

Produced Water: Oil and Gas Terminology Glossary

What Is Produced Water?

Produced water is water that comes out of the well with the crude oil during crude oil production. Produced water contains soluble and non-soluble oil/organics, suspended solids, dissolved solids, and various chemicals used in the production process. The ratio of produced water to oil varies from well to well and over the life of the well. Generally, this ratio is more than 3 and can be more than 20 in some parts of the world. Not only does the flowrate of the produced water change over time, but so does the composition. The composition of produced water also varies widely from well to well.

Although oil and water are generally thought to not mix well, multiple separation steps are typically required to separate the two. The degree of produced water treatment depends on the site's treatment requirements-typically deep well injection, reinjection, evaporation ponds, or surface water discharge. As regulations have become more stringent, disposal method costs increase, and water becomes more scarce, beneficial reuse is becoming a more viable option. Depending on the degree of chemical and mechanical emulsification, removal of oil and suspended solids from the water can be a treatment challenge. The American Petroleum Institute (API) gravity, a measure of oil density, varies by region (see Table 6, page 4), which affects the effectiveness of gravity separation methods.

Produced water treatment is typically considered an upstream oil and gas (O&G) process. The treatment steps and many terms are unique to this process but common in the industry. This fact sheet has been produced as a single reference primer that provides a broad overview of definitions, treatments, and use related to produced water.

Typical Produced Water Treatment

Table 1: Produced Water Treatment Equipment

Treatment step	Removal efficiencies	Description	Technology	Technology description
Primary	Influent - 500-10,000 ppm total O&G and 200-500 ppm total suspended solids (TSS)	Typically removes a rough cut of TSS and free O&G	API (which is the organization that established the specifications for the industry in the United States)	Typically, a rectangular tank with gravity settling for solids and skimmer for free O&G
	Effluent - 200-500 ppm free O&G and 100-200 ppm TSS		Corrugated plate separators (CPS) or corrugated plate interceptors (CPIs)	Contains stacks of angled corrugated plates which result in a reduced settling distance for solids and rise distance for free O&G; prone to plugging in high solids/scaling applications
			Hydrocyclone	Typically used offshore due to space and weight constraints and not affected by boat's pitch and roll; no moving parts but requires pressure drop for separation; sizing based on differences in density; can for either a liquid/liquid (L/L) or solid/liquid (S/L) variety

Table 1: Produced Water Treatment Equipment (continued)

Treatment step	Removal efficiencies	Description	Technology	Technology description
Secondary	Effluent - free O&G - 50-200 ppm* TSS - 50-100 ppm* *dependent on particle size	Typically, variety of flotation units introducing small gas bubbles (nitrogen, air, or fuel gas most common) to attach and float O&G with a bottom solids removal device; may use chemical (coagulant and/or flocculant) for better removal efficiencies; industry may use these terms interchangeably	Induced gas flotation (IGF)	Gas (nitrogen, air, fuel gas, etc.) introduced to a recycle stream via top mixers, which create a supersaturated solution. When the solution is reinjected to the flotator, bubbles are formed, resulting in flotation of solids.
	Effluent - free O&G - 20-200 ppm* TSS - 50-100 ppm* *dependent on particle size		Dissolved gas flotation (DGF)	Gas (nitrogen, air, fuel gas, etc.) introduced via pump or saturation tank system. Recycle steam is supersaturated and reinjected into the flotator, where solids float to the surface.
			Dissolved air flotation (DAF)	Same as above but specifically uses air (cannot always be used for produced water due to safety and environmental concerns).
			Dissolved nitrogen flotation (DNF)	Same as above but specifically uses nitrogen.
			Compact flotation unit (CFU)	Generic term for flotation unit with a short residence time, which is typically desired for offshore water treatment; tangential inlet (centrifugal force) aids in separation.
Tertiary	Effluent - 1-10 ppm free O&G and 1-10 ppm TSS* *dependent on particle size and media size	Various filtration methods	Nutshell or walnut shell filters	Bed of nut shells (typically 20-30 mesh) that naturally has affinity for free oil; periodically backwashed to remove the oil and dislodge suspended solids through agitation of the filter bed; although not designed for TSS removal, bed inherently also traps TSS.
			Filter media	Consumable media can be filter cartridges, bag filters, or proprietary (organoclay)
			Multimedia filters (MMF)	Bed with layers of media of different density and particle size to trap various-sized TSS; different media densities allow media to re-stratify during backwash to retain separate layers; not designed for O&G removal, but can be effective at polishing effluent from other treatment processes.
			Activated carbon filters	Granular activated carbon for removal of organics; typically used for offshore flowback with vessels returned onshore when job completed.
			Microfiltration (MF) or ultrafiltration (UF)	Ceramic or polymeric membranes provide a physical barrier to remove particles from the filtrate; few installations but emerging as a technology due to need for better particle removal.

