

# Separation of oil and water

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## 1. System oil water - water

### Length annual consumption

Nearly all industrial process use mineral oil and synthetic oil as lubricant, as hydraulic power transmission and rust-proofing. Because of the annual consumption of approx. 1.2 million tons of lubricants in Germany only it is clear, that considerable amounts of oil will contaminate the water

in example

- because of leakage motor oil will contaminate surface water
- lubricants, conservation oils and coolants are removed by cleaning fluids based on water
- because of small leaks in hydraulic systems hydraulic oil may contaminate cooling water
- lubricants and hydraulic oil will contaminate coolants and emulsions in tool machines



oil floating on washing water



oil floating on waste water



cooling water with floating oil

## Important differences between water and mineral oil

physical parameters		water	mineral oil (typical lubrication oil)
dielectric constant at 20 °C		80,4	approx. 2,3
viscosity at 20 °C	mm <sup>2</sup> /s	1,0	approx. 75
density at 20 °C	g/cm <sup>3</sup>	0,997	approx. 0,87
pure point	°C	0	approx.. -18
specific heat at 20 °C	kJ/kg K	4,2	approx. 2,1
enthalpy of evaporation	kJ/kg	2282	approx. 210
heat conduction	W/mK	0,6	approx. 0,12
boiling temperature	°C	100	approx. 320 <sup>1)</sup>
dipole moment	D	1,85	approx. 0,08
surface tension	µN/cm	730	approx. 250
vapor pressure at 100 °C	mbar	980	< 1
<b>chemical information:</b>			
flashpoint	°C	-	approx. 210
composition		H <sub>2</sub> O	approx. C <sub>n</sub> H <sub>2n+</sub>
biological identification		necessary for all life processes	only realisable for low organism

<sup>1)</sup> under corrosion

### Separation of oil and water

Normally it's not possible to mix oil with water. Small amounts of oil can be solved in the water. In many hydraulic oils up to 500 ppm of dissolved water can be found. Small amounts of oil (up to approx. 5%) can be mixed with water by adding emulsifiers. The oil and water will not form a mixture but an emulsion. That means that very small droplets of oil are mixed with the water. The emulsion is dispersion and not a mixture of oil and water. Compared to clean water or clean oil the emulsion is obscure and not clear.

### Different boiling temperature

The separation of oil and water is based on the physical characteristics. There are some strong differences between oil and water. These are

1. density
2. viscosity
3. boiling temperature

Because of the different boiling temperature it is pretty easy to separate an oil-water-mixture simply by distillation. When heating the water-oil-mixture under vacuum the boiling point is lower and the separation process needs less energy. Because of the high energy cost distillation or vacuum distillation is only useful when treating small amounts of oil mixed with water and other chemicals.

### Different density

Because of the different density, the oil which is mixed with water, will float on top of the water surface. Oil droplets 60µ and bigger will rise to the water surface just by gravity. Important for good results is, that the water is calm. Turbulences or strong flow will prevent the oil droplets from rising to the water surface. As soon as the oil floats on top it's pretty simple to remove the oil from the water surface. Many separation systems use the difference in density and viscosity between oil and water.



open channel in longitudinal clarifier

**Viscosity**

Especially lubricants and hydraulic oils have a significant higher viscosity than water. Compared to oil the water has a very low viscosity. The water will not stick as good as the oil to other materials. It is possible to separate the floating oil when using a moving part on the water surface. The oil will stick to the part while the water will drop off.

**2. Procedural principle**

**Oil skimmer/  
Viscosity and  
adhesive power**

A plastic tube, that is connected to an endless ring, floats on the oily water surface. A drive wheel, that is mounted inside the oil skimmer, moves the oil collector tube slowly through the floating oil. Because of the high viscosity and the good adhesive power the oil sticks to the outside of the oil collector tube. The oil will be drawn with the oil collector tube into the oil skimmer.

**Scraper**

Around the drive wheel scrapers are mounted. The scrapers remove the oil mechanically from the surface of the oil collector tube. The clean oil collector tube returns to the water surface and picks up new oil.



oil sticks to the outside of the oil collector tube

The oil, removed by the scrapers, runs into an oil collecting pan and floats from there into a waste oil collecting tank or in a pump station.



