Approved Exam Provider

ABC Association of Boards of Certification

Ohio EPA Formula/Conversion Table for Wastewater Treatment & Collection Exams

Ohio EPA

Alkalinity, as mg $CaCO_3$/L = $\frac{\text{(Titrant Volume, mL)(Acid Normality)(50,000)}}{\text{Sample Volume, mL}}$

Amps = $\frac{\text{Volts}}{\text{Ohms}}$

*Area of Circle = (.785) (Diameter^2)

= (π) (Radius^2)

Area of Cone (lateral area) = (π) (Radius) $\sqrt{\text{Radius}^2 + \text{Height}^2}$

Area of Cone (total surface area) = (π) (Radius) (Radius + $\sqrt{\text{Radius}^2 + \text{Height}^2}$)

Area of Cylinder (total exterior surface area) = [Surface Area of End #1] + [Surface Area of End #2] + [(π) (Diameter) (Height or Depth)]

*Area of Rectangle = (Length) (Width)

*Area of a Right Triangle = $\frac{\text{(Base)(Height)}}{2}$

Average (arithmetic mean) = $\frac{\text{Sum of All Terms}}{\text{Number of Terms}}$

Average (geometric mean) = $[(X_1)(X_2)(X_3)(X_4)(X_n)]^{1/n}$ *The* n*th root of the product of* n *numbers*

Biochemical Oxygen Demand (unseeded), mg/L = $\frac{\text{[(Initial DO, mg/L) - (Final DO, mg/L)][300mL]}}{\text{Sample Volume, mL}}$

Chemical Feed Pump Setting, % Stroke = $\frac{\text{Desired Flow}}{\text{Maximum Flow}} \times 100\%$

Chemical Feed Pump Setting, mL/min = $\frac{\text{(Flow, MGD)(Dose, mg/L)(3.785 L/gal)(1,000,000 gal/MG)}}{\text{(Liquid, mg/mL)(24 hr/day)(60 min/hr)}}$

Circumference of Circle = (π) (Diameter)

= 2 (π) (Radius)

Composite Sample Single Portion = $\frac{\text{(Instantaneous Flow)(Total Sample Volume)}}{\text{(Number of Portions)(Average Flow)}}$

Cycle Time, min = $\frac{\text{Storage Volume, gal}}{\text{Pump Capacity, gpm - Wet Well Inflow, gpm}}$

*Pie Wheel format for this equation is available at the end of this document.

Degrees Celsius $= (\text{Degrees Fahrenheit} - 32)\,(5/9)$

$$= \frac{(°F - 32)}{1.8}$$

Degrees Fahrenheit $= (\text{Degrees Celsius})\,(9/5) + 32$

$$= (\text{Degrees Celsius})\,(1.8) + 32$$

Detention Time $= \frac{\text{Volume}}{\text{Flow}}$ *Units must be compatible*

Dose = Demand + Residual

*Electromotive Force (EMF), volts = (Current, amps) (Resistance, ohms) *or* $E = IR$

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

Filter Backwash Rise Rate, in/min $= \frac{(\text{Backwash Rate, gpm/ft}^2)\,(12\text{ in/ft})}{7.48\text{ gal/ft}^3}$

Filter Flow Rate or Backwash Rate, gpm/ft² $= \frac{\text{Flow, gpm}}{\text{Filter Area, ft}^2}$

Filter Yield, lbs/hr/ft² $= \frac{(\text{Solids Loading, lbs/day})\,(\text{Recovery, \% expressed as a decimal})}{(\text{Filter Operation, hr/day})\,(\text{Area, ft}^2)}$

*Flow Rate, cfs = (Area, ft²) (Velocity, ft/sec) *or* $Q = AV$ *Units must be compatible*

Food/Microorganism Ratio $= \frac{BOD_5\text{, lbs/day}}{\text{MLVSS, lbs}}$

*Force, lbs = (Pressure, psi) (Area, in²)

Gallons/Capita/Day $= \frac{\text{Volume of Water Produced, gpd}}{\text{Population}}$

