Problem of the Day

2015.Jul.17

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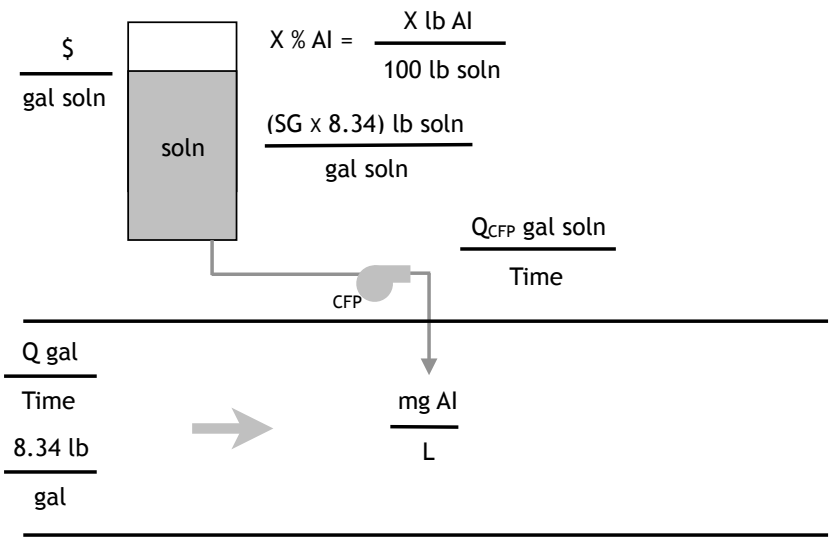
Polymer is being dosed from a 55-gallon drum of PolyPerfect to 13,000 gallons of waste activated sludge (WAS) in a holding tank. The polymer concentration in PolyPerfect is 20%. The PolyPerfect solution has a density of 11.75 lb/gal. The TSS concentration in the WAS is 10,500 mg/L. The target polymer dose is 6.2 lb polymer/2,000 lb TSS. How many gallons of PolyPerfect should be added to the WAS holding tank?

Introduction

The first step in approaching this problem is to recognize this as a chemical dosing problem. WWTT uses the same basic graphic, repeated below, for all chemical dosing problems.



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).

In today's problem, the polymer solution (PolyPerfect) is being added from a 55-gallon drum, and instead of being added to a flow, as shown in the graphic, it is being added to a volume. If I was drawing this on the whiteboard, instead of a open-ended pipe, I'd put "ends" on the pipe so it would look like a tank rather than a pipe. Also in today's problem, the dose is not given in the typical units, mg/L, but lb polymer/2,000 lb TSS. No worries because the units, as always, tell us what to do.

Solution

It is helpful to list the "givens" in the problem in the same order used in all chemical dosing problems expressed very specifically (the WWTT way!). Note: the active ingredient in this problem is polymer (poly)

1. Polymer (poly) concentration in PolyPerfect (PPerf) = 20 lb poly/100 lb PPerf
2. Density of solution = 11.75 lb PPerf/gal PPerf
3. Solution feed rate = **unknown**
4. Volume to which solution is fed = 13,000 gal (0.013 Mgal) @ 10,500 mg TSS/L
5. Density of water = 8.34 lb/gal
6. Dose = 6.2 lb poly/2,000 lb TSS

The question asks for gallons of PolyPerfect so the units gal PPerf are put between heavy vertical lines, as always, followed by an equals sign and the blank solution bridge.

