ABBREVIATIONS

English

ac-ft. = acre-foot or acre-feet

b = base (of right triangle)

°C = degrees Celsius

cfs or **ft³/sec** = cubic feet per second

cfm or **ft³/min** = cubic feet per minute

cfd or **ft³/day** = cubic feet per day

D = diameter (circle)

°F = degrees Fahrenheit

fps or **ft./sec** = feet per second

ft. = feet

ft² or **sq. ft.** = square feet

ft³ or **cu. ft.** = cubic feet

gpd = gallons per day

gpg = grains per gallon

gpm = gallons per minute

gps = gallons per second

h = height

hp = horsepower

hr = hour

hrs/day = hours per day

in = inches

in² = square inches

in³ = cubic inches

lbs. = pounds

mi = miles

min = minute

MG = million gallons

mgd or **MGD** = million gallons per day

oz = ounces

ppb = parts per billion

ppm = parts per million

ppt = parts per trillion

psi = pounds per square inch

Q = flow

r = radius (circle)

sec = second

V = volume

W = watts

Metric

cm = centimeters

g = gram

Ha = Hectare

kg = kilogram

km = kilometer

kW = kilowatt

L or **l** = liters

m = meter

m³ = cubic meter

mg = milligram

mg/L or **mg/l** = milligrams per liter

mL = ml or milliliter

mm = millimeter

CONVERSION FACTORS

LENGTH

English

1 foot = 12 in.
1 foot = 0.305 m
1 inch = 2.54 cm
1 mile = 5,280 ft.
1 mile = 1.609 km
1 yard = 3 ft.

Metric

1 centimeter = 0.3937 in.
1 kilometer = 0.6214 mi.
1 meter = 39.37 in.

AREA

English

1 acre (ac) = 43,560 ft^2
1 acre = 0.405 Hectare (Ha)
1ft^2 = 144 in^2
1 in^2 = 6.45 cm^2
1yd^2 = 9 ft^2

Metric

1 Hectare = 2.47 acres

VOLUME

English

1 acre-ft. = 325,828.8 gallons
1 acre-ft. = 43,560 ft^3
1 cfs = 0.646 MGD
1 ft^3 = 7.48 gallons
1 ft^3 = 1,728 in^3
1 gallon = 231 in^3
1 gallon = 0.1337 ft^3
1 gallon = 0.000001 MG
1 gallon = 3.785 liter
1 gallon = 3,785 mL
1yd^3 = 27 ft^3

Metric

1 liter = 1,000 mL
1 liter = 0.2642 gallons
1 m^3 = 264.2 gallons
1 m^3 = 35.315 ft^3

FLOW

1 ft^3/sec = 646,300 gpd
1 ft^3/sec = 0.6463 MGD
1 ft^3/sec = 448.8 gpm
1 gpm = 0.00144 MGD

1 MGD = 694.4 gpm
1 MGD = 1.545 cfs
1 MGD = 3.07 acre-ft/day

WEIGHT & MASS

English

1 ft^3 water = 62.4 lbs.
1 gallon water = 8.34 lbs.
1 gpg = 17.118 mg/L
1 lb. = 16 oz
1 lb. = 7,000 grains
1 lb. = 453.6 g
1 lb. = 0.4536 kg
1 ton = 2,000 lbs.

Metric

1 g = 1,000 mg
1 kg = 1,000 g
1 kg = 2.2 lbs.
1 mg/L = 0.0584 gpg
1% = 10,000 mg/L

DOSAGE

1% = 10,000 mg/L
1 gpg = 17.1 ppm
1 ppm = 1 mg/L
1 ppm = 8.34 lbs. per million gal

POWER

1 hp = 0.746kW
1 hp = 746 W
1 hp = 550 ft-lb/sec
1 hp = 33,000 ft-lbs/min
1 kW = 1.34 hp

PRESSURE

1 ft. water = 0.433 psi
1 psi = 2.31 ft. water

TIME

1 min = 60 sec
1 hr. = 60 min
1 day = 24 hrs
1 day = 1,440 min

FORMULAS

For the operator's convenience, both equation formulas and pie wheel formulas are included in this document. When using the pie wheel formula to solve a problem, multiply together the pie wedges below the horizontal line to solve for the quantity above the horizontal line. To solve for one of the pie wedges below the horizontal line, cover the pie wedge for which you are solving and divide the remaining pie wedge(s) below the horizontal line into the quantity above the horizontal line.

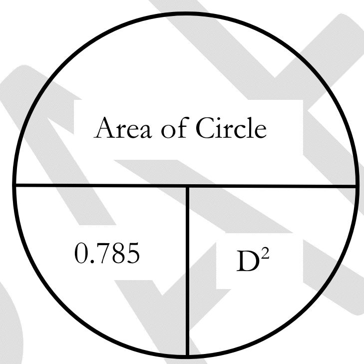
Area Formulas

Circle = (0.785) x (D^2)

Where: Circle = area of circle
D = diameter of circle

Circle = (π) x (r^2)

Where: Circle = area of circle
r = radius of circle
π = 3.1416



Cone (lateral area) = (π) x (r) x ($\sqrt{r^2 + h^2}$)

Where: π = 3.1416
r = radius of circle
h = height of cone

Cone (area) = [(b) x (h)]/2

Where: b = circumference
h = height

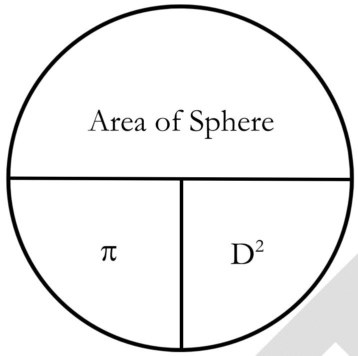
Cone (surface area) = (π) x (r) x (r+ $\sqrt{r^2 + h^2}$)

Where: π = 3.1416
r = radius of circle
h = height of cone

Sphere (area) = $(\pi) \times (D^2)$ or

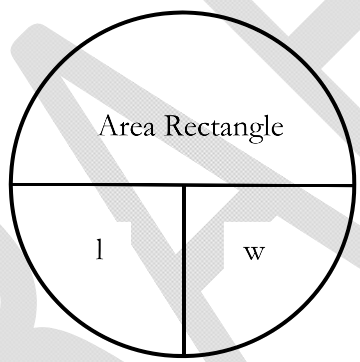
Sphere (area) = $4 \times (\pi) \times (r^2)$

Where: $\pi = 3.1416$
r = radius of circle
D = diameter of circle



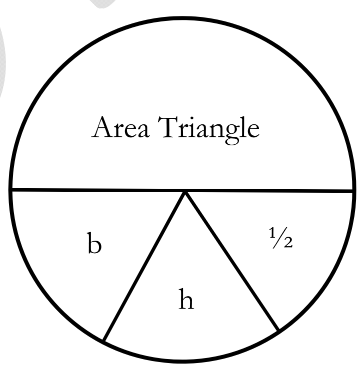
Rectangle = $(l) \times (w)$

Where: l = length of rectangle
w = width of rectangle



Triangle (area) = $[(b) \times (h)]/2$

Where: b = base of triangle
h = height of triangle



Circumference of Circle

Circumference = $(\pi) \times (D)$ Where: $\pi = 3.1416$
D = diameter of circle

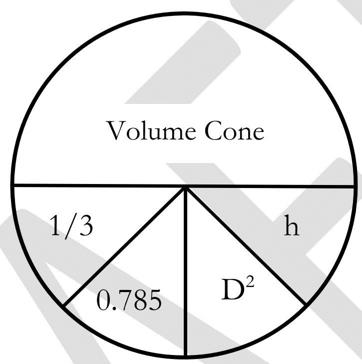
-.-

Circumference = $(2) \times (\pi) \times (r)$ Where: $\pi = 3.1416$
r = radius of circle

-.-

Volume Formulas

Cone = $(1/3) \times (0.785) \times (D^2) \times (h)$ Where: D = diameter of cone
h = height of cone



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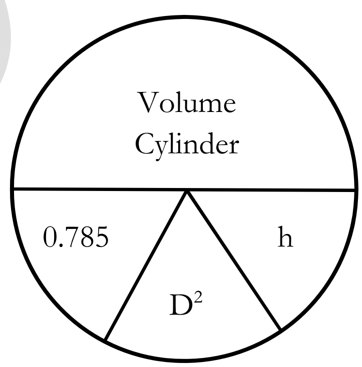
Cone = $1/3 \times [(\pi) \times (r^2) \times (h)]$ Where: $\pi = 3.1416$
r = radius of cone
h = height of cone

-.-

Cylinder = $(0.785) \times (d^2) \times (h)$ Where: D = diameter of cylinder
h = length of cylinder



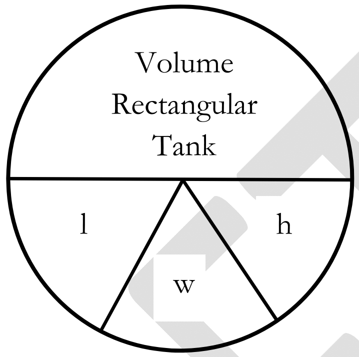
Cylinder = (π) x (r^2) x (h)

Where:
π = 3.1416
r = radius of cylinder
h = length of cylinder

-.-

Rectangular Tank = (l) x (w) x (h)

Where:
l = length of tank
w = width of tank
h = height of tank



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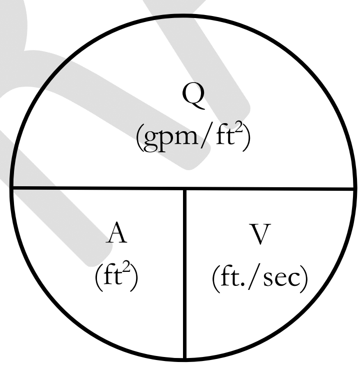
Flow Formulas

Q = (A) x (V)

Where:
Q = flow (ft^3/sec)
A = cross-section area (ft^2)
V = water velocity (ft./sec)



-.-

Q = (w) x (d) x (V)

Where:
Q = flow in channel (ft^3/sec)
w = width (ft.)
d = depth (ft.)
V = velocity (ft./sec)

-.-

Q = (0.785) x $(D)^2$ x (V)

Where:
Q = flow in full pipe (ft^3/sec)
D = diameter (ft.)
V = velocity (ft./sec)

$$Q = \{1.333 \times (h)^2 \times \sqrt{(D/h) - 0.608}\ \} \times (V)$$

Where:
Q = flow in partially full pipe (ft^3/sec)
h = height (ft.)
D = diameter (ft.)
V = velocity (ft./sec)

-.-

See also **Appendix A: Flow Through a Partially Full Pipe** (table)

-.-

$$V = (Q)/\{(0.785) \times (D)^2\}$$

Where:
V = velocity (ft./sec)
Q = flow (ft^3/sec)
D = diameter (ft.)

-.-

$$V = (d)/(T)$$

Where:
V = velocity (ft./sec)
d = distance (ft.)
T = time (sec)

-.-

$$Q = (\sum Q_{\text{daily}})/(n_{\text{daily}})$$

Where:
Q = avg. daily flow (MGD)
$\sum Q_{\text{daily}}$ = sum all daily flows (MGD)
n_{daily} = number of daily flows

-.-

$$Q = (\sum Q_{\text{monthly}})/(n_{\text{monthly}})$$

Where:
Q = avg. daily flow (MGD)
$\sum Q_{\text{monthly}}$ = sum all monthly avg. daily flows (MGD)
n_{monthly} = number of monthly avg. daily flows

-.-

Q = (Water used)/(Population)

Where:
Q = daily flow (gal/capita/day)
water used or produced = gal/day
population = total # people served

-.-

Overflow rate = (Q)/(L)

Where:
overflow rate = weir overflow rate (gpd/ft.)
Q = flow (gpd)
L = weir length (ft.)

-.-

Dosage Formulas

$$\text{Dosage} = \frac{\text{Feed rate}}{(Q) \times (8.34\ \text{lbs./gal})}$$

Where:
dosage = mg/L
feed rate = chemical feed rate (lbs./day)
Q = flow rate (MGD)

$$\text{Dosage} = \frac{(\text{Feed rate}) \times (\text{Purity})}{(Q) \times (8.34 \text{ lbs./gal})}$$

Where:
dosage = mg/L
feed rate = chemical feed rate (lbs./day)
purity = chemical purity, % expressed as decimal
Q = flow rate (gal/min.)

