Problem of the Day

2015.Jun.01

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A treatment plant receives a flow of 3.5 MGD. If the primary clarifier is 100 ft long and 30 ft wide with a water depth of 15 ft, what is the surface loading rate?

Introduction

The 2015.May.29 Problem of the Day included the calculation of the hydraulic loading, or hydraulic loading rate, to a pond. As discussed then, hydraulic loading is a cleverly disguised velocity calculation. When it comes to clarifiers—primary, secondary or tertiary—hydraulic loading is also called surface loading, surface loading rate, and surface overflow rate. All these terms are the same thing and refer to the velocity of the effluent flow exiting the clarifier. It is common for wastewater treatment plant operators to have to calculate velocity in pipelines and through channels. The equation to do so is the same every time; it's the same equation for calculating hydraulic loading in ponds and clarifiers. And above all else, it is very simple:

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

where v is velocity, Q is flow rate and A is the area through which the flow passes. For clarifiers the "area through which the flow passes" is the surface area.

Solution

As with most problems, the solution bridge starts with identifying the units needed in the answer. Unfortunately, the problem does not ask for the answer to be in specific units. What to do? You have to know that surface loading (also known as hydraulic loading, hydraulic loading rate, surface loading rate, and surface overflow rate) in clarifiers is **always in units of gal/d·ft²**. Always! All operators must commit these units to memory. Once we know this, the units needed in the answer, gal/d·ft², are entered between heavy vertical lines, as before, followed by an equals sign and the blank solution bridge.

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gal / d·ft²	=				

Let's say you forget the equation above to calculate the solids loading rate to this clarifier, but you remember the units on surface loading rate. The units are such, gal/d·ft², they remind you: flow (Q) is in units of gal/d and area (A) is in ft². So the units tell you what the equation is. The units on flow given in the problem are not gal/d, but we enter what we're given. Doing so puts the units d needed in the denominator of the answer (shown in bold).

gal / **d**·ft²	=	3.5 Mgal / **d**			

Surface area, length times width (note the depth given in the problem is not used to find the answer), is entered in the denominator to get the units ft² needed in the answer.

gal / **d·ft²**	=	3.5 Mgal / **d**	100 **ft**	30 **ft**	

The only conversion necessary is to convert Mgal to gal. A lot of folks will do this in their heads, but WWTT always uses 10^6 gal/Mgal (that is, 1,000,000 gal/Mgal) so mistakes are not made like dividing when I should have multiplied. This is entered onto the solution bridge so the Mgal cancel in the numerator and denominator as shown.

$$\left|\frac{\textbf{gal}}{\textbf{d}\cdot\textbf{ft}^2}\right| = \left|\frac{3.5\ \cancel{\text{Mgal}}}{\textbf{d}} \quad \frac{}{100\ \textbf{ft}} \quad \frac{}{30\ \textbf{ft}} \quad \frac{10^6\ \textbf{gal}}{\cancel{\text{Mgal}}}\right|$$

Since all the units have cancelled except the units needed in the answer, gal/d·ft^2, we know the solution bridge is complete. The arithmetic gives the answer:

3.5 x 1,000,000 ÷ 100 ÷ 30 = **1,167 gal/d·ft^2**.

Discussion

Wait a second, how are the units gal/d·ft^2 units of velocity?!?!? Can you convert gal to ft^3? I challenge you to convert this answer to units of ft/s. We remember that a velocity of 2 ft/s in a pipeline or channel keeps solids in suspension. We remember that a velocity of 1 ft/s in a grit channel lets inorganic solids settle out but organic solids stay in suspension. What about clarifiers? You should get 0.0018 ft/s from 1,167 gal/d·ft^2, which is a very slow velocity. This is why solids settle in clarifiers!

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.