Problem of the Day

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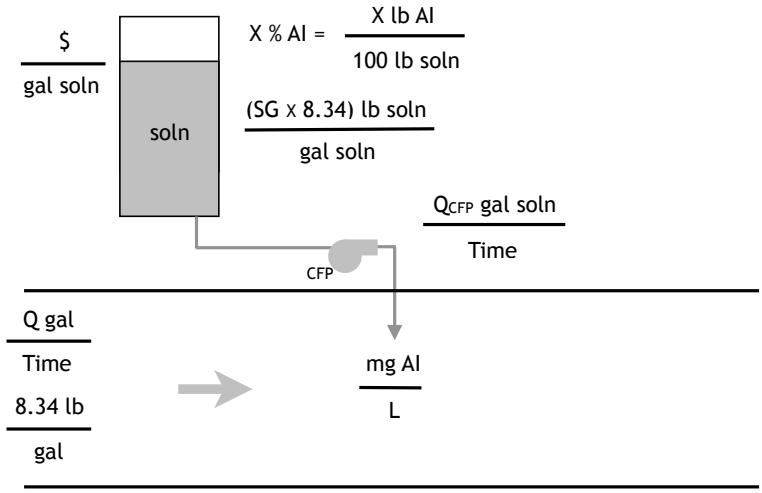
Sodium hypochlorite (hypo) is used to disinfect the effluent. Hypo is 10.5% available chlorine and has a specific gravity of 1.2. The average effluent flow is 6.5 MGD. The necessary chlorine dose is 25 mg/L. What should the feed rate be (gal/hr) of the sodium hypochlorite dosing pump?

Introduction

This is a chemical dosing problem just like yesterday's problem. All chemical dosing problems can be described by the following graphic.



Generic graphic for setting up chemical dosing problems (AI = active ingredient, SG = specific gravity, CFP = chemical feed pump, Q_{CFP} = flow rate of chemical feed pump, and Q = process flow).

As described below, there are six pieces of information contained in this graphic. Typically, a certification exam question will give the examinee five of those pieces and ask to solve for the sixth. Many trainers will solve these kinds of problems with algebra: "Let x equal ..." If you label the information as taught by WWTT, the units will do the algebra for you! That's pretty cool!

Notice in today's problem the specific gravity (SG) of the solution (hypo) is given, otherwise this problem looks very much like yesterday's problem. The density of the hypo is calculated using a small solution bridge where the density of water is multiplied by the SG, which has no units associated with it. Take special note of the units after the equals sign.

$$\left| \frac{8.34 \text{ lb}}{\text{gal}} \quad \frac{1.2}{} \right| = \left| \frac{10.0 \text{ lb hypo}}{\text{gal hypo}} \right|$$

Solution

Notice in the graphic that the suction to the chemical feed pump is coming from the solution (soln) tank. So even though the question asks for the answer to be in gal/hr, we need to be specific with our labeling. Gallons of what per hour? Gallons of solution. If I was drawing this figure on the board, instead of labeling the solution tank "soln," I'd write "hypo." So, the units needed in the answer are gal hypo/hr. Therefore, as before, these units are entered between heavy vertical lines followed by an equals sign and the blank solution bridge.

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$$\left| \frac{\text{gal hypo}}{\text{hr}} \right| = \_\_\_\_\_$$

The six pieces of information shown in the graphic above, specific to this problem, are listed here (one of them is the unknown). Note it is very important to label each as shown. (Note $/gal soln in the graphic is not used in this problem, but you should know it is often given instead of No. 3, which is the unknown in this case.)

1. Percent active ingredient (AI = Cl_2) in feed solution = 10.5% Cl_2 = 10.5 lb Cl_2/100 lb hypo
2. Density of solution = 10.0 lb hypo/gal hypo (from calculation above)
3. Solution feed rate delivered by the chemical feed pump, Q_{CFP} = **unknown gal hypo/hr**
4. Flow rate of water to which the chemical is being dosed, Q = 6.5 Mgal/d
5. Density of water = 8.34 lb/gal
6. Concentration of active ingredient (AI = Cl_2) in water = 25 mg Cl_2/L

In this list, the only place the units gal hypo show up is in No. 2 (calculated above). so it is use to start the solution bridge.

$$\frac{\textbf{gal hypo}}{\text{hr}} = \frac{\textbf{gal hypo}}{10.0 \text{ lb hypo}}$$

The units in the denominator, lb hypo, need to be canceled. No. 1 is the only other place in the list with these units so it is entered next on the solution bridge. The unwanted units cancel, denominator and numerator.

