



**WASTEWATER TECHNOLOGY  
T R A I N E R S**

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

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**Problem of the Day  
2015.Dec.18**

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The detention time in a primary clarifier is 1 hour 23 minutes. The flow through the primary clarifier is 3.7 MGD. What is the volume of the clarifier in gallons?

## Introduction

We have reviewed in many previous Problems of the Day the equation for calculating how long it takes to fill a tank, how long it takes to empty a tank, and detention time. All these calculations use the same equation. But I'm not going to repeat it here because I know the units will tell me how to do this problem.

With that said, there is one thing that has to be done before starting. Mixed units, like 1 hour 23 minutes, are cumbersome in the solution bridge, so we have to express 1 hour 23 minutes as one unit. Should it be hours or minutes? In order to convert this to hours, we have to divide 23 minutes by 60 minutes/hour and add the result to 1 hour to get 1.383 hr. This needs a calculator. Alternatively, knowing that there are 60 minutes per hour, I can add 23 to 60 to get 83 min. I can do this in my head, although, remember, doing things "in your head" during a certification exam is never a good idea because under the pressure of a test, we all make stupid mistakes.

Does it matter hr or min?

No, it doesn't. Detention time in primary clarifiers is always expressed in hr, but I can convert min to hr in the solution bridge. Doing so puts all the calculator work in one place: the solution bridge. Besides, it doesn't matter because we're going to have to convert to days anyway. Let's see.

## Solution

The question asks for the answer in gallons (gal). These units are entered between heavy vertical lines, as always, followed by an equals sign and the blank solution bridge.

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$$\left| \text{gal} \right| = \underline{\hspace{10em}}$$

The following list summarizes the information given in the problem statement expressed in the appropriate units:

1. Detention time = 1 hr 23 min = 83 min
2. Flow = 3.7 Mgal/d

We like to start the solution bridge out with the units we need in the numerator of the answer, in this case gal. But we don't have anything with these units so we start the solution bridge with a conversion factor converting what we have (Mgal) to what we need (gal) as shown in bold.

$$\left| \text{gal} \right| = \frac{\left| 10^6 \text{ gal} \right|}{\left| \text{Mgal} \right|} \underline{\hspace{10em}}$$

We now have the units we need in the answer in the solution bridge. To proceed, we cancel out unwanted units until we have only what we need remaining. We cancel Mgal by entering the flow next (No. 2 in the list).

$$\left| \text{gal} \right| = \frac{\left| 10^6 \text{ gal} \right| \left| 3.7 \text{ Mgal} \right|}{\left| \text{Mgal} \right| \left| \text{d} \right|} \underline{\hspace{10em}}$$

We need to cancel d but nothing in the list has these units. In the list, though, we have min, so we enter another conversion factor converting what we have (min) to what we need to cancel (d).

gal	=	10 <sup>6</sup> gal	3.7 Mgal	d	
		Mgal	d	1,440 min	

To cancel the units min in the denominator, the detention time (No. 1) is entered in the numerator.

gal	=	10 <sup>6</sup> gal	3.7 Mgal	d	83 min
		Mgal	d	1,440 min	

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

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gal	=	10 <sup>6</sup> gal	3.7 Mgal	d	83 min
		Mgal	d	1,440 min	

$$1,000,000 \times 3.7 \times 83 \div 1,440 = \underline{\underline{213,264 \text{ gal}}}$$

### Discussion

The equation for calculating how long it takes to fill a tank, how long it takes to empty a tank and detention time is:

$$\text{Time} = \frac{V}{Q}$$

But in today's problem we know Q and Time. If we solve this equation for the unknown, V, using algebra the equation is:

$$V = Q \times \text{Time}$$

That's exactly what we did: we multiplied Q (3.7 Mgal/day) times Time (83 min) because that's what the units told us to do. With a couple of conversions we had our answer. Works every time!

**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.**