

Produced Water Treatment



Hydrocyclone Vessel

Product Definition

Produced water is a term for reservoir water that is separated during the oil and gas production process. Oil and gas reservoirs normally contain amounts of water, oil, solids, condensates and gas. When the oil and gas is processed, water is separated and pumped back into the reservoir in order to maintain the right pressure in the well. Alternatively, the water is discharged to the sea or sewerage. Both methods involve a set of conditions and strict regulations aimed at preventing well contamination and water pollution.

When the oil and gas reservoirs are depleted, water content may be as much as 98% of the total fluids being produced. As a result, the handling and treatment of produced water up to the required quality levels becomes an increasing cost factor in the total Life Cycle Cost of an operated asset.

Product Description

Frames designs produced water treatment packages in accordance with client specifications and project requirements.

Following a thorough analysis of the inlet conditions and outlet requirements, our team of specialists selects the most suitable combination of technologies and integrates them into a process package to achieve the required performance.

The Frames Produced Water Treatment Packages enable high availability, a large turndown range and practical operation as well as easy access to valves, instruments and pumps. During the design phase, our team pays special attention to aspects such as plot space, weight, maintenance and total life-cycle costs.

Our solutions for removal of hydrocarbons and/or suspended solids from the produced water are divided into systems for Onshore and for Offshore locations, each with the most appropriate and effective technologies. Offshore applications have special requirements in terms of space and weight limitations. In case of "Floating or FPSO" production, the process is subject to wave motions.

Technologies for onshore locations include:

- Coalescing plate separation (CPI)
- Induced gas flotation (IGF)
- Multimedia filtration

Technologies employed in offshore locations:

- Cyclonic de-oiling and de-sanding
- Compact flotation (CFU)
- Solids removal & cleaning

Frames system configurations for produced water treatment usually consist of a first stage separation process for bulk free oil removal, followed by a secondary treatment step for removal of small oil droplets. The combination of primary and secondary systems will meet 90% of the requirements for discharge limits. If required, we can extend these systems with media filters and sand extraction/cleaning equipment to meet specific demands.

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Process Descriptions

Onshore technologies

The produced water from the separators is typically processed with a so-called Water-Oil Separator (WOSEP) or a Coalescing Plate Separator (CPI), followed by Induced Gas Flotation (IGF) and Multi-Media Filtration.

Coalescing plate separation

Produced water coming from upstream separators is saturated with dissolved gas, which will partially evolve when it enters the Frames Coalescing Plate Separator (CPI). The inlet distributor and inlet section of the CPI are designed to allow this gas to be flashed out, and to reduce turbulences of the incoming liquids. The inlet section contains an inlet distributor and a distribution baffle to evenly distribute the liquids over the cross-sectional area of the vessel.

When the water has passed the inlet section, it is treated by a coalescing plate package that enhances the oil/ water separation process. The plate package is designed to cope with the expected content of solids.

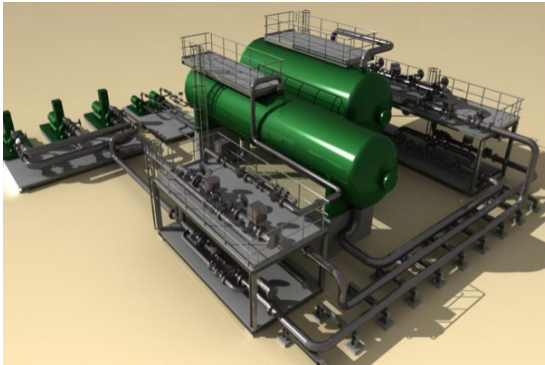
The following step consists of a separation compartment that allows the agglomerated oil droplets to float to the oil layer. The oil is skimmed off by an oil weir, designed as a bucket. The water passes underneath the bucket and over a water weir into the water compartment.

The water level in the CPI separator is controlled by an overflow weir; the oil level is controlled by means of a downstream control valve.

