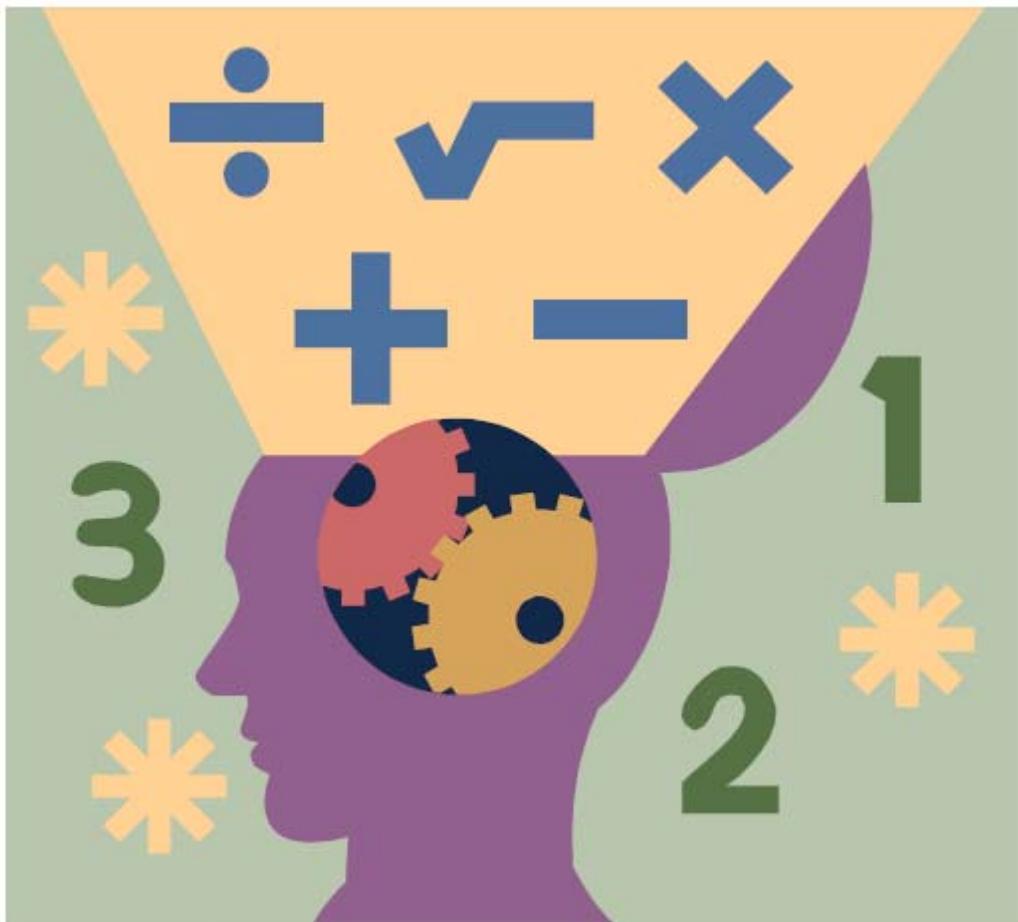


Wastewater Treatment Mathematical Formulas

Second Edition



Fleming Training Center
Murfreesboro, TN
Updated January 13, 2011

Index

Activated Sludge	11, 12
Area	4
Chlorination	9
Conversion Factors	1, 2
Converting lbs/gal to mg/mL.....	2
Depth/Diameter Table	18
Dosage, general.....	5
Flow	4
Flow Conversions Chart.....	3
Flow, Partially Full Pipe.....	18
Laboratory	15, 16, 17
Metric Conversion	2
Pounds Formulas	5
Power	5
Preliminary Treatment.....	7
Pumps.....	6, 7
Sedimentation	8
Solution Preparation.....	7
Sludge, Dewatering and Disposal	14
Sludge, Digestion	12, 13
Sludge, Production and Thickening.....	13
Temperature.....	2 and 17
Trickling Filters	9
Volume.....	4
Waste Treatment Ponds.....	14, 15

Conversion Factors

Length

1 foot (ft)	12 inches (in)
1 yard (yd)	3 feet (ft)
1 mile (mi).....	5,280 feet (ft)

Area

1 acre (ac)	43,560 square feet (ft ²)
1 acre	0.405 Hectare (Ha)
1 Hectare	2.47 acres
1 square foot (ft ²).....	144 square inches (in ²)

Volume

1 cubic foot (ft ³)	7.48 gallons (gal)
1 yd ³	27 ft ³
1 gallon.....	231 cubic inches (in ³)
1 gallon.....	0.1337 ft ³
1 gallon.....	3.785 Liters (L)
1 gallon.....	0.000001 Million Gallon (MG)
1 liter.....	1,000 milliliters (mL)
1 liter.....	0.2642 gal
1 acre/foot (ac-ft)	43,560 cubic feet (ft ³)
1 acre-foot (ac-ft).....	325,828.8 gallons (gal)

Flow

1 cubic foot per second (ft ³ /sec)	449 gal/min
1 cubic foot per second (ft ³ /sec)	0.6463 MGD
1 gal/min	0.00144 MGD

Weight and Mass

1 gallon of water	8.34 pounds (lbs)
1 cubic foot of water (ft ³).....	62.4 lbs
1 pound (lb)	453.6 grams (g)
1 kilogram (kg).....	1,000 grams (g)
1 kilogram	2.2 pounds
1 gram	1,000 milligrams (mg)
1%	10,000 milligrams per liter (mg/L)
1 mg/L	0.0584 grains per gallon
1 grain per gallon.....	17.118 mg/L

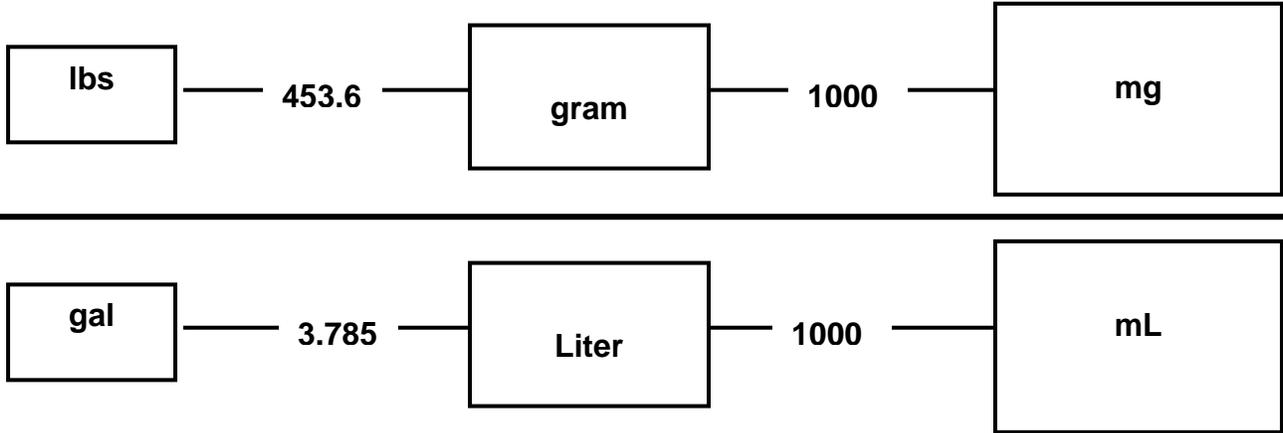
Pressure and Head

1 foot of head..... 0.433 pounds per square in (psi)
 1 pound per square inch (psi)2.31 feet of head

