VIKRANT-CONCENTER Series Separators/Scrubbers

- Vertical Gas Scrubbers
- Low Pressure Horizontal Three Phase Separator
- Low Pressure Horizontal Two Phase Separator
- Low Pressure Vertical Three Phase Separator
- Low Pressure Vertical Two Separator
- High Pressure Vertical Separator
- High Pressure Horizontal Three Phase Separator

Technical Information

Separators are mechanical devices for removing and collecting liquids from natural gas. A properly designed separator will also provide for the release of entrained gases from the accumulated hydrocarbon liquids. A well stream separator must perform the following:

1. Cause a primary-phase separation of the mostly liquid hydrocarbons from those that are mostly gas.
2. Refine the primary separation by removing most of the entrained liquid mist from the gas.
3. Further refine the separation by removing the entrained gas from the accumulated liquid.
4. Discharge the separated gas and liquid from the vessel and insure that no re-entrainment of one into the other takes place.

If these functions are to be accomplished, the separator design must:

1. Control and dissipate the energy of the well stream as it enters separator;
2. Insure that the gas and liquid flow rates are low enough so that gravity segregation and vapor-liquid equilibrium can occur;
3. Minimize turbulence in the gas section of the separator and reduce velocity;
4. Eliminate re-entrainment of the separated liquid into the gas;
5. Accumulate and control froths and foams in the vessel;
6. Provide outlets for gases and liquids with suitable controls to maintain pre-set operating pressure and liquid levels;
7. Provide relief for excessive pressure in case the gas or liquid outlets should become plugged or valves malfunction;

8. Provide equipment (pressure gauges, thermometers, and liquid-level gauge assemblies) to visually check the separator for proper operation;
9. Provide cleanout opening at points where solids will accumulate when solids are present in the inlet stream.

Separator Selection: Basic Considerations

The goal for ideal separator selection and design is to separate the well stream into liquid-free gas and gas-free liquid. Ideally, the gas and liquids reach a state of equilibrium at the existing conditions of pressure and temperature within the vessel. As it is generally not economically justifiable to separate to the state of true equilibrium, industry consensus standards as to liquid retention time for solution gas break-out and liquid carry-over in the gas have been set. In some cases, the process equipment and conditions downstream of a separator will dictate the necessary degree of separation and the actual design.

Well stream Characteristics

The following characteristics influence vessel selection, in addition to the obvious quantities of liquids and gas to be separated:

1. Proportions of gas and liquids composing the inlet stream.
2. Differences between the densities of the gas and liquids.
3. Differences between the viscosities of the gas and liquids.
4. Temperature and pressure at which separation is to be made.
5. Particle sizes of liquids in the gas phase or gas in the liquid phase.
6. Identification of impurities or special conditions such as H_2S, CO_2, pipe scale, dust, foam, fogs, etc.
7. Instantaneous flow rates (slugs or heading).

Vertical Separators

Vertical separators are capable of handling large slugs of liquid and are therefore most often used on low to intermediate gas-oil ratio well streams. They are ideally suited as inlet separators to processing plants since they can smooth out surging liquid flows. They are well suited for handling production that contains sand and other sediment. When excessive sand production is expected, a cone bottom is placed in the vertical separator to properly handle the sand. Vertical separators occupy less floor space than comparably sized other types. This is an important consideration where floor space can be very expensive, as on an offshore platform. However, because the natural upward flow of gas opposes the falling liquid droplets, vertical separators may be larger and more expensive than a horizontal separator for the same gas handling capacity.

Applications

1. Well streams having large liquid to gas ratios.
2. Well streams having sizable quantities of sand, mud, or other related substances.
3. Areas having horizontal space limitations, but little or no vertical height limitations.
4. Well streams or process flow streams which are characterized by large instantaneous volumes of liquid.
5. Upstream of other process equipment tolerating essentially no entrained liquid droplets in the gas.
6. Downstream of equipment causing liquid formation.