Oil sticks to the outside of the oil collector tube

## Processing

The oil collector tube creates movement on liquid surfaces and attracts the oil. Because of this unique principle it is possible to clean big surfaces (more than 10 m<sup>2</sup>) with only one unit. The oil collector tube floats on the water surface balances changing water levels. This makes sure that the oil collector tube exactly works at the boundary layer oil/water.



oil collector tube creates a movement on the water surface

## Capacity of the oil skimmer

This principle uses the lower specific weight of the oil compared to the water and the adhesive power of the oil. Therefore the capacity of the oil skimmer depends on conditions as follows:

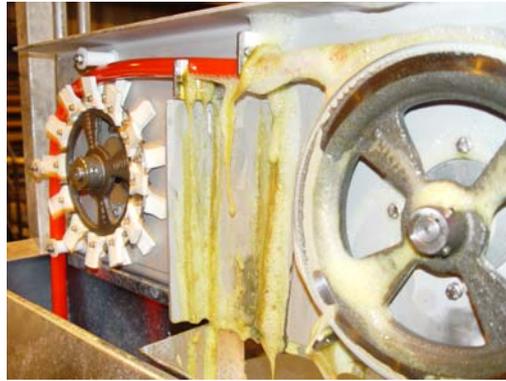
1. viscosity of the oil
2. thickness of the oil layer
3. speed of the oil collector tube

Capacity <b>FRIESS</b> oil skimmer model 1U	2 - 30 l/h
Capacity <b>FRIESS</b> oil skimmer model W40	10 – 230 l/h
Capacity <b>FRIESS</b> oil skimmer model S 100	max. 500 l/h

## Oil viscosity

**Viscosity min. 3  
cst (mm<sup>2</sup>/s)**

In general the capacity of the oil skimmer rises when the viscosity of the oil rises. The minimum viscosity has to be 3 cst (mm<sup>2</sup>/s) (diesel or kerosene). Hydrocarbons with low viscosity, for example fuel, will not stick to the oil collector tube. Hydrocarbons with very high viscosity (in example fat) can be removed with the oil collector tube in case that the fat clumps are not too big. In case that the clumps are too big the weight of the clump will be higher than the adhesive power and the clump will not be transported with the oil collector tube.



**high capacity of the oil skimmer S 100**

## Thickness of the oil layer

**Low limit**

The capacity of the oil skimmer rises because of rising thickness of the oil layer. The lower limit of the oil layer is approx. 10 µm - 50 µm. In case that the oil layer is very thin the oil collector tube will be coated with oil but the amount of water in the collected oil will be higher than the amount of oil.

The separation of oil and water becomes more difficult. The mixture of floating oil and water that has been collected by the oil skimmer will be separated in an additional decanter tank. In the decanter tank the heavy water will settle on the bottom of the tank while the light oil will float on the surface. The decanter tank has two outlets at the same height. The outlet for the oil is an overflow edge; the oil will float over the edge into an oil collecting tank. A tube that goes down to the bottom of the decanter tank is the drain for the water. The water will rise inside the tube to the outlet and will float back into the main tank.

In addition it is possible to reduce the speed of the oil skimmer so that the amount of water in the collected oil is as low as possible while the floating oil layer will be removed.



**oil skimmer 1U with built-in decanter tank**

## Upper limit

The thickness of the floating oil is unlimited. In case that the amount of oil is very big and the oil layer is thicker than 100 mm other technologies maybe faster.



oil collector tube floating on longitudinal clarifier

## Speed of the oil collector tube

### Speed of the oil collector tube

The speed of the oil collector tube is very important for the capacity in case that all other conditions are the same. Depending on the speed of the oil collector tube may vary between ca. 40 m/min and 10 m/min. When removing low viscos oils we recommend to use higher speed of the oil collector tube in order to avoid dripping back of the oil from the oil collector tube. When removing high viscos oil the speed of the oil collector tube should be lower so that the oil has enough time to stick to the oil collector tube.

## 4. Constructive configuration

### Robust construction/ Wear parts

Most of the oil skimmer are used at fully automatic systems. Many of the equipment is not near the manufacturing. That means the oil skimmer will not be continuously observed. It has to work reliably. For this reason a robust construction is necessary. Only few wear parts are allowed. The wear parts have to have a lifetime of minimum six months.