General

- Vapor recovery typically required for environmental and safety reasons, often entailing flaring
- Minimal pumping of produced water desired to minimize oil shearing

Onshore vs. Offshore Produced Water Treatment

Table 2: Onshore vs. Offshore Produced Water Treatment

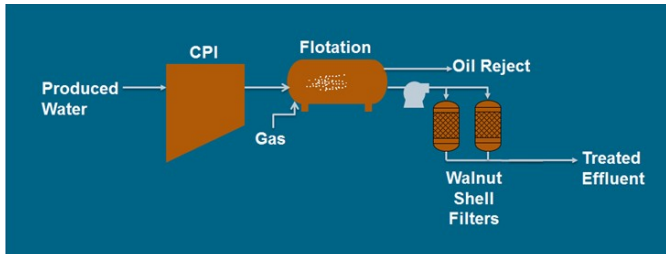
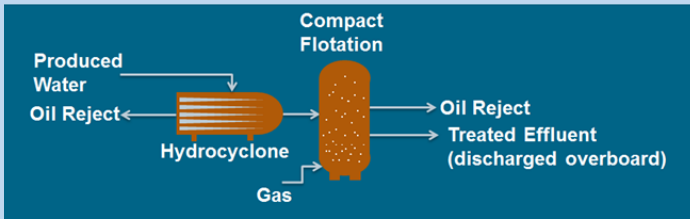
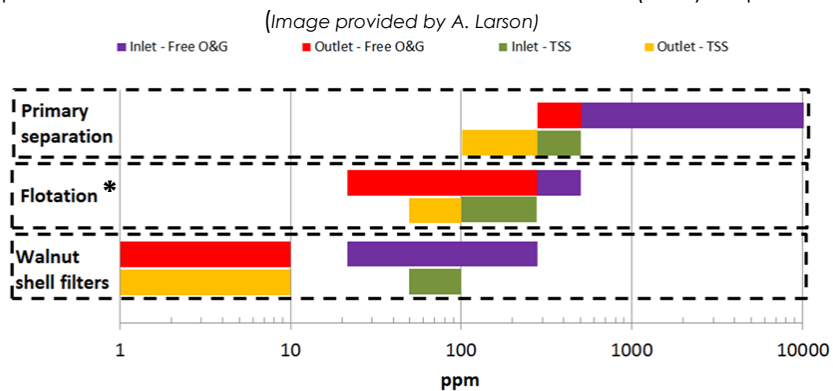
Onshore	Offshore
<p>Figure 1: Typical Onshore Produced Water Treatment (Image provided by A. Larson)</p>  <ul style="list-style-type: none"> Typically not limited by space/weight constraints so primary separation is based on gravity separation Typically preferred to have an equalization tank between three-phase separator (often batch) and primary separator to reduce swings Often requires tertiary treatment but dependent on project requirements Treatment end objectives are dictated by end use, with deep well injection requiring the least rigorous treatment, followed by reuse in the oil field with a moderate treatment requirement, and environmental discharge having the greatest treatment requirement 	<p>Figure 2: Typical Offshore Produced Water Treatment (Image provided by A. Larson)</p>  <ul style="list-style-type: none"> Typical limits do not require tertiary treatment, so usually only primary separation and a compact flotation unit used Limited by space/weight constraints; typically no equalization tank following three phase separator

Figure 3: Typical Produced Water Treatment Removal Efficiencies (*may require chemicals)



Typical Units of Measure

Table 3: Typical Units of Measure

Abbreviation	Definition	Reference	Context
BPD	barrels per day	1 barrel = 42 U.S. gal	Most common flow rates for produced water
pound brine	lb/gal	10 lb brine = 1.2 g/mL	Brine density of completion fluid
ppg	Pound per gallon (lb/gal)	10 ppg = 1.2 g/mL	Brine density of completion fluid
CMH	Cubic meter per hour	m ³ /hr	Flow rates for produced water
CMD	Cubic meter per day	m ³ /day	Flow rates for produced water
ppm	parts per million by weight	1 ppm = 1 mg/kg	Concentrations of contaminants
ppm_v	parts per million by volume	1 ppm = 1 mL/m ³	Concentrations of contaminants
ppb	parts per billion by weight	1 ppb = 1 mg/metric ton	Concentrations of contaminants