Hardness, as mg $CaCO_3$/L $= \frac{(\text{Titrant Volume, mL})\,(1{,}000)}{\text{Sample Volume, mL}}$ *Only when the titration factor is 1.00 of EDTA*

Horsepower, Brake (bhp) $= \frac{(\text{Flow, gpm})\,(\text{Head, ft})}{(3{,}960)\,(\text{Pump Efficiency, \% expressed as a decimal})}$

Horsepower, Motor (mhp) =

$$\frac{(\text{Flow, gpm})\,(\text{Head, ft})}{(3{,}960)\,(\text{Pump Efficiency, \% expressed as a decimal})\,(\text{Motor Efficiency, \% expressed as a decimal})}$$

*Horsepower, Water (whp) $= \frac{(\text{Flow, gpm})\,(\text{Head, ft})}{3{,}960}$

Hydraulic Loading Rate, gpd/ft² $= \frac{\text{Total Flow Applied, gpd}}{\text{Area, ft}^2}$

*Pie Wheel format for this equation is available at the end of this document.

$$\text{Leakage, gpd} = \frac{\text{Volume, gallons}}{\text{Time, days}}$$

*Mass, lbs = (Volume, MG) (Concentration, mg/L)(8.34 lbs/gal)

*Mass Flux, lbs/day = (Flow, MGD) (Concentration, mg/L) (8.34 lbs/gal)

$$\text{Mean Cell Residence Time (MCRT) or Solids Retention Time (SRT), days} = \frac{\text{Aeration Tank TSS, lbs} + \text{Clarifier TSS, lbs}}{\text{TSS Wasted, lbs/day} + \text{Effluent TSS, lb/day}}$$

Milliequivalent = (mL) (Normality)

$$\text{Molarity} = \frac{\text{Moles of Solute}}{\text{Liters of Solution}}$$

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

$$\text{Normality} = \frac{\text{Number of Equivalent Weights of Solute}}{\text{Liters of Solution}}$$

$$\text{Number of Equivalent Weights} = \frac{\text{Total Weight}}{\text{Equivalent Weight}}$$

$$\text{Number of Moles} = \frac{\text{Total Weight}}{\text{Molecular Weight}}$$

$$\text{Organic Loading Rate, lbs BOD}_5\text{/day/ft}^3 = \frac{\text{Organic Load, lbs BOD}_5\text{/day}}{\text{Volume, ft}^3}$$

$$\text{Organic Loading Rate-RBC, lbs BOD}_5\text{/day/1,000 ft}^2 = \frac{\text{Organic Load, lbs BOD}_5\text{/day}}{\text{Surface Area of Media, 1,000 ft}^2}$$

$$\text{Organic Loading Rate-Trickling Filter, lbs BOD}_5\text{/day/1,000 ft}^3 = \frac{\text{Organic Load, lbs BOD}_5\text{/day}}{\text{Volume, 1,000 ft}^3}$$

$$\text{Oxygen Uptake Rate or Oxygen Consumption Rate, mg/L/min} = \frac{\text{Oxygen Usage, mg/L}}{\text{Time, min}}$$

$$\text{Population Equivalent, Organic} = \frac{\text{(Flow, MGD) (BOD, mg/L) (8.34 lbs/gal)}}{\text{BOD/day/person, lbs}}$$

$$\text{Recirculation Ratio-Trickling Filter} = \frac{\text{Recirculated Flow}}{\text{Primary Effluent Flow}}$$

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

$$\text{Reduction of Volatile Solids, \%} = \left(\frac{\text{In} - \text{Out}}{\text{In} - (\text{In} \times \text{Out})}\right) \times 100\%$$ *All information (In and Out) must be in decimal form*

$$\text{Removal, \%} = \left(\frac{\text{In} - \text{Out}}{\text{In}}\right) \times 100\%$$

*Pie Wheel format for this equation is available at the end of this document.

