Distribution Systems Mathematical Formulas

5th Edition

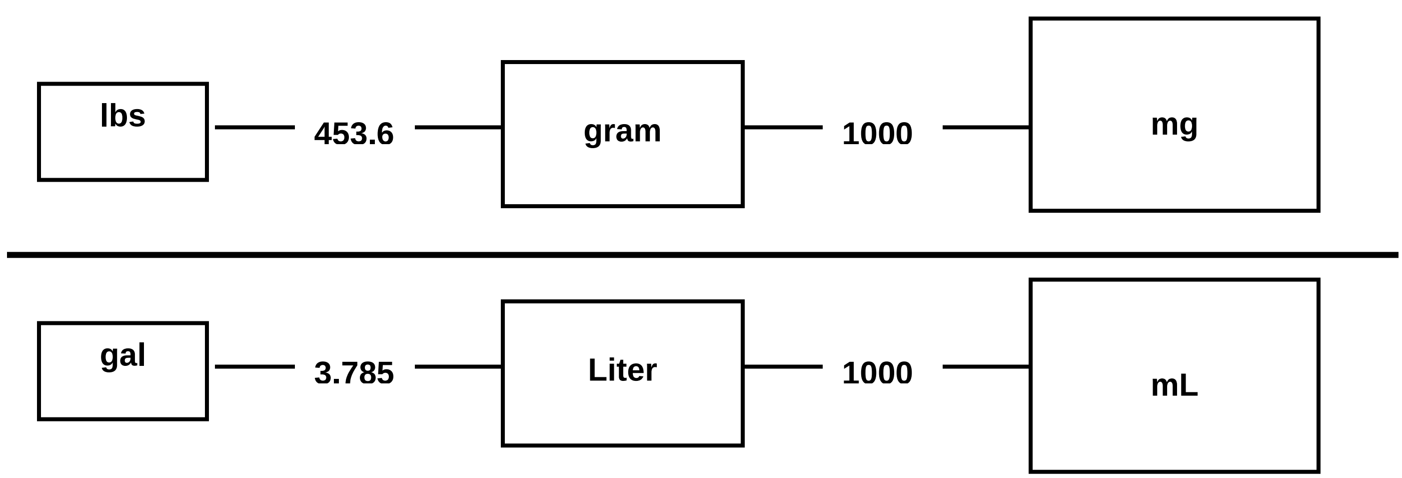
Fleming Training Center
Murfreesboro, TN

Index

Conversion Factors

1 acre	=	43,560 ft^2
1 foot of head	=	0.433 psi
1 psi	=	2.31 feet of head
1 yd^3	=	27 ft^3
1 gal	=	3.785 Liters
1 gallon of water	=	8.34 lbs
1 cubic foot of water	=	7.48 gallons
1 lb	=	453.6 grams
1 mile	=	5280 feet
1%	=	10,000 mg/L

Converting $^{mg}/_{mL}$ to $^{lb}/_{gal}$



To use this diagram: First, find the box that coincides with the beginning units (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 final number, divide top number by bottom number.

Area

Rectangle: Area, ft^2 = (length, ft)(width, ft)

Circle: Area, ft^2 = $(0.785)(\text{Diameter, ft})^2$

Triangle: Area, ft^2 = (0.5)(base, ft)(height, ft)

Volume

Rectangle: Volume, ft^3 = (length, ft)(width, ft)(depth, ft)

Cylinder: Volume, ft^3 = $(0.785)(\text{Diameter, ft})^2(\text{depth or length, ft})$

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

Volume, gallons = $(\text{volume, ft}^3)(7.48\ \text{gal/ft}^3)$

Temperature

°C = 5/9(°F – 32)

°F = 9/5 (°C) + 32

Flow

Q = AV

Q = (Area)(Velocity)

