Radiometric Solutions
Whitepaper –
Technologies for Desalters

Endress+Hauser
People for Process Automation

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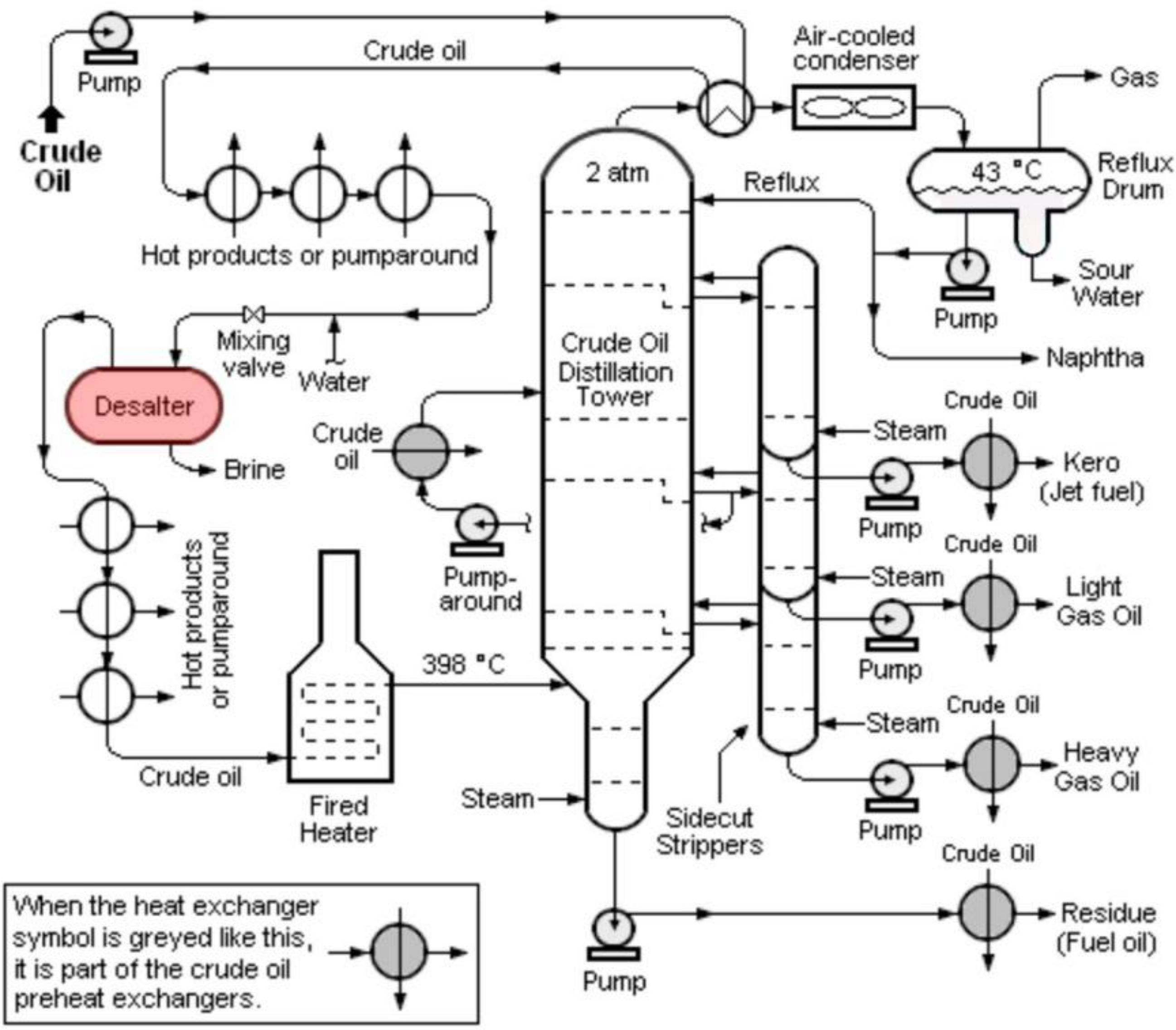
1 General information about desalters

1.1 Areas where desalters are used

Crude oil enters the separation train (separator), where it is separated into its constituent components, namely oil, gas, water and sediments. The crude oil is then processed further in the crude oil distillation unit (CDU). This is the first processing unit in virtually all petroleum refineries. The CDU distills the incoming crude oil into various fractions with different boiling ranges, each of which is then processed further in the other refinery processing units.

The desalter is typically installed in the heat exchange train that heats the incoming crude oil before it flows through a fired heater and into the distillation tower. FPSOs (Floating Production Storage and Offloading Units) may also have desalters located between production separators and storage tanks.



https://en.wikipedia.org/wiki/Petroleum_refining_processes#/media/File:Crude_Oil_Distillation_Unit.png (08/2017)

1.2 Purpose of desalters

Crude oil often contains water, inorganic salts, suspended solids and water-soluble trace metals. The salt content of crude oil is highly variable and results principally from production practices used in the field. It is often measured in **PTB**, an acronym for **P**ound of salt per **T**housand **B**arrels of crude oil. As a first step in the refining process, in order to reduce corrosion, plugging and fouling of equipment and to prevent contamination of the catalysts in processing units, the contaminants must be removed by desalting (which includes dehydration, i.e. the removal of any free water). An increase in the use of unconventional extraction methods (e.g. oil sands and shale oils) has given rise to tremendous variability in the quality of crude blends (API grade), prompting many refiners to rethink the role of the desalter. These crudes can also contain a large amount of solids due to hydraulic fracturing of reservoirs and the use of sand, which is injected downhole as a proppant to hold open the fractures. Nowadays, these new challenges can be overcome only through a combination of baseline monitoring and continuous monitoring in the desalting process.

Rationale

- Reduce dissolved salts including chlorides, sulfates and bicarbonates of alkali metals
- Remove unwanted **B**asic **S**ediment (salt) and **W**ater (**BS&W**) from the crude oil
- Reduce the crude salt content from 100 to 150 PTB (285 to 428 g/1 000 l) to <3 PTB (8.6 g/1 000 l)
- Reduce the outlet water content to less than 0.2%

1.3 Typical PTB values of different crude oils

Source of Oil	Average Salt Content (PTB)
Middle East	8
Venezuela	11
Pennsylvania	1
Wyoming	5
East Texas	28
Gulf Coast	35
Oklahoma and Texas	78
West Texas	261
Canada	200

1.4 Dangers posed by salt and water in refinery systems

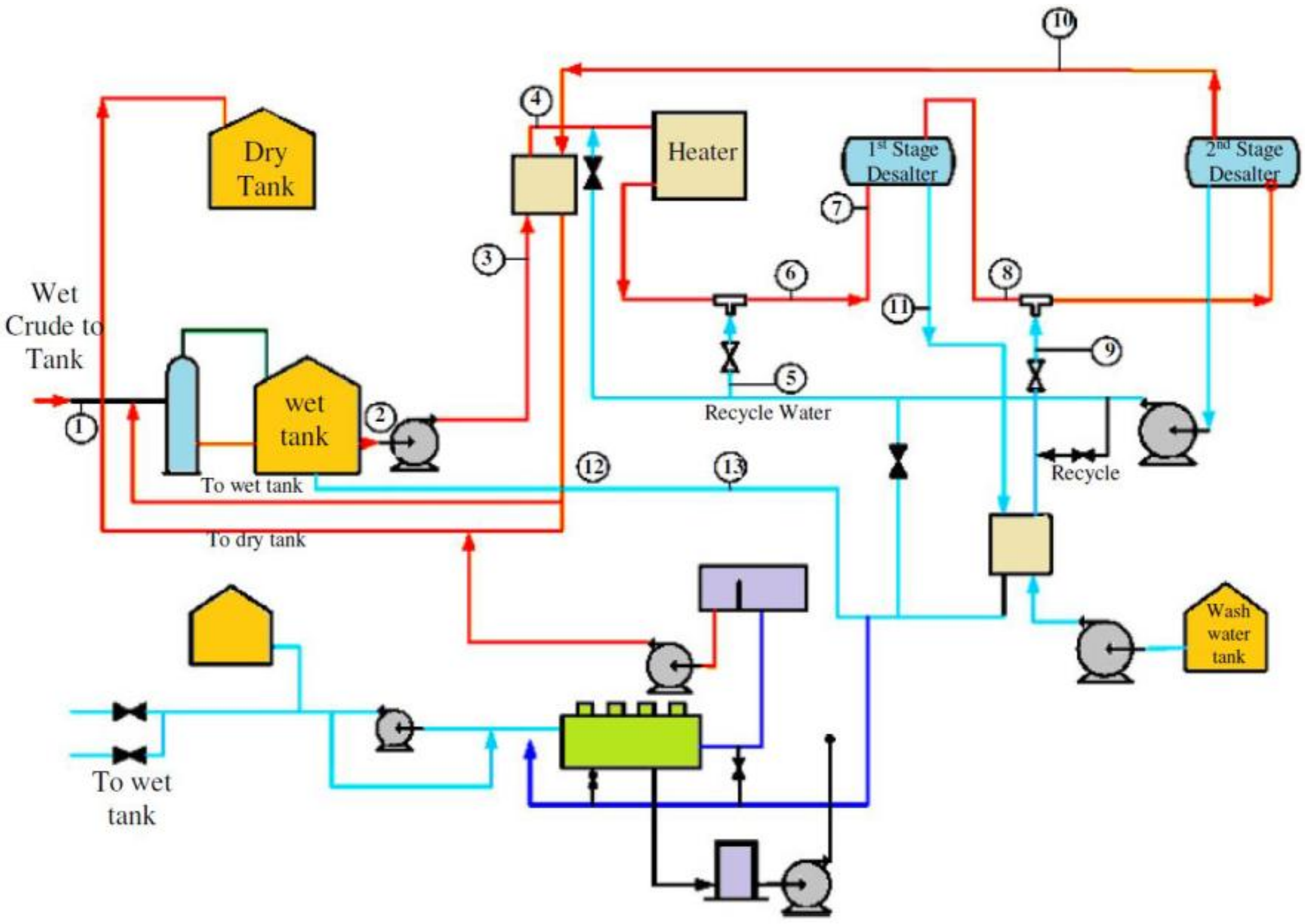
Even in small concentrations, salt and water in the subsequent downstream process can have many undesirable effects, for example:

- Salt leads to **corrosion in the subsequent downstream process.**
- Chlorides can **hydrolyze to HCL**, which is extremely corrosive.
- Some mineral salts can **contaminate expensive catalysts.**
- Salt accumulates in stills, heaters and exchangers and leads to fouling that requires **expensive cleanup.**
- Salt cakes reduce the heat transfer rates in exchangers – as they cause higher heater tube-wall temperatures – thus resulting in **increased fuel consumption and higher operating costs.**
- Salt cakes cause poor flow and cause a risk of blockages inside tubes – thus **lowering the capacity and efficiency of the piping.**
- Hot spots in plugged fractionator trays and burned-out fire tubes lead to **reduced design life.**
- Too much water entering the preheat train could lead to vaporization and cause interference/noise and pipe vibrations due to high pressure. This could also lead to a **serious shutdown.**
- Heat exchange in process equipment (desalter and downstream application) resulting in process efficiency being compromised.

2 Desalter functionality

The two most typical methods of crude-oil desalting - chemical and electrostatic separation - involve the use of hot water as the extraction agent.
In chemical desalting, water and chemical surfactant (demulsifiers) are added to the crude, then heated so that salts and other impurities dissolve in the water or attach to the water and then kept in a tank where they settle.
Electrical desalting, in a vessel completely filled with liquid (water and oil), is the application of high-voltage electrostatic charges in order to concentrate suspended water globules in the bottom of the settling tank. Surfactants are added only when the crude contains a large amount of suspended solids. Both methods of desalting are continuous. A third and less common process involves filtering heated crude using diatomaceous earth.

2.1 Process flow diagram of a desalter system



http://www.klmtechgroup.com/PDF/EGD2/ENGINEERING_DESIGN_GUIDELINES_crude_unit_desalter_system_rev_web.pdf (08/2017)

1. Wet crude flow to wet tank
2. Demulsifier / Chemical injection
3. Crude flow to heat exchanger
4. Flow to heater
5. Wash water recycled from 2nd stage vessel
6. Flow to 1st stage desalting mixing valve
7. Mixed fluid to 1st stage vessel
8. Flow to 2nd stage desalting mixing valve
9. Fresh water from water-water heat exchanger originated from wash water tank
10. Treated crude flow
11. Effluent water from 1st stage desalter vessel to water treatment plant / or disposal pit
12. BS&W Analyzer – A signal to diverting valve
13. Formation (free) water settled down at the bottom of wet tank, to water treatment plant and / or disposal pit

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2.2 How crude oil is processed in a desalter

- **Wash water** is injected and mixed into the continuous flow of crude oil and the resulting oil-water emulsion (**wet crude oil**) then continuously **enters the electrostatic desalter**.
- **Wet crude oil flows up** and **passes through a high-voltage electrostatic field** (**electrical grid**).
- The **water droplets**, sprayed from the overhead dilution header, **coalesce** and then become large enough to **drop to the bottom** of the vessel.
- The **separated water** (**brine/effluent water**) is removed via the **water outlet.** In a single-stage system it is **discharged to disposal,** and in a 2nd stage system it is **reused from the 1st stage and injected into the 2nd stage** vessel.
- The **settled sediments** (**sludge**) at the bottom are withdrawn via the **sand wash outlet**.
- The **dry oil** is discharged via a **collection header** at the **top of the vessel**.