Horizontal Separators

Horizontal separators are ideally suited to well streams having high gas-oil ratios, constant flow, and small liquid surge characteristics. Horizontal separators are smaller and less expensive than vertical separators for a given gas capacity. Liquid particles in the well stream travel horizontally and downward at the same time as a result of two forces acting upon them-the horizontal force of the gas stream and the downward force of gravity. Therefore, higher gas velocities can be permitted in horizontal separators and still obtain the same degree of separation as in vertical separators. Also, the horizontal separators have a much greater gas-liquid interface area than other types, which aids in the release of solution gas and reduction of foam. A special de-foaming section is used when severe foaming of the inlet stream is anticipated. The horizontal configuration is best suited for liquid-liquid-gas, or three phases, separations because of the large interfacial area available between the two liquid phases. In addition to being easier to hook-up, easier to service, and easier to skid-mount, horizontal separators can be stacked in piggy-back fashion to form stage separation assemblies and minimize horizontal space requirements.

Applications

1. Areas where there are vertical height limitations.
2. Foamy production where the larger liquid surface area available will allow greater gas breakout and foam breakdown.
3. Three phase separation applications for efficient liquid-liquid separation.
4. Upstream of process equipment, which will not tolerate entrained liquid droplets in the gas.
5. Downstream of equipment causing liquid formation.
6. Well streams having a high gas to oil ratio and constant flow with little or no liquid surges.
7. Applications requiring bucket and weir construction for three phase operation.

The Separation Process

All separators have at least three and usually four sections comprising the separation process:

- The primary separation section
- The secondary separation section
- The liquid accumulation section
- The mist extractor section

Primary Separator Section

The primary separation section is the portion of the vessel around the inlet where the energy of the entering well stream is dissipated. The purpose of this section and its mechanical components is to make the initial separation of liquid from gas using deflectors or impingement baffles. The bulk of the liquid is diverted to the liquid accumulation section. The larger quantities of liquid and large liquid drops immediately start falling as a result of the gravitational force. In vertical separators the inlet deflector forces the liquid to change direction toward the vessel shell where it spreads out in a thin film, allowing solution gas to break out. In horizontal separators, the liquid is usually directed against a deflector plate which may or may not be dish shaped. The liquid is thrown against the vessel shell to divert it from the main gas stream and allow rapid release of solution gas. In some cases, impingement baffles are used in horizontal separators to break the liquid stream into smaller streams and droplets so that solution gas can be more readily released.

Secondary Separator Section

The area of the separator immediately beyond the inlet deflector, between the liquid accumulation section, and the mist extractor (or outlet head where a mist extractor is not used) is called the secondary separation section. In this section the velocity of the gas and liquid is reduced because of the increased cross-sectional area.

This allows the liquid particles to begin falling toward the liquid accumulation section as a result of gravitational force on the mass of the liquid particle. In vertical separators the upward gas velocity tends to counter the gravitational force effect on the liquid particles as it exerts a drag force on the particle. If the particle is large, the gravitational force will be the greater force and the particle will settle to the bottom. Very small particles will be carried along with the gas as entrainment and will leave the separator, if not removed by some other device such as a mist extractor. In horizontal separators the drag force is exerted at right angles to the gravitational force and does not hinder the particles' fall to the liquid accumulation section. The resultant path of the particle is a diagonal path or trajectory toward the outlet of the separator. The horizontal separator must be large enough in cross-section and long enough so the reduction of the gas velocity and the diagonal paths for the bulk of the liquid particles will carry them into the liquid accumulation section.

Liquid Accumulation Sections

All separators must provide an area where the collected liquid from the primary separation section, the secondary separation section, and the mist extractor can be held for a short period of time and then dumped to storage. The liquid retention time is normally one minute for two phase (i.e., liquid-gas) separation. This allows time for the solution gas to break out of the accumulated liquid. In vertical separators a baffle plate is positioned between the liquid accumulation section and the secondary separation section. This is to insure little, if any, re-entrainment of liquid into the gas. It also minimizes wave action and turbulence on the liquid surface which could upset the liquid level control system.

