pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Commonwealth of Pennsylvania
State Board for Certification of Water and Wastewater Systems Operators

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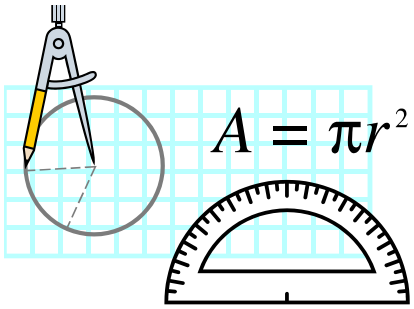
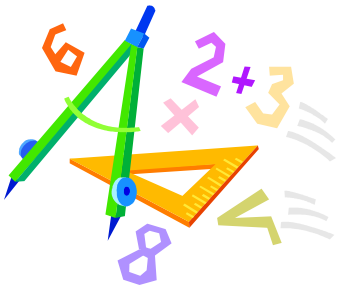
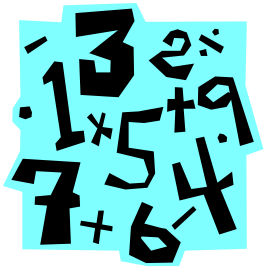
Formulas, Conversions, and Common Scientific Units



Formulas, Conversions & Abbreviations





Units of Weight, Volume, Time, Density, Concentration & Flow

Formulas & Conversions

Formulas

AREA

Area of Rectangle = (Length) x (Width)

Area of Triangle = ½ x (Base) x (Height)

Area of Circle = (0.785) x (Diameter^2) or (3.14) x (Radius^2)

Area of Cylinder Surface = [(0.785) x (Diameter^2)] + [(3.14) x (Diameter) x (Height)]

Circumference of Circle = (3.14) x (Diameter) or (2) x (3.14) x (Radius)

Curved Surface Area of a Cylinder = (2) x (3.14) x (Radius) x (Height)

End Surface Areas of a Cylinder (both ends) = (2) x (3.14) x (Radius^2)

VOLUME

Volume of Rectangular Tank (ft^3) = (Length) x (Width) x (Height)

Volume of Cone (ft^3) = (.333) x (0.785) x (Diameter^2) x (Height)

Volume of Cylinder (ft^3) = (0.785) x (Diameter^2) x (Height) or (3.14) x (Radius^2) x (Height)

Volume of a Treatment Vessel, gal = Volume (ft^3) x (7.48 gal/ ft^3)

WATER FORMULAS

$$\text{Alkalinity} = \frac{(\text{mL of Titrant})(\text{Acid Normality})(50{,}000)}{\text{mL of Sample}}$$

Chlorine Demand (mg/L) = Chlorine dose – chlorine residual

CT = Concentration of disinfectant residual X contact time (mins)

$$\text{Detention Time (minutes)} = \frac{\text{Volume of Tank (gallons)}}{\text{Influent Flow (gpm)}}$$

Dilution Formula:
Volume of Solution 1 (gal) x % of Solution 1 = Volume of Solution 2 (gal) x % of Solution 2

$$\text{Discharge} = \frac{\text{Volume}}{\text{Time}}$$

$$\text{Dose, mg/L} = \frac{\text{Feed Rate, lbs/day}}{(\text{Flow, MGD}) \times (8.34 \text{ lbs/gal})}$$

Dry Chemical, lbs. = 8.34 x Volume (gallons) x % Solution (as a decimal)

$$\text{Efficiency, \%} = \frac{\text{In} - \text{Out}}{\text{In}} \times 100$$

Feed Rate, lbs/day = (Flow, MGD) x (Dosage, mg/L) x (8.34 lbs/gal)

$$\text{Feed Rate, gal/day} = \frac{\text{(Flow, MGD) x (Dosage, mg/L) x (8.34 lbs/gal)}}{\text{(Active ingredient weight (lbs/gal)}}$$

$$\text{Filter Backwash or Loading rate} = \frac{\text{Flow (gpm)}}{\text{Filter surface area (ft}^2\text{)}}$$

$$\text{Hardness} = \frac{\text{(mL of Titrant) (1,000)}}{\text{mL of Sample}} \text{ (for 0.2 N EDTA)}$$

