Tikrit University

College of Petroleum Processes Engineering

Department of Petroleum and Gas Refining Engineering

Gas Technology

Forth Class

Lectures 9

By

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Phase Separation

Separation of oil and gas is a critical field processing operation. As producing pressure is increased and lighter condensates are produced, efficient separation has become more critical than ever. Moreover, some of the new concepts in separation technology have been applied to advantage on old lease producing oil at moderate or low pressures. As gas transmission lines raise their standards, separation becomes a part of the overall field processing necessary to condition the gas. Several technologies are available to remove liquids and solids from gases. However, selecting gas/liquid separation technologies requires not only knowledge of the process conditions, but a knowledge of the characteristics of the liquid contaminants. Selection should be made based on the droplet size, concentration, and whether the liquid has waxing or fouling tendencies.

Three principles used to achieve physical separation of gas and liquids or solids are momentum, gravity settling, and coalescing. Any separator may employ one or more of these principles; however, the fluid phases must be immiscible and have different densities for separation to occur.

Gravity Separators

Gravity separators are pressure vessels that separate a mixed-phase stream into gas and liquid phases that are relatively free of each other. In a gravity separator, gravitational forces control separation, and the efficiency of the gas/liquid separation is increased by lowering the gas

velocity. Because of the large vessel size required to achieve settling, gravity separators are rarely designed to remove droplets smaller than 250 µm.

Separators are sometimes called “scrubbers” when the ratio of gas rate to liquid rate is very high. These vessels usually have a small liquid collection section and are recommended only for the following items:

- Secondary separation to remove carryover fluids from process equipment such as absorbers and liquid dust scrubbers.
- Gas line separation downstream from a separator and where flow lines are not long.
- Miscellaneous separation where the gas–liquid ratio is extremely high.

Separation Gas & Liquid

- The well-stream may consist of crude oil, gas, condensates, water and various contaminants.
- The purpose of a separator is to split the flow into desirable fractions.
- Primary separation of produced water from gas and oil is carried out in production separator.
- Separators work on the principle of gravity separation.

The following are the types of separators generally used in the oil industry:

- Two Phase Separator; A two phase separator is used to separate well fluids into gas and liquid mixtures.
- Three Phase Separator; this type of separator is used when the expected outlet streams are gas, oil/condensate, and water.

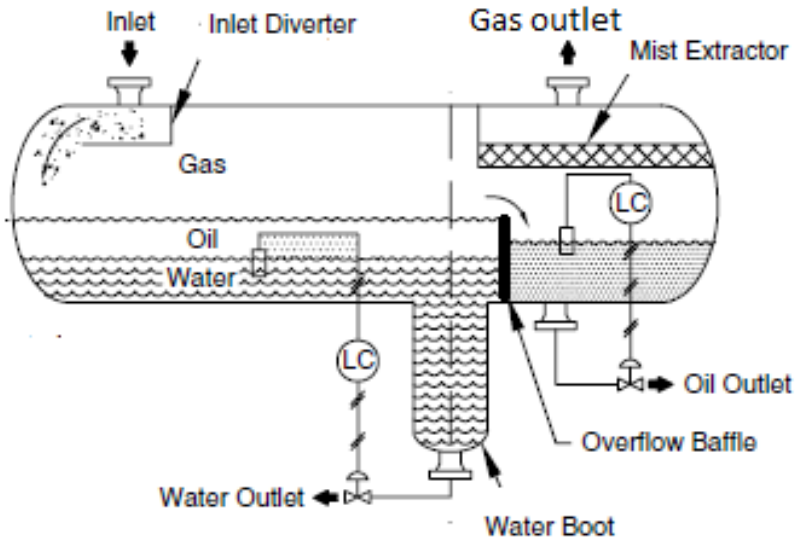

Figure 1: Typical Three Phase Separator (horizontal).

A separator can be either horizontal or vertical configuration

Horizontal separator

Horizontal separator is preferred for low GOR well fluids and three phase separation. Table below shows the advantages and disadvantages of horizontal separators:

Advantages	Disadvantages
Provide sufficient residence time for liquid-liquid separation	Only part of shell available for passage of gas
Large liquid surface area for foam dispersion generally reduces turbulence	Larger foot print / plot area
Large surge volume capacity	Liquid level control is more critical
Lend themselves to skid mounting and shipping	More difficult to clean produced sand, mud, wax, paraffin. etc.