Horizontal separators normally utilize approximately half of the cross-section for liquid accumulation. Because of their configuration, horizontal separators have less instantaneous surge capacity than vertical separators. However, the large surface area at the gas liquid interface provides excellent release of solution gas. Wave breakers or stilling baffles are provided to stop wave action caused by gas eddy currents near the gas-liquid interface to prevent liquid re-entrainment into the gas stream.

Liquid outlet connections in either vertical or horizontal separators are usually located as far away from the inlet as possible to assure maximum liquid retention time for release of solution gas. These connections are also designed with antivortex baffles or siphon type drains to prevent vortex development. Development of a vortex at the liquid outlet can cause gas to be re-entrained in the liquid being discharged.

Mist Extractors

The two types of mist extractors most commonly used in oil and gas separators are knitted wire mesh and vane. Mist extractors cause small entrained particles to form into larger droplets. As the gas stream passes thru the mist extractor, the surfaces of the mist extractor itself are wetted with the entrained liquid particles. Continued contact with the wetted surfaces causes coalescing into larger droplets. This action is promoted by the changing of direction forced on the gas by the tortuous path it must take to get thru the mist extractor. When the droplets reach sufficient size to overcome the lifting force imposed by the gas velocity, they will fall into the liquid accumulator section of the separator. The standard mist extractor for VIKRANT-CONCENTER separators is the knitted wire mesh.

Knitted Wire Mesh Mist Extractors

Knitted wire mesh mist extractors consist of horizontal or vertical pads of knitted stainless steel or Monel wire mesh either in layers or wound for insertion into the separator. On vertical separators the pad is placed in the horizontal position near the top of the vessel. Horizontal separators use vertical pads near the gas outlet end of the separator. The pads are generally 4" to 6" thick and can vary in bulk density depending upon the particle size to be removed and the efficiency of removal desired. Wire mesh mist extractors normally are designed to remove 99% of all liquid particles which are 10 microns or larger.

Vane Type Mist Extractors

Vane type mist extractors are the most efficient. They are standard on VIKRANT-CONCENTER vertical scrubbers where large volumes of gas must be handled with small liquid loads and are available in any type of VIKRANT-CONCENTER separator. Vane type mist extractors consist of a series of parallel impingement baffles which provide the surface area for the small entrained particles to collide and coalesce into larger drops. The vanes are also arranged to cause the gas stream to change direction and velocity; creating a centrifugal force and thereby improving the collection and coalescing of the small liquid particles. Vane type mist extractors are the best units to use with well streams containing paraffin or wax since they do not plug as readily as the knitted wire mist units.

Separators: Three-Phase Operation

Three-phase operation in vertical and horizontal separators requires different internal construction to assure dependable operation. Experience has proven that it is wise to use a longer retention time to obtain better water-oil separation. The standard retention time for 3 phase separator design is 3 minutes. This result in a reduction of the overall liquid capacity for any given size separator as compared to 2-phase operation which is based on one minute liquid retention time. Separation of the water and oil is simply due the specific gravity difference of the two liquids. A separator cannot separate water and oil that exists as an emulsion. The water and oil must be as free liquids in the separator. In the vertical separator, three-phase operation is similar to the two-phase operation previously discussed except that all the separated liquids drop on to a divider or isolation baffle located above the liquid accumulation section. From this baffle the liquids flow through a down comer into the liquid section where the water and oil are released below or near the water-oil interface. This assures that the water does not have to settle through the separated clean oil, thereby providing efficient oil-water separation.

Three-phase operation in horizontal separators varies from the two-phase operation in the liquid zone only. Instead of being controllable as in the two-phase separator, the liquid level in the 3-phase separator is set by the oil spillover height. There are two types of construction used in three phase separators. These are "oil spill-over baffle" and "bucket and weir". The water-oil interface level in the bucket and weir system is not controllable unless the weir height is made to be adjustable.

