Problem of the Day

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A large wastewater treatment plant's raw sludge flow averages 450,000 gal/d. The raw sludge has a TS content of 4.8% of which 72.5% is volatile. The specific gravity of the raw sludge is 1.0. The volatile solids reduction (VSR) in the anaerobic digester complex is 56%. For every pound of VS destroyed in the digesters, 15.5 ft^3 of digester gas is produced with a heat content of 600 BTU/ft^3. Calculate the BTUs produced per day.

Introduction

Whenever a anaerobic digester gas problem is given, the operator must know (s)he will have to calculate the VSR. However, the VSR is given in this problem, 56%.

Students ask all the time, “How do I know if I’m going to use all the information given in a problem.”

My response is always, “If you don’t use it on the solution bridge to get to the units needed in the answer, you don’t need the information given.” Today’s problem is a classic example of this very important lesson.

Solution

As with most problems, the solution bridge starts with identifying the units needed in the answer. The problem asks to calculate the BTUs produced per day. These units, therefore, are entered between heavy vertical lines followed by an equals sign and the blank solution bridge.

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$$\left| \frac{\text{BTU}}{\text{d}} \right| = \left| \frac{\quad}{\quad} \right|$$

There is a lot of information given in this problem. It is summarized in the following list with appropriate units (note: get in the habit of labeling these sludge/gas problems as shown here; doing so makes the problems very straightforward):

1. Raw sludge flow = 450,000 gal sldg/d
2. Sludge density with a specific gravity of 1.0 = 8.34 lb sldg/gal sldg
3. 4.8% TS = 4.8 lb TS/100 lb sldg
4. 72.5% VS = 72.5 lb $VS_{applied}$/100 lb TS
5. VSR = 55.8% = 55.8 lb $VS_{destroyed}$/100 lb $VS_{applied}$
6. Gas production on VS basis = 15.5 ft^3 gas/lb $VS_{destroyed}$
7. Gas production on daily basis = 1,130,000 ft^3 gas/d
8. Heat content of gas = 600 BTU/ft^3 gas

There is only one place in this entire list where the units BTU appear: No. 8. This is how the solution bridge is started, with the units BTU needed in the numerator of the answer.

$$\left| \frac{\textbf{BTU}}{\text{d}} \right| = \left| \frac{600\ \textbf{BTU}}{ft^3\ \text{gas}} \right| \frac{\quad}{\quad} \Bigg|$$

As always, we have to preserve the units on the solution bridge that are needed in the answer, so the units ft^3 gas need to be canceled. There are two places where these units appear in the list: Nos. 6 and 7. Oh, no! The solution bridge method doesn’t work!

Oh, yes it does! By entering No. 7 so the unwanted units cancel, numerator and denominator, the unit d needed in the denominator of the answer is entered.

$$\frac{\textbf{BTU}}{\textbf{d}} = \frac{600\ \textbf{BTU}}{\cancel{ft^3\ gas}} \times \frac{1{,}130{,}000\ \cancel{ft^3\ gas}}{\textbf{d}}$$

Whoa! No way: a two-step solution bridge with all that information given in the problem?

Yep, if you don't use it on the solution bridge, you didn't need it to calculate the answer. Let the units tell you how to find the answer.

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Since the units remaining are the units needed in the answer, BTU/d, shown in bold on both sides of the equals sign, we know the solution bridge is complete. The arithmetic gives the answer:

600 x 1,130,000 = **678,000,000 BTU/d**.

Discussion

Looking at the answer, you can see why many plants report millions of BTU/d. If those were the units asked for in the question, the answer would have been 678 MBTU/d, but be careful, on certification exams, always give the answer in the units asked for even if it's not what you typically do at your plant.

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.