Problem of the Day

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The influent to the Oxbow Water Reclamation Facility averages 46.5 MGD. The influent TSS concentration is 385 mg/L, 74.2% of which is volatile. Using small dosages of ferric chloride and anionic polymer for chemically enhanced primary treatment (CEPT), the operators keep the primary effluent TSS concentration to a fairly stable 106 mg/L. In previous Problems of the Day it was found that 108,199 lb TSS/d and 80,284 lb VSS/d are removed in the primary clarifiers and that 249,490 gallons of primary sludge are pumped to the digesters each day at a solids concentration of 5.2% TS. There are four primary digesters at the plant, each holds 750,000 gallons. The digested sludge has a VS content of 53.2%. The VSR is 60.5%. A total of 796,578 ft^3 gas are produced per day. If the gas is 34% CO_2 and 1% other gases, and CH_4 has a heat content of 932 BTU per cubic foot, calculate the total BTUs generated per day.

Introduction

This is the last in this series of Problems of the Day. There is a lot of anxiety on the part of operators taking certification exams that there are multiple steps in many math solutions and "what if I get the first step wrong, all the other steps will be wrong, too." While this is a valid concern, operators shouldn't let it diminish their confidence. Understanding the labeling convention presented by WWTT and the mechanics of the solution bridge will get you to the correct answer no matter how many steps there are. A hugely important point to emphasize, a point many operators struggle with, is that almost every number we deal with in wastewater math problems comes with units (there are very few exceptions). It's not 8.34 but 8.34 lb/gal; it's not 7.48 but 7.48 gal/ft^3; it's not 43,560 but 43,560 ft^2/ac. Moreover, get in the habit of fully describing what you're talking about. For example, stop using MGD because it's million gallons **per** day; stop using cfs because it's ft^3 **per** second; stop using gpm because it's gallons **per** minute; stop using cu.ft. and sq.ft. because they're ft^3 and ft^2. Sometimes I think that operators don't like using units in their calculations because they think it's cheating or it doesn't demonstrate their prowess with the math. Using units in our calculations tell us how to set problems up, when a conversion factor is needed and whether to divide or multiply by that conversion factor, and they even do algebra for you. Follow the convention that WWTT presents in these pages and you will succeed.

There is a very important lesson in today's Problem of the Day.

There's a second important lesson. There is only one place in wastewater math problems where percent (%) is **not** on a weight basis and that one place is digester gas. In the list that follows, Nos. 3, 7 and 11 are expressed as so many pounds per 100 pounds. When dealing with digester gas, percent is on a volumetric basis: so many ft^3 per 100 ft^3 (see No. 15 in the list). This is very, very important.

Solution

The following information is given, expressed in the units recommended by WWTT (sludge is abbreviated "sldg"):

1. Influent flow = 46.5 Mgal/d
2. Influent TSS concentration = 385 mg TSS/L
3. Influent VSS concentration = 74.2% = 74.2 lb VSS/100 lb TSS
4. Primary effluent TSS concentration = 106 mg TSS/L
5. Pounds TSS per day removed = 108,199 lb TSS/d
6. Pounds VSS per day removed = 80,284 lb VSS/d
7. Primary sludge solids concentration = 5.2% TS = 5.2 lb TS/100 lb sldg
8. Number of anaerobic digesters = 4 DIG
9. Volume of each anaerobic digester = 750,000 gal
10. VS content in digested sludge = 53.2% VS
11. VSR = 60.5% = 60.5 lb $VS_{destroyed}$/100 lb $VS_{applied}$
12. Gas production = 796,578 ft^3 gas/d (from yesterday's Problem of the Day)
13. CO_2 content of digester gas = 34%
14. Inert content of digester gas = 1%
15. CH_4 content of digester gas = 100% − (34% + 1%) = 65% = 65 ft^3 CH_4/100 ft^3 gas
16. Heat content of CH_4 = 932 BTU/ft^3 CH_4

Today's problem asks to calculate "the total BTUs generated per day." These units, BTU/d, are put between heavy vertical lines, as always, followed by an equals sign and the blank solution bridge.

