Oregon Operators Conference
Operator Math Workshop
Module II

Lance Mason, Senior Operations Specialist

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Conversion Math

Brief Review From Module I

Conversions to Remember

- 8.34 lbs. / gallon
- 7.48 gallons / Ft^3 (cubic foot)
- PSI (pounds per $in.^2$) = 2.31 ft.
- 1% = 10,000 mg/L
- 3,785 mL / gallon

Three Steps to Conversions

Remember manipulate your ratio to cancel the units! i.e.

$$\frac{7.48 \text{ gallons}}{1 \text{ Cubic ft. } (Ft^3)} = \frac{1 \text{ Cubic ft. } (Ft^3)}{7.48 \text{ gallons}}$$

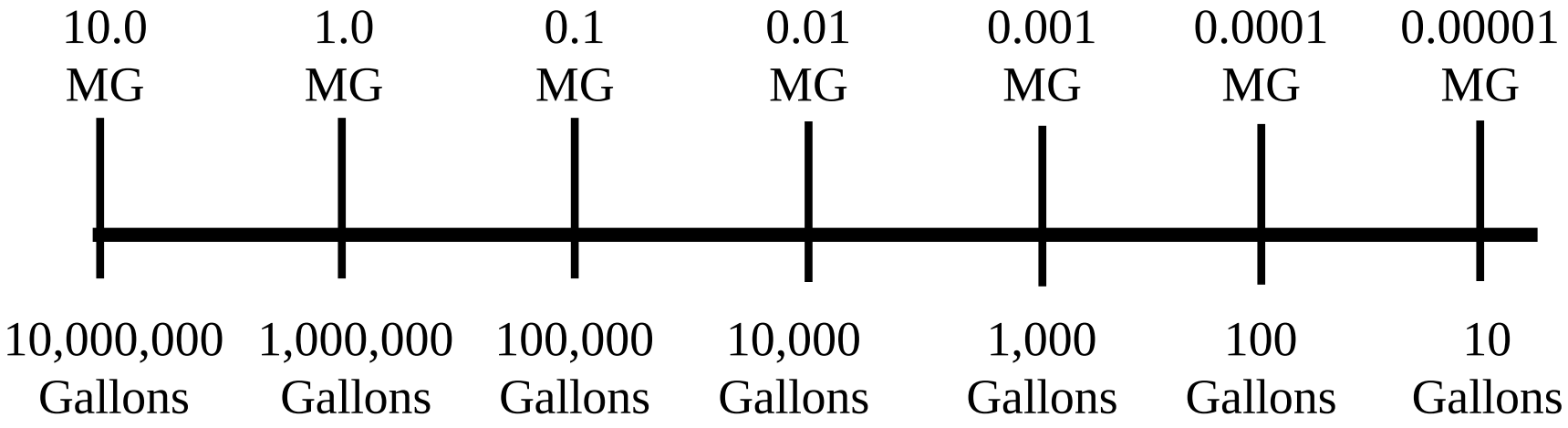
Three Steps to Conversions

- Locate the given
- Locate the ratio (the “per”)
- Determine units in final answer

Conversion Math

Flow

Conversion Math: Gallons



Conversion Math: Gallons – Millon Gallons

Convert the following from MG to Gallons and vice versa:

1,000,000 Gallons = 1.0 MG

500,000 Gallons = 0.5 MG

12,000 Gallons = 0.012 MG

250,000 Gallons = 0.25 MG

1,630,000 Gallons = 1.63 MG

3,400 Gallons = 0.0034 MG

Flow Conversion Math

Q indicates Flow

$$Q = \frac{\text{Volume Unit}}{\text{Time Unit}}$$

$$\frac{\text{Million Gallons}}{\text{Day}} \qquad \frac{\text{Cubic Feet}}{\text{Second}}$$

Flow Conversion Math

1 MG = 1,000,000 Gallons

Ratio

$$\frac{\text{MG}}{\text{1,000,000 Gallons}} = \frac{\text{1,000,000 Gallons}}{\text{MG}}$$

Flow Conversion Example:

Convert 1,000 gallons/minute (gpm) to million gallons/day (MGD)

$$\frac{1{,}000\ \text{gal}}{\text{min}} \times \frac{1{,}440\ \text{min}}{\text{Day}} \times \frac{1\ \text{MG}}{1{,}000{,}000\ \text{gal}}$$

$$\frac{1{,}440{,}000}{1{,}000{,}000} = 1.44\ \text{MGD}$$

Flow Conversion Example:

Convert 1,000 gallons/minute (gpm) to million gallons/day (MGD)

$$\frac{1{,}000\ \text{gal}}{\cancel{\text{min}}} \quad \frac{1{,}440\ \cancel{\text{min}}}{\text{Day}}$$

1,000 gal x 1,440 = 1,440,000 gallons/day

1,440,000 gallons/day = 1.44 MGD

Conversion Math

$$Q = VA$$

Flow = Velocity x Area

Velocity = Flow/Area ($V = Q/A$)

Who Needs the Formula?