Temperature Conversions

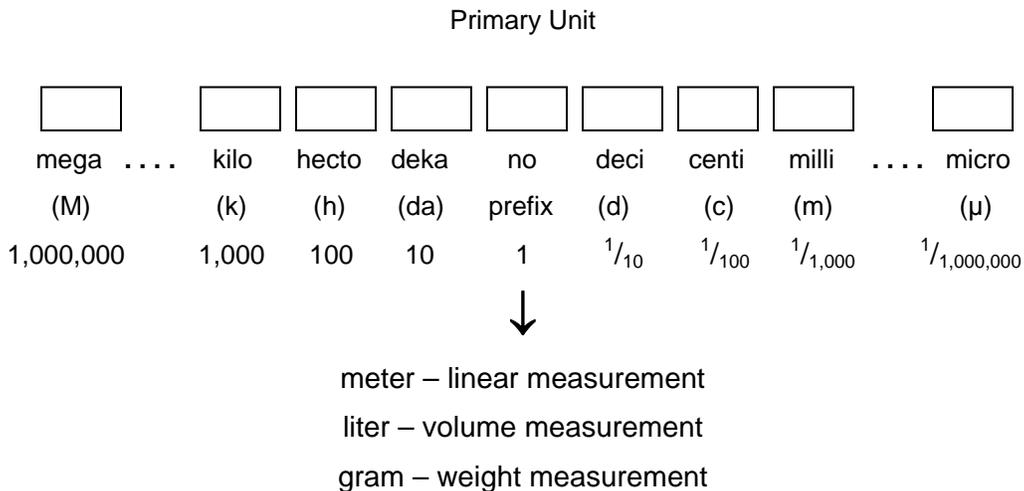
°C 0.556 (°F-32°)
 °F 1.8(°C) + 32°

Converting lbs/gal to mg/mL

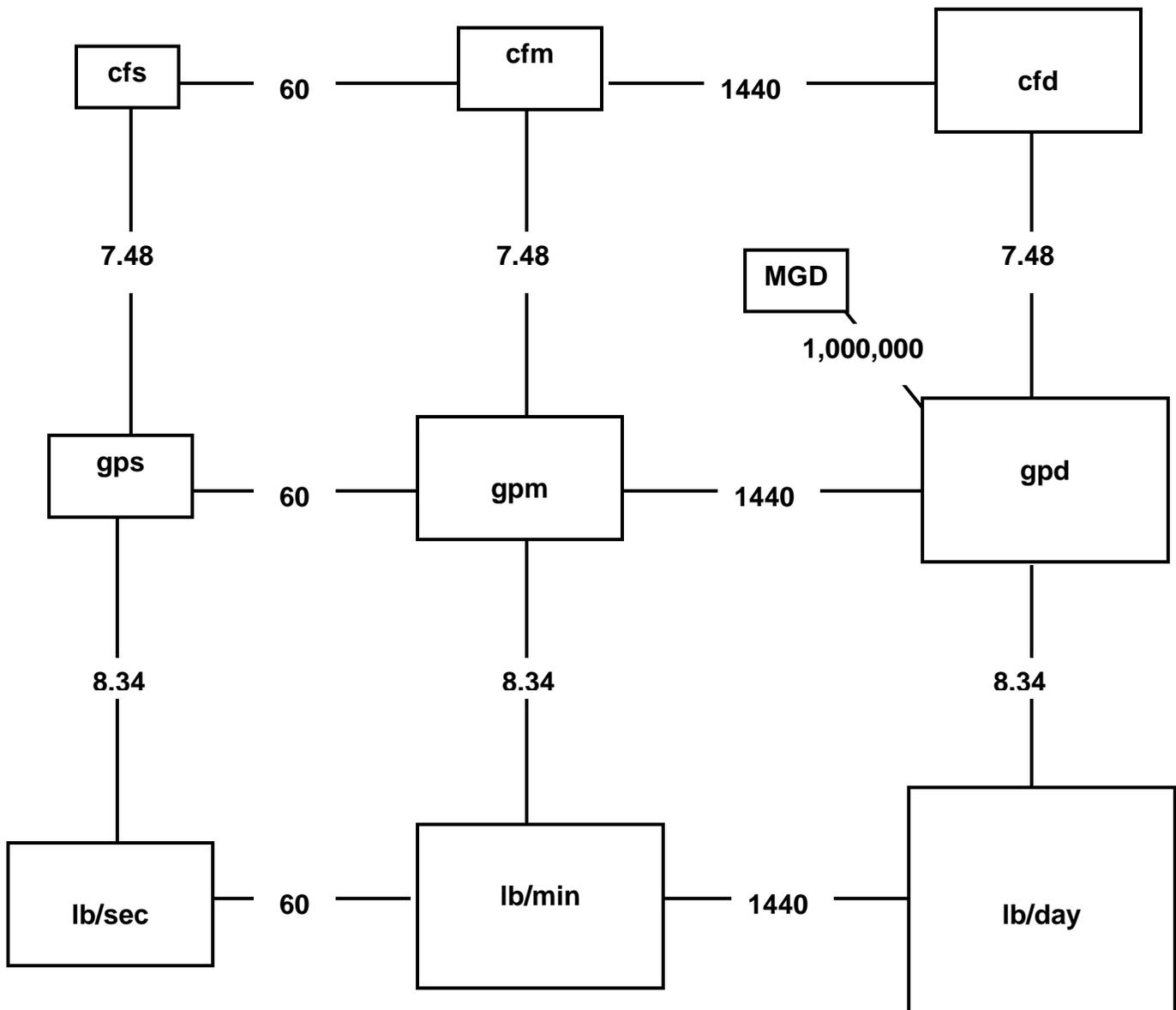


To use this diagram: First, find the box that coincides with the beginning unit (i.e. mg/mL). Then find the box that coincides with the desired ending units (i.e. lbs/gal). The numbers between the starting point and ending point are the conversion factors. When moving from a smaller box to a larger box, multiply by the factor between them. When moving from a larger box to a smaller box, divide by the factor between them. For the final number, divide the top number by the bottom number.

