

Dissolved Air Flotation Defined

Understanding DAF systems is imperative to sizing, choosing features, applying DAF to the application and is key to the successful outcome of the entire treatment system performance.



Introduction

Dissolved Air Flotation is the separation process whereby very fine gas bubbles attach to suspended materials to increase their buoyancy and force them to the water's surface.

DAF Principal

The primary underlying principal behind dissolved air flotation is based on Henry's Law, which states that the amount of dissolved gas in a liquid is directly proportional to pressure and inversely proportional to temperature. This establishes the physics of being able to dissolve more air at higher pressures. Increased temperature, however, will reduce the amount of gas dissolved.

Henry's Law

$$C_{eq} = K_H * P_{gas}$$

C_{eq} = Liquid-phase gas concentration
 K_H = Henry's constant
 P_{gas} = Partial pressure of the gas above the liquid

Operation

Dissolved Air flotation (DAF) operates by supersaturating (dissolving) a gas into a liquid under high pressure.

Releasing the pressure precipitates fine gas bubbles which attach to the materials, reducing their net specific gravity to less than that of water.

The driving force behind dissolved air flotation is the micron sized air bubbles. Typical bubble size range between 20 to 80 microns in diameter. The heart of a DAF system is the recycle saturation system.

Waste Types Treated

DAF systems can be used to treat most effluents especially those containing suspended solids, metal hydroxides, protein material (particulate or dissolved), fat and/or oil (FOG, animal & vegetable based) petroleum oils, crudes and refined, fuels., animal/vegetable matter.

Each system is designed to meet the specific requirements of the particular operation. The design of a specific system depends upon the factors such as the volume of wastewater to be treated the degree and nature of contamination, the extent of treatment required, and any subsequent treatment that is required for the recovered product concentrate.

DAF System Features

The following DAF features make up the DAF system design:

- Rectangular tank design
- Surface drag skimmer system
- Flat bottom or sludge hopper bottom
- Sludge auger
- Float chamber
- Adjustable effluent weir
- Effluent chamber
- Flotation chamber
- Recycle saturation system
- Controls

Design Parameters

When designing a DAF system the following parameters are taken into account:

- Hydraulic loading
- Solids loading
- Recycle rate
- Air/solids ratio
- Air release
- Saturator characteristics
- Inlet injection performance
- Flow path
- Cross-sectional velocity

Hydraulic Loading

This is a measure of GPM per ft² of DAF surface area. This number is the incoming flow rate and recycle flow rate added together. The totalized flow rate is then divided by the surface area resulting in a hydraulic loading.

Solids loading

This loading is expressed as lbs solids/ft²/hr. Typically 1.5 – 2.5 lbs/ft²/hr.

Recycle Rate

This flow rate is expressed as a percentage of the incoming flow rate and is variable based on the application characteristics.

Air to Solids Ratio

The A/S ratio is a quantification of the amount of air required to float the desired amount of solids, which would be expressed as quantity of air / quantity of solids to be removed.

Air Release

Effects due to losses attributed to liquid/gas physics, saturator efficiency and air retention, less than 100% of the air input is released as usable bubbles.

Saturator Characteristics

The recycle saturator performs the dissolving of air into the water. The design imparts a certain dissolving efficiency and flow rate. The design is important to the DAF performance.

Inlet Injection Method

The design of the injection point is important to the distribution of the flow path and bubbles.

Flow Path

The tank internal flow path is important to the overall performance as related to inefficiencies due to turbulent or disrupted flow effects.

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Cross-sectional Velocity

This number is determined by calculating the flow in CFM based on the tank vertical cross-section.

Factors Influencing DAF Efficiency

- Coagulation/flocculation prior to DAF
- Waste concentrations
- A/S Ratio
- Hydraulic loading
- Particle rise rate
- Recycle rate
- Proper maintenance

Tank Design

The DAF tank design consists of the features listed above and are discussed here.

Tank Type

Tank shape is rectangular providing a space efficient design.

Tank Bottom Type

The DAF systems are offered with either a flat bottom or a V-hopper bottom with sludge auger depending on application.

Surface Drag Skimmer

A chain & flight surface drag skimmer is provided at the tank top to continuously skim the water surface removing the floating materials and convey them into the Float chamber where they are temporarily held until pumped out.

The skimmer is driven by a variable speed gear motor with speed controls in the MCP.

The skimmer can provide continuous skimming or an adjustable timer system can be provided to stop skimming as needed to build up the float layer thereby dewatering the floating sludge prior to skimming.

Sludge Auger

If the V-hopper bottom is provided a sludge auger is provided to convey settled sludge to the sludge outlet.

Adjustable Effluent Weir

An adjustable water weir plate is provided in the effluent chamber to determine the operating water level in the flotation chamber.