-.-

$$\text{Dosage} = \frac{(\text{Feed rate}) \times (1{,}000 \text{ mg/g})}{(Q) \times (3.785 \text{ L/gal})}$$

Where:
dosage = mg/L
feed rate = chemical feed rate (lbs./day)
Q = flow rate (gal/min.)

-.-

Dose = Demand + Residual

-.-

Chemical Feed/Feed Rate Formulas (aka pounds)

$$\text{Chemical feed} = (d) \times (V) \times (8.34 \text{ lbs./gal})$$

Where:
chemical fee = lbs.
d = dose (mg/L)
V = volume (MG)

-.-

$$\text{Chemical feed} = \frac{(d) \times (V) \times (8.34 \text{ lbs./gal})}{\text{Chemical purity}}$$

Where:
chemical fee = lbs.
d = dose (mg/L)
V = volume (MG)
Chemical purity = %, expressed as decimal

-.-

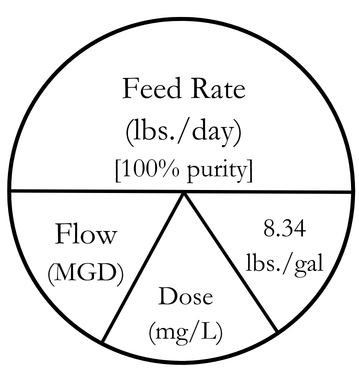
$$\text{Feed rate} = (d) \times (Q) \times (8.34 \text{ lbs./gal})$$

Where:
feed rate = lbs./day
d = dose (mg/L)
Q = flow (MGD)

-.-

$$\text{Feed rate} = \frac{(d) \times (Q) \times 8.34 \text{ lbs./gal}}{\text{Chemical Purity}}$$

Where:
feed rate = lbs./day
d = dose (mg/L)
Q = flow (MGD)
Chemical purity = %, expressed as decimal



$$\text{Feed rate} = \frac{(C) \times (V) \times (1{,}440 \text{ min/day})}{(T) \times (1{,}000 \text{ mg/g}) \times (453.6 \text{ g/lb.})}$$

Where:
feed rate = lbs./day
C = concentration (mg/mL)
V = volume pumped (mL)
T = time pumped (min.)

-.-

Chemical Feed Pump Formulas

$$\text{Chemical Feed Stroke} = (Q_d/Q_m) \times 100\%$$

Where:
chemical feed stroke, expressed as %
Q_d = desired flow
Q_m = maximum flow

-.-

$$\text{Feed pump rate} = \frac{(Q) \times (d) \times (3.785 \text{ L/gal}) \times (1{,}000{,}000 \text{ gal/MG})}{(L) \times (24 \text{ hr./day}) \times (60 \text{ min/hr.})}$$

Where:
feed pump rate =mL/min
Q = flow (MDG)
d = dose (mg/L)
L = liquid (mg/mL)

-.-

Power Formulas

$$\text{AC circuit} = V \times A \times PF$$

Where:
AC = AC circuit
V = volts
A = amps
PF = power factor

-.-

$$\text{Amps (A)} = \frac{V}{O}$$

Where:
A = amps
V = volts
O = ohms

-.-

$$\text{Amps} = \frac{(746 \text{ watts/hp}) \times (hp)}{(V) \times (Eff) \times (Pf)}$$

Where:
Amps is single phase
hp = horsepower
V = volts
Eff = efficiency (%, as decimal)
Pf = power factor

-.-

$$\text{Amps} = \frac{(746 \text{ watts/hp}) \times (hp)}{(1.732) \times (V) \times (Eff) \times (Pf)}$$

Where:
Amps is three-phase
hp = horsepower
V = volts
Eff = efficiency (%, as decimal)
Pf = power factor

Watts = V x A

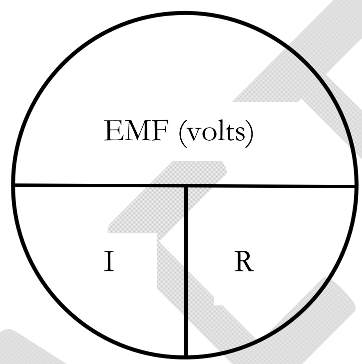
Where: Watts = DC or AC circuit
V = volts
A = amps

-.-

Electromotive Force (EMF) = I x R

Where: (volts)
EMF = electromotive force

I = current (amps)
R = resistance (ohms)



-.-

PUMPS

Pumping Formulas

Pumping Rate = V/T

Where: pumping rate in gal/min
V = volume (gal.)
T = time (min.)

-.-

$$\text{Pumping Rate} = \frac{L \times W \times D \times 7.48\ \text{gal/ft}^3}{T}$$

Where: pumping rate in gal/min
L = length (ft.)
W = width (ft.)
D = depth (ft.)
T = time (min.)

-.-

$$\text{Pumping Rate} = \frac{0.785 \times d^2 \times D \times 7.48\ \text{gal/ft}^3}{T}$$

Where: pumping rate in gal/min
d = diameter (ft.)
D = depth (ft.)
T = time (min.)

-.-

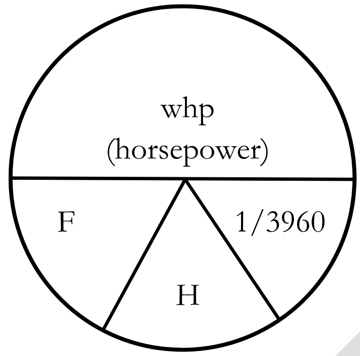
$$\text{Time to Fill} = \frac{\text{Tank volume}}{\text{Flow Rate}}$$

Where: time to fill in min.
tank volume in gal.
flow rate in gal/min.

Horsepower, Motor & Pump Efficiency

$$whp = \frac{F \times H}{3{,}960}$$

Where: whp = water horsepower
F = flow (gpm)
H = head (ft.)



