# Formula/Conversion Table for Water Treatment and Water Distribution

Measurement Conversion	Measurement Conversion	Measurement Conversion	Measurement Conversion
1 ft. = 12 in.	1  MGD = 1.55  cfs	1 grain / gal = 17.1 mg/L	$1 \min = 60 \sec \theta$
1  yd. = 3  ft.	1 cu. yd. = 27 cu. ft.	1  gm = 1000  mg	1  hour = 60  min
1  m = 3.28  ft.	1 cu. ft. = 7.48 gal	1 kg = 1000 gm	1 day = 1440 min
1 mi = 5280 ft.	1 gal = 8.34 lbs	1 liter = $1000 \text{ ml}$	1% = 10,000  mg/L
1 sq. ft. = 144 sq. in.	1  cu. ft. = 62.4  lbs	1 gal = 3.785L	1  mg/l = 1  ppm
1  acre = 43,560  sq. ft.	1  kg = 2.2  lbs	1  psi = 2.31  ft. of water	1 hp= 0.746 kW
1 acre-ft. = 43,560 cu. ft.	1 lb. = 454 gm	1 ft. water = 0.433 psi	1 hp = 33,000 ft. lbs/min
1 acre-ft. = 325,829 gal		1 in Mercury = 1.133 ft. of water	1kW = 1,000 W

L = Length B = Base

W = Width H = Height

R = Radius D = Diameter  $\pi = 3.14$ 

#### <u>Alkalinity</u>

Phenolphthalein Alkalinity, as mg  $CaCO^{3}/L =$ 

(Titrant Volume A, ml)(Acid Normality)(50,000) Sample Volume, ml

Total Alkalinity, as mg CaCO $^{3}/L =$ 

(Titrant Volume B, ml)(Acid Normality)(50,000) Sample Volume, ml

Alkalinity Relationships: Alkalinity, mg/l as CaCO3

Result of	Hydroxide	Carbonate	Bicarbonate
Titration	Alkalinity	Alkalinity	Concentration
	as CaCO <sub>3</sub>	as CaCO <sub>3</sub>	as CaCO <sub>3</sub>
$\mathbf{P} = 0$	0	0	Т
$P < \frac{1}{2} T$	0	2P	T - 2P
$P = \frac{1}{2} T$	0	2P	0
$P > \frac{1}{2} T$	2P - T	2(T – P)	0
$\mathbf{P} = \mathbf{T}$	Т	0	0
$K_{ev} \cdot P_{-}$ nhe	nolphthalein alkalinity	· T – total alkalinity	

<u>Key: P – phenolphthalein alkalinity; T – total alkalinity</u>

#### Area, Circumference and Volume

Area, sq ft

Circle:  $A = \pi x R^2$  or  $A = 0.785 x D^2$ Cylinder (total outside surface area):  $A = (2 x \pi x R^2) + \pi x D x H$  or  $A = (2 x 0.785 x D^2) + (\pi x D x H)$ Rectangle: A = L x WTriangle:  $A = \frac{1}{2} x B x H$ 

#### Circumference, ft

Circle, ft =  $\pi$  x D Rectangle, ft = 2 x L + 2 x W

#### Volume, cu ft:

Cone:  $V = 1/3 \ge 0.785 \ge D^2 \ge H$  or  $V = 1/3 \ge \pi \ge R^2 \ge H$ Cylinder:  $V = \pi \ge R^2 \ge H$  or  $V = 0.785 \ge D^2 \ge H$ Rectangle:  $V = L \ge W \ge H$ 

Average (arithmetic mean) =	Sum of All Terms or Measurements Number of Terms or Measurements
Annual Running Average =	Sum of All Averages

