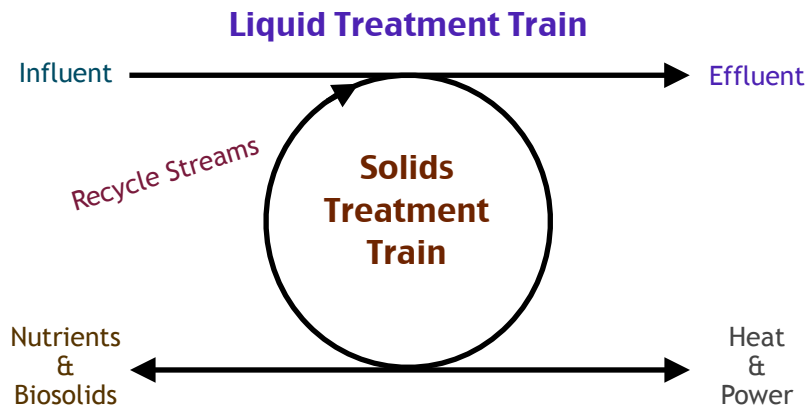




Problem of the Day
2014.Oct.22

Discussion

This graphic was given in yesterday's Problem of the Day to emphasize the impact return streams from the solids treatment train have on the capacity and performance of the liquid treatment train.



Generic WWTP graphic showing interaction between liquid and solids treatment trains, potential for resource recovery in the effluent, heat and power, and nutrients and biosolids outputs, and the potential impacts of recycle streams.

One calculation operators do that quantifies the quality of recycle streams is the percent solids recovery (PSR), also known as the solids capture efficiency, of thickening and dewatering process units in the solids treatment train. In railroad track format, the equation for calculating the PSR was given as:

$$\left| \begin{array}{c} \text{PSR, \%} \end{array} \right| = \left| \begin{array}{cc} \text{lb TS}_o & 100 \\ \text{lb TS}_i & \end{array} \right|$$

where **lb TS_o** = **pounds of TS in the output** coming out of the thickening or dewatering unit and **lb TS_i** = **pounds of TS in the input** going to the thickening or dewatering unit. Also in yesterday's Problem of the Day, a practical definition of the PSR was given. For example, a belt filter press PSR of 96% (PSR is always given in percent) means that **96 lb of TS end up in the cake for every 100 lb of TS applied or fed to the belt filter press**. This is demonstrated in today's problem.

Problem

Problem of the Day: A belt filter press dewatering anaerobically digested sludge as a PSR of 96%. The sludge, with a TS concentration of 4.2%, is fed to the press at 250 gpm. The cake has a TS concentration of 26% and a density of 68 lb/ft³. How many cubic feet of cake is produced in 8 hours?

Solution

As discussed yesterday, WWTT uses a little “accounting trick” to distinguish between the TS in the cake (TS_c) and the TS in the sludge (TS_s), by using the subscripts c and s. doing so allows the units to do algebra without you knowing it’s being done! Also, it is important to note how the PSR, 96% in the problem, is expressed for use in the railroad track:

$$96\% \text{ PSR} = \left| \frac{96 \text{ lb TS}_c}{100 \text{ lb TS}_s} \right|$$

The PSR, so labeled, is entered into the railroad track to cancel units.

Here is what we know from the problem statement, labeled the way WWTT recommends:

- Sludge flow = 250 gal sldg/min
- Sludge TS = 4.2% = 4.2 lb TS_s/100 lb sldg
- Sludge density = 8.34 lb sldg/gal sldg (assumed since not given)
- PSR = 96% = 96 lb TS_c/100 lb TS_s
- Cake TS = 26% = 26 lb TS_c/100 lb cake
- Cake density = 68 lb cake/ft³ cake
- Hours of operation = 8 hr = 480 min

Notice in this list that the 8 hours of operation were converted to 480 minutes:

$$\left| \frac{8 \text{ hr} \quad 60 \text{ min}}{\text{hr}} \right| = 480 \text{ min}$$

This was done because the sludge flow to the belt filter press is given in units of gal sldg/min.

As before, the units needed in the answer are identified from the problem statement. The problem specifically asks for “...cubic feet of cake...” or ft³ cake. These units are entered between thick vertical lines followed by an equals sign and the blank track.

Problem of the Day: A belt filter press dewatering anaerobically digested sludge as a PSR of 96%. The sludge, with a TS concentration of 4.2%, is fed to the press at 250 gpm. The cake has a TS concentration of 26% and a density of 68 lb/ft³. How many cubic feet of cake is produced in 8 hours?

$$\left| \text{ft}^3 \text{ cake} \right| = \underline{\hspace{15em}}$$

In the list given above there is only one place the units, ft³ cake, appear: the density of the cake is 68 lb cake/ft³ cake. In order to get ft³ cake in the numerator, the density is inverted when entered into the railroad track.

