Problem of the Day

2015.Jul.29

Problem of the Day

A secondary clarifier has a side water depth of 18 feet. It is 120 feet in diameter and the depth in the center is 23 feet. The influent flow to the clarifier averages 32.5 MGD (18.1 MGD plant influent flow + 14.4 MGD RAS flow). What is the detention time in this tank in hours?

Introduction

In water and wastewater treatment, operators are often tasked with calculating how long it takes to fill a tank or reservoir, how long it takes to empty a tank or reservoir, or what the detention time is in a tank or reservoir. The equation is the same for calculating all of these:

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

where T is time, V is volume and Q is flow into or out of the tank or reservoir. Yesterday's Problem of the Day calculated how long it would take to fill the secondary clarifier at the same flow rate. You should know that detention time is the exact same calculation using the exact same numbers used to find fill time.

This seems like a pretty straightforward equation to me. What makes it difficult is that the units of T, V and Q may not be consistent. This is not a concern when using the solution bridge: V is entered into the numerator of the solution bridge in whatever units it is given in (or calculated as in today's problem), Q is entered into the denominator of the solution bridge in whatever units it is given in, and whatever conversion factors are necessary to get T in the units requested are used. Just remember the equation is the same for all problems with T, V and Q:

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

Solution

The list of "givens" expressed in the units used by WWTT:

1. Secondary clarifier diameter = 120 ft
2. Side water depth = 18 ft
3. Center depth = 23 ft
4. Influent flow = 18.1 Mgal/d
5. RAS flow = 14.4 Mgal/d

The dimensions given for the secondary clarifier tell us it has a conical bottom and the depth of the cone is 5 ft (23 ft − 18 ft = 5 ft). The total secondary clarifier volume, then, is the sum of the volume of the cylindrical portion (V_{cyl}) plus the volume of the conical portion (V_{cone}). These are calculated here in Mgal. You should know how to calculate volume of cylindrical and conical tanks. Using units assures you are doing the calculations correctly.

V_{cyl} Mgal	=	0.785	120 ~~ft~~	120 ~~ft~~	18 ~~ft~~	7.48 ~~gal~~	Mgal
						~~ft³~~	10^6 ~~gal~~

V_{cyl} = 0.785 x 120 x 120 x 18 x 7.48 ÷ 1,000,000 = 1.522 Mgal.

V_{cone} Mgal	=		0.785	120 ~~ft~~	120 ~~ft~~	5 ~~ft~~	7.48 ~~gal~~	Mgal
		3					~~ft³~~	10^6 ~~gal~~

V_{cone} = 0.785 x 120 x 120 x 5 x 7.48 ÷ 3 ÷ 1,000,000 = 0.141 Mgal.

The total volume of the secondary clarifier is:

$V = V_{cyl} + V_{cone}$ = 1.522 Mgal + 0.141 Mgal = 1.663 Mgal.

The question specifically asks to find how many hours it takes to fill the tank so the units hr are put between heavy vertical lines, as always, followed by an equals sign and the blank solution bridge.

Problem of the Day: A secondary clarifier has a side water depth of 18 feet. It is 120 feet in diameter and the depth in the center is 23 feet. The influent flow to the clarifier averages 32.5 MGD (18.1 MGD plant influent flow + 14.4 MGD RAS flow). What is the detention time in this tank in hours?

hr	=	______________________

The equation above tells us how to start the solution bridge: V is entered in the numerator and Q is entered in the denominator. But what flow (Q) do we use? Plant influent flow? RAS flow? Secondary clarifier influent flow (plant flow plus RAS flow)?

The best way to think about this is to consider what would happen to the secondary **effluent** flow if the RAS flow was suddenly dropped from 14.4 Mgal/d to 7.2 Mgal/d? Or even turned off completely?

Think about it.

Answer: the effluent flow from the secondary clarifier would be unchanged and would equal the plant influent flow, 18.1 MGD. This confuses a lot of operators and engineers, but don't let it. The RAS flow is **not** used to calculate the detention time in either the secondary clarifier or, for that matter, the aeration basin. **Never**. So, V and Q are entered into the solution bridge just as they were yesterday.

hr	=	1.663 ~~Mgal~~	d	
			18.1 ~~Mgal~~	

All that remains is the conversion of days (d) to hours (hr). By using the solution bridge we don't have to think about whether we divide or multiply by 24, because the units tell us what to do. This is very important under the pressure of an exam, believe me.

hr	=	1.663 ~~Mgal~~	~~d~~	24 **hr**
			18.1 ~~Mgal~~	~~d~~

Since all the unwanted units have now canceled and only the units needed in the answer remain (hr, in bold), we know the solution bridge is complete. The arithmetic gives the answer.

Problem of the Day: A secondary clarifier has a side water depth of 18 feet. It is 120 feet in diameter and the depth in the center is 23 feet. The influent flow to the clarifier averages 32.5 MGD (18.1 MGD plant influent flow + 14.4 MGD RAS flow). What is the detention time in this tank in hours?

hr	=	1.663 ~~Mgal~~	~~d~~	24 **hr**
			18.1 ~~Mgal~~	~~d~~

1.663 x 24 ÷ 18.1 = **<u>2.2 hr</u>**.

Discussion

The calculation here is identical to the calculation in yesterday's Problem of the Day because the detention time in a tank at a given flow is the same as the time it takes to fill the tank at the same flow. Remember, whether you are calculating how long it takes to fill a tank or reservoir or how long it takes to empty a tank or reservoir or what the detention time is in a tank or reservoir, the equation is the same, only the units differ.

Happy calculating! Let us know, by leaving a comment, if you want us to do a specific problem, if you see a mistake, or if you have a question on any of the Problems of the Day you are looking at.