$$\text{Return Rate, \%} = \frac{\text{Return Flow Rate}}{\text{Influent Flow Rate}} \times 100\%$$

$$\text{Return Sludge Rate-Solids Balance} = \frac{\text{(MLSS) (Flow Rate)}}{\text{Return Activated Sludge Suspended Solids} - \text{MLSS}}$$

$$\text{Slope, \%} = \frac{\text{Drop or Rise}}{\text{Distance}} \times 100\%$$

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

$$\text{Sludge Volume Index (SVI), mL/g} = \frac{(\text{SSV}_{30}\text{, mL/L}) \text{(1,000 mg/g)}}{\text{MLSS, mg/L}}$$

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

$$\text{Solids Concentration, mg/L} = \frac{\text{Weight, mg}}{\text{Volume, L}}$$

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

Solids Retention Time (SRT): *see* Mean Cell Residence Time (MCRT)

$$\text{Specific Gravity} = \frac{\text{Specific Weight of Substance, lbs/gal}}{\text{Specific Weight of Water, lbs/gal}}$$

$$\text{Specific Oxygen Uptake Rate or Respiration Rate, (mg/g)/hr} = \frac{\text{OUR, mg/L/min (60 min)}}{\text{MLVSS, g/L (1 hr)}}$$

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

Three Normal Equation = $(N_1 \text{ x } V_1) + (N_2 \text{ x } V_2) = (N_3 \text{ x } V_3)$ *Where* $V_1 + V_2 = V_3$

Two Normal Equation = $N_1 \text{ x } V_1 = N_2 \text{ x } V_2$ *Where N = normality, V = volume or flow*

$$\text{Velocity, ft/sec} = \frac{\text{Flow Rate, ft}^3\text{/sec}}{\text{Area, ft}^2} \quad \text{or} \quad \frac{\text{Distance, ft}}{\text{Time, sec}}$$

$$\text{Volatile Solids, \%} = \left(\frac{\text{Dry Solids, g} - \text{Fixed Solids, g}}{\text{Dry Solids, g}}\right) \times 100\%$$

*Volume of Cone = (1/3) (.785) (Diameter^2) (Height)

= (1/3) [(π) (Radius^2) (Height)]

*Volume of Cylinder = (.785) (Diameter^2) (Height)

= (π) (Radius^2) (Height)

*Volume of Rectangular Tank = (Length) (Width) (Height)

Watts (AC circuit) = (Volts) (Amps) (Power Factor)

*Pie Wheel format for this equation is available at the end of this document.

Watts (DC circuit) = (Volts) (Amps)

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

$$\text{Wire-to-Water Efficiency, \%} = \frac{\text{Water Horsepower, hp}}{\text{Power Input, hp or Motor hp}} \times 100\%$$

$$\text{Wire-to-Water Efficiency, \%} = \frac{(\text{Flow, gpm})(\text{Total Dynamic Head, ft})(0.746\ \text{kW/hp})}{(3{,}960)(\text{Electrical Demand, kW})} \times 100\%$$

Abbreviations:

BOD	biochemical oxygen demand
CBOD	carbonaceous biochemical oxygen demand
cfs	cubic feet per second
COD	chemical oxygen demand
DO	dissolved oxygen
ft	feet
F/M ratio	food to microorganism ratio
g	grams
gpd	gallons per day
gpg	grains per gallon
gpm	gallons per minute
hp	horsepower
hr	hour
in	inches
kW	kilowatt
lbs	pounds
mg/L	milligrams per liter
MCRT	mean cell residence time
MGD	million gallons per day
min	minute
mL	milliliter
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solid
OCR	oxygen consumption rate
ORP	oxidation reduction potential
OUR	oxygen uptake rate
ppb	parts per billion
ppm	parts per million
psi	pounds per square inch
PE	population equivalent
Q	flow

Abbreviations(continued):

RAS	return activated sludge
RBC	rotating biological contactor
SDI	sludge density index
SRT	solids retention time
SS	settleable solids
SSV_{30}	settled sludge volume 30 minute
SVI	sludge volume index
TOC	total organic carbon
TS	total solids
TSS	total suspended solids
VS	volatile solids
WAS	waste activated sludge