Horsepower (hp):

$$\text{Motor hp} = \frac{\text{(Flow, gpm) (Total Water Head, ft)}}{3960}$$

$$\text{Brake hp} = \frac{\text{Motor hp}}{\text{pump efficiency}}$$

$$\text{Ion Exchange Regeneration Brine (gal)} = \frac{\text{Salt dosage (lbs/ft3) x Volume of Resin (ft3)}}{\text{Brine solution active strength (lbs/gal)}}$$

$$\text{Reduction in Flow, \%} = \frac{\text{(Original Flow - Reduced Flow) (100\%)}}{\text{Original Flow}}$$

$$\text{Surface Loading Rate (gpd/ft}^2\text{)} = \frac{\text{Flow Rate, gpd}}{\text{Surface Area, ft}^2}$$

UV Absorbance (A) = Log (100%/%T) where $T = I/I_o$

I = Intensity at sensor (milliwatts per square centimeter)

I_o = Intensity at source (milliwatts per square centimeter)

T = Transmittance

$$\text{Velocity} = \frac{\text{Flow}}{\text{Area}} \text{ or } \frac{\text{Distance}}{\text{Time}}$$

Weight of a liquid, lbs = gallons x Specific Gravity x 8.34 lbs/gal

Weight of active ingredient, lbs = gallons x Specific Gravity x 8.34 x % solution (as a decimal)

WASTEWATER FORMULAS

Chlorine Demand (lbs/day) = Dose (lbs/day) – Residual (lbs/day)

$$\text{Detention Time} = \frac{\text{Volume of Tank}}{\text{Influent Flow}}$$

$$\text{Efficiency, \% removal} = \frac{\text{In} - \text{Out}}{\text{In}} \times 100$$

$$\text{Food/Microorganism Ratio} = \frac{\text{Influent BOD, lbs/day}}{\text{MLVSS, lbs}}$$

Horsepower (hp):

$$\text{Motor hp} = \frac{\text{(Flow, gpm)} \times \text{(Total Water Head, ft)}}{3960}$$

$$\text{Brake hp} = \frac{\text{Motor hp}}{\text{pump efficiency}}$$

$$\text{Hydraulic Surface Loading Rate (gpd/ft}^2\text{)} = \frac{\text{Flow Rate (gpd)}}{\text{Surface Area (ft}^2\text{)}}$$

Load, lbs = (Concentration, mg/L) x (Volume, mil. Gal) x 8.34

Loading, lbs/day = (Concentration, mg/L) x (Flow, MGD) x 8.34

Mean Cell Residence Time (MCRT) =

$$\frac{\text{(Suspended Solids in Aeration System, lbs)}}{\text{(Suspended Solids Wasted, lbs/day + Suspended Solids Lost in Effluent, lbs/day)}}$$

$$\text{Organic Loading Rate Trickling Filter} = \frac{\text{Organic Load (BOD), lbs/day} \times 1{,}000\text{ft}^3}{\text{Volume, ft}^3}$$

$$\text{Oxygen Uptake} = \frac{\text{Oxygen Usage (mg/L)}}{\text{Time (min)}}$$

$$\text{Pump rate} = \frac{\text{Volume}}{\text{Time}}$$

$$\text{Slope} = \frac{\text{Drop or Rise}}{\text{Distance}}$$

$$\text{Sludge Volume Index} = \frac{\text{(Settleable Solids, \%)} \times (10{,}000)}{\text{MLSS, mg/L}}$$

$$\text{Solids Loading Trickling Filter, (lbs/day/ft}^2\text{)} = \frac{\text{Solids Applied, lbs/day}}{\text{Surface Area, ft}^2}$$

