

Flotation: DAF, IAF, SAF

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Flotation is a method of separating solids or liquids from water by introducing fine gas bubbles. The bubbles attach to the particulate matter, and the buoyant force of the combined particle and gas bubbles is great enough to cause the particle to rise to the surface. Particles or liquids less dense than water such as oil will naturally rise, but also particles more dense than water can be made to rise. Once the particles have been floated to the surface, a skimming process can collect them.

In wastewater treatment, the advantage of flotation over sedimentation includes:

- When the stream is variable and there is a tendency for some of the particles to rise or oil is present, a sedimentation process could be compromised as some of the waste naturally floats to the surface. Flotation will cause everything to go in the same direction, to the surface.
- Very small or light particles that otherwise would settle slowly can be removed more completely and in a shorter period of time.

Four primary ways of introducing the bubbles are:

1. Injection of the air while the liquid is under pressure, followed by the release of the pressure. This is called dissolved air flotation (DAF) because the air actually dissolves into the water at the increased pressure.
2. Aeration at atmospheric pressure, which is just called air flotation. Air is simply introduced in the gas phase directly to

the liquid through diffusers. This method is not particularly effective at floating the particles.

3. Induced air flotation (IAF) involves saturating the wastewater with air either directly in an aeration tank or by permitting air to enter on the suction side of a pump or with a venturi. The partial vacuum, which is applied, causes the dissolved air to come out of solution as minute bubbles.
4. Suspended air flotation (SAF) is a newer process where a bubble generator makes bubbles with the use of a surfactant. The bubble generator operates at a relatively low pressure of 15 – 25 psig and it is reported that the minute bubbles that are made are smaller than those made by DAF's, are more numerous, and rise as a mass faster.

DAF is considered by many to be more effective than IAF in creating cleaner effluents. The air is actually dissolved into a stream of water under pressure so when it is released it occurs as very minute bubbles, which can attach directly to the particles.

Typically a recycle flow of the DAF effluent is returned to a pressure tank where the air is added and the tank is pressurized to 50 – 75 psig. The recycled water is mixed with raw influent allowing intimate contact to occur with the released bubbles and the influent particles. The amount of recycle needed is 15 – 100% and depends upon the total suspended solids.

Many different companies and organizations have conducted laboratory and field evaluations on the size of the air bubble required for effective liquid-solid separation. The data generally demonstrates that the smaller the air bubble, the more efficient the separation. It has been the goal of IAF systems to try to duplicate

the microbubble formation of a DAF and to obtain the same level of effectiveness of a DAF. The bubbles formed by various techniques actually have a range of sizes and can be quite varied.

By comparison, one study showed that the effluent from an IAF system commonly contains twice as much TSS and FOG as the effluent from a DAF. Others report that if sized and operated correctly, both DAF and IAF can yield similar effluent qualities. The solids removal rate can be >95% with properly designed and operated DAF, IAF, or SAF systems.

DAF Systems

There are five important factors to be considered in a DAF process:

Air to Solids Ratio is the quantity of air required to float a given amount of solids and fats, oils and greases (FOG's). Under design conditions of 75 psig at 70°F, the average amount of air dissolved is about 9% by weight. The total suspended solids (TSS) must be analyzed and the appropriate percent recycle rate established. A waste stream of 1,000 mg/L TSS will require a recycle rate of 30-50%, and 2,000 mg/L TSS will likely require 100% recycle of the cleaned water back to the influent stream.

Hydraulic Loading (gpm/ft²) is total flow rate divided by the effective surface separation area. Design hydraulic loading varies from 1.5 to 5.0 gpm/ft².

Weir Overflow Flow Rate must allow for the mechanical separation of the floated solids from the clear water.

- **Solids Loading** considers the effective surface area of the DAF cell and the total amount of TSS and FOG entering the system. The average design load is 1.0 to 3.5 lbs/hr/ft². The calculation should include the influent TSS and all the chemicals added to condition and flocculate the waste stream.

Coagulants and flocculants are used to break emulsified oils and to destabilize colloidal material.

- **Solids Handling** is required to adequately remove the floated solids and any sediment that may occur

A common DAF design uses a portion of the treated water to deliver the dissolved air to the DAF by pumping into a pressure tank with compressed air at 50-75 psig. The liquid level in the pressure tank is controlled by level control that vents all undissolved air (large bubbles) to prevent their entering the DAF separation chamber. The pressurized water and compressed air are mixed and held long enough to create a saturated solution. The saturated recycle water passed through a pressure reduction valve as it enters the mixing area. When the pressure is relieved, the saturated solution becomes super-saturated and the air evolves as bubbles from solution.

Comparison of DAF to IAF

DAF is known for the micro air bubbles of 30-50 micron, which are formed as the pressurized water is released into the influent stream. The bubbles quickly stick to the impurities in the water and therefore cause a high degree of clarification. DAF is claimed by some as providing higher quality effluents because of smaller microbubbles and how they are formed and released onto influent solids.

IAF is generally regarded as a flotation process where the air bubbles are 70-150 micron in size. Some manufacturers state that they have mechanisms using impeller mechanisms pump veins or diffusers or other methods to make microbubbles as small or smaller than DAF systems. The "DAF" pumps are a hybrid design of IAF and DAF where air is aspirated into the seal chamber then mixed with the

pumpage and compressed into micro-bubbles. The micro-bubbles are then dissolved into the pumpage and moved through the discharge of the pump and out into the system. The air bubbles stick to the particles and then rise to the surface where they are scraped off by a scraper mechanism.

The amount of air released by DAF is limited by the solubility of the air under the design pressure conditions. To achieve comparable effluent quality, IAF can introduce more air by operating at a higher pressure of say 100 psig.

Advantages of IAF

- Fewer parts and therefore requires less overall maintenance.
- Self-aspirating and simple to operate.
- No compressor is required in IAF as the air is self-induced.
- Low residence time resulting in a smaller footprint.
- Slightly to moderately lower capital cost.
- Lower recycle rate necessary because of higher possible air injection rate, so smaller flotation cell and smaller over footprint. Recycle rate may be 60% of DAF required rate. The recycle rate for a DAF will be 30 to 50% when TSS is less than 1,500 ppm.

Disadvantages of IAF

- If diffusers are used for introduction of air, they can become plugged requiring maintenance or reduced effectiveness.
- Regarded by some as to yield poorer solids and oil removal than DAF.
- Weak link is the single pump, which can also see lots of wear and a relatively short life.

- The DAF and IAF may have similar capital cost with DAF being a little higher due to larger float cell and the air system.
- The relative rise rate for a given application may be:
 - Conventional DAF: 2 gpm/ft²
 - High Rate IAF: 4 gpm/ft²
 - SAF: 8 gpm/ft²
- The SAF operates without recycle, and its capital cost is reported to be about 60% of the DAF or IAF. To date, the SAF has been mostly used as a field retrofit to allow increased flow to existing DAF systems.
- DAF, IAF, and SAF have similar chemical operating costs. SAF's will be about \$0.03 per 1000 gallons higher because of the added use of the surfactant.
- Power cost will be highest for the IAF due to the high pump pressure, followed by IAF, and then SAF has the lowest power cost.

High Rate DAF or IAF

The efficiency may be increased by adding floc tubes between the chemical mixing tanks and the flotation cell and introducing the air and the flocculant into the floc tubes instead of into a floc tank in front of the system. This allows the microbubbles to form within the floc better. The number of bubbles colliding that create larger and ineffective bubbles is reduced.

The capital cost may be a little higher than conventional designs, but higher allowable rise rates and lower air requirements are reported.

Other Comparison:

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