

# AN EFFECTIVE SYSTEM TO PRESERVE THE ENVIRONMENT FROM OIL & GREASE POLLUTION

Industrial & petrochemical activities



Mechanical activities



Oil & Gas production



Marine applications

## ZerOil®

*the most cost-effective solution to the oil pollution*

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## 1. ZerOil<sup>®</sup> Process

The treatment of an oil-in-water dispersion to obtain the separation of the insoluble oily phase has been object of many studies, due to its importance in the industrial and environmental fields.

Several techniques have been developed so far, including membrane, adsorption, absorption, distillation, gravitational, inertial and centrifugal systems; all these techniques show inconveniences in the treatment of large quantities of water: some are limited by the need of high energy requirements, some by the need of long separation times, some other by high dependence on varying inflow conditions.

Italtraco has developed ZerOil<sup>®</sup>, a new-concept separator which permits a practically complete separation of non-miscible liquids at considerably higher flow rates than state-of-the-art separation devices, utilizing, as only motive power, the hydrostatic head generated by the liquid above “two phase media” (with this term we indicate the filtering media after proper activation).

Taking, as an example, a dispersion of hydrocarbons in water (only because this is the case that has been investigated more in detail because of its frequency) we are going to give here below some indications on the invention under review.

Said efficient separation is possible thanks to the “interfacial film” originating, from the molecular and/or electrostatic mutual interaction between water/filtering media and the hydrocarbons.

The “interfacial film” is provoked by an additional interface tension that must be function of the interfacial tension existing between the non-miscible liquids (hydrocarbon and water) and the radius of the hydrocarbon droplet moving towards the “interfacial film”.

## 2. The “interfacial film”

The filtering media is preferentially wetted by the continuous water phase, therefore supporting a liquid-liquid interfacial film acting as a barrier against the passage of the dispersed oily phase: this mechanism is similar to the principle of liquid-liquid separation by porous membranes, but no external pressure gradient is imposed across the filter, and no micro-scale capillaries are present.

This fact is clearly demonstrated by the high flow rate of the water that passes through the two phase media.

As a matter of fact the flow rate in the system under review does not follow the basic law of the capillary flow.

This can be explained with the onset of an additional liquid-liquid interfacial tension  $\sigma'$  originating from the molecular and/or electrostatic mutual interaction between water / filtering media and the hydrocarbon. This additional interface tension must be function of the interfacial tension  $\sigma_i$  existing

between the non-miscible liquids (hydrocarbon and water), and of the radius  $r_d$  of the hydrocarbon droplet moving towards the interfacial film. The resulting expression is:

$$s' = C s_i r_d$$

where the constant  $C$  has the dimensions of the inverse of a length and it is characteristic for every type of media; its value is determined experimentally.

An hydrocarbon droplet reaching the surface of the two phase media will therefore pass through it if the force due to the additional interfacial tension  $s'$  is less than the force necessary to revert the droplet momentum. The pressure force exerted by the droplet on the layer surface, due to its dynamic pressure, is

$$F_p = \rho v^2 \pi r_{eff}^2,$$

where  $r_{eff} = \max(r_d, D_{int})$  is the largest between the droplet radius and the mean distance between fibres in the two phase filtering media, to account for entrainment of smaller droplets and for different density of fibres in the filtering layer.

The surface tension force resulting from (1) is

$$F_s = s' 2\pi r_d = 2\pi C s_i r_d^2.$$

The incident oil droplet is therefore rejected by the filter surface if the condition  $F_s > F_p$  is satisfied.

To complete the description of the **ZerOil**<sup>®</sup> system, we want to add that it has been possible to develop a physical model that can explain the high performance capabilities of the system.

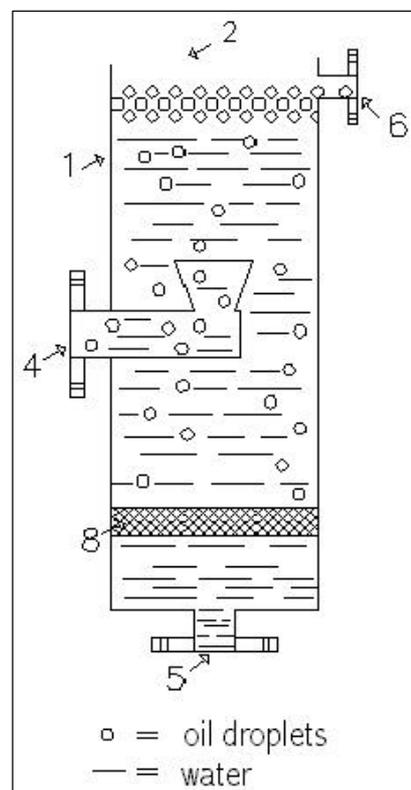
This model has been implemented in a numerical algorithm for the direct simulation of the movement of the hydrocarbon droplets in a laminar water flow.