Area = $(\text{Dimension})^2$

Flow or Q = Volume/Time

Velocity = Dimension/Time

So

Dimension^2 x Dimension/Time =

Dimension^3/Time

=

Volume/Time

Flow, Velocity, Area Example:

A channel is 42” wide and the water is a depth of 24”. You toss a float in and determine that it travels 30 feet in 15 seconds. What is the flow rate in ft^3/sec?

First step – We know our answer is in ft^3/sec so lets convert all dimensional units to feet.

$$\frac{42\ \text{in.}}{} \left| \begin{array}{l} 1\ \text{Foot} \\ \hline 12\ \text{in.} \end{array} \right. = \frac{42}{12} = 3.5\ \text{Feet}$$

$$\frac{28\ \text{in.}}{} \left| \begin{array}{l} 1\ \text{Foot} \\ \hline 12\ \text{in.} \end{array} \right. = \frac{24}{12} = 2.0\ \text{Feet}$$

Flow, Velocity, Area Example:

A channel is 42” wide and the water is a depth of 24”. You toss a float in and determine that it travels 30 feet in 15 seconds. What is the flow rate in ft^3/sec?

Second step – Calculate area and Volume

Area = 3.5 Ft. x 2.0 Ft = 7.0 Ft^2

Volume = 3.5 Ft x 2.0 Ft x 30 Ft = 210 Ft^3

Third step – Match the units to what the answer requires.

$$\frac{210\ Ft^3}{15\ Sec} = 14.0\ Ft^3/Sec$$

Pressure Math

Pressure

2.31 feet of head = 1 psi

Or

$$\frac{2.31 \text{ feet}}{\text{psi}}$$

Pressure Example 1:

An elevated water storage tank is 35 feet high; what would be the pressure in the pipe at the bottom of the tank?

$$\frac{35\ \text{Ft.}}{\left|\begin{array}{c} 1\ \text{PSI} \\ \hline 2.31\ \text{Ft.} \end{array}\right.} \quad \frac{35}{2.31} = 15.2\ \text{PSI}$$

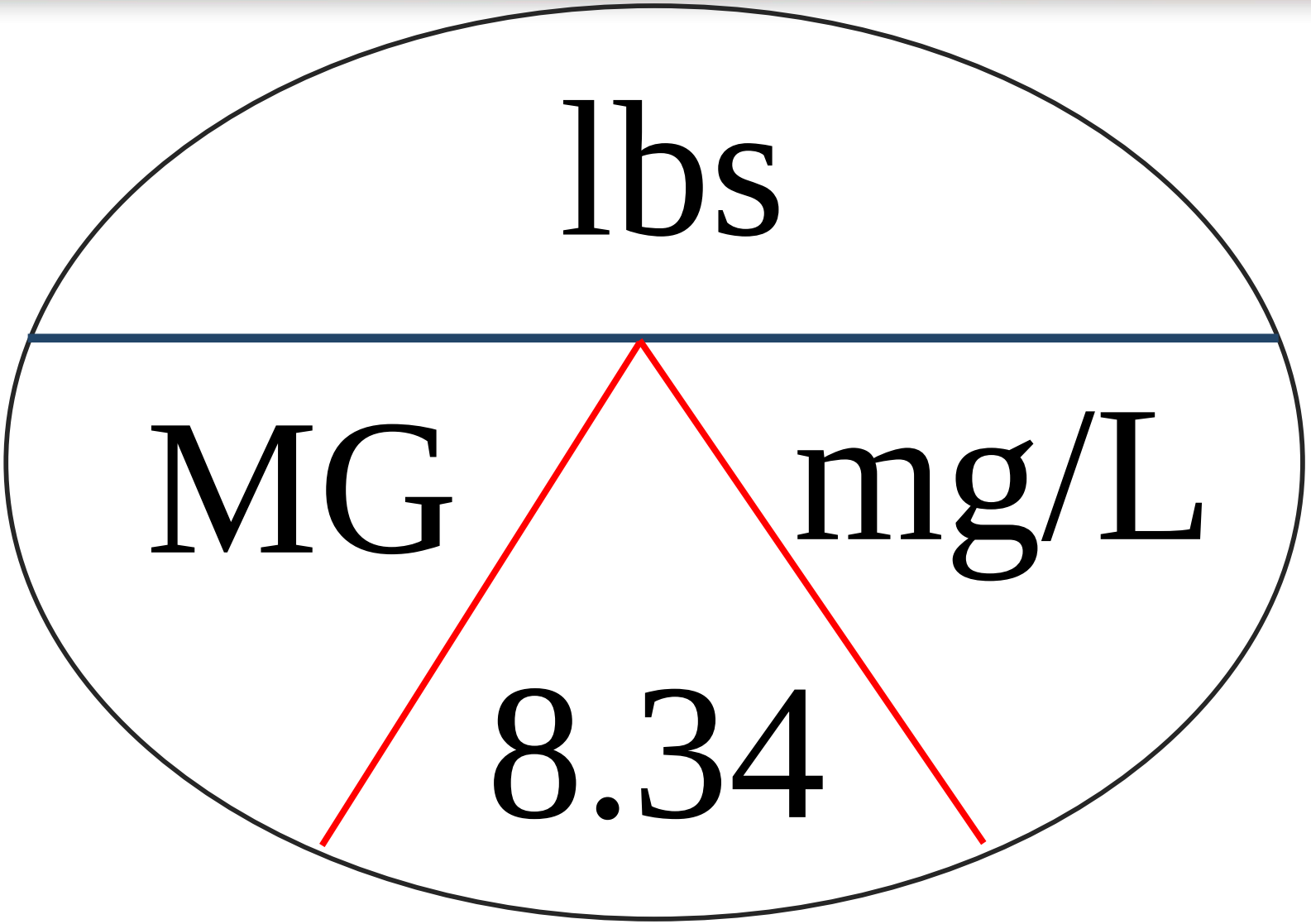
Pressure Example 2:

What is the approximate head (height) of water which will produce a pressure at the base of the tank of 25 psi?

$$\frac{25\ \text{PSI}}{1\ \text{PSI}} \left| \frac{2.31\ \text{Ft.}}{} \right.$$

$$25 \times 2.31 = 57.8\ \text{PSI}$$

Pie Chart Math



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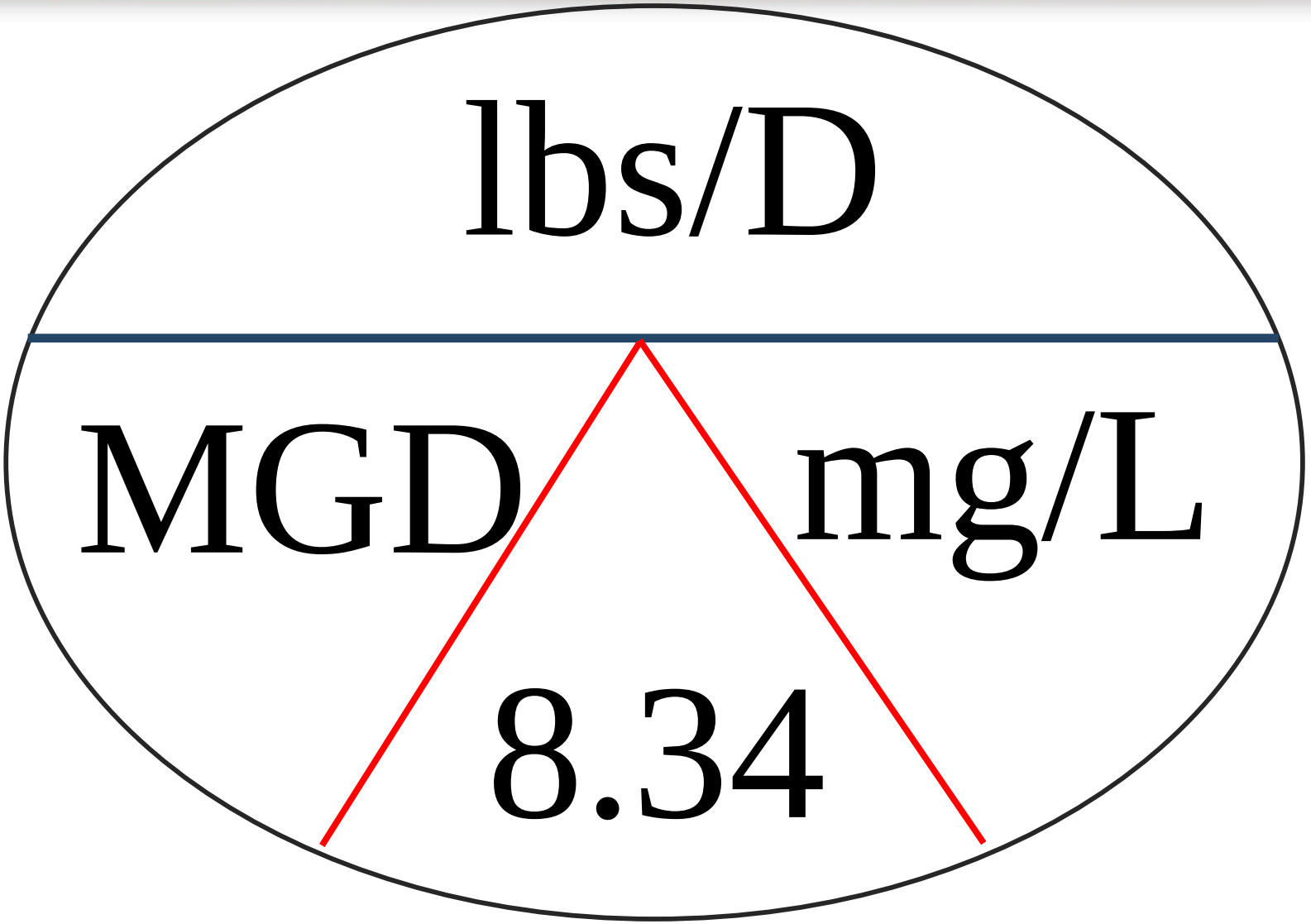
Pie Chart Math



