Problem of the Day

2015.Dec.02

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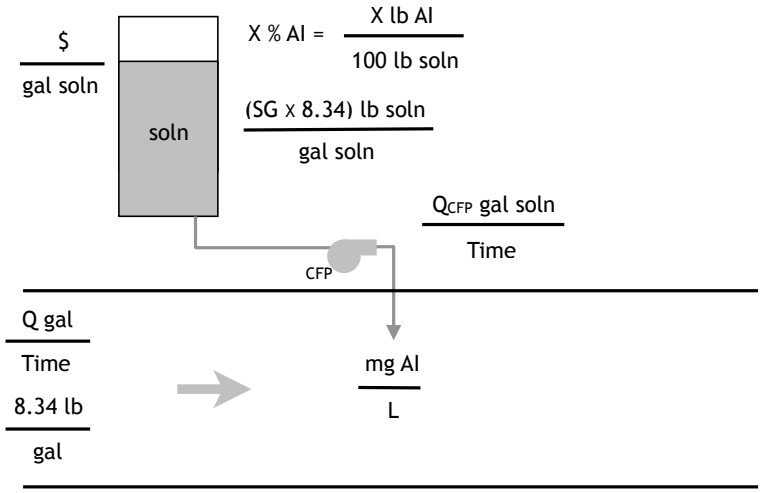
Sodium hypochlorite (hypo) is used to disinfect the effluent. The hypo on site has just been checked by the lab to contain 11.2% available chlorine. The chemical supplier's documents show the hypo has a specific gravity of 1.21. The average effluent flow is 26.5 MGD. The necessary chlorine dose is 28 mg/L. What should the feed rate be (gal/hr) of the sodium hypochlorite dosing pump?

Introduction

This is a chemical dosing problem. WasteWater Technology Trainers (WWTT) describes all chemical dosing problems with 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, 1.21. The density of the hypo is calculated using a small solution bridge where the density of water is multiplied by the SG given. Note: SG never has units. Take special note, however, of the units after the equals sign.

$$\left| \frac{8.34 \text{ lb}}{\text{gal}} \right| \left| \frac{1.21}{} \right| = \left| \frac{10.1 \text{ lb hypo}}{\text{gal hypo}} \right|$$

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

The six pieces of information shown in the graphic above, specific to this problem, are listed here (one of them is the unknown). It is very important to label each as shown and I'm using my "new" approach to labeling, so pay close attention. (Note: $/gal soln in the graphic is not used in this problem, but you should know it is often given instead of No. 3 in the list below, which is the unknown in this problem.)

1. Percent active ingredient (AI = Cl_2) in feed solution = 11.2% Cl_2 = 11.2 lb Cl_2/100 lb hypo
2. Density of solution = 10.1 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 final effluent (FE) to which the chemical is being dosed, Q = 26.5 Mgal FE/d
5. Density of FE = 8.34 lb FE/gal FE (assumed since not given)
6. Concentration of active ingredient (AI = Cl_2) in FE = 28 mg Cl_2/L = 28 lb Cl_2/M lb FE

The only place the units gal hypo appear in the list given above is in the denominator of No. 2. This, then, is entered "upside down" to start the solution bridge to get the units needed in the numerator of the answer as shown in bold.

gal hypo	=	**gal hypo**	
hr		10.1 lb hypo	

I have been convinced by several students in recent classes to get all the units on the solution bridge needed in the answer before starting to cancel units. To this end, I look in the list above for the units hr needed in the denominator of the answer. We don't have them in our list. I note the only units of time in the entire list, d, is in the denominator of No. 4. But since these are not the units needed, the conversion factor, 24 hr/d, is entered to get the units needed in the denominator of the answer as shown in bold.

gal hypo	=	**gal hypo**	d	
hr		10.1 lb hypo	24 **hr**	

The solution bridge now contains all the units needed in the answer. To proceed, the unwanted units are canceled until only the units in bold remain. 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. (It would have been equally "correct" to cancel d out using No. 4 in the list instead.)

gal hypo	=	**gal hypo**	d	100 ~~lb hypo~~	
hr		10.1 ~~lb hypo~~	24 **hr**	11.2 lb Cl_2	

The units in the denominator, lb Cl_2, need to be canceled. The only other place they appear is in No. 6. Note: this is my new "way" of expressing mg/L, lb something per million (M) pounds. This is entered on the solution bridge so the units lb Cl_2 cancel in the denominator and numerator.

gal hypo	=	**gal hypo**	d	100 ~~lb hypo~~	28 ~~lb Cl_2~~	
hr		10.1 ~~lb hypo~~	24 **hr**	11.2 ~~lb Cl_2~~	M lb FE	

The units lb FE (pounds final effluent) are canceled by entering No. 5 on the solution bridge so the units cancel denominator and numerator.

gal hypo	=	**gal hypo**	d	100 ~~lb hypo~~	28 ~~lb Cl_2~~	8.34 ~~lb FE~~	
hr		10.1 ~~lb hypo~~	24 **hr**	11.2 ~~lb Cl_2~~	M ~~lb FE~~	gal FE	

Finally, entering the final effluent flow rate, No. 4, cancels everything else (i.e., d, M and gal FE).

gal hypo	=	**gal hypo**	~~d~~	100 ~~lb hypo~~	28 ~~lb Cl_2~~	8.34 ~~lb FE~~	26.5 ~~Mgal FE~~
hr		10.1 ~~lb hypo~~	24 **hr**	11.2 ~~lb Cl_2~~	~~M~~ ~~lb FE~~	~~gal FE~~	~~d~~

Since all the units have now canceled except those needed in the answer, **gal hypo/hr**, we know the solution bridge is complete. The arithmetic gives the answer.

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gal hypo	=	**gal hypo**	~~d~~	100 ~~lb hypo~~	28 ~~lb Cl_2~~	8.34 ~~lb FE~~	26.5 ~~Mgal FE~~
hr		10.1 ~~lb hypo~~	24 **hr**	11.2 ~~lb Cl_2~~	~~M~~ ~~lb FE~~	~~gal FE~~	~~d~~

100 × 28 × 8.34 × 26.5 ÷ 10.1 ÷ 24 ÷ 11.2 = **228 gal hypo/hr**.

Discussion

This approach makes all chemical dosing problems pretty easy. The trick is in the labeling, and now I'm using a somewhat modified labeling convention. Get the labeling down, though, 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.