Conversion Factors:

1 acre = 43,560 square feet
1 acre foot = 326,000 gallons
1 cubic foot = 7.48 gallons
= 62.4 pounds
1 cubic foot per second = 0.646 MGD
1 foot = 0.305 meters
1 foot of water = 0.433 psi
1 gallon = 3.79 liters
= 8.34 pounds
1 grain per gallon = 17.1 mg/L
1 horsepower = 0.746 kW
= 746 watts
= 33,000 foot lbs/min
1 mile = 5,280 feet
1 million gallons per day = 694 gallons per minute
= 1.55 cubic feet per second (cfs)
1 pound = 0.454 kilograms
1 pound per square inch = 2.31 feet of water
1 ton = 2,000 pounds
1% = 10,000 mg/L
π or pi = 3.14159

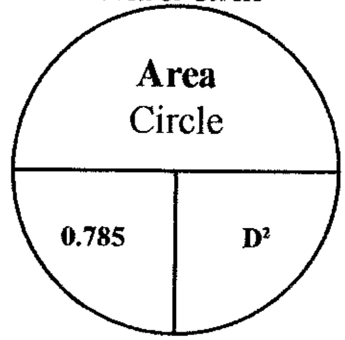
*Pie Wheel format for this equation is available at the end of this document.

***Pie Wheels:**

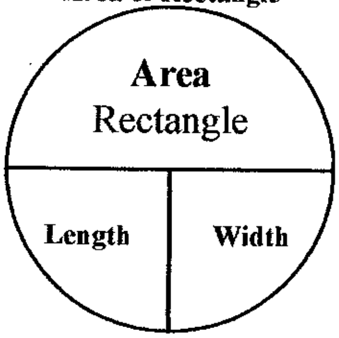
- To find the quantity above the horizontal line: multiply the pie wedges below the line together.
- To solve for one of the pie wedges below the horizontal line: cover that pie wedge, then divide the remaining pie wedge(s) into the quantity above the horizontal line.

Given units must match the units shown in the pie wheel.

