7. Condensate Production

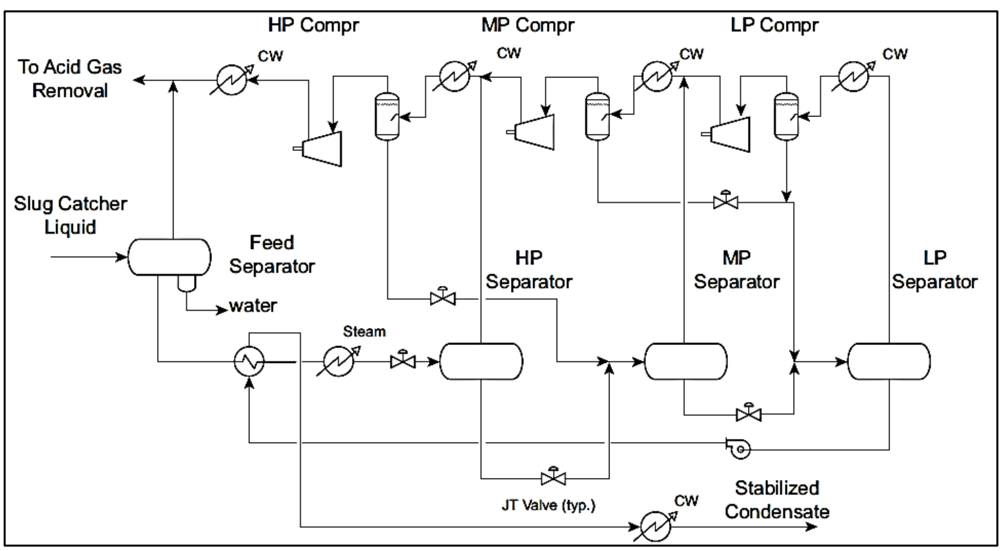
- The hydrocarbon liquid stream contains mainly **light hydrocarbons** (methane and ethane in particular), **water**, **salts**, **corrosion and hydrate inhibitors**, **acid gases**, **mercaptans**, and **other sulfur compounds**.
- The condensate production unit is designed to separate these contaminants to produce a marketable hydrocarbon liquid (condensate).
- Condensate production involves three steps: **water washing**, **condensate stabilization**, and **condensate treating**.
- Depending upon the associated water quality, the condensate may require a water wash to remove salts and additives.
- After dewatering step, the condensate goes to the condensate stabilization unit where remaining lighter hydrocarbons are stripped.
- The process of increasing the amount of intermediate (C_3 to C_5) and heavy (C_6^+) components in the condensate is called **condensate stabilization**. This process is performed primarily to reduce the vapor pressure of the condensate so that a vapor phase is not produced upon flashing the liquid to atmospheric storage tanks.
- Stabilized condensate generally has a vapor pressure specification, typically identified by its Reid vapor pressure (RVP1) or true vapor pressure. Typical RVP specification ranges from 4 to 8 psia.
- After the stabilization step, condensate must be treated to remove heavy mercaptans and other undesirable contaminants to very low levels to produce a liquid product that has specifications to be sold as "**natural gasoline**."
- Other typical specifications of the commercial grade condensate are water content (0.05 volume %), butanes (2 volume %), H_2S (10 ppmw), and total sulfur content as S (50 ppmw).

7.1. Condensate Stabilization

- There are two basic stabilization processes: **cascade flash separation** and **distillation separation**.
- Cascade flash separation consists multiple separators and compressors, is common in offshore gas processing plants due to its simplicity, but its efficiency and condensate yields are lower.
- The distillation separation type is more complex, and more efficient, which is common in onshore gas processing plants.

7.1.1 Stabilization by cascade flash separation

- The principle of the cascade flash separation is to remove the lighter components by flashing to lower pressures in several steps. The condensate can also be heated to promote removal of the light components.
- The process is more suitable for processing crude oil or heavier condensate.
- A typical cascade flash separation process is shown in Fig. below.



Condensate stabilization by cascade flash separation. HP, high pressure; MP, medium pressure; LP, low pressure.

- The condensate is flashed and separated at three successive pressures at 500, 100, and 15 psig. The flashed vapor can be used as a fuel gas in the facility or sent to the flare (during early production developments).

- Typically, the vapors are compressed back to the feed section for recovery. Vapor from compressor discharge is cooled and the condensed liquid is blended with the condensate product, which helps to reduce the condensate losses.
- To achieve a low RVP condensate, the feed must be heated to higher temperatures, typically about 150-250ºF.
- In fact, the feed temperature must be sufficiently high to drive off its H_2S content to meet the H_2S specification in the product. Once the H_2S specification has been met, heating can be adjusted as needed to meet the vapor pressure specification.

