POLLUTION CONTROL SOLUTIONS FOR
AIR, WATER, SOLID & HAZARDOUS WASTE

PE Pollution Engineering

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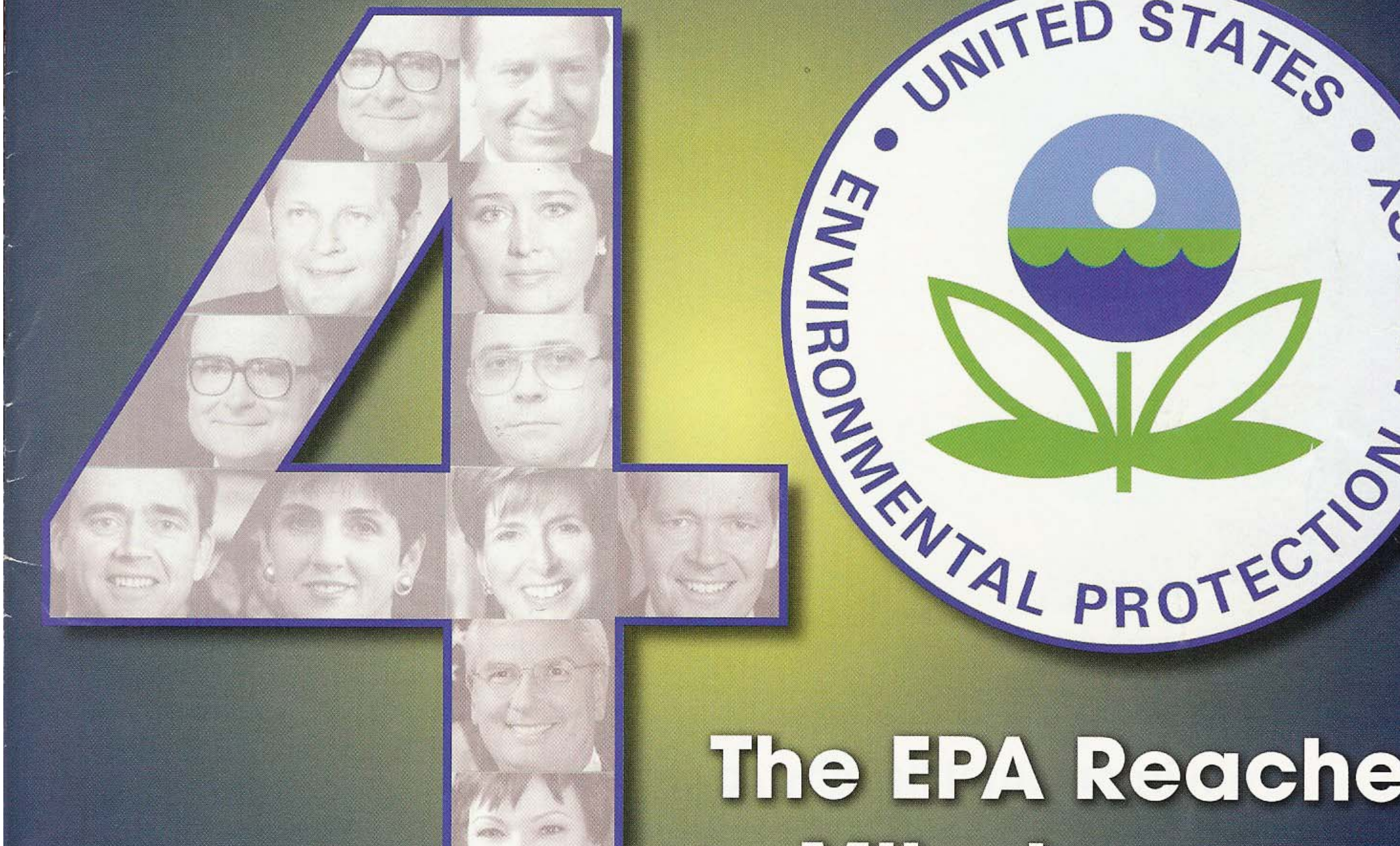

The EPA Reaches a Milestone

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DAF DESIGNS

Three critical dissolved air flotation design parameters for successful aeration of wastewater are described.

By **STUART WARD**, General Manager, Process Engineered Water Equipment LLC

Today's wastewater managers and technicians routinely encounter a variety of clarification situations. Such encounters may be an opportunity to improve performance of an existing dissolved air flotation (DAF) system or to help in selecting a new unit. Through application of a critical analysis, managers and technicians will find their water clarification results will be improved in the long term. By understanding these design parameters, potential limitations or design flaws can be avoided.

