



## WASTEWATER TECHNOLOGY TRAINERS

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

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### Problem of the Day 2014.Dec.18

#### Introduction

I have always heard that the Chinese character meaning “crisis” is two characters superimposed on each other. The first, taken by itself, means “danger.” The second, taken by itself, means “opportunity.” With the drought in California, we have certainly been in crisis mode. But what amazing opportunity! **It is a good time to be in the water business.** We really can live without oil. It's impossible to live without water.

But the water business is getting more and more sophisticated. So much of protecting the public's health rests on the shoulders of water and wastewater treatment plant operators. We also must do our jobs as cost effectively as possible to protect our ratepayers' hard earned money. Our jobs aren't just about “meeting permit.” Consider this, or something like it, as the professional operator's credo:

**The mission of wastewater treatment plant operators is to remove pollutants from the incoming water while complying with all permit requirements—water, land and air—and convert them to safe disposable biosolids as sustainably and cost effectively as possible.**

How do we prove to our ratepayers, regulators and ourselves that we're up for the task: **by attaining increasing levels of certification.**

Primary clarifiers remove more organics for less money than any other process unit at a wastewater treatment plant. The process objective of primary clarification is the removal of settleable total suspended solids (TSS<sub>set</sub>). The BOD (or COD) associated with those solids is removed when the solids are removed. This is important. The reason it is important is because secondary treatment, where the remaining BOD is “removed” (I will explain “removed” in a subsequent post), is expensive, so **the more BOD removed in the primary clarifiers, the better.**

Indeed, wastewater treatment **is** expensive (see operator's credo above: “... as cost effectively as possible.”). The organic carbon captured by primary clarifiers, measured in terms of BOD, COD, or VS, can be converted to methane in anaerobic digesters that can then be burned in engines driving electrical generators. Augmenting the organic carbon captured in primary clarifiers, some plants feed fats, oils and grease (FOG) to their digesters to increase methane production and electricity generation. East Bay Municipal Utilities District (EMBUD) has been so successful doing so, they produce more electricity than they use. **This is the future.**

### **Problem of the Day**

The Running Springs wastewater treatment plant receives an average dry weather flow of 2.5 MGD. The peak wet weather flow is 8 MGD. There are two primary clarifiers, each is 60 feet in diameter with an average depth of 16.5 feet. There is a single effluent weir around the periphery of each primary clarifier. The average influent TSS and BOD concentrations during dry weather flow are 325 and 350 mg/L, respectively. The influent TSS are 72% volatile. The average primary effluent TSS and BOD concentrations during dry weather flow are 105 and 205 mg/L, respectively. Each primary sludge pump pumps 30 gpm. Calculate the VSS removal efficiency.

## Discussion

Because primary clarifiers are such treatment plant workhorses, operators really need to “get their heads around them.” We’re going to use this same problem statement and do every primary clarifier type problem we can think of, maybe even make up a few! We’ll keep track of the types of problems in the following list so you can refer back to individual Problems of the Day if you have a question on a specific type of primary clarifier problem.

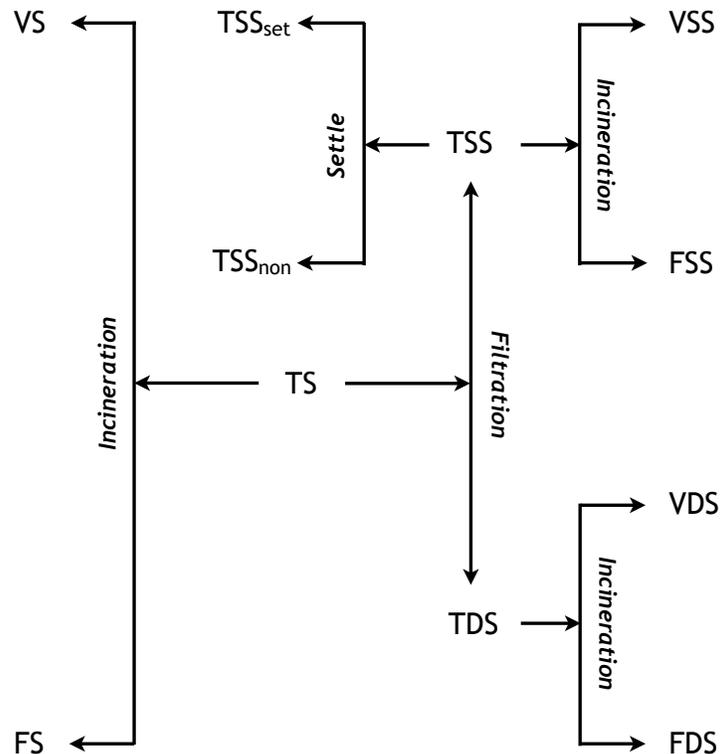
- ◆ 2014.Dec.16—TSS removal efficiency
- ◆ 2014.Dec.17—BOD removal efficiency
- ◆ 2014.Dec.18—VSS removal efficiency

In today’s problem we’re asked to calculate the VSS removal efficiency in the primary clarifiers but no VSS primary effluent concentration data are given. How can we do this problem?

**Three important points** have been made in previous Problems of the Day that operators need to fully understand:

1. We make the assumption, always, that the VSS removal efficiency in primary clarifiers equals the TSS removal efficiency (but **never** the BOD or TSS<sub>set</sub> removal efficiencies).
2. On account of this assumption, the percent volatile solids in the influent remains the same in the primary effluent and in the primary sludge.
3. VSS and particulate BOD both measure the same material but, because the two tests are conducted completely differently, they will not be numerically equal.

**The different solids of interest in wastewater treatment are a source of confusion for many operators.** WWTT uses the figure below to try to sort out this confusion.



*Solids of interest in wastewater treatment: Total Solids (TS), Volatile Solids (VS), Fixed Solids (FS), Total Suspended Solids (TSS), Volatile Suspended Solids (VSS), Fixed Suspended Solids (FSS), Settleable TSS (TSS<sub>set</sub>), Non-settleable TSS (TSS<sub>non</sub>), Total Dissolved Solids (TDS), Volatile Dissolved Solids (VDS), and Fixed Dissolved Solids (FDS); Incineration at 550°C, Filtration through 1.2-um filter, Settle for 30 minutes.*

## Solution

Calculating percent removal of various pollutants across different process units and across the entire plant is important. The equation, in railroad track format, is:

$$\text{Removal efficiency (\%)} = \frac{(C_{in} - C_{out})}{C_{in}} \times 100$$

$C_{in}$  = the concentration, mg/L, of BOD, TSS or other constituent, or mL/L of settleable solids in the influent to any process unit or treatment plant

$C_{out}$  = the concentration, mg/L, of BOD, TSS, or other constituent, or mL/L settleable solids in the effluent from any process unit or treatment plant.

As can be seen, removal efficiency is always expressed as a **percent**. It is important to note that **when calculating percent, all the units must cancel out**. Also, from the assumption discussed on the previous page, because TSS and VSS are removed in the same portions in primary clarifiers, we calculate the VSS removal efficiency using the primary influent and effluent TSS concentrations given in the problem.

**Problem of the Day:** The Running Springs wastewater treatment plant receives an average dry weather flow of 2.5 MGD. The peak wet weather flow is 8 MGD. There are two primary clarifiers, each is 60 feet in diameter with an average depth of 16.5 feet. There is a single effluent weir around the periphery of each primary clarifier. The average influent TSS and BOD concentrations during dry weather flow are 325 and 350 mg/L, respectively. The influent TSS are 72% volatile. The average primary effluent TSS and BOD concentrations during dry weather flow are 105 and 205 mg/L, respectively. Each primary sludge pump pumps 30 gpm. Calculate the VSS removal efficiency.

Information summary, specifically labeled (**bold** indicates used in today's problem):

- Average dry weather flow = 2.5 MGD
- Peak wet weather flow = 8 MGD
- Number of primary clarifiers = 2 PC
- Primary clarifier diameter = 60 ft
- Primary clarifier depth = 16.5 feet
- Primary influent dry weather TSS = **325 mg TSS/L**
- Primary influent dry weather BOD = 350 mg BOD/L
- Primary influent TSS = 72% VSS
- Primary effluent dry weather TSS = **105 mg TSS/L**
- Primary effluent dry weather BOD = 205 mg BOD/L
- Primary sludge pumps, each = 30 gal sldg/min
- Calculate: **VSS removal efficiency**.

$$\text{Removal efficiency (\%)} = \frac{(325 - 105) \text{ mg TSS/L}}{325 \text{ mg TSS/L}} \times 100$$

= **67.7%**.

**Math is not random. Use units, PRACTICE, and you will succeed.**

Again, because of the assumption made that TSS and VSS are removed in the same portions in primary clarifiers, the percent VSS of the influent solids (72% VSS) will be the same in the primary effluent solids (72% VSS) and the primary sludge solids (72% VSS/VS). It is **very** important to remember this when doing calculations around primary clarifiers.

**Happy calculating. Let us know, by leaving a comment, if you want us to do a specific problem or if you see a mistake.**