$$\frac{\textbf{gal hypo}}{\text{hr}} = \frac{\textbf{gal hypo}}{10.0 \text{ } \cancel{\text{lb hypo}}} \frac{100 \text{ } \cancel{\text{lb hypo}}}{10.5 \text{ lb } Cl_2}$$

The units in the denominator, lb Cl_2, need to be canceled. The units lb Cl_2 don't appear anywhere else in the list, but mg Cl_2 do (No. 6). This is entered on the solution bridge so the unit Cl_2 cancels in the denominator and numerator.

$$\frac{\textbf{gal hypo}}{\text{hr}} = \frac{\textbf{gal hypo}}{10.0 \text{ } \cancel{\text{lb hypo}}} \frac{100 \text{ } \cancel{\text{lb hypo}}}{10.5 \text{ lb } \cancel{Cl_2}} \frac{25 \text{ mg } \cancel{Cl_2}}{\text{L}}$$

The units mg/L are canceled by using the conversion factor M·mg/L entered so the units cancel denominator and numerator.

$$\frac{\textbf{gal hypo}}{\text{hr}} = \frac{\textbf{gal hypo}}{10.0 \text{ } \cancel{\text{lb hypo}}} \frac{100 \text{ } \cancel{\text{lb hypo}}}{10.5 \text{ lb } \cancel{Cl_2}} \frac{25 \text{ } \cancel{\text{mg}} \text{ } \cancel{Cl_2}}{\cancel{\text{L}}} \frac{\cancel{\text{L}}}{\text{M}\cdot\cancel{\text{mg}}}$$

The M in this conversion factor reminds us that we need an Mgal to cancel the Ms. The units Mgal only show up in No. 4 so it is entered so the Ms cancel denominator and numerator.

$$\frac{\textbf{gal hypo}}{\text{hr}} = \frac{\textbf{gal hypo}}{10.0 \text{ } \cancel{\text{lb hypo}}} \frac{100 \text{ } \cancel{\text{lb hypo}}}{10.5 \text{ lb } \cancel{Cl_2}} \frac{25 \text{ } \cancel{\text{mg}} \text{ } \cancel{Cl_2}}{\cancel{\text{L}}} \frac{\cancel{\text{L}}}{\cancel{\text{M}}\cdot\cancel{\text{mg}}} \frac{6.5 \text{ } \cancel{\text{M}}\text{gal}}{\text{d}}$$

Both lb and gal cancel when the density of water (No. 5) is entered.

gal hypo	=	**gal hypo**	100 ~~lb hypo~~	25 ~~mg~~ ~~Cl_2~~	~~L~~	6.5 ~~Mgal~~	8.34 ~~lb~~	
hr		10.0 ~~lb hypo~~	10.5 ~~lb~~ ~~Cl_2~~	~~L~~	~~M·mg~~	d	~~gal~~	

Currently the unit d is in the denominator of the solution bridge, but we need hr so 24 hr/d is used to cancel the unwanted units and get the time unit needed in the answer. Since all the units have cancelled except those that are needed in the answer (in bold), the solution bridge is complete. The arithmetic gives the answer.

gal hypo	=	**gal hypo**	100 ~~lb hypo~~	25 ~~mg~~ ~~Cl_2~~	~~L~~	6.5 ~~Mgal~~	8.34 ~~lb~~	~~d~~
hr		10.0 ~~lb hypo~~	10.5 ~~lb~~ ~~Cl_2~~	~~L~~	~~M·mg~~	~~d~~	~~gal~~	24 **hr**

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gal hypo	=	**gal hypo**	100 ~~lb hypo~~	25 ~~mg~~ ~~Cl_2~~	~~L~~	6.5 ~~Mgal~~	8.34 ~~lb~~	~~d~~
hr		10.0 ~~lb hypo~~	10.5 ~~lb~~ ~~Cl_2~~	~~L~~	~~M·mg~~	~~d~~	~~gal~~	24 **hr**

100 x 25 x 6.5 x 8.34 ÷ 10.0 ÷ 10.5 ÷ 24 = **53.8 gal hypo/hr**.

Discussion

This approach makes all chemical dosing problems pretty easy. The trick is in the labeling. Get the labeling down and you'll have these problems licked. Practice, practice, practice.

Happy calculating! Let us know, by leaving a comment, if you want us to do a specific problem, if you see a mistake, or if you have a question on any of the Problems of the Day you are looking at.