Metric Conversions



Flow Conversions



cfs = cubic feet per second
 cfm = cubic feet per minute
 cfd = cubic feet per day

gps = gallons per second
 gpm = gallons per minute
 gpd = gallons per day

To use this diagram: First, find the box that coincides with the beginning units (i.e. gpm). Then, find the box that coincides with the desired ending units (i.e. cfs). The numbers between the starting point and ending point are the conversion factors. When moving from a smaller box to a larger box, multiply by the factor between them. When moving from a larger box to a smaller box, divide by the factor between them.

Area

Rectangle: Area, ft² = (Length, ft)(Width, ft)

Circle: Area, ft² = (0.785) (Diameter, ft)²

Segment of a Circle, ft² Volume, ft³ = 1.333 (Height, ft)² $\sqrt{\frac{\text{Diameter, ft}}{\text{Height, ft}} - 0.608}$

Volume

Rectangle, ft³: Volume, ft³ = (Length, ft)(Width, ft)(Depth, ft)

Cylinder, ft³: Volume, ft³ = (0.785) (Diameter, ft)² (Depth or Length, ft)

Cone, ft³: Volume, ft³ = $\frac{(0.785) (\text{Diameter, ft})^2 (\text{Depth, ft})}{3}$

Segment of Cylinder, ft³: Volume, ft³ = $\left[1.333 (\text{Height})^2 \sqrt{\frac{\text{Diameter, ft}}{\text{Height, ft}} - 0.608} \right] (\text{Length, ft})$

Wedge, ft³: Volume, ft³ = $\frac{(\text{Length, ft})(\text{Width, ft})(\text{Depth, ft})}{2}$

Volume, gallons = Volume, gal = (Volume, ft³)(7.48gal/ft³)

Flow

Q = AV OR Q = (Area) (Velocity)

Q (Channel), ft³/sec = (Width, ft)(Depth, ft)(Velocity, ft/sec)

Q (Pipeline), ft³/sec = (0.785) (Diameter, ft)² (Velocity, ft/sec)

Partially Full Pipe = Flow, ft³/sec = $\left[1.333 (\text{Height})^2 \sqrt{\frac{\text{Diameter, ft}}{\text{Height, ft}} - 0.608} \right] (\text{Velocity, ft/sec})$

Velocity, ft/sec = $\frac{\text{Flow, ft}^3/\text{sec}}{(0.785) (\text{Diameter, ft})^2}$

Velocity, ft/sec = $\frac{\text{Distance, ft}}{\text{Time, sec}}$

Average Daily Flow, MGD = $\frac{\text{Sum of All Daily Flows, MGD}}{\text{Number of Daily Flows}}$

Annual Average Daily Flow, MGD = $\frac{\text{Sum of All Monthly Average Daily Flows, MGD}}{\text{Number of Monthly Average Daily Flows}}$

Daily Flow, gal/day/capita = $\frac{\text{Water Used, gal/day}}{\text{Total Number of People Served}}$

Dosage

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

$$\text{Dosage, mg/L} = \frac{(\text{Chemical Feed Rate, lbs/day}) (\text{Chemical Purity, \%, expressed as a decimal})}{(\text{Flow, MGD}) (8.34 \text{ lbs/gal})}$$

$$\text{Dosage, mg/L} = \frac{(\text{Feed Rate, grams/min}) (1,000 \text{ mg/gram})}{(\text{Flow, gal/min}) (3.785 \text{ L/gal})}$$

Pounds

$$\text{Chemical Fed, lbs} = (\text{Dose, mg/L}) (\text{Volume, MG}) (8.34 \text{ lbs/gal})$$

$$\text{Chemical Fed, lbs} = \frac{(\text{Dose, mg/L}) (\text{Volume, MG}) (8.34 \text{ lbs/gal})}{\text{Chemical Purity, \%, expressed as a decimal}}$$

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

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dose, mg/L}) (\text{Flow, MGD}) (8.34 \text{ lbs/gal})}{\text{Chemical Purity, \%, expressed as a decimal}}$$

$$\text{Feed Rate, lbs/day} = \frac{(\text{Concentration, mg/mL}) (\text{Volume Pumped, mL}) (1,440 \text{ min/day})}{(\text{Time Pumped, min}) (1,000 \text{ mg/g}) (453.6 \text{ g/lb})}$$

$$\text{Loading, lbs/day} = (\text{Concentration, mg/L}) (\text{Flow, MGD}) (8.34 \text{ lbs/gal})$$

Power

$$1 \text{ Horsepower} = 746 \text{ watts or } 0.746 \text{ kilowatts}$$

$$\text{Power, watts} = (\text{Volts}) (\text{Amps})$$

$$\text{Amps, single - phase} = \frac{(746 \text{ watts/HP}) (\text{Horsepower})}{(\text{Volts}) (\text{Efficiency, \%, as decimal}) (\text{Power Factor})}$$

$$\text{Amps, three - phase} = \frac{(746 \text{ watts/HP}) (\text{Horsepower})}{(1.732) (\text{Volts}) (\text{Efficiency, \%, as decimal}) (\text{Power Factor})}$$

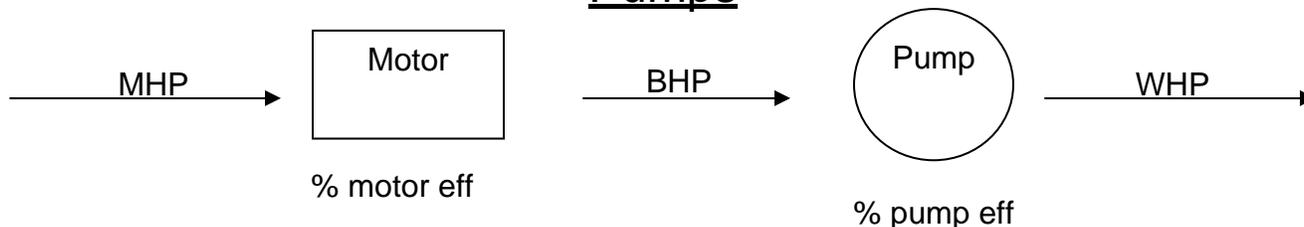
$$\text{Horsepower} = \frac{(\text{Volts}) (\text{Amps})}{(746 \text{ watts/HP})}$$

$$\text{Kilowatts, single - phase} = \frac{(\text{Volts}) (\text{Amps}) (\text{Power Factor})}{1,000 \text{ watts/kilowatt}}$$

$$\text{Kilowatts, three - phase} = \frac{(\text{Volts}) (\text{Amps}) (\text{Power Factor}) (1.732)}{1,000 \text{ watts/kilowatt}}$$

