



Problem of the Day 2014.Sept.20

Discussion

While there are many approaches to problem solving, math is unique in the sense that provided all the relevant information given in the problem statement, the numbers can be added, subtracted, multiplied and divided in only one specific sequence to get the correct answer. This is so important it is worth saying again: **there is only one way the numbers relevant to solving the problem can be manipulated to give the correct answer.**

The approach most people take in teaching math to operators is based on memorizing a multitude of formulas or piecharts. This “multitude of formulas or piecharts” is the direct result of all the various units used in the wastewater treatment profession. Flow, for example, can be expressed in cubic feet per second, gallons per minute, gallons per day, million gallons per day, etc. Any calculation involving flow, therefore, would, theoretically, require a different formula or piechart depending on what units flow is expressed in, or, just as tediously, all flows would first have to be converted to one set of units in order to use one equation or one piechart. **In fact, most math required of wastewater treatment plant operators is converting from one set of units to another.** Beyond adding, subtracting, multiplying and dividing, there is little “math” that operators need to know to pass their certification tests and to do their jobs.

WasteWater Technology Trainers (WWT), and others, does not advocate memorization of formulas and piecharts. While there are some conversion factors and formulas the operator is strongly encouraged to memorize, or already knows (for example, “12 inches/foot,” “1,440 minutes/day” and “7.48 gallons/cubic foot”), WWT believes rout memorization of the “multitude of formulas and piecharts” is a gigantic waste of time.

In the end, every problem must end up with the units called for in the problem statement with all other units cancelled out; the process of doing so is called “dimensional analysis.” It is important to understand that there are very, very few numbers used in wastewater calculations that do **not** have units associated with them (exceptions are few but include π , specific gravity, and percent expressed as decimal). To succeed on certification exams, **operators should include all units in all calculations.** This cannot be over stated so I’ll state it again: **operators should include all units in all calculations.**

WWT does all calculations in two “dimensions,” top and bottom—numerator and denominator—in what has been called by various students the “box method,” “railroad track,” “monorail track,” or “bridge” between problem and solution. The calculations begin with identifying the units desired at the end of the calculation. **These may be units needed in an interim calculation or the units the problem statement asks the answer to be expressed in.** These desired units are shown on the left-hand side of the calculation in square brackets when written or, here, with heavy vertical lines, so as not to be confused for the answer. The units of the answer are identified and shown to start the railroad track followed by an equals sign (=), and a line that is the “track,” which separates the numbers and units to be entered into the numerator from the numbers and units to be entered into the denominator.

Problem

Now for today’s problem.

Problem of the Day: How many pounds does 1 gallon of water weigh?

Solution

The first thing we have to do is identify what units are needed in the answer. The question specifically states, "... in pounds," so we put pounds (lb) between heavy vertical lines on the left-hand side of the equals sign to indicate the units we have to end up with:

$$\left| \text{ lb} \right| = \underline{\hspace{2cm}}$$

As shown, the desired units are followed by an equals sign and the blank "track."

This problem is essentially a problem of conversion. In all conversion problems the railroad track is started with what is being converted, in this case, "1 gallon" from the problem statement (1 gal):

Problem of the Day: How many pounds does 1 gallon of water weigh?

$$\left| \text{ lb} \right| = \left| \begin{array}{|c|} \hline 1 \text{ gal} \\ \hline \end{array} \right|$$

There are three "rules" for starting and working your way down the railroad track:

1. As just discussed, for conversion problems the railroad track is started with that which is being converted.
2. To get the units needed in the answer into the railroad track.
3. To cancel one or more set of units already in the railroad track.

Returning to the problem, we see that the gal unit needs to be cancelled because it is not in the answer. Two possible conversion factors with gal in them come to mind:

$$\frac{8.34 \text{ lb}}{\text{gal}}$$

and

$$\frac{\text{ft}^3}{7.48 \text{ gal}}$$

So, which one do you think we should use?

The second one (perhaps more commonly known as 7.48 gal/ft³), introduces the unit, ft³, into the railroad track. This unit, also, would need to be somehow cancelled because it is not in the answer.

The right conversion factor, then, is the first one, 8.34 lb/gal, and it must be entered in the railroad track so gal in the numerator is cancelled by the gal in the denominator:

Problem of the Day: How many pounds does 1 gallon of water weigh?

$$\left| \text{ lb} \right| = \left| \begin{array}{|c|c|} \hline 1 \text{ gal} & 8.34 \text{ lb} \\ \hline & \text{gal} \\ \hline \end{array} \right|$$

The answer (1 x 8.34) is 8.34 lb. (But you knew that!)