$$\text{Solids, mg/L} = \frac{(\text{Dry Solids, grams}) \times (1{,}000{,}000)}{\text{ML of Sample}}$$

$$\text{Surface Loading Rate (gpd/ft}^2\text{)} = \frac{\text{Flow Rate, gpd}}{\text{Surface Area, ft}^2}$$

$$\text{Velocity} = \frac{\text{Flow}}{\text{Area}} \text{ or } \frac{\text{Distance}}{\text{Time}}$$

$$\text{Volatile Solids, \%} = \frac{(\text{Dry Solids} - \text{Ash Solids}) \times (100\%)}{\text{Dry Solids}}$$

$$\text{Weir Overflow Rate} = \frac{\text{Flow (gpd)}}{\text{Weir Length, (ft)}}$$

Weight of a liquid, lbs = gallons x Specific Gravity x 8.34

Conversion Factors:

1 acre = 43,560 square feet	1 horsepower = 0.746 kilowatts
1 cubic foot = 7.48 Gallons	1 million gallons per day = 694 gallons per minute
1 foot = 0.305 meters	1 pound = 0.454 kilograms
1 gallon = 3.79 liters	1 pound per square inch = 2.31 feet of water
1 gallon = 8.34 pounds	Degrees Celsius = (Degrees Fahrenheit – 32) (5/9)
1 grain per gallon = 17.1mg/L	Degrees Farenheit = (Degrees Celsius x 1.8) + 32
1 mg/L = 1 ppm	1 Ft of water column = 0.43 psi

Abbreviations:

BOD	Biochemical Oxygen Demand
ft	feet
gpd	gallons per day
gpg	grains per gallon
gpm	gallons per minute
lbs	pounds
mg/L	milligrams per Liter
MGD	million gallons per day
mL	milliliter
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solids
ppm	parts per million

UNITS OF WEIGHT	
English	Metric
pound - lb	gram - g milligram - mg kilogram - kg
CONVERSIONS	
Metric/Metric	Metric/English
1000 mg = 1 g or 1000 mg/g 1000 gm = 1 kg or 1000 g/kg	1 lb = 454 g or 454 g/lb 1 kg = 2.2 lbs or 2.2 lbs/kg

UNITS OF VOLUME		
English	Metric	
gallon - gal million gallon - Mgal cubic feet - cu ft	liter - L milliliter - mL	
CONVERSIONS		
Metric/Metric	Metric/English	English/English
1000 mL = 1 liter or 1000 mL/L	1 gal = 3.785 L or 3.785 L/gal 1 gal = 3785 mL or 3785 mL/gal	7.48 gal = 1 cu ft or 7.48 gal/cu ft

UNITS OF TIME	
day - day hour - hr	minute - min second - sec
CONVERSIONS	
1 day = 24 hr or 24 hr/day 1 hr = 60 min or 60 min/hr	1 min = 60 sec or 60 sec/min 1 day = 1440 min or 1440 min/day

UNITS OF DENSITY	
English	Metric
lbs/gal lbs/cu ft	kg/L g/mL
THE DENSITY OF WATER	
English	Metric/Metric
8.34 lbs/gal 62.4 lbs/cu ft	1 kg/L 1 g/mL

UNITS OF CONCENTRATION	
English	Metric
lbs/gal	mg/L
CONVERSIONS	
1 lb/gal = 120,000 mg/L	

UNITS OF FLOW	
English	Metric
gallons per minute - gal/min - GPM gallons per day - gal/day - GPD million gallons per day - Mgal/day - MGD cubic feet per second - cu ft/sec - CFS	milliliters per minute - mL/min
CONVERSIONS	
English/English	English/Metric
1 MGD = 694 GPM or 694 GPM/MGD 1 MGD = 1.55 CFS or 1.55 CFS/MGD	1 gal/day = 2.63 mL/min

Davidson Pie