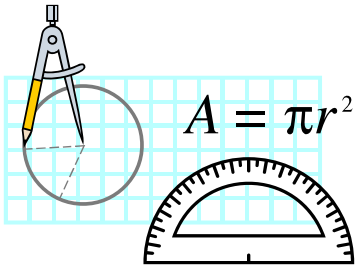
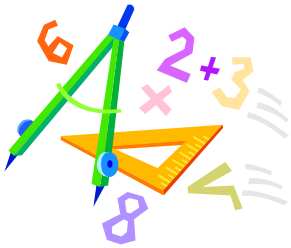
Commonwealth of Pennsylvania
State Board for Certification of Water and Wastewater Systems Operators

2/1/2007

Formulas, Conversions, and Common Scientific Units



ABC Formulas, Conversions & Abbreviations



DEP Dry and Liquid Chemical Feed Diagrams

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Unit Cancellation Steps

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

Formulas & Conversions

Formulas

AREA

Area of Rectangle = (Length) (Width)

Area of Triangle = (Base) (Height)

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

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

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

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

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

VOLUME

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

Volume of Cone (ft^3) = (1/3) (0.785) (Diameter^2) (Height)

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

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

WATER AND WASTEWATER

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

Chemical Feed Pump Setting (mL/min) = (Flow, MGD)(Dose, mg/L)(3.785 L/gal)(1,000,000 gal/MG) / (liquid, mg/mL)(24hr/day)(60 min/hr)

Chlorine Demand (lbs/day) =
lbs of Chlorine Fed/day – [(Chlorine Residual, mg/l) (Flow, MGD) (8.34)]

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

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

$$\text{Dose, mg/L} = \frac{\text{Feed Rate, lbs/day}}{\text{Flow, MGD X 8.34 lbs/mg/L./MG}}$$

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mL of Sample¶
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Volume of a Cylinder = (Π) (Radius^2) (Height)

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2¶
Circumference of Circle = (∏) (Diameter) or (2) (∏) (Radius)¶

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Dry Chemical, lbs. = water (lbs)
{100% / Chemical (%)) - 1

Efficiency, % = (In – Out) X 100
In

Feed Rate, lbs/day = (Plant Capacity, MGD) (Dosage, mg/L) (8.34 lbs/gal)

Filter Backwash rate = Flow (gpm)
Filter surface area (ft^2)

Food/Microorganism Ratio = Influent BOD, lbs/day
Aeration System MLVSS, lbs

Gallons/Capita/Day = Gallons Per Day
Population

Hardness = (mL of Titrant) (1,000) (for 0.2 N EDTA)
mL of Sample

Horsepower (hp):
theoretical hp = (Flow, gpm) (Total Water Head, ft)
3960

brake hp = theoretical hp
pump efficiency

Hydraulic Surface Loading Rate (gpd/ft^2) = Flow Rate (gpd)
Surface Area (ft^2)

Loading rate (lbs/day) = (Concentration, mg/l) (Flow, MGD) (8.34)

Mean Cell Residence Time (MCRT):
(lbs of Suspended Solids in Aeration System)
(lbs of Suspended Solids Wasted/Day + lbs of Suspended Solids Lost in Effluent/Day)

Organic Loading Rate = Organic Load, lbs BOD/day
Volume in 1000 ft^3

Oxygen Uptake = Oxygen Usage (mg/L)
Time (min)

Population Equivalent = (Flow, MGD) (BOD, mg/L) (8.34 lbs/gal)
0.18 lbs BOD/day/person

Reduction in Flow, % = (Original Flow - Reduced Flow) (100%)
Original Flow

Slope = Drop or Rise
Distance

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

Solids Applied (liquid), lbs/day = (Flow, MGD) (Concentration, mg/l) (8.34 lbs/gal)

Solids Loading, lbs/day/sq ft = $\frac{\text{Solids Applied, lbs/day}}{\text{Surface Area, sq ft}}$

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

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

Suspended Solids Under Aeration = (mlss, mg/L)(Tank volume, million gallons)(8.34 lbs/gal)

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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

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

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

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Waste Milliequivalents = (mL) (Normality)

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

¶

Volume of Cone (ft^3) = (1/3) (.785) ($Diameter^2$) (Height)¶

¶

Volume of Cylinder (ft^3) = (.785) ($Diameter^2$) (Height) or¶

(Π) ($Radius^2$) (Height)¶

Waste Normality = $\frac{\text{(Titrant Volume) (Titrant Normality)}}{\text{Sample Volume}}$ Note: Volumes are in same units