-.-

$$bhp = \frac{F \times H}{3{,}960 \times PE}$$

Where: bhp = brake horsepower
F = flow (gpm)
H = head (ft.)
PE = pump efficiency (%, as decimal)

-.-

$$bhp = whp/PE$$

Where: bhp = brake horsepower
whp = water horsepower
PE = pump efficiency (%, as decimal)

-.-

$$mhp = \frac{F \times H}{3{,}960 \times PE \times ME}$$

Where: mhp = motor horse power
F = flow (gpm)
H = head (ft.)
PE = pump efficiency (%, as decimal)
ME = motor efficiency (%, as decimal)

-.-

$$mhp = bhp/ME$$

Where: mhp = motor horse power
Bhp = brake horsepower
ME = motor efficiency (%, as decimal)

-.-

$$ME = (bhp/mhp) \times 100\%$$

Where: ME = motor efficiency (%)
bhp = brake horsepower
mhp = motor horse power

-.-

$$PE = (whp/bhp) \times 100\%$$

Where: PE = pump efficiency (%)
whp = water horsepower
bhp = brake horsepower

$$\text{Efficiency} = \frac{\text{hp output}}{\text{hp supplied}} \times 100\%$$

Where: efficiency is %

$$\text{Overall Efficiency} = (\text{whp}/\text{mhp}) \times 100\%$$

Where:
overall efficiency is %
whp = water horsepower
mhp = motor horse power

$$\text{Wire to water efficiency} = \frac{\text{whp}}{\text{Power input or mhp}}$$

Where:
wire to water efficiency is %
whp = water horsepower
mhp = motor horse power
power input is hp

$$\text{Wire to water efficiency} = (\text{PE} \times \text{ME}) \times 100\%$$

Where:
wire to water efficiency is %
PE = pump efficiency (%)
ME = motor efficiency (%)

$$\text{Static Head} = \text{Suction lift} + \text{Discharge Head}$$

Where:
Static Head in ft.
Suction Lift in ft.
Discharge Head in ft.

$$\text{Static Head} = \text{Discharge Head} - \text{Suction Head}$$

Where:
Static Head in ft.
Discharge Head in ft.
Suction Head in ft.

$$\text{Friction Loss} = (0.1) \times (\text{Static Head})$$

** use this formula in absence of other data

Where:
Friction Loss is ft.
Static Head is ft.

$$\text{Total Dynamic Head} = \text{Static Head} + \text{Friction Loss}$$

Where:
Total Dynamic Head is ft.
Static Head is ft.
Friction Loss is ft.

$$\text{Cost} = (\text{Motor hp}) \times (0.746\ \text{kW/hp}) \times (\text{Cost, \$/kW-hr})$$

Where: Cost is $/hr.

$DT = \frac{(V) \times (24\ hr./day)}{Q}$

Where: DT = detention time (hr.)
V = volume of tank or basin (gal)
Q = flow rate (gal/day)

-.-

DT = (V)/(Q)

Where: DT = detention time (days)
V = volume of tank or basin (gal)
Q = flow rate (gal/day)

-.-

Weir Overflow Rate = (Q)/(L)

Where: weir overflow rate = gal/day/ft.
Q = flow rate (gal/day)
L = total weir length (ft.)

-.-

Weir Overflow Rate (rectangular basin) $= \frac{Q}{[2 \times (l)] + [2 \times (w)]}$

Where: weir overflow rate = gal/day/ft.
Q = flow rate (gal/day)
l = weir length (ft.)
w = weir width (ft.)

-.-

Weir Overflow Rate (circular basin) $= \frac{Q}{(3.14) \times (D)}$

Where: weir overflow rate = gal/day/ft.
Q = flow rate (gal/day)
D = weir diameter (ft.)

-.-

Surface Overflow Rate = (Q)/(A)

Where: surface overflow rate = gal/day/ft^2
Q = flow rate (gal/day)
A = surface area (ft^2)

-.-

TRICKLING FILTERS

HLR = $(Q_1 + Q_2)/(A)$

Where: HLR = hydraulic loading rate (gpd/ft^2)
Q_1= primary effluent flow (gpd)
Q_2= recirculated flow (gpd)
A = surface area (ft^2)

-.-

BOD_5 of RBC = $(BOD_5)/(A)$

Where: BOD_5 of RBC = lbs./day/1,000 ft^2
BOD_5 = lbs./day
A = surface area of media (1,000ft^2)

$BOD_5 = (BOD_5)/(V)$

Where: BOD_5 = lbs./day/1,000 ft^3
BOD_5 = lbs./day
V = volume of media (1,000ft^3)

-.-

$V = [(0.785) \times (D)^2 \times (d)]/1,000$

Where: V = volume of media (1,000ft^3)
D = diameter of trickling filter (ft)
d = media depth (ft)

-.-

$$PE = \frac{(Q) \times (BOD_5) \times (8.34 \text{ lbs./gal})}{BOD}$$

Where: PE = population equivalent
Q = flow (MGD)
BOD_5 = mg/L
BOD = lbs./day/person

-.-

Recirculation Ratio = $(Q_2)/(Q_1)$

Where: Q_2= recirculated flow (MGD)
Q_1= primary effluent flow (MGD)

-.-

Recirculation Rate, % = $[(Q_2)/(Q_1)] \times 100\%$

Where: Q_2= recirculated flow (MGD)
Q_1= primary effluent flow (MGD)

-.-

Reduction in flow, % = $[(Q_{original} – Q_{reduced})/(Q_{original})] \times 100\%$

Where: $Q_{original}$ = original flow
$Q_{reduced}$ = reduced flow

-.-

Reduction of volatile solids, % = $\{(In – Out)/[In – (In \times Out)]\} \times 100\%$

Where: VS = volatile solids, expressed as %
All information (In & Out) must be in decimal form

-.-

Efficiency, % = = $[(In – Out)/(In)] \times 100\%$

-.-

BOD removed (lbs./day) = $[\text{BOD removed (mg/L)}] \times (Q) \times (8.34 \text{ lbs./gal})$

Where: Q = flow (MGD)

SS removed (lbs./day) = [SS removed (mg/L)] x (Q) x (8.34 lbs./gal)

Where: SS = suspended solids
Q = flow (MGD)

-.-

ACTIVATED SLUDGE

$$BOD_5 = \frac{(DO_I - DO_F) \times 300}{V_{sample}}$$

Where: BOD_5 = mg/L
DO_I = initial DO (mg/L)
DO_F = final DO (mg/L)
V_{sample} = sample volume (mL)
BOD bottle = 300 mL

-.-

BOD loading = (BOD_5) x (Q) x (8.34 lbs./gal)

Where: BOD loading = lbs./day
BOD_5 = biological oxygen demand (mg/L)
Q = flow (MGD)

-.-

COD loading = (COD) x (Q) x (8.34 lbs./gal)

Where: COD loading = lbs./day
COD = chemical oxygen demand (mg/L)
Q = flow (MGD)

-.-

MLSS (lbs.) = (MLSS, mg/L) x (V) x (8.34 lbs./gal)

Where: MLSS = mixed liquor suspended solids
V = aerator volume (MG)

-.-

MLVSS = (MLSS) x (V) x (8.34 lbs./gal) x (VS)

Where: MLVSS = lbs.
MLSS = mixed liquor suspended solids (mg/L)
V = aerator volume (MG)
VS = volatile solids % (expressed as decimal)

-.-

$$SVI = \frac{(SSV_{wet}) \times (1{,}000)}{SSM_{dried}}$$

Where: SVI = sludge volume index (mL/g)
SSV_{wet} = wet settled sludge volume (mL)
SSM_{dried} = dried sludge solids mass (mg)

$$SVI = \frac{(SSC) \times (1{,}000{,}000)}{MLSS}$$

Where:
SVI = sludge volume index (mL/g)
SSC = settleable solids concentration % (expressed as decimal)
MLSS = mixed liquor suspended solids (mg/L)

-.-

$$SVI = \frac{(SSV) \times (1{,}000 \text{ mg/g})}{MLSS}$$

Where:
SVI = sludge volume index (mL/g)
SSV = settled sludge volume (mL/L)
MLSS = mixed liquor suspended solids (mg/L)

-.-

$$SDI = (100)/(SVI)$$

Where:
SDI = sludge density index
SVI = sludge volume index (mL/g)

-.-

Seeded BOD

$$BOD_5 = \frac{(D_1 - D_2) - (S) \times (V_S)}{P}$$

Where:
BOD_5 = lbs./day
D_1 = DO of sample after prep (mg/L)
D_2 = DO of sample after 5-day incubation at 20°C (mg/L)
S = oxygen uptake of seed (S = 0 if sample not seeded)
V_S = volume of seed in test bottle (mL)
P = decimal volumetric fraction of sample used. (1/P = dilution factor)

-.-

F/M Ratio ('Food to Mass' or 'Food to Microorganism' Ratio)

$$F/M \text{ ratio} = \frac{(BOD \text{ or } COD)}{MLVSS}$$

Where:
BOD = biological oxygen demand (lbs./day)
COD = chemical oxygen demand (lbs./day)
MLVSS = mixed liquor volatile suspended solids (lbs.)

-.-

$$F/M \text{ ratio} = \frac{(BOD \text{ or } COD)}{(MLSS) \times (VS)}$$

Where:
BOD = biological oxygen demand (lbs./day)
COD = chemical oxygen demand (lbs./day)
MLSS = mixed liquor suspended solids (lbs.)
VS = volatile solids, % (expressed as decimal)

$$\text{F/M ratio} = \frac{(\text{BOD or COD}) \times (Q) \times (8.34\ \text{lbs./gal})}{(\text{MLVSS}) \times (V) \times (8.34\ \text{lbs./gal})}$$

Where:
BOD = biological oxygen demand (mg/L)
COD = chemical oxygen demand (mg/L)
Q = flow (MGD)
MLVSS = mixed liquor volatile suspended solids (mg/L)
V = aerator volume (MG)

-.-

$$\text{F/M ratio} = \frac{(\text{BOD or COD}) \times (Q) \times (8.34\ \text{lbs./gal})}{(\text{MLVSS}) \times (\text{VS}) \times (V) \times (8.34\ \text{lbs./gal})}$$

Where:
BOD = biological oxygen demand (mg/L)
COD = chemical oxygen demand (mg/L)
Q = flow (MGD)
MLVSS = mixed liquor volatile suspended solids (mg/L)
VS = volatile solids, % (expressed as decimal)
V = aerator volume (MG)

-.-

$$\text{MLVSS (desired)} = \frac{(\text{BOD or COD})}{\text{F/M Ratio (desired)}}$$

Where:
MLVSS = mixed liquor volatile suspended solids (lbs.)
BOD = biological oxygen demand (lbs./day)
COD = chemical oxygen demand (lbs./day)

-.-

$$\text{MLSS (desired)} = \frac{\text{MLVSS (desired)}}{\text{VS}}$$

Where:
MLSS = mixed liquor suspended solids (lbs.)
MLVSS = mixed liquor volatile suspended solids (lbs.)
VS = volatile solids, % (expressed as decimal)

-.-

RAS (Return Activated Sludge)

$$\text{RAS flow} = \left[\frac{\text{SSV}}{(1000\ \text{mL}) - (\text{SSV})}\right] \times 100\%$$

Where:
RAS flow expressed as %
SSV = settled sludge volume (mL)

-.-

$$\text{RAS flow} = \left[\frac{Q_{RAS}}{Q_{Influent}}\right] \times 100\%$$

Where:
RAS flow expressed as %
Q_{RAS} = RAS flow (MGD)
$Q_{Influent}$ = influent flow (MGD)

-.-

$$\text{RAS flow}_{final} = (\text{RAS flow }\%) \times Q$$

Where:
RAS flow_{final} = final RAS flow (gal/day)
RAS flow % is expressed as decimal
Q = flow (gpd)

$$\text{RAS flow} = \frac{(Q_{Influent}) \times (MLSS)}{(RSC) - (MLSS)}$$

Where:
RAS flow = gal/day
$Q_{Influent}$ = aerator influent flow (gpd)
MLSS = mixed liquor suspended solids (mg/L)
RSC = return sludge concentration (mg/L)

-.-

$$RSC = (1{,}000{,}000)/(SVI)$$

Where:
RSC = return sludge concentration (mg/L)
SVI = sludge volume index (mL/g)
(SVI calculations in 'Activated Sludge' section)

-.-

$$\text{RAS (solids balance)} = \frac{(MLSS) \times (Q)}{(RAS\ SS) - (MLSS)}$$

Where:
RAS = return activated sludge
MLSS = mixed liquor suspended solids
Q = flow rate
RAS SS = return activated sludge suspended solids

-.-

MCRT or SRT ('Mean Cell Residence Time' or 'Solids Retention Time')

$$MLSS_{final} = (MLSS_{actual}) \times (V) \times (8.34\ \text{lbs./gal})$$

Where:
$MLSS_{final}$ = final actual MLSS (lbs.)
$MLSS_{actual}$ = actual MLSS (mg/L)
V = aerator volume (MG)