The oil spill over type operates with a gas-liquid interfacial control for the oil and water-oil interfacial control for the water.

The bucket and weir type arrangement is used so that a gas-liquid interfacial control is used on the oil and the water in their own separate compartments for positive control.

In horizontal three phase separators, since the liquid top level is usually set by a baffle at 50% of the vessel cross-section the gas capacity of a given size will usually be reduced compared to a horizontal two phase separator. This applies to both types of three-phase design in the liquid section.

Special Separation Problems

Liquid-Liquid Separations

Liquid-Liquid separations are generally based upon adequate retention or settling time to allow for gravity separation. The process is very similar to that of gas-liquid separation; however, the difference in densities and viscosities of each phase exert a more important influence in determining how rapidly a particle will rise or fall to become a part of each continuous phase.

Settling time is determined by using Stokes law and the distance the selected particle travels to reach a surface for coalescence into a continuous phase.

Stokes law is as follows:

Ut= K (Ps -Pe) g (Dp) 2

18gM

where:

Ut = terminal settling velocity in ft/sec.

g = acceleration due to gravity, normally 32.17 ft/(sec.) (sec.)

M = viscosity of the continuous phase in (lb mass)/ft (sec.)

Dp = particle diameter of dispersed phase in ft.

As = density of the heavier liquid (lb/ft.3)

pi = density of the lighter liquid (lb/ft.3)

K = 3.3 proportionality factor

Settling velocity and total volume of liquid to be separated are used to determine the retention time and vessel dimensions. The final vessel size is determined by trial and error method; but in any case, the final length to diameter ratio should not be less than 4 to 1 in order to minimize turbulence.

Special internals can be used to shorten the liquid particles' path in getting away from the bulk of the continuous phase. This increases the efficiency of the separation and increases the capacity.

Dust, Fogs, and Mist

The removal of dust, fogs and mists from natural gas requires special separators. These units are referred to as coalescing separators and are designed to remove particles smaller than 10 microns from the gas stream. Dusts, fogs and mists are common problems with natural gas transmission lines, compressor stations, and gas gathering systems. Dusts cause erosion of valve trim in control valves, erosion of compressor intake valves, and plugging of small orifices in various controlling and processing equipment. Fogs and mists create problems for processing equipment because they can contaminate lubricants, processing chemicals, and desiccants.

VIKRANT-CONCENTER manufacture a special line of coalescing gas separators for the removal of these contaminants. These units use removable fiberglass filters. The gas stream flows through the fiberglass filters. At this point the solids begin accumulating on the exterior of the filters with the smaller particles accumulating within the filter material. Fog or mist particles pass through the filter and are coalesced into larger particles and liquid droplets. The separated solids remain in place on and in the filters. The liquids pass through the filters and emerge as larger droplets which either settle out of the gas and are accumulated in the liquid sump, or pass into the mist extractor section where they are removed from the gas and drained to the sump.

Coalescing separators are usually horizontal vessels but can be vertical if so required. The VIKRANT-CONCENTER horizontal coalescing separator incorporates wire mesh mist extractors or vane type mist extractors.

Gas Scrubbers

VIKRANT-CONCENTER scrubbers are two-phase separators, which are designed to handle gas streams with relatively light liquid loads and in applications where it is essential that liquid particles be removed from the gas stream. A scrubber does not take the place of a production separator but is usually installed in pipeline after the gas stream has been thru production separators and the gas has been transported some distance. These scrubbers are normally vertical units, but horizontal units are available for specific applications. All scrubbers operate in the same manner as vertical and horizontal two-phase separators. The standard mist extractor, however, is the very efficient vane type. Typical applications are as follows:

1. Upstream of units using either wet or dry desiccants which would lose efficiency, be damaged, or destroyed if contaminated with liquid hydrocarbon.
2. Downstream of equipment, which cause liquids to condense from a gas stream.
3. Upstream of mechanical equipment such as compressors, which would be damaged, destroyed, or rendered ineffective by free liquid.

