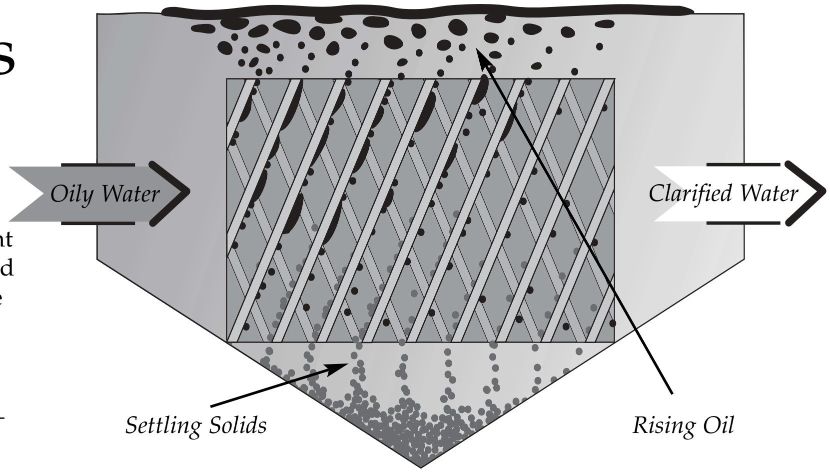
Oil/Water Separators

Plastic parallel plate packs are designed to enhance the separation of oil from water through added horizontal surface area and by creating less turbulent flow. This coalescing media improves the use of conventional steel basin oil/water separators by providing improved effluent or by allowing higher flow rates of wastewater. Brentwood AccuPac™ Crossflow Media is an extremely cost-effective way to upgrade existing separators and decrease the required volume of newly designed oil/water separators.



The Problem: Oily Wastewater

Industrial pollutants in rainwater runoff and storm sewer overflow have seriously degraded the environment. The EPA has issued the National Pollution Discharge Elimination System (NPDES) Regulations for Storm Water Discharge (40 CFR 122) for industrial facilities discharging storm water. Industries such as transportation facilities have oil drippings and spills which pollute rainwater runoff and equipment washdown wastewater. These industrial facilities must find a way separate the oil, grease, and other pollutants out of wastestreams to meet federal, state, and local requirements.

Gross free oil in wastewater left untreated can harm downstream treatment equipment. Lubricating oils and machinery coolants can be separated out of water, not only to protect other equipment but also to recover and reuse these fluids, thereby creating significant cost savings. Tramp oil in washwater or coolant reservoirs can be removed to extend the life of these fluids in a wide variety of applications such as metalworking mills and industrial parts washing.

The pollutants in wastestreams which represent the problem for oil/water separators include Free Oil, Oily-Coated Solids, Mechanical Dispersions, Emulsions, and Dissolved Oil.

- **Free Oil** will rise to the surface of the water, given time.
- **Oily Solids** will settle to the bottom of the water.
- **Mechanical Dispersions** are fine oil droplets spread throughout the water which do not easily separate out on their own.
- **Emulsions** are fine oil droplets which cannot be separated from water physically because of other chemicals in the water, such as soap.
- **Dissolved Oil** is no longer in droplet form so that physical removal is impossible.

Both emulsified and dissolved oils cannot be removed in physical oil/water separators.

The Solution: Oil/Water Separation

Free oil can be removed by gravity separation given proper quiescent flow conditions. Gravity oil/water separators exploit the differences in specific gravity between the fluids by providing adequate retention time for the less dense oil globules to rise to the surface of the water. The theory of this type of separation is based on the rise rate of oil droplets in the water and the surface-loading rate of the separator. The surface-loading rate is the ratio of the flow rate to the separator and the surface area of the separator.

$$\textbf{Surface Loading Rate} = \frac{\textbf{Flow Rate (gpm)}}{\textbf{Separator Surface Area (ft}^2\textbf{/ft}^3\textbf{)}}$$

If the oil globule rises towards the surface of the separator faster than the surface loading rate, the oil will reach the surface and can be skimmed off mechanically.