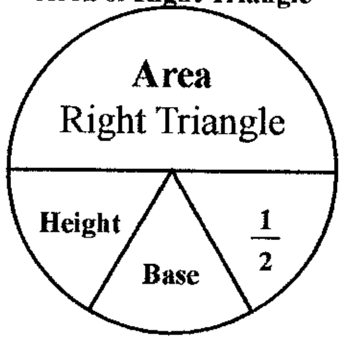
Area of Circle



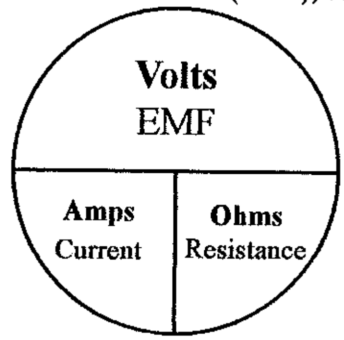
Area of Rectangle



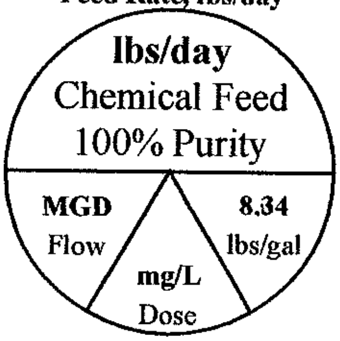
Area of Right Triangle



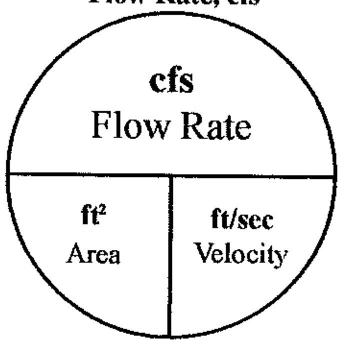
Electromotive Force (EMF), volts



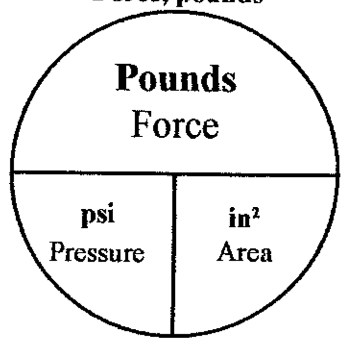
Feed Rate, lbs/day



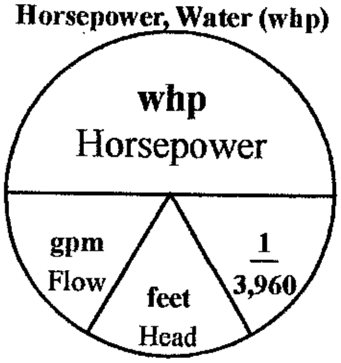
Flow Rate, cfs



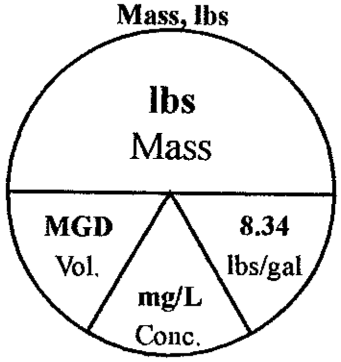
Force, pounds



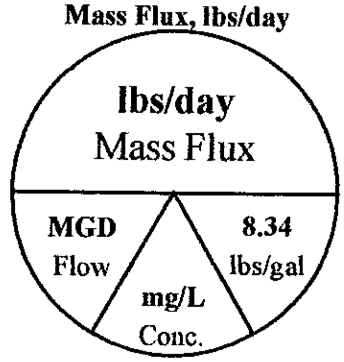
Horsepower, Water (whp)



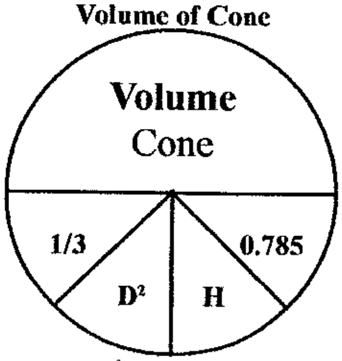
Mass, lbs



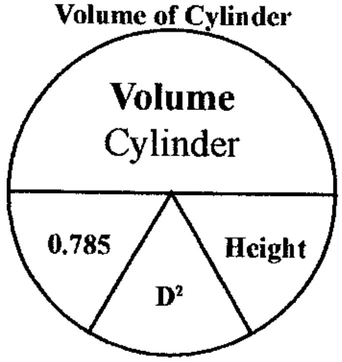
Mass Flux, lbs/day



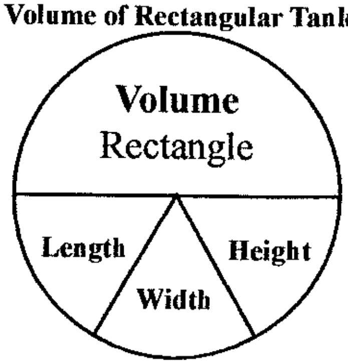
Volume of Cone



Volume of Cylinder



Volume of Rectangular Tank



Ohio EPA

Division of Drinking and Ground Waters

APPLIED WASTEWATER MATH FORMULA SHEET AND CONVERSION FACTORS

12 in = 1 ft	27 cu ft = 1 cu yd	1,000 mg = 1 gm	60 sec = 1 min
3 ft = 1yd	7.48 gal = 1 cu ft	1,000 gm = 1 kg	60 min = 1 hour
5,280 ft = 1 mi	8.34 lbs = 1 gal water	1,000 ml = 1 liter	1,440 min = 1 day
144 sq in = $1 ft^2$	62.4 lbs = 1 ft^3 water	2.31 ft water = 1 psi	10,000 mg/L = 1%
43,560 ft^2 = 1 acre	746 watts = 1hp	0.433 psi = 1 ft water	454 gm = 1 lb