-.-

$$MCRT = (SS_{in})/(SS_{leaving})$$

Where:
MCRT = days
SS_{in} = suspended solids in system (lbs.)
$SS_{leaving}$ = suspended solids leaving system (lbs./day)

-.-

$$MCRT = \frac{(SS_{in})}{(WAS\ SS) + (SE\ SS)}$$

Where:
MCRT = days
SS_{in} = suspended solids in system (lbs.)
WAS SS = waste activated sludge SS (lbs./day)
SE SS = secondary effluent SS (lbs./day)

-.-

<u>NO CLARIFIER INFO GIVEN:</u>

$$MCRT = \frac{(MLSS) \times (V) \times (8.34\ \text{lbs./gal})}{[(WAS\ SS) \times (Q_{WAS}) \times (8.34\ \text{lbs./gal})] + [(SE\ SS) \times (Q_{Plant}) \times (8.34\ \text{lbs./gal})]}$$

Where:
MCRT = days
MLSS = mixed liquor suspended solids (mg/L)
V = aerator volume (MG)
WAS SS = waste activated sludge SS (mg/L)
Q_{WAS} = WAS flow (MGD)
SE SS = secondary effluent SS (mg/L)
Q_{Plant} = plant flow (MGD)

FINAL CLARIFIER VOLUME GIVEN BUT NO CLARIFIER CORE SUSPENDED SOLIDS (CCSS):

$$MCRT = \frac{(MLSS) \times [(V_{aerator}) + (V_{clarifier})] \times (8.34 \text{ lbs./gal})}{[(WAS\ SS) \times (Q_{WAS}) \times (8.34 \text{ lbs./gal})] + [(SE\ SS) \times (Q_{Plant}) \times (8.34 \text{ lbs./gal})]}$$

Where:
MCRT = days
MLSS = mixed liquor suspended solids (mg/L)
$V_{aerator}$ = aerator volume (MG)
$V_{clarifier}$ = final clarifier volume (MG)
WAS SS = waste activated sludge SS (mg/L)
Q_{WAS} = WAS flow (MGD)
SE SS = secondary effluent SS (mg/L)
Q_{Plant} = plant flow (MGD)

-.-

FINAL CLARIFIER VOLUME & CLARIFIER CORE SUSPENDED SOLIDS (CCSS)GIVEN:

$$MCRT = \frac{[(MLSS) \times (V_{aerator}) \times (8.34 \text{ lbs./gal})] + [(CCSS) \times (V_{clarifier}) \times (8.34 \text{ lbs./gal})]}{[(WAS\ SS) \times (Q_{WAS}) \times (8.34 \text{ lbs./gal})] + [(SE\ SS) \times (Q_{Plant}) \times (8.34 \text{ lbs./gal})]}$$

Where:
MCRT = days
MLSS = mixed liquor suspended solids (mg/L)
$V_{aerator}$ = aerator volume (MG)
CCSS = clarifier core suspended solids (mg/L)
$V_{clarifier}$ = final clarifier volume (MG)
WAS SS = waste activated sludge SS (mg/L)
Q_{WAS} = WAS flow (MGD)
SE SS = secondary effluent SS (mg/L)
Q_{Plant} = plant flow (MGD)

-.-

$$MCRT = \frac{TSS_{Aeration} + TSS_{Clarifier}}{TSS_{Wasted} + TSS_{Effluent}}$$

Where:
MCRT = days
$TSS_{Aeration}$ = aeration tank TSS (lbs.)
$TSS_{Clarifier}$ = clarifier TSS (lbs.)
TSS_{Wasted} = TSS wasted (lbs./day)
$TSS_{Effluent}$ = effluent TSS (lbs./day)

-.-

Waste Activated Sludge (WAS)

$$WAS = \left[\frac{(MLSS) \times (V_{aerator}) \times (8.34 \text{ lbs./gal})}{MCRT}\right] - [(SE\ SS) \times (Q_{Plant}) \times (8.34 \text{ lbs./gal})]$$

Where:
WAS = lbs./day
MLSS = mixed liquor suspended solids (mg/L)
$V_{aerator}$ = aerator volume (MG)
MCRT = days
SE SS = secondary effluent SS (mg/L)
Q_{Plant} = plant flow (MGD)

$$MLSS_{final} = \left[\frac{MLSS_{initial}}{(RAS) \times (8.34 \text{ lbs./gal})} \right] \times 1{,}000{,}000$$

Where:

$MLSS_{final}$ = MLSS to waste (gal)
$MLSS_{initial}$ = MLSS to waste (lbs.)
RAS = RAS concentration (mg/L

-.-

$$\text{Min. to WS} = \frac{\text{MLSS}}{\text{WS Pump Capacity}}$$

Where:

min. to WS = minutes to waste sludge
MLSS = MLSS to waste (gal)
WS pump capacity = waste sludge pump capacity (gal/min.)

-.-

$$\text{Min/Hr. to WS} = \frac{\text{WS}}{\text{24hrs./day}}$$

Where:

min/hr. to WS = minutes per hour to waste sludge
WS = min per day to waste sludge

-.-

Wastewater Treatment Ponds

PL = (Population)/(A)

Where:

PL = population loading (persons/acre)
Population = population served (persons)
A = pond area (acres)

-.-

V = (A) x (d)

Where:

V = pond volume (ac-ft.)
A = pond area (acres)
d = pond depth (ft.)

-.-

V = [(L) x (W) x (d)]/(43,560 ft^2/ac)

Where:

V = pond volume (ac-ft.)
L = length (ft.)
W = length (ft.)
d = pond depth (ft.)