$$V_t > \textbf{Surface Loading Rate}$$

The required rise rate can be found using Stoke's Law:

$$V_t = (g/18\mu)(p_w - p_o)D^2$$

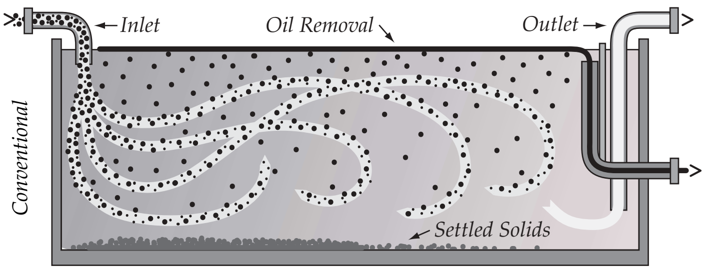
Where: V_t is the rise rate of the oil drop
g is the acceleration due to gravity
μ is the viscosity of the wastewater
p_w is the density of the wastewater
p_o is the density of the oil, and
D is the diameter of the oil droplet.

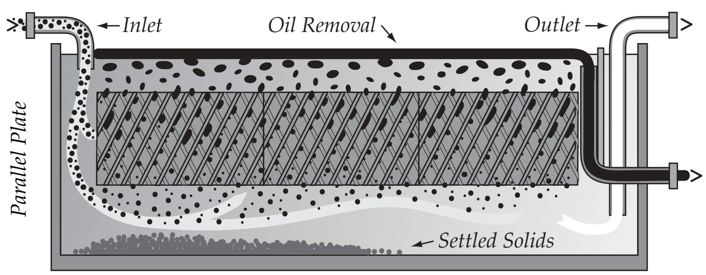
The design of oil-water separators should carefully consider these characteristics of the wastewater and the oil itself.

Additionally, the separator design should take into account the amount of settleable solids in the wastewater and other contaminants, such as surfactants, which might hinder the treatment of the system. Usually many of these characteristics must be assumed based on the type of facility generating the wastewater.

The Parallel Plate Advantage

Conventional Oil/Water Separators are simple rectangular channel tanks which provide nominal retention time to remove larger oil molecules. This type of equipment has only been found to remove free oil droplets with a diameter greater than or equal to 150 microns. These separators typically do not achieve effluent oil concentrations of less than 100 ppm because of the abundance of smaller oil droplets which are harder to remove. Ideal separators are those that have no turbulence, short circuiting, or eddies.





Parallel Plate Oil/Water Separators offer improved performance by increasing the horizontal surface area of the separator and creating less turbulent flow. Conventional channel units can often be retrofitted with parallel plates to either improve the wastewater effluent or allow for higher flow rates of wastewater. Separators with Parallel Plate Coalescing Media can allow flow rates up to three times that of conventional units. They can also remove free oil droplets with smaller diameters than conventional oil/water separators. Effluent from parallel plate separators is reported to have up to 60% less oil than conventional separators and the oil collected from these units contains less water.