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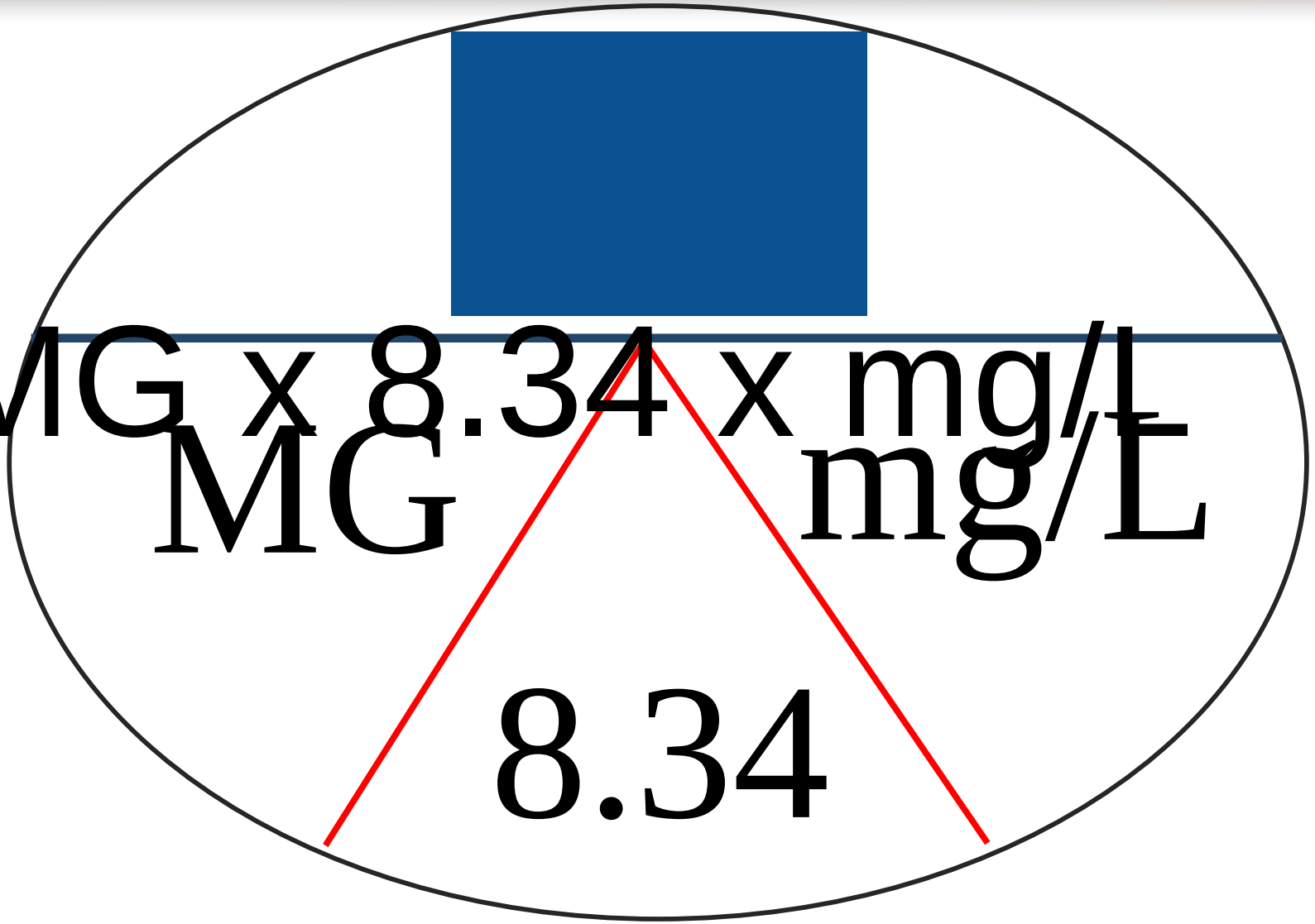

