Problem of the Day

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Introduction

I understand that math gives many operators angst. Math gives many people angst. But as operations professionals, we can't dwell on the angst that math causes us because it is self defeating. Instead, we need to put that negative energy into understanding the problem at hand and practice, practice, practice.

Without being disrespectful, I would venture that the root cause of math anxiety for many of us can largely be explained by one or more poor math teachers in the beginning of our schooling. I don't have any statistics or scholarly papers to back up that assertion, but from my own experience as a trainer I have observed, over and over, this scenario: (1) a talented operator during introductions at the beginning of one of our classes admits, "I can't do math; I have never been able to do math; I am going to fail," and (2) said operator passes his/her certification exam with "... no problem with the math; a couple of stupid mistakes" (http://wastewatertechnologytrainers.com/testimonials/).

And, unfortunately, it's not just bad math teachers when we were young and overwhelmingly impressionable; it continues through life. Again without being disrespectful, I was forlorn after reading an article in *TPO Magazine* entitled, "5 Tips for Acing Wastewater Exam Math Questions" (http://www.tpomag.com/online_exclusives/2014/12/5_tips_for_acing_wastewater_exam_math_questions). I have multiple problems with this list of "helpful hints," two of which I will address here. You would think the author and the magazine editor, in an article on lessening math anxiety for operators, would be super extra careful to get everything correct. Disappointingly, in Tip No. 1, an example problem asks (and I quote): "What is the volume in million gallons per day of the aerbay?" And then the last two sentences in this helpful (?) tip are, "The plant **data** already **gives** the capacity as 523,545 gallons, so you only need to convert gallons to mgd. 523,545/1,000,000 = 0.523545 mgd." (emphasis added, see below)

This is inexcusable. **Gallons** is a unit of **volume**; **mgd** is a unit of **flow**. While flow is volume per unit time, **volume and flow are not the same thing**. There is no conversion factor known to humankind that will convert gallons to mgd. *TPO Magazine* should be ashamed.

In Tip No. 3 a series of detention time (DT) calculations for the same problem is given seemingly as if math is some random exercise where operators "look" for the correct answer. The first calculation, admittedly incorrect, is rewritten here:

DT, hrs = (523,345 x 24)/13.5
DT, hrs = 12,560,280/13.5
930,391 hrs

This, too, is inexcusable. Math is not some random, plug-and-chug exercise. It is very precise and there is only one answer. If units had been carried through the solution on this problem like WWTT teaches,

hr	=	523,345 gal	24 **hr**	~~d~~
			~~d~~	13.5 Mgal

it can be seen, clearly, that this "solution" doesn't solve for **hr** but **gal•hr/Mgal**, obviously not what is wanted. I am embarrassed for *TPO Magazine* and all the operators reading it.

Let's do some "detention time" problems, shall we?

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Upstream of the filters, alum is fed to a secondary effluent flow of 13.9 MGD in a flash mix basin that is 10 feet long, 10 feet wide and 15 feet deep. What is the detention time, in seconds, in this flash mix basin?

Discussion

Wastewater treatment plant operators often have to calculate how long it takes to fill a tank or a reservoir, how long it takes to empty a tank or a reservoir, or what the detention time is in a tank or a reservoir. **Whenever a question arises asking about time (T) and includes volume (V) and flow rate (Q), the equation will almost always be the same**:

$$T = \frac{V}{Q}$$

Repeat for emphasis, **this is the equation that will be used for every question asking about fill time, empty time or detention time**. All that is needed to do the calculation is the volume and flow rate and the units required in the answer. And sometimes questions will arise that ask to find volume given time and flow rate, or to find flow rate given time and volume. **Same equation**.

When adding a coagulant, like alum, rapid and complete dispersion is key. Flash mix basins are designed to impart a lot of mixing intensity very quickly, with detention times measured in seconds.

Solution

Unlike the solution to the detention time problem given in *TPO Magazine* and shown at the beginning of this post, WWTT carries units through all problems because the units will tell you how to set up a problem, whether to divide or multiply, and they'll even do algebra for you.

The question asks specifically for "... seconds ..." These units, **s**, are put between heavy vertical lines followed by the equals sign and the blank track. The equation, T = V/Q, is shown as it will be used to populate the railroad track.

Problem of the Day: Upstream of the filters, alum is fed to a secondary effluent flow of 13.9 MGD in a flash mix basin that is 10 feet long, 10 feet wide and 15 feet deep. What is the detention time, in seconds, in this flash mix basin?