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

The only place the units BTU appear in the list is in the numerator of No. 16. This, then, is entered to start the solution bridge.

$$\left|\frac{\textbf{BTU}}{\text{d}}\right| = \left|\frac{932\ \textbf{BTU}}{ft^3\ CH_4}\right| \text{———————————}$$

The only other place the units ft^3 CH_4 appear in the list is in the numerator of No. 15. This, then, is entered so like units cancel, denominator and numerator.

$$\left|\frac{\textbf{BTU}}{\text{d}}\right| = \left|\frac{932\ \textbf{BTU}}{ft^3\text{-}CH_4}\right| \left|\frac{65\ ft^3\text{-}CH_4}{100\ ft^3\ \text{gas}}\right| \text{———————————}$$

The only other place the units ft^3 gas appear in the list is in the numerator of No. 12. This, then, is entered so like units cancel, denominator and numerator.

$$\left|\frac{\textbf{BTU}}{\textbf{d}}\right| = \left|\frac{932\ \textbf{BTU}}{ft^3\text{-}CH_4}\right| \left|\frac{65\ ft^3\text{-}CH_4}{100\ ft^3\text{-}gas}\right| \left|\frac{796{,}578\ ft^3\text{-}gas}{\textbf{d}}\right|$$

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

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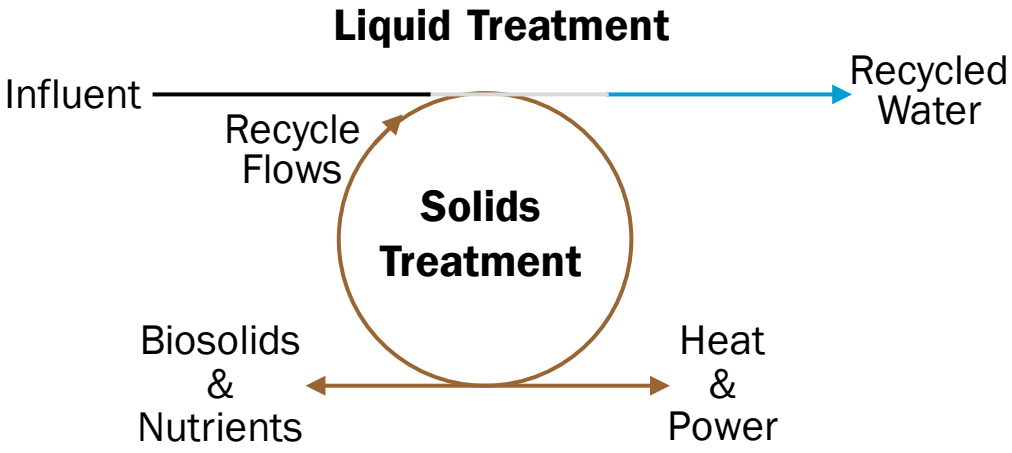
$$\left|\frac{\textbf{BTU}}{\textbf{d}}\right| = \left|\frac{932\ \textbf{BTU}}{ft^3\text{-}CH_4}\right| \left|\frac{65\ ft^3\text{-}CH_4}{100\ ft^3\text{-}gas}\right| \left|\frac{796{,}578\ ft^3\text{-}gas}{\textbf{d}}\right|$$

932 x 65 x 796,578 ÷ 100 = **<u>482,570,000 BTU/d</u>**.

Discussion

As we said yesterday, “Thar’s gold in them thar hills!” (A misquote, according to Wikipedia, from a speech by M.F. Stephenson attempting to dissuade Dahlonega, Georgia, gold miners from moving to California for the gold rush there.)

Four hundred eighty million BTU/d, wow! To repeat myself from yesterday, while the overarching objective of wastewater treatment will always be public health and environmental protection, more and more wastewater treatment plants will become resource recovery facilities in the future. It has to be. The essence of resource recovery is captured in this simplified schematic of a resource recovery facility showing the recovery of usable water (recycled water), heat and power (from the heat energy production calculated in today’s Problem of the Day, and biosolids and nutrients (recovering organic carbon, nitrogen and phosphorus).



Schematic of a Resource Recovery Facility

The future of wastewater treatment is so very exciting! It’s good to be part of it!

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.