BASIC CONVERSION FACTORS
(ENGLISH SYSTEM)

LENGTH		
12 in	= 1 ft	12 in/ft
3 ft	= 1 yd	3 ft/yd
5,280 ft	= 1 mi	5,280 ft/mi
AREA		
144 sq in	= 1 sq ft	144 sq in/sq ft
43,560 sq ft	= 1 acre	43,560
VOLUME		
7.48 gal	= 1 cu ft	7.48 gal/cu ft
1000 ml	= 1 Liter	1,000 ml/L
3.785 L	= 1 gal	3.785L/gal
231 cu in	= 1 gal	231 cu in/gal
WEIGHT		
1,000 mg	= 1 gm	1,000 mg/gm
1,000 gm	= 1 kg	1,000 gm/kg
454 gm	= 1 lb	454 gm/lb
2.2 lbs	= 1 kg	2.2 lbs/kg
POWER		
0.746 kw	= 1 HP	0.746 kw/HP
DENSITY		
8.34 lbs	= 1 gal	8.34 lbs/gal
62.4 lbs	= 1 cu ft	62.4 lbs/cu ft
PRESSURE		
2.31 ft water	= 1 psi	2.31 ft water/psi
0.433 psi	= 1 ft water	0.433 psi/ft water
1.133 ft water	= 1 in Mercury	1.133 ft water/in Mercury
FLOW		
694 GPM	= 1 MGD	694 GPM/MGD
1.55 CFS	= 1 MGD	1.55 CFS/MGD

BASIC FORMULAS

Flows

$$\text{Flow, MGD} = \frac{\text{(Flow, GPM)(60 min/hr)(24hr/day)}}{\text{1,000,000/M}}$$

$$\text{Flow, GPM} = \frac{\text{(Flow, MGD)(1,000,000/M)}}{\text{(60min/hr)(24 hr/day)}}$$

$$\text{Flow, CFS} = \frac{\text{(Flow, MGD)(1,000,000/M)}}{\text{(7.48 gal/cu ft)(60min/hr)(24 hr/day)}}$$

$$= \text{(Flow, MGD)(1.55 CFS/MGD)}$$

Grit Channels

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

$$= \frac{\text{Flow, CFS}}{\text{Area sq ft}}$$

$$\text{Grit Removed, cu ft /MG} = \frac{\text{Volume of Grit, cu ft}}{\text{Volume of Flow, MG}}$$

Sedimentation Tanks and Clarifiers

$$\text{Detention Time, hr} = \frac{\text{(Tank Volume, cu ft)(7.48 gal/cu ft)(24 hr/day)}}{\text{Flow, gal/day}}$$

Tank Volume, cu ft = (Area, sq ft)(Depth, ft)

Circular Clarifiers Area, sq ft = 0.785 $(\text{Diameter, ft})^2$

Rectangular Clarifier Area, sq ft = Length, ft x Width, ft

$$\text{Surface Loading Rate, GPD/ sq ft} = \frac{\text{Flow, GPD}}{\text{Area, sq ft}}$$

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

Length of Weir, ft (Circular Clarifiers) = 3.14 (Diameter, ft)

Solids Applied lbs/day = (Flow, MGD)(SS mg/L)(8.34 lbs/gal)

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

Trickling Filters

$$\text{Hydraulic Loading GPD/sq ft} = \frac{\text{Flow, GPD}}{\text{Surface Area, sq ft}}$$

$$\text{Organic Loading lbs BOD/day/1,000 cu ft} = \frac{\text{BOD Applied, lbs/day}}{\text{Volume of Media, 1000 cu ft}}$$

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

$$\text{Plant Efficiency, \%} = \frac{\text{(In – Out)}}{\text{In}} \times 100\%$$

Rotating Biological Contactors

$$\text{Hydraulic Loading GPD/sq ft} = \frac{\text{(Flow, GPD)}}{\text{Surface Area, sq ft}}$$

$$\text{Organic Loading, lbs BOD/day/1,000 sq ft} = \frac{\text{(Flow, MGD)(BOD, mg/L)(8.34 lbs/gal)}}{\text{Surface Area of Media, 1000 sq ft}}$$