$$\text{Power Factor} = \frac{\text{Watts}}{(\text{Volts}) (\text{Amps})}$$

Pumps



$$\text{Pumping Rate, gal/min} = \frac{\text{Volume, gal}}{\text{Time, min}}$$

$$\text{Pumping Rate, gal/min} = \frac{(\text{Length, ft})(\text{Width, ft})(\text{Depth, ft})(7.48 \text{ gal/ft}^3)}{\text{Time, min}}$$

$$\text{Pumping Rate, gal/min} = \frac{(0.785)(\text{Diameter, ft})^2(\text{Depth, ft})(7.48 \text{ gal/ft}^3)}{\text{Time, min}}$$

$$\text{Time to Fill, min} = \frac{\text{Tank Volume, gal}}{\text{Flow Rate, gal/min}}$$

$$\text{Water HP} = \frac{(\text{Flow, gal/min})(\text{Head, ft})}{3960}$$

$$\text{Brake HP} = \frac{(\text{Flow, gal/min})(\text{Head, ft})}{(3960)(\text{Pump Efficiency, \%, expressed as a decimal})}$$

$$\text{Motor HP} = \frac{(\text{Flow, gal/min})(\text{Head, ft})}{(3960)(\text{Pump Eff., \%, expressed as decimal})(\text{Motor Eff., \%, expressed as decimal})}$$

$$\text{Brake HP} = \frac{(\text{Water Horsepower})}{\text{Pump Efficiency, \%, expressed as a decimal}}$$

$$\text{Motor HP} = \frac{(\text{Brake Horsepower})}{\text{Motor Efficiency, \%, expressed as a decimal}}$$

$$\text{Motor Efficiency, \%} = \frac{\text{Brake Horsepower}}{\text{Motor Horsepower}} \times 100\%$$

$$\text{Pump Efficiency, \%} = \frac{\text{Water Horsepower}}{\text{Brake Horsepower}} \times 100\%$$

$$\text{Efficiency, \%} = \frac{\text{Horsepower Output}}{\text{Horsepower Supplied}} \times 100\%$$

$$\text{Overall Efficiency, \%} = \frac{\text{Water Horsepower}}{\text{Motor Horsepower}} \times 100\%$$

$$\text{Wire - to - Water Efficiency, \%} = (\text{Pump Eff., \%, as decimal})(\text{Motor Eff., \%, as decimal})(100\%)$$

Wastewater Treatment Math Formulas

Static Head, ft = Suction Lift, ft + Discharge Head, ft

Static Head, ft = Discharge Head, ft - Suction Head, ft

Friction Loss, ft = (0.1) (Static Head, ft) **use this formula in absence of other data

Total Dynamic Head, ft = Static Head, ft + Friction Losses, ft

Cost, \$/hr = (Motor Horsepower) (0.746 kW/HP)(Cost, \$/kW - hr)

Solution Preparation

Percent Strength, % (by weight) = $\frac{\text{Weight of Chemical, lbs}}{(\text{Weight of Water, lbs} + \text{Weight of Chemical, lbs})} \times 100\%$

Concentration, % = $\frac{\text{Concentration, lbs/gal}}{\text{Density, lbs/gal}} \times 100\%$

(Concentration₁) (Volume₁) = (Concentration₂) (Volume₂)

(Normality₁) (Volume₁) = (Normality₂) (Volume₂)

Chemical, lbs = $\frac{(\text{Water Volume, gal}) (8.34 \text{ lbs/gal}) (\text{Desired Concentration, \%})}{(100\% - \text{Desired Concentration, \%})}$

Water Volume, gal = $\frac{(\text{Chemical, lbs}) (100\% - \text{Desired Concentration, \%})}{(\text{Desired Concentration, \%}) (8.34 \text{ lbs/gal})}$

Preliminary Treatment

Screenings Removed, ft³/day = $\frac{\text{Screenings, ft}^3}{\text{Day}}$

Screenings Removed, ft³/MG = $\frac{\text{Screenings, ft}^3}{\text{Flow, MG}}$

Screening Pit Capacity, days = $\frac{\text{Screening Pit Volume, ft}^3}{\text{Screenings Removed, ft}^3/\text{day}}$

Grit Removal, ft³/MG = $\frac{\text{Grit Volume, ft}^3}{\text{Flow, MG}}$

Sedimentation

$$\text{Detention Time, hrs} = \frac{(\text{Volume of Basin, gal}) (24 \text{ hr/day})}{\text{Flow, gal/day}}$$

$$\text{Weir Overflow Rate, gal/day/ft} = \frac{\text{Flow, gal/day}}{\text{Total Weir Length, ft}}$$

$$\begin{array}{l} \text{Weir Length, ft} \\ \text{(rectangular basin)} \end{array} = (2)(\text{Length, ft}) + (2)(\text{Width, ft})$$

$$\begin{array}{l} \text{Weir Length, ft} \\ \text{(circular basin)} \end{array} = (3.14)(\text{Diameter, ft})$$

$$\begin{array}{l} \text{Weir Overflow Rate, gal/day/ft} \\ \text{(rectangular basin)} \end{array} = \frac{\text{Flow, gal/day}}{(2)(\text{Length, ft}) + (2)(\text{Width, ft})}$$

$$\begin{array}{l} \text{Weir Overflow Rate, gal/day/ft} \\ \text{(circular basin)} \end{array} = \frac{\text{Flow, gal/day}}{(3.14)(\text{Diameter, ft})}$$

$$\text{Surface Overflow Rate, gal/day/ft}^2 = \frac{\text{Flow, gal/day}}{\text{Surface Area, ft}^2}$$

$$\text{Solids Loading Rate, lbs/day/ft}^2 = \frac{\text{Solids Applied, lbs/day}}{\text{Surface Area, ft}^2}$$

$$\begin{array}{l} \text{Solids Loading Rate, lbs/day/ft}^2 \\ \text{(rectangular basin)} \end{array} = \frac{\text{Solids Applied, lbs/day}}{(\text{Basin Length, ft}) (\text{Basin Width, ft})}$$

$$\begin{array}{l} \text{Solids Loading Rate, lbs/day/ft}^2 \\ \text{(circular basin)} \end{array} = \frac{\text{Solids Applied, lbs/day}}{(0.785) (\text{Basin Diameter, ft})^2}$$

$$\text{BOD Removed, lbs/day} = (\text{BOD Removed, mg/L}) (\text{Flow, MGD}) (8.34 \text{ lbs/gal})$$

$$\text{Suspended Solids Removed, lbs/day} = (\text{Suspended Solids Removed, mg/L}) (\text{Flow, MGD}) (8.34 \text{ lbs/gal})$$

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

Chlorination

Chlorine Demand, mg/L = Chlorine Dose, mg/L - Chlorine Residual, mg/L

Chlorine Feed Rate, lbs/day = $\frac{(\text{Dosage, mg/L}) (\text{Flow, MGD}) (8.34 \text{ lbs/gal})}{\text{Chemical Purity, \%, expressed as a decimal}}$