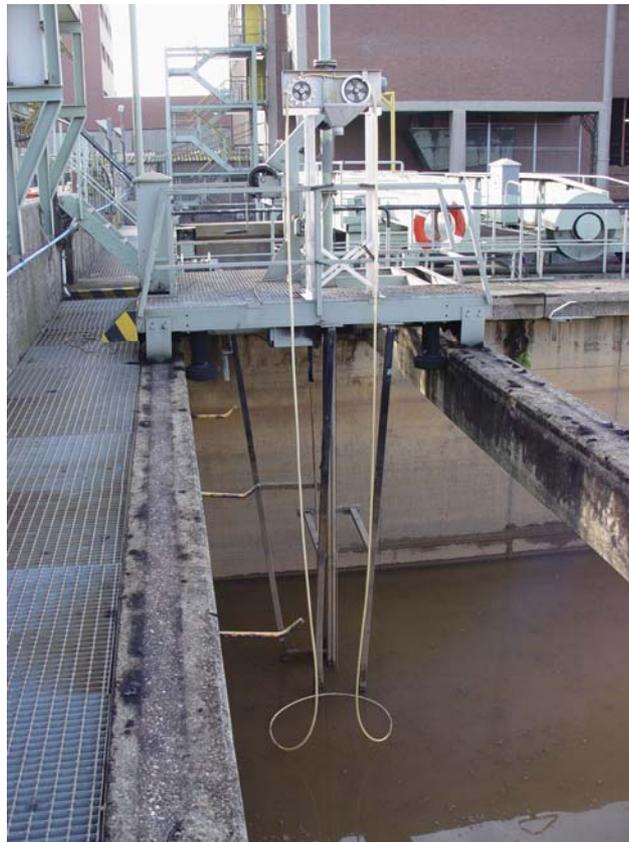
### Corrosion free materials

The oil skimmer have to work at -20 °C outside and at up to 80 °C in degreasing baths. Because of the continuous contact with water the units have to be made of corrosion free materials. Based on this specifications FRIESS has developed a product line of five different oil skimmers. With these five different models FRIESS is able to offer perfect solution for nearly all application. The size of the surface where the oil can be collected is between 0,2 m x 0,2 m and up to several 100 m<sup>2</sup>.



**oil skimmer S 100 at cooling water basin with more than 1000 m<sup>2</sup> surface**

In case that the basins are even bigger we recommend to use oil booms. The oil booms are able to limit the surface where the oil floats. By concentration of the floating oil on a small surface the separation of oil from the water with an oil skimmer is much easier and faster.



**oil skimmer S 100 approx. 6m above water surface**

The lifting height of the oil skimmer differs between 100 mm up to 20 m. In order to reduce production cost and sales price the different oil skimmers use many identical parts (modular conception).



**oil skimmer S 100 made of corrosion free plastic**

The main body of all different oil skimmer is made of stainless steel. This material is absolutely corrosion free. In case that the oil skimmer should be used at aggressive media it is possible to make the oil skimmer from highly corrosion resistant special stainless steels or of plastic. All units are lightweight and can be used as portable or mobile or stationary unit.

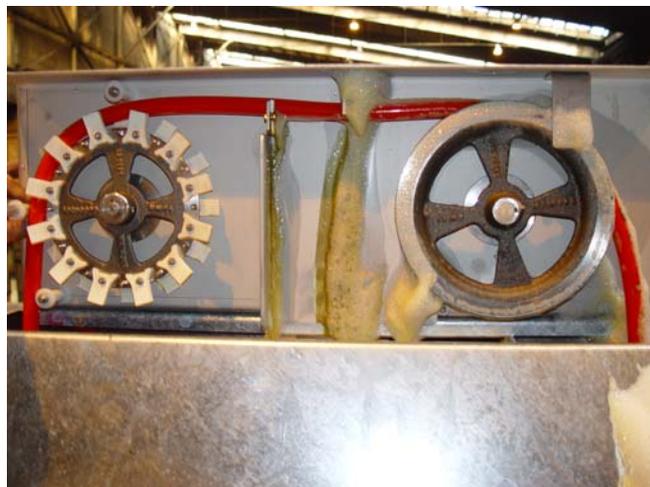
All units are driven by robust geared motor. These geared motor are extremely reliably and tough. Anyhow if a gear of motor is defect the change of parts can be done fast and easy.

Maintenance like oil change or oil level control is not necessary.

### **Drive wheel**

The drive wheel that moves the oil collector tube is equipped with ceramic fingers. The ceramic fingers are made of extremely hard and abrasive resistant aluminium oxyd ceramic. The collected oil contains abrasive dirt particles, scale or chips. Soft materials like steel will wear much too fast and the movement of the oil collector tube is not guaranteed.

Around the oil collector tube U shaped scrapers are mounted. Because of the special design of the scrapers the endless oil collector tube can be changed without connecting the oil collector tube on site. We recommend to use premanufactured oil collector tubes to avoid difficulties during mounting. The scraper and the other tube guides are made of abrasive resistant aluminium oxyd ceramics. The lifetime of these parts is several years even if the oil is contaminated with abrasive particles.



**ceramic parts at the drive wheel and at the scrapers**

## Oil collector tube

Depending on the application different viscoplastic materials are used for the oil collector tube. The materials do not contain softening agents and are extremely abrasive resistant. Depending on temperature and aggressivity of the medium (acid or base) we select the material of the oil collector tube fitting to the application.

Depending on the application different process are used to connect both ends of the oil collector tube to a closed lube.