Recycle Saturation System

The Recycle Saturation System provides the recycling and air dissolving function and consists of the following components:

- Recycle pump
- Saturation vessel
- Air preparation and control assembly
- Auto-Q controls

- Plumbing and control valves
- Level sensor sight glass and sensors

Controls

A Master Control Panel (MCP) is provided to control all the DAF components. The Nema 4 controls are mounted to the system and wired to each device.

Tank Construction

The standard DAF design is provided as a factory assembled, A36 coated carbon steel, 304/316 SS or polypropylene construction for above grade or concrete for below ground installations.



- Internal/external plumbing, wiring
- Chemical metering pumps
- Solution makeup/storage tanks
- Polymer on demand aging/makeup
- Controls



Chemical Pretreatment Systems

In many applications chemical pretreatment is required to condition the waste in order to improve and increase their removal.

Treatment systems can consist of reaction tank based systems or inline injection/mixing systems, also known as tube flocculators.

Each chemical pretreatment system is matched to the wastewater being treated.

Some typical types of systems that can be provided:

- pH neutralization or adjustment
- Coagulation
- Flocculation
- Emulsion breaking
- Metals precipitation
- Metals reduction
- Hydroxide precipitation/flocculation

The system construction can be polyethylene, coated carbon steel, stainless steel, FRP.

The treatment systems are generally fed by pump or gravity and then gravity flow through the system to maintain the integrity of the reactions.

System consist of the following components:

- Reaction tanks
- Agitators



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System Considerations

The DAF separator may not be a complete system in and of itself depending on the application. A full treatment system can also consist of peripheral components such as chemical pretreatment, sludge pumps, feed pump, walkways, alarms and other components as needed to complete the application.

Jar Testing & Pilot Testing

To fully determine system design, recycle rates, chemical processes required, dosages and metering pump settings it is recommended that jar testing be performed. Where possible pilot testing is recommended if the application requires it.

Common Waste Oils Found in Wastewater

Oils and fuels can exist in a variety of states depending on the forces exerted on them.

Free Oils: Oils in a natural state will typically be a “free and/or dispersed” product, meaning it will maintain its typical characteristics, (oily, hydrophobic) and will eventually form into a layer separate from the water phase. The free phase oil can also be “dispersed” or spread throughout the body of the water due to being broken into a range of droplet sizes.

Dispersed Oils: Are oil droplets that have been spread throughout the body of the water due to an oil droplet smaller than the free droplet.

Emulsions: oils can be changed to an “emulsified” state where the oil droplet size is drastically reduced and with it, it’s electrical strength. This is achieved by mechanical shearing forces where the reduced oil molecule becomes a temporary companion to water molecule or by a third, chemical component that controls the oil molecule and forces it into contact with the water molecule. The chemical being the bridge between the water and oil holds it in a stable, permanent or semi-permanent state.

Dissolved: The oils are dissolved into solution with the water due to their innate characteristics, nature and external influences.

Crude Oils

Crude oil is classified by its characteristics.

Class A: Light, Volatile Oils. these oils are highly fluid, often clear, spread rapidly on solid or water surfaces, have a strong odor, a high evaporation rate, and are usually flammable. They penetrate porous surfaces such as dirt and sand, and may be persistent in such a matrix. They do not tend to adhere to surfaces; flushing with water generally removes them. Class A oils may be highly toxic to humans, fish, and other biota. Most refined products and many of the highest quality light crudes can be included in this class.

Class B: Non-Sticky Oils. These oils have a waxy or oily feel. Class B oils are less toxic and adhere more firmly to surfaces than Class A oils, although they can be removed from surfaces by vigorous flushing. As temperatures rise, their tendency to penetrate porous substrates increases and they can be persistent. Evaporation of volatiles may lead to a Class C or D residue. Medium to heavy paraffin-based oils fall into this class.

Class C: Heavy, Sticky Oils. Class C oils are characteristically viscous, sticky or tarry, and brown or black. Flushing with water will not readily remove this material from surfaces, but the oil does not readily penetrate porous surfaces. The density of Class

C oils may be near that of water and they often sink. Weathering or evaporation of volatiles may produce solid or tarry Class D oil. Toxicity is low, but wildlife can be smothered or drowned when contaminated. This class includes residual fuel oils and medium to heavy crudes.

Class D: Non fluid Oils. Class D oils are relatively non-toxic, do not penetrate porous substrates, and are usually black or dark brown in color. When heated, Class D oils may melt and coat surfaces making cleanup very difficult. Residual oils, heavy crude oils, some high paraffin oils, and some weathered oils fall into this class.

These classifications are dynamic in that the characteristics can change depending on temperature or evaporation or other conditions. So, one class can become another and can also revert to its class depending on external influences.

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DAF Reference Photos