Chlorine Dosage, mg/L = $\frac{(\text{Chlorine Feed Rate, lbs/day})(\text{Chemical Purity, \%, expressed as a decimal})}{(\text{Flow, MGD})(8.34 \text{ lbs/gal})}$

Bleach

Bleach Chlorine Dose, mg/L = $\frac{(\text{Bleach Fed, gal/day}) (\text{Available Chlorine, \%, expressed as a decimal})}{\text{Flow, MGD}}$

Hypochlorite Feed Rate, gal/day = $\frac{(\text{Chlorine Dose, mg/L}) (\text{Flow, MGD})}{\text{Available Chlorine, \%, expressed as a decimal}}$

Bleach Volume, gal (dilution) = $\frac{\left(\frac{(\text{Desired Available Chlorine Concentration, \%, expressed as a decimal})}{\text{Bleach Available Chlorine, \%, expressed as a decimal}} \right) (\text{Desired Volume, gal})}{1}$

HTH

HTH Feed Rate, lbs/day = $\frac{(\text{Dosage, mg/L}) (\text{Flow, MGD}) (8.34 \text{ lbs/gal})}{\text{Chemical Purity, \%, expressed as a decimal}}$

HTH, lbs (solution mix) = $\frac{(\text{Desired Available Chlorine, \%, expressed as decimal}) (\text{Desired Volume, gal}) (8.34 \text{ lb/gal})}{\text{HTH Available Chlorine, \% expressed as a decimal}}$

Trickling Filters

Hydraulic Loading Rate, gal/day/ft² = $\frac{\text{Flow Rate, gal/day}}{\text{Surface Area, ft}^2}$

Hydraulic Loading Rate, gal/day/ft² = $\frac{\text{Primary Effluent Flow Rate, gal/day} + \text{Recirculated Flow Rate, gal/day}}{\text{Surface Area, ft}^2}$

Organic (BOD) Loading, lbs/day/1,000ft³ = $\frac{\text{BOD Applied, lbs/day}}{\text{Volume of Media, 1,000 ft}^3}$

BOD, lbs/day = (BOD, mg/L) (Flow, MGD) (8.34 lbs/gal)

Volume of Media, 1,000ft³ = $\frac{(0.785) (\text{Trickling Filter Diameter, ft})^2 (\text{Media Depth, ft})}{1,000}$

Recirculation Ratio = $\frac{\text{Recirculated Flow, MGD}}{\text{Flow, MGD}}$

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

BOD Removed, lbs/day = (BOD Removed, mg/L) (Flow, MGD) (8.34 lbs/gal)

Suspended Solids Removed, lbs/day = (Suspended Solids Removed, mg/L) (Flow, MGD) (8.34 lbs/gal)

Activated Sludge

$$\text{BOD Loading, lbs/day} = (\text{BOD, mg/L})(\text{Flow, MGD})(8.34 \text{ lbs/gal})$$

$$\text{COD Loading, lbs/day} = (\text{COD, mg/L})(\text{Flow, MGD})(8.34 \text{ lbs/gal})$$

$$\text{MLSS, lbs} = (\text{MLSS, mg/L})(\text{Aerator Volume, MG})(8.34 \text{ lbs/gal})$$

$$\text{MLVSS, lbs} = (\text{MLSS, mg/L})(\text{Aerator Volume, MG})(8.34 \text{ lbs/gal})(\text{Volatile Solids, \%}, \text{ expressed as a decimal})$$

Food to Microorganism (F/M) Ratio

$$\text{F/M Ratio} = \frac{\text{BOD or COD, lbs/day}}{\text{Mixed Liquor Volatile Suspended Solids, lbs}}$$

$$\text{F/M Ratio} = \frac{\text{BOD or COD, lbs/day}}{(\text{MLSS, lbs})(\text{Volatile Solids, \%}, \text{ expressed as a decimal})}$$

$$\text{F/M Ratio} = \frac{(\text{BOD or COD, mg/L})(\text{Flow, MGD})(8.34 \text{ lbs/gal})}{(\text{MLVSS, mg/L})(\text{Aerator Volume, MG})(8.34 \text{ lbs/gal})}$$

$$\text{F/M Ratio} = \frac{(\text{BOD or COD, mg/L})(\text{Flow, MGD})(8.34 \text{ lbs/gal})}{(\text{MLSS, mg/L})(\text{Volatile Solids, \%}, \text{ expressed as a decimal})(\text{Aerator Volume, MG})(8.34 \text{ lbs/gal})}$$

$$\text{Desired MLVSS, lbs} = \frac{\text{BOD or COD, lbs/day}}{\text{Desired F/M Ratio}}$$

$$\text{Desired MLSS, lbs} = \frac{\text{Desired MLVSS, lbs}}{\text{Volatile Solids, \%}, \text{ expressed as decimal}}$$

Return Activated Sludge

$$\text{Return Sludge Flow, \%} = \frac{\text{Settled Sludge Volume, mL}}{1,000 \text{ mL} - \text{Settled Sludge Volume, mL}} \times 100\%$$

$$\text{Return Activated Sludge Flow, \%} = \frac{\text{Return Activated Sludge Flow, MGD}}{\text{Influent Flow, MGD}} \times 100\%$$

$$\text{Return Sludge Flow, gal/day} = (\text{Return Sludge Flow, \%}, \text{ expressed as a decimal}) (\text{Flow, gal/day})$$

$$\text{Return Sludge Flow, gal/day} = \frac{(\text{Aerator Influent Flow, gal/day})(\text{MLSS, mg/L})}{\text{Return Sludge Concentration, mg/L} - \text{MLSS, mg/L}}$$

$$\text{Return Sludge Concentration, mg/L} = \frac{1,000,000}{\text{SVI}} \quad (\text{SVI calculations are in Laboratory section})$$

Wastewater Treatment Math Formulas

Mean Cell Residence Time (MCRT) also called Solids Retention Time (SRT)