2.3 Different vessel designs

Viewed externally, the typical electrostatic desalter is a horizontal, cylindrical vessel. The type and size of the desalter used is dependent on a number of fundamental factors such as:

- Pressure, temperature, fluid viscosity and flow rate
- Customer requirements relating to maximum salt content allowed in the product oil stream
- Different electrostatic technologies and design concepts

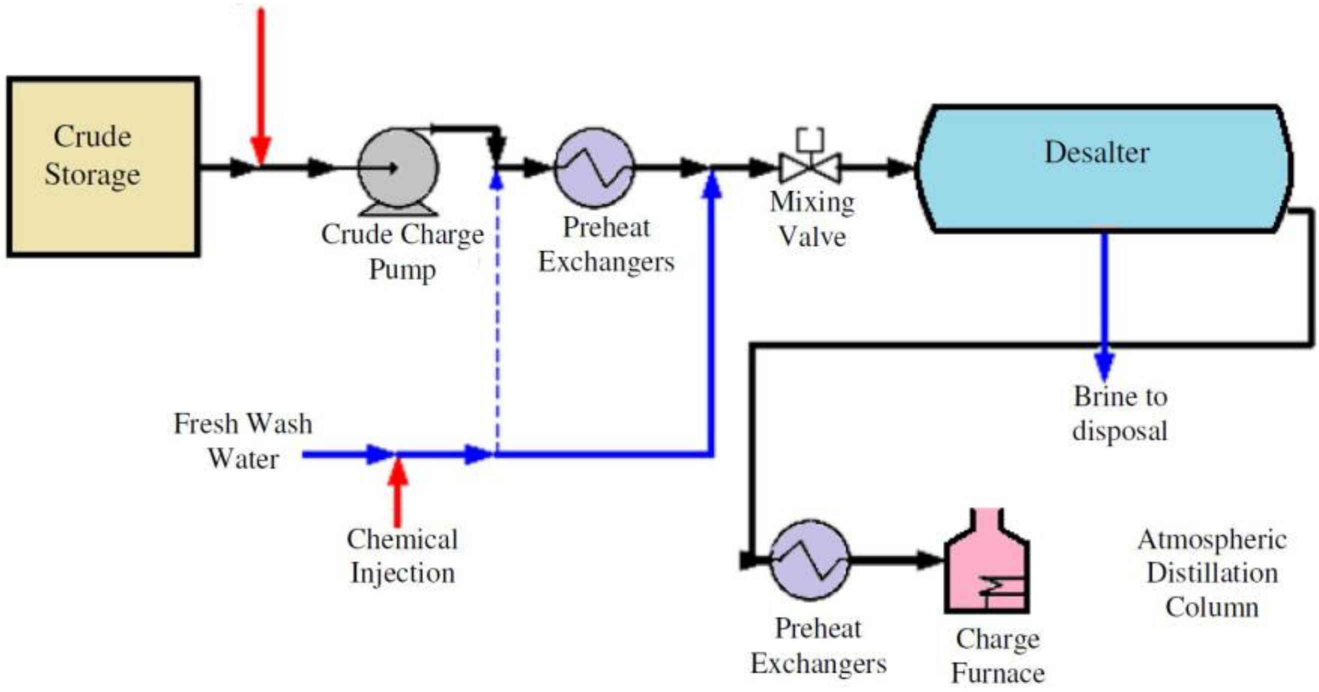
Typical dimensions

Vessel Design	Conventional A/C	Current Technology	Dual Frequency
Length	80’ / 24 384mm	60’ / 18 288mm	38’ / 11 582mm
Diameter	12’ / 3 658mm	12’ / 3 658mm	12’ / 3 658mm
Capacity	805 200lbs / Approx. 405 813 l	622 600lbs / Approx. 313 785 l	422 400lbs / Approx. 212 886

- Wall thickness: 22 to 38mm (7/8 to 1.5”) steel
- Insulation: 50 to 90mm (2 to 3.5”) mineral wool
- Shell: 1mm (1/25”) aluminum

2.4 Single-stage desalter

As an economically satisfactory salt content in oil cannot be achieved solely by means of the dehydration process, whereby the entrained produced water is removed, a subsequent desalting process is needed. Here, fresh dilution water is injected into the oil stream before it enters the desalter. The resulting oil-water emulsion then enters the single-stage electrostatic desalter. The typical dehydration efficiency of such a system is 95%.



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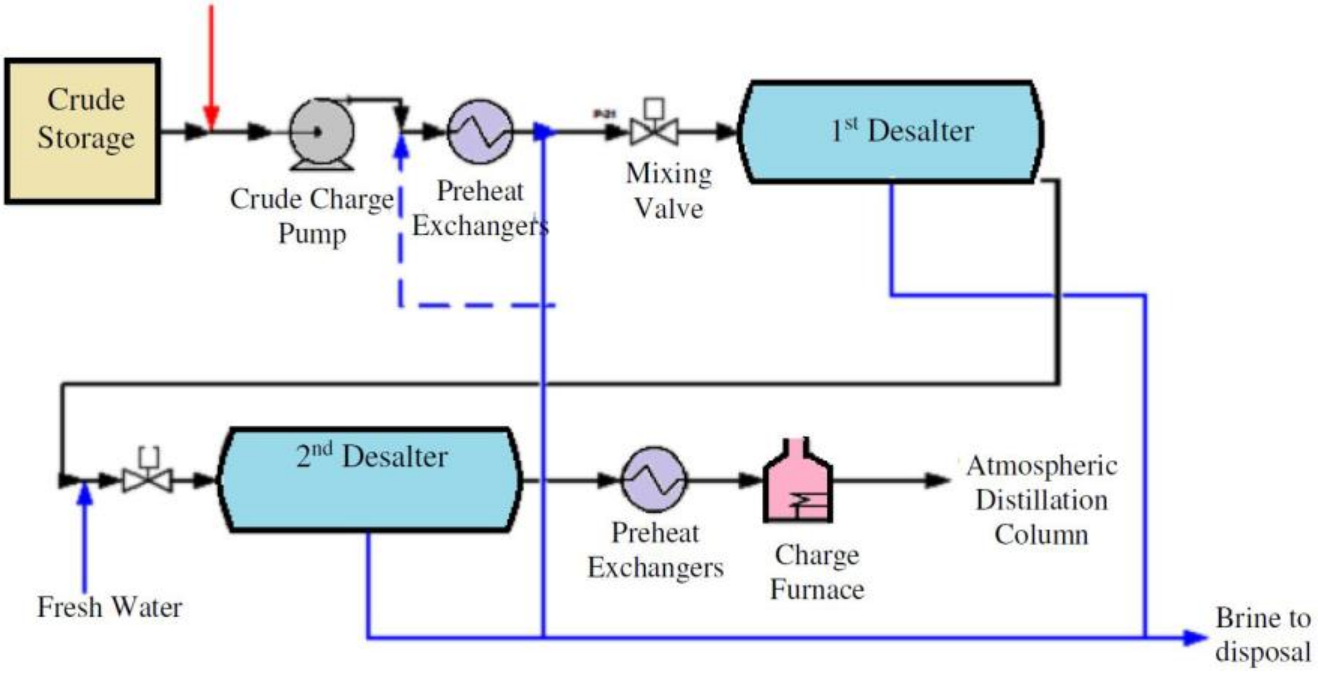
2.5 Two-stage desalter

If a single-stage desalting system requires too much dilution water or is unable to reach the desired salt concentration, then a two-stage system is used. In this case, the fresh water injected from the 1st stage flows into the 2nd stage. The effluent water discharged from the 2nd stage will be recycled and flow back to the 1st stage. If further desalting is needed, it is possible to add more stages in a similar manner. Such a multistage desalting system can increase dehydration efficiency by up to 99%.



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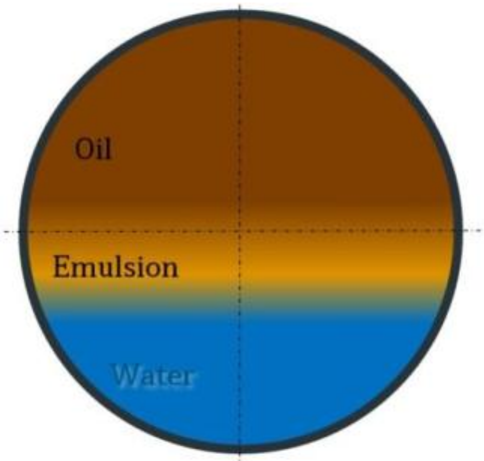
2.6 Emulsion layer

In most separation processes, there is no clear interface between two media, as separation progresses continuously inside the vessel. Instead, there is a hydrocarbon/water transition zone, also known as an emulsion layer. Standard level measurement does not enable sufficient control of the desalting process. Continuous, reliable information about the thickness and position of the emulsion layer is required, as these parameters are continuously changing. The desalting process runs at optimal efficiency when the emulsion layer is maintained at a level just below the electrostatic grid (approximately 150mm / 0.5ft). The emulsion layer has a typical thickness of 1 to 2ft. This means that the typical measuring range (MR) is 300 to 600mm (12 to 24”), depending on the customer´s specifications.

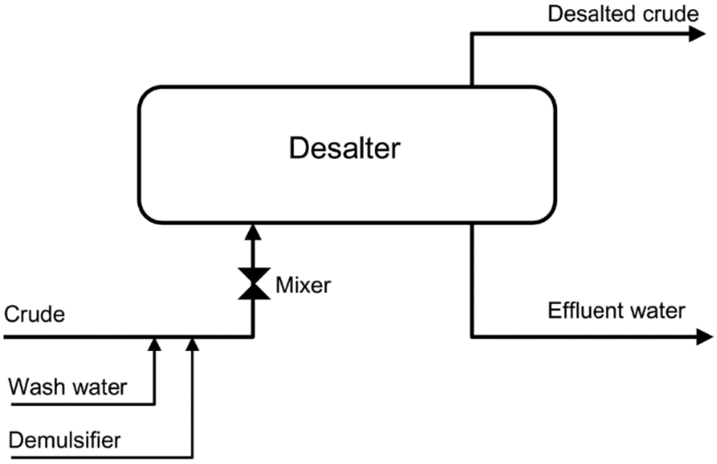


2.7 Emulsifier

In addition to oil and water, a third substance called an emulsifier or emulsifying agent must be present for a stable emulsion to be produced. This emulsifier usually exists as a film on the surface of the dispersed droplets. The amount of mixing depends on several factors and is difficult to avoid. In general, the greater the mixing, the smaller the droplets of water dispersed in the oil and the tighter the emulsion. Crude with a small amount of emulsifier forms a less stable emulsion and separates relatively easily. Other crudes contain the right type and amount of emulsifier, which leads to very stable or tight emulsions.

2.8 Demulsifier

Emulsion separation into oil and water requires the destabilization of emulsifying films around water droplets. This process is accomplished by using demulsifiers to neutralize the emulsifying agent. The demulsifier acts on the water-oil interface. The surface-active chemicals break the film that surrounds the water drops, enabling these drops to coalesce / collide and, through the natural force of molecular attraction, become sufficiently large. The demulsifier, together with the wash water, is injected into the oil stream via a mixing device located at a point before the crude oil enters the desalter. The mixing ratio is usually 1.4 ml/100 l to 2.85 ml/100 l (0.005 to 0.01 lbs/barrel). The mixing device is commonly a valve with a 0.3 to 1.4 bar (5 to 20 psi) pressure drop. It has been observed that good mixing helps to ensure successful removal of salt from oil.



