Liquids Processing
Chapter 15
Reasons for Liquids Processing

Make a shippable liquid product
  ▪ Reduce vapor pressure

Sweeten – reduce sulfur content

Make individual salable products
Plant Block Schematic

Adapted from Figure 7.1, *Fundamentals of Natural Gas Processing*, 2nd ed. Kidnay, Parrish, & McCartney
Topics

Condensate processing
- Vapor pressure control
- Sweetening
- Dehydration

NGL processing
- Fractionation
- Sweetening
  - Amine treating
  - Adsorption
  - Caustic treating
- Dehydration
  - Adsorption
  - Dessicant (nonrenewable)
  - Gas stripping
  - Fractionation
Condensate processing
Simple condensate processing

Vapor pressure spec –
10 – 34 psi RVP

- If trucked off site, more typically 9 – 12 psi RVP

D86 end point no more than 375°F

NGL processing
Typical NGL Fractionation Conditions

**TABLE 15.1**

<table>
<thead>
<tr>
<th>Fractionator</th>
<th>Operating Pressure, psig (barg)</th>
<th>Number of Actual Trays</th>
<th>Reflux Ratioa</th>
<th>Tray Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deethanizer</td>
<td>350–450 (24–30)</td>
<td>25–40</td>
<td>0.8–2.0</td>
<td>60–85</td>
</tr>
<tr>
<td>Depropanizer</td>
<td>240–270 (16–19)</td>
<td>30–45</td>
<td>1.8–3.5</td>
<td>80–90</td>
</tr>
<tr>
<td>Debutanizer</td>
<td>70–130 (5–9)</td>
<td>25–40</td>
<td>1.2–1.8</td>
<td>85–95</td>
</tr>
<tr>
<td>Deisobutanizer(b)</td>
<td>80–100 (5–7)</td>
<td>70–100</td>
<td>4–16</td>
<td>90–100</td>
</tr>
<tr>
<td>Condensate Stabilizer</td>
<td>50–400 (3–30)</td>
<td>16–24</td>
<td>Varies</td>
<td>30–50</td>
</tr>
</tbody>
</table>

*a* Reflux ratio relative to overhead mol/mol.

*b* Also called a butane splitter.

Ref: *Fundamentals of Natural Gas Processing, 2nd ed.*, Kidnay, et. al.

![Diagram of NGL fractionation train](image-url)
Typical NGL Fractionation

<table>
<thead>
<tr>
<th>Operating Pressure, psig</th>
<th>Number of Actual Trays</th>
<th>Reflux(^1) Ratio</th>
<th>Reflux(^2) Ratio</th>
<th>Tray Efficiency, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demethanizer</td>
<td>200 – 400</td>
<td>18 – 26</td>
<td>Top Feed</td>
<td>45 – 60</td>
</tr>
<tr>
<td>Deethanizer</td>
<td>375 – 450</td>
<td>25 – 35</td>
<td>0.9 – 2.0</td>
<td>60 – 75</td>
</tr>
<tr>
<td>Depropanizer</td>
<td>240 – 270</td>
<td>30 – 40</td>
<td>1.8 – 3.5</td>
<td>80 – 90</td>
</tr>
<tr>
<td>Debutanizer</td>
<td>70 – 90</td>
<td>25 – 35</td>
<td>1.2 – 1.5</td>
<td>85 – 95</td>
</tr>
<tr>
<td>Butane Splitter</td>
<td>80 – 100</td>
<td>60 – 80</td>
<td>6.0 – 14.0</td>
<td>90 – 100</td>
</tr>
<tr>
<td>Rich Oil Fractionator</td>
<td>130 – 160</td>
<td>20 – 30</td>
<td>1.75 – 2.0</td>
<td>Top 67 Bottom 50</td>
</tr>
<tr>
<td>Rich Oil Deethanizer</td>
<td>200 – 250</td>
<td>40</td>
<td>–</td>
<td>Top 25 – 40</td>
</tr>
<tr>
<td>Condensate Stabilizer</td>
<td>100 – 400</td>
<td>16 – 24</td>
<td>Top Feed</td>
<td>Bottom 40 – 60</td>
</tr>
</tbody>
</table>

\(^1\) Reflux ratio relative to overhead product, mol/mol
\(^2\) Reflux ratio relative to feed, gal/gal.

Ref: GPSA Engineering Data Book, 13\(^{th}\) ed.
Liquid Sweetening & Dehydration
Liquid Sweetening

Upstream treatment of the gases will usually remove H$_2$S but not CS$_2$ or mercaptans

Liquid treating options

- Amines – effectiveness is similar to gas treating
- Adsorption
  - Effective if no water is present
- Caustic treating
  - Converts sulfur compounds into water soluble mercaptan salt; oxidized with air to form dissulfide oil

\[
\text{RSH} + \text{NaOH} \rightarrow \text{RSNa} + \text{H}_2\text{O} \\
2 \text{RSNa} + \frac{1}{2} \text{O}_2 + \text{H}_2\text{O} \rightarrow \text{RSSR} + 2 \text{NaOH}
\]
Liquid Sweetening

UOP’s Merox process is very common

- Catalytic oxidation process. Carried out in an alkaline environment with aqueous solution of NaOH (strong base) or NH3 (weak base).
- Reactions (using NaOH)
  - Extraction:
    \[ R-\text{SH} + \text{NaOH} \rightarrow \text{NaS-R} + \text{H}_2\text{O} \]
  - Regeneration:
    \[ 4 \text{NaS-R} + \text{O}_2 + 2 \text{H}_2\text{O} \rightarrow 2 \text{R-S-S-R} + 4 \text{NaOH} \]
  - Overall:
    \[ 4 \text{R-\text{SH}} + \text{O}_2 \rightarrow 2 \text{R-S-S-R} + 2 \text{H}_2\text{O} \]
- Can control to less than 10 ppmw mercaptan level
- Dissulphides leave in the Merox reactor in caustic/aqueous phase. Once oxidized forms a non-soluble disulfide oil.


Liquid Dehydration

Low mutual solubility of liquid water & liquid hydrocarbons

- Greatest mutual solubility is with water & aromatics (benzene, ...)

Process options:

- Adsorption (e.g., mole sieves)
- Desiccant
- Gas stripping
Summary
Summary

Extent of processing depends on product(s) to be made
  ▪ Simplest processing is to stabilize the condensate

Separation into multiple products usually done at large facility or centralized processing facility
  ▪ Separate the lightest fractions first
  ▪ Separate isomers after carbon-number fraction separated from rest of liquids

Sweetening
  ▪ Merox unit can remove all sulfur compounds – makes disulfide oils

Dehydration
  ▪ Typical processes are mole sieve adsorption, desiccant adsorption, & gas stripping