Actual MLSS, lbs = (Actual MLSS, mg/L) (Aerator Volume, MG) (8.34 lbs/gal)

$$\text{MCRT, days} = \frac{\text{Suspended Solids in System, lbs}}{\text{Suspended Solids Leaving System, lbs/day}}$$

$$\text{MCRT, days} = \frac{\text{Suspended Solids in System, lbs}}{\text{Waste Activated Sludge SS, lbs/day} + \text{Secondary Effluent SS, lbs/day}}$$

$$\text{MCRT, days} = \frac{(\text{MLSS, mg/L})(\text{Aerator Volume, MG})(8.34 \text{ lbs/dal})}{\text{no clarifier info} \quad (\text{WAS SS, mg/L})(\text{WAS Flow, MGD})(8.34 \text{ lbs/gal}) + (\text{S. E. SS, mg/L})(\text{Plant Flow, MGD})(8.34 \text{ lbs/gal})}$$

$$\text{MCRT, days} = \frac{(\text{MLSS, mg/L})(\text{Aerator Volume, MG} + \text{Final Clarifier Volume, MG})(8.34 \text{ lbs/dal})}{\text{given final clarifier} \quad (\text{WAS SS, mg/L})(\text{WAS Flow, MGD})(8.34 \text{ lbs/gal}) + (\text{S. E. SS, mg/L})(\text{Plant Flow, MGD})(8.34 \text{ lbs/gal})}$$

volume, but no CCSS

$$\text{MCRT, days} = \frac{(\text{MLSS, mg/L})(\text{Aerator Vol., MG})(8.34 \text{ lbs/gal}) + (\text{CCSS, mg/L})(\text{Final Clarifier Vol., MG})(8.34 \text{ lbs/dal})}{\text{given CCSS and final} \quad (\text{WAS SS, mg/L})(\text{WAS Flow, MGD})(8.34 \text{ lbs/gal}) + (\text{S. E. SS, mg/L})(\text{Plant Flow, MGD})(8.34 \text{ lbs/gal})}$$

clarifier volume

$$\text{WAS, lbs/day} = \left(\frac{(\text{MLSS, mg/L})(\text{Aerator Vol., MG})(8.34 \text{ lbs/gal})}{\text{MCRT, days}} \right) - (\text{S. E. SS, mg/L})(\text{Plant Flow, MGD})(8.34 \text{ lbs/gal})$$

$$\text{MLSS, gal to waste} = \frac{\text{MLSS, lbs to waste}}{(\text{Return Activated Sludge Concentration, mg/L}) (8.34 \text{ lbs/gal})} \times 1,000,000$$

$$\text{Minutes to Waste Sludge} = \frac{\text{MLSS, gal to waste}}{\text{Waste Sludge Pump Capacity, gal/min}}$$

$$\text{Minutes per Hour to Waste Sludge} = \frac{\text{Minutes per Day to Waste Sludge}}{24 \text{ hr/day}}$$

*******Note: CCSS = Clarifier Core Suspended Solids*******

Sludge Digestion

Solids Added, lbs = (Flow, gal/day) (8.34 lbs/gal) (Total Solids Conc., %, as a decimal)

$$\text{Volatile Solids Concentration, \%} = \left[\frac{\text{Volatile Solids Feed Rate, lbs/day}}{\text{Total Solids Feed Rate, lbs/day}} \right] \times 100\%$$

$$\text{Volatile Solids Feed Rate, lbs/day} = \left(\frac{\text{Total Solids Feed Rate, lbs/day}}{\text{as a decimal}} \right) \left(\text{Volatile Solids Concentration, \% as a decimal} \right)$$

$$\text{Volatile Solids Feed Rate, lbs/day} = \left(\frac{\text{Sludge Feed Rate, lbs/day}}{\text{as a decimal}} \right) \left(\frac{\text{Solids Concentration, \% as a decimal}}{\text{as a decimal}} \right) \left(\frac{\text{Volatile Solids Concentration, \% as a decimal}}{\text{as a decimal}} \right)$$

$$\text{Seed Sludge Concentration, \%} = \left[\frac{\text{Seed Sludge Volume, gal}}{\text{Total Digester Capacity, gal}} \right] \times 100\%$$

$$\text{Digester Loading, lbs/day/ft}^3 = \frac{\left(\frac{\text{Sludge Loading Rate, lbs/day}}{\text{as a decimal}} \right) \left(\frac{\text{Solids Concentration, \% as a decimal}}{\text{as a decimal}} \right) \left(\frac{\text{Volatile Solids Conc., \% as a decimal}}{\text{as a decimal}} \right)}{(0.785) (\text{Diameter, ft})^2 (\text{Water Depth, ft})}$$

$$\text{Volatile Acids/Alkalinity Ratio} = \frac{\text{Volatile Acids Concentration, mg/L}}{\text{Total Alkalinity, mg/L as CaCO}_3}$$

Volatile Acids, lbs = (Volatile Acids Concentration, mg/L) (Digester Volume, MG) (8.34 lbs/gal)

*******Note: Volatile Acids, lbs = Lime Required, lbs*******

$$\text{Volatile Solids Reduction, \%} = \left[\frac{\text{Volatile Solids Reduced, lbs}}{\text{Total Volatile Solids Entering, lbs}} \right] \times 100\%$$

$$\text{Volatile Solids Reduction, \%} = \left[\frac{\text{VS Concentration In, \%} - \text{VS Concentration Out, \%}}{\text{VS Concentration In, \%} - \left(\frac{\text{VS Concentration In, \% as a decimal}}{\text{as a decimal}} \right) \left(\frac{\text{VS Concentration Out, \% as a decimal}}{\text{as a decimal}} \right)} \right] \times 100\%$$

$$\text{Volatile Solids Reduction, \%} = \left[\frac{\text{In} - \text{Out}}{\text{In} - (\text{In})(\text{Out})} \right] \times 100\%$$

$$\text{Volatile Solids Destroyed, lbs/day/ft}^3 = \frac{\text{Volatile Solids Destroyed, lbs/day}}{\text{Digester Volume, ft}^3}$$

$$\text{Volatile Solids Destroyed, lbs/day/ft}^3 = \frac{(\text{Sludge, gal/day})(8.34 \text{ lbs/gal}) \left(\frac{\text{Solids Conc., \% as a decimal}}{\text{as a decimal}} \right) \left(\frac{\text{VS Conc., \% as a decimal}}{\text{as a decimal}} \right) \left(\frac{\text{VS Reduced, \% as a decimal}}{\text{as a decimal}} \right)}{(0.785)(\text{Diameter, ft})^2 (\text{depth, ft})}$$

Wastewater Treatment Math Formulas

$$\text{Gas Produced, ft}^3/\text{lb VS Destroyed} = \frac{\text{Gas Produced, ft}^3}{\text{Volatile Solids Destroyed, lbs}}$$

$$\text{Digester Gas Production, ft}^3/\text{lb VS Destroyed} = \frac{\text{Gas Produced, ft}^3/\text{day}}{(\text{VS to Digester, lbs/day}) (\text{VS Reduction, \% as decimal})}$$

$$\text{Digestion Time, days} = \frac{\text{Digester Volume, gal}}{\text{Sludge Flow Rate, gal/day}}$$

$$\text{Digestion Time, days} = \frac{(0.785) (\text{Diameter, ft})^2 (\text{depth, ft}) (7.48 \text{ gal/ft}^3)}{\text{Sludge Flow Rate, gal/day}}$$

$$\text{Lime or Caustic, lbs} = (\text{Lime or Caustic, mg/L}) (\text{Digester Volume, MG}) (8.34 \text{ lbs/gal})$$

