SPECIAL PROBLEMS IN OIL AND GAS SEPARATION

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Annotation. Oil and gas produced from wells are normally complex mixtures of hundreds of different compounds. A typical well stream is a turbulent mixture of oil, gas, water, and sometimes solid particles. The well stream should be processed as soon as possible after bringing it to the surface. Field separation processes fall into two categories: (1) separation of oil, water, and gas; and (2) dehydration that removes condensable water vapor and other undesirable compounds, such as hydrogen sulfide or carbon dioxide.

Key words: Separators, horizontal separators, vertical separators, foaming crude oil, paraffin, corrosion.

SEPARATING FOAMING CRUDE OIL

When pressure is reduced on certain types of crude oil, tiny spheres (bubbles) of gas are encased in a thin film of oil when the gas comes out of solution. This may result in foam, or froth, being dispersed in the oil and creates what is known as "foaming" oil. In other types of crude oil, the viscosity and surface tension of the oil may mechanically lock gas in the oil and can cause an effect similar to foam. Oil foam will not be stable or long-lasting unless a foaming agent is present in the oil. Crude oil is more likely to foam when (1) the API*

API gravity is a measure of how heavy or light a petroleum liquid is compared to water, developed by the American Petroleum Institute. A higher API gravity indicates a lighter liquid, with a higher value meaning it is less dense than water and will float on it.*

- higher API gravity = lighter oil: A higher number means the oil is less dense and lighter.

- lower API gravity = heavier oil: A lower number means the oil is more dense and heavier.

gravity is less than 40^0 API, (2) the operating temperature is less than 72 ^{0}C, and (3) the crude oil is viscous, having a viscosity greater than 5000 SSU *("Saybolt Universal Seconds" is considered a very thick, highly viscous fluid that flows very slowly, such as heavy fuel oils or molasses*).

Foaming greatly reduces the capacity of oil and gas separators because a much longer retention time is required to separate adequately a given quantity of foaming crude oil. Foaming crude oil cannot be measured accurately with positive-displacement meters or with conventional volumetric metering vessels. These problems, combined with the potential loss of oil and gas because of improper separation, emphasize the need for special equipment and procedures in handling foaming crude oil.

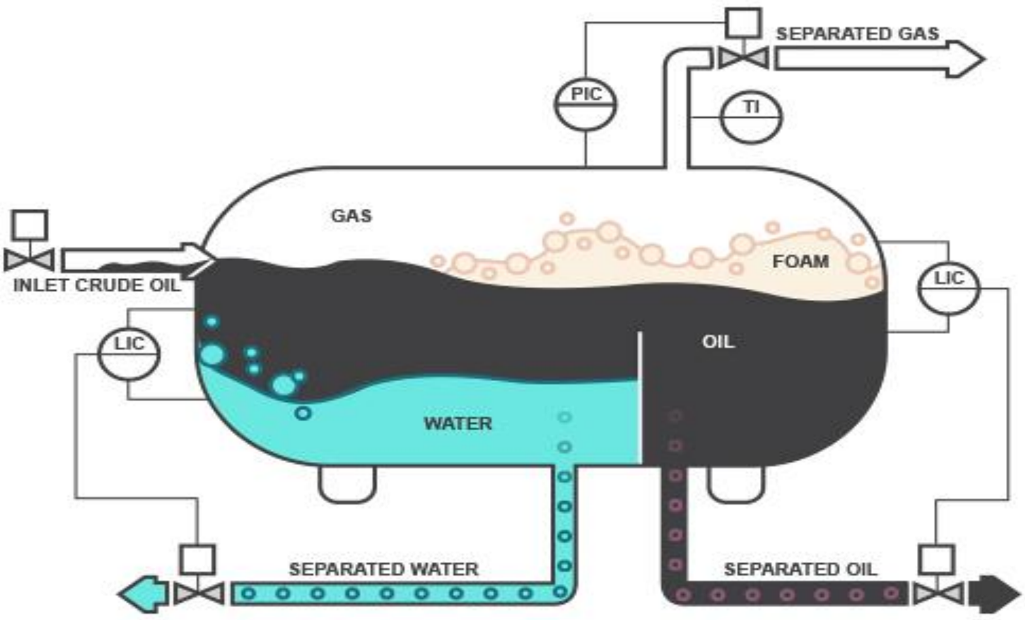
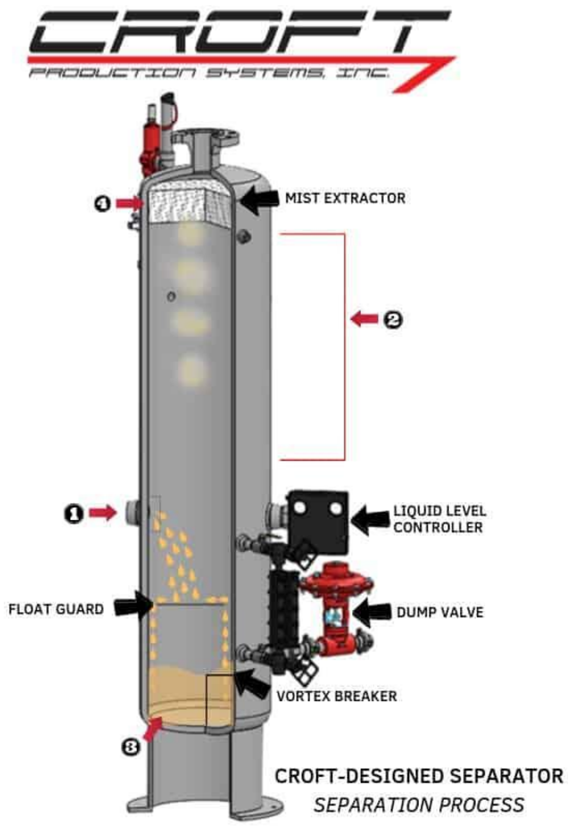


Fig. 1 – Horizontal oil and gas separator with special internals for separating foaming crude oil.

