

# API Oil water Separators

Selecting the right API oil water separator for the application is key to the successful outcome of the entire treatment system performance.



The Pan America API separator design is based on the American Petroleum Institute (API) Monographs on Refinery Environmental Control, Design and Operation of Oil-Water Separators.

The flow capacities of Pan America's design are based on an influent of fresh water and No. 2 fuel oil at 40°F operating temperature. The API guide has established optimum depth to width ratios with controlled velocities allowing oil droplets of 150 microns diameter or larger to separate from the water phase as predicted by Stokes Law. The rectangular shape of the API separator along with an efficient diffusion baffle and weirs creates a consistent laminar flow throughout the separation chamber cross section. This allows optimum use of the working volume.

## Operation

### Flow Diffusion

Pan America's API separator uses a special diffusion baffle to diffuse the flow prior to the separation chamber.

### Oil Skimming

Oil skimming utilizes the specific gravity differential between lighter oil and heavier water. The oil floats on the surface and in so doing displaces the water. Since oil has a lower specific gravity than water the level of the oil upstream of the oil baffle rises above the water level set by the water weir plate.

As the oil continues to accumulate the level rises until it spills into the oil skimmer reservoir and automatically exits the separator via gravity flow.

### Skimmer Types

Three types of skimmers can be provided, fixed weir oil skimming baffle integrated with an oil reservoir, adjustable rotating slotted pipe skimmer and the drum skimmer.

The drum skimmer design is a motor driven stainless steel drum spanning the tank width partially submerged in the water. As the drum rotates oil attaches to the drum and is removed via a blade riding on the drum face.

### Solids Removal

Solids are typically present in varying amounts in waste water. The API design is excellent for handling solids without upset. If the solids loading is light, a flat bottom design may be sufficient. However, when heavier solids loads are expected hopper bottoms should be used to allow easy solids removal and prevent solids accumulation from reducing the effective volume of the separation chamber.

As each application is different and solids occur in a wide range of sizes, different concentrations and densities ultimate solids settling performance is quite variable and each application must be reviewed for proper API design.

Refinery sludge can be highly viscous with high concentrations of solids and oils mixed together. These characteristics need to be considered during system design for sludge removal as well as cleanout during maintenance.

Inlet screens can be provided as required or desired.

Sludge scrapers, sludge screw augers hopper bottoms and inverted pyramid bottoms can be provided depending on the style of sludge removal required or desired for a particular application.

### Chain & Flight Skimmers

Three styles of flight skimmers are offered to remove solids and oils depending on the required design to fit the application.

*Type 1:* surface drag skimmer located at the tank top to move floating oils to the oil skimmer.

*Type 2:* sludge scraper located at tank bottom to move settled sludge from the effluent end toward a sludge collecting v-hopper at the influent end.

*Type 3:* types 1 & 2 are combined into a single system that skims the surface and scrapes the bottom to perform both oil movement and sludge movement.

Chain & flight construction can be provided as hardened carbon/stainless chain, sprockets & shafts or polymeric chain & sprockets. Each material has differing life expectancies, stretch modulus and liquid compatibilities. The flight construction of preference is a fiberglass channel design where strength vs. length and liquid compatibilities are usually excellent.

Wearing components such as flight shoes, guide strips and other components are typically UHMWPE or XLPE.

# Industrial Wastewater Engineering Solutions

## API Features

Some typical API features as dictated by the API 421 are:

- Depth-to-width ratio 0.3-0.5
- Length-to-width ratio of 5:1
- Horizontal velocity no greater than 3 feet per second
- Removal of oil droplets 150 micron & larger
- Influent diffuser or reaction jet design

## Covers

Multi-sectional covers are provided to contain vapors. Each section is attached to the tank and to neighboring covers via gasket and bolts.

Hatches can be provided for inspections without having to remove bolts and heavy cover sections.

Nitrogen blanketing and GAC vapor/vent scrubbers can be provided to remove VOCs from vapor space content.

## API Performance

While the API421 guide typically provides for an effluent discharge performance of 100 mg/L, 150 micron oil droplets it is possible with a properly designed API to provide performance in the 50 mg/L and larger range.

These performance figures are typically independent of the influent concentrations and are calculated as if in an ideal environment, which is not accurate to real-world experience. Actual performance is highly dependent on the type of waste entering the separator and the conditions within the separator.

## System Considerations

The API separator is not a complete system in and of itself. A full treatment system also consists of peripheral components such as sludge pumps, oil pumps, feed pumps, walkways, alarms and other components needed to complete the application.

## Tank Construction

The API design can be provided as a factory assembled, A36 coated carbon steel design for above or below grade or concrete for below ground installations.

## What is the Difference Between Separator Types?

### Separator Types

API421 outlines two types of separator: 1. API gravity differential separator and 2. API coalescing separator.

### Gravity Separation vs. Coalescing Plate Separators

Two basic types of oil water separator exist today in varying types of design, but all are derived from these two types of design.