Activated Sludge

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

OR

$$\text{(SVI)} = \frac{\text{(Set. Sol., ml/L)(1,000)}}{\text{MLSS, mg/L}}$$

Aerator Solids, lbs =(Tank Vol., MG)(MLSS, mg/L)(8.34 lbs/gal)

Aerator Loading, lbs BOD/day = (Flow, MG) (Pri. Eff. BOD, mg/L) (8.34 lbs/gal)

Sludge Age

$$\text{Sludge Age, days} = \frac{\text{Mixed Liquor Solids, lbs}}{\text{Primary Effluent Solids, lbs/day}}$$

$$= \frac{\text{(Tank Volume, MG)(MLSS, mg/L)(8.34 lbs/gal)}}{\text{(Flow, MG) (Pri. Eff. BOD, mg/L) (8.34 lbs/gal)}}$$

Ponds

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

$$\text{Pond Area, acres} = \frac{\text{(Average Width, ft)(Average Length, ft)}}{\text{43,560 sq ft/acre}}$$

Pond Volume, ac ft = (Area, acre)(Depth, ft)

$$\text{Flow Rate, ac-ft/day} = \frac{\text{Flow gal/day}}{\text{(7.48 gal/ cu ft)(43,560 sq ft)}}$$

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

$$\text{Hydraulic Loading inches/day} = \frac{\text{Depth of pond, inches}}{\text{Detention Time, days}}$$

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

Chlorination

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

Chlorine Feed Rate, lbs/day = (Flow, MGD)(Chlorine Dose, mg/L)(8.34 lbs/gal)

Chemical Doses

Chemical Feeder Setting lbs/day = (Flow, MGD)(Dose mg/L)(8.34 lbs/gal)

$$\text{Polymer Feeder Setting, ml/min} = \frac{\text{(Flow, MGD)(Polymer dose, mg/L)(3.785 L/gal)(1,000,000)}}{\text{(Liquid Polymer mg/ml)(24hr/day)((60min/hr)(1 Million)}}$$

$$\text{Polymer Feeder Setting, gal/day} = \frac{\text{(Flow, MGD)(Polymer dose, mg/L)(8.34 lbs/gal)}}{\text{(Liquid Polymer lbs/gal)}}$$

TYPICAL WASTEWATER TREATMENT PLANT PROBLEMS
(ENGLISH SYSTEM)

Flows

EXAMPLE 1

Convert a flow of 600 gallons per minute to million gallons per day

$$\text{Flow, MGD} = \frac{(\text{Flow, gal/min})(60\ \text{min/hr})(24\ \text{hr/day})}{1{,}000{,}000/\text{M}}$$

$$= \frac{(600\ \text{gal/min})(60\ \text{min/hr})(24\ \text{hr/day})}{1{,}000{,}000/\text{M}}$$

$$= 0.86\ \text{MGD}$$

EXAMPLE 2

Convert a Flow from 1.2 MGD to cubic feet per second

$$\text{Flow, CFS} = \frac{(\text{Flow, MGD})(1{,}000{,}000/\text{M})}{(7.48\ \text{gal/cu ft})(60\ \text{min/hr})(24\ \text{hr/day})}$$

$$= \frac{(1.2\ \text{MGD})(1{,}000{,}000/\text{M})}{(7.48\ \text{gal/cu ft})(60\ \text{min/hr})(24\ \text{hr/day})}$$

$$= 1.86\ \text{CFS}$$

Grit Channels

EXAMPLE 3

Estimate the velocity of wastewater flowing through a grit channel if a stick travels 32 feet in 36 seconds.