Problem of the Day: A belt filter press dewatering anaerobically digested sludge as a PSR of 96%. The sludge, with a TS concentration of 4.2%, is fed to the press at 250 gpm. The cake has a TS concentration of 26% and a density of 68 lb/ft³. How many cubic feet of cake is produced in 8 hours?

$$\left| \text{ft}^3 \text{ cake} \right| = \left| \frac{\text{ft}^3 \text{ cake}}{68 \text{ lb cake}} \right| \underline{\hspace{15em}}$$

As shown in bold, the units needed in the answer are now in the railroad track. While these units need to be preserved, other units need to be canceled. There is only one other instance in the list above where the units, lb cake, appear. Since lb cake are in the denominator of the railroad track, the next entry must have lb cake in the numerator in order for units to cancel.

Problem of the Day: A belt filter press dewatering anaerobically digested sludge as a PSR of 96%. The sludge, with a TS concentration of 4.2%, is fed to the press at 250 gpm. The cake has a TS concentration of 26% and a density of 68 lb/ft³. How many cubic feet of cake is produced in 8 hours?

ft³ cake	=	ft³ cake	100 lb-cake		
		68 lb-cake	26 lb TS _c		

Next, the units, lb TS_c, in the denominator need to be canceled. These units only appear in the list in one other place, the PSR, so it is entered in order to cancel the unwanted units.

Problem of the Day: A belt filter press dewatering anaerobically digested sludge as a PSR of 96%. The sludge, with a TS concentration of 4.2%, is fed to the press at 250 gpm. The cake has a TS concentration of 26% and a density of 68 lb/ft³. How many cubic feet of cake is produced in 8 hours?

ft³ cake	=	ft³ cake	100 lb-cake	96 lb-TS_c		
		68 lb-cake	26 lb-TS_c	100 lb TS _s		

This is kind of like taking one step forward then one step backward: we cancel one set of units, but now have to cancel another. There is only one other place in the list above where lb TS_s appear. These are entered so they cancel.

Problem of the Day: A belt filter press dewatering anaerobically digested sludge as a PSR of 96%. The sludge, with a TS concentration of 4.2%, is fed to the press at 250 gpm. The cake has a TS concentration of 26% and a density of 68 lb/ft³. How many cubic feet of cake is produced in 8 hours?

ft³ cake	=	ft³ cake	100 lb-cake	96 lb-TS_c	4.2 lb-TS_s		
		68 lb-cake	26 lb-TS_c	100 lb-TS_s	100 lb sldg		

Now there is only one other place in the list above where lb sldg appear, so these are entered so units cancel.

Problem of the Day: A belt filter press dewatering anaerobically digested sludge as a PSR of 96%. The sludge, with a TS concentration of 4.2%, is fed to the press at 250 gpm. The cake has a TS concentration of 26% and a density of 68 lb/ft³. How many cubic feet of cake is produced in 8 hours?

ft³ cake	=	ft³ cake	100 lb-cake	96 lb-TS_c	4.2 lb-TS_s	8.34 lb sldg		
		68 lb-cake	26 lb-TS_c	100 lb-TS_s	100 lb sldg	gal sldg		

Now there is only one other place in the list above where gal sldg appear, so these are entered so units cancel.

Problem of the Day: A belt filter press dewatering anaerobically digested sludge as a PSR of 96%. The sludge, with a TS concentration of 4.2%, is fed to the press at 250 gpm. The cake has a TS concentration of 26% and a density of 68 lb/ft³. How many cubic feet of cake is produced in 8 hours?

ft ³ cake	=	ft ³ cake	100 lb-cake	96 lb-TS _e	4.2 lb-TS _s	8.34 lb sldg	250 gal sldg	
		68 lb-cake	26 lb-TS _e	100 lb-TS _s	100 lb sldg	gal sldg	min	

If min were canceled with 1,440 min/d, then there would be no way to cancel d out. The min now in the railroad track are minutes of operation (obviously the sludge pump feeding the belt filter press is not pumping unless it is being operated). As presented above, the 8 hours of operation were converted to 480 min of operation, so this is the final entry in the railroad track.

Problem of the Day: A belt filter press dewatering anaerobically digested sludge as a PSR of 96%. The sludge, with a TS concentration of 4.2%, is fed to the press at 250 gpm. The cake has a TS concentration of 26% and a density of 68 lb/ft³. How many cubic feet of cake is produced in 8 hours?

ft ³ cake	=	ft ³ cake	100 lb-cake	96 lb-TS _e	4.2 lb-TS _s	8.34 lb sldg	250-gal sldg	480 min
		68 lb-cake	26 lb-TS _e	100 lb-TS _s	100 lb sldg	gal sldg	min	

Since all the units have canceled except the ones needed in the answer, **ft³ cake**, the math is done and the arithmetic gives the answer:

$$100 \times 96 \times 4.2 \times 8.34 \times 250 \times 480 \div 68 \div 26 \div 100 \div 100 = \underline{\underline{2,282 \text{ ft}^3 \text{ cake}}}$$

Happy calculating and good operating. If you see any mistakes or have any questions, leave us a comment!