Number of Averages

#### **Chemical Feed, Mixing and Solution Strengths**

Chemical Feed, lbs/day = (Dry Chemical Feeder)	(Dry Chemical Collected, gm)(60 min/hr)(24 hr/day) (454 gm/lb)(Time, min)	
Chemical Feed, lbs/day =	(Polymer Feeder) Polymer Conc, mg/l)(Volume Pumped, ml)(60 min/hr)(24 hr/day) (Time Pumped, min)(1,000 mg/l)(1,000 mg/gm)(454 gm/lb)	
Chemical Feed Pump Setting, % S	troke = <u>(Desired Flow)(100%)</u> Maximum Flow	
Chemical Feed Pump Setting, mL/	$\frac{(Flow, MGD)(Dose, mg/L)(3.785 L/gal)(1,000,000 gal/MG)}{(Liquid, mg/ml)(24 hr/day)(60min/hr)}$	
Chemical Flow, gpm = (Put	<u>Volume Pumped, gal</u> mping Time, hr)(60 min/hr)	
Dry Polymer, lbs = (Water, lbs) /	((100 / polymer %) -1)	
	<u>Rate, lbs/day)(100%)/</u> (Maximum Feed Rate, lbs/day) or <u>Rate,gph(100%)/</u> (Maximum Feed Rate, gph)	
Hypochlorite Strength, % =	(Chlorine Required, lbs)(100%) (Hypochlorite Solution Needed, gal)(8.34 lbs/gal)	
Liquid Polymer, gal =	(Polymer Solution, %)(gal of solution) Liquid Polymer, %	
Mixture Strength, % =	(Amount 1, gals)(Strength 1, %) + (Amount 2, gals)(strength 2, %) (Amount 1, gals) + (Amount 2, gals)	
Polymer Strength, % = (Dry Polym	ner, lbs)(100%)/(Dry Polymer, lbs + Water, lbs) or	
Polymer Strength, $\% = (Weight of $	Solute, lbs)(100%)/Weight of Solution	
Water, lbs = <u>(Dry Polymer, lb</u> Polyme	os)(100%) - Dry polymer, lbs er %	
Water added, $gal = (hypo, gal)$	gal)(hypo,%) – (hypo, gal)(desired hypo,%) Desired hypo, %	
<b>Demineralization</b>		
Membrane Area, sq ft = (Number o	of Vessels)(Number of Elements/Vessel)(Surface Area/Element)	
Average Flux Rate, GFD = (flow through membranes)	<u>Permeate Flow, gpd</u> Membrane Area, sq ft	
Mineral Rejection, % =	Product Concentration (TDS), mg/l[1 - Feedwater Concentration (TDS), mg/l] x 100%	
Recovery, % = <u>(Product Flow, n</u>	<u>ngd)(100%)</u>	

Recovery, % = (Product Flow, mgd)(100%) (Feed Flow, mgd)

#### **Detention Time**

Detention Time (days)= <u>Volume, gallons</u> Note: For detention time in hours multiply by 24hr/day and for Flow, gpd detention time in minutes multiply by 1440 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

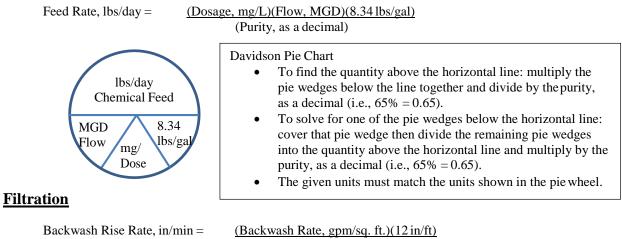
Chlorine Residual, mg/L = Chlorine Dosage, mg/L – Chlorine Demand, mg/L

CT calculation, time = (Disinfectant Residual Concentration, mg/L)(Time) Units must be compatible