Vertical separator

Vertical separator is preferred for high GOR well fluids and two phase separation. Table below shows the advantages and disadvantages of vertical separators:

Advantages	Disadvantages
Have full diameter for gas flow at top and oil flow at bottom	Not suitable for bulk liquid-liquid separation
Occupy smaller plot area	Occupy more vertical spacing between decks in offshore
Liquid level control is not so critical	More difficult to skid mount and ship
Have good bottom drain and clean out facilities. Can handle more sand, mud, paraffin, wax, etc.	More difficult to reach and service top-mounted instruments and safety devices

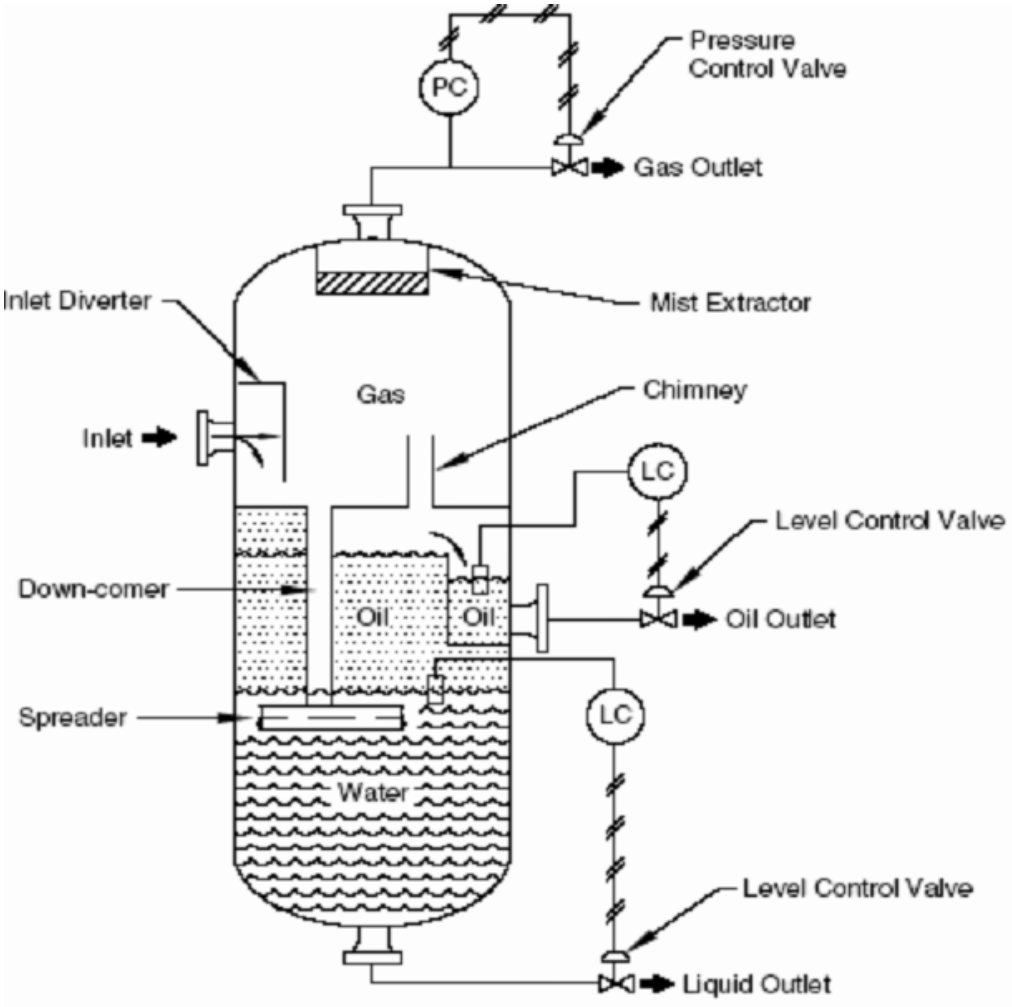

Figure 2: Typical Three Phase Separator (vertical).