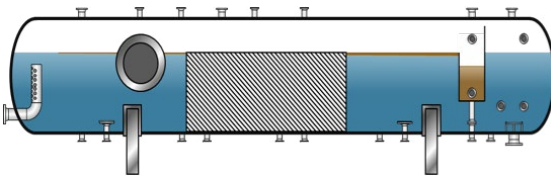
Induced gas flotation

A Frames Induced Gas Flotation Unit (IGF) receives water from the Coalescing Plate Separator (CPI), as well as an additional stream from the second stage separators and dehydrators. Water from the CPI still contains dissolved gas, which will be used in the IGF vessel for gas flotation.

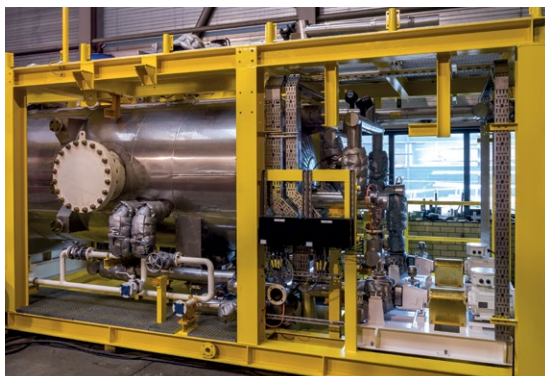
The produced water enters the inlet section of the vessel where a deflector plate / baffle ensures even flow distribution across the cross sectional area of the vessel. The water then passes down the length of the vessel through flotation cells. Each flotation cell is separated from the next by a perforated baffle, which is designed to maintain a uniform flow through the flotation cell.



CPI + IGF Separator



Typical CPI Vessel Lay Out



Skid Mounted CPI Separator



Coalescing Plate Packs with Sand Jetting

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The vessel utilizes gas dissolved in the incoming water to entrain gas into the vessel bulk liquid. In order to optimize the flotation effect, a clean water recycle is taken from the downstream section of the IGF vessel and enriched with fuel gas. This gas passes through a bubble shear plate, creating small gas bubbles. These entrained gas bubbles have the effect of floating oil droplets to the surface of the water where they form a foam/scum layer. The final step consists of removing the foam and oily water scum by overflowing a weir into a side launder. In addition to gas flotation, the flotation vessel also acts as a gravity separator, which means that the longer the gas remains in the vessel, the greater the performance of the vessel will be.

The IGF is controlled with a level control valve that is located downstream of the flotation unit. Water from the unit is routed to downstream media filters, whereas oil is routed to a reject tank.

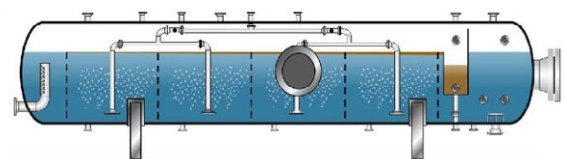
Multi-media filtration

Frames Media Filters involve hybrid technology that combines the oil removal performance of nutshells with the solids filtering ability of fine garnet. The filter bed essentially includes three layers: the top layer consists of nutshell for oil removal, the middle layer is composed of fine garnet for the removal of fine solids, and the bottom layer consists of coarse garnet that acts as a bed support for the two upper layers.