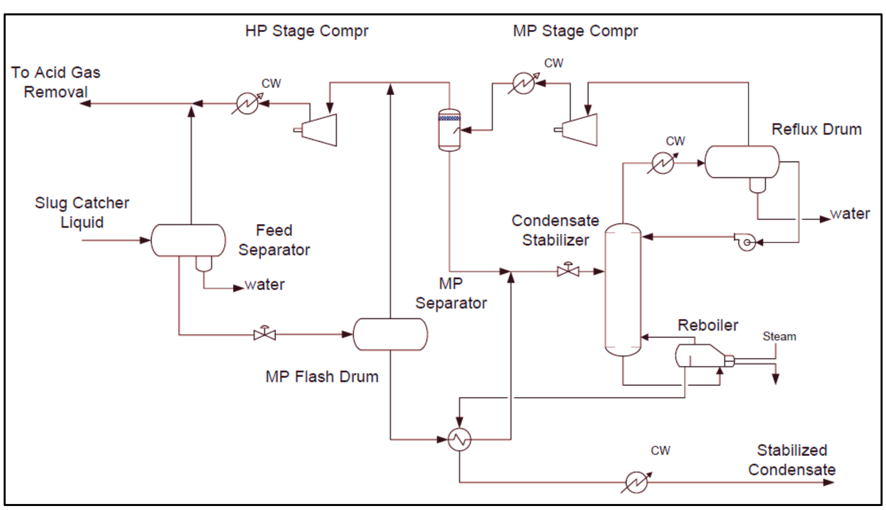
7.1.2 Stabilization by Distillation

- Distillation process is an efficient method for separating the C_5^+ from the lighter components, instead of using multiple flash stages.
- The distillation column can be a refluxed type or a non-refluxed type (simple stripper).
- A non-refluxed type is lower in capital cost, as the overhead reflux condenser system is not required.
- The drawback is the loss of C_5^+ components in the overhead. The C_5^+ components can be partially recovered by recycling the condensate later.
- With the refluxed column, there are two design options. **The first option** is to produce a condensate product, with the butane and lighter components returned to the acid gas removal unit (AGRU). **The second option** is to produce a condensate and a liquefied petroleum gas (LPG) fraction.

1. **Condensate Production Only**

- The process flow schematic of a condensate stabilization unit is shown in Fig. below.
- The condensate is flashed and separated in an intermediate separator, with flashed vapors compressed and returned to the AGRU.

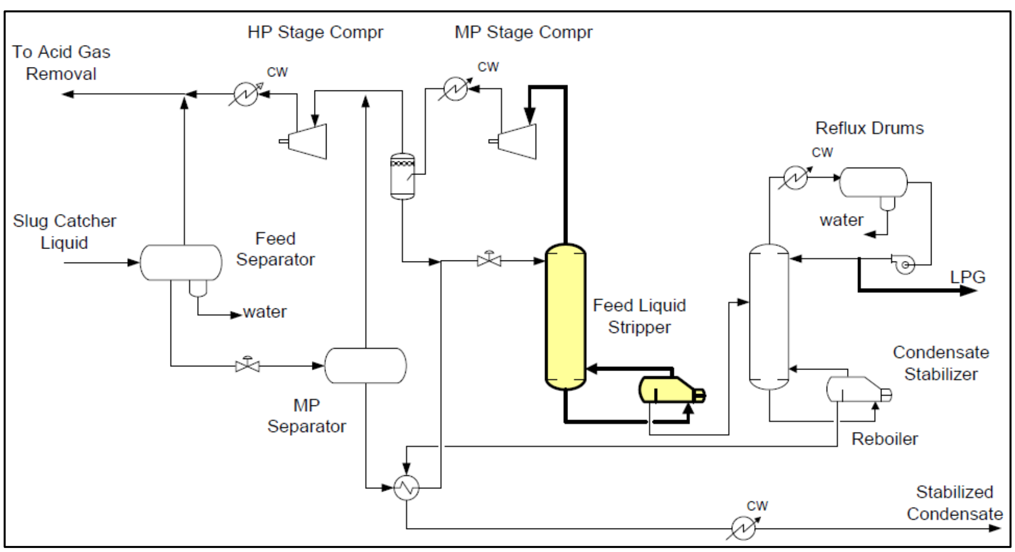
- The flashed liquid is preheated with the stabilizer bottom and routed to the stabilizer for separation.
- The stabilizer typically operates between 150 and 250 psia and contains about 20-25 trays. The stabilizer column is heated with medium pressure steam to meet the RVP specification.
- The overhead vapor is partially condensed, by air or cooling water (cw), producing a reflux to the column and a butane and lighter vapor that is compressed to the AGRU.
- No liquid overhead product is produced in this configuration.
- Because the condensate is saturated with water, water will be stripped and condensed in the upper column.
- Water is collected in the reflux drum as an aqueous phase and may be trapped in the upper section of the stabilizer column.
- Any free water must be removed from the column or it will build up inside the column, resulting in column flooding.
- The advantage of the condensate only design is that it recycles the LPG portion to the gas processing plant.
- The disadvantage is that the gas plant has to be designed for a higher duty from the recycled LPG.