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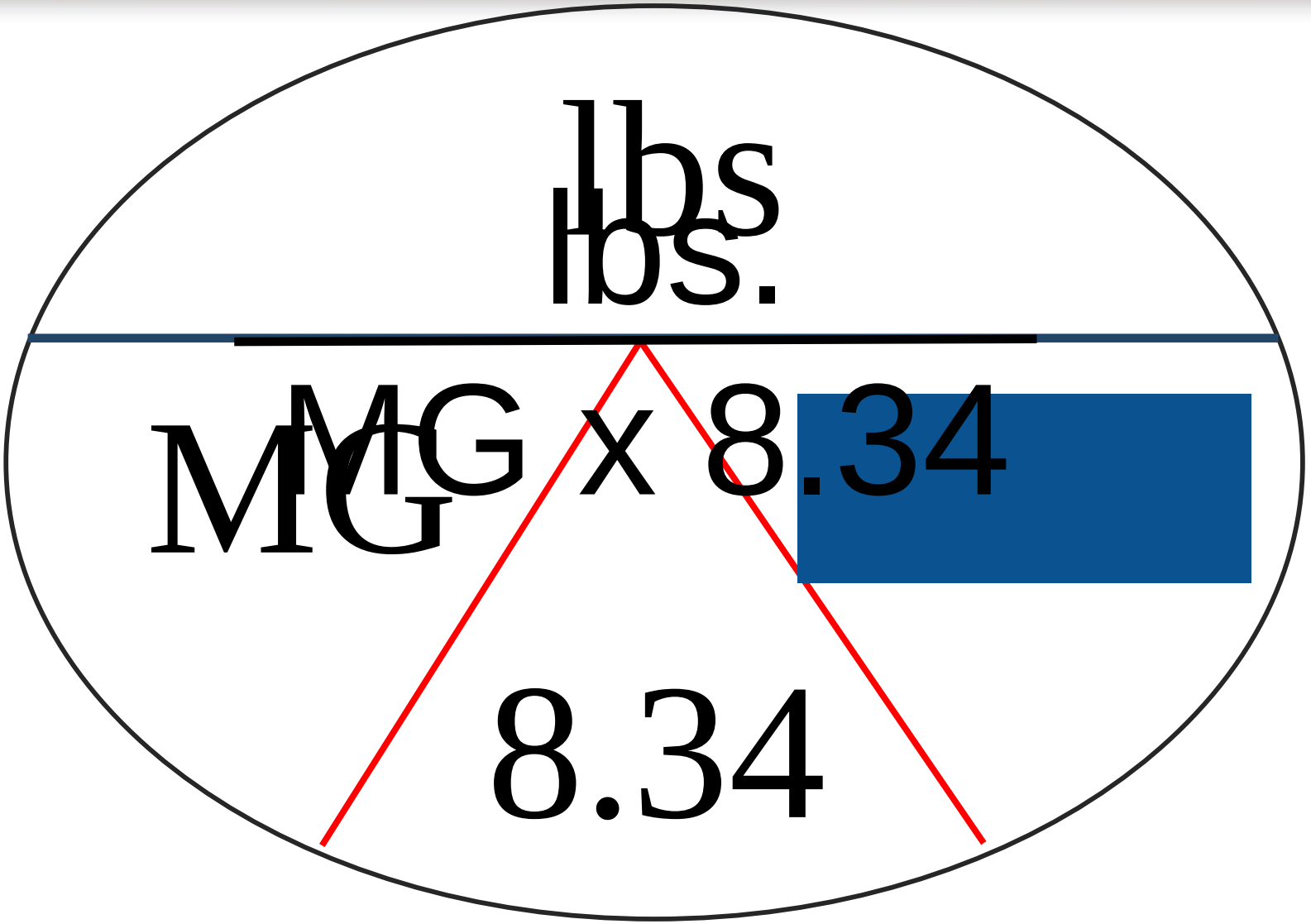
Pie Chart Math