The results obtained by the model show a complete accordance with the experimental data measured in a number of tests made with water/hydrocarbon mixtures in which the oil particulate size distribution was measured using laser light scattering. This accordance is the best proof of the validity of the model and hence of the validity of the hypothesis upon which the model has been developed.

While explaining the extraordinary efficiency of **ZerOil**<sup>®</sup> separation process, this model renders also possible a preliminary definition of the parameters for the optimization of any given separation problem.

## OPERATING PRINCIPLE

The new process of separation by filtration **ZerOil<sup>®</sup>** concerns a device (1) to separate two components of a mixture of non-miscible liquids. Said device (1) consists of a hollow body (2), having an inlet port (4) to feed the mixture and outlet ports (5, 6) to discharge the separate components, and a “filtering media” (8) formed of specific material, and positioned between said inlet port (4) and the outlet port (5) of the separated water. Said “filtering media” (8), after proper activation, becomes a “two phase media” that lets through only the continuous phase of the said mixture, while the dispersed phase is repelled therefrom.



**The water molecules can penetrate and flow through the interstices of the “two phase filtering media” while the oil droplets are prevented from passing through.**

The pre-activation treatment creates a strong interfacial film that inhibits the passage of the dispersed phase. The droplets of the dispersed phase remain above the film until they become enough big that buoyancy forces bring them towards the upper surface of the water column forming a layer that is continuously skimmed out recovering the dispersed fraction. The same phenomenon holds true for water-in-oil separation.

**OPERATING PRINCIPLE**

The separation device operates apparently as a selective filter or separating membrane in the sense that the water passing through the two-phase media is free of oily and fatty pollutants.

As the dispersed droplets of oils contained in the water flowing toward the “two-phase media” arrive at its surface, macroscopic droplets of oils are being formed. These droplets, being lighter than water, begin to move upward creating a flow from the bottom to the upper free level. As one droplet is moving upward it becomes bigger and bigger when contacting other descending tiny droplets. Thus a dynamic gradient of concentration is created along the height of the water column over standing the “two-phase media”. Only a minor fraction of the total entering dispersed pollutants actually reaches the surface of the “filtering media” (the quantity is influenced from the size of the drops in the in-flowing mixture).

**Motive power required to separate oil-in-water is limited to that generated by the free hydrostatic head of the continuous water layer maintained over the “filtering media” (~ 0.05 bar or 0.7 psi).**

The “two phase filtering media” does not work as a depth coalescing factor. The water molecules can in fact penetrate and flow through the interstices of the “filtering media”, while the oil droplets are prevented from passing through.

**Specifications**

- ♦ Working temperature tested are from 0 °C or less (sea water) to about 80 °C (from 32 °F or less to 200 °F).
- ♦ Separation capacity (flow rate) is in the range of 60 cu.m./sq.m. per hour, depending on the characteristics of the wastewater.
- ♦ Removal efficiency: residual oil contents is even lower than the solubility value.
- ♦ Virtually no maintenance is required.
- ♦ Very good chemical resistance of the media in different working environments.