-.-

V (gal) = [V (ac-ft.)] x (43,560 ft^2/ac) x (7.48 gal/ft^3)

Where:

V = pond volume

-.-

A = [(L) x (W)]/(43,560 ft^2/ac)

Where:

A = pond area (acre)
L = length (ft.)
W = length (ft.)

$$Q\ (\text{ac-ft./day}) = [Q\ (\text{gal/day})]/[(7.48\ \text{gal/ft}^3) \times (43{,}560\ \text{ft}^2/\text{ac})]$$

Where: Q = flow

-.-

$$DT = (V)/(Q)$$

Where:
DT = detention time (days)
V = volume (gal)
Q = flow (gal/day)

-.-

$$DT = (V)/(Q)$$

Where:
DT = detention time (days)
V = volume (ac-ft.)
Q = flow (ac-ft./day)

-.-

$$\text{BOD loading} = (BOD_5) \times (Q) \times (8.34\ \text{lbs./gal})$$

Where:
BOD loading = lbs./day
BOD_5 = biological oxygen demand (MGD)
Q = flow (MGD)

-.-

$$OLR = (BOD)/(A)$$

Where:
OLR = organic loading rate (lbs./day/acre)
BOD = influent BOD (lbs./day)
A = pond areas (acres)

-.-

$$OLR = [(BOD) \times (Q) \times (8.34\ \text{lbs/gal})]/(A)$$

Where:
OLR = organic loading rate (lbs./day/acre)
BOD = influent BOD (mg/L)
Q = flow (MGD)
A = pond areas (acres)

-.-

$$\text{BOD removal efficiency, \%} = [(BOD_{removed})/(BOD_{total})] \times 100\%$$

Where:
$BOD_{removed}$ = BOD removed (mg/L)
BOD_{total} = total BOD (mg/L)

-.-

$$HLR = [(Q)/(A)] \times 12\ \text{in/ft.}$$

Where:
HLR = hydraulic loading rate (in/day)
Q = flow (ac-ft./day)
A = pond area (acres)

Loading Formulas (general)

Loading = (Concentration) x (Q) x (8.34 lbs./gal)

Where: Loading is TSS or BOD = lbs./day
Concentration of TSS or BOD = mg/L
Q = flow

-.-

$$\text{Hydraulic loading rate} = \frac{\text{Flow}}{A}$$

Where: Hydraulic Loading = gpd/ft^2
Flow = gpd
A = area (ft^2)

-.-

$$\text{Surface loading rate or Surface overflow rate} = \frac{\text{Flow}}{A}$$

Where: Surface Loading/Surface Overflow rate in gpd/ft^2
Flow = gpd
A = area (ft^2)

-.-

LABORATORY FORMULAS

Alkalinity & Hardness

$$P = \frac{(A) \times (N) \times (50{,}000)}{V_{sample}}$$

Where: P = phenoltphthalein alkalinity (mg $CaCO_3$/L)
A = titrant volume used to reach 8.3 pH (mL)
N = acid normality
V_{sample} = sample volume (mL)

-.-

$$T = \frac{(B) \times (N) \times (50{,}000)}{V_{sample}}$$

Where: T = total alkalinity (mg $CaCO_3$/L)
B = total titrant used (mL)
N = acid normality
V_{sample} = sample volume (mL)

-.-

$$\text{Hardness} = \frac{(B) \times (1{,}000)}{V_{sample}}$$

Where: Hardness = mg $CaCO_3$/L
B = titrant volume (mL)
V_{sample} = sample volume (mL)
Only when the titration factor is 1.00 of EDTA

-.-

Bacteriological

Average (arithmetic mean) = (sum of all terms)/(number of terms)

$$\text{Average (geometric mean)} = \sqrt[n]{(X_1)(X_2)(X_3)(X_4)\ \dots\ (X_n)}$$

The nth root of the product of n numbers

$$BC = \frac{(CC) \times (100)}{V}$$

Where: BC = bacteriological colonies/100 mL
CC = number of colonies counted
V = sample volume filtered (mL)

-.-

Laboratory Solutions Formulas

$$(N_1 \times V_1) + (N_2 \times V_2) = (N_3 \times V_3)$$

$$(N_1 \times V_1) = (N_2 \times V_2)$$

Where: $V_1 + V_2 = V_3$
N = normality
V = volume or flow

-.-

Milliequivalent = mL x Normality

-.-

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{Liters of solution}}$$

-.-

$$\text{Normality} = \frac{\text{Number of equivalent weights of solute}}{\text{Liters of solution}}$$

-.-

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

-.-

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

-.-

$$\text{Specific gravity} = \frac{\text{Specific weight of substance, lbs./gal}}{\text{Specific weight of water, lbs./gal}}$$

-.-

Oxygen Uptake Rate (OUR)

Respiration Rate = (OUR)/(MLSS)

Where: respiration rate = mg/g/hr.
OUR = oxygen uptake rate (mg/L/hr.)
MLSS = mixed liquor suspended solids (g/L)

$$\text{OUR mgL/min} = \left[\frac{DO_{starting} - DO_{ending}}{T}\right] \times 60 \text{ min/hr.}$$

Where: OUR = mg/L/hr.
$DO_{starting}$ = starting DO (mg/L)

DO_{ending} = ending DO (mg/L) T = elapsed time (min)

Load Index = $(OUR_{fed})/(OUR_{unfed})$

Where: OUR_{fed} = fed OUR (mg/L/hr.)
OUR_{unfed} = unfed OUR (mg/L/hr.)

$$SOUR = \frac{(OUR) \times (1{,}000\ mg/g)}{MLVSS}$$

Where: SOUR = specific OUR (mg O_2/hr./g)
OUR = oxygen uptake rate (mg/L/hr.)
MLSS = mixed liquor volatile suspended solids (g/L)

Solids

$$SS = \frac{(A - B) \times (1{,}000{,}000)}{V_{sample}}$$

Where: SS = suspended solids (mg/L)
A = final weight of pan, filter & residue (g)
B = weight of prepared filter & pan (g)
V_{sample} = sample volume (mL)

$$TS = \frac{(C - D) \times (1{,}000{,}000)}{V_{sample}}$$

Where: TS = total solids (mg/L)
C = weight of dish & dried solids (g)
D = weight of dish (g)
V_{sample} = sample volume (mL)

$$VS = \frac{(C - E) \times (1{,}000{,}000)}{V_{sample}}$$

Where: VS = volatile solids (mg/L)
C = weight of dish & dried solids (g)
E = weight of dish & ash (g)
V_{sample} = sample volume (mL)

$$FS = \frac{(C - D) \times (1{,}000{,}000)}{V_{sample}}$$

Where: FS = fixed solids (mg/L)
E = weight of dish & ash (g)
D = weight of dish (g)
V_{sample} = sample volume (mL)

$$\text{Volatile solids} = \frac{\text{Dry solids - Fixed solids}}{\text{Dry solids}} \times 100\%$$