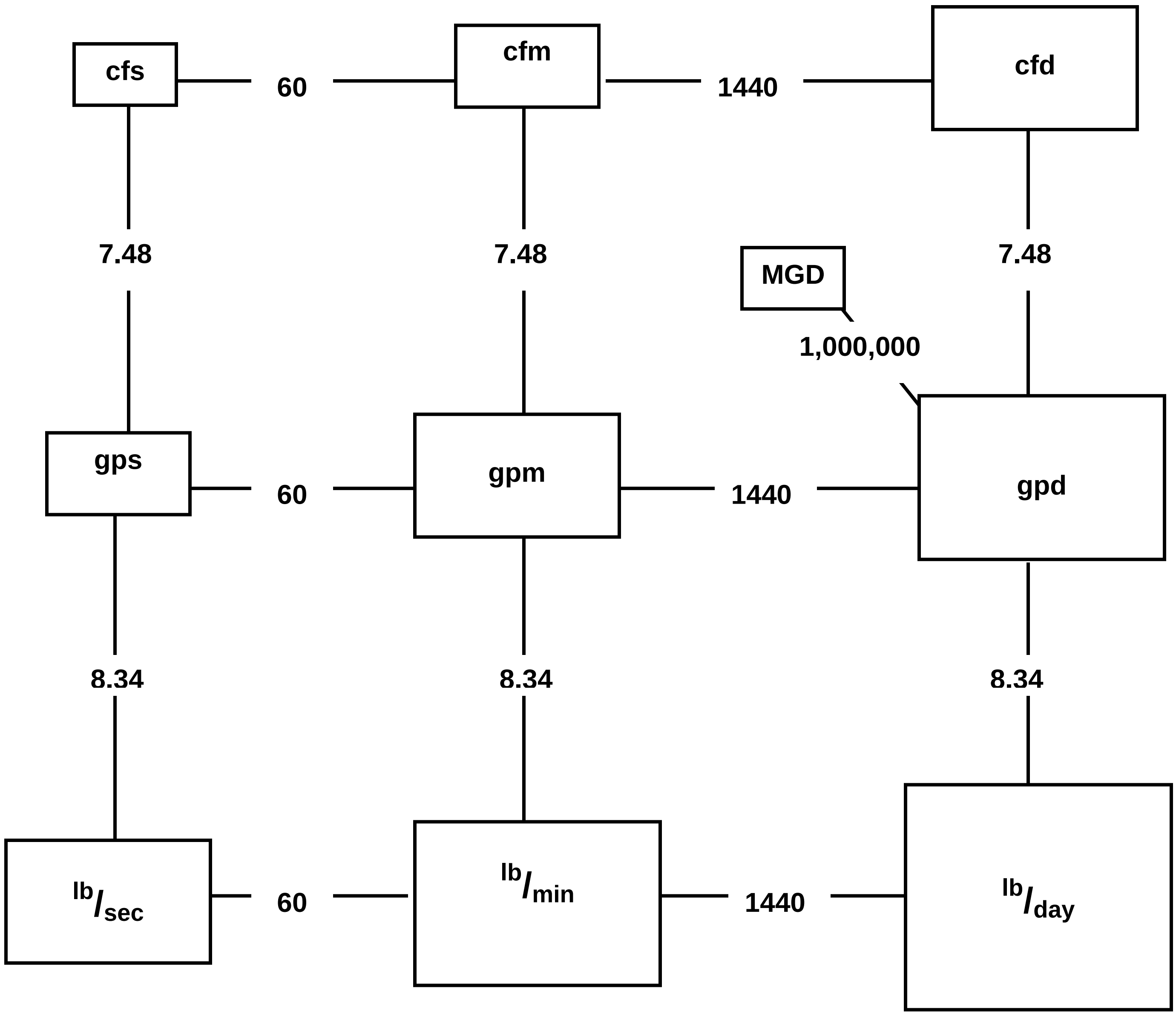
Q (channel), cfs = (width, ft)(depth, ft)(Velocity, fps)

Q (pipeline), cfs = $(0.785)(\text{Diameter, ft})^2(\text{Velocity, fps})$

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

Average Flow, MGD = $\frac{\text{sum of daily flows, MGD}}{\text{Number of daily flows}}$

Flow Conversions



cfs	=	cubic feet per second	gps	=	gallons per second
cfm	=	cubic feet per minute	gpm	=	gallons per minute
cfd	=	cubic feet per day	gpd	=	gallons per day

<ins>To use this diagram</ins>: 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.

