# HYDROCARBON SEPARATOR FSH

Besides floating, oil can be present in waste water in the form of large and unstable globules, fine stable globules, stuck to solids, or as a small quantity of dissolved oil.

The design of a separator is based on the complete elimination of oil globules with a certain separation rate. The choice of separation rate adopted for the design, depends on the amount of finely dispersed oil present.

On the other hand, the solubility of hydrocarbons in water is very small, even insignificant. The solubility is with respect to the number of carbon atoms in the molecule. It is also related to the configuration of the molecule and increases along with the temperature. The solubility increases considerably the lower the molecular weight is, and aromatic hydrocarbons are more soluble than the paraffin ones with the same carbon number.

In contrast to the reduced solubility mentioned above, a considerable increase in solubility can occur if the aqueous stage contains a sufficiently high concentration of superficially active materials capable of electrolytic-splitting, as is the case with, for example, Detergents. This property is called solubilization and is related to the formation of micro-organisms of superficially active materials.

The micelle has a colloidal internal structure, highly dissoluable, and the increase in solubility can be considered as the passing of the hydrocarbon molecules within and around the ordered structure of the micelle.

Solubility is thus a property of the colloidal electrolytes. It is a special solubility case that can be defined as the passing of an insoluble substance to a detergent solution.

The complete installation is made up of:

1. Predecantation.
2. Oil flotation and separation.
3. Oil storage.

## DESCRIPTION OF THE PROCESS

### 1. PREDECANTATION

The treatment begins with a decanter in which the solid particles contained in the waste water, such as sand, earth, metallic filings, etc., are separated.

Its purpose is to protect the separators from getting dirty and to avoid the continual discharge of solids into them. Its installation is always to be recommended when the presence of important quantities of solids is to be expected (rainwater from car parks, areas with frequent passage and/or cleaning of lorries...). With the certainty that great quantities of solids will not appear, this piece of equipment can be dispensed with as the separator itself has a filtering system for decanted solids.

### 2. FLOTATION AND SEPARATION OF LIGHT WASTE MATERIALS

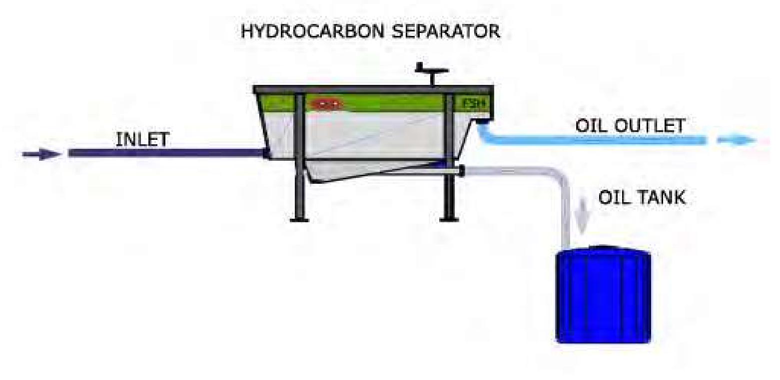
‘From the decanter we pass to the hydrocarbon separator. This separates the two phases: water and oil (light phase that will contain oils, grease, immiscible dissolvent...).

This piece of equipment is the nucleus of the installation. It channels the water towards a laminar flow, causing the effluent to pass through the package of laminated coalescing sheets. The light phase is separated and sent to the storage tank. The levels have been carefully studied so that the separation is effective and only oil, along with the impurities it carries, is separated and never the water itself.

### 3. OIL STORAGE

The separated oil travels by means of gravity to an independent tank where it is stored. This allows it to be emptied without interfering with the working of the separator. The waste can be sucked out from the exterior by the same vehicles that normally collect used oil and handled by the same firms.

The filling time of these tanks will depend greatly on the characteristics of the activity. Normally, however, their size is designed to cover froeseeable periods of three to six months.



## PRINCIPLES OF SEPARATION

The oil can take different forms, for each of which there are different means to treat it:

1. Free, neither dissolved nor emulsified.
2. Emulsified.
3. Dissolved.

**1. FREE, NEITHER DISSOLVED NOR EMULSIFIED.**

This form can be separated by simply using flotation chambers in which the effluent to be treated is kept there for sufficient time. These chambers don't produce good results, even using long retention times. Normally, the oil concentration in the effluent will be between 100 - 150 ppm.

**2. EMULSIFIED.**

Here, the oil is free but in a dispersed or emulsified form. The emulsion may have one of two causes: mechanical or chemical. The mechanical emulsion is mainly generated through a process of shaking caused by a pumping action, transport, etc. The size of the particles generated reaches 60 µm or even less. Separation is not possible simply in a separation chamber. The separation can only take place in later treatment processes. The chemical emulsions are produced by the presence of tensoactive products (detergents, emulsifiers). If the emulsion is not very stable, it can be separated by means of a conventional hydrocarbon separator, while very stable emulsions can only be treated with chemical systems capable of breaking it down, or by tangential separation by means of membranes.

