mathrm{mg} / \mathrm{l}$ as $\left.\mathrm{CaCO}_{3}\right)(106 / 100)$
Carbon Dioxide: dosage to recarbonate
Total $\mathrm{CO}_{2}$ Feed, $\mathrm{mg} / \mathrm{l}=($ excess lime, $\mathrm{mg} / \mathrm{l})(44 / 56)+\left(\mathrm{Mg}^{2}+\right.$ residual, $\left.\mathrm{mg} / \mathrm{l}\right)(44 / 58.3)$
Feeder Setting, lbs/day = (Flow, MGD)(Dose, mg/l)(8.34lbs/gal)
Feed Rate, lbs/min = Feeder Setting, lbs/day
(60 min/hr)(24 hr/day)

## Ion Exchange Softening

Hardness, grains/gallon =

## (Hardness, mg/l)(1 grain/gallon)

$17.1 \mathrm{mg} / \mathrm{l}$
Exchange Capacity, grains $=($ Media Volume, cu ft $)($ Removal Capacity, grains/cuft

| Water Treated, gal $=$ | Exchange Capacity, grains <br> Hardness Removed, grains/gallon |
| :--- | :---: |
| Operating Time, $\mathrm{hr}=$ | Water Treated, gal |
| $($ Avg Daily Flow, gpm) $(60 \mathrm{~min} / \mathrm{hr})$ |  |

Salt Needed for Regeneration, lbs Salt Required, lbs/1,000 grains)(Hardness Removed, grains
Brine, gal $=\frac{\text { Salt Needed, lbs }}{\text { Salt Solution, lbs/gal of brine }}$
Bypass Flow, gpd $=\quad($ Total Flow, gpd $)($ Finished Water Hardness, gpg) Source Water Hardness, gpg

Bypass Water, gal = (Softener Capacity, gal)(Bypass Flow, gpd)
Softener Flow, gpd
Total Flow, gal = Softener Capacity, gal + Bypass Water, gal

## Temperature

Degrees Celsius =: $\quad\left[\left({ }^{\circ} \mathrm{F}-32\right)\left({ }^{5} / 9\right)\right]$ or $\left[\left({ }^{\circ} \mathrm{F}-32\right)(0.555)\right.$ or $\left({ }^{\circ} \mathrm{F}-32\right)$

Degrees Fahrenheit $=\left[\left({ }^{\circ} \mathrm{C}\right)(9 / 5)+32\right]$ or $\left[\left({ }^{\circ} \mathrm{C}\right)(1.8)+32\right]$

## Turbidity

Removal Percentage, \% =
(Influent Turbidity - Effluent Turbidity)(100\%) Influent Turbidity

## Water Production

Gallons/Capita/Day $=\quad$ Volume of Water Produced, gpd
Population
Abbreviations:

| Abbreviations |  | Types of Measurement | Abbreviations |
| :--- | :--- | :--- | :--- |
| cfs | Cubic feet per second | m | Measurement Volumes |
| DO | Dissolved oxygen | mg | Milligrams |
| ft | Feet | $\mathrm{mg} / \mathrm{L}$ | Milligrams per liter |
| fps | Feet per second | lbs | Pounds |
| GFD | Gallons per day per square foot | MGD | Million gallons per day |
| gm | Grams | mL | Milliliter |
| gpd | Gallons per day | ppb | Parts per billion |
| gpg | Grains per gallon | ppm | Parts per million |
| gpm | Gallons per minute | psi | Pounds per square inch |
| gph | Gallons per hour | Q | Flow |
| gr | Grains | SS | Settleable solids |
| hp | Horsepower | TTHM | Total trihalomethanes |
| in | Inch | TOC | Total organic carbon |
| kg | Kilogram | TSS | Total suspended solids |
| kW | Kilowatt | VS | Volatile solids |
| kWh | Kilowatt-hour | W | Watt |