Dosage

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

$$\text{Dosage, mg/L} = \frac{\text{chemical feed, lbs/day}}{\text{(flow, MGD)(8.34 lbs/gal)}}$$

Pounds

$$\text{Chemical Feed, lbs} = \text{(dose, mg/L)(volume, MG)(8.34 lbs/gal)}$$

$$\text{Chemical Feed, lbs} = \frac{\text{(dose, mg/L)(volume, MG)(8.34 lbs/gal)}}{\text{\% chemical purity, expressed as decimal}}$$

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

$$\text{Feed Rate, lbs/day} = \frac{\text{(dose, mg/L)(flow, MGD)(8.34 lbs/gal)}}{\text{\% chemical purity, expressed as decimal}}$$

$$\text{Feed Rate, lbs/day} = \frac{\text{(conc., mg/L)(vol. pumped, mL)(1440 min/day)}}{\text{(time pumped, min)(1000 mL/L)(1000 mg/g)(453.6 g/lb)}}$$

Power

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

$$\text{Power, watts} = \text{(volts)(amps)}$$

$$\text{Amps, single-phase} = \frac{\text{(746)(horsepower)}}{\text{(volts)(\% efficiency, as decimal)(power factor)}}$$

$$\text{Amps, three-phase} = \frac{\text{(746)(horsepower)}}{\text{(1.732)(volts)(\% efficiency, as decimal)(power factor)}}$$

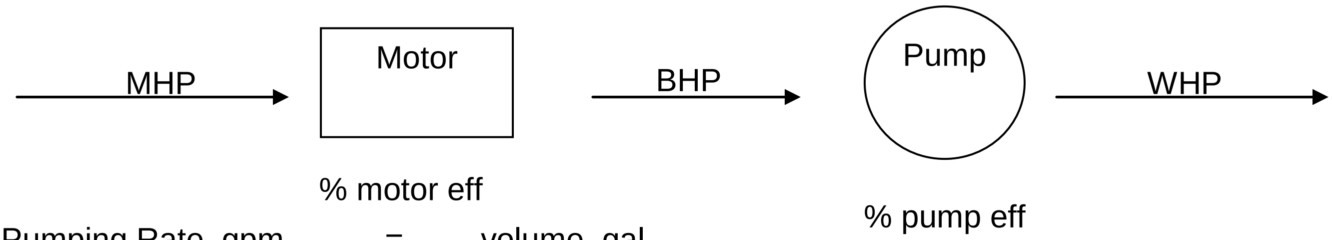
$$\text{Horsepower} = \frac{\text{(volts)(amps)}}{746}$$

$$\text{Kilowatts, single-phase} = \frac{\text{(volts)(amps)(power factor)}}{1000}$$

$$\text{Kilowatts, three-phase} = \frac{\text{(volts)(amps)(power factor)(1.732)}}{1000}$$

$$\text{Power Factor} = \frac{\text{watts}}{\text{(volts)(amps)}}$$

Pumps



Pumping Rate, gpm $= \dfrac{\text{volume, gal}}{\text{time, min}}$

Pumping Rate, gpm $= \dfrac{(\text{length, ft})(\text{width, ft})(\text{depth, ft})(7.48\ \text{gal/ft}^3)}{\text{time, min}}$

Pumping Rate, gpm $= \dfrac{(0.785)(\text{Diameter, ft})^2(\text{depth, ft})(7.48\ \text{gal/ft}^3)}{\text{time, min}}$

Time to fill, min $= \dfrac{\text{tank volume, gal}}{\text{flow rate, gpm}}$

Water hp $= \dfrac{(\text{flow, gpm})(\text{head, ft})}{3960}$

Brake hp $= \dfrac{(\text{flow, gpm})(\text{head, ft})}{(3960)(\text{\%pump efficiency, as decimal})}$

Motor hp $= \dfrac{(\text{flow, gpm})(\text{head, ft})}{(3960)(\text{\%pump efficiency, as decimal})(\text{\%motor efficiency, as decimal})}$

Brake hp $= \dfrac{\text{water hp}}{\text{\%pump efficiency, as decimal}}$

Motor hp $= \dfrac{\text{brake hp}}{\text{\%motor efficiency, as decimal}}$

% Motor Efficiency $= \left(\dfrac{\text{brake hp}}{\text{motor hp}}\right) \times 100$

% Pump Efficiency $= \left(\dfrac{\text{water hp}}{\text{brake hp}}\right) \times 100$