**3. DISSOLVED.**

The solution of oil (solute) in a liquid (solvent), can only be separated by using such processes as, for example, extraction by other solvents in which the oil is more soluble and, at the same time, has a phase where it can be separated from water.

## PRINCIPLES OF SEPARATION

SPEED OF ASCENT

Separation can occur whenever the speed of ascent of the drop of oil or grease to be separated through the aqueous medium is sufficient to allow contact with the oil phase layer and when the adequate conditions of laminar flow are present.

The factors governing the speed of ascent of the particle or drop of oil are given by Stokes Law on stable, laminar flow:

$$\boxed{V_s = (\varphi_w - \varphi_o)\, D^2\, g / 18\mu}$$

Where:

**$V_s$**: speed of ascent of the drop of oil, m/s.

**g**: acceleration due to gravity ( 9.81 $m/s^2$ ).

**μ**: viscosity of the water ( at 20ºC 0.001 Kg / m·s ).

**$\varphi_w$**: specific density of water, $Kg/m^3$.

**$\varphi_o$**: specific density of the oil, $Kg/m^3$.

**D**: diameter of the drop of oil, m.

SPEED OF ASCENT FOR DROPS FROM 20 TO 300 μM IN NORMAL CONDITIONS

| Gravity<br>g | Viscosity of water at 20°C<br>μ | Density of the water<br>$\varphi_w$ | Density of the oil<br>$\varphi_o$ | Diameter drop of oil.<br>Ø | Speed of ascent<br>$V_s$ |
|---|---|---|---|---|---|
| $m/s^2$ | kg/m·s (poises) | $kg/m^3$ | $kg/m^3$ | μm | m/h |
| 9.8 | 0.001 | 1 | 850 | 20 | 0.1176 |
| 9.8 | 0.001 | 1 | 850 | 40 | 0.4704 |
| 9.8 | 0.001 | 1 | 850 | 60 | 10.584 |
| 9.8 | 0.001 | 1 | 850 | 80 | 18.816 |
| 9.8 | 0.001 | 1 | 850 | 100 | 29.400 |
| 9.8 | 0.001 | 1 | 850 | 200 | 11.760 |
| 9.8 | 0.001 | 1 | 850 | 300 | 26.460 |

The smallest drops will tend to be dragged away by the flow and cannot be separated as their ascending component is cancelled out.

## EFFECTIVE SEPARATION AREA

What we call the Effective horizontal separation Area is the quotient between the separator's capacity and the fluid's overflow speed. A correctly designed separator will eliminate all particles from the incoming fluid with a speed of elevation (or sedimentation) equal to or greater than the rate of overflow through the separator.

The effective separation area of a ripple plated separator is given by the length, width and number of plates, as well as the angle of inclination of the plates in the separator and its performance (90%). The surface needed for the separation is the result of dividing the capacity of waste water to be treated by the speed of ascent.

## COALESCING

As can be deduced from Stokes Law, the efficiency of the separation can only be increased (increase Vs) by increasing the diameter of the drop (D). The other parameters are either constant or are determined by the characteristics inherent to the waste water. An increase in D would also be of great importance as this term would be squared.

When considering an increase in the size of the drops, it is evident that larger drops can only be formed by joining together smaller ones. To achieve this, sufficient turbulence must be created to provoke the greatest possible number of collisions between the small drops so that they join together to form larger drops.

The separator of TORO EQUIPMENT is equipped with a system of laminated sheets that cause flows which bring about more collisions between the particles, thus uniting them rapidly so as to be able to separate even particles of 20µm. It is this technology that guarantees concentrations of free oil of less than 5-10 ppm at the outlet of our equipment.

The flow of water through the laminated sheets is of the CROSSFLOW type. In this kind of flow the water travels through the laminated sheets in a direction perpendicular to the ascending flow of the floated particles and descending flow of the heavy solids.

CROSSFLOW increases the effectiveness of the separation (as compared with the conventional counter current flow) since, in the package of laminated sheets, the flow is completely laminar, except on the crest of the corrugations, where controlled microturbulence is generated. This turbulence causes the air/solid particles to collide forming compact particles with a diameter of between 250 and 300µm, which, in the form of bunches, make up a kind of stable floccule of air and solids. This is the ideal size.

The flotation speed of the air particles generated, 40 to 60 µm, with a gravitational differential between the water and the particles of 0.2 g/cm$^2$ being 1 m/h. This implies that the flotation must be carried out with a superficial load smaller than 1.75 m$^3$/m$^2$/h.

The system has a superficial load equivalent to half of its developed useful surface, that is: with the same effectiveness, double the capacity can be treated.

## HYDROCARBON SEPARATORS. SELECTION

The basic criteria when selecting a Hydrocarbon Separator, type TORO EQUIPMENT, are two:

- Capacity
- Composition of the waste water

The main parameter to be taken into account is the flow of waste water. This can be evaluated using various methods. Basically, what must be taken into account is: the consumption of the water supply, pluvial waste or waste from machines or significant sources of waste water, waste water from refrigeration systems, etc.

AN EXAMPLE OF THE SELECTION CALCULATION:

| | | |
|---|---|---|
| Garaje: | The mean monthly flow consuption is of 95 $m^3$. For 20 days/month and 8h/day applying a rush-hour coeficient of 6 | 3,6 $m^3$/h |
| Carwash: | Its consuption is independent | 2 $m^3$/h |
| Pluvial: | 9 l/$m^2$xh per 1,000 $m^2$ | 9 $m^3$/h |
| **TOTAL:** | | **14,6 $m^3$/h** |

Repair garage for motor vehicles with 600 $m^2$ of warehouses and 400 $m^2$ of external land. It has paint tunnels and dust vacuuming area with curtains of water. There is also an automatic carwash. The drainpipes from the roof are connected to other drainage systems.

Considering that the oil and particles to be separated are of a standard density (95% > 100 µm) and the limit is of 25 ppm, the separator to be installed will have a total surface of:

Surface: 14.6 ($m^3$/h) / 2.94 ( m/h) = 4.96 $m^2$

The separator FSH 5 for a nominal capacity of up to 30 $m^3$/h would be sufficient for a surface equivalent to 9.96m.

Considering that the oil and particles to be separated are of a standard density (95% > 60 µm) and the limit is of 25 ppm, the separator to be installed must have a total surface of:

Surface: 15.6 ($m^3$/h) / 1.0584 (m/h) = 14.7 $m^2$

The separator FSH 10 for a nominal flow of up to 65 $m^3$/h would be sufficient for a surface equivalent to 2.5$m^2$

That approximately 60% of the total capacity will correspond to rainfall must be taken into account. It can then be established that 95% of particles will have a density greater than 100 µm, in which case the best choice would be an FSH 5.

The composition of the waste water is thus fundamental for choosing the equipment, yet this information is rarely available. The composition of the oil can be divided into three case types in order to have some kind of orientation:

| Size of oil drop ( µm ) | % in weight | | |
|---|---|---|---|
| | A | B | C |
| > 100 | 95 | 80 | 40 |
| 60 - 100 | 2.5 | 10 | 30 |
| 20 - 60 | 1.5 | 6 | 20 |
| < 20 | 1 | 4 | 10 |
| Concentration of oil ( mg/l ) | 50 to 200 | 200 to 500 | 300 to 2,000 |

A: Rainwater from car parks and tracks.
B: Water from the cleaning of workshops.
C: Water from carwashes using detergents

## DESCRIPTION OF THE EQUIPMENT

The Hydrocarbon Separator Float is an open rectangular tank made of PRFV and divided into three main chambers:

- Overflow chamber
- Oil separation and flotation chamber
- Collection chamber

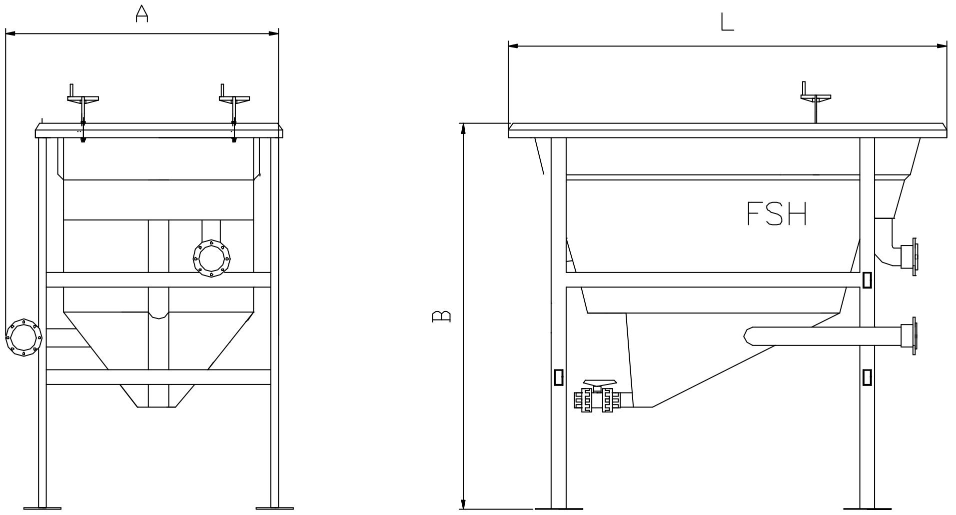
The inlet leads to a laminar flow by way of a special spillway which makes the effluent pass through the coalescing laminated sheet package.

The coalescing laminated sheet package is situated in the separation and flotation chamber, along with the oil evacuation and collection canal controlled and regulated by two wheels, to adjust the level in the float and the collection of the layer of oil in the previous chamber. The separation of the two phases: water and oil, takes place in this chamber.

The treated water falls through a spillway into a collection chamber, from where it is evacuated through a tube.

There is an escape valve in the lower part of the float to eliminate the small decanted solids and to empty the tank.

## TECHNICAL SPECIFICATIONS




| Model | FSH-2 | FSH-5 | FSH-10 | FSH-15 | FSH-20 | FSH-40 | FSH-80 |
|---|---|---|---|---|---|---|---|
| **Medium capacity ($m^3$/h)** | 5-7 | 15-30 | 45-65 | 70-80 | 80-1400 | 160-200 | 280-450 |
| **Dimensions** | | | | | | | |
| Maximum width A (mm.) | 795 | 1.500 | 1.450 | 1.500 | 1.500 | 2.546 | 2.736 |
| Useful width (mm.) | 530 | 1.010 | 1.010 | 1.010 | 1.010 | 1.700 | 2.130 |
| Maximum height B (mm.) | 1.300 | 2.075 | 2.290 | 2.295 | 2.280 | 2.500 | 2.500 |
| Height (mm) | 1 | 2,035 | 2,03 | 2,035 | 2,03 | 2,03 | 2,03 |
| Length L (mm.) | 2.120 | 2.330 | 3.360 | 4.670 | 5.900 | 7.200 | 9.200 |
| Useful surface (mm.) | 0,95 | 1,66 | 2,83 | 3,84 | 5,25 | 11,22 | 17,78 |
| Equivalent surface ($m^2$) | 2,38 | 9,96 | 22,53 | 31,19 | 36,39 | 75,39 | 152,52 |
| Space for installation | 3 x 1.5 | 3.2x2.5 | 4.5x2.5 | 6x2.5 | 7x2.5 | 8.5x4 | 10.5x4 |
| **Material** | P.R.F.V. | P.R.F.V. | P.R.F.V. | P.R.F.V. | P.R.F.V. | P.R.F.V. | P.R.F.V. |
| **Structure** | Galv steel | Galv stee | lGalv steel | Galv stee | lGalv stee | lGalv steel | Galv steel |
| **Tubing** | | | | | | | |
| Water inlet (mm.) | 63 | 75 | 110 | 110 | 160 | 200 | 315 |
| Water outlet (mm.) | 63 | 110 | 110 | 125 | 160 | 250 | 2x200 |
| Oils outlet (mm.) | 50 | 110 | 110 | 110 | 110 | 125 | 140 |
| Bottom drainage (mm.) | 63 | 75 | 75 | 75 | 75 | 90 | 90 |
| **Package of laminar sheets** | | | | | | | |
| Distance between plates, (mm.) | 26 | 26 | 26 | 26 | 26 | 26 | 26 |
| Plate surface ($m^2$) | 0,275 | 0,55 | 1,1 | 1,65 | 2,2 | 3,3 | 4,4 |
| Material | P.R.F.V. | P.R.F.V. | P.R.F.V. | P.R.F.V. | P.R.F.V. | P.R.F.V. | P.R.F.V. |
| **Alarm units** | Optional | Optional | Optional | Optional | Optional | Optional | Optional |

NOTE: The average work capacity has been calculated as the maximum for a separation of 100% of drops greater than 100 μm of oil with a density of less than 850 kg/$m^3$ in water at 20º C (Vs: 2.94 m/h). To obtain outputs of less than 10 ppm of free oil of these characteristics.

## CONSIDERATIONS

The norms governing how much oil can be discharged at each discharge point vary. As a general rule, the least strict norms allow up to 100 ppm to be discharged (into the municipal sewage system); while discharges allowed into rivers, according to the level, vary from 40 to 20 ppm. When there is a subsequent biological treatment, discharges should be in concentrations lower than 25 ppm.

If the oil to be separated has a density of between 850 - 950 kg/m$^3$, the separator must be chosen taking into account the fact that the speed of ascent obtained by applying the above-mentioned formula should be greater than the work load to produce the separation. In general, the size can be considered as:

| | |
|---|---|
| 850 kg/m$^3$ | SIMPLE |
| Between 850 and 900 kg/m$^3$ | DOUBLE |
| Between 900 and 950 kg/m$^3$ | TRIPLE |

For densities greater than 950 kg/m$^3$, the dissolved air float must be used.