Problem of the Day

2014.Dec.13

Introduction

I have always heard that the Chinese character meaning "crisis" is two characters superimposed on each other. The first, taken by itself, means "danger." The second, taken by itself, means "opportunity." With the drought in California we have certainly been in crisis mode. But what amazing opportunity! It is a good time to be in the water business. We really can live without oil but it is impossible to live without water.

But the water business is getting more and more sophisticated. So much of protecting the public's health rests on the shoulders of water and wastewater treatment plant operators. But we're up to the task and we can prove it to our ratepayers, regulators and ourselves by attaining higher levels of certification.

Primary clarifiers remove more organics for less money than any other process unit at wastewater treatment plants. The process objective of primary clarification is the removal of settleable total suspended solids (TSS_{set}). Fortuitously, the BOD (or COD) associated with those solids also is removed and this is important. The reason it is important is because secondary treatment, where the remaining BOD is "removed" (I will explain "removed" in a subsequent post), is expensive, so the more BOD removed in the primary clarifiers, the better. Indeed, wastewater treatment **is** expensive. The organic carbon captured by primary clarifiers, measured in terms of BOD, COD, or VS, can be converted to methane in anaerobic digesters that can then be burned in engines driving electrical generators. Augmenting the organic carbon captured in primary clarifiers, some plants feed fats, oils and grease (FOG) to their digesters to increase methane production and electricity generation. East Bay Municipal Utilities District (EMBUD) has been so successful doing so, they produce more electricity than they use. This is the future.

Problem of the Day

How long does it take, in hours, to fill a primary clarifier that has a diameter of 95 feet and a depth of 12 feet. Flow into the clarifier is 7.63 MGD.

Discussion

The equation for calculating detention time, **fill time** and empty time is always:

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

where T is time (detention, **fill** or empty), V is volume, and Q is flow. Same equation over and over and over again.

Solution

The question asks to calculate fill time in hours. These units, **hr**, are put between heavy vertical lines followed by the equals sign and the blank track.

Problem of the Day: How long does it take, in hours, to fill a primary clarifier that has a diameter of 95 feet and a depth of 12 feet. Flow into the clarifier is 7.63 MGD.

Information summary, specifically labeled:

- Primary influent flow = 7.63 Mgal/d
- Primary clarifier diameter = 95 ft
- Primary clarifier depth = 12 feet
- **Calculate: Time to fill primary clarifier in hr**.

hr	=	

The railroad track is started by dividing by the flow rate. “Dividing by” means we start entering the flow in the denominator. As we’re doing so, when we hear “per” come across our lips (7.63 Mgal **per** day), we jump across the railroad track. Whenever we hear the word “per” come across our lips, whatever side of the railroad track we’re on, we go to the other side. The reason we start out the railroad track by dividing by flow is because it puts a unit of time, **d**, in the numerator because the answer has a unit of time, **hr**, in the numerator.

hr	=	d
		7.63 Mgal

Mgal is a unit of volume. In order to cancel volume out in the denominator, we have to enter volume in the numerator. On this account, we enter the volume of the primary clarifier in the numerator.

hr	=	d	0.785	95 ft	95 ft	12 ft
		7.63 Mgal				

That didn’t do much for canceling units, but we see now that we have volume in the numerator (**ft^3**) and volume in the denominator (**Mgal**), so we start converting units.

hr	=	d	0.785	95 ~~ft~~	95 ~~ft~~	12 ~~ft~~	7.48 gal
		7.63 Mgal					~~ft^3~~

The conversion factor WWTT uses that basically says, “There’s a million gallons in a million gallons,” or **10^6 gal/Mgal**, seems kind of silly, but under the pressure of an exam, it will take the thinking out of "should I divide by 1,000,000 or multiply?" You won't make a mistake if you use it to cancel units as shown.

hr	=	d	0.785	95 ~~ft~~	95 ~~ft~~	12 ~~ft~~	7.48 ~~gal~~	~~Mgal~~	
		7.63 ~~Mgal~~					~~ft^3~~	10^6 ~~gal~~	

Now we have to convert **d** to **hr**.

hr	=	~~d~~	0.785	95 ~~ft~~	95 ~~ft~~	12 ~~ft~~	7.48 ~~gal~~	~~Mgal~~	24 **hr**
		7.63 ~~Mgal~~					~~ft^3~~	10^6 ~~gal~~	~~d~~

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

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hr	=	~~d~~	0.785	95 ~~ft~~	95 ~~ft~~	12 ~~ft~~	7.48 ~~gal~~	~~Mgal~~	24 hr
		7.63 ~~Mgal~~					~~ft^3~~	10^6 ~~gal~~	~~d~~

The arithmetic gives the answer:

0.785 x 95 x 95 x 12 x 7.48 x 24 ÷ 7.63 ÷ 1,000,000 = **2.0 hr**.

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

If this primary clarifier was full and had the same influent flow, what would the detention time be?

Detention time and fill time are the **exact** same calculation. Detention time = **2.0 hr**.

Let's suppose we shut the flow off to this primary clarifier and drained it using the primary sludge pump which pumps 225 gal/min. How long will it take to empty this clarifier?

That's tomorrow's Problem of the Day.

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