L = Length B = Base $\pi = 3.14$ W = Width H = Height R = Radius

Q = Flow Rate A = Area V = Volume v = velocity SG = Specific Gravity

Chlorine Demand (mg/L) = dosage (mg/L) – residual (mg/L)

AREA

Rectangle: $A = L \times W$ Triangle: $A = \frac{1}{2} B \times H$ Circle: Area = πR^2

VOLUME

Cylinder: $V = \pi R^2 H$ Rectangle: $V = L \times W \times H$ Cone: $V = 1/3 \pi R^2 H$

VELOCITIES and FLOW RATES

1. Velocity = $\frac{\text{distance}}{\text{time}}$

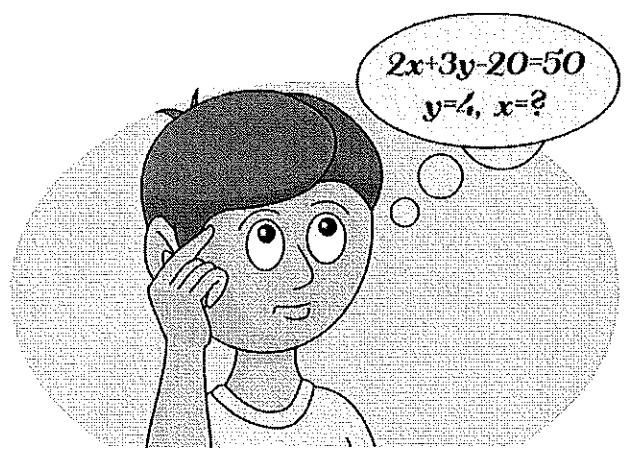
2. $Q = v \times A$

DETENTION TIME

Detention Time = $\frac{V}{Q}$

PARTS PER MILLION / POUNDS

lbs = 8.34 lbs / gal x mg/L x MG x SG



SEDIMENTATION AND LOADINGS

1. Weir overflow rate = $\frac{\text{total flow}}{\text{length of weir}}$

2. Surface overflow rate = $\frac{\text{Influent flow}}{\text{surface area}}$

3. Solids Loading rate = $\frac{\text{solids applied}}{\text{surface area}}$

SEDIMENTATION AND LOADINGS (continued)

4. Efficiency, % = $\frac{\text{(in)} - \text{(out)}}{\text{(in)}} \times 100\%$

5. Organic loading rate (activated sludge) = $\frac{\text{CBOD applied}}{V}$

6. Hydraulic loading rate = $\frac{Q}{A}$

7. Centrifuge hydraulic loading: hydraulic loading rate = $\frac{Q \times \text{run time}}{\text{run time} + \text{skim time}}$

ACTIVATED SLUDGE

1. SVI = $\frac{\text{30 min settling, ml/L}}{\text{MLSS, mg/L}} \times \frac{\text{1,000 mg}}{\text{gram}}$

2. SDI = $\frac{100}{\text{SVI}}$

3. Solids inventory, lbs = (Tank volume, MG) x (solids concentration, mg/L) x (8.34 lbs / gal)

4. Sludge age, days = $\frac{\text{solids under aeration, lbs}}{\text{solids added, lbs / day}}$

5. F/M = $\frac{\text{CBOD applied}}{\text{Organic solids under aeration}}$

6. MCRT = $\frac{\text{solids inventory}}{\text{[effluent solids + WAS solids]}}$

7. Change, WAS rate, MGD = $\frac{\text{(current solids inventory, lbs)} - \text{(desired solids inventory, lbs)}}{\text{WAS, mg/L} \times 8.34 \text{ lbs / gal}}$

8. Return sludge rate, MGD = $\frac{\text{(settleable solids, mL)} \times Q}{\text{(1,000 mL)} - \text{(settleable solids, mL)}}$

SLUDGE DIGESTION

1. Dry solids, lbs = $\frac{\text{(sludge, gal)} \times \text{(sludge, \% solids)} \times \text{(8.34 lbs / gal)} \times \text{SG}}{100\%}$

