Tech File Series

Oil & Fuels Removal

The Most Common Pollutant

Oils and fuels are the most common pollutants in industrial, groundwater, storm water, surface waters and many everyday water sources due to the escape of petroleum from common sources into the water. With tighter regulations on oils and fuels release, most sources are required to reduce their discharge of oils by using oil separation devices.

Pan America's treatment technologies offer a variety of oil water separation choices to fit most oil and fuel separation projects. The basic separation concepts that our oil water separators and separation systems are designed around are described in this Tech File.

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 out through out the body of the water due to being broken into a range of droplet sizes.

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 molecules 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 state.

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

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 oil grease interceptors or 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:

$V = (2gr^2)(d1-d2)/9\mu$
where
V = velocity of rise (cm sec^{-1}),
g = acceleration of gravity (cm sec^{-2}),
r = "equivalent" radius of particle (cm),
dl = density of particle (g cm^{-3}),
d2 = density of medium (g cm^{-3}), and
μ = viscosity of medium (dyne sec cm^{-2}).

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 size and the distance the object must travel.

Our separators are built to exploit both 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 which ever 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

Tech File Series

Oil & Fuels Removal

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).

Gravity Separation vs. Coalescing Plates

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 (or greater) PPM based on a 150 micron droplet size. The API type design relies on a large water volume. This correlates to a tank size that can be 5 times the size of an equally sized coalescing separator.

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.

Current oil water separator designs can not separate oil-in-water emulsions.

Oil-In-Water Emulsions

Emulsions Defined

Emulsions are defined as a colloidal suspension of a liquid within another liquid (with droplet sizes typically less than 20 micron). A colloidal suspension is a concentration of particles or droplets homogeneously dispersed through the carrier liquid (water). This means the oil droplets are reduced in size to such a degree that the oil's normal electrical repulsion of the water molecule is overcome due to it's minute size. Oil in water emulsions may contain a variety of oil types and concentrations, as well as various types of solids contaminants. The oil in water emulsion in a stable or unstable state maintains the emulsification through mechanical and/or chemical means.

Determining Chemical Process

Each emulsion must be tested in order to determine the chemistry, but also to determine system design. Analytical testing should be performed after the bench testing to verify process efficiency. We recommend the use of a chemical supply company that can perform on site jar testing and provide the proper chemicals for the daily operation.

Emulsions Are Created In Two Ways

Mechanical emulsion: In mechanical emulsions a common method of creating the emulsion is by violent mixing or shearing of the oil droplet in the wastestream with a high shear transfer pump, vigorous mixer or other device that might disperse the oil droplets into minute droplets. Given enough time, the mechanical emulsion may break without any treatment. But with most processes and manufacturing time frames this time may be too long for practical use.

Chemical emulsion: Are created when a surface-active chemical or chemicals are used, such as alkaline cleaners containing surfactants, soaps and detergents having ionic or nonionic characteristics. These chemicals interfere with the natural coalescing of oil droplets and generally create a permanently stabilized emulsion with little chance of breaking by itself.

Emulsion cracking can be facilitated by the use of a coagulant, flocculent and/or pH adjusting chemical (acid/caustic). The chemical used depends on the particular emulsion. These chemicals change droplet electrical charges by the effect of their own charge, usually a cationic (positive) charge. This charge manipulation allows the oil droplets to become free and lets them coalesce (gather together) into larger droplets. The oils don't always break out of emulsion into a free distinct layer. Sometimes they may be combined with solids or create a light mass that is in suspension, sinks or (usually) floats. The form and appearance of chemical emulsion cracking results can vary quite a bit from emulsion to emulsion. This variation helps to determine the type of equipment and processes required to treat the water.

Coagulation / Flocculation

The destruction of the emulsifying properties of the surface-active agent or neutralization of the charged droplet can be effected with the use of polymer products. A polymer or combination of polymers and/or coagulants destabilize the electrical bond between oil and water allowing oils to free themselves, creating droplets and a distinct free layer or flocculated masses. Flocculation refers to the successful collisions that occur when the destabilized particles (oil) are agglomerated via a bridging effect due to the flocculating polymer. The polymer acts like a broom, effectively stretching out in the water and bringing many small microfloc particles together into a larger mass. Depending on the nature of the flocculated mass it may sink, float or stay in suspension. Numerous bench tests should be performed to determine the proper chemical types, concentrations and combinations in order to achieve optimum treatment.

Current Separation Technologies Available

- **American Petroleum Institute (API) Oil Water Separator:** When designed per API's guidelines typically removes oil droplets 150 micron and larger, the typical effluent concentrations achieved are 100 PPM or greater.