% Efficiency $= \left(\dfrac{\text{hp output}}{\text{hp supplied}}\right) \times 100$

% Efficiency, overall $= \left(\dfrac{\text{water hp}}{\text{motor hp}}\right) \times 100$

Wire-to-water Efficiency, % = (% pump eff., as decimal)(% motor eff., as decimal)(100)

Pumps, cont

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 hp)(0.746 kW/hp)(cost, $/kW-hr)

Metric Conversions

Primary Unit

mega (M)	. .	kilo (k)	hecto (h)	deka (da)	no prefix	deci (d)	centi (c)	milli (m)	. .	micro (μ)
1,000,000		1,000	100	10	1	$^1/_{10}$	$^1/_{100}$	$^1/_{1,000}$		$^1/_{1,000,000}$

↓

meter – linear measurement
liter – volume measurement
gram – weight measurement

Disinfection

Cl_2, lbs = (dosage, mg/L)(volume, MG)(8.34 lbs/gal)

HTH, lbs = $\dfrac{\text{(dosage, mg/L)(volume, MG)(8.34 lbs/gal)}}{\text{\% chemical purity, expressed as decimal}}$

Bleach, gal = $\dfrac{\text{(dosage, mg/L)(volume, MG)}}{\text{\% concentration, bleach, expressed as decimal}}$

Bleach, gal (dilution) = $\dfrac{\text{(\% desired conc., expressed as decimal)(desired volume, gal)}}{\text{\% concentration, bleach, expressed as decimal}}$

HTH, lbs (solution mix) = $\dfrac{\text{(\% desired conc, expressed as decimal)(desired vol, gal)(8.34 lbs/gal)}}{\text{\% available HTH, expressed as decimal}}$

Distribution

$$\text{Pressure, psi} = \frac{\text{pressure head, ft}}{2.31\ \text{ft/psi}}$$

$$\text{Pressure, psi} = (\text{pressure head, ft})(0.433\ \text{psi/ft})$$

$$\text{Pressure head, ft} = (\text{pressure, psi})(2.31\ \text{ft/psi})$$

$$\text{Pressure head, ft} = \frac{\text{pressure, psi}}{0.433\ \text{psi/ft}}$$

$$\text{C Factor} = \frac{\text{flow, gpm}}{(193.75)(\text{diameter, ft})^{2.63}(\text{slope})^{0.54}}$$

$$\text{Slope} = \frac{\text{energy loss, ft}}{\text{distance, ft}}$$

$$\text{Slope} = \frac{\text{head loss, ft}}{\text{distance, ft}}$$

$$\text{Slope} = \frac{(\text{pressure drop, psi})(2.31\ \text{ft/psi})}{\text{distance, ft}}$$

$$\text{Meter accuracy, \%} = \frac{(\text{volume of water registered, gal})(100)}{\text{actual volume, gal}}$$

$$\text{Flow from hydrant, gpm} = \frac{(2.83)(\text{diameter, in})^2(\text{length, in})}{\sqrt{height}}$$

$$\text{Flow from hydrant, gpm} = (27)(\text{nozzle ID, in})^2(\sqrt{\text{pitot pressure, psi}})$$

$$\text{Uplift force, lbs} = (\text{area, ft}^2)(\text{pressure, lbs/ft}^2)$$

$$\text{Pressure, lbs/ft}^2 = (62.4\ \text{lbs/ft}^3)(\text{height, ft})$$

$$\text{Uplift force, lbs} = (62.4\ \text{lbs/ft}^3)(\text{volume, ft}^3)$$

Leak Test

Ductile Iron

Allowable leakage, gph

$$L = \frac{SD\sqrt{P}}{133{,}200}$$

Where: L = allowable leakage, gph

S = length of pipe tested, ft

D = diameter of pipe, in

P = average test pressure, psig

PVC Pipe

Allowable leakage, gph

$$L = \frac{ND\sqrt{P}}{7400}$$

Where L = allowable leakage, gph

N = number of joints in the length of pipeline tested

D = diameter of the pipe, in

P = average test pressure, psig

$$\text{Number of joints} = \frac{\text{pipeline length, ft}}{\text{pipe section, ft/joint}}$$