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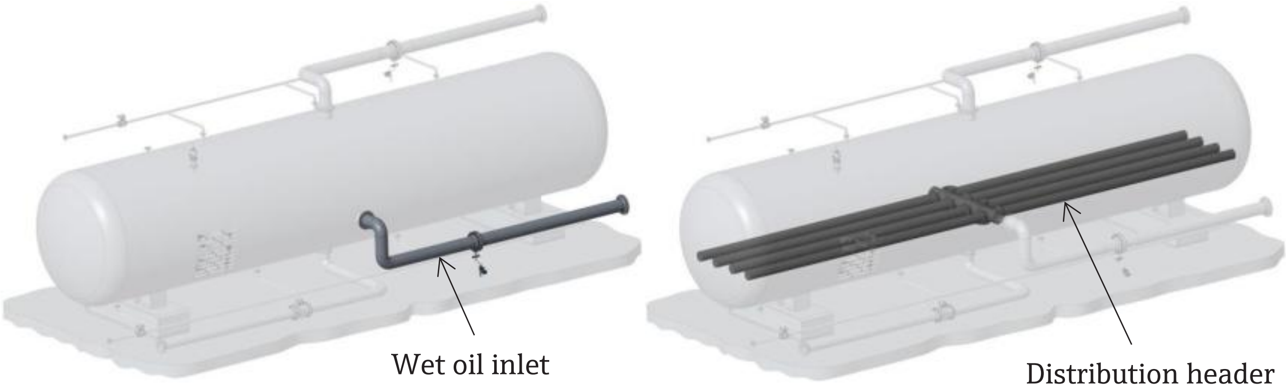
2.9 Desalter problems, causes and solutions

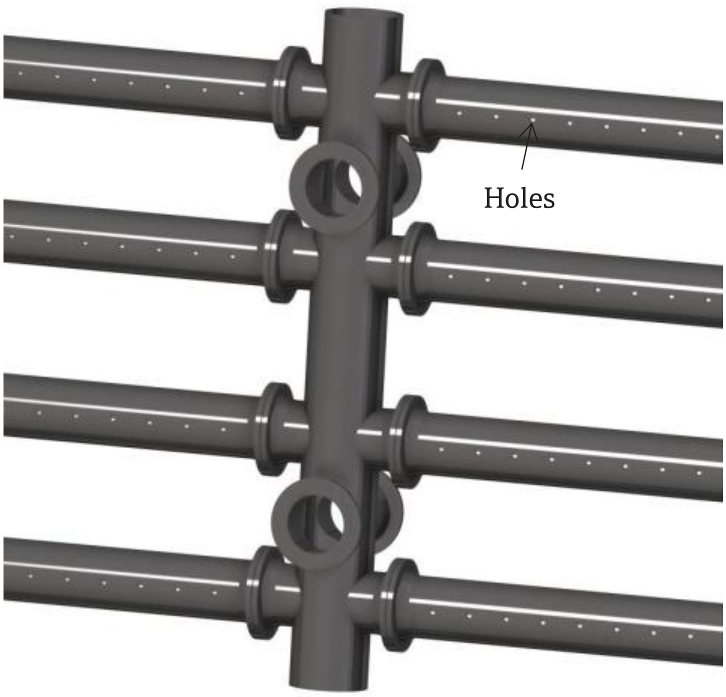
Problems	Causes	Solutions
High salt content in desalted dry oil outlet	▪ Feed salt content too high ▪ Wash water injection low ▪ Crude oil flow rate exceeds design flow rate ▪ Insufficient mixing of crude oil and wash water	▪ Increase wash water rate ▪ Reduce crude oil flow rate ▪ Increase mix value pressure drop
Too much oil in desalter effluent water	▪ Interface level too low ▪ Wide emulsion band at interface ▪ Excessive mixing of crude oil wash water ▪ Poor wash water quality ▪ Crude temperature too low	▪ Increase interface level ▪ Inject a chemical or dispose of emulsion ▪ Reduce mix valve pressure drop ▪ Check for waste in wash water source
High water carry-over in desalted dry oil outlet	▪ Wash water flow rate too high ▪ Excessive formation water in crude oil inlet	▪ Reduce wash water flow rate and commence or increase chemical injection ▪ Reduce interface level and check effluent water valve

3 Mechanical construction details

3.1 Wet oil inlet and distribution header

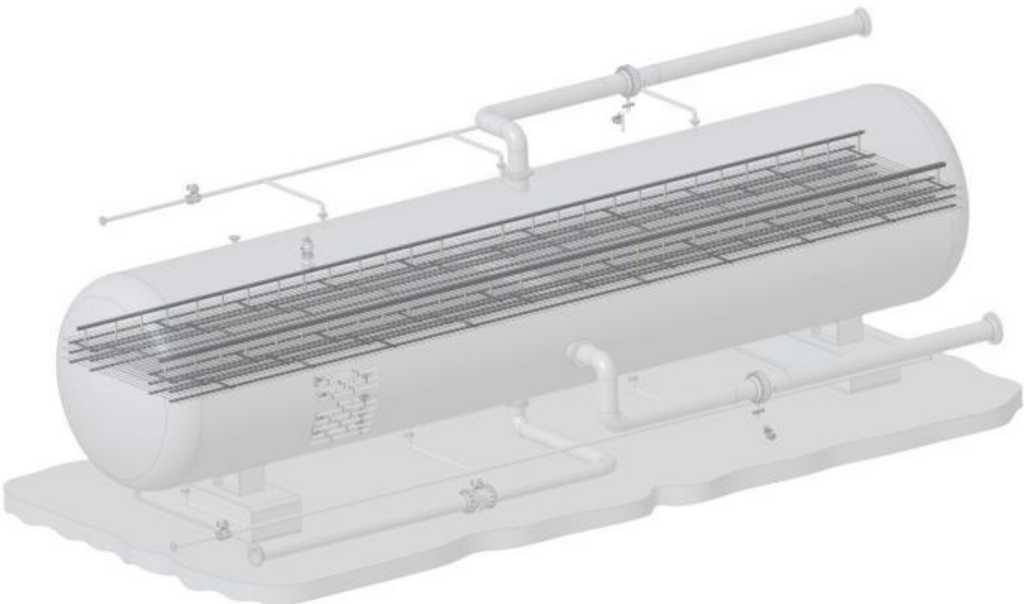
The wet oil (water and oil) entering the desalter via the wet oil inlet is preheated and mixed in a ratio of 1:20 (in general between 3 and 10% fresh water). It has been heated to about 110 to 150°C (230 to 302°F) and flows through a DN 250 to DN 400 (10 to 16”) pipe, depending on the inlet oil flow rate and vessel size. Higher temperature requirements will decrease the size of the vessel, but there is a trade-off between the vessel cost and heating costs. In order to ensure an equal volume and distribution of fluid, a “distribution header” is installed. It is positioned in the oil phase below the electrical grid, which ensures minimal disturbance to the interface pad. Numerous holes placed along the bottom portion of the spreaders result in an equal volume and distribution of fluid.

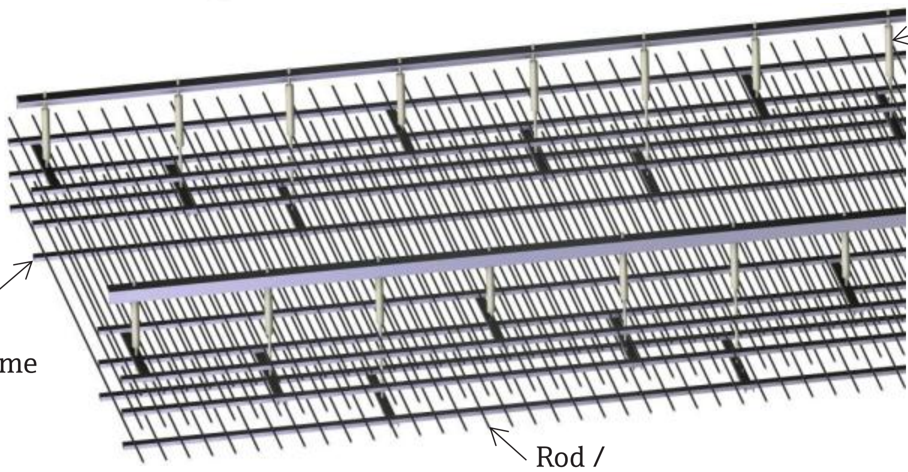




3.2 Electrical grid system

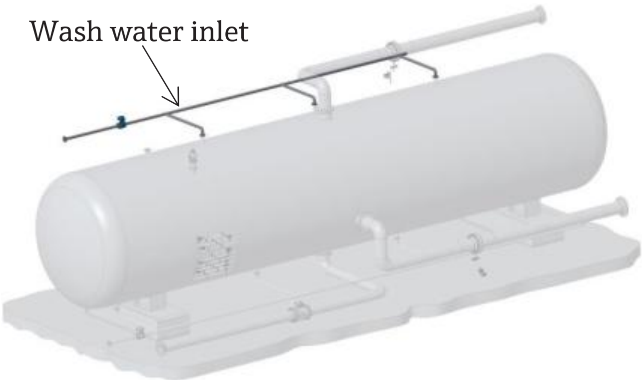
An electrical system connected to the electrodes within the desalter generates an electrostatic field at potentials ranging from approx. 6 000 volts to approx. 20 000 volts that induce dipole attractive forces between neighboring droplets of water. The electrostatic field results in each droplet having a positive charge on one side and a negative charge on the other. This causes the droplets to coalesce because of the attractive force generated by the opposite charges on neighboring droplets. The resulting larger water droplets (globules), along with water-insoluble solids, then settle to the bottom of the desalter where they will be withdrawn intermittently. This electrical grid system usually consists of rods / fences in horizontal layers. A design with vertical plates instead of rods is rarely used. The electrodes are suspended from the upper portion of the vessel shell using insulated hangers so as to electrically isolate them from conductive metals in the vessel. The typical grid spacing varies from 100 to 130mm (4 to 5”). A 2-grid system (2 planes) is still widely used. However, more modern and improved low-salt treaters are available in various other proven styles – 3 grids and 1-, 2- or 3-phase power supplies to achieve oil purity of 0.1% BS&W or better.

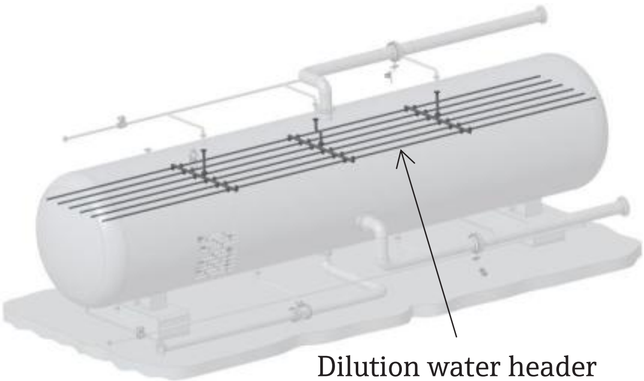


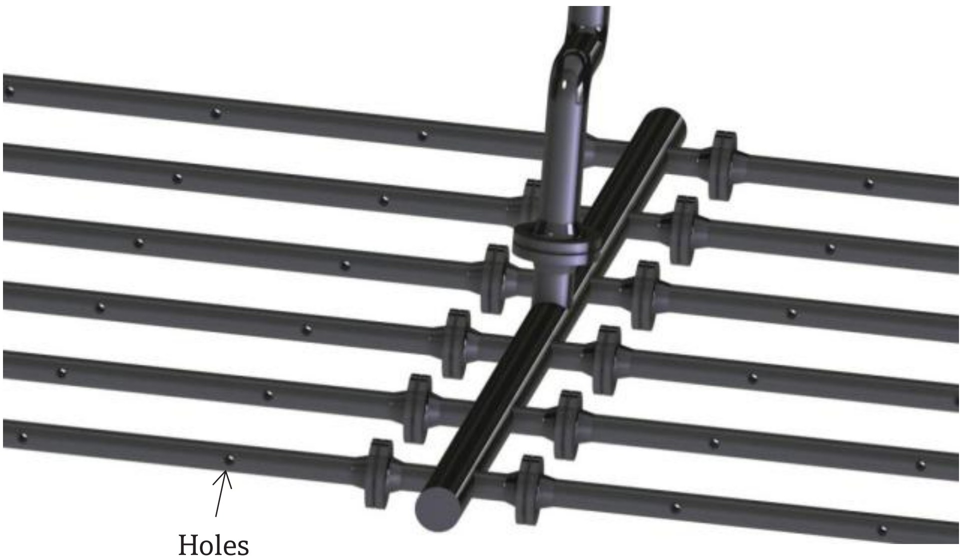


3.3 Wash water injection

With a preheated temperature of approximately 93 to 121°C (200 to 250°F), wash water for dissolving the salt is injected into the crude via an inlet having a typical pipe size of DN 80 (3”). As this water has a lower salinity than the remnant water in the wet oil, it washes out the salt and dilutes the salt concentration. This dilution water supplied to the desalter vessel must be deoxygenated to less than 10 ppb oxygen content, as too much oxygen can create high rates of corrosion. The pH value of the water should be between 6.5 and 9.0. Higher values lead to increased emulsion stability, with the result that excessive quantities of demulsifier are required for subsequent neutralization. Lower values lead to corrosion within the vessel. The water flows in laterals with orifices, sized to produce a slight pressure drop. It is sprayed in the zone of dry oil above the electrodes, in the form of coarse drops so as to prevent carry-over. These dilution water drops must be large enough (> 30µm / 1 200µin) to drop and flow vertically down between the high-voltage grid of electrodes. If the drops are too small, they will be carried up to the top and discharged with the dry oil into the top outlet. The rate of wash water required is about 4 to 10% by volume of the crude oil rate. The optimum rate varies in accordance with the API gravity of the crude oil and the desalter temperature and design. In a single-stage desalter there is a need for 5-7%, whereas only 1-2% is needed in a two-stage system.