#### **Electrical**

Amps (I) = <u>Volts (</u> Ohms	
Electromotive Force (E.M.F.), vol	ts = (Current, amps)(Resistance, ohms) or $E = I \times R$   R
Power, kilowatts (3 phase AC circ	$\frac{(E, \text{ volts})(I, \text{ amps})(Power Factor)(1.73)}{1,000 \text{ watts/kilowatt}}$
Power, kilowatts (single phase AC	$C \text{ circuit}) = \frac{(E, \text{ volts})(I, \text{ amps})(Power Factor)}{1,000 \text{ watts/kilowatt}} P$
Power, watts (DC circuit) = (E, vo	
Power Output, horsepower =	(Power Input, kilowatts)(Efficiency, %) (0.746 kilowatt/horsepower)(100%)
Power Requirements, kW-hr =	(Power, kilowatts)(Time, hours)

#### Feed Rate



#### (7.48 gal/cu. ft.)

Backwash Pumping Rate, gal/min	= (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 =	<u>Water Drop in Filter, ft</u> Time to Drop, min
Filtration Rate or Backwash Rate	GPM/sq ft = Flow GPM

Filtration Rate or Backwash Rate, GPM/sq. ft. =

<u>Flow, GPM</u> Filter Surface Area, sq. ft. Hydraulic or Surface Loading Rate, gpd/sq ft =

<u>Total Flow Applied, gpd</u> Surface Area, sq ft

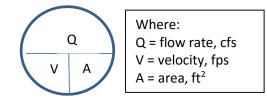
Unit Filter Run Volume, gal/sq. ft. =

<u>Volume Filtered, gal</u> 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, ft/sec) or  $Q = V \times A$ 



Flow Rate, gpm = (Area, sq. ft.)(Velocity, ft/sec)(7.48 gal/cu ft)(60 sec/min) or Q = V x A x 7.48 x 60

Velocity, fps = Flow rate, cfs/Area, sq. ft or Distance, ft/Time, seconds

Reduction in Flow, % = <u>(Original Flow – Reduced Flow)(100%)</u> Original Flow

### <u>Fluoridation</u>

Feed Rate, lbs/day = (Dosage, mg/L)(Flow, MGD)(8.34 lbs/gal) (Fluoride solution, as a decimal)(Purity, as a decimal)
Feed Rate, gpd = <u>Feed Rate, lbs/day</u> Chemical solution, lbs/gal
Feed Rate, lbs/day = <u>Fluoride, lbs/day</u> Fluoride, lbs / lb of commercial chemical
Fluoride ion purity, % = (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 ml = (Actual Weight, gm)(1,000 ml) (desired Weight, gm)

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

# Leakage and Pressure Testing Pipelines

Leakage, gpd =	Volume, gal
	Time, days

AC or Ductile Iron Pipe, gpd/mi-in = <u>Leak Rate, gpd</u> (length, mi)(Diameter, in)

Plastic pipe, gph/100 joints = <u>Leak Rate, gph</u> (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

ppm = mg/l =	Pounds of Chemical, lbs
	(8.34 lbs/gal)(gallons, MG)

#### **Pressure and Head**

Head (Height of Water), ft = (Pressure, psi)(2.31 ft/psi)

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

Pressure, psi =	<u>Height, ft</u>	or	Pressure, psi = Height, ft x 0.433 psi/ft
	2.31 ft/psi		

#### **Pumps and Motors**

Brake (bhp) = $(Flow, GPM)(Head, ft)$ (3,960)(Decimal Pump Efficiency)
Motor (mhp) = (Flow, GPM)(Head, ft) (3,960)(Decimal Pump Efficiency)(Decimal Motor Efficiency)
Water (whp) = $(Flow, GPM)(Head, ft)$ 3,960
Pumping Rate, GPM = <u>Volume, gal</u> Time, min
Total Dynamic Head, ft = Static Head, ft + Discharge Head, ft + Friction Losses, ft
Wire-to-Water Efficiency, % = (Water Horsepower, HP)(100%) Power Input, (Brake HP or Motor HP)
Wire-to-Water Efficiency, % =(Flow, gpm)(Total Dynamic Head, ft)(100%) (Voltage, volts)(Current, amps)(5.308)
Kilowatt- hr/day = (Motor, HP) $\frac{x 24 \text{ hr}}{\text{day}}$ x $\frac{0.746 \text{ kW}}{\text{HP}}$
Cost, \$/day = Kilowatt-hr/day x cost, \$/kWh