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

Weight in lbs = gallons X Specific Gravity X 8.34 lbs/gal

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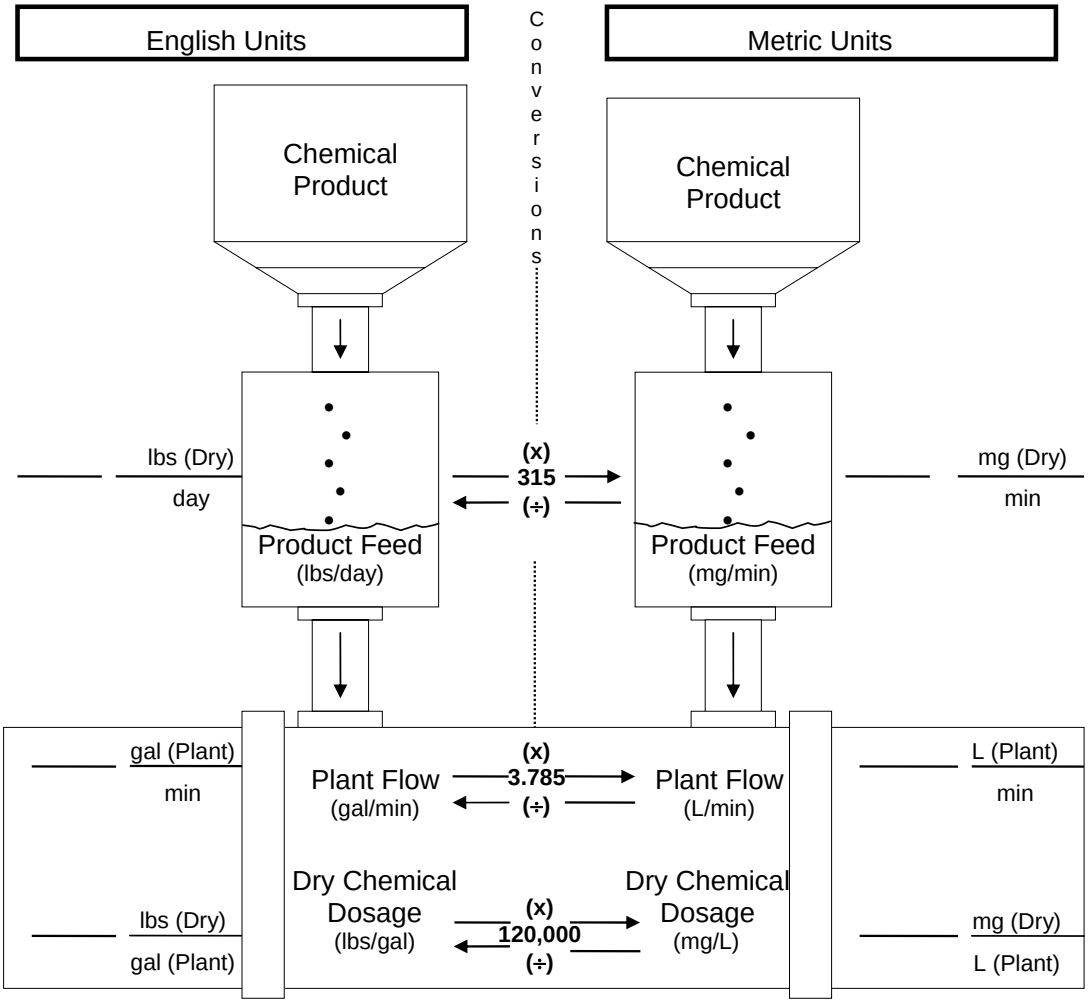
Conversion Factors:

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 = 17.1 mg/L	Degrees Farenheit = (Degrees Celsius) * 1.8 + 32
1 mg/l = 1 ppm	1 Ft of water column = 0.43 psi

Abbreviations:

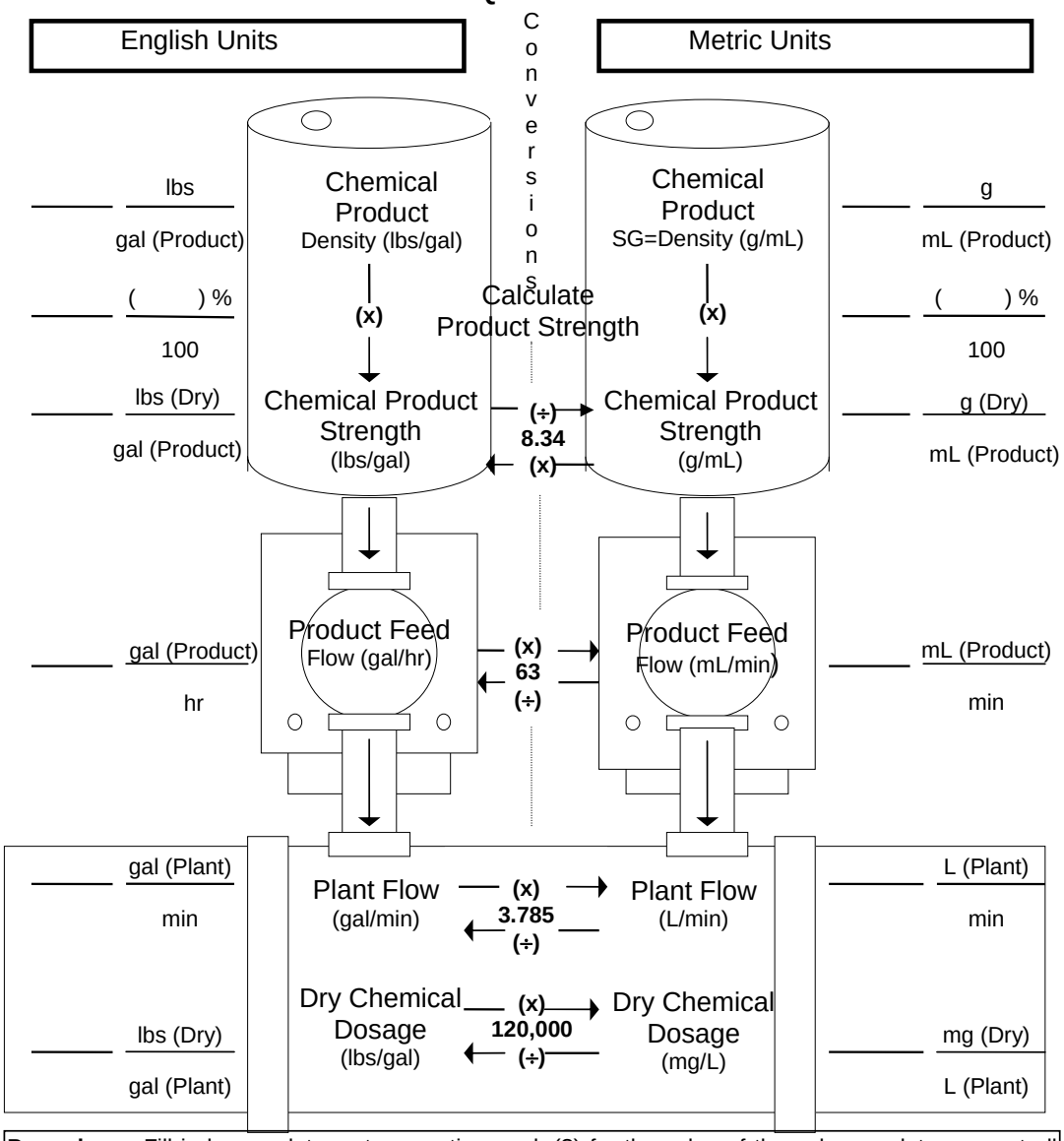
BOD	Biochemical Oxygen Demand
ft	feet
gpd	gallons per day
gpg	grains per gallon
gpm	gallons per minute
lbs	pounds
mg/L	milligrams per Liter
MGD	million gallons per day
mL	milliliter
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solids
ppm	parts per million

CHEMICAL FEED CALCULATION DIAGRAM
DRY FEED



Procedure: Fill in known data; put a question mark (?) for the value of the unknown data; convert all data to the units on the side where the (?) was placed and fill in the values; use unit cancellation to solve for the unknown.

CHEMICAL FEED CALCULATION DIAGRAM
LIQUID FEED



Procedure: Fill in known data; put a question mark (?) for the value of the unknown data; convert all data to the units on the side where the (?) was placed and fill in the values; use unit cancellation to solve for the unknown.

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	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

Deleted: Unit Cancellation Steps¶
¶
¶
Step 1: . List unknown data as a question mark (?) including units, followed by an equals sign (=).¶
¶
Sept 2: . Place data with same numerator unit to the right of the equal sign followed by a multiplication sign.¶
¶
Step 3: . To cancel unwanted denominator unit, next place data with same numerator unit.¶
¶
Step 4: . Continue to place data into equation to systematically cancel all unwanted units until only the unknown units remain.¶
¶
Step 5: . Do the math (multiply all numerator values, multiply all denominator values; then divide numerator by the denominator.)¶
¶
<sp>¶
<sp>Example: ? lbs = 1 x 1 g x 3785 mL = 8.34 lbs ¶
gal 454 g mL 1 gal¶
¶
¶
¶
Helpful Hints:¶
¶
Numerator¶
Denominator¶
¶
Vertical format: 5 gal = 5 gal¶
1¶
¶
1 g = 1000 mg is written: 1 g OR 1000 mg¶
1000 mg 1 g ¶
¶
"per" means divided by: Example: 5 gpm = 5 gal¶
min¶
¶
Inverting: 5 gal = 1 min¶
min 5 gal¶
¶
Page Break

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
CONVERSION	
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