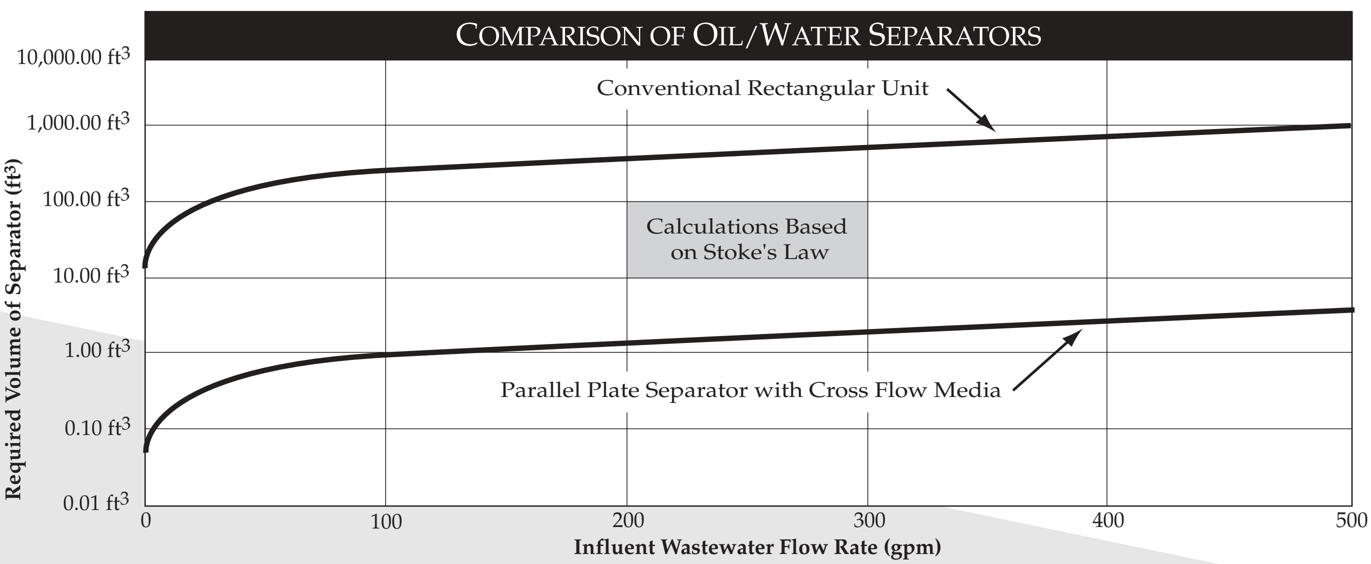
In conventional rectangular oil/water separators, more separation (higher flowrate or better effluent) is accomplished only by added volume of the tank. Adding volume in an open-channel rectangular tank is the only way to create the necessary surface area for improved treatment. Since these tanks are traditionally manufactured from welded steel, increased volume translates to increased steel at a tremendous material cost. Adding PVC parallel plate coalescing media is an inexpensive and easy way to increase treatment without adding volume to existing steel separators.

> *"Adding PVC parallel plates is an inexpensive way to achieve greater treatment capacity without increasing volume (and steel cost)."*

Coalescing Media Packs incorporate inclined channels which allow oil drops to collect on the underside of the plates and form larger globules which then rise toward the surface of the water. As demonstrated by Stoke's Law, larger diameter drops of oil will rise to surface of the water faster. Additionally, these corrugated plates encourage solids material to settle faster and slide to the bottom of the separator. Sludge hoppers and similar solids collection systems are often incorporated into the design of the separator basin.

Parallel Plate Pack Criteria

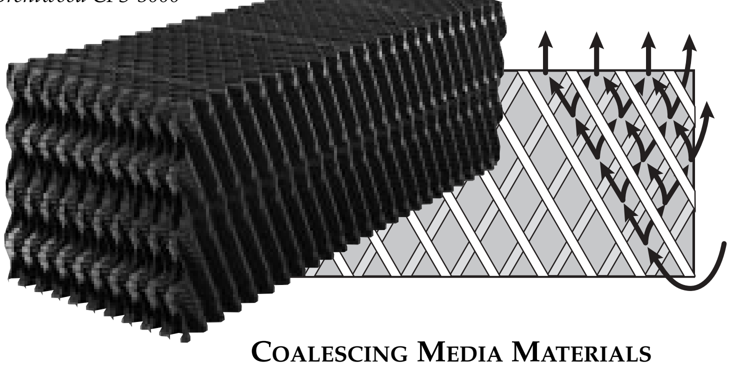
The direction of water flow is generally crossflow or downflow through the coalescing packs. According to API design recommendations (API Publication 421 Design and Operation of Oil/Water Separators), the typical range of spacing between the plates is .75 to 1.5 inches. However, spacings down to .25 inches have been used successfully. When using a more dense plate pack the concern arises for plugging of the oil and solids inside the media. To correct this problem the plate packs can be removed and cleaned with high pressure water.



While packs with higher amounts of surface area can theoretically remove oil more efficiently, they may require more frequent maintenance. The angle of the plates should be somewhere between 45 and 60 degrees. Plate packs with 60 degree angles should be used if significant solids accumulation in the separator is anticipated.

Crossflow corrugated media forces the water to keep changing directions, which helps the smaller oil droplets impinge on the plate surface. While quiescent flow is important to liquid/liquid separation, the slight turbulence in the media will help the oil coalesce.