There are many special designs of separators for handling foaming crude oil. The special horizontal separator for handling foaming oil shown in Fig. 1 is one of the simpler, more effective units available for this service.



The special degassing element used on the inlet of this separator, gently agitates the well fluid and assists in removing gas from the oil and in breaking foam bubbles as they flow through the inlet element.

The defoaming plates, which extend from near the inlet end to near the outlet end of the separator, are spaced 10.16 cm apart and are shaped with an apex at the vertical center of the separator. The plates that are immersed in oil assist in removing nonsolution gas from the oil and in breaking foam in the oil. The plates that are above the oil/gas interface in the gas section of the separator remove oil mist from the gas and assist in breaking foam that may exist in the Fig. 2 – Vertical oil and gas separator gas section of the vessel.

with special baffling to remove gas from

oil, especially handling foaming oil.

The 15.24 cm – thick knitted – wire – mesh mist extractor (located below the gas outlet) removes the remainder of the liquid mist from gas and breaks or removes the remaining foam bubbles from the gas.

The vertical separator shown in Fig. 2 can be used to handle foam crude oil. As the oil cascades down the plates in this unit, the foam bubbles will be distorted and broken. This design can increase the capacity of the separator to handle foaming oil by 10 to 50%.

The main factors that assist in "breaking" foaming oil are settling, agitation (baffling), heat, chemicals, and centrifugal force. These factors or methods of "reducing" or "breaking" foaming oil are also used to remove entrained gas from oil. Many different designs of separators for handling foaming crude oil have evolved. They are available from various manufacturers – some as standard foam – handling units and some designed especially for a specific application.

PARAFFIN

Paraffin deposition in oil and gas separators reduces their efficiency and may render them inoperable by partially filling the vessel and/or blocking the mist extractor and fluid passages. Paraffin can be effectively removed from separators by use of steam or solvents. However, the best solution is to prevent initial deposition in the vessel by heat or chemical treatment of the fluid upstream of the separator. Another deterrent, successful in most instances, involves the coating of all internal surfaces of the separator with a plastic for which paraffin has little or no affinity. The weight of the paraffin will cause it to slough off of the plastic-coated surface before it builds up to harmful thickness.

SAND, SILT, MUD, SALT, ETC.

If sand and other solids are continuously produced in appreciable quantities with well fluids, they should be removed before the fluids enter the pipelines. Medium-grained sand in small quantities can be removed by settling in an oversized vertical vessel with a conical bottom and by periodically draining the residue from the vessel. Salt may be removed by mixing water with the oil, and after the salt is dissolved, the water can be separated from the oil and drained from the system.

CORROSION

Produced well fluids can be very corrosive and cause early failure of equipment. The two most corrosive elements are hydrogen sulfide (H_2S) and carbon dioxide (CO_2). These two gases may be present in the well fluids in quantities from a trace up to 40 to 50% of gas by volume.

Hydrogen sulfide and carbon dioxide are both acid contaminants found in gases like natural gas and biogas, and their removal is crucial for preventing corrosion, improving catalyst performance, and reducing harmful emissions. While CO_2 is often tolerated or removed for its greenhouse gas effects, H_2S is a toxic and corrosive pollutant with a foul odor that must be removed to meet pipeline standards and for safety. Various methods exist for their removal, including physical and chemical absorption, amine-based processes, and membrane separation.

Key differences and relationships

- Nature of contaminant: H_2S is highly toxic and has a strong odor, making its removal a priority for safety and environmental reasons. CO_2 is less toxic but is a major greenhouse gas that needs to be managed for climate change mitigation.
- Interactions: In certain conditions, such as in some zeolite catalysts, H2S and CO2 can react to form carbonyl sulfide (COS) and water (H_2O).
- Treatment goals: The primary goal in treating gases is often to remove the corrosive and toxic H_2S while potentially also reducing the CO_2 to meet product specifications or reduce its environmental impact.
- Removal methods:

1. Amine-based scrubbing: Using solutions like monoethanolamine (MEA) or hybrid solvents to absorb the acid gases.
2. Physical absorption: A straightforward method that can convert H_2S into elemental sulfur.
3. Membrane separation: Using selective membranes to separate the gases.
4. Biological methods: Certain biological processes can consume H_2S.
5. Molecular sieves: Used in dehydration units to remove both water and acid gases through a temperature-swing adsorption process.

Why removal is necessary

Corrosion - both gases can cause corrosion in pipelines and equipment, with H_2S being particularly aggressive.

Catalyst poisoning - H_2S can poison catalysts used in processes like the Fischer-Tropsch reaction, reducing efficiency.

Environmental concerns - removing CO_2 is essential for mitigating greenhouse gas emissions.

Safety - H_2S is highly toxic and can be lethal in high concentrations.

Product specifications - the final gas product must meet strict purity and safety standards, which requires the removal of both H_2S and CO_2.

LITERATURE

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