Number of Separation Stage (Multistage Separation)

- The well fluid pressure is often reduced in several stages of separation.
- If the reservoir fluid can flow adequately against a wellhead pressure, separation in more than one stage will generally offer an economic advantage.

- The purpose of multi stage separation is to achieve maximum hydrocarbon liquid recovery, to get the liquid stabilized, and minimize compression power required for the gas stream.
- Multi stage separation of oil and gas involves a series of separators operating at sequentially reduced pressures, with liquid flowing from first separator to the next lower pressure separator.
- The optimum number of separation stages varies with Flowing Wellhead Pressure (FWHP), reservoir composition, off-gas compression requirement, and export specification for crude vapor pressure. A quick assessment of separation stages number based on FWHP is given in the table below:

FWHP, Bar	Number of Stage
1-20	**1 or 2**
20-70	**2 or 3**
Over 70	**3 or 4**

- The flowing tubing pressure usually decrease during the life of the field, a common practice is to install separate production manifolds for each separator.
- In this case, wells with decreased well pressure would be rerouted to a lower pressure separator, thus maximizing production. Figure 3 shows a typical flow scheme of 3 stages separation.

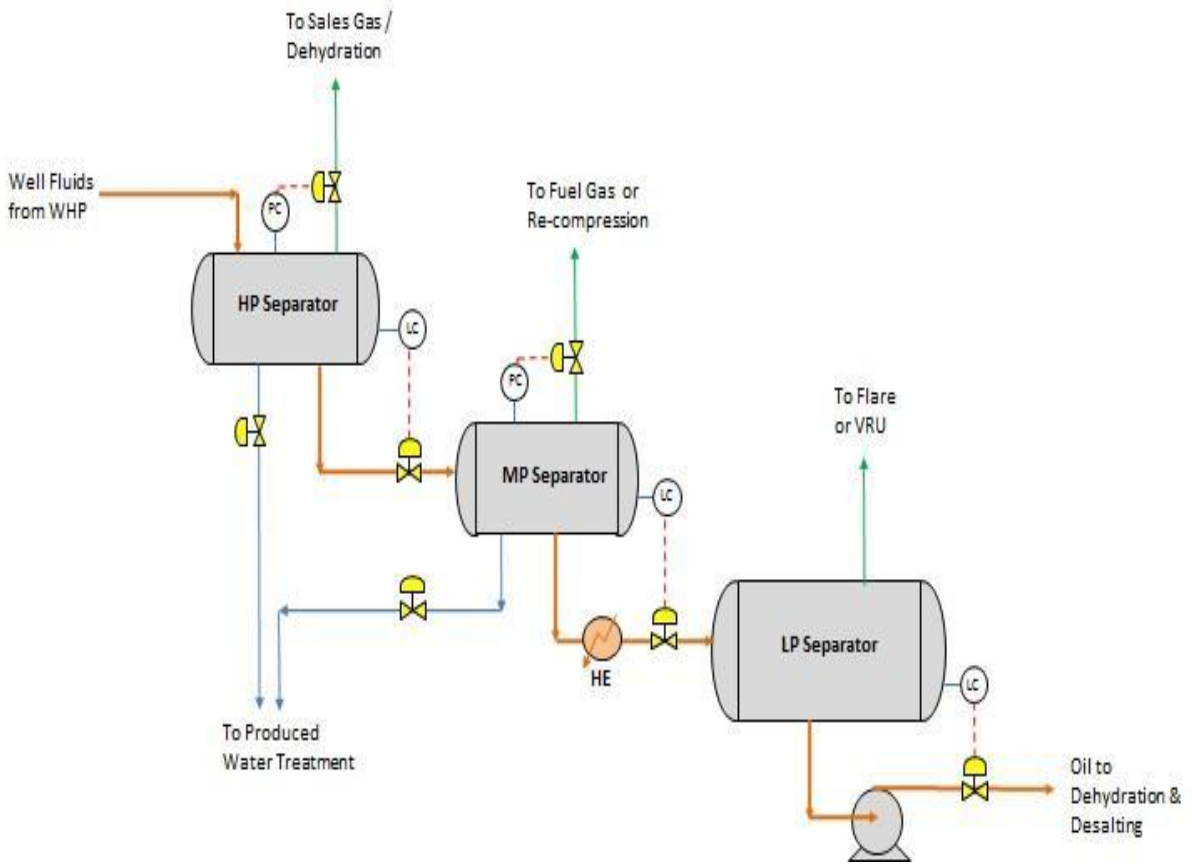

Figure 3: Typical 3 Stages Separation

- HP separator is a 3-phase separator. The separator pressure must be low enough to allow effective choke operation and thus control of well behavior. Therefore, wells with high enough flowing wellhead pressure are routed to the HP Separator. Gas separated from the HP Separator normally flows to the gas compression and dehydration system, and then exported through pipeline.
- MP separator is similar to the HP Separator but operates in lower pressure. MP separator receives liquid (oil) from the HP Separator, and due to pressure reduction, the light components of the liquid will vaporize. Gas separated from the MP separator normally flows

to an inter-stage compressor and then combines with the gas off from HP separator.

- LP separator is a 2-phase (gas/liquid) separator which operates slightly above atmospheric pressure. The operating pressure and temperature of the final gas-oil separation stage dictates the vapor pressure of the export crude. Generally stable crude (10-12 psia RVP) requires a very low pressure and high temperature.
- The off gas from each separation stage can be compressed and treated for use as fuel gas, exported, or flared if quantities are minimal and applicable regulations permit flaring.
- Bulk water in the well fluid is generally removed from the first stage separator, in order to minimize heating/cooling of excess liquid at further processing.
- The removed water is routed to the water treatment plant.

Separators of all types are sized according to the following parameters, to suit product specifications:

- Fluid flow rates.
- Operating Pressure and Temperature.
- Oil in Water Specification (500-1000 ppm).
- Water in Oil Specification (1-3% vol).
- Liquid losses to vapor stream (subject to demister type).