Sludge Production and Thickening

$$\text{Solids Concentration, \%} = \left[\frac{\text{Solids Loading Rate, lbs/day}}{\text{Sludge Production Rate, lbs/day}} \right] \times 100\%$$

$$\text{Sludge Production Rate, lbs/day} = \frac{\text{Solids Loading Rate, lbs/day}}{\text{Solids Concentration, \% , expressed as a decimal}}$$

$$\text{Hydraulic Loading Rate, gal/day/ft}^2 = \frac{\text{Total Flow, gal/day}}{\text{Area, ft}^2}$$

$$\text{Solids Loading Rate, lbs/day/ft}^2 = \frac{\text{Solids Loading Rate, lbs/day}}{\text{Area, ft}^2}$$

$$\text{Solids Loading Rate, lbs/day/ft}^2 = \frac{(\text{Sludge, gal/day}) (8.34 \text{ lbs/gal}) (\text{Solids Concentration, \% , as a decimal})}{\text{Area, ft}^2}$$

$$\text{Sludge Detention Time, days} = \frac{\text{Sludge Blanket Volume, gal}}{\text{Sludge Pumping Rate from Thickener, gal/day}}$$

$$\text{Sludge Detention Time, days} = \frac{(0.785) (\text{Diameter, ft})^2 (\text{Sludge Blanket Depth, ft}) (7.48 \text{ gal/ft}^3)}{\text{Sludge Pumping Rate from Thickener, gal/day}}$$

Sludge Dewatering and Disposal

Filter Press Dewatering (Plate-and-Frame)

$$\text{Solids Loading Rate, lbs/hr/ft}^2 = \frac{\text{Sludge Feed Rate, lbs/hr}}{\text{Plate Area, ft}^2}$$

$$\text{Solids Loading Rate, lbs/hr/ft}^2 = \frac{(\text{Sludge Feed Rate, gal/hr}) (8.34 \text{ lbs/gal}) (\text{Solids Concentration, \% as a decimal})}{\text{Plate Area, ft}^2}$$

Belt Press Dewatering

$$\text{Hydraulic Loading Rate, gal/min/ft} = \frac{\text{Flow, gal/min}}{\text{Belt Width, ft}}$$

$$\text{Sludge Feed Rate, lbs/hr} = \frac{\text{Sludge to be Dewatered, lbs/day}}{\text{Operating Time, hr/day}}$$

Vacuum Filter Dewatering

$$\text{Filter Loading, lbs/hr/ft}^2 = \frac{\text{Solids to Filter, lbs/hr}}{\text{Surface Area, ft}^2}$$

$$\text{Filter Loading, lbs/hr/ft}^2 = \frac{\left[\frac{\text{Solids to Filter, lbs/day}}{\text{Filter Operations, hr/day}} \right]}{(3.14) (\text{Diameter, ft}) (\text{Width, ft})}$$

Sand Drying Beds

$$\text{Total Sludge Applied, gal} = (\text{Length, ft}) (\text{Width, ft}) (\text{Depth, ft}) (7.48 \text{ gal/ft}^3)$$

Wastewater Treatment Ponds

$$\text{Population Loading, persons/acre} = \frac{\text{Population Served, persons}}{\text{Pond Area, acres}}$$

$$\text{Pond Volume, ac - ft} = (\text{Area, acres}) (\text{Depth, ft})$$

$$\text{Pond Volume, ac - ft} = \frac{(\text{Length, ft}) (\text{Width, ft}) (\text{Depth, ft})}{43,560 \text{ ft}^2/\text{ac}}$$

$$\text{Pond Volume, gal} = (\text{Volume, ac - ft}) (43,560 \text{ ft}^2/\text{ac}) (7.48 \text{ gal/ft}^3)$$

$$\text{Pond Area, ac} = \frac{(\text{Length, ft}) (\text{Width, ft})}{43,560 \text{ ft}^2/\text{ac}}$$

Wastewater Treatment Math Formulas

$$\text{Flow, acre - feet/day} = \frac{\text{Flow, gal/day}}{(7.48 \text{ gal/ft}^3)(43,560 \text{ ft}^2/\text{ac})}$$

$$\text{Detention Time, days} = \frac{\text{Volume, gal}}{\text{Flow, gal/day}}$$

$$\text{Detention Time, days} = \frac{\text{Volume, acre - ft}}{\text{Flow, acre - ft/day}}$$

$$\text{BOD Loading, lbs/day} = (\text{BOD, mg/L}) (\text{Flow, MGD}) (8.34 \text{ lbs/gal})$$

$$\text{Organic Loading Rate, lbs/day/acre} = \frac{\text{Influent BOD, lbs/day}}{\text{Pond Areas, acres}}$$

$$\text{Organic Loading Rate, lbs/day/acre} = \frac{(\text{BOD, mg/L}) (\text{Flow, MGD}) (8.34, \text{ lbs/gal})}{\text{Pond Areas, acres}}$$

$$\text{BOD Removal Efficiency, \%} = \left[\frac{\text{BOD Removed, mg/L}}{\text{BOD Total, mg/L}} \right] \times 100\%$$

$$\text{Hydraulic Loading Rate, inches/day} = \frac{\left[\frac{\text{Flow, gal/day}}{(7.48 \text{ gal/ft}^3)(43,560 \text{ ft}^2/\text{acre})} \right]}{\text{Pond Area, acres}} \times 12 \text{ in/ft}$$

$$\text{Hydraulic Loading Rate, inches/day} = \left[\frac{\text{Flow, acre - ft/day}}{\text{Pond Area, acres}} \right] \times 12 \text{ in/ft}$$

Laboratory

Activated Sludge

$$\text{Sludge Volume Index (SVI), mL/g} = \frac{(\text{Wet Settled Sludge Volume, mL})(1,000)}{\text{Dried Sludge Solids Mass, mg}}$$

$$\text{SVI, mL/g} = \frac{(\text{Settleable Solids Concentration, \%}, \text{ expressed as a decimal}) (1,000,000)}{\text{Mixed Liquor Suspended Solids, mg/L}}$$

$$\text{SVI, mL/g} = \frac{(\text{Settled Sludge Volume, mL/L}) (1,000)}{\text{Mixed Liquor Suspended Solids, mg/L}}$$

$$\text{Sludge Density Index (SDI)} = \frac{100}{\text{SVI}}$$

Alkalinity

$$\text{Total Alkalinity, mg/L as CaCO}_3 = \frac{(B)(N)(50,000)}{\text{Sample Volume, mL}}$$