Hydraulic loading rate

A DAF unit's hydraulic loading rate is given as the flow in gallons per square foot of surface area. The hydraulic loading rate is sometimes also called the surface overflow rate or the overflow hydraulic rate. The loading rate is a mathematical function that is descriptive of two competing velocities within a DAF vessel. These are the horizontal velocity of the water and vertical velocity of any suspended solid within that water column. This is illustrated in **Figure 1**.

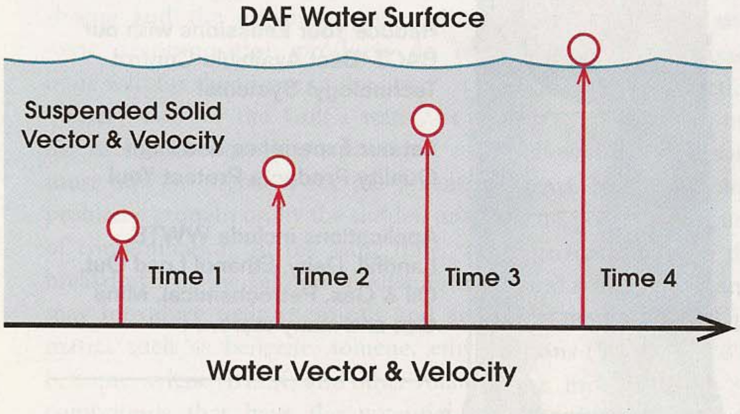


Figure 1: The loading rate is a function of horizontal water flow and vertical suspended solids velocity.

Managers and technicians may evaluate a traditional DAF system for hydraulic efficiency by following these steps. Multiply the length and width of the vessel to find the surface area. Next divide the DAF's designed flow rate by the surface area to arrive at that particular system's designed hydraulic loading rate.

The examples given here are for a DAF that has a designed feed rate of 125 gallons per minute with 1,500 ppm TSS and 20-percent recirculation. From this, we can measure and calculate several points of evaluation for the DAF design parameters as follows:

Example 1: *Hydraulic Loading Rate*

Given DAF	Width: 6 ft Length: 14 ft Depth: 6 ft
Surface Area:	6 ft x 14 ft = 84.0 ft^2
DAF Flow Rate:	125 gpm + (125 x 20 %) = 150 gpm
Hydraulic Loading Rate:	150 gpm ÷ 84 ft^2 = 1.79 gpm/ft^2
Rule of Thumb Comparison:	0.3 gpm/ft^2 to 3.0 gpm/ft^2
	................*we're good!*

Whether the discussion is about floating or settling solids, a given particle that is entering the DAF must have time to float to the surface or sink to the bottom before it is carried out of the vessel with the effluent. This floating or sinking is defined as the rise rate or settling rate, as the case may be. It follows then that a particle that has a rise rate equal to or greater than the DAF's designed rise rate will be removed before the water exits the vessel.

A good way of looking at this is to first lab test the particle rise rate by collecting a field sample of the water before the DAF and measure its specific solids rise rate in feet per minute. This can be accomplished using a 1- or 2-liter graduated cylinder and a controllable air sparger to simulate a DAF. Next divide the DAF flow by that particle's rise rate to find the required DAF surface area. Compare that number to the actual surface area of system being evaluated.

Example 2: *Required DAF Surface Area*

Given DAF	Width: 6 ft Length: 14 ft Depth: 6 ft
Sample Lab Test Rise Rate:	0.5 ft/min
DAF Flow Rate:	150 gpm ÷ 7.48 ft^3 = 20.05 ft3/min
Required Surface Area:	20.05 ft^3/min ÷ 0.5 ft/min = 40.1 ft^2
Rule of Thumb DAF Surface Area:	125 % of the required minimum
Required DAF versus Actual DAF:	40.1 f^2 versus 84.0 ft^2
	................*we're good!*

We can take this one step further. Empirically, the particle rise rate must be equal to or greater than the depth of the vessel divided by the water's retention time within that vessel. A direct comparison of the particle rise rate versus the DAF's designed rise rate is also a valuable evaluation tool.

Example 3: *Test Sample Rise Rate*

Given DAF	Width: 6 ft Length: 14 ft Depth: 6 ft
DAF Volume:	6 ft x 14 ft x 6 ft x 7.48 g/ft^3 = 3,770 gallons
Sample Lab Test Rise Rate:	0.5 ft/min
DAF Retention Time:	3,770 gallons ÷ 150 gpm = 25.1 min
DAF Rise Rate:	6 ft depth ÷ 25.1 min = 0.24 ft/min
Sample Rise Rate versus DAF:	0.5 ft/min versus 0.24 ft
	................we're good!