- Liquid droplet size in gas outlet (150 microns and larger droplets can be removed when internals are not used).

Centrifugal Separators

In centrifugal or cyclone separators, centrifugal forces act on droplet at forces several times greater than gravity as it enters a cylindrical separator. This centrifugal force can range from 5 times gravity in large, low-velocity units to 2000 times gravity in small, high-pressure units. Generally, centrifugal separators are used for removing droplets greater than 100 µm in diameter, and a properly sized centrifugal separator can have a reasonable removal efficiency of droplet sizes as low as 10 µm. Centrifugal separators are also extremely useful for gas streams with high particulate loading

Twister Supersonic Separator

The Twister supersonic separator is a unique combination of known physical processes, combining expansion, cyclonic gas/liquid separation, and recompression process steps in a compact, tubular device to condense and separate water and heavy hydrocarbons from natural gas. Condensation and separation at supersonic velocity are key to achieving step-change reductions in both capital and operating costs. The residence time inside the Twister supersonic separator is only milliseconds, allowing hydrates no time to form and avoiding the requirement for hydrate inhibition chemicals. Elimination of the associated chemical regeneration systems avoids harmful benzene, toluene, and xylene emissions to the environment or the expense of chemical recovery systems. The simplicity and reliability

of a static device, with no rotating parts, which operates without chemicals, ensure a simple facility with a high availability suitable for unmanned operation in harsh and/or offshore environments. In addition, the compact and low weight Twister system design enables debottlenecking of existing space and weight-constrained platforms.

Slug Catchers

Slug catchers are used at the terminus of offshore pipelines to catch large slugs of liquid in pipelines, to hold these slugs temporarily, and then to allow them to follow into downstream equipment and facilities at a rate at which the liquid can be handled properly. Slug catchers may be either a vessel or constructed of pipes. Pipe-type slug catchers are frequently less expensive than vessel type slug catchers of the same capacity due to thinner wall requirements of smaller pipe diameter.

High-Efficiency Liquid–Gas Coalescers

Aerosols in gas streams can often be less than 5 μm in size and require the use of special separation equipment. High-efficiency liquid–gas coalescers have been applied effectively for the removal of fine aerosols in gas production, processing, and transmission. Coalescers are typically constructed as cartridges that use pleated glass fiber media supported by a metal core. The coalescer cartridges are then placed in a housing that controls the inlet/outlet gas velocities to ensure good separation and prevent any reentrainment of liquids.

Coalescer media contain a much finer pore structure and larger surface area as compared to traditional separators that often use mesh pads or vane pack internals.