Where: B = Volume of Titrant Used, mL
 N = Normality of Sulfuric Acid

Bacteriological

$$\text{Mean} = \frac{\text{Sum of Items or Values}}{\text{Number of Items or Values}}$$

$$\text{Geometric Mean} = (X_1)(X_2)(X_3)\dots(X_n)^{1/n}$$

$$\text{Geometric Mean} = \sqrt[n]{(X_1)(X_2)(X_3)\dots(X_n)}$$

$$\text{Bacteriological Colonies/100 mL} = \frac{(\text{Number of Colonies Counted})(100)}{\text{Sample Volume Filtered, mL}}$$

BOD

$$\text{BOD}_5, \text{mg/L} = \frac{D_1 - D_2}{P}$$

$$\text{BOD}_5, \text{mg/L} = \frac{(D_1 - D_2) - (B_1 - B_2)f}{P}$$

Where: D₁ = Initial Dissolved Oxygen Concentration in Sample, mg/L
 D₂ = Final Dissolved Oxygen Concentration in Sample, mg/L
 B₁ = Initial Dissolved Oxygen Concentration in Seed Control, mg/L
 B₂ = Final Dissolved Oxygen Concentration in Seed Control, mg/L
 P = Sample Concentration, % (expressed as a decimal)
 f = $\frac{\text{Seed in Sample, \%}}{\text{Seed in Seed Control, \%}}$

Oxygen Uptake Rate

$$\text{Respiration Rate, mg/g/hr} = \frac{\text{Oxygen Uptake Rate, mg/L/hr}}{\text{Mixed Liquor Suspended Solids, grams/L}}$$

$$\text{Oxygen Uptake Rate, mg/L/hr} = \left[\frac{\text{Starting DO, mg/L} - \text{Ending DO, mg/L}}{\text{Elapsed Time, min}} \right] \times 60 \text{ min/hr}$$

$$\text{Load Index} = \frac{\text{Fed Oxygen Uptake Rate, mg/L/hr}}{\text{Unfed Oxygen Uptake Rate, mg/L/hr}}$$

$$\text{SOUR, mg O}_2/\text{hr/gm} = \frac{(\text{Oxygen Uptake Rate, mg/L/hr})(1000 \text{ mg/gram})}{\text{Mixed Liquor Suspended Solids, mg/L}}$$

Solids

$$\text{Suspended Solids, mg/L} = \frac{(A - B)(1,000,000)}{\text{Sample Volume, mL}}$$

Where: A = Final Weight of Pan, Filter, and Residue in grams
 B = Weight of Prepared Filter and Pan in grams

$$\text{Total Solids, mg/L} = \frac{(A - B)(1,000,000)}{\text{Sample Volume, mL}}$$

Where: A = Weight of Dish and Dried Solids in grams
 B = Weight of Dish in grams

$$\text{Volatile Solids, mg/L} = \frac{(A - B)(1,000,000)}{\text{Sample Volume, mL}}$$

Where: A = Weight of Dish and Dried Solids in grams
 B = Weight of Dish and Ash in grams

$$\text{Fixed Solids, mg/L} = \frac{(B - C)(1,000,000)}{\text{Sample Volume, mg/L}}$$

Where: B = Weight of Dish and Ash in grams
 C = Weight of Dish in grams

$$\text{Volatile Solids, \%} = \frac{\text{Volatile Solids, mg/L}}{\text{Total Solids, mg/L}} \times 100\%$$

Solutions

$$(C_1)(V_1) = (C_2)(V_2)$$

Where C_1 = Concentration of Solution 1

C_2 = Concentration of Solution 2

V_1 = Volume of Solution 1

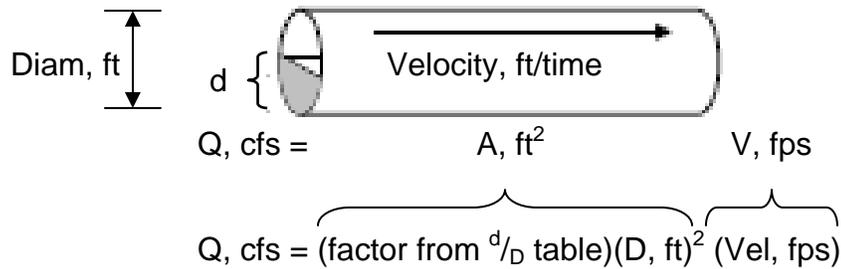
V_2 = Volume of Solution 2

Temperature

$$\text{Temperature, } ^\circ\text{C} = 0.556(^{\circ}\text{F} - 32^{\circ})$$

$$\text{Temperature, } ^\circ\text{F} = 1.8(^{\circ}\text{C}) + 32^{\circ}$$

Flow Through a Partially Full Pipe



d, in / D, in	Factor						
0.01	0.0013	0.26	0.1623	0.51	0.4027	0.76	0.6404
0.02	0.0037	0.27	0.1711	0.52	0.4127	0.77	0.6489
0.03	0.0069	0.28	0.1800	0.53	0.4227	0.78	0.6573
0.04	0.0105	0.29	0.1890	0.54	0.4327	0.79	0.6655
0.05	0.0147	0.30	0.1982	0.55	0.4426	0.80	0.6736
0.06	0.0192	0.31	0.2074	0.56	0.4526	0.81	0.6813
0.07	0.0242	0.32	0.2167	0.57	0.4625	0.82	0.6893
0.08	0.0294	0.33	0.2260	0.58	0.4724	0.83	0.6969
0.09	0.0350	0.34	0.2355	0.59	0.4822	0.84	0.7043
0.10	0.0409	0.35	0.2450	0.60	0.4920	0.85	0.7115
0.11	0.0470	0.36	0.2546	0.61	0.5018	0.86	0.7186
0.12	0.0534	0.37	0.2642	0.62	0.5118	0.87	0.7254
0.13	0.0600	0.38	0.2739	0.63	0.5212	0.88	0.7320
0.14	0.0668	0.39	0.2836	0.64	0.5308	0.89	0.7384
0.15	0.0739	0.40	0.2934	0.65	0.5404	0.90	0.7445
0.16	0.0811	0.41	0.3032	0.66	0.5499	0.91	0.7504
0.17	0.0885	0.42	0.3130	0.67	0.5594	0.92	0.7560
0.18	0.0961	0.43	0.3229	0.68	0.5687	0.93	0.7612
0.19	0.1039	0.44	0.3328	0.69	0.5780	0.94	0.7662
0.20	0.1118	0.45	0.3428	0.70	0.5872	0.95	0.7707
0.21	0.1199	0.46	0.3527	0.71	0.5964	0.96	0.7749
0.22	0.1281	0.47	0.3627	0.72	0.6054	0.97	0.7785
0.23	0.1365	0.48	0.3727	0.73	0.6143	0.98	0.7816
0.24	0.1449	0.49	0.3827	0.74	0.6231	0.99	0.7841
0.25	0.1535	0.50	0.3927	0.75	0.6318	1.00	0.7854