Problem of the Day
2014.Oct.07

Discussion

In the 2014.Oct.02 Problem of the Day, the difference between concentration given in units of mg/L and concentration given as a percent (%) was discussed. There is a **big** difference between a part per million parts (mg/L) and a part per hundred parts (%). As previously discussed, WWTT does **not** use the conversion, 1%/10,000 mg/L, because it only applies to solutions or slurries that have a density equal to the density of water, which is often not the case. **Once the labeling WWTT advocates is mastered, the "math" basically takes care of itself simply by canceling units**.

In most problems when concentration is given in % it is expressed as so many pounds per 100 pounds. For example, if the concentration of a chlorine solution is given as 12.5% available chlorine, this is written exactly the way it appears substituting "lb" for "%" and putting it over 100 lb: 12.5 lb Cl_2/100 lb. Here the reader has to stop and answer the question "per hundred pounds of what?" In this case the answer is "solution" (abbreviated "soln"), so it is written as 12.5 lb Cl_2/100 lb soln. Again, if this is mastered, the units will do the math for you! WWTT promises it.

Problem

In many sludge problems, TS and VS concentrations are given in percent not mg/L.

Problem of the Day: What is the sludge flow, in gallons per day, to an anaerobic digester if the flow to the plant is 2.1 MGD, and the influent and primary effluent TSS concentrations are 240 and 105 mg/L, respectively? The sludge is pumped at 3.2% TS.

Solution

A list of the information given in the problem:

- Q = 2.1 Mgal/d
- Influent TSS = 240 mg TSS/L
- Primary effluent TSS = 105 mg TSS/L
- TSS removed in primary clarifier = (240 − 105) mg TSS/L = 135 mg TSS/L
- TS concentration in sludge = 3.2% TS = 3.2 lb TS/100 lb sldg
- Sludge density = 8.34 lb sldg/gal sldg (assumed)
- Wanted: **gal sldg/d**

The units wanted in the answer, gal sldg/d, are entered between heavy vertical lines followed by an equals sign and the blank track.

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$$\left|\frac{\text{gal sldg}}{\text{d}}\right| = \_\_\_\_\_$$

WWTT is very specific in labeling. In this particular example, the reader must understand that it's not just "gal/d," but "**gal sldg/d**." This is very, very important and cannot be overemphasized.Notice in the list above, there is only one piece of information given that has "gal sldg" as a unit. This is part of the units that the question is asking for in the problem statement, and it most be in the numerator. Most of the time, WWTT starts the railroad track out with the units needed in the answer in the first position in the numerator of the railroad track as shown. Notice the density of the sludge has to be inverted in order to get the unit, gal sldg, in the numerator.

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$$\left|\frac{\textbf{gal sldg}}{\text{d}}\right| = \left|\frac{\textbf{gal sldg}}{\text{8.34 lb sldg}}\right| \_\_\_\_\_$$

Once the railroad track is started and the information given in the problem precisely labeled (see list above), doing the problem is simply a matter of canceling out the units that are not needed. Here, we want to keep gal sldg but cancel lb sldg. This unit appears in only one other place in the list above, so it is entered so the units cancel.

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$$\left|\frac{\textbf{gal sldg}}{\text{d}}\right| = \left|\frac{\textbf{gal sldg}}{\text{8.34 } \cancel{\text{lb sldg}}}\right| \left|\frac{\text{100 } \cancel{\text{lb sldg}}}{\text{3.2 lb TS}}\right| \_\_\_\_\_$$

Next, lb TS needs to be canceled, but there is nothing in the list with this unit. What to do?

In the list there isn't lb TS, but there is mg TS(S). Why do I put the second S in parentheses?

TS and TSS are not the same. TS, total solids, is the sum of the TSS, total suspended solids, and TDS, total dissolved solids. For these problems, however, we assume that TS and TSS are equal. I put the second S in parentheses to say, "I know that TS and TSS are not the same, but I am going to assume that they are." So, mg TS(S) are entered into the railroad track in the numerator and the units TS and TS(S) cancel.

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gal sldg	=	**gal sldg**	100 ~~lb sldg~~	135 mg ~~TS(S)~~	
d		8.34 ~~lb sldg~~	3.2 lb ~~TS~~	L	

If **not** solving for concentration, whenever mg/L are entered into the railroad track, they are canceled.

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gal sldg	=	**gal sldg**	100 ~~lb sldg~~	135 ~~mg~~ ~~TS(S)~~	~~L~~	
d		8.34 ~~lb sldg~~	3.2 lb ~~TS~~	~~L~~	M~~·mg~~	

In the railroad track right now, we have lb and M that need to be canceled, and we still don't have d in the denominator that is needed in the answer. The M reminds us that we need an Mgal in the numerator. Flow is entered next to cancel the Ms and get d in the railroad track.

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gal sldg	=	**gal sldg**	100 ~~lb sldg~~	135 ~~mg~~ ~~TS(S)~~	~~L~~	2.1 ~~M~~gal	
d		8.34 ~~lb sldg~~	3.2 lb ~~TS~~	~~L~~	~~M·mg~~	**d**	

The only units remaining to cancel are lb and gal, so the density of water is entered. Notice 8.34 is entered in both the numerator and the denominator. This is because we are talking about two different liquids: the water flowing into the plant and the sludge being removed from the primary clarifier. Even though they are the same numerically, the way they are labeled is very specific: 8.34 lb/gal is the density of the water, and 8.34 lb sldge/gal sldg is the density of the sludge. If you aren't using the units like WWTT teaches, you might be confused under the pressure of an exam that you have "8.34" in both the numerator and the denominator. Using units eliminates this confusion. Also, to save yourself a little calculator time, the 8.34 in the denominator cancels the 8.34 in the numerator.

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gal sldg	=	**gal sldg**	100 ~~lb sldg~~	135 ~~mg~~ ~~TS(S)~~	~~L~~	2.1 ~~Mgal~~	8.34 ~~lb~~
d		8.34 ~~lb sldg~~	3.2 ~~lb TS~~	~~L~~	~~M·mg~~	**d**	~~gal~~

All the units have canceled except those needed in the answer, **gal sldg/d**, so the math is done. The arithmetic completes the problem:

100 x 135 x 2.1 x 8.34 ÷ 8.34 ÷ 3.2 = 8,859 gal sldg/d.