Separator Construction

All separators and scrubbers are stamped and fabricated in accordance with the latest edition of the ASME Code Section VIII Division I. Design pressures normally start at 125 PSI. Lower design pressures may be designed and fabricated upon request. Larger sizes of separators and scrubbers than those shown in the individual sections may be designed and fabricated to meet special applications.

Wire mesh mist extractors for separators are usually of 304SS wire mesh. Mesh densities varies from application to application. Pads may be formed by spooling pad layers in concentric fashion. In larger diameter separators the wire mesh pad may be made up of smaller pre-formed rectangular pads. Wire mesh mist extractors may be made removable if necessary. The internal parts of separators and scrubbers, such as inlet deflector, vortex breakers, and mist extractor supports are fabricated of carbon steel.

Vane mist extractors of carbon steel are standard in VIKRANT-CONCENTER vertical scrubbers. As previously stated, these mist extractors are the most efficient units used. This ensures that gas streams processed through VIKRANT-CONCENTER vertical scrubbers will be essentially free of entrained liquid droplets larger than 10 microns in diameter.

Control Systems and Accessories

All **VIKRANT-CONCENTER** separators are equipped with properly engineered controls. The various controls used are. Properly sized liquid valves, coupled with the selection of the correct level controller, are a must. **VIKRANT-CONCENTER's** Engineering will size and select liquid and gas valves, level controllers, and safety relief devices on each application. Level gauges are selected and positioned with care. Pressure gauges are selected with an eye toward dependability as well as durability.

Separator Guarantees

When operated within the limits as described in the sizing information, VIKRANT-CONCENTER separators will separate liquid from gas with a carryover of liquid particles no greater than the equivalent of 0.1 U.S. gallons of particles larger than 10 microns in diameter per million standard cubic feet of gas thru-put.

Separator capacities as given in the individual sections are based on 0.7 specific gravity gas, 45 API liquid and 1-minute retention time for two-phase operation, and 3-minute retention time for three-phase operation.

Separator Applications

VIKRANT-CONCENTER builds a full line of Two and Three Phase Separators to meet any application with sizes ranging from 12 inch to 60-inch diameter in stock for immediate delivery. Separators constructed as Vertical or Horizontal with operating pressure from 125 psig to 1440 psig. Separators for exceptional conditions can be manufactured to engineered specifications.

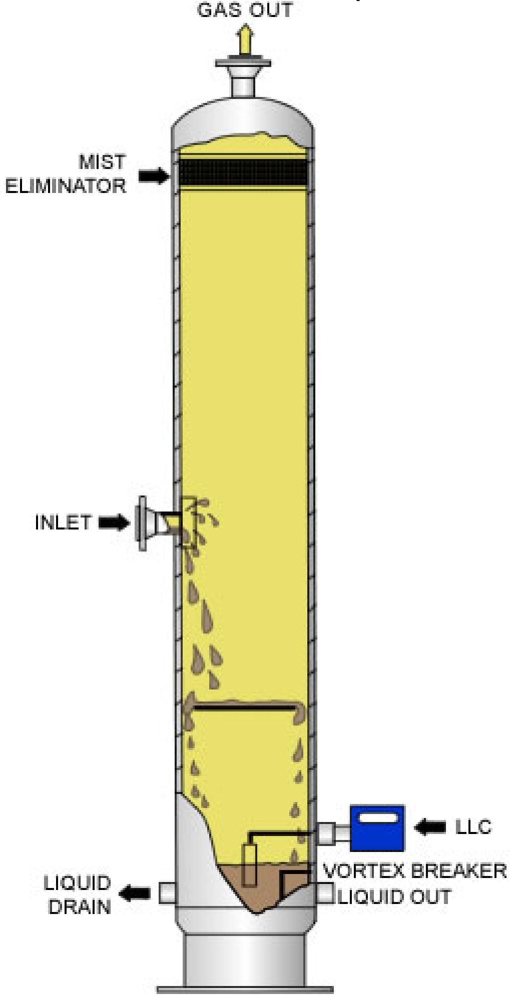
Vertical Separator Application

- Low to moderate Gas to Oil production
- Capable of handling large slugs of liquids
- Removal of excessive quantities of sand, mud, and sediment.
- Upstream of process equipment tolerating no entrained liquids.
- Downstream of liquid formation processing