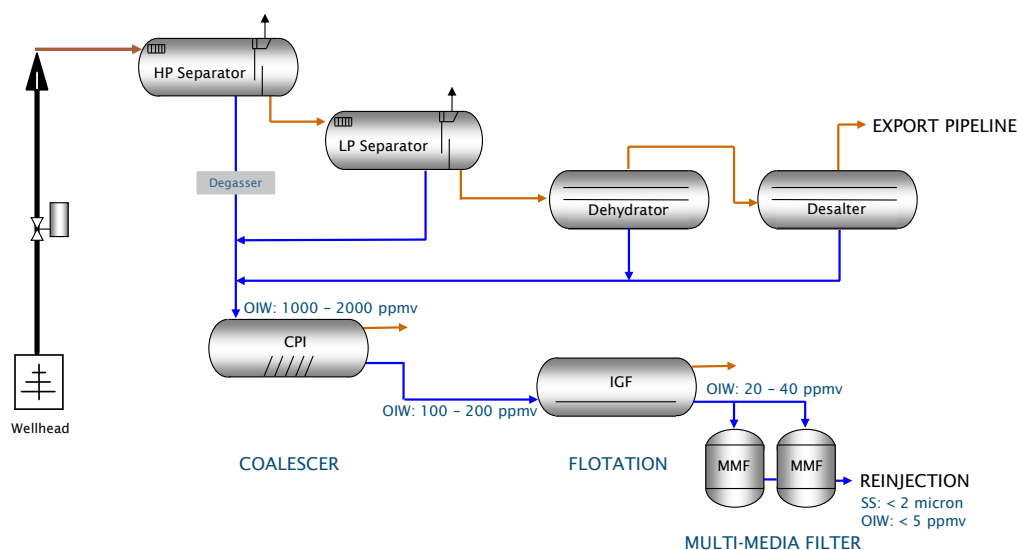
Filters that only utilize nutshell are unlikely to perform as required because of the very small mean solids diameter associated with the package feed. For this reason Frames uses a combined nutshell/garnet media filter, to provide the required solids and oil removal guarantees in a single stage of filtration.



Induced Gas Flotation Vessel



Typical IGF Vessel lay-out



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Process Descriptions

Offshore technologies

Offshore the produced water from the separators is typically processed with Hydrocyclones followed by Compact Flotation.

Cyclonic de-oiling and de-sanding

Our hydrocyclones remove 90 – 95% of free oil from the produced water flow. As the water enters a hydrocyclone liner, the tangential inlet creates a spin within the short cylindrical inlet section. The cylindrical section helps to establish the spin prior to the fluid passing downwards into the conical section, where it is accelerated as it moves towards the apex.

Separation efficiency is governed by five main factors:

- Droplet/particle size
- Differential density
- Viscosity of the bulk fluid
- Gravity (or centrifugal force)
- Distance of droplet/particle to outlet

Compact flotation unit

A compact flotation unit uses centrifugal force to direct the heavier water droplets to the outside and the lighter oil droplets to the vessel core. To enhance the liquid/liquid separation process, the unit is equipped with a clean water recycle stream that contains fuel gas (dry gas) bubbles. The combined inlet stream is forced through a bubble shear plate, which optimizes the contact between the gas bubbles and oil droplets.

Gas bubbles enhance liquid/liquid separation due to their tendency to adhere to oil droplets. Oil droplets together with the gas bubbles are forced to the vessel core due to the centrifugal force and density difference and float to the surface. The combined reject oil phase is transferred to the closed drain or degasser vessel.

Compact flotation units are limited in terms of the maximum capacity per unit because minimum centrifugal forces must be achieved.

The units are equipped with twin tangential inlets, which maximizes turndown and produces the required flow patterns, even at lower flow rates.



Hydrocyclone Skid



Compact Gas Flotation Skid



Produced Water Treatment Skid

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Vertically designed vessels require a much smaller plot space than horizontally designed flotation units. Moreover, they offer excellent performance with wave motions.

Solids removal & cleaning

The sand/water slurry from the separators and the reject flow from cyclonic de-sanders can be transferred to a sand cleaning package.