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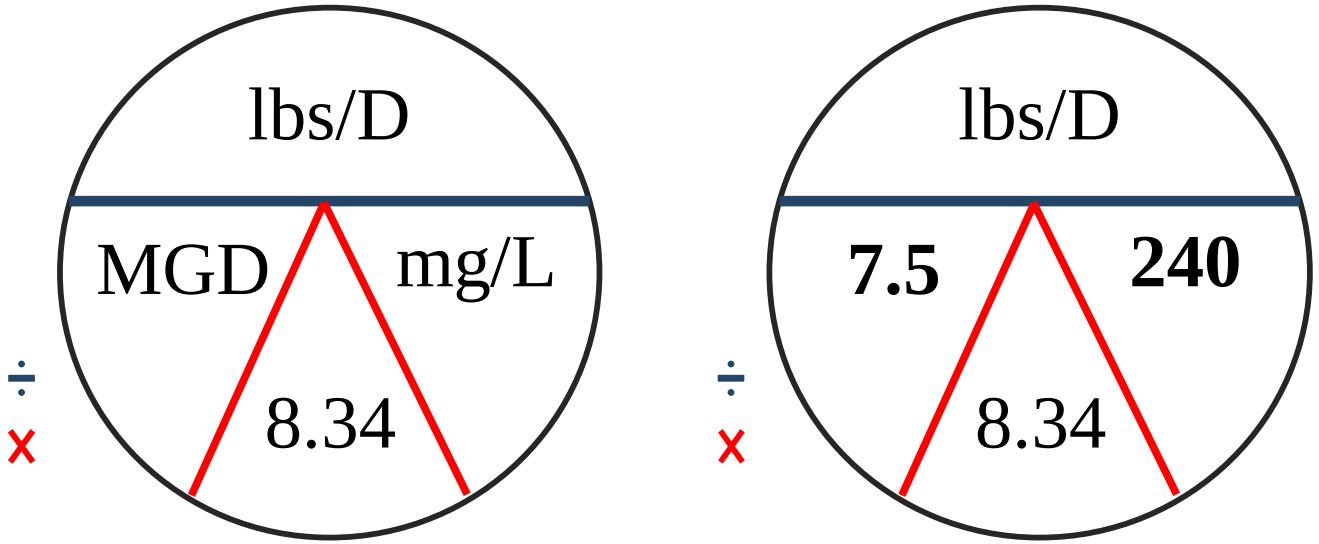
Pie Chart Math Example:

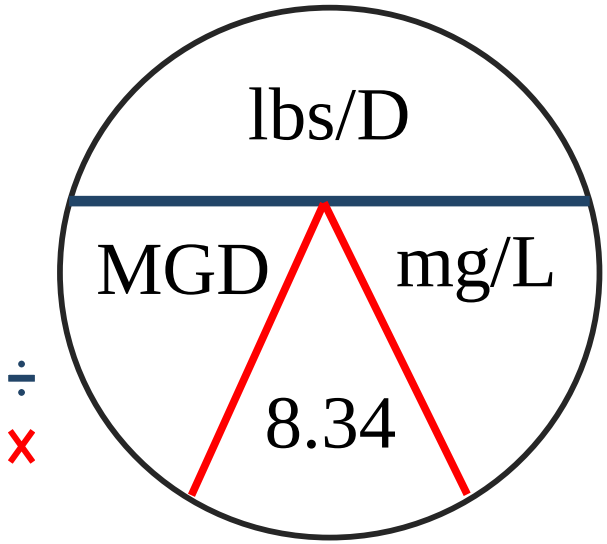
A plant with an average flow rate of 7.5 mgd and an influent TSS concentration of 240 mg/L; how many pounds per day of TSS are coming into the plant?

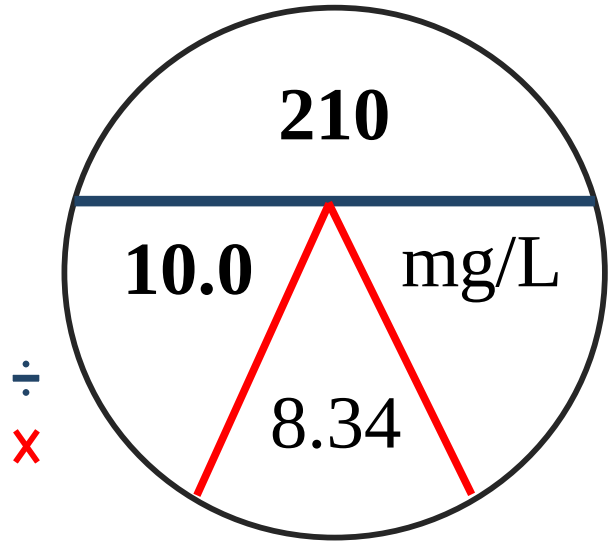


7.5 x 8.34 x 240 = 15,012 lbs/day

Pie Chart Math Example:

A plant with an average flow rate of 10.0 mgd and added 210 lbs/day of chlorine to disinfection; what is the anticipated chlorine residual in mg/L?





$$\frac{210}{(10 \times 8.34)} = 2.5 \text{ mg/L}$$

Key Points to Pie Chart Math

- If there is information for flow, concentration (mg/L), and/or pounds…it's a pie chart!
- Always make sure your volume or flow rate is in MG or MGD.
- Most certification math questions dealing with the pie chart require a flow conversion.
- Answers on the test will have a number that is calculated using incorrect flow conversion.
- Make sure your answer makes sense!

Pie Chart or Not Pie Chart Problem???

1. Calculate the dosage (mg/L) if your chlorinator is set to feed chlorine at 95 lbs into a flow rate of 4 MGD. **Yes**

2. The wastewater plant influent flow is 7.8 MGD and has a TSS concentration of 237 mg/L. If the effluent TSS is 6.5 mg/L, what is the percent removal of TSS? **No**

3. How much chlorine gas (lbs) is required to treat 5 million gallons of water to provide a 0.7 residual? **Yes**

4. What is the volume (in gallons) of a circular clarifier with a diameter of 115 feet and a depth of 18 feet? **No**

Detention Time

$$\frac{\text{Volume}}{\text{Flow Rate (Q)}}$$

Note: You don't have to remember this formula necessarily, the units will tell you what to do!

$$\frac{\text{Volume}}{\text{Flow Rate (Q)}} = \frac{\cancel{\text{Volume}}}{\cancel{\text{Volume}}/\text{Time}}$$

Therefore your units will be in time!

Detention Time Example:

1. What is the detention time (days) for a tank 50 ft. high & 40 ft. diameter & flow is 0.35 MGD?

$$\text{Area} = (40\ \text{Ft.})^2 \times 0.785 = 1{,}256\ \text{Ft}^2$$

$$\text{Volume} = 1{,}256\ \text{Ft}^2 \times 50\ \text{Ft} = 62{,}800\ \text{Ft}^3$$

$$\frac{62{,}800\ \cancel{\text{Ft}^3} \quad | \quad 7.48\ \cancel{\text{Gal}} \quad | \quad \text{Day}}{\qquad\qquad | \quad \cancel{\text{Ft}^3} \quad | \quad 350{,}000\ \cancel{\text{Gal}}}$$

$$\frac{(62{,}800 \times 7.48)}{350{,}000} = 1.3\ \text{Days}$$

Chlorination Terminology

- Free Residual
  - Hypochlorus Acid (HOCl)
  - Hypochlorite (OCl^-)
  - pH dependent
- Combined Residual
  - Free chlorine that combines with ammonia or other nitrogen containing organics
  - Typically chloramines
- Free + Combined = Total Chlorine Residual

Chlorination Terminology

- Chlorine Demand - The demand created by inorganic and organic materials. The difference between the amount of chlorine applied to the wastewater and the amount of residual chlorine after a given contact time is called chlorine demand.
- Dose – The amount of chlorine applied to overcome the demand and produce a chlorine residual

Chlorine Dose = Chlorine Demand + Chlorine Residual

Chlorine Dose Example

Your plant final effluent typically has a chlorine demand of 12.5 mg/L and you want a chlorine residual of 3.5 mg/L. What will be your chlorine dose in mg/L?

Chlorine Dose	=	Chlorine Demand	+	Chlorine Residual

Chlorine Dose = 12.5 + 3.5

Chlorine Dose = 16.0 mg/L

Chlorine Dose Example

Typical percentages for the chlorine chemicals used:

- Chlorine Gas – 100%
- Sodium hypochlorite – 12.5%
- Calcium hypochlorite – 65%

The lbs/day answer you get is divided by the decimal of the percentage of the chemical.

- Chlorine Gas – Divide by 1 or basically leave answer as is.
- Sodium hypochlorite – Divide by 0.125
- Calcium hypochlorite – Divide by 0.65

Filtration Rates

Let the units tell you what to do!

1. The flow to a trickling filter is 0.64 MGD. The filter is 60 ft. in diameter and the media depth is 6 ft. Calculate the hydraulic loading on the filter (GPD/ft^2).

2. Calculate the filtration rate in gpm/ft^2 for a filter with a surface length of 75 ft and a width of 17 ft when the applied flow is 2 MGD.