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

$$= \frac{32 \text{ ft}}{36 \text{ sec}}$$

$$= 0.89 \text{ ft/sec}$$

EXAMPLE 4

A grit channel removed 3.2 cu ft of grit during a period when the total flow was 0.8 MG. How many liters of grit are removed per cubic meter?

$$\text{Grit Removed, cu ft/MG} = \frac{\text{Volume of Grit, cu ft}}{\text{Volume of Flow, MG}}$$

$$= \frac{3.2 \text{ cu ft}}{0.8 \text{ MG}}$$

$$= 4.0 \text{ cu ft/MG}$$

Sedimentation Tanks and Clarifiers

EXAMPLE 5

A circular secondary clarifier handles a flow of 0.9 MGD and suspended solids of 3,600 mg/L. The clarifier is 50 ft in diameter and 8.0 ft deep. Find the detention time, surface loading rate, weir over flow rate and solids loading.

$$\text{Detention Time, hr} = \frac{(\text{Tank volume, cu ft})(7.5 \text{ gal/cu ft})(24\text{hr/day})}{\text{Flow, GPD}}$$

Tank volume = (Area, sq ft)(Depth, ft)

Clarifier Area, sq ft = $0.785(\text{Diameter, ft})^2$

$$= 0.785(50 \text{ ft})^2$$

$$= 1{,}962.5 \text{ sq ft, or}$$

$$= 1{,}960 \text{ sq ft}$$

Tank volume, cu ft = (Area, sq ft)(Depth, ft)

= (1,960 sq ft)(8 ft)

= 15,680 cu ft

$$\text{Detention Time, hr} = \frac{(15{,}680 \text{ cu ft})(7.5 \text{ gal/cu ft})(24 \text{ hr/day})}{900{,}000 \text{ GPD}}$$

$$= \frac{2{,}820{,}000}{900{,}000} = 3.1 \text{ hr}$$

$$\text{Surface Loading GPD/sq ft} = \frac{\text{Flow, GPD}}{\text{Area, Sq ft}}$$

$$= \frac{900{,}000 \text{ GPD}}{1{,}960 \text{ sq ft}}$$

= 459/GPD/sq ft

$$\text{Weir Overflow GPD/ft} = \frac{\text{Flow, GPD}}{\text{Length of Weir, ft}}$$

Length of Weir, m = 3.14(Diameter, ft)

= 3.14(50 ft)

= 157 ft

$$\text{Weir Overflow GPD/ft} = \frac{900{,}000 \text{ GPD}}{157 \text{ ft}}$$

= 5,730 GPD/ft

Solids Applied lbs/day = (Flow, MGD)(SS, mg/L)(8.34 lbs/gal)

$$= (0.9 \text{ MGD})(3{,}600 \text{ mg/L})(8.34 \text{ lbs/gal})$$

$$= 27{,}022 \text{ lbs/day}$$

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

$$= \frac{27{,}022 \text{ lbs/day}}{1{,}960 \text{ sq ft}}$$

$$= 14 \text{ lbs/day/sq ft}$$

Trickling Filters

EXAMPLE 6

A flow of 1.1 MGD is applied to 50 ft diameter trickling filter, which is 4 feet deep. The BOD of the wastewater applied to the filter is 120 mg/L. Calculate the hydraulic and organic loadings on the filter.

$$\text{Hydraulic Loading GPD/sq ft} = \frac{\text{Flow, GPD}}{\text{Surface Area, sq ft}}$$

$$\text{Surface Area, sq ft} = 0.785(\text{diameter, ft})^2$$

$$= 0.785(50 \text{ ft})^2$$

$$= 1{,}960 \text{ sq ft}$$

$$\text{Hydraulic Loading GPD/sq ft} = \frac{1{,}100{,}000 \text{ GPD}}{1{,}960 \text{ sq ft}}$$

$$= 561 \text{ GPD/sq ft}$$

$$\text{Organic Loading, lbs BOD/day/1000 cu ft} = \frac{\text{BOD Applied, lbs/day}}{\text{Volume of Media, 1,000 cu ft}}$$

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

= (120 mg/L)(1.1 MGD)(8.34 lbs/gal)

= 1,100 lbs BOD/day

Volume of Media, 1,000 cu ft = (Surface Area, sq ft)(Depth, ft)

= (1,960 sq ft)(4 ft)

= 7,840 cu ft

$$\text{Organic Loading, lbs BOD/day/1,000 cu ft} = \frac{\text{BOD Applied, lbs/day}}{\text{Volume of Media, 1,000 cu ft}}$$

$$= \frac{\text{1,100 lbs BOD/day}}{\text{7.84 (1,000 cu ft)}}$$

= 140 lbs BOD/day/1,000 cu ft

EXAMPLE 7

The influent BOD to a trickling filter plant is 200 mg/L, and the effluent BOD is 20 mg/L. What is the BOD removal efficiency of the plant?