## 5. Applications

Oil skimmer maybe used for different task. Generally we can differentiate between two main applications:

1. Maintenance of re-usable liquids
2. First step in waste water treatment

### 5.1 Removing oil from re-usable liquids

Re-usable liquids like cooling water, coolant or washing water are used in industrial applications as long as even possible in order to reduce cost for separation and discharge. Therefor it is necessary to maintain the process media as good as even possible.

## Cooling water

Steel industry and rolling mills use huge amount of cooling water. Because of leakage in the hydraulic system and loss of lubricants noteworthy amounts of oil endup in the cooling water. In the scale pit or in the longitudinal clarifier the oil will float on top of the water. In order to avoid sticky scale blocking filters, contamination of gravel filters and so on, it is necessary to continuously remove the floating oil with an oil skimmer.



oil skimmer model S 100 mounted at longitudinal clarifier

**Coolant**

In order to reduce high cost for disposal of waste coolant many companies use the coolant much longer than years ago. Tramp oil that ends up in the coolant has to be removed regularly. Most of the tramp oil is caused by lubrication and leaks in the hydraulic system. Sometimes corrosion protection oil ends up in the coolant. If the oil is not removed, the coolant will be covered by a closed oil film on the surface of the coolant.

Because of missing contact with oxygen anaerobe bacteria will grow in the coolant and the coolant starts to smell and has to be changed. In extreme cases the bacteria may cause skin disease. Especially when the coolant is not pumped through the system floating oil film can be removed easily with an oil skimmer.



oil skimmer W40 at coolant tank

**Part washer and degreasing bath**

Most of the part washer and degreasing systems work with cleaners based on water. It is recommended to use a non emulsifying cleaning agent in the part washer. As soon as the water rests for some minutes the washed off oil will float on top of the water. It is easy to remove this floating oil. The lifetime of the degreasing bath, that is equipped with an oil skimmer, is up to 5 times longer than a degreasing bath with an emulsifying cleaning agent. The emulsifying cleaning agent will emulsify the washed off oil. In very short time the cleaning agent is saturated with oil and has to be exchanged.



oil skimmer 1U at degreasing bath

## **The liquid is not 100% free of oil**

In most applications it is not necessary, that absolutely 100% of the tramp oil is removed from the process media. Mostly it is sufficient that the amount of tramp oil is less than a certain limit of tolerance. Because of tolerating a certain very small amount of tramp oil complex and costly separation technology such as separators, cracking plants, big decanters and so on, are not necessary for maintenance of process media.

## **First step in waste water treatment**

Waste water treatment systems are able to clean dirty oily coolants and washing liquids in a way, that the clean water can be discharged into a public sewer. Most of waste water treatment systems have a buffer tank to collect the dirty liquid, different treatment steps in order to separate the contamination, particles and oils from the water, pH-control and automatic quality control. Depending on the cleaning process the operation cost of a waste water treatment plant can be relatively high. For this reason companies try to reduce the amount of water, that has to be discharged, as much as even possible.



**oil skimmer S 100 at collecting basin for waste water**

Many waste water treatment systems use an oil skimmer at the buffer tank in order to separate floating oils from the water. A separation of oil in the first step helps to reduce the operation cost of waste water treatment systems dramatically. In example the membranes of ultra filtration systems, that are used for separation of coolants into water and oil, can be blocked in short time by free oils. Water droplet, that floats in the water, may cause failures and the system has to be flushed very often.

When using a chemical physical treatment free oils cause higher consumption of chemicals. The operation cost can be reduced by using an oil skimmer at the buffer tank.

**Oil removal  
from a decon-  
tamination well**

In order to clean up ground field sites which are contaminated with oils it is necessary to fill wells to clean the ground water. By pumping down the ground water the ground water level in the area of the well sinks and the oil, that floats on the ground water, is concentrated in the ground water well. The cleaning process takes many years. In order to remove the floating oil you can use oil skimmer model 2H or 1U special version. The oil collector tube is guided in a way, that the oil can be removed from a well with a minium diameter of 125 mm. The oil can be lifted up to more than 10m.



oil skimmer S 100 at small well  
□ 400 mm x 400 mm



oil skimmer 2H at ground water well Ø 300 mm

## 6. Abstract

With adequate technologies it is easy to separate oil and water. Especially as first step in the waste water treatment and for maintenance of industrial process media oil skimmer with oil collector tube are the perfect solution.

In many applications the lifetime of a process liquid could be doubled or rised up to 5 times by just using a **FRIESS** oil skimmer with oil collector tube.

Up to now **FRIESS** GmbH has sold more than 5000 oil skimmer with oil collector tube worldwide. In average these machines removed approx. 50 m<sup>3</sup> oil/hour from water and have a share to protect our environnement and nature.