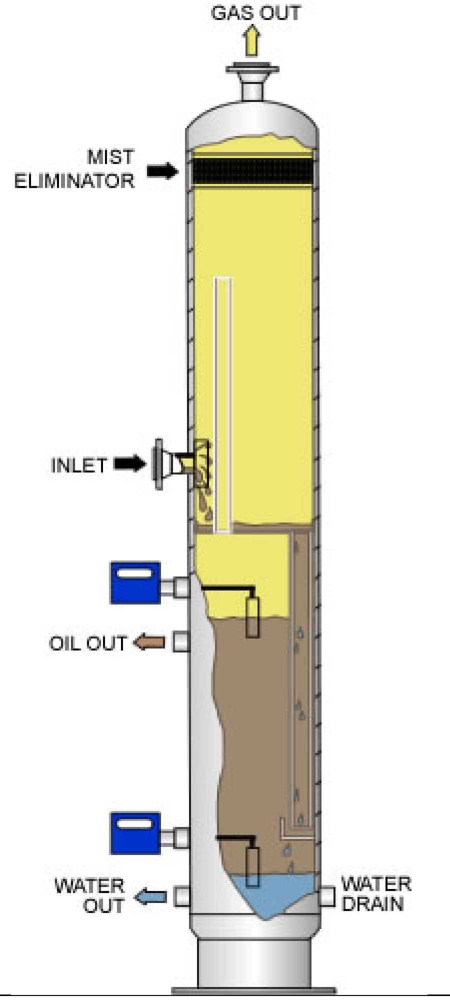
Two phase Vs Three Phase

Two-phase separators remove the liquids from the gas. Three phase separators separate the gas from the liquid and separate the oil from the free water. Separators cannot break an emulsion. Three phase separators use specific gravity and retention time to separate the oil and free water. In a three phase vertical separator the liquid droplets fall on isolation baffle and flow through a downcomer into the liquid accumulation area where the oil and water are released near the oil-water interface to provide efficient separation.

Two-Phase Vertical Separator



Three-Phase Vertical Separator



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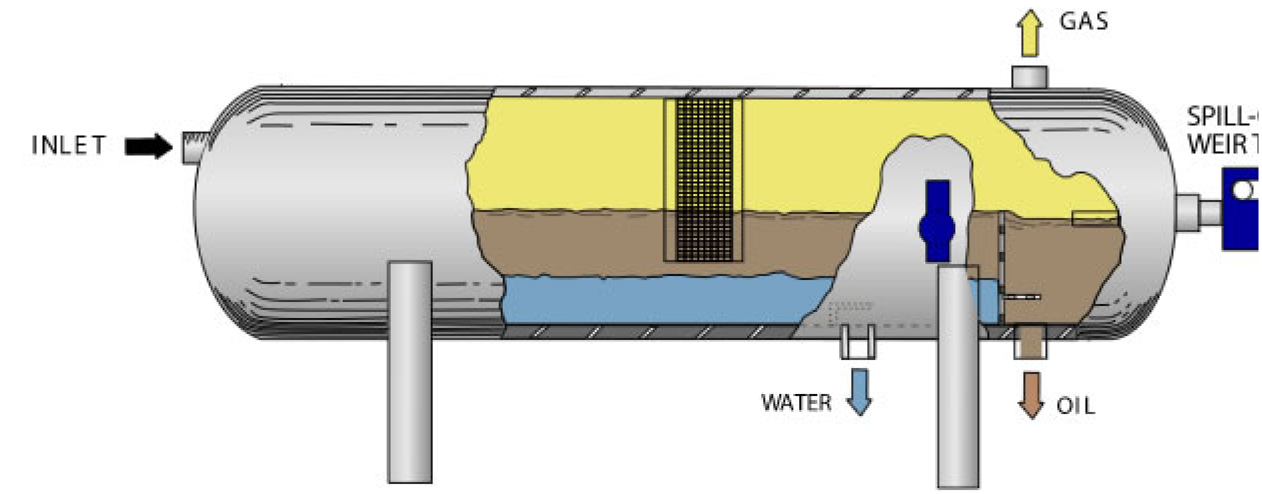
Horizontal Separator Application