Where: Volatile solids (as %)
Dry solids in grams
Fixed solids = inorganics (g)

$$\%\ VS = \{(VS)/(TS)\} \times 100\%$$

Where: VS = volatile solids (mg/L)
TS = total solids (mg/L)

$SC = (W)/(V)$

Where:
SC = solids concentration (mg/L)
W = weight (mg)
V = volume (L)

Temperature Conversions

$°C = (°F – 32) \times (0.566)$

$°F = (°C \times 1.8) + 32$

Where:
°C = degrees Celsius
°F = degrees Fahrenheit

Average Formulas

Average (arithmetic mean) = (sum of all terms)/(number of terms)

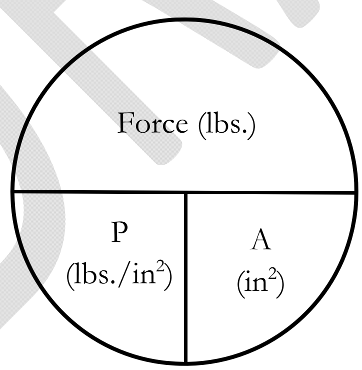
Average (geometric mean) = $\sqrt[n]{(X_1)(X_2)(X_3)(X_4)\ \ldots\ (X_n)}$

The nth root of the product of n numbers

FORCE

$F = (P) \times (A)$

Where:
F = force (lbs.)
P = pressure (psi or lbs./in^2)
A = area (in^2)



Coagulation/Flocculation Formulas

$$DT = \frac{(V) \times (1{,}440\ \text{min/day}) \times (60\ \text{sec/min})}{Q}$$

Where:
DT = detention time (sec)
V = volume (gal)
Q = flow rate(gal/day)

$$DT = \frac{(V) \times (1{,}440 \text{ min/day})}{Q}$$

Where: DT = detention time (min)
V = volume (gal)
Q = flow rate (gal/day)

-.-

Filter Formulas

$$\text{Backwash rise rate} = \frac{\text{Backwash rate} \times 12 \text{ in/ft.}}{7.48 \text{ gal/ft}^3}$$

Where: backwash rinse rate = in/min.
backwash rate = gpm/ft^2

-.-

$$V = (R) \times (T) \times (A)$$

Where: V = backwash water volume (gal)
R = backwash rate (gpm/ft^2)
T = backwash time (min)
A = filter area (ft^2)

-.-

$$\text{Yield} = \left[\frac{\text{Backwash water}}{\text{Water Filtered}}\right] \times 100\%$$

Where: yield = backwash water yield, %
backwash water = gal
water filtered = gal

-.-

$$\text{Flow/Backwash rate} = (Q)/(A)$$

Where: flow/backwash rate = gpm/ ft^2
Q = flow (gpm)
A = filter area (ft^2)

-.-

$$\text{Filtration Rate} = (V)/(T)$$

Where: filtration rate = gpm
V = volume (gal)
T = average time (min)

-.-

$$T = \frac{(test_1) + (test_2) \ldots (test_n)}{n}$$

Where: T = average time (sec)
n = number of tests

-.-

$$\text{Filter Production Rate} = (R) \times (A)$$

Where: filter production rate = gal/min
R = filtration rate (gpm/ft^2)
A = filter area (ft^2)

$$\text{Yield} = \frac{(\text{Loading}) \times (\text{Recovery})}{(\text{Filter operation}) \times (A)}$$

Where:

yield = lbs./hr./ ft^2
loading = solids loading (lbs./day)
recovery = %, expressed as a decimal
filter operation = hr./day
A = area (ft^2)

SEDIMENTATION

DT = (Vol x 24 hr./day)/Q

Where:

DT = detention time, hr.
Vol = volume of tank (gal)
Q = flow rate (gal/day)

Weir Overflow rate = F/L

Where:

overflow rate = gal/day/ft.
F = flow (gal/day)
L = total weir length (ft.)

Weir Length (Rectangular Basin)
Weir length = (2 x L) + (2 x W)

Weir Length (Circular Basin)
Weir length = 3.14 x D

Where:

weir length = ft.
L = length (ft.)
W = width (ft.)
D = diameter (ft.)

Weir Overflow rate (Rectangular Basin)
Overflow rate = F/[(2 x L) + (2 x W)]

Weir Overflow rate (Circular Basin)
Overflow rate = F/(3.14 x D)

Where:

overflow rate = gal/day/ft.
F = flow (gal/day)
L = length (ft.)
W = width (ft.)
D = diameter (ft.)

Surface Overflow rate = F/A

Where:

overflow rate = gal/day/ft^2
F = flow (gal/day)
A = surface area (ft^2)

Solids Loading rate = Solids Applied/A

Where:

loading rate = lbs./day/ft^2
solids applied = lbs./day
A = surface area (ft^2)

Solids Loading rate (Rectangular Basin)
Loading rate = Solids Applied/(L x W)

Solids Loading rate (Circular Basin)
Loading rate = Solids Applied/(0.785 x D)

Where:

loading rate is lbs./day/ft2
solids applied is lbs./day
L = length (ft.)
W = width (ft.)
D = diameter (ft.)

BOD removed (lbs./day) = BOD removed x F x 8.34 lbs./gal

Where: BOD removed is mg/L
F = Flow (MGD)

-.-

SS Removed (lbs./day) = SS Removed x F x 8.34 lbs./gal

Where: SS removed is mg/L
F = Flow (MGD)

-.-

Efficiency = [(In – Out)/In] x 100%

-.-

WET WELL

$$\text{Cycle time (min)} = \frac{SV}{PC - \text{Inflow}}$$

Where: SV = storage volume (gal)
PC = pump capacity (gpm)
Inflow = wet well inflow (gpm)

-.-

COLLECTION SYSTEM

$$\text{Slope, \%} = \left[\frac{\text{Drop or rise}}{\text{Distance}}\right] \times 100\%$$

OR

$$\text{Slope, \%} = \left[\frac{\text{Rise}}{\text{Run}}\right] \times 100\%$$

-.-

Velocity = F/A

Where: Velocity is ft./sec
F = flow (ft^3/sec)
A = area (ft^2)

-.-

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}}$$

Where: Velocity is ft./sec
D = distance (ft.)
T = time (sec)