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$$\text{gal PPerf} = \frac{\quad}{\quad}$$

The solution bridge is started by entering the density of the PolyPerfect, No. 2 in the list, so that the units gal PPerf are in the numerator as needed in the answer (shown in bold). In the list given above, this is the only piece of information given with the units gal PPerf.

$$\text{gal PPerf} = \frac{\textbf{gal PPerf}}{11.75 \text{ lb PPerf}}$$

To cancel the units lb PPerf, item No. 1 is entered so these units cancel, denominator and numerator.

$$\text{gal PPerf} = \frac{\textbf{gal PPerf} \quad 100 \text{ ~~lb PPerf~~}}{11.75 \text{ ~~lb PPerf~~} \quad 20 \text{ lb poly}}$$

To cancel the units lb poly, item No. 6 is entered so these units cancel, denominator and numerator.

$$\text{gal PPerf} = \frac{\textbf{gal PPerf} \quad 100 \text{ ~~lb PPerf~~} \quad 6.2 \text{ ~~lb poly~~}}{11.75 \text{ ~~lb PPerf~~} \quad 20 \text{ ~~lb poly~~} \quad 2{,}000 \text{ lb TSS}}$$

There is no other item in the list with the units lb TSS, but there is the next best thing, mg TSS (item No. 4). This is entered so the units TSS cancel, denominator and numerator.

$$\text{gal PPerf} = \frac{\textbf{gal PPerf} \quad 100 \text{ ~~lb PPerf~~} \quad 6.2 \text{ ~~lb poly~~} \quad 10{,}500 \text{ mg ~~TSS~~}}{11.75 \text{ ~~lb PPerf~~} \quad 20 \text{ ~~lb poly~~} \quad 2{,}000 \text{ lb ~~TSS~~} \quad \text{L}}$$

The next entry cancels mg and L.

$$\text{gal PPerf} = \frac{\textbf{gal PPerf} \quad 100 \text{ ~~lb PPerf~~} \quad 6.2 \text{ ~~lb poly~~} \quad 10{,}500 \text{ ~~mg~~ ~~TSS~~} \quad \text{~~L~~}}{11.75 \text{ ~~lb PPerf~~} \quad 20 \text{ ~~lb poly~~} \quad 2{,}000 \text{ lb ~~TSS~~} \quad \text{~~L~~} \quad \text{M}\cdot\text{~~mg~~}}$$

The M in the conversion factor just entered reminds us that an Mgal is needed (this portion of the solution bridge is a pounds calculation). This is the volume of the WAS tank expressed in Mgal, item No. 4.

$$\text{gal PPerf} = \frac{\textbf{gal PPerf} \quad 100 \text{ ~~lb PPerf~~} \quad 6.2 \text{ ~~lb poly~~} \quad 10{,}500 \text{ ~~mg~~ ~~TSS~~} \quad \text{~~L~~} \quad 0.013 \text{ ~~M~~gal}}{11.75 \text{ ~~lb PPerf~~} \quad 20 \text{ ~~lb poly~~} \quad 2{,}000 \text{ lb ~~TSS~~} \quad \text{~~L~~} \quad \text{~~M·mg~~}}$$

Remaining in the solution bridge is gal in the numerator and lb in the denominator both of which are canceled by entering the density of water.

gal PPerf	=	**gal PPerf**	100 ~~lb PPerf~~	6.2 ~~lb poly~~	10,500 ~~mg~~ ~~TSS~~	~~L~~	0.013 ~~Mgal~~	8.34 ~~lb~~
		11.75 ~~lb PPerf~~	20 ~~lb poly~~	2,000 ~~lb~~ ~~TSS~~	~~L~~	~~M~~~~mg~~		~~gal~~

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

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gal PPerf	=	**gal PPerf**	100 ~~lb PPerf~~	6.2 ~~lb poly~~	10,500 ~~mg~~ ~~TSS~~	~~L~~	0.013 ~~Mgal~~	8.34 ~~lb~~
		11.75 ~~lb PPerf~~	20 ~~lb poly~~	2,000 ~~lb~~ ~~TSS~~	~~L~~	~~M~~~~mg~~		~~gal~~

100 x 6.2 x 10,500 x 0.013 x 8.34 ÷ 11.75 ÷ 20 ÷ 2,000 = **1.5 gal PPerf**.

Discussion

This problem is a testament to the amazing power of the solution bridge. If the information given in the problem statement is labeled the way WWTT advocates, working down the solution bridge canceling unwanted units until only the units needed in the answer remain works every time and you don't have to memorize any equations or piecharts!

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.