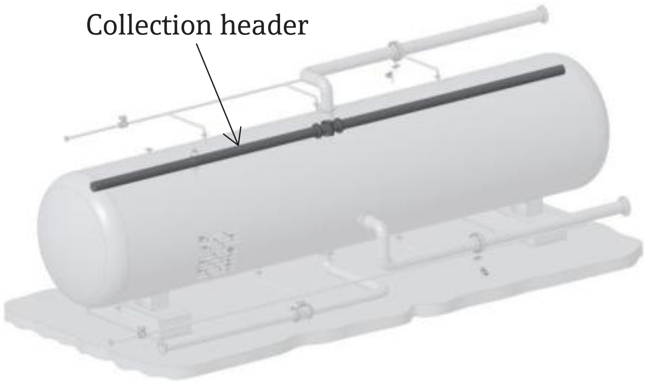


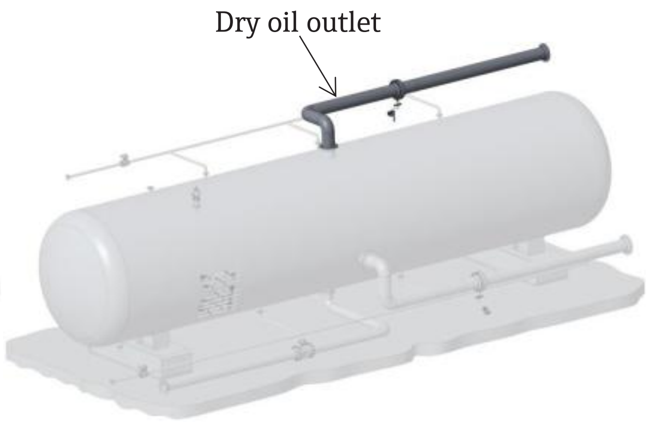


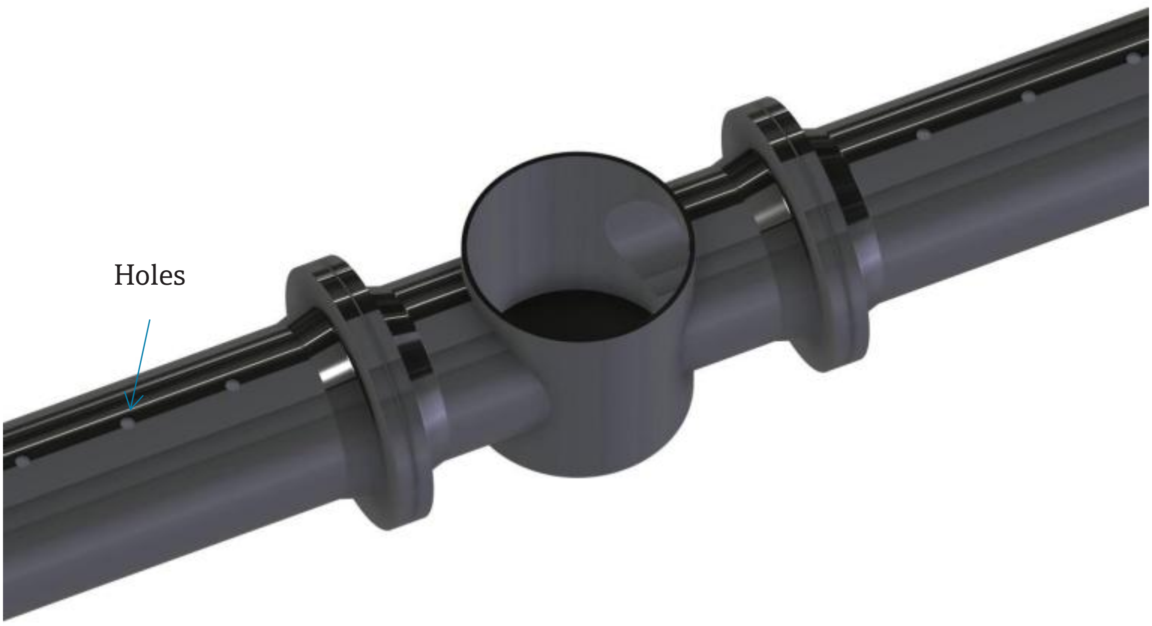


3.4 Oil outlet and collection header

The dehydrated oil (dry oil) rises to the top of the vessel where it is collected in the collection header and discharged through the crude oil outlet piping. The collection headers extend the full length of the vessel and have holes in the collector tray which are sized to provide a sufficient pressure drop so as to ensure uniform collection. The dry oil leaves the desalter through a DN 250 to DN 400 (10 to 16”) outlet pipe at approximately 88°C (190°F) and proceeds either to the next process step or, in the case of an FPSO, to the export pipeline or a tanker.

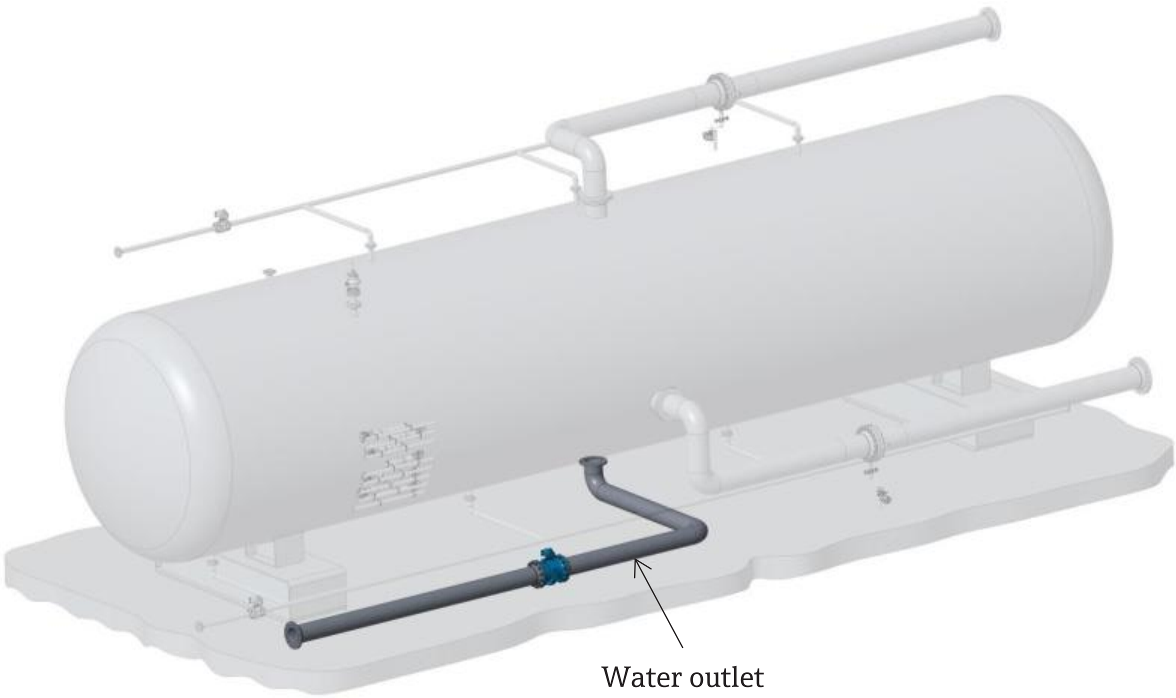






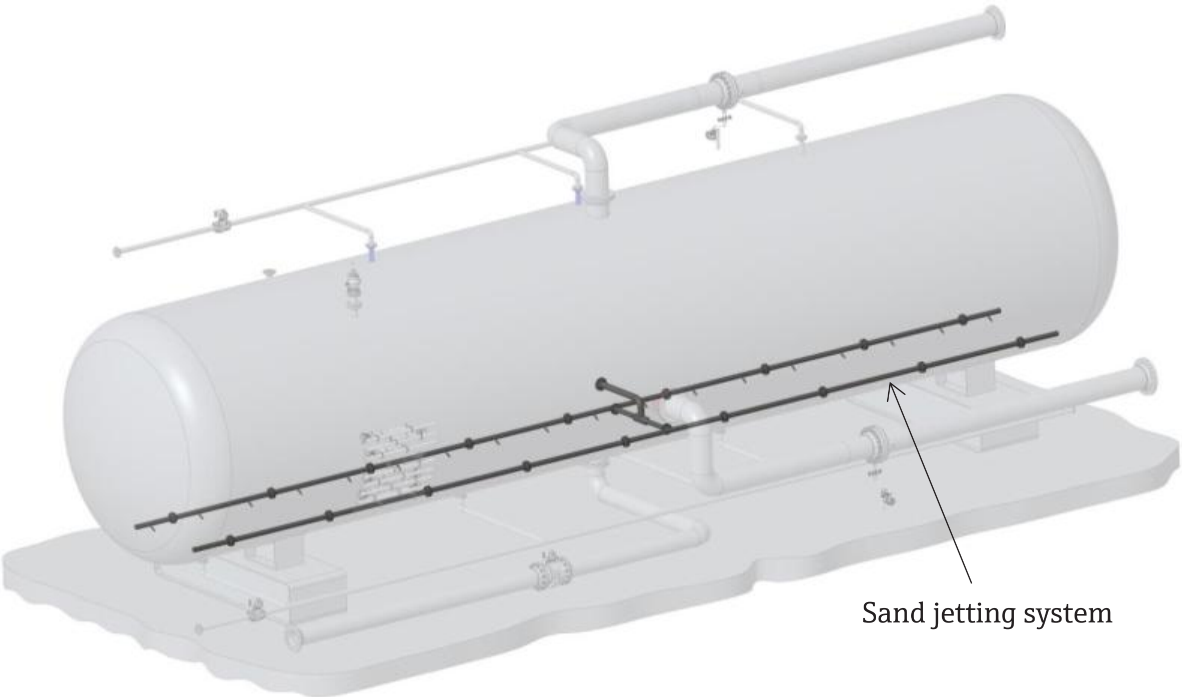
3.5 Water outlet

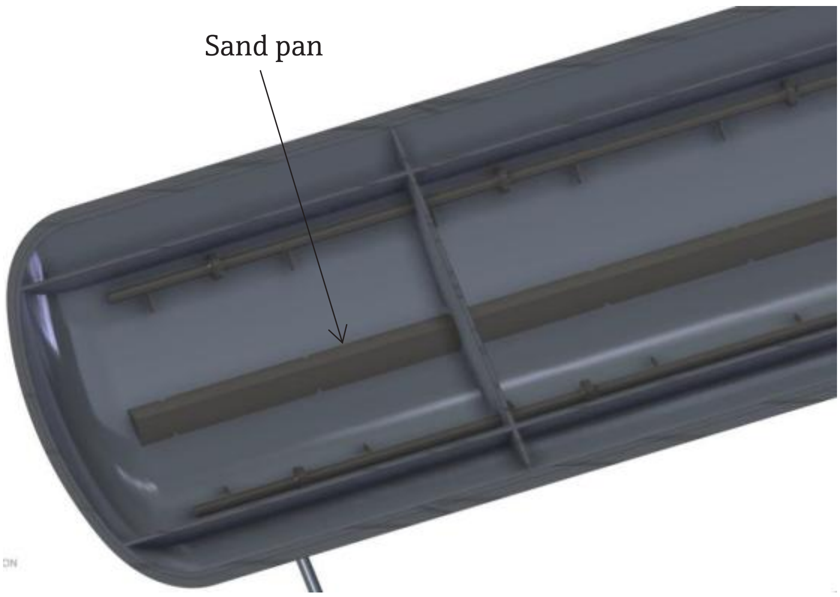
The settled water is extracted continuously from a point located above the base of the desalter, via the water outlet with a typical pipe size of DN 300 (12”). It is referred to as brine because it contains the inorganic salts that originally entered the desalter with the water in the crude oil.
The maximum acceptable oil content of the effluent water must be specified. This is normally done in terms of ppm. The value depends on the acceptable limit for any downstream effluent plant or the local authority regulations for effluent waters or injection water (if the water is injected into a reservoir via water injection wells). If local authority regulations are very stringent, emulsifying chemicals may have to be injected to achieve the required levels. The amount of effluent water from a properly operating desalter is < 250 ppm oil in water. In difficult applications, this wash water can be recovered and recycled in a 2nd stage dehydration and desalting process.