The first and oldest type is gravity or conventional separation, simple separation via gravity (density differential between two immiscible liquids leads to one of them rising above the other). This design, when designed properly (or even improperly) provides a certain tank length, width and depth that provides a wide, quiet spot in the pipeline to give oils time to rise. This design (also known as an API separator) generally provides a discharge oil concentration of +/-100 PPM based on a 150-micron droplet size. The API type design relies on a large water volume shaped as dictated by the API-421 criteria to maximize separation.

The API design has its origin in the refineries of the world where the excess volumes are advantageous for reducing a wide variety of oil & solids types and characteristics.

The coalescing design is known by many names i.e. parallel plate interceptor, corrugated plate interceptor, slant rib coalescer so on and so forth. However, the concept, operation and design are generally the same. The coalescing concept is based on having a large surface area in contact with the wastestream (coalescing plates). The more surface area provided, the more enhanced the separation process will typically be. By using the coalescing media, the size of the tank is reduced and a higher performance is attained than by gravity separation. Pan America's Flopak coalescing design provides a

discharge oil concentration of 10 PPM or less with an oil droplet size of 20 or 30-micron oil droplet.

### Coalescing Oil Water Separators

are passive, physical, oil water separator systems designed for removal of oils, fuels, hydraulic fluids, LNAPL and DNAPL products from water. Pan America Environmental's designed performance can be described by a combination of Stoke's Law and current coalescing plate theory, wherein; the oil droplet rise rate and other parameters dictate the surface area required for gravity & coalescing separation.

**Gravity Separators** also referred to as API oil water separators are also passive, physical separation devices where the tank is basically an empty, baffled design that provides sufficient retention time to allow oils to separate. This type of oil water separator is very common and lower in performance than a coalescing design.

**Separation Process:** The water/oil mixture enters the separator and is spreadout horizontally, distributed through an energy and turbulence-diffusing device. The mixture enters the Flopak coalescing media where laminar and sinusoidal flow is established and the oils impinge on the media surface. As oils accumulate they coalesce into larger droplets, rising upward through the pack corrugations until they reach the top of the pack, where they detach and rise to the water's surface. At the same time solids encounter the media and slide down the corrugations, falling into the v-hopper under the Flopak media.

**Stoke's Law:** This equation relates the terminal settling or rise velocity of a smooth, rigid sphere in a viscous fluid of known density and viscosity to the diameter of the sphere when subjected to a known force field (gravity). The equation is:

# Industrial Wastewater Engineering Solutions

$$V = \frac{(2gr^2)(d_1 - d_2)}{9\mu}$$

where

V = velocity of rise (cm sec<sup>-1</sup>),  
g = acceleration of gravity (cm sec<sup>-2</sup>),  
r = "equivalent" radius of particle (cm),  
d<sub>1</sub> = density of particle (g cm<sup>-3</sup>),  
d<sub>2</sub> = density of medium (g cm<sup>-3</sup>), and  
μ = viscosity of medium (dyne sec cm<sup>-2</sup>).

**Coalescence:** Gravity separation utilizes the difference in specific gravity between the oil and water. Oil separates from a fluid at a rate explained by Stoke's Law. The formula predicts how fast an oil droplet will rise or settle through water based on the density and size of the oil droplet and the distance the object must travel.

Our separators are built to exploit the variables of Stokes Law. With the use of our Flopak media oil only need rise a short distance before encountering the oleophilic, coalescing media plates inside the separation chamber as opposed to rising a great distance in gravity separation before reaching the water's surface. Upon impinging on the plates the oils coalesce (gather) into larger droplets until the droplet buoyancy is sufficient to pull away from the media and rise to the water's surface. The design will meet particular design criteria as indicated below:

⇒The hydraulic distribution of the influent flow must assure full usage of the cross-sectional area of the media to fully utilize the plate pack's surface area.

⇒Flow control and direction must be determined to prevent hydraulic short circuiting around, under or over the media pack.

⇒A laminar flow condition must be maintained (Reynolds "Re" number less than 500) in order to assist droplets to rise. Per the American Petroleum Institute's (API) Publication 421 of February 1990.

⇒Horizontal flow through velocities in the separator must not exceed 3 feet per minute or 15 times the rate of rise of the droplets whichever is smaller.

⇒The media containment chamber design, plate design/angle and spacing sufficient to facilitate removal

of accumulating solids. Plates are to be angled at 60° from the horizontal.

## Flopak Coalescing Media Design

Pan America's Flopak coalescing media provides a laminar flow path that creates a quiescent zone to facilitate the impact with and attachment of oils to the media surface by reducing waste stream turbulence and velocity. This control of the waste stream creates a more ideal environment for oil removal.

By virtue of our Flopak media design, solids will also collide with the media and settle to the separator bottom to some degree, depending on the solids characteristics and loading. Due to oil typically being lighter than water, they (oils) will rise up the coalescing plate. As the oil droplets rise up the plate they will coalesce or come together with other droplets, creating progressively larger droplets. Once the droplet size is sufficient or the droplet reaches the top of the media plate the droplet pulls away from the plate and rises to the water surface. To some degree, the solids replicate this process in reverse (settling).

## Oil Descriptions

**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.



## Industrial Wastewater Engineering Solutions

**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.



Custom twin APIs

### Reference System Photos



Concrete API-CPI 9,400 GPM



API before paint



Elevated API combined with CRT chemical treatment system and DAF