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

$$= \frac{(200 \text{ mg/L} - 20 \text{ mg/L})}{200 \text{ mg/L}} \times 100\%$$

$$= \frac{180 \text{ mg/L}}{200 \text{ mg/L}}$$

= 90%

Rotating Biological Contactors

EXAMPLE 8

A rotating biological contactor treats a flow of 2.4 MGD. The surface area of the media is 720,000 square feet. The influent has a total BOD of 220 mg/L and suspended solids of 240 mg/L. Assume a K value of 0.5 to calculate the soluble BOD. Calculate the hydraulic loading in liters per day per square meter and the organic loading in kilograms of soluble BOD per day per 1,000 square feet of media surface.

$$\text{Hydraulic Loading, GPD/sq ft} = \frac{\text{(Flow, GPD)}}{\text{Surface Area, sq ft}}$$

$$= \frac{2{,}400{,}000 \text{ GPD}}{720{,}000 \text{ sq ft}}$$

$$= 3.3 \text{ GPD/sq ft}$$

Soluble BOD, mg/L = Total BOD – (K)(Suspended Solids, mg/L)

= 220 mg/L – (0.5)(240 mg/L)

= 100 mg/L

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

= (2.4 MGD)(100 mg/L)(8.34 lbs/gal)

= 2,002 lbs/day

$$\text{Organic Loading, lbs BOD/day/1,000 sq ft} = \frac{\text{Soluble BOD Applied, lbs/day}}{\text{Surface Area of Media, 1000 sq ft}}$$

$$= \frac{2{,}002 \text{ lbs/day}}{720}$$

= 2.8 lbs BOD/day/1,000 sq ft

Activated Sludge

EXAMPLE 9

Lab results and flow rate for an activated sludge are listed below under the known column. Information helpful to the operator in controlling the process is listed in the unknown column. The aerator or aerator tank volume is 2,000 cu m.

Known

Mixed Liquor Suspended Solids (MLSS)	= 1,800 mg/L
Mixed Liquor Volatile Content	= 76%
Thirty –Minute Settleable solids Test	= 170 ml/L, or 17%
Primary Effluent BOD	= 140 mg/L
Primary Effluent Suspended solids	= 110 mg/L
Flow Rate	= 2.0 MGD

Unknown

Sludge volume Index
Kilograms of Solids In the Aerators
Kilograms of BOD Applied per Day to Aerator
Sludge Age, days

Sludge Volume Index SVI ml/gm

$$= \frac{\text{(Settleable Solids, \%)(10,000)}}{\text{MLSS, mg/L}} = \frac{\text{(Set. Sol., ml/L)(1,000)}}{\text{MLSS, mg/L}}$$

$$= \frac{(17\%)(10{,}000)}{1{,}800} \qquad = \frac{(170)(1{,}000)}{1{,}800}$$

$$= 94 \qquad = 94$$

Aerator Solids, lbs = (MLSS, mg/L)(Tank Vol., MG)(8.34 lbs/gal)

= (1,800 mg/L)(0.5 MG)(8.34 lbs/gal)

= 7,500 lbs

Aerator Loading, lbs BOD/day = (Primary Effluent BOD, mg/L)(Flow, MGD)(8.34 lbs/gal)

= (140 mg/L)(2.0 MGD)(8.34 lbs/gal)

=2,335 lbs BOD/day Applied to Aerator

$$\text{Sludge Age, days} = \frac{\text{Mixed Liquor Solids, lbs}}{\text{Primary Effluent Solids, lbs/day}}$$

$$= \frac{\text{(MLSS, mg/L)(Tank Volume, MG)(8.34 lbs/gal)}}{\text{(SS in Primary Eff., mg/L)(Flow, MGD)(8.34 lbs/gal)}}$$

$$= \frac{\text{7,500 lbs}}{\text{(110 mg/L)(2.0 MGD)(8.34 lbs/gal)}} = \frac{\text{7,500 lbs}}{\text{1,835 lbs/day}} = \text{4.1 days}$$

Ponds

EXAMPLE 10

To calculate the different loadings on a pond, the information listed under known must be available.