3.6 Sand jetting system

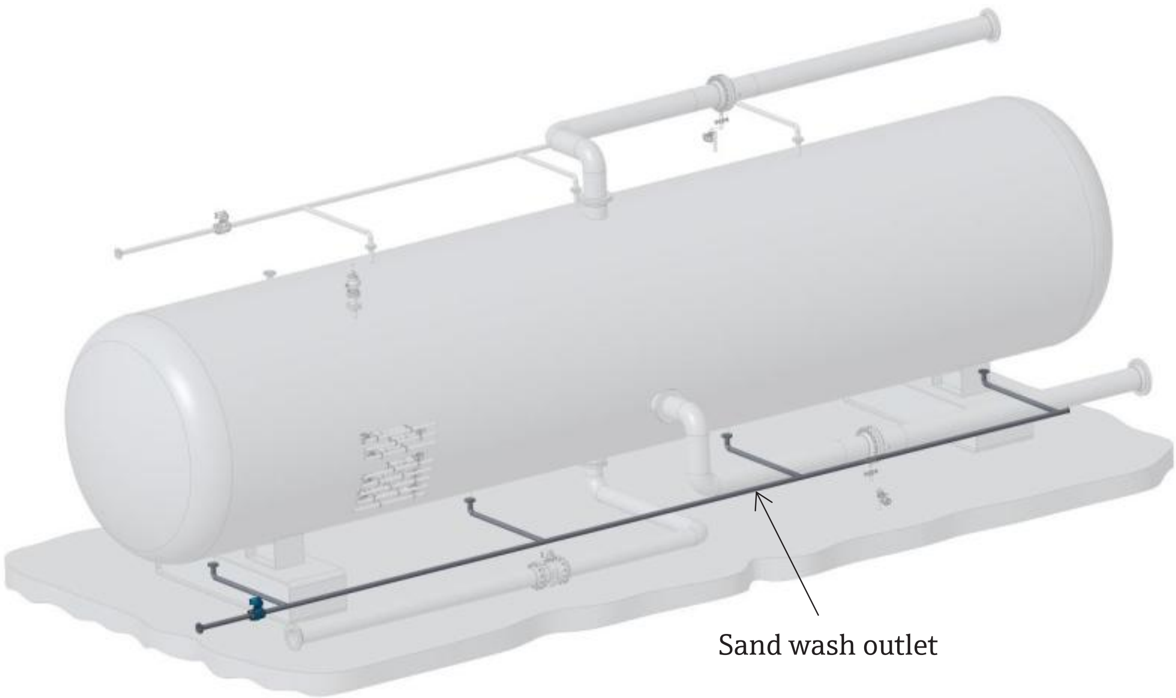
In order to remove sediments that have settled and collected at the bottom of the vessel, a sand jetting system is installed. The system consists of spray headers, which are positioned 0.3 to 0.5m (1 to 1.6ft) from the bottom of the vessel and spray either vertically or at an angle to the vertical, with an injection pressure that is typically 3.5 bar (50 psi) above the vessel operating pressure. The jets fluidize the sediments in the zone that is being washed. Above the sand drains runs a sand pan that prevents clogging of the sand wash outlet.





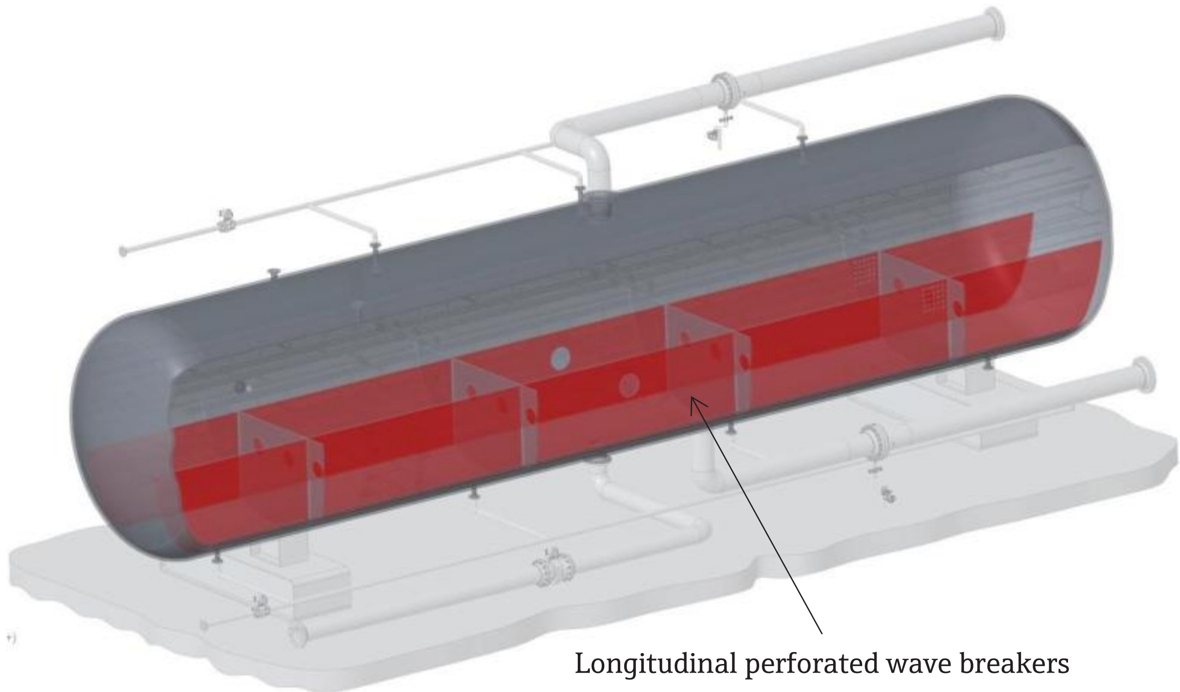
3.7 Sand wash outlet

The settled sediment is then withdrawn as sludge intermittently as needed, to prevent solids from entering the settled water withdrawal outlet. They leave the vessel via the sand wash outlet, which has a typical pipe size of DN 80 (3”). Some of the separated sand wash water will be recycled and pumped back into the sand jetting system. The operating frequency of the sand jetting system depends on the solids (mud) load and may be once per day or once per week. It should be adjusted onsite, based on operating experience. The removal of suspended solids is important because substances can go all the way through the refining process only to be expelled with the flue gas. As a result, the flue gas opacity may not comply with environmental requirements.

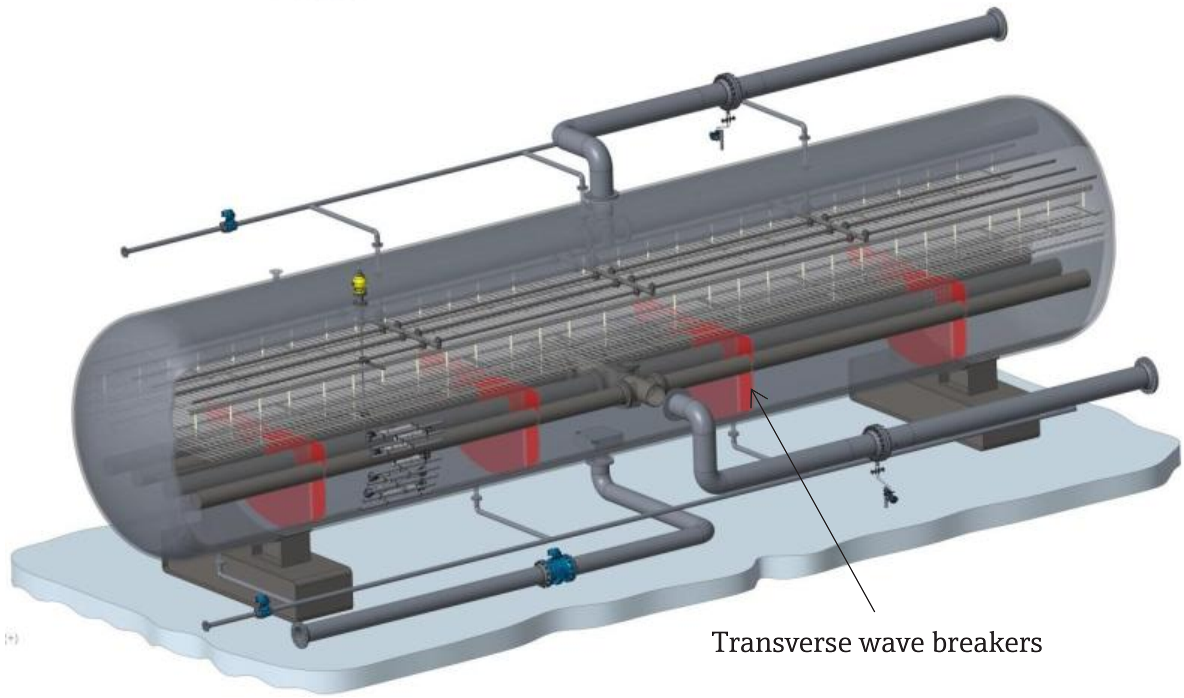


3.8 Wave breakers and calming devices

Calming devices are installed in separators and desalters for the purpose of distributing the fluids evenly throughout the vessel area, reducing surface waves and helping to maximize the efficiency of the separation process due to enhanced settling of the liquid. “Perforated calming baffles”, also known as wave breakers, are commonly used in separators on FPSOs, where there is a high degree of vessel motion and oscillation.



Longitudinal perforated wave breakers



Transverse wave breakers

4 Segmentation in interface applications

4.1 Measuring technologies used

In the desalting process, it is important that oil/water emulsion is maintained at the correct level. However, measuring the top and bottom of the emulsion layer presents a significant challenge for many measurement technologies because of variations in the properties of the fluids and the emulsion layer. In addition, the crude oil may contain sticky components that tend to build up on surfaces and coat probes or cause mechanical parts to stick. This can make measurements unreliable and inaccurate and increase the frequency of maintenance. The accuracy of many level measurement technologies is impacted by oil/water density fluctuations and coating caused by the crude oil and emulsion layer. However, for operators in the desalting process it is crucial to have confidence in the interface level measurement in order to maximize system efficiency and avoid a short-circuit when the water layer comes in contact with the high-voltage electrostatic grid.

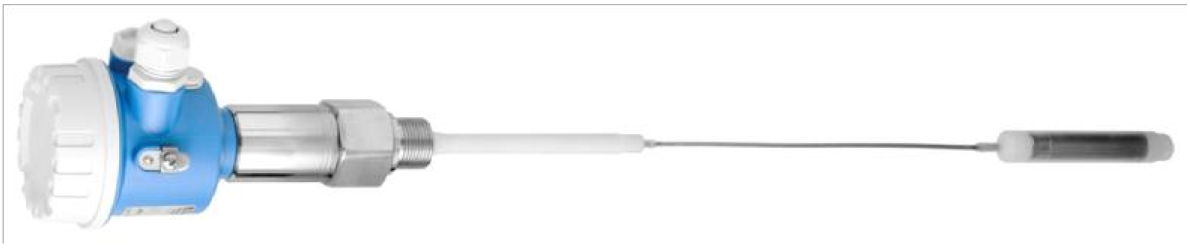
4.2 Sample tubes

Due to the challenges posed by the various technologies and the critical need to know the interface, desalters have been built with sample tubes to allow the interface location to be manually verified. However, this is by no means a state-of-the-art solution and certainly not what operators would wish for.

4.3 Capacitance

The capacitive measuring principle measures, as its name indicates, the capacitance of a measuring probe in a tank in relation to the tank wall or a reference. The grounded tank wall acts as a counter-electrode to the fully insulated probe rod/rope. Thus, changes in the level of the product can be measured using the altered capacitance value. Changes in the dielectric constant or the conductivity of the liquid do not affect the measurement result.

Liquicap M FMI52, fully insulated capacitive rope probe



Using capacitance probes or any other internal probes to measure/control the level interface in a desalter entails the risk of buildup formation, as these probes are susceptible to errors due to coating, resulting in unstable and unpredictable measurements. As desalters typically run for about five years before they are shut down for cleaning, the capacitive measuring principle is not ideal for desalter applications.

4.4 Guided wave radar

A guided wave radar device, e.g. Levelflex, is a “downward-looking” measuring system that functions according to the ToF method (**ToF** = **T**ime **o**f **F**light). The distance from the reference point to the product surface is measured. High-frequency pulses are injected into a probe and guided along the probe. The pulses are reflected by the product surface, received by the electronic evaluation unit and converted into level information. This method is also known as **TDR** (**T**ime **D**omain **R**eflectometry).