Information summary, specifically labeled:

- Plant flow = 13.9 Mgal/d
- Flash mix basin length = 10 ft
- Flash mix basin width = 10 ft
- Flash mix basin depth = 15 ft
- **Calculate: Detention time in s**.

$$\Big|\; s \;\Big| = \frac{V}{Q} = \underline{\qquad\qquad\qquad\qquad\qquad\qquad}$$

The railroad track is started by entering the volume of the flash mix basin (length x width depth) in the numerator divided by the flow. "Divided" means the flow is entered in the denominator.

$$\Big|\; s \;\Big| = \frac{V}{Q} = \begin{array}{c|c|c|c|c} 10\text{ ft} & 10\text{ ft} & 15\text{ ft} & \text{d} & \\ \hline & & & 13.9\text{ Mgal} & \end{array}$$

Obviously, there is several conversions/cancelations we need to do to get from where we are to **s**. But there are a couple of things to note that give us confidence we're going in the right direction: (1) **d** (days) is a unit of time as are **s** (seconds) and they are both in the numerator on either side of the equals sign, and (2) **ft^3** (cubic feet), in the numerator, are units of volume and **Mgal** (million gallons), in the denominator of the railroad track, also are a unit of volume and all we have to do is express them in the same units so they cancel. There are a number of "next steps" that could be taken. Here we convert **ft^3** to **gal** using a well-known conversion factor so we can cancel ft x ft x ft.

s	=	V	=	10 ~~ft~~	10 ~~ft~~	15 ~~ft~~	d	7.48 gal
		Q					13.9 Mgal	~~ft^3~~

The next conversion factor to be used, **Mgal/10^6 gal**, cancels **Mgal** and **gal** on both sides of the railroad track. Remember, 10^6 is shorthand for 1,000,000.

s	=	V	=	10 ~~ft~~	10 ~~ft~~	15 ~~ft~~	d	7.48 ~~gal~~	~~Mgal~~
		Q					13.9 ~~Mgal~~	~~ft^3~~	10^6 ~~gal~~

We now have **d** in the railroad track, but we need **s**. I know there is a conversion factor to convert **d** to **s** and vice versa, but I forget it. What I remember is how many minutes are in a day,

s	=	V	=	10 ~~ft~~	10 ~~ft~~	15 ~~ft~~	~~d~~	7.48 ~~gal~~	~~Mgal~~	1,440 min
		Q					13.9 ~~Mgal~~	~~ft^3~~	10^6 ~~gal~~	~~d~~

and how many seconds are in a minute.

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Information summary, specifically labeled:

- Plant flow = 13.9 Mgal/d
- Flash mix basin length = 10 ft
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- **Calculate: Detention time in s**.

s	=	V	=	10 ~~ft~~	10 ~~ft~~	15 ~~ft~~	~~d~~	7.48 ~~gal~~	~~Mgal~~	1,440 ~~min~~	60 **s**
		Q					13.9 ~~Mgal~~	~~ft^3~~	10^6 ~~gal~~	~~d~~	~~min~~

Everything has canceled except the units we need in the answer, **s**, so **we know** the math is done. The arithmetic gives the answer:

10 x 10 x 15 x 7.48 x 1,440 x 60 ÷ 13.9 ÷ 1,000,000 = **<u>70 s</u>**.

Math is not random. Use units and you will succeed.

A couple of things to note. First, if you remember that there are 86,400 s/d, that's fine because 1,440 x 60 = 86,400. One of the things I tell our students all the time is, "**Be confident of what you do know** because it will get you through a lot of math problems if you use units like WWTT teaches." Second, in the last sentence of the third paragraph at the beginning of the post I highlighted **data** and **gives**. *TPO Magazine* should know that "data" is plural. It should be "The plant **data** already **give** the capacity ..."

Many of you in California may have heard that **water** treatment plant certification has been moved from the California Department of Health Services to the Office of Operator Certification in the State Water Resources Control Board. We think our approach to doing math problems is so sound and can help so many operators, water and wastewater, WWTT is going to start doing math review classes for water treatment plant operators. If you know of anybody who is pursuing water treatment plant or distribution operator certification, or if you are, visit WWTT's courses webpage here. The water classes aren't up as of this writing, but they will be soon!

Happy calculating. Let us know, by leaving a comment, if you want us to do a specific problem.