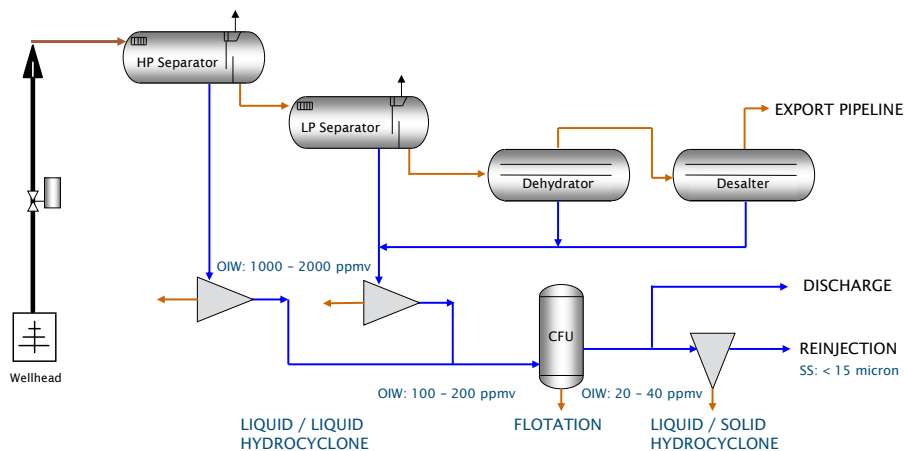
This package separates solids from the oily water in the accumulation vessel by means of Ceramic Cyclone Liners. The solids accumulate in the accumulation vessel for further treatment, with water routed to the closed drain or separators. When the accumulation vessel is full, sand is transferred from the bottom of the vessel and recycled through the solid-liquid hydrocyclones placed on top of the accumulation vessel. After a few washing cycles the sand is clean enough to be collected in the sand bags.



Sand Cleaning Skid



Desanding Skid



Our Family Tree

Challenges never fall neatly into one category. That's why we work one-on-one with our customers to craft unique solutions to their specific needs. With our Frames family of oil and gas solutions, we have a wide breadth of products and services available in the onshore, offshore and floaters segments. In each segment, we design, build and deliver solutions to specific projects in oil and water; gas; and flow control and safeguarding. We can also design integrated solutions, drawing from all these areas. All of our products are supported by our high-quality services.

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Frames Family Tree



Produced Water Treatment

Project Management

At Frames, we know that precise project management is only the starting point for completing complex oil and gas projects. Our clients can rely on sharp thinking and a deep understanding of their operating conditions to find the best solution. Our quality management system focuses on a process of continuous improvement, and our team is always looking for new solutions that improve productivity, cut operating costs, and give our clients a competitive edge.

In a challenging industry, we understand that safety is a priority. We also know that in order to deliver maximum value to our clients we must complete each project on schedule, on spec and within budget. At Frames, our close-knit team of engineering experts is open, honest, and focused on delivering you the best possible solutions. We are passionate about the oil and gas industry, and have been a leading provider of safe, high-productivity systems for more than 30 years.

Technical Details

- Optimization of vessel dimensions
- CFD verification of design
- 2-phase, 3-phase
- Custom made
- Wider turndown
- Lower fouling

Added Value Frames

- 30 years of experience
- Sturdy and reliable design
- Lower footprint
- Lower CAPEX and low maintenance costs
- Lower pressure loss
- Applicability to full turndown range
- Field and lab testing
- Debottlenecking studies: analysis of operational problems and their solutions
- CFD studies: intrinsic physical characteristics of separators. Performance enhancement studies

References (selection)

- Dunga Field - Maersk, Kazakhstan
- Lower Fars - Kuwait Oil Company, Kuwait
- Haoud Berkaoui - Sonatrach, Algeria
- Viura Project - Union Fenosa Gas E&P, Spain
- Manifa AH Crude - Saudi Aramco, Saudi Arabia
- Khurais CPF - Saudi Aramco, Saudi Arabia
- Hout Crude - Khafji Joint Operations, Saudi Arabia
- Shah Deniz - BP, Azerbaijan
- K5A - Total E&P, The Netherlands
- F15-A Platform - Total E&P, The Netherlands
- Greater Stella - Ithaca Energy, United Kingdom
- Kraken FPSO - Enquest, United Kingdom
- P-57 FPSO - Petrobras, Brazil
- Replicantes (P-66 / P-71 FPSO) - Petrobras, Brazil
- P-74 FPSO - Petrobras, Brazil

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