WASTEWATER TECHNOLOGY
TRAINERS

Transforming today's operators into tomorrow's water quality professionals

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Problem of the Day

2014.Dec.10

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/).

The solution to water and wastewater math problems for folks who struggle with math is to carry units through the problem. **Units show you how to do the problem**. In previous posts I discussed an article on the *TPO Magazine* website 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). There are multiple issues I have with the article, which, overall, I see as a disservice to the operations profession, but the most unforgiving is where the article express volume in MGD! **Gallons** is a unit of **volume** and **million gallons** is a unit of **volume**, but **MGD** is a unit of **flow**. While flow is volume per unit time, **volume and flow are not the same thing**. *TPO Magazine* should know better.

Add the words "math" and "pond" together and operators get even more angst!

The reason for this, I think, is that most operators have little or no experience with wastewater treatment ponds. The other thing about ponds that is a source of confusion is that some of the units associated with ponds are fairly unique to ponds. For example, area is expressed in **ac**, volume is expressed in **ac•ft**, hydraulic loading is expressed in **in/d**, organic loading is expressed in **lb BOD/d•ac**. Just keep the units straight, and enjoy finding the solution to all your pond problems!

Problem of the Day

How deep (feet) must a wastewater pond be operated in order to maintain a 45-day detention time? The flow to the 55-acre pond is 1.6 MGD.

Discussion

We're going to forget about the equation we've used the last several days and see how the units tell us how to do the problem. But we're still going to need the "holy grail" conversion factor for ponds:

$$\frac{3.069\ \text{ac}\cdot\text{ft}}{\text{Mgal}} \quad \text{or} \quad \frac{\text{Mgal}}{3.069\ \text{ac}\cdot\text{ft}}$$

Solution

The question asks specifically for "... feet ..." These units, **ft**, are put between heavy vertical lines followed by the equals sign and the blank track.

Problem of the Day: How deep (feet) must a wastewater pond be operated in order to maintain a 45-day detention time? The flow to the 55-acre pond is 1.6 MGD.

Information summary, specifically labeled:

- Plant flow = 1.6 Mgal/d
- Pond area = 55 ac
- Target detention time = 45 d
- **Calculate: Operating depth in ft**.

$$|\ \text{ft}\ | = \text{———————————————}$$

How are we going to start the railroad track?

Flow is in units of volume per time, in this case Mgal/d. Volume can be converted to length x length x length (for example, ft x ft x ft or ft^3) no matter what the starting units are. Acres (ac) is a unit of area. Area can be converted to length x length (for example, ft x ft or ft^2) no matter what the starting units are. Detention time, the other piece of information given in the problem, is in units of time so we don't have to consider it yet. Depth, which we are asked to calculate, is a unit of length, specifically in this case, ft. So, if Mgal (volume) can be converted to ft^3 and ac (area) can be converted to ft^2, how can we enter these in the railroad track so we end up with ft in the numerator? Here's a hint:

$$\frac{Q}{A} \dashrightarrow \frac{ft^3}{ft^2} = \frac{ft \times \cancel{ft} \times \cancel{ft}}{\cancel{ft} \times \cancel{ft}} = ft$$

Dividing Q by A is the only way we can end up with **ft**, so that's how we start the railroad track.

$$|\ \text{ft}\ | = \left|\ \frac{1.6\ \text{Mgal}}{\text{d}}\ \right|\ \left|\ \frac{}{55\ \text{ac}}\ \right|\ \text{———}$$

This is a very simple thing to remember: if you are doing a pond problem and you have **Mgal** and **ac** on opposite sides of the railroad track (or opposite signs of the equals sign), you are probably going to use the holy grail pond conversion factor. We do so here.

$$|\ \textbf{ft}\ | = \left|\ \frac{1.6\ \cancel{\text{Mgal}}}{\text{d}}\ \right|\ \left|\ \frac{}{55\ \cancel{\text{ac}}}\ \right|\ \left|\ \frac{3.069\ \cancel{\text{ac}}\textbf{ft}}{\cancel{\text{Mgal}}}\ \right|\ \text{———}$$

We have the units in the railroad track that we need in the answer, **ft**. But in the railroad track we also have a **d** that we need to get rid of. How are we going to do that? There is one more piece of information

given in the problem, the target detention time, that we haven't used and, guess what, it is in units of days (**d**)! In order for **d** to cancel, the detention time has to be entered in the numerator.

$$\left| \textbf{ft} \right| = \left| \frac{1.6\ \cancel{\text{Mgal}}}{\cancel{\text{d}}} \right| \left| \frac{}{55\ \cancel{\text{ac}}} \right| \left| \frac{3.069\ \cancel{\text{ac}}\textbf{ft}}{\cancel{\text{Mgal}}} \right| \left| \frac{45\ \cancel{\text{d}}}{} \right|$$

Because all the units have canceled in the railroad track except those needed in the answer, **ft**, we know the math is done.

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The arithmetic gives the answer:

1.6 x 3.069 x 45 ÷ 55 = **4.0 ft**.

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

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**:

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

Something else operators should know is that volume is surface area (A) times depth (D), something we have recently discussed. With this substitution in our equation here, we get:

$$T = \frac{A \times D}{Q}$$

This equation can be algebraically rearranged to this:

$$D = \frac{Q \times T}{A}$$

This is exactly what we did to solve today's problem (T equaled detention time today) using units not algebra!

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