3. A filter is 38 feet long and 26 feet wide. To verify the flow rate through the filter, the filter influent valve is closed for a period of 5 minutes and the water drop is measured. If the water level in the filter drops 14 inches during the 5-minute period, what is the gpm flow rate through the filter?

Filtration Example:

Calculate the filtration rate in gpm/ft^2 for a filter with a surface length of 75 ft and a width of 17 ft when the applied flow is 2 MGD.

Area = 75 Ft. x 17 Ft = 1,256 Ft^2

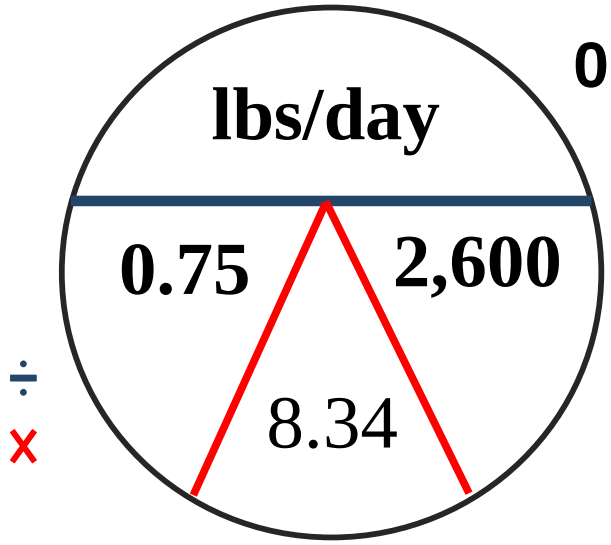
$$\frac{\frac{2{,}000{,}000\ \text{Gal}}{\cancel{\text{Day}}}}{\frac{1\ \cancel{\text{Day}}}{1{,}440\ \text{min}}} = \frac{2{,}000{,}000}{1{,}440} = 1{,}389\ \text{GPM}$$

$$\frac{1{,}389}{1{,}256} = 1.1\ \text{GPM/FT}^2$$

Solids Loading Rate

Again…Let the units tell you what to do!

Calculate the Solids Loading Rate for a clarifier in lbs/day/Ft^2 with a 31 foot diameter and a depth of 9 feet, and receives a flow of 750,000 gallons per day with a suspended solids concentration of 2600 mg/L. Pie Chart! For starters



0.75 x 8.34 x 2,600 = 16,263 lbs/day

Solids Loading Rate (Continued)

Calculate the Solids Loading Rate for a clarifier in lbs/day/Ft^2 with a 31 foot diameter and a depth of 9 feet, and receives a flow of 750,000 gallons per day with a suspended solids concentration of 2600 mg/L.

0.75 x 8.34 x 2,600 = 16,263 lbs/day

Area = $(31\ Ft.)^2$ x 0.785= 754 Ft^2

$$\frac{16{,}263}{754} = 21.6\ lbs/day/FT^2$$

Surface Overflow Rate

And…Let the units tell you what to do!

A secondary clarifier has a diameter of 125 feet and receives a daily maximum flow of 4.1 MGD. What is the surface overflow rate (gpd/ft^2)?

Area = (125 Ft)^2 x 0.785 = 12,266 Ft^2

4.1 MGD = 4,100,000 GPD

$$\frac{4{,}100{,}000}{12{,}266} = 334 \text{ GPD/FT}^2$$

Review

Certification Sample Problems

Flow Rate Conversions

Convert 5.0 Ft^3/sec to MGD and GPM.

Velocity Example Problem

An 8-inch diameter pipe is flowing full at 600 gpm, what is the velocity in ft/sec?

Pressure Example Problem

A 30-foot storage tank has 26 feet of water in it; what is the anticipated pressure at the bottom of the tank?

Loading Problem

The latest influent lab results have shown a BOD concentration of 210 mg/L. The average daily flow is 13.7 MGD. What is the plant loading in lbs/Day?

Detention Time Problem

A tank is 82 feet in diameter and 31 feet high. The flow is 1,600 gpm. What is the detention time in hours?

Filtration Problem

The flow to a trickling filter is 0.64 MGD. The filter is 60 ft. in diameter and the media depth is 6 ft. Calculate the hydraulic loading on the filter (GPD/ft^2).

Solids Loading Rate Problem

Calculate the Solids Loading Rate for a clarifier in lbs/day/Ft^2 with a 70 foot diameter and a depth of 15 feet. This tank receives a flow of 3.6 MGD with a suspended solids concentration of 2,900 mg/L.

Surface Overflow Rate Problem

A secondary clarifier has a diameter of 125 feet and receives a daily maximum flow of 4.1 MGD. What is the surface overflow rate (gpd/ft^2)?