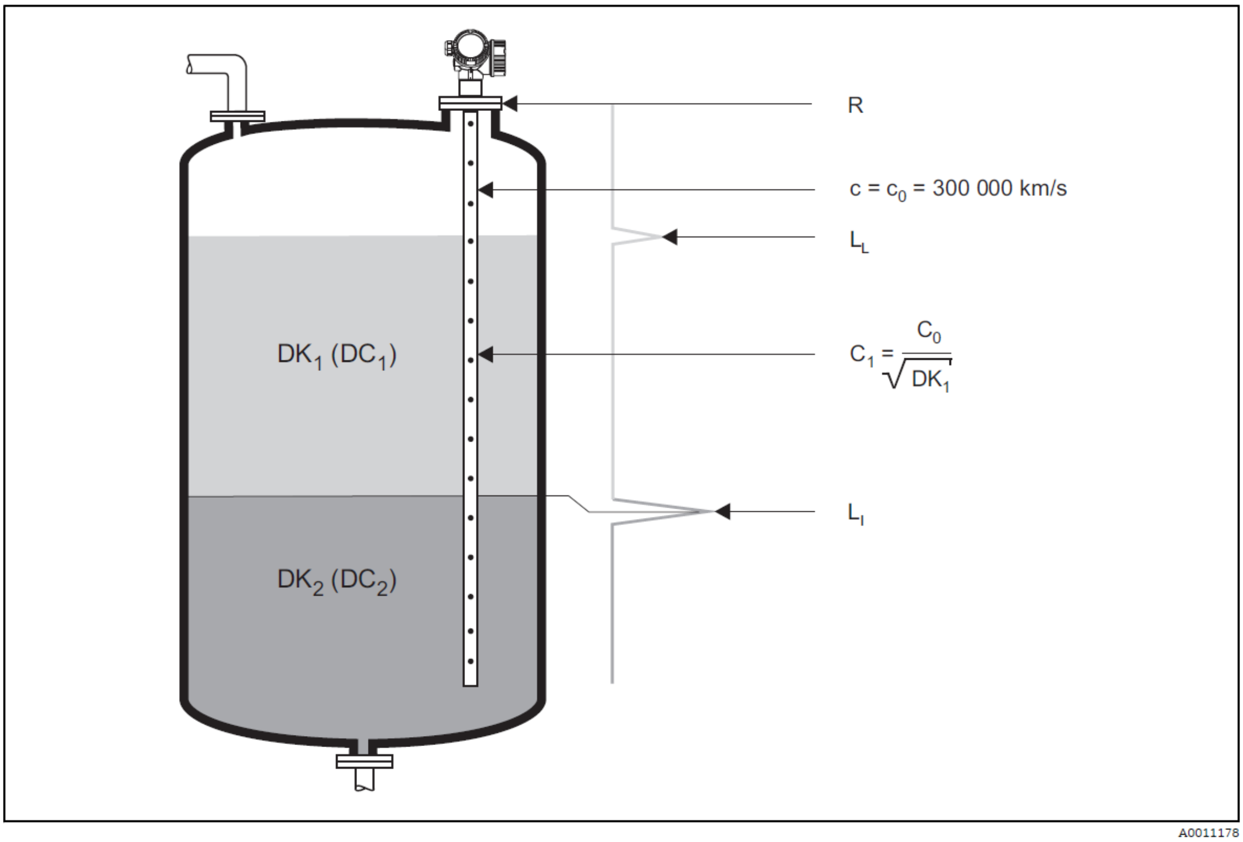
Interface measurement

When the high-frequency pulses hit the surface of the medium, only a percentage of the transmission pulse is reflected. In the case of media with a low dielectric constant DC1 (e.g. oil) in particular, the remainder penetrates the medium. The pulse is reflected once more at the interface point to a second medium with a higher DC2 (e.g. water). The distance to the interface layer can now also be determined taking into account the delayed time-of-flight of the pulse through the upper medium.

4.5 Multiparameter: Guided wave radar combined with capacitance

Measurement with emulsion layer

For interface applications, this method can be combined with a capacitive measurement as in the Multiparameter Levelflex FMP55, which measures the radar echo as well as the capacitance of the probe. This enables interface measurements even if the second echo is missing due to an emulsion layer between the two phases.



2 *Interface measurement with the guided radar*

LL Level complete
LI Level interface
R Reference point of measurement

When installing in tanks with a lot of internals or with internals situated close to the probe (which is the case in desalters), the use of a coax probe version is recommended in order to achieve a stable signal. This involves the use of an additional perforated pipe around the probe itself, which serves as a shield.

Levelflex FMP55, multiparameter probe

Unfortunately, with the problem of buildup that exists in every desalter, it does not make any sense to use a coax version of an FMP55, due to the fact that buildup will be present and will block the coax. True and correct level evaluation is not possible under these circumstances. Therefore, it is not possible for any FMP55 to work over a long period of time. The use of a standard Levelflex FMP55 (without coax) is not possible either because the electrical grid of the desalter will cause severe interference signals (a Levelflex does not have what is known as an inactive component). A guided wave radar device, such as an FMP55, can determine the total level and the interface but not the emulsion layer thickness.

4.6 Interface selection guide

	Guided radar Levelflex FMP51/52/54	Multiparameter Levelflex FMP55	Capacitance Liquicap FMI51/52	Radiometry Gammapilot FMG60
Clear interface liquid / liquid	Total level + interface layer	Total level + interface layer	Interface layer	Interface layer (Total level with separate measurement)
Interface with emulsion layer liquid / liquid	Not possible	Total level + interface layer	Interface layer	Interface layer + emulsion thickness (Total level with separate measurement)
▪ Interface with emulsion layer liquid / liquid ▪ Interface liquid / solid ▪ Multiple layer interfaceliquid / solid	Not possible	Not possible	Not possible	Interface-density-profile (Total level with separate measurement)

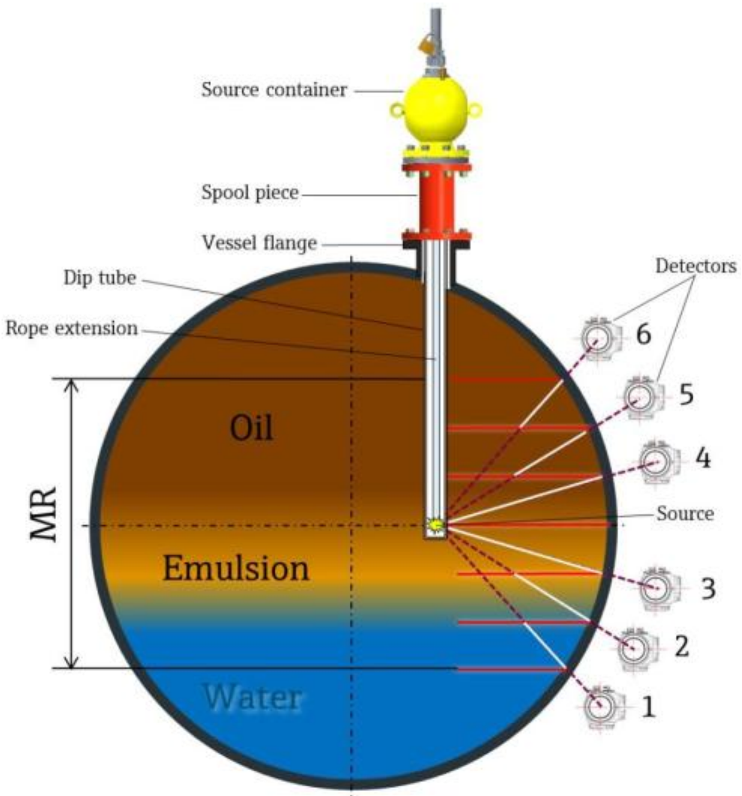
Our proposal

5 Density Profiling System – DPS

The inadequacies of the measuring principles described above mean that there is only one option available when reliable, long-term measurement with a high resolution is required – the Gamma Density Profiling System (DPS). Due to the high energy of gamma rays, this system is virtually unaffected by buildup and offers us a new way to see clearly inside a desalter.

5.1 Functionality

The measuring principle used in a Gamma Density Profiling System (DPS) is based on the absorption of radiation by the medium to be measured. The gamma source emits radiation, which is attenuated / absorbed as it passes through the medium. The requested measuring range (MR) is subdivided into several zones, known as layers. As the specific density value for each layer is measured by the absorption rate of the medium in this particular zone, the profile is calculated as a result. The measuring resolution / accuracy can be increased by reducing the layer height or by increasing the number of layers for the MR. Each detector on the outside of the desalter converts the measured radiation effect into an electrical signal. The resulting density profile is then analyzed by a special algorithm and the result visualized on a monitor. The main advantage of using such a profiling setup is that you are able to determine the exact position and density as well as the thickness of the emulsion layer in the desalting process.



5.2 Mechanical setup

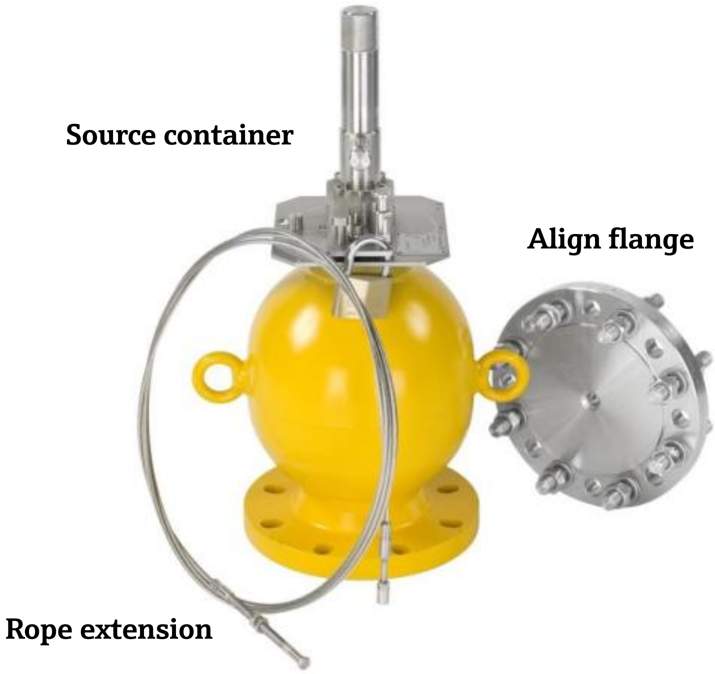
The following components are required for a Gamma Density Profiling System:

1) Radioactive source FSG60/61

The radioactive source (FSG60/61) is a radioactive isotope Cs137 or Co60, with a double steel encapsulation that complies with the highest classification of sources.

The source is placed in a source container (FQG63). In the “OFF” position the source container shields the radiation during transportation and storage. The FQG63 is designed for applications that require the radioactive source to be positioned inside the process vessel (to reduce the penetration length and thus the necessary source activity in larger vessels). For a perfect fit and easy installation on the desalter’s process connection, an align flange is provided (including thread bolts, nuts and washers). This flange is available in two versions - to fit either an ASME B16.5 NPS 4”150# flange or an EN1092-1 DN100 PN16 connection.

2) Source container FQG63 with rope extension element and align flange



When the source container is in the “ON” position, the radioactive source with a flexible extension can be lowered down inside the desalter via the dip tube with spool piece. This special protection pipe design is needed for two reasons. Firstly, the source container FQG63 must not be pressurized and secondly, the radioactive source should not come into direct contact with the crude oil – the dip tube keeps the source dry and clean. In addition to this safety aspect, the construction of the dip tube with spool piece allows the source container to be replaced without interrupting the desalting process.

3) Dip tube with spool piece (provided by customer)

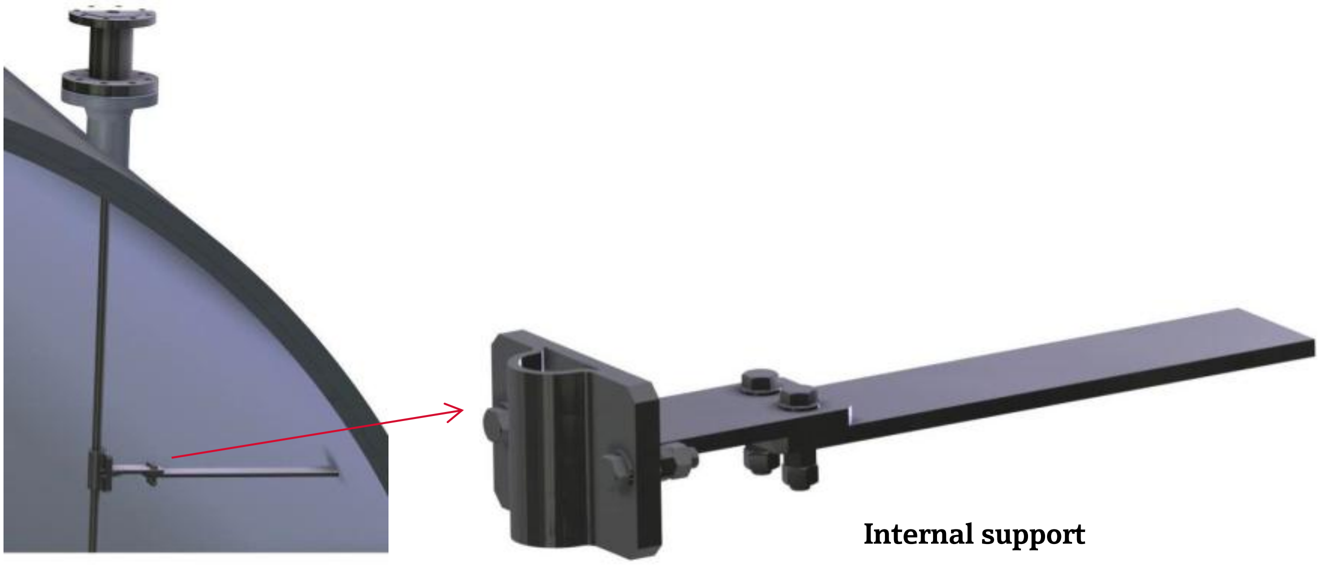
a) Straight version

b) **Bent version**

If there is an existing nozzle on the desalter, the distance between the radiation source and the inner tank wall may be too big if a straight pipe is used. In this case, a bent version with a specific bend radius is used. This allows us to reduce the distance between source and detector and thus reduce the penetration length through the media and the necessary source activity.