Known

Average Depth	= 4 ft
Average Width	= 400 ft
Average Length	= 600 ft
Flow	= 0.5 MGD
BOD	= 150 mg/L
Population	= 5,000 persons

Unknown

Detention time, days
Population Loading, persons/acre
Hydraulic Load, in/day
Organic Load, gm BOD/Day/acre

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

$$\text{Pond Area, acres} = \frac{\text{(Average Width, ft)(Average Length, ft)}}{\text{43,560 sq ft/acre}}$$

$$= \frac{(400 \text{ ft})(600 \text{ ft})}{43{,}560 \text{ sq ft/acre}}$$

= 5.51 acres

Pond Volume, Ac-ft = (Area, ac)(Depth, ft)

= (5.51 acres) (4 ft)

= 22.0 ac-ft

$$\text{Flow Rate, ac-ft/day} = \frac{500{,}000 \text{ gal/day}}{(7.48 \text{ gal/cu ft})(43{,}560 \text{ sq ft/acre})}$$

= 1.53 ac-ft/day

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

$$= \frac{22.0 \text{ ac-ft}}{1.53 \text{ ac-ft/day}}$$

= 14.4 days

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

$$= \frac{5{,}000 \text{ persons}}{5.51 \text{ acres}}$$

= 907 persons/acre

$$\text{Hydraulic Loading in/day} = \frac{\text{Depth of pond, inches}}{\text{Detention Time, days}}$$

$$= \frac{(4\ \text{ft})(12\ \text{in/ft})}{14.4\ \text{days}}$$

= 3.33 in/day

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

$$= \frac{(150,\ \text{mg/L})(0.5\ \text{MGD})(8.34\ \text{lbs/gal})}{5.51\ \text{ac}}$$

$$= \frac{625.5\ \text{lb BOD/day}}{5.51\ \text{ac}}$$

= 114 lbs BOD /day/ac

Chlorination

EXAMPLE 11

Determine the chlorine demand of an effluent it the chlorine dose is 10.0 mg/L and the chlorine residual is 1.1 mg/L.

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

= 10.0 mg/L – 1.1 mg/L

= 8.9 mg/L

EXAMPLE 12

To maintain satisfactory chlorine residual in a plant effluent, the chlorine dose must be 10 mg/L when the flow is 0.37 MGD. Determine the chlorinator setting, (feed rate) in kg/day

Chlorine Feed Rate, lb/day = (Dose, mg/L)(Flow, MGD)(8.34 lbs/gal)

= (10 mg/L)(0.37 MGD)(8.34 lbs/gal)

= 30.9 lbs/day

Chemical Doses

EXAMPLE 13

Determine the chlorinator setting in kg per 24 hours if 2 MG of water per day are to be treated with a desired chlorine dose of 3.0 mg/L.

Chlorinator Setting, lbs/day = (Flow, MGD)(Dose mg/L)(8.34 lbs/gal)

= (2 MGD)(3.0 mg/L)(8.34 lbs/gal)

= 50 lbs/day

EXAMPLE 14

The optimum liquid polymer dose from the jar tests is 12 mg/L Determine the setting on the liquid polymer chemical feeder in milliliters per minute when the plant flow is 4.7 MGD. The liquid polymer delivered to the plant contains 642.3 milligrams of polymer per milliliter of liquid solution.