2. Seed Sludge, lbs volatile solids = $\frac{\text{volatile solids pumped (lbs volatile solids / day)}}{\text{loading factor (lbs VS / day) / lb VS in digester}}$

3. Seed Sludge, gal = $\frac{\text{seed sludge (lbs volatile solids)}}{\text{seed sludge (lbs / gal)} \times \frac{\text{(solids \%)}}{100\%} \times \frac{\text{(volatile solids \%)}}{(100\%)}}$

4. Digested sludge removed = Total sludge in – volatile solids destroyed

5. Lime required, lbs = (sludge, MG) x (volatile acids, mg/L) x (8.34 lbs / gal)

SLUDGE DIGESTION (continued)

6. Percent volatile solids reduction = $\frac{(\text{in} - \text{out}) \times 100\%}{\text{in} - (\text{in} \times \text{out})}$

7. VS destroyed, lbs / day / cu ft = $\frac{\text{volatile solids added (lbs / day)} \times \text{volatile solids reduction (\%)}}{\text{digester volume (ft}^3\text{)} \times 100\%}$

8. Gas production (cu ft / lb VS) = $\frac{\text{gas produced (ft}^3\text{ / day)}}{\text{VS destroyed (lbs / day)}}$

HORSEPOWER, FORCE, CHEMICAL PUMPS

1. Water HP = $\frac{\text{Q(gpm)} \times 8.34 \text{ lbs / gal} \times \text{head (ft)}}{33{,}000 \text{ ft-lbs / min}}$

2. Break HP = $\frac{\text{Water HP}}{\text{pump efficiency}}$

3. Motor HP = $\frac{\text{BHP}}{\text{motor efficiency}}$

4. Upward force = 62.4 (lbs / ft^3) x height (ft) x area (ft^2)

5. Side wall force = 31.2 (lbs / ft^3) x volume (ft^3)

6. Chemical solution, lbs / gal = $\frac{\text{(solution \%)} \times 8.34 \text{ lbs / gal)}}{100\%}$

7. Feed pump flow, gal / day = $\frac{\text{chemical feed (lbs / day)}}{\text{Chemical solution (lbs / gal)}}$

8. Scale setting, % = $\frac{\text{desired flow (gal / day) (100\%)}}{\text{maximum feed rate (gal/day)}}$

9. Total Dynamic Head = Static Head + Friction Losses

10. Static Head = Suction Lift + Discharge Head

11. $\frac{\text{Polymer solution \%}}{100\%} = \frac{\text{dry polymer (lb)}}{\text{Vol of solution (gal)} \times 8.34 \text{ (lbs / gal)}}$

LAB PROCEDURES AND MEASUREMENTS

1. TSS, mg/L = $\frac{\text{(RDD – DD)} \times 1\text{M}}{\text{sample vol (mL)}}$
2. VSS, mg/L = $\frac{\text{(RDD – FDD)} \times 1\text{M}}{\text{sample vol (mL)}}$

where: RDD = dried residue + dish + disc (filter)(grams)
DD = dish + disc, grams
FDD = fired residue + dish + disc (grams)
1M = 1,000,000

LAB PROCEDURES AND MEASUREMENTS (continued)

3. VSS, % = $\frac{\text{volatile solids (mg/L)} \times 100\%}{\text{total suspended solids (mg/L)}}$

4. CBOD sample size (mL) = $\frac{1{,}200}{\text{estimated CBOD (mg/L)}}$

5. Seed correction, mg/L for 1 mL seed = $\frac{\text{seed initial D.O.} - \text{seed final D.O.}}{\text{mL seed added}}$

6. CBOD, mg/L = $\frac{[(\text{Initial D.O.} - \text{Final D.O.}) - \text{seed correction factor}] \times \text{bottle volume (mL)}}{\text{sample volume (mL)}}$

7. Initial D.O. = $\frac{(\text{mL sample} \times \text{D.O. sample}) + (\text{mL dilution water} \times \text{D.O. dilution water})}{\text{bottle volume (mL)}}$

8. Temperature Conversion: Temperature, F = (temperature C)(1.8) + 32