Note:

In most cases it is recommended that the protection pipe be secured using some internal supports to enable it to withstand the shear forces prevailing in the desalter. It is important that these supports are not positioned directly in the radiation beam path, as this would interfere with the measurement signal due to additional absorption.



Internal support

4) Gammapilot M FMG60 detector

Several detectors (Gammapilot M FMG60) are installed on the exterior of the desalter vessel. They receive the emitted gamma rays and convert them into electrical impulses.

5) Mounting accessory FHG60-3A1

To allow easy installation and precise adjustments to be made to the position during commissioning, a mounting accessory set (FHG60-3A1) is recommended for each detector. Using this mounting accessory, the detector can be affixed to a typical DN 50 (2“) pipe on the mounting frame of the desalter.

Mounting accessory set FHG60-3A1

6) Mounting frame

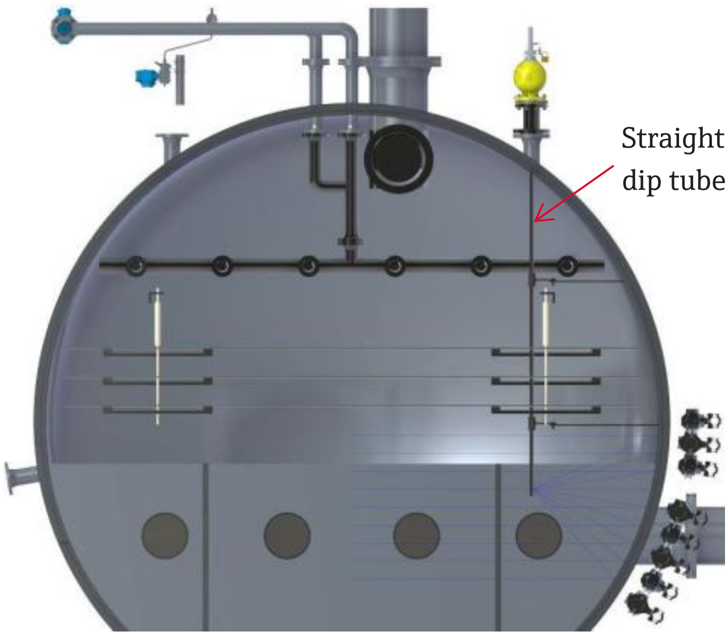
Mounting frame welded onto vessel

Freestanding mounting frame

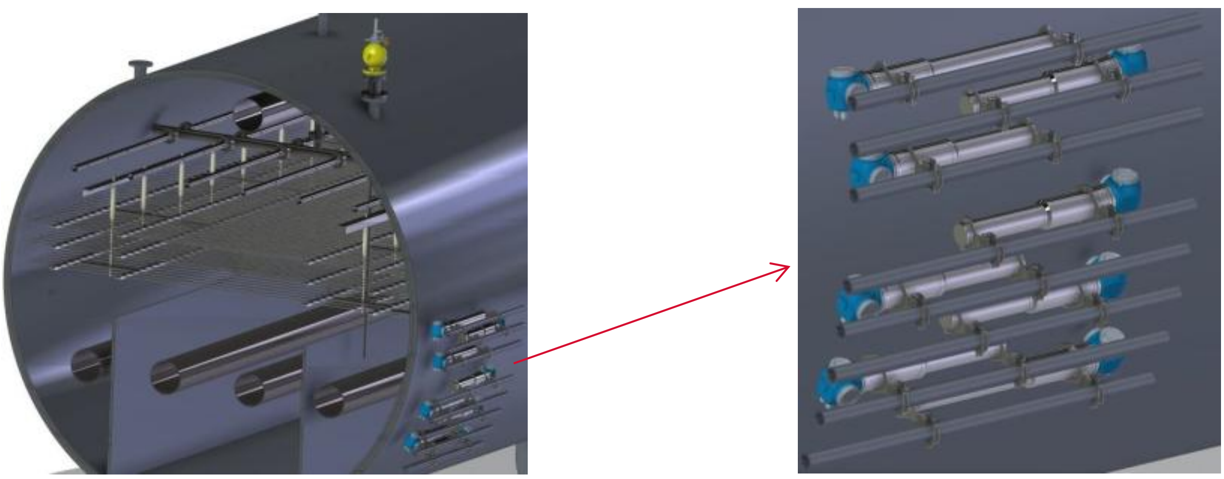
5.3 First desalter example with high resolution / large MR

Process/Vessel information

- Internal diameter: 4 267mm (14ft)
- Wall thickness: 30mm (1.2”)
- Insulation: 50mm (2“) Rockwool
- Shell: 1mm (0.04“) aluminum
- Density range: 0.8 to 1g/cm³ (50 to 62 lbs/ft³)
- **MR: 1 000mm (40“)** (8 layers with 125mm/5”)
- **Straight dip tube** with spool piece



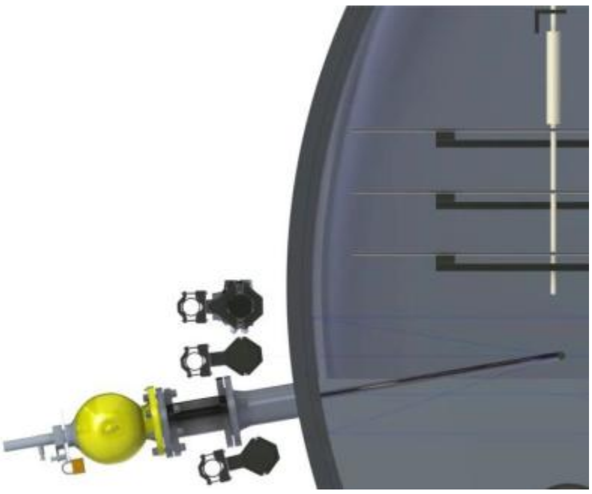
Arrangement with eight FMG60 detectors

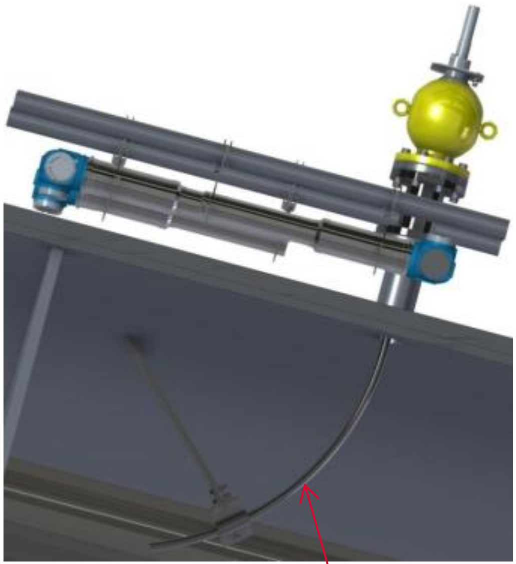


5.4 Second desalter example with low resolution / small MR

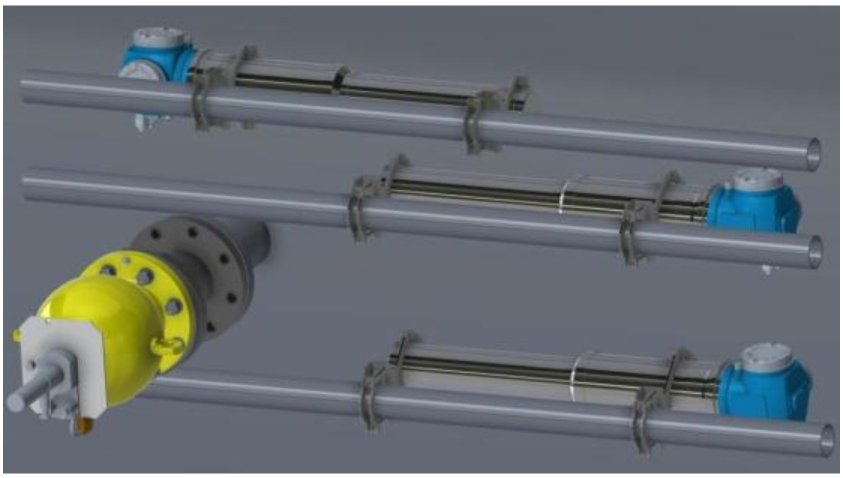
Process/Vessel information

- Internal diameter: 4 267mm (14ft)
- Wall thickness: 30mm (1.2”)
- Insulation: 50mm (2“) Rockwool
- Shell: 1mm (0.04“) aluminum
- Density range: 0.8 to1g/cm^3 (50 to 62 lbs/ft^3)
- **MR: 375mm (15“)** (3 layers with 125mm/5”)
- **Bent dip tube** with spool piece





Bent
dip tube



Arrangement with three FMG60 detectors

5.5 Calculating the density of each layer

The density of each layer (y) is calculated using the average densities ρ∅1 to x determined by detectors D1 to Dx.

Denotation:

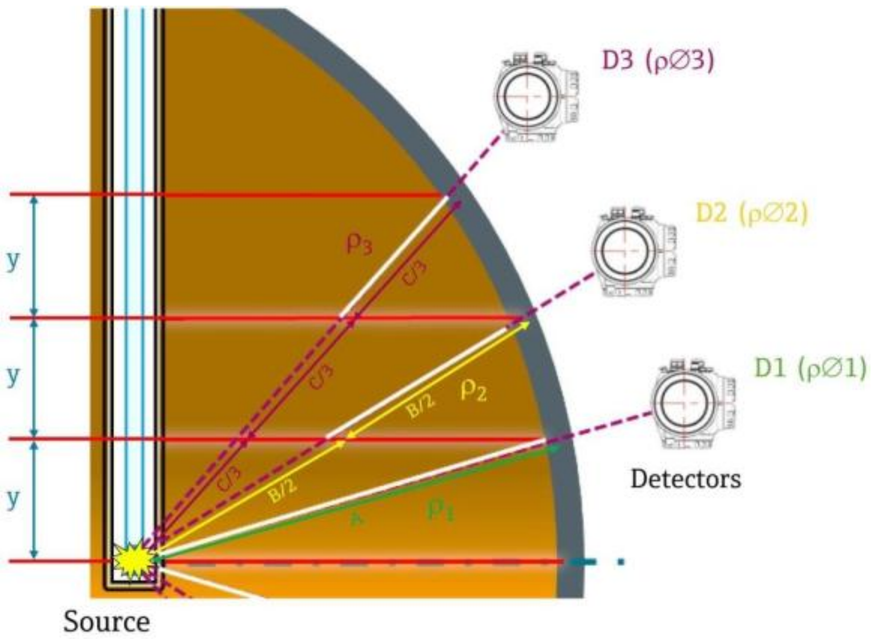
y = Height of layer

A, B, C = Penetration length through media and distance from source to inner tank wall, aligned to the corresponding detector D1, D2 and D3

ρ∅1, ρ∅2, ρ∅3 = Average density value measured by detectors D1, D2 and D3

B/2, C/3 = Geometrical section of penetration length for corresponding layer

Detector	Calculation step	Result
D1	$\rho\emptyset 1 \cdot A = \rho_1 \cdot A$	$\rho_1 = \rho\emptyset 1$
D2	$\rho\emptyset 2 \cdot B = \rho_1 \cdot \frac{B}{2} + \rho_2 \cdot \frac{B}{2}$	$\rho_2 = 2 \cdot \rho\emptyset 2 - \rho_1$
D3	$\rho\emptyset 3 \cdot C = \rho_1 \cdot \frac{C}{3} + \rho_2 \cdot \frac{C}{3} + \rho_3 \cdot$	$\rho_3 = 3 \cdot \rho\emptyset 3 - \rho_1 - \rho_2$



5.6 Defining the density ranges for visualization

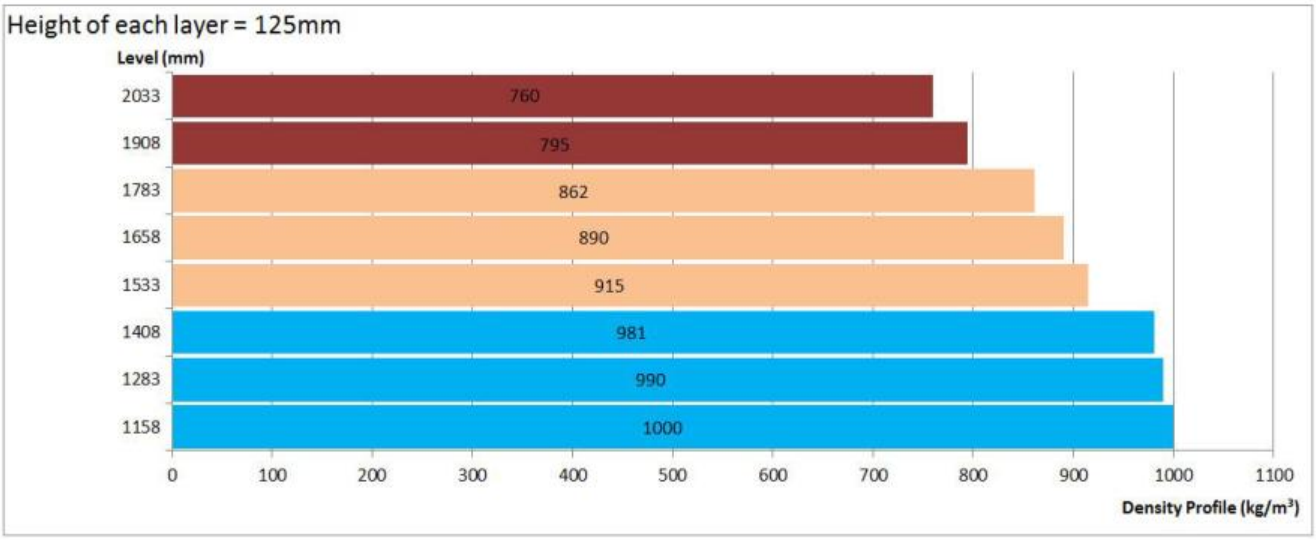
In the next step the different density ranges are defined. This involves assigning the calculated density of each layer to a medium based on a defined range. For example: Oil 750 to 860 kg/m³ (47 to 54 lbs/ft³), Water 980 to 1 050 kg/m³ (61 to 66 lbs/ft³) etc.