$$\text{Polymer Feeder Setting, ml/min} = \frac{\text{(Flow, MGD)(Polymer dose, mg/L)(3.785 L/gal)(1,000,000)}}{\text{(Liquid Polymer mg/ml)(24hr/day)((60min/hr)(1 Million)}}$$

$$= \frac{\text{(4.7 MGD)(12 mg/L)(3.785 L/gal)(1,000,000)}}{\text{(642.3 mg/ml)(24hr/day)(60min/hr)(1 Million)}}$$

$$= 231 \text{ ml/min}$$

EXAMPLE 15

Determine the actual chemical dose or chemical feed in pounds per day from a dry chemical feeder. A bucket placed under the chemical feeder weighed 0.3 pounds empty and 2.1 pounds after 30 minutes.

$$\text{Chemical Feed, lbs} = \frac{\text{Chemical Applied, lbs}}{\text{Length of Application, days}}$$

$$= \frac{(2.1 \text{ lbs} - 0.2 \text{ lbs})(60 \text{ min/hour})(24 \text{ hr/day})}{30 \text{ min}}$$

$$= 86 \text{ lbs/day}$$

EXAMPLE 16

Determine the chemical feed in pounds of polymer per day from a chemical feed pump. The polymer solution is 1.5 percent or 15,000 mg polymer per liter. Assume a specific gravity of the polymer solution of 1.0. During a test run the chemical feed pump delivered 800 ml of polymer solution during five minutes.

$$\text{Polymer Feed, lbs/day} = \frac{(\text{Poly Conc., mg/L})(\text{Vol. Pumped, ml})(60 \text{ min/hour})(24 \text{ hr/day})}{(\text{Time Pumped, min})(1{,}000 \text{ ml/L})(1{,}000 \text{ mg/gm})(454 \text{ gm/lb})}$$

$$= \frac{(15{,}000 \text{ mg/L})(800 \text{ ml})(60 \text{ min/hour})(24 \text{ hr/day})}{(5 \text{ min})(1{,}000 \text{ ml/L})(1{,}000 \text{ mg/gm})(454 \text{ gm/lb})}$$

$$= 7.6 \text{ lbs polymer/day}$$

EXAMPLE 17

A small chemical feed pump lowered the chemical solution in a three feet diameter tank 1.58 feet during an eight-hour period. Estimate the flow delivered by the pump in gallons per minute and gallons per day.

Volume Pumped, Gal = (Surface Area, sq ft)(Drop, ft)(7.48 gal/ cu ft)

= $(0.785)(3 \text{ ft})^2 (1.58 \text{ ft})(7.48 \text{ gal/ cu ft})$

= 83.5 gal

$$\text{Flow, GPM} = \frac{\text{Volume Pumped, gal}}{(\text{Time, hr})(60 \text{ min/hr})}$$

$$= \frac{83.5 \text{ gal}}{(8 \text{ hr})(60 \text{ min/hr})}$$

= 0.17 GPM

EXAMPLE 18

Determine the settings in percent stroke on a chemical feed pump for various doses of a chemical in milligrams per liter. (The chemical could be chlorine, polymer, potassium permanganate or any other chemical solution fed by a pump). The pump delivering water to be treated pumps at a flow rate of 400 GPM. The solution strength of the chemical being pumped is 4.8 percent. The chemical feed pump has a maximum capacity of 92 gallons per day at a setting of 100 percent capacity.

Convert the pump flow from gallons per minute to million gallons per day

Pump Flow, MGD = (Pump Flow, GPM)(60 min/hr)(24 hr/day)

= (400 GPM)(60 min/hr)(24 hr/day)

= 576,000 gal/day

= 0.576 MGD

Change the chemical solution strength from a percent to pounds of chemical per gallon of solution. A 4.8 percent solution means we have 4.8 milligrams of chemical in a solution of water and chemical weighing 100 pounds.

$$\text{Chemical Solution, Lbs/gal} = \frac{\text{4.8 lbs chemical}}{\text{100 lbs of chemical and water}}$$

$$= \frac{\text{(4.8 lbs)(8.34 lbs/gal)}}{\text{100 lbs}}$$

$$= \text{0.4 lbs chemical/gallon solution}$$

Calculate the chemical feed in pounds per day for a chemical dose of 0.5 milligrams per liter. We are going to assume various chemical doses of 0.5, 1.0, 1.5, 2.0, 2.5 mg/L and upward so that if we know the desired chemical dose, we can easily determine the setting (percent stroke) on the chemical feed pump.