**MAIN USES FOR THE ZerOil<sup>a</sup>**

- **OIL & GAS PRODUCTION (onshore / offshore):**
  - ◇ production water (oil)
  - ◇ condensate water (gas)
  - ◇ deck washing.
- **INDUSTRIAL USES:**
  - ◇ power plants condensate and cooling water
  - ◇ petrochemical plants and refineries effluents
  - ◇ rolling oil effluents from any rolling mill
  - ◇ machine tool coolants
  - ◇ oily wastewater from:
    - chemical industry
    - pharmaceutical industry
    - food processing plants
    - mining operation
    - wool and textile industry
  - ◇ mechanical industry:
    - METAL WORKING: water soluble, semi-synthetic, synthetic and biostable fluids used in grinding, turning, and general machining operations;
    - METAL FINISHING: water soluble acid, alkaline and neutral cleaners containing free and mechanically dispersed tramp oils;
    - SCREW MACHINES: tramp oil from water soluble fluids used in screw machine reservoirs;
    - PRIMARY METALS: roll forming, cold heading, stamping and tube mill water soluble fluids used for ferrous and non-ferrous operation.
- **MARINE APPLICATIONS:**
  - ◇ bilge water separation
  - ◇ tank ballast water deoiling
  - ◇ oil spill response
  - ◇ sea water deoiling / desalinization plant protection.
- **POLLUTION ABATEMENT:**
  - ◇ surface water cleanup
  - ◇ ground water cleanup
  - ◇ storm water, rain water runoff cleanup.
- **SEPARATION PROCESSES:**
  - ◇ diesel / water
  - ◇ kerosene / water
  - ◇ benzene / water
  - ◇ machine oil / water
  - ◇ animal fat / water
  - ◇ immiscible organic chemicals / water.
- **OTHER APPLICATIONS:**
  - ◇ oily wastewater from:
    - fuels terminals
    - railway yards.

**DEMONSTRATION PLANT SERVICE**

ITALTRACO offers full laboratory testing of your effluent to determine process parameters, such as specific flow rate and separated liquids properties.

In some applications an ITALTRACO's patented pre-treatment may be needed to remove excess amounts of suspended solids.

ITALTRACO also provides on site demonstration plant services. The demonstration plant(s) use a proprietary pre-treatment process, a separator and "media" identical to those used in full scale models. This insures accurate test results and reliable scale up for any end-user specific requirement(s).

The information gathered during testing ensures that ITALTRACO can deliver equipment that will satisfy end-user effluent treatment requirement(s).



ZerOil<sup>®</sup> demonstration system with transparent columns

**QUESTIONS AND ANSWERS ABOUT ZerOil<sup>®</sup>****1. What is the principle which allows ZerOil<sup>®</sup> to gain very high separation rates?**

A: This extraordinary result is due to the uniqueness of the **ZerOil<sup>®</sup>** process: the separation of the two non-miscible liquids is not effected by some kind of «barrier» letting only one component flow through while materially retaining the other; the separation is effected by the action of natural molecular attraction/repulsion forces, whereby while the continuous phase can freely pass through the “two phase media” (with this term we indicate the filtering media), the dispersed phase is literally repelled at the surface of the media. We can really say that the natural interface tension between water and the oily component is greatly enhanced by the interaction with the “two phase media”. This simple, but powerful system, determines a better and faster separation of the two components. The same phenomenon holds true for water-in-oil separation.

**2. Which are the main factors that affect the design of the ZerOil<sup>®</sup> oil-in-water separator?**

A: There are six main factors (the first two of them having surely a greater importance than the last four ones):

- a) Maximum flow rate.
- b) Oily water characteristics (% of free oil, % of soluble oil, diameter of oil droplets, oil particle size distribution, extent of mechanical dispersions and presence of chemical emulsions).
- c) Interfacial tension between the two phases of the dispersion.
- d) Specific gravity of the oil.
- e) Operating temperature.
- f) Presence of suspended solids in the oily water.

**3. What is the maximum operational ZerOil<sup>®</sup> flow rate?**

A: **ZerOil<sup>®</sup>** hasn't specific flow rate limitations. On the average, the actual flow rate is in the order of 60 m<sup>3</sup> / m<sup>2</sup> per hour, depending on oil droplet size. Modular compact systems can be designed to operate at practically any flow rate.

**4. Is ZerOil<sup>®</sup> affected by the oil concentration in the feed stream?**

A: No, **ZerOil<sup>®</sup>** can easily work with oil concentration ranging from 2 ppm. to 50% or more.

**5. Can ZerOil<sup>®</sup> work with mechanical dispersions?**

A: Yes, regardless of the sizes of oil droplet diameters. **ZerOil<sup>®</sup>** doesn't need any of the methods currently used to treat mechanical dispersions such as:

- Heat
- pH adjustment
- De-emulsifying chemicals.

**QUESTIONS AND ANSWERS ABOUT ZerOil<sup>®</sup>****6. Is ZerOil<sup>®</sup> affected by the pH of the feed stream?**

A: No, *ZerOil<sup>®</sup>* media can successfully handle inlet streams with pH ranging from 2 to 12.

**7. Is ZerOil<sup>®</sup> affected by oil viscosity?**

A: No, *ZerOil<sup>®</sup>* can successfully handle oil phases ranging from low to very high viscosity.

