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**College of Petroleum Processes Engineering**

**Department of Petroleum and Gas Refining  
Engineering**

**Gas Technology**

**Forth Class**

**Lecture 15**

**By**

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# RECOVERY, SEPARATION, AND FRACTIONATION OF NATURAL GAS LIQUIDS

## Introduction:

Natural gas coming directly from a well contains many natural gas liquids that are commonly removed. In most instances, natural gas liquids (NGLs) have a higher value as separate products, and it is thus economical to remove them from the gas stream. The removal of natural gas liquids usually takes place in a relatively centralized processing plant, and uses techniques similar to those used to dehydrate natural gas.

There are two basic steps to the treatment of natural gas liquids in the natural gas stream. First, the liquids must be extracted from the natural gas. Second, these natural gas liquids must be separated themselves, down to their base components.

To recover and separate NGL from a bulk of gas stream, a change in phase has to take place. In other words, a new phase has to be developed for separation to occur. Two distinctive options are in practice depending on the use of

- **Energy Separating Agent (ESA) or**
- **Mass Separating Agent (MSA).**

## Energy Separating Agent

The distillation process best illustrates a change in phase using ESA. To separate, for example, a mixture of alcohol and water heat is applied. A vapor phase is formed in which alcohol is more concentrated, and then separated by condensation. This case of separation is expressed as follows:

A mixture of liquids + Heat  $\rightarrow$  Liquid + Vapor

For the case of NGL separation and recovery in a gas plant, removing heat (by refrigeration) on the other hand, will allow heavier components to condense; hence, a liquid phase is formed. This case is represented as follows:

A mixture of hydrocarbon vapor – Heat  $\rightarrow$  Liquid + Vapor

Partial liquefaction is carried out for a specific cut, whereas total liquefaction is done for the whole gas stream.

## Mass Separating Agent

To separate NGL, a new phase is developed by using either a solid material in contact with the gas stream (adsorