Problem of the Day

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Four of the six 125 ft diameter primary clarifiers are in service. Flow to the plant is 36.8 MGD. Calculate the surface overflow rate on these primary clarifiers.

Introduction

Surface overflow rate (SOR) on clarifiers—primary, secondary or tertiary—is also known as the hydraulic loading, the hydraulic loading rate, and the surface loading rate. **The units on SOR are always gal/d·ft^2**. Always. These units are very peculiar given the fact that SOR is calculated using the same equation we have been using to calculate velocity (v) given flow rate (Q) and the area through which the flow is passing (A):

$$v = \frac{Q}{A}$$

Here is the SOR equation:

$$SOR = \frac{Q}{A}$$

It turns out that the SOR **is** a measure of the velocity of water passing through a clarifier. It is easier to see in a circular clarifier: the SOR is the velocity of the effluent flow passing up through the clarifier. In this case, the area through which that flow is passing is the surface area of the clarifier. And, it turns out if you look at the units on SOR, gal/d·ft^3, if we converted gal to ft^3 (using 7.48 gal/ft^3), two of the ft in the numerator would cancel with the two in the denominator resulting in ft/d, which, like miles per hour (mi/hr), are more recognizable units of velocity.

Solution

The question does not ask the answer to be in any specific units, but all wastewater treatment plant operators should know that the units on SOR are always gal/d·ft^2. Always. These units, then, are put between heavy vertical lines, as always, followed by an equals sign and the blank solution bridge.

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$$\left|\frac{\text{gal}}{\text{d·ft}^2}\right| = \frac{\quad}{\quad}$$

Let's say you didn't remember the equation above for calculating SOR. I hope this is not the case, but let's just pretend. Assuming you do know that SOR is always in units of gal/d·ft^2, the units tell you how to calculate it: gal/d is flow rate and ft2 is area; divide flow rate by area, so that's what we enter onto the solution bridge, flow rate in the numerator, area in the denominator. Remember the area is **per** primary clarifier (PC).

$$\left|\frac{\textbf{gal}}{\textbf{d·ft}^2}\right| = \frac{36.8\ \text{M}\textbf{gal} \quad \text{PC}}{\textbf{d} \quad 0.785 \quad 125\ \textbf{ft} \quad 125\ \textbf{ft}}$$

That gets all of the units on the solution bridge that we need in the answer (shown in **bold**), but the solution bridge still has an M and PC we need to cancel. How many primary clarifiers are on-line (don't be fooled here by the fact that there are a total of six primary clarifiers; only the four in service go into the calculation)?

$$\left|\frac{\textbf{gal}}{\textbf{d·ft}^2}\right| = \frac{36.8\ \text{M}\textbf{gal} \quad \sout{\text{PC}}}{\textbf{d} \quad 0.785 \quad 125\ \textbf{ft} \quad 125\ \textbf{ft} \quad 4\ \sout{\text{PC}}}$$

To get rid of the M, we use one of WWTT's favorite conversion factors.

gal	=	36.8 ~~M~~**gal**	~~PC~~				10^6 ~~gal~~
d·ft²		**d**	0.785	125 **ft**	125 **ft**	4 ~~PC~~	~~Mgal~~

Since all the units have now canceled except those needed in the answer, we know the solution bridge is complete. The arithmetic gives the answer.

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gal	=	36.8 ~~M~~**gal**	~~PC~~				10^6 ~~gal~~
d·ft²		**d**	0.785	125 **ft**	125 **ft**	4 ~~PC~~	~~Mgal~~

36.8 x 1,000,000 ÷ 0.785 ÷ 125 ÷ 125 ÷ 4 = **750 gal/d•ft²**.

Discussion

As a point of reference, 750 gal/d·ft² is equivalent to 0.00116 ft/s (you should be able to calculate this). That's really slow which is why solids settle in clarifiers. You should know, too, that as the flow into a clarifier goes up, the velocity, or SOR, of the water passing up through the clarifier increases and solids removal efficiency goes down. That's why the SOR is so important to both operators and engineers.

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.