- **Coalescing Oil Water Separator:** Designed to remove droplets down to 20 micron. They can attain effluent concentrations down to 10 PPM or less.

- **Separation Tank:** Batch treatment of a fixed water volume for a fixed period of time. The diameter of the smallest removed droplets is a function of the treatment time. Systems are theoretically capable of removing droplets below 20 microns with 16-hour retention times. This method is typically used by end users where high performance needs and long processing times are not an issue.

- **Concrete Separation Vault:** Modified, baffled or non-baffled septic tanks or standard utility vaults, which are very common, low-performance (or no performance), inexpensive separator design size usually dictated by some type of local/state plumbing code formula. They usually do not meet any type of engineered product design criteria or API separator guidelines. Due to typical non-professional review (or no credible review at all) of

Tech File Series

Oil & Fuels Removal

application or contaminants, performance can be widely variable and usually quite poor. Often used as an “insurance policy” against petroleum release. This design can usually be retrofitted with our Flopak coalescing media to greatly improve performance and/or possibly increase flow rate.

- **Coalescing Filter Systems:** Capable of removing droplets down to 5 microns. Easily blinded by solids or heavy or viscous oil loads in the wastewater. They are capable of producing effluent concentrations of 10 to 20 PPM. They may be able to remove unstable emulsion but not stable emulsions.

- **Dissolved Air Flotation:** These systems use air bubbles to float the oil to the surface. They are often used for primary (or coarse) treatment prior to higher performance separation depending on the waste stream characteristics. Flotation systems with chemical pre-treatment can remove oil-in-water emulsions. Unstable, mechanical emulsion may break in the flotation tank without chemical breaking treatment, but this can’t be counted on.

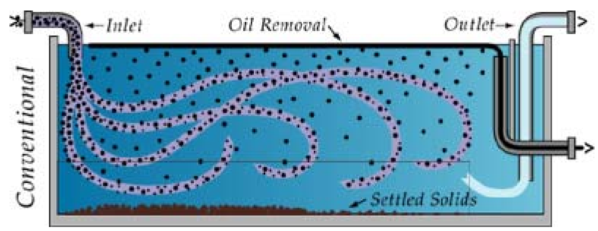
- **Centrifuges:** Enhances separation by placing wastewater under high centrifugal acceleration. Used mostly for offshore application (e.g. ships, oil platforms). They have high energy and maintenance requirements. Can produce effluent concentrations down to 70 PPM.

- **Chemical Separation (emulsion breaking):** Best solution for removing emulsified oil. With emulsification the oil droplet electrical potential is neutralized to some degree via mechanical or chemical means by reduction of droplet size, allowing the greatly size reduced oil droplet to temporarily (mechanical) or permanently (chemical) attach to the water molecule. Chemicals can be used to de-stabilize this bond, freeing the oil droplet.

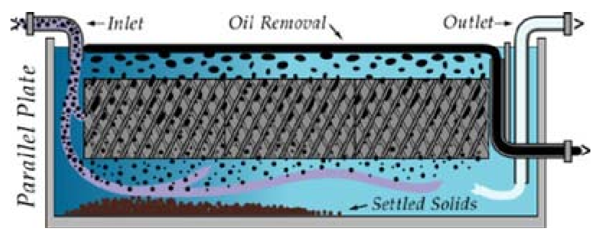
- **Membrane Filtration:** May be effective for removing emulsified products. Most economical at lower flow rates or batch quantities when compared to chemical treatment/flotation capital/consumable costs for like sized systems. Use is application specific where testing indicates it can be used.

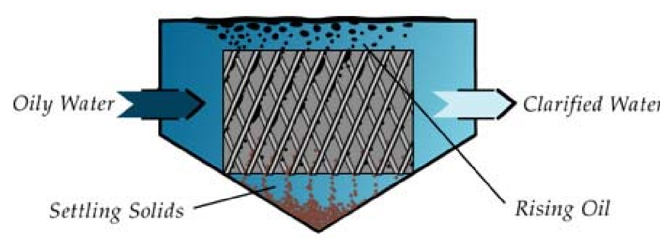
Separator Design Reference Drawings

API, Separation Vault, Oil Grease Interceptor type design



Coalescing Type design with flat & hopper bottoms





Pan America Environmental, Inc. 950 N. Rand Rd., Ste 120 Wauconda, IL 60084 USA 847.487.9166 panam@panamenv.com
www.panamenv.com