Condensate stabilization by distillation

2. Condensate and Liquefied Petroleum Gas Production

- ❖ The condensate stabilization process can be configured to produce LPG from the stabilizer column.
- ❖ To meet the ethane content in the LPG product, a feed liquid stripper is required upstream of the stabilizer. This stripper is designed to remove all the acid gases and lighter components such that the LPG product from the downstream stabilizer would meet the H_2S and vapor pressure specifications.
- ❖ The process flow schematic for the feed liquid stripper and stabilizer is shown in Fig. below.
- ❖ The feed liquid stripper pressure is typically set at about 200 psia or at slightly higher pressure than the stabilizer such that pumping can be avoided. The advantage of this process is that it avoids recycling the LPG portion and minimizes the size of the gas processing plant. However, the LPG product may contain other contaminants that may not meet specifications for export.



Condensate and liquified petroleum gas production

7.2 Condensate Hydrotreating

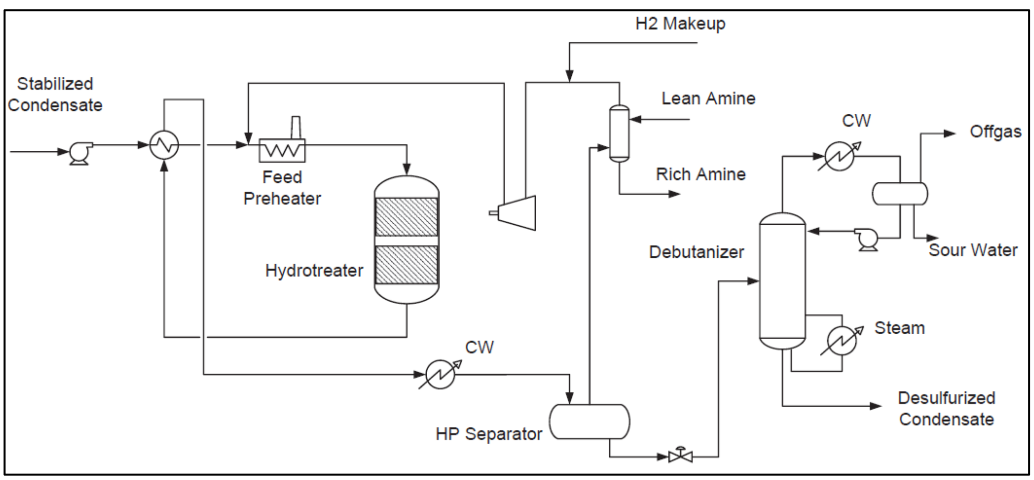
- If the condensate contains the lower molecular- weight mercaptans (methyl mercaptan), it can be treated by conventional liquid-treating technologies, such as caustic wash, UOP's Merox, molecular sieves, and catalyst solid beds.
- If the condensate contains the higher-molecular-weight mercaptans, aromatic compounds, and other undesirable sulfur components, it must be processed with a hydrotreater, which is a common process in refinery to desulfurize high sulfur feedstock. The primary function is to use a hydrotreater catalyst to promote the following desulfurization reactions:

$$R - S - H + H_2 = R - H + H_2S$$

$$R - S - R' + 2H_2 = R - H + R' - H + H_2S$$

where, R and $R^/$ are hydrocarbon and alternate hydrocarbon chains, respectively.

- A typical process flow scheme of a condensate hydrotreating unit is shown in Fig. below.



Condensate hydrotreating

- The process consists of a high-pressure reactor loop where sulfur compounds are converted to H_2S, and aromatic hydrocarbons are saturated and converted to paraffinic hydrocarbons.
- The reactor effluent is cooled; recycle gas and product liquids are separated.

- The H_2S content in the flashed gas is removed by an amine-treating unit.
- The flashed liquid is letdown in pressure and fractionated in a debutanizer, which strips off the H_2S, butane, and light components from the condensate to produce a sulfur-free hydrocarbon liquid.
- Hydrogen compression is necessary to maintain the hydrogen partial pressure in the hydrotreater reaction loop.