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

$$= \text{(0.576 MGD)(0.5 mg/L)(8.34 lbs/gal)}$$

$$= \text{2.4 lbs/day}$$

Determine the desired flow from the chemical feed pump in milliliters per minute.

$$\text{Feed Pump, GPD} = \frac{\text{Chemical Feed, lbs/day}}{\text{Chemical Solution, lbs/gal}}$$

$$= \frac{\text{2.4 lbs/day}}{\text{0.4 lbs/gal}} = \text{6 GPD}$$

Determine the setting in the chemical feed pump as a percent. In this case we want to know the setting as a percent of the pump stroke.

$$\text{Setting \%} = \frac{\text{(Desired Feed Pump, GPD)(100\%)}}{\text{Maximum Feed Pump, GPD}}$$

$$= \frac{(6 \text{ GPD})(100\%)}{92 \text{ GPD}}$$

$$= 6.5\%$$

Chemical Dose, mg/L	Chemical Feed, lbs/day	Feed Pump, GPD	Pump Setting % Stroke
0.5	2.4	6.0	6.5
1.0	4.8	12.0	13.0
2.0	9.6	24.0	26.1
4.0	19.2	48.0	52.2
6.0	28.8	72.0	78.2

APPENDIX

WASTEWATER MATHEMATICS

SUBJECT INDEX

PERCENTAGE

To change a fraction to a percent

EXAMPLE 19

Change 2/5 to a percent

$$\frac{2}{5} \text{ x } 100\ \% = 40\ \%$$

To change a percent to a fraction

EXAMPLE 20

Change 40% to a fraction

$$40\ \% \div 100\ \% = \frac{2}{5}$$

EXAMPLE 21

What percent is 20 of 25?

$$\frac{20}{25} \text{ x } 100\ \% = 80\ \%$$

EXAMPLE 22

Find 7% of 32

$$32 \text{ X } \frac{7}{100} = 2.24$$

Finding a number when a given percent of it is known

EXAMPLE 23

If 7% of a number is 2.24, what is the number?

2.24 ÷ 7 % = 32

EXAMPLE 24

Percent removal of BOD in a clarifier is 35%, if 70 mg/L are removed. What is the influent BOD?

$$\%\ \text{BOD Removal} = \frac{\text{BOD in, mg/L} - \text{BOD out, mg/L}}{\text{BOD in, mg/L}}$$

$$35\ \%\ \text{BOD Removal} = \frac{70\ \text{mg/L}}{\text{BOD in mg/L}}$$

$$\text{BOD in mg/L} = \frac{70\ \text{mg/L}}{35\ \%} = \frac{70 \times 100}{35} = 200\ \text{mg/L}$$

Arithmetic & Geometric Means

EXAMPLE 25

What is the arithmetic mean of 10, 8, 11, and 5?

$$\text{Arithmetic Mean} = \frac{\text{Sum of All Measurements}}{\text{Number of Measurements}}$$

$$= \frac{10 + 8 + 11 + 5}{4} = 8.5$$

EXAMPLE 26

What is the geometric mean of 1 and 100?

$$\text{Geometric Mean} = \frac{\text{Log } 1 + \text{Log } 100}{2}$$

$$= 10$$

EXAMPLE 27

What is the geometric mean of 2, 8, and 12?

$$\text{Geometric Mean} = \text{Antilog } \frac{\text{Log } 2 + \text{Log } 8 + \text{Log } 12}{3}$$

$$= \text{Antilog } \frac{(0.30 + 0.9 + 1.07)}{3}$$

$$= \frac{2.2}{3}$$

$$= 5.7$$

Range = Largest value – Smallest value

Median = Middle measurement when numbers are arranged in ascending or descending order

EXAMPLE 28

What is the median for the following measurements?

20, 30, 30, 30, 40, 40, 50, 60, 70, 80, 100

Median = 40

Mode

Measurement occur most frequently

EXAMPLE 29

In the above example what is the mode?