Typical Produced Water Terminology

Table 4: Oil Production Terms

Term	Explanation
Chemical enhanced oil recovery (CEOR)	To further extract oil from aging fields using polymers
Cyclic steam stimulation (CSS)	Intermittent steam injection for heating heavy oil for well stimulation; also known as huff-and-puff
Enhanced oil recovery (EOR)	To further extract oil from aging fields using thermal, chemical, water or gas means
Floating production storage and offloading (FPSO)	Floating oil platform used offshore
Low salinity flooding	Method to reduce the total dissolved solids (salinity) for enhanced oil recovery; LoSal is trademarked by BP
Open pit	Surface mining, typically for bitumen (heavy oil) production
Spar	Floating oil platform used in deep water operations
Steam-assisted gravity drainage (SAGD)	Continuous steam injection into wells to heat oil for heavy oil production
Sulfate recovery unit (SRU)	Sulfate removal as pretreatment of seawater for injection for oil production; necessary if barium or strontium is present in the formation to prevent well plugging
Seawater reinjection (SWRI)	Injection of seawater to wells following treatment to remove suspended solids and ions not compatible with the formation (often sulfate) for well production
Water injection (WI)	Injection of water to wells for disposal or for well production

Table 5: Oil Terms

Term	Definition	Typical units
BS&W	Basic sediment and water-a specification for water and solids in crude oil	%
BTEX	Benzene, toluene, ethylbenzene, and xylene	mg/L or ppm
Dispersed oil	Small oil droplets in produced water	mg/L or ppm
Dissolved oil	Compounds that are soluble in water such as BTEX and some aromatics	mg/L or ppm
Emulsified oil	Very small oil droplets in produced water (typically < 20 microns)	mg/L or ppm
FOG	Free Oil & Grease	mg/L or ppm
HEM	n-Hexane extractable materials, Method 1664 in the United States	mg/L
OiW	Oil in water	mg/L or ppm
TOC	Total organic carbon	mg/L
TPH	Total petroleum hydrocarbons	mg/L or ppm
VOC	Volatile organic compounds, a class of light organic materials typically consisting of 12 or fewer carbon atoms per molecule	mg/L or ppm
WSO	Water soluble organics - includes BTEX; EPA Method 1664 includes these non-hydrocarbon organic materials	mg/L or ppm

Table 6: Oil Classification by API Gravity (Measure of Oil Density)

	API range	Density*	Region
Light	>31.1° API	<0.87 g/mL	North America unconventional, North Sea, Middle East, Russia
Medium	22.3 to 31.1° API	0.87 to 0.92 g/mL	Middle East, Gulf of Mexico
Heavy	<22.3° API	>0.92 g/mL	Canada (particularly bitumen), California, Venezuela

*Conversion of API gravity to density = $141.5 / (\text{specific gravity}) - 131.5$

Table 7: Stream Types

Term	Definition	Use
Coal bed methane (CBM) or coal seam gas (CSG)	CMB produced water typically low in oil but high in total dissolved solids, requiring extensive treatment	Primary market is Australia
Completion fluid	High density brine pumped downhole during well completion to keep well casing in place prior to flow of water back out of new well	-
Condensate	Very light (API > 50)	Typical in gas fields
Conventional	Standard methods of oil field development using vertical drilling and completion	Organization of the Petroleum Exporting Countries (OPEC) nations (Middle East) and other mature oil fields
Deepwater	Offshore with depths >400 m	Locations include Gulf of Mexico, Brazil, West Africa
Downhole or deepwell injection	Disposal method of flowback/produced water after desired oil recovery; also needs TSS removal to prevent well plugging	-
Drilling fluid	Shear thinning fluid used during well drilling that prevents drilling cuttings and formation fluids from filling the hole and also cools the drill bit	-
Drilling muds	Liquid drilling fluid	-
Flowback	Initial flow of water after bringing a well online; includes both completion fluid and formation water, but will be similar composition of completion fluid	Duration of flowback period changes depending on the formation. Flowback may last anywhere from 2 weeks to 6 months
Produced water	Water "produced" from the well; flow rate and concentration of oil typically decline over the many years a well is online; transition from flowback to produced water is typically within the first few weeks when most of the completion fluid chemicals are no longer in high concentrations	Produced water volume typically 3 to 20 times greater than the hydrocarbons produced by the well
Shale gas/tight oil	Primary market is the United States; China has large reserves but inaccessible. Typically requires horizontal drilling and hydraulic fracturing to provide adequate recovery to justify development	Primary market is the United States with China and Argentina as potential markets
Unconventional oil and gas (UOG)	Oil and natural gas extracted from unconventional formations (shale and/or tight formations, oil sands, and CBM), typically require advanced techniques, such as horizontal drilling and hydraulic fracturing	Primary market is the United States, with China, Argentina, Australia, and the United Kingdom as potential markets

Additional Resources

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Acknowledgments

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