## Softening Processes

#### <u>Hardness</u>

Total Hardness, mg/l as  $CaCO_3 =$ = Calcium Hardness, mg/l as  $CaCO_3 +$  Magnesium Hardness, mg/l as  $CaCO_3$ = (2.5)(Ca, mg/l) + (4.12)(Mg, mg/l)

If alkalinity is greater than total hardness:

Carbonate Hardness, mg/l as  $CaCO_3 = Total Hardness$ , mg/l as CaCO3 and Noncarbonate Hardness, mg/l as  $CaCO_3 = 0$ 

If alkalinity is less than total hardness:

Carbonate Hardness, mg/l as CaCO<sub>3</sub> = Alkalinity, mg/l as CaCO<sub>3</sub> and Noncarbonate Hardness, mg/l as CaCO<sub>3</sub> = Total Hardness Removed, mg/l as CaCO<sub>3</sub> – Alkalinity removed, mg/l as CaCO<sub>3</sub>

Lime Softening - If hydrated lime (Ca(OH)<sub>2</sub>) is used instead of quicklime (CaO), substitute 74 for 56 in equations below.

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Excess Lime, $mg/l = (A + B + C + D)(0.15)$				
Soda Ash: dosage to remove noncarbonated hardness Soda Ash (Na <sub>2</sub> CO <sub>3</sub> ) Feed, mg/l = (Noncarbonate Hardness, mg/l as CaCO <sub>3</sub> )(106/100)				
Carbon Dioxide: dosage to recarbonate Total CO <sub>2</sub> Feed, mg/l = (excess lime, mg/l)(44/56) + (Mg <sup>2</sup> + residual, mg/l)(44/58.3)				
Feeder Setting, lbs/day = (Flow, MGD)(Dose, mg/l)(8.34lbs/gal)				
Feed Rate, $lbs/min = \frac{Feeder Setting, lbs/day}{(60 min/hr)(24 hr/day)}$				
Ion Exchange Softening				
Hardness, grains/gallon = <u>(Hardness, mg/l)(1 grain/gallon)</u> 17.1 mg/l				
Exchange Capacity, grains = (Media Volume, cu ft)(Removal Capacity, grains/cuft				
Water Treated, gal = <u>Exchange Capacity, grains</u> Hardness Removed, grains/gallon				
Operating Time, hr = <u>Water Treated, gal</u> (Avg Daily Flow, gpm)(60 min/hr)				
Salt Needed for Regeneration, lbs Salt Required, lbs/1,000 grains)(Hardness Removed, grains				
Brine, gal = <u>Salt Needed, lbs</u> Salt Solution, lbs/gal of brine				
Bypass Flow, gpd = (Total Flow, gpd)(Finished Water Hardness, gpg) Source Water Hardness, gpg				
Bypass Water, gal = <u>(Softener Capacity, gal)(Bypass Flow, gpd)</u> Softener Flow, gpd				
Total Flow, gal = Softener Capacity, gal + Bypass Water, gal				

# **Temperature**

Degrees Celsius =:  $[(°F - 32)(^{5}/_{9})]$  or [(°F - 32)(0.555) or (°F - 32)1.8

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

#### **Turbidity**

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

## Water Production

Gallons/Capita/Day = <u>Volume of Water Produced, gpd</u> Population

# **Abbreviations:**

Abbreviations	Types of Measurement	Abbreviations	Measurement Volumes
cfs	Cubic feet per second	m	Meter
DO	Dissolved oxygen	mg	Milligrams
ft	Feet	mg/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