Brentwood CFS-3000



Coalescing Media Materials

Coalescing media can be inexpensively made of polyvinyl chloride (PVC) corrugated sheets. PVC is an oleophilic (oil-loving) material which attracts the smaller oil droplets to its surface where they coalesce to form larger drops which slide up the to the surface of the media and break free, rising quickly to the oily surface of the water. PVC is chemically inert to most oils and contaminants, and can be used in wastewater at moderate temperatures. For higher temperature wastewater, specially formulated PVC can be used, as well as polypropylene. Polypropylene is also very oleophilic and can be used up to 185°, but it is significantly more expensive than PVC. For much higher wastewater temperatures, stainless steel plate packs are commercially available at costs at least an order of magnitude higher.

Maximum Operating Temperature of Brentwood Media Materials

Standard PVC	High Temp PVC	Polypropylene	Stainless Steel
Up to 140°F	Up to 150°F	Up to 185°F	Above 185°F

Parallel Plate Separator Design

The design of parallel plate separators can be done using a derivation of Stoke's Law, which relates the oil droplet's rise rate to the surface loading rate. For the design of parallel plate oil/water separators where details of the wastewater characteristics are not known, a oil globule diameter of 60 microns can be safely assumed. The following equation assumes an oil globule diameter of 60 microns:

$$Q_m/A_h = .00386\ [(S_w - S_o)/\mu]$$

Where: Q_m is the design flow in ft^3/min
A_h is the horizontal separator area in ft^2
S_w is the specific gravity of the water
S_o is the specific gravity of the oil, and
μ is the viscosity of the water in poise

The equation includes the specific gravity of both the oil and the water, which simply refers to the density of each material. The inclusion of this parameter in the equation highlights its importance, since the difference in the density of oil from water is what causes it to separate out. Any material, such as dirt and sand, which is more dense than water will sink, and any material less dense than water, such as oil, will float and rise through the water to be skimmed off the top. Another important component of the equation is the viscosity of the water, which is simply a measure of how readily it will flow. Water which contains a great deal of oil is more viscous and flows more slowly than pure water. Both the density and viscosity of the oil and water change depending on temperature.

The Design Examples below use the following Brentwood AccuPac® Cross Flow Media:

AccuPac Product	Plate Spacing	Surface Area
CFS-3000	1.20″	31 ft^2/ft^3
CF-1900	.75″	48 ft^2/ft^3
CF-1200	.50″	69 ft^2/ft^3
CF-650	.25″	119 ft^2/ft^3

To calculate the examples below, we use the equation above and the following constants:

minimum temperature = 70°F
μ (viscosity of water in poise) = 0.01
S_w (specific gravity of water) = 0.9975
S_o (specific gravity of oil) = 0.92
oil globule diameter = 60 microns

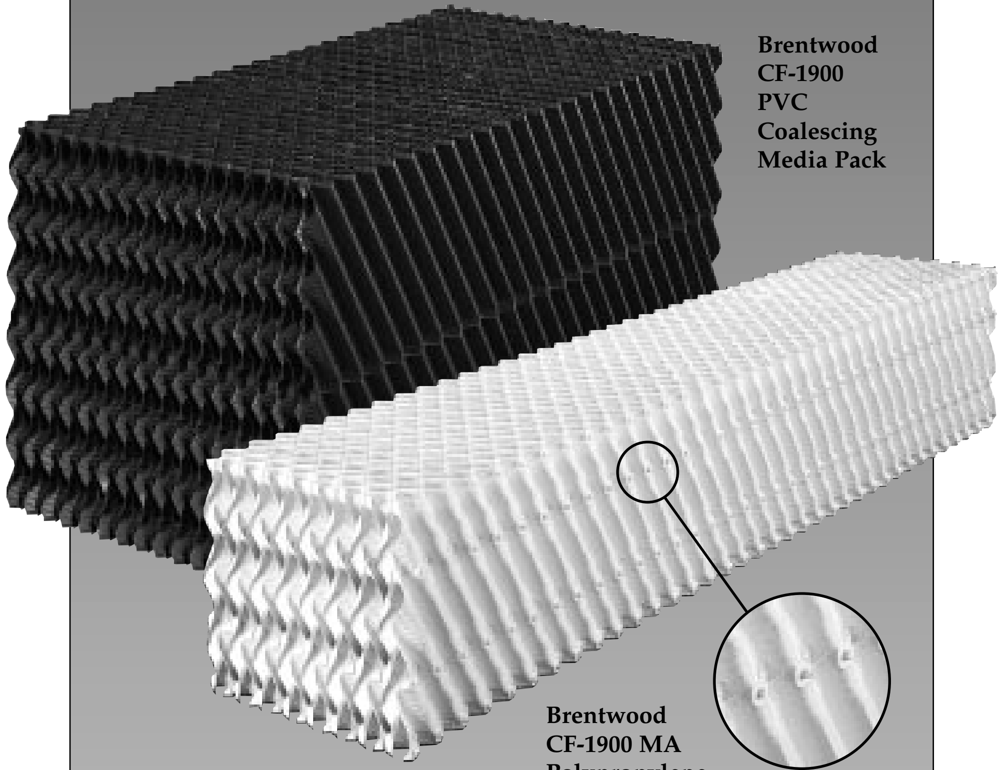
Example: To remove oil from a 25 gallon per minute wastewater flow, first convert 25 gpm to 3.34 ft^3/minute. Then, using the above equation and constants, find A_h = 111.7 ft^2. To use Brentwood CF-1900 Cross Flow Media (which has a specific surface area of 48 ft^2/ft^3, as listed in the table above), you will need A_h/48 or approximately 3 ft^3 of the CF-1900 media for this application. The table below provides more design examples:

Q_m (gpm)	Q_m (ft^3/min)	A_h (ft^2)	Volume of Media Required (ft^3)			
			CFS-3000	CF-1900	CF-1200	CF-650
5	0.67	22.3	0.74	0.47	0.32	0.19
25	3.34	111.7	3.72	2.33	1.62	0.94
50	6.69	223.5	7.45	4.66	3.24	1.88
100	13.37	446.9	14.90	9.31	6.48	3.76
500	66.85	2234.7	74.49	46.56	32.39	18.78
1000	133.70	4469.3	148.98	93.11	64.77	37.56
2000	267.40	8938.7	297.96	186.22	129.55	75.11

BRENTWOOD INDUSTRIES

OIL/WATER SEPARATION APPLICATIONS

- Grinding and milling machinery
- Rainwater runoff
- Equipment washdown
- Oil drilling
- Offshore platforms
- Stormwater sewer overflows
- Transportation facilities
- Manufacturing facilities
- Mineral industries
- Hazardous waste facilities
- Landfills
- Recycling facilities
- Electric power generation
- Construction sites
- Machinery coolant and tramp oil recovery
- Steel mills
- Tube mills
- Machine shops
- Remediation
- Automotive industry
- Parts suppliers
- Oil refineries
- Parking lot runoff
- Marine equipment
- Bilge water
- Ocean vessels
- Pressure washers
- Airports
- Bulk plants
- Chemical plants
- Glass factories
- Pulp and paper mills
- Railroad yards



Brentwood CF-1900 PVC Coalescing Media Pack

Brentwood CF-1900 MA Polypropylene Coalescing Media Pack

BRENTWOOD ACCUPAC® COALESCING PLATE PACKS

Brentwood Industries manufactures five different types of crossflow media which are applicable in oil/water separators. The media is available in a variety of sheet thicknesses for structural strength and can be cut from our standard modules sizes into the required size for any oil/water separator. The coalescing media is made from rigid, non-flammable PVC sheets, which are UV-protected and resistant to most chemicals and naturally-occuring constituents in the wastewater. The sheets are thermo-formed specifically for each spacing. The “CF-1900 MA” packs are mechanically assembled (without glues or adhesives) using Brentwood’s patented pressure-sealed attachment tabs, and all the other media types are solvent-bonded together at patented dedicated bonding points.

ACCUPAC PRODUCT	STANDARD HEIGHTS	STANDARD WIDTHS	STANDARD LENGTHS
CFS-3000	1 or 2 ft.	1 or 2 ft.	4, 6, 8, or 10 ft.
CF-1900	1 or 2 ft.	1 or 2 ft.	4, 6, 8, or 10 ft.
CF-1900 MA	1 or 2 ft.	1 or 2 ft.	4, 6, 8, or 10 ft.
CF-1200	1 ft.	1 ft.	4, 6, 8, or 10 ft.
CF-650	1 ft.	1 ft.	4, 6, or 8 ft.

NOTE: Brentwood can cut standard packs to any height, width, or length.

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