Medium			Density Range (kg/m³)		
Used	Name	Color	Min	Mean	Max
✗	Empty		0.0	0.0	0.0
✓	Oil		750.0	800.0	860.0
✓	Emulsion		860.0	920.0	980.0
✓	Water		980.0	1000.0	1050.0

Sample table from Profile Vision Compact (units in kg/m³)

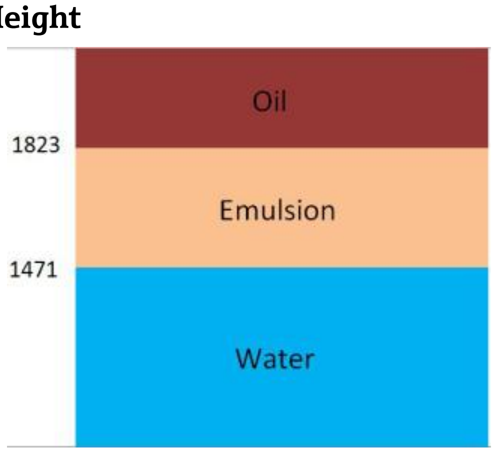
5.7 Calculating and visualizing the emulsion level

The average density of each layer can then be displayed based on the defined density ranges.



Eight layers – Evaluations from eight detectors (units in kg/m³ and mm)

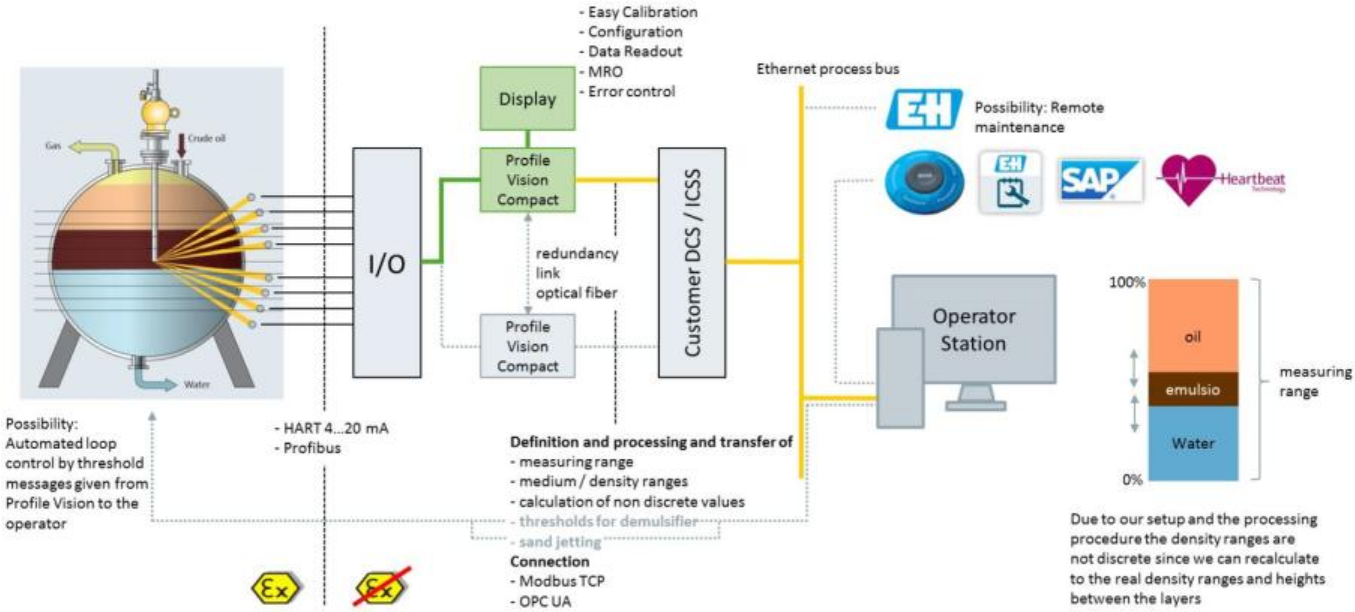
By calculating the respective positions of the different interfaces, it is also possible to show the exact heights of the media along the measuring range, or rather the height in relation to the horizontal tangent line of the inner vessel wall.



Derived high inter-layer resolution

5.8 Visualization with Profile Vision Compact / System overview

The density profile computer ("Profile Vision Compact") is a software solution that has been specially designed for this type of measurement. It visualizes the measurement results simply and clearly, so that the results can be utilized quickly for further process optimizations and user control. The solution package consists of a panel PC with a **H**uman **M**achine **I**nterface (HMI) and density algorithm software.



Front view:

7" Touch display

Back view:

Panel PC IO Card

- Cabinet friendly design
- Configurable IO's e.g. to
  - Define Demulsifier injection
  - Crude oil density
  - Start sand jetting

The visualization on the HMI is customized according to the customer's specific requirements. At the same time the information is transferred to the customer's system. For integration, the data can be transferred via Modbus, Ethernet/IP or Profibus, making it possible to visualize the process within the control room.

With "Profile Vision Compact", multiple desalters can be connected via the visualization software for easy access to complete site information. A local touchscreen displays all of the details about the site, enabling operators in the field to access the same data as the operator in the control room. From the homepage you can zoom into the details of each measurement. Digital communication enables status monitoring of connected devices. This allows operators to perform predictive maintenance and to quickly identify problems. A password protects against unauthorized access.

It is also possible to connect other sensors to "Profile Vision Compact", for example pressure or temperature devices. This makes it possible to quickly view other process parameters within the desalter.

5.9 Calibrating the system

For a correct definition of the exponential curve of the density measurement, a two-point wet calibration of the system is performed while commissioning the desalter measurement. The procedure is as follows:

- **Background calibration**

With the source container in the OFF position, the detectors systematically scan the environment for any natural radiation present, such as cosmic or terrestrial radiation, or for interference from other radiometric measurements nearby. Later on, these values will be factored into the regular measurement.

- **Water calibration for point 1**

In the next step, the vessel is filled with water to at least 100mm (4“) above the height of the highest detector position. Then the source is switched on and water calibration is performed for point 1.

- **Oil calibration for point 2**

Next the source is switched off before emptying the vessel and refilling the desalter with a crude oil of a known density value / API grade. As before, it must be ensured that the desalter is sufficiently filled before the source is switched on again and oil calibration is performed for point 2. The calibration of the system is now complete.

6 Increasing desalter efficiency

6.1 Potential refineries for DPS

Generally, using Endress+Hauser’s Gamma Density Profiling System enables the operator to gain a detailed insight into the medium interface levels and emulsion layers in a desalter. The DPS is particularly suitable for use in refineries with the following characteristics:

- Oil with a low API grade(<35)
- Old desalter vessels with low efficiency
- Changing crude oil with different API grades
- Crude oil with high water content
- Any issues with buildup /coating
- Any issues with higher sulphur content
- Any other issues which create emulsion > 100mm (4”)

6.2 Commercial considerations

a) Savings on demulsifier

The average amount of demulsifier required is up to 2 ml per 100 l crude oil (0.0075 lbs/barrel). In a typical desalter with a flow rate of 70 000 bpd, a quantity of 227 liters (60 US gallons) of demulsifier is needed per day. At a cost of $35 US per gallon, this results in $2,100 US being spent per day on demulsifiers. If the desalting process were to become 10% more effective through the use of Endress+Hauser's Gamma Density Profiling System, **the potential operational cost savings would be $210 US per day / $77 000 US per year.**

b) Savings on labor and associated costs

If the desalting process is fully automated due to the use of the Density Profiling System, savings can also be achieved in terms of labor and associated costs. A typical sampling procedure can take up to 6 hours of an operator's time during a 12-hour shift. Using the Density Profiling System, time savings of 30% can be achieved.

Customer testimonial:

"The costs of such a system are not exactly low, however through lower lab costs and less downtime the system has paid for itself quickly. If the system provides accurate and reliable data there is a long-term advantage over the lifetime of the equipment."

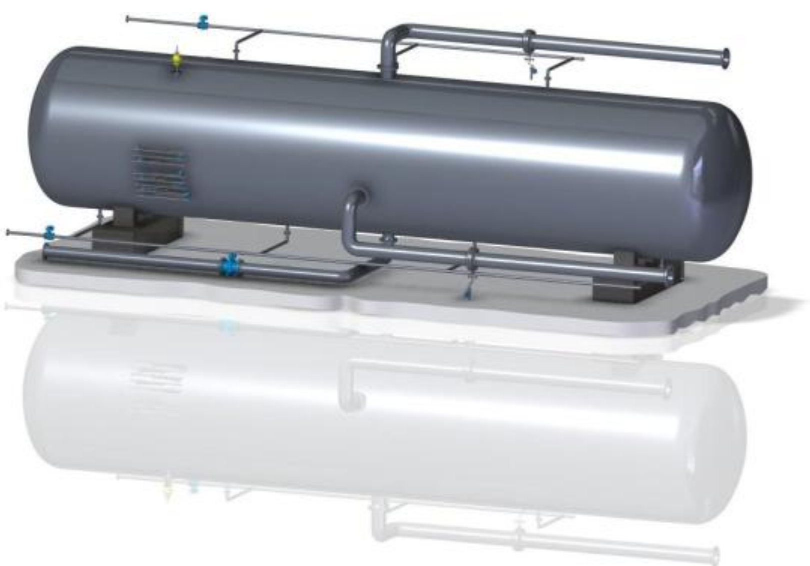
c) Reduced desanding frequency with additional sand layer measurement

During the desalting process, a certain amount of sediment accumulates in the bottom of the desalter. Typically, once a week the sand jetting system is turned on without interrupting the process. By means of spray nozzles in the bottom of the vessel, a high-pressure water jet fluidizes the sediment so that it can be extracted via the sand wash outlet. By using an additional measurement in the sand layer, the operator can actually see any sediment deposits in the desalter and not only when they reach a certain level. This enables the operator to run the mud wash system safely in fully automatic mode.

6.3 Benefits of Gamma Density Profiling System in desalters

Benefits at a glance

- **More effective desalting process**
  due to “monitored” emulsion layer of a certain thickness and position
- **Less fouling and corrosion of equipment**
- **Longer run times**
- **Reduced maintenance requirements** between and during shutdowns
- **Reduced frequency of desanding**
- **Reduced wastewater treatment**
  Significant in light of emission limits being more stringently enforced through government legislation. (A more efficient desalting process minimizes the quantity of hydrocarbons released into the wastewater)
- **Cleaner flue gas**
  Reduced quantities of suspended solids in the downstream process make it easier to fulfill more demanding environmental requirements
- **Cost savings due to reduction in chemical additives** (emulsifier and demulsifier)
  Reduction in the use of very expensive agents that can have negative side-effects on subsequent downstream processes
- **Lower operating temperatures** (less salt cakes)
- **Lower fuel costs** (less heating)
- Reduction in water means a **decrease in pumping costs**
- **Crude oils of different qualities and densities can be used**
  since the system automatically adjusts to changing process conditions
- **Increased production of saleable oil**
  due to reduced volume loss and residue



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