- High gas to oil production
- Constant flow with small liquid surges
- Smaller in size for same gas capacity
- Higher gas velocities allowed with same efficiency of separation
- Greater liquid to gas interface area
- Improved release of solution gas and reduction of foam
- Three phase separation for efficient liquid-liquid separation
- Areas with vertical height limitations
- Applications requiring bucket and weir construction for three phase operation.

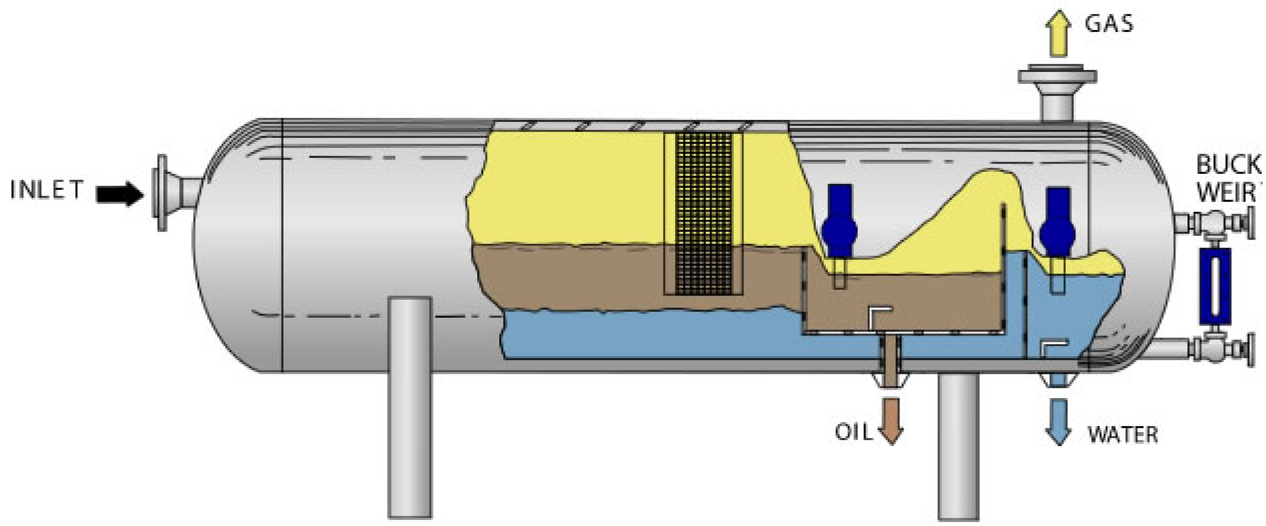
Two phase Vs Three Phase

Two-phase separators remove the liquids from the gas. Three phase separators separate the gas from the liquid and separate the oil from the free water. Separators cannot break an emulsion. Three phase separators use specific gravity to separate the oil and free water. Liquid levels in three phase separators are set by the oil spill over height. This is either set by an oil spill over baffle or a bucket and weir.

Easier installation and service with option of skid mounting and stacking in a piggy back fashion to form staged separation assemblies.



TYPICAL 3-PHASE CONSTRUCTION



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