Mode = 30

Significant Figures

Significant figures approach is used to determine how many figures or numbers are used in an answer

EXAMPLE 30

	Measurements	Significant figures
	11,300	3
	2,438.9	5
	87.62	4
Sum	13,826.52	

The answer should be reported in three significant figures or 13,800.

When adding, subtracting, multiplying or dividing, the number of significant figures in the answer should not be more than the term in the calculations with the least number of significant figures.

Decimal points require special attention when determining the number of significant figures in a measurement.

EXAMPLE 31

Measurements	**Significant Figures**
0.00325	3
11.078	5
21,000	2

Temperature

Celsius and Fahrenheit

EXAMPLE 32

Convert 20^o C to Fahrenheit

$F = (C° \times 9/5) + 32°$

$F = (20° \times 9/5) + 32°$

$$F = \frac{180°}{5} + 32°$$

$= 36° + 32°$

$= 68°F$

EXAMPLE 33

Convert $– 10^oC$ to F^o

$F = (–10^o \times 9/5) + 32°$

$F = – 90°/5 + 32°$

$F = –18° + 32°$

$= 14°F$

EXAMPLE 34

Convert $–13^o$ F to C^o

$C = (°F – 32°) \times 5/9$

$C = (–13^o – 32°) \times 5/9$

$= – 45^o \times 5/9$

$= – 25^o C$

Milligram per liter

1000 liters = 1 cubic meter = 1,000,000 cubic centimeters

Therefore

1 liter = 1,000 cubic centimeters

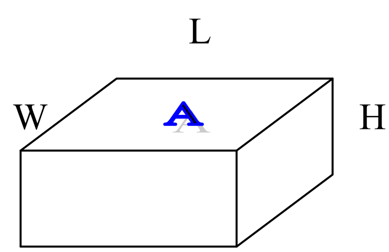
Since one cubic centimeter of water weighs one gram:

1 liter of water = 1,000 grams or 1,000,000 milligrams

$$\frac{1 \text{ milligram}}{\text{liter}} = \frac{1 \text{ milligram}}{1{,}000{,}000 \text{ milligrams}} = \frac{1 \text{ part}}{\text{million parts}} = \text{1 part per million (ppm)}$$

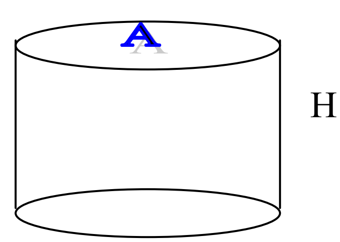
AREAS AND VOLUMES

Rectangular tanks



Volume = Surface Area x Height
V = A x H
Surface Area = Width x Length
A = W x L

Circular tanks



Volume = Surface Area x Depth
V = A x H

Surface Area = $\pi R^2 = 0.785 D^2$

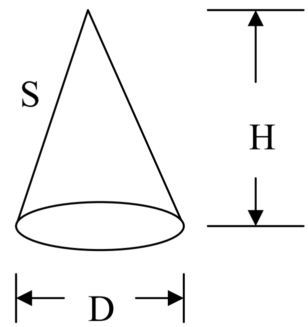
R = Radius D = Diameter

Circumference = π x D

$\pi = 3.14$

Cones

$$V = \frac{\pi}{3} R^2 \times H$$

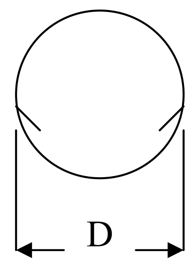


$$\text{Volume} = \frac{\pi}{3} (\text{Radius})^2 \times \text{Height}$$

Lateral Area of a cone $A_L = ½ S \times \pi \times D$

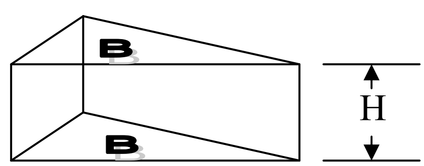
Spheres

Surface Area of A Sphere $A_s = \pi D^2$



Prisms

Volume = Area of Base x Height



Triangle Area = ½ Base x Height