To put a finer point on the matter, any particle with a rise rate of 0.24 feet per minute or greater will float to the surface of the DAF and be scraped out by the chain and paddle system. The objective is not to exceed the hydraulic load rate of the DAF and hinder that process.

Solids loading rate

Similar to the hydraulic loading rate, the solids loading rate is calculated as the pounds of solids per square foot of DAF surface area per hour of operation. In basic terms, there is a limit to the volume of solids that can accumulate on the surface of a DAF before performance suffers.

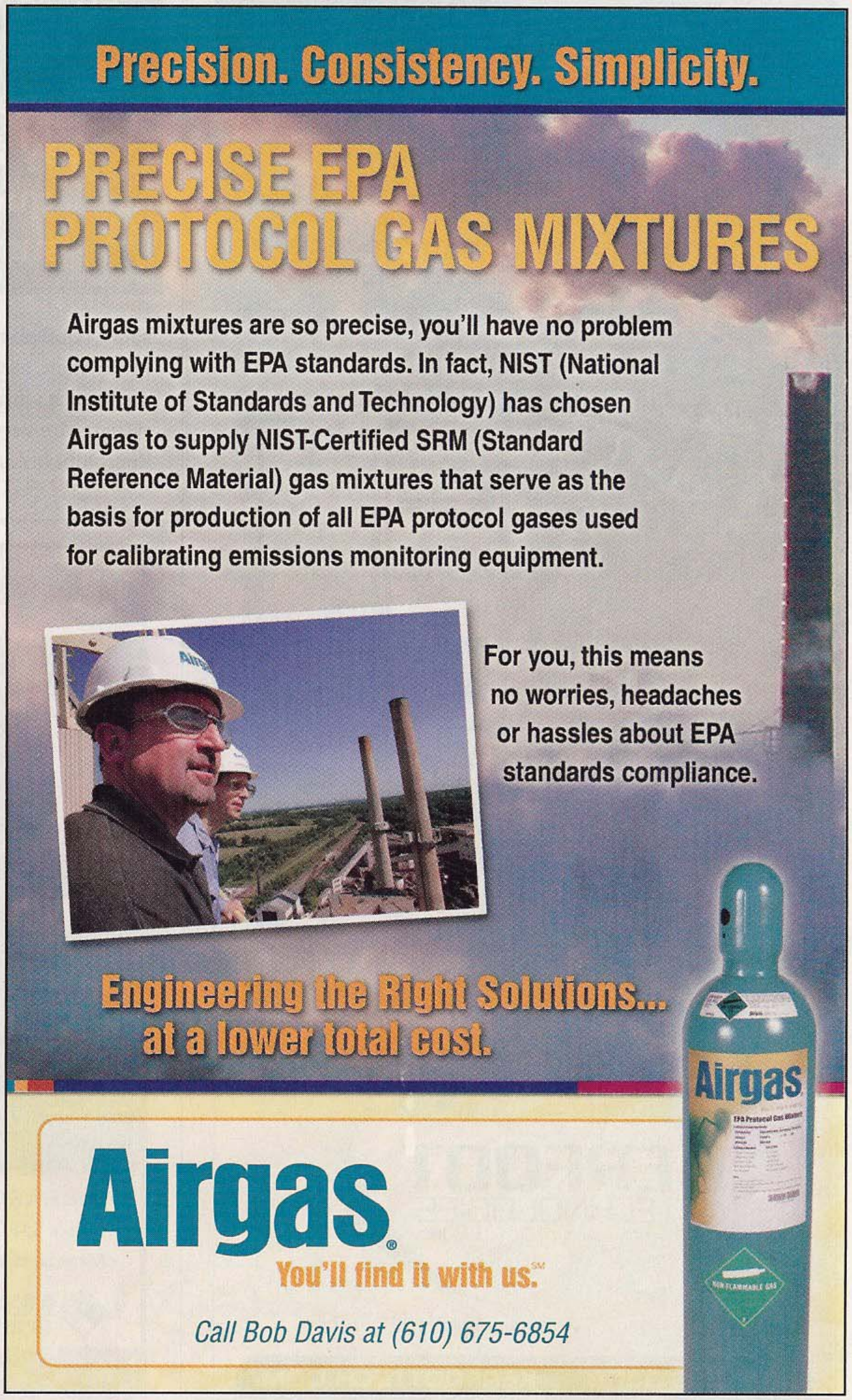
Example 4: *Solids Loading Rate*

Given DAF	Width: 6 ft Length: 14 ft Depth: 6 ft
Surface Area:	6 ft x 14 ft = 84.0 ft^2
DAF TSS Load:	(1,500 ppm x 125 gpm x 8.34) ÷ 1,000,000 ÷ 84 ft^2 = 0.019 lbs/ft^2/min
Surface Loading Rate:	0.019 lbs/ft^2/min x 60 = 1.14 lbs/ft^2/hr
Rule of Thumb Comparison:	1.0 lbs/ft^2/hr to 6.0 lbs/ft^2/hr
	................we're good!

