



WASTEWATER TECHNOLOGY TRAINERS

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

Problem of the Day 2014.Dec.14

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 (EBMUD) 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 empty a full primary clarifier after it has been isolated? The primary clarifier has a diameter of 95 feet and a depth of 12 feet. The primary sludge pump is being used to empty the clarifier. It pumps at 225 gpm.

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 how long it will take to empty the primary clarifier 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 empty a full primary clarifier after it has been isolated? The primary clarifier has a diameter of 95 feet and a depth of 12 feet. The primary sludge pump is being used to empty the clarifier. It pumps at 225 gpm.

Information summary, specifically labeled:

- Primary sludge (drain) flow = 225 gal/min
- Primary clarifier diameter = 95 ft
- Primary clarifier depth = 12 feet
- **Calculate: Time to empty primary clarifier in hr.**

hr	=	
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The railroad track is started by dividing by the pumping rate (drain rate) of the primary sludge pump. "Dividing by" means we start entering the flow in the denominator. As we're doing so, when we hear the word "per" come across our lips (225 gallons **per** minute), 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, **min**, in the numerator because the answer has a unit of time, **hr**, in the numerator.

hr	=	min	
		225 gal	

gal 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	=	min	0.785	95 ft	95 ft	12 ft	
		225 gal					

That didn't do much for canceling units, but we see now that we have volume in the numerator (**ft³**) and volume in the denominator (**gal**). Both are canceled using the well-known conversion factor

hr	=	min	0.785	95 ft	95 ft	12 ft	7.48 gal	
		225 gal					ft ³	

Now we have to convert **min** to **hr** (**min** have to cancel).

hr	=	min	0.785	95 ft	95 ft	12 ft	7.48 gal	hr
		225 gal					ft ³	60 min

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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The arithmetic gives the answer:

$$0.785 \times 95 \times 95 \times 12 \times 7.48 \div 225 \div 60 = \underline{\underline{47 \text{ hr}}}.$$

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

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