Problem of the Day

2014.Dec.03

Introduction

Every operator should know how to calculate pounds and pounds per day given concentration (in mg/L or ppM). We will call both calculations the "pounds calculation."

There are two elements that have to come together for the pounds calculation to work. First, volume—whether it's volume to calculate pounds or volume/time (that's flow) to calculate pounds per day—has to be converted to Mgal (million gallons). We can do this very easily in the railroad track so there is no need to convert the volume to Mgal before working the railroad track, in fact WWTT recommends against doing this conversion "on the side." Second and the reason for the first, is there is an embedded M (million) in mg/L and, of course, ppM (parts per million parts). If concentration is given in ppM, WWTT recommends it be expressed as mg/L because in our business **mg/L = ppM**. And this conversion factor tells us why that's so:

$$\frac{M \cdot mg}{L} \quad \text{or} \quad \frac{L}{M \cdot mg}$$

Today's and several previous days' Problems of the Day demonstrate.

For those of you who may be new to WWTT's Problem of the Day, we insert a page break before and after the problem statement so you can print it without looking at the solution. **See what you can do to solve the problem before looking at the solution**.

Problem of the Day

How many pounds of chlorine does the operator have to add to super-chlorinate a reservoir, recently cleaned, that is 75 feet in diameter and has 25 feet of water in it? The chlorine dose the operator wants to achieve is 45 mg/L.

Discussion

Key words and information: "**How many pounds**" and "**mg/L**." You **know** you're going to be using the "pounds calculation."

I can't tell you how often we calculate pounds and pounds per day in the wastewater treatment business. We do these calculations over and over and over again. Doing them should be second nature to all operators. No matter how comfortable you are doing these calculations, WWTT recommends you always carry the units **all the way through** so you don't forget anything. Today's problem is another good example of "there's a lot going on here." Remember: units are your friend and they will tell how how to do a problem in almost all instances. Practice the problems with the units. It will pay off huge.

Solution

If diameter is given, we know it's a cylindrical tank. Given diameter and depth of a cylindrical tank, we can calculate volume. We know we can convert this volume to Mgal. To begin, we put the units we want the answer to be in, **lb Cl_2**, between heavy vertical lines followed by an equals sign and the blank track.

Problem of the Day: How many pounds of chlorine does the operator have to add to super-chlorinate a reservoir, recently cleaned, that is 75 feet in diameter and has 25 feet of water in it? The chlorine dose the operator wants to achieve is 45 mg/L.

Information summary, specifically labeled:

- Reservoir diameter = 75 ft
- Water depth = 25 ft
- Desired chlorine concentration = 45 mg Cl_2/L
- **Calculate: pounds of chlorine (lb Cl_2) to be added**.

$$\left| \text{lb } Cl_2 \right| = \_\_\_\_\_$$

The unit, **Cl_2**, needed in the answer only shows up in the list of information given in the problem in one other place, 45 mg **Cl_2**/L. Entering this starts the railroad track.

$$\left| \text{lb } \mathbf{Cl_2} \right| = \left| \frac{45 \text{ mg } \mathbf{Cl_2}}{\text{L}} \right| \_\_\_\_\_$$

Whenever mg/L are entered into the railroad track, WWTT recommends they be canceled with the conversion factor, **M•mg/L**, unless the problem is solving for mg/L.

$$\left| \text{lb } \mathbf{Cl_2} \right| = \left| \frac{45 \text{ } \cancel{\text{mg}} \text{ } \mathbf{Cl_2}}{\cancel{\text{L}}} \right| \left| \frac{\cancel{\text{L}}}{\text{M}\cdot\cancel{\text{mg}}} \right| \_\_\_\_\_$$

The M that remains in the denominator is a reminder that an Mgal is needed in the numerator to cancel the Ms, as discussed at the beginning of this post. But there is no Mgal in the information given in the problem. What do we do? We use the conversion factor, **Mgal/10^6 gal**, to enter the Mgal needed. Notice, too, that gal cancels in the numerator and denominator.

$$\left| \text{lb } \mathbf{Cl_2} \right| = \left| \frac{45 \text{ } \cancel{\text{mg}} \text{ } \mathbf{Cl_2}}{\cancel{\text{L}}} \right| \left| \frac{\cancel{\text{L}}}{\text{M}\cdot\cancel{\text{mg}}} \right| \left| \frac{\cancel{\text{Mgal}}}{10^6 \text{ } \cancel{\text{gal}}} \right| \_\_\_\_\_$$

It looks like we're in trouble because we've canceled all the units in the railroad track except **Cl_2**. But we still need **lb** in the answer so it has to be entered in the railroad track. We do this with the density of water. Notice that the unit, **lb**, has to go in the numerator.

$$\text{lb } Cl_2 = \frac{45\ \cancel{mg}\ \textbf{Cl}_2 \quad \cancel{L} \quad \cancel{M}gal \quad 8.34\ \textbf{lb}}{\cancel{L} \quad \cancel{M}mg \quad 10^6\ \cancel{gal} \quad gal}$$

Now we have the units needed in the answer, **lb Cl_2**, but we've added, and need to cancel, **gal**. But there is no other information given in the problem that has **gal** in it. What do we do? We enter another conversion factor in order to cancel gal, **7.48 gal/ft^3**.

$$\text{lb } Cl_2 = \frac{45\ \cancel{mg}\ \textbf{Cl}_2 \quad \cancel{L} \quad \cancel{M}gal \quad 8.34\ \textbf{lb} \quad 7.48\ \cancel{gal}}{\cancel{L} \quad \cancel{M}mg \quad 10^6\ \cancel{gal} \quad \cancel{gal} \quad ft^3}$$

We now enter the volume of reservoir, 0.785 times diameter squared times depth, to cancel **ft^3**, which is ft x ft x ft.

Problem of the Day: How many pounds of chlorine does the operator have to add to super-chlorinate a reservoir, recently cleaned, that is 75 feet in diameter and has 25 feet of water in it? The chlorine dose the operator wants to achieve is 45 mg/L.

Information summary, specifically labeled:

- Reservoir diameter = 75 ft
- Water depth = 25 ft
- Desired chlorine concentration = 45 mg Cl_2/L
- **Calculate: pounds of chlorine (lb Cl_2) to be added**.

$$\text{lb } Cl_2 = \frac{45\ \cancel{mg}\ \textbf{Cl}_2 \quad \cancel{L} \quad \cancel{M}gal \quad 8.34\ \textbf{lb} \quad 7.48\ \cancel{gal} \quad 0.785 \quad 75\ \cancel{ft} \quad 75\ \cancel{ft} \quad 25\ \cancel{ft}}{\cancel{L} \quad \cancel{M}mg \quad 10^6\ \cancel{gal} \quad \cancel{gal} \quad \cancel{ft}^3}$$

The only units remaining in the railroad track are **lb Cl_2** needed in the answer so the math is done. The arithmetic gives the answer:

45 x 8.34 x 7.48 x 0.785 x 75 x 75 x 25 ÷ 1,000,000 = **<u>310 lb Cl_2</u>**.

Many of you in California may have heard that water treatment plant certification has been moved from the California Department of Health Services to the Office of Operator Certification in the State Water Resources Control Board. We think our approach to doing math problems is so sound, WWTT is going to start doing math review for water treatment plant operators. If you know of anybody who is pursuing water treatment plant operator certification, or if you are, visit our courses webpage here. The water classes aren't up yet, but they will be soon!

Happy calculating. Let us know, by leaving a comment, if you want us to do a specific problem.