**8. Can ZerOil<sup>®</sup> work with soluble aromatics and/or with chemical emulsions?**

A: No, it is necessary to pre-treat the wastewater stream using Italtraco's patented S.P.R. technology in order to remove soluble aromatics and to achieve phases separation before feeding the *ZerOil<sup>®</sup>*.

**9. Can ZerOil<sup>®</sup> work with small interfacial tension values between oil and water?**

A: Yes, *ZerOil<sup>®</sup>* "two phase" media greatly enhances the existing interfacial tension between oil and water.

**10. Can ZerOil<sup>®</sup> work with small differences between oil and water specific gravity?**

A: Yes, *ZerOil<sup>®</sup>* is very selective, only water can pass through the media. The oily phase is repelled before it can even touch the media.

**11. Can ZerOil<sup>®</sup> separate oils heavier than water?**

A: Yes, properly designed *ZerOil<sup>®</sup>* units having clean water outlet higher than the "two phase media" can easily separate heavy oil droplets.

**12. What is the range of temperature ZerOil<sup>®</sup> can work within?**

A: *ZerOil<sup>®</sup>* can easily work with a temperature of the waste water ranging from -15 to 80°C.

**13. Which kind of problems may be caused in ZerOil<sup>®</sup> by the presence of suspended solids in the wastewater?**

A: One of the major obstacles to good separation, in conventional systems, is the presence of dirt in the wastewater. The lighter oil droplets may attach to a heavier solid particle resulting in a particle near to neutral buoyancy. This particle may not rise into the separated oil layer to be decanted and it may not settle into the sludge chamber to be isolated from the flow. The oil/dirt particle may not coalesce and will be present in the effluent water contributing to the total oil concentration. The presence of solid particles in *ZerOil<sup>®</sup>* system, thanks to its unique design, doesn't affect the quality of separation. The only consequence of their presence is that solids, captured by the filtering media, induce head losses and, eventually, lead to a reduction of the flow through the "two phase media" itself.

**QUESTIONS AND ANSWERS ABOUT ZerOil<sup>®</sup>****14. What is the solution to the presence of suspended solids in the wastewater stream, granted by Italtraco?**

A: Italtraco has properly designed the self-cleaning *ZerOil<sup>®</sup>* and the *ROTOZEROIL* (a self-cleaning rotating system), or when it is useful an integrated Italtraco's proprietary technology to remove solid and colloidal particles, heavy metals and soluble aromatics is available.

**15. What can I do if I have colloid particles in the wastewater stream?**

A: If, as in the case of most industrial effluents, substantial quantities of solid or colloidal particles are also present, the use of the self-cleaning *ZerOil<sup>®</sup>*, the *ROTOZEROIL* or a pre-treatment by another Italtraco's patented specific technology is sufficient to eliminate such impurities, securing a long trouble free operation.

**16. Where do water and oil go after the ZerOil<sup>®</sup> oil-in-water separation?**

A: Most companies have wastewater disposal regulations to meet. After *ZerOil<sup>®</sup>* system treatment, the water effluent stream will easily meet state or local specifications and can be discharged into the local sewage system or nearby river or recycled in the same processing plant. The oil phase can be reused as marketable product or as fuel oil.

**17. Why should I choose the ZerOil<sup>®</sup> separator over other separator systems?**

A: One of the main advantages the *ZerOil<sup>®</sup>* separator has over other types of separators is its higher overall separation efficiency between oil and water. Other additional advantages include:

1. Really negligible power requirement: a static head of less than 1 meter water column above the "two phase media" is sufficient to maintain a throughput as high as 100 m<sup>3</sup> / m<sup>2</sup>·hr.
2. There is no limit with regard to the separation of oil-in-water.
3. The extremely simple and compact construction of *ZerOil<sup>®</sup>* separator, with no moving parts, secures very low maintenance and depreciation costs and, at the same time, high reliability of long, trouble free operation.
4. *ZerOil<sup>®</sup>* separator doesn't require heat, chemicals, polymers or pH alterations.
5. Skid mounted systems with a complete automation of the entire process are easily attainable. Unattended operation is possible in any location.

**18. Can Italtraco provide rental units for the evaluation of my oil-in-water separation problems?**

A: Yes, we have pilot plants for rental applications on short notice. Please contact Italtraco for more detailed information.

**19. Does Italtraco sell off-the-shelf ZerOil<sup>®</sup> systems?**

A: Italtraco has many standard designed systems. However, each client has unique requirements. *ZerOil<sup>®</sup>* separators are also custom designed to meet specific customer needs.