An optimally operating system will accumulate solids evenly across the DAF surface. The solids will build from a fine layer to a gradually thickened, cracking oatmeal-like consistency. These solids will be scraped off at a point prior to their mass being such that particles break away from the bottom of the blanket and exit in the effluent stream. The surface rake cycle is used to dictate that timing. Again, the objective is not to exceed the surface-loading rate of the DAF and degrade the solids before removal by the chain and paddle system.

Air to solids ratio

The air to solids ratio is a calculation of how much air is being applied to a given volume of suspended solids within the DAF process. This value is expressed as pounds of air to pounds of solids. The amount of air required for efficient performance varies from DAF to DAF due to their individual design characteristics; and from waste-stream to waste-stream primarily due to the suspended



> The real DAF world being what it is, the experienced technician could bring an efficiency factor to bear by multiplying the numerator by 50- to 95-percent, depending upon the quality of the DAF aeration system. The key is to have an enough quality air for a given suspended solids load.

solids relative size/density and the viscosity of the water. Suffice it to say there are a number of methods for achieving air entrainment, each with their own merits and faults (inefficiencies). Some systems are very efficient at dissolving and generating the 20-30 micron bubbles for optimal DAF operation, while others are not.

However, the equipment to entrain air in water is for another discussion. Going forward, the air to solids ratio formula is:

$$\frac{A}{S} = \frac{1.3 \times Sa\ (P - 1) \times R}{SS \times Q}$$

Given:

Sa = solubility of air
P = pressure in atmosphere @ 20°C
SS = ppm suspended solids
R = recirculation rate gpm
Q = DAF feed rate gpm

For our example evaluation purposes we'll use data from the previously provided DAF example.

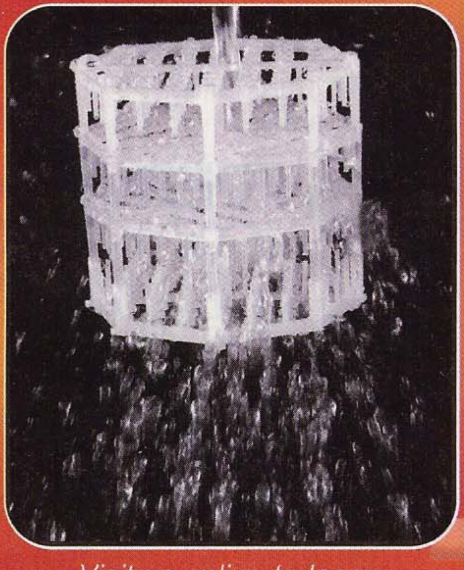
Example 5: *Air to Solids Ratio*

Given DAF Flow: 125 gpm Air Recirculation Rate: 20 %
DAF TSS Load: 1,500 ppm
Rule of Thumb Comparison: 0.005 lbs to 0.06 lbs

$$\frac{A}{S} = \frac{1.3 \times 15.7\ (18.7 - 1) \times 25}{1{,}500 \times 125} = \underline{\textbf{0.048 lb of air per pound of TSS}}$$

…….........…..*we're good!*





The above example yields results for a system with 100-percent air saturation and efficiency. But the real DAF world being what it is, the experienced technician could bring an efficiency factor to bear by multiplying the numerator by 50- to 95-percent, depending upon the quality of the DAF aeration system. The key is to have an enough quality air for a given suspended solids load.

Summary

The hydraulic loading rate, solids loading rate and air to solids ratios are all critical DAF design parameters. The numbers derived from these three areas of evaluation determine the optimal performance envelope for a given DAF system. In plain terms, this determines how much water can be fed to the DAF, the amount of solids that can be in the water and how much air is required to remove those solids before the DAF ceases to operate efficiently. Wastewater managers and technicians can gather this data from the existing DAF or equipment sales literature. He or she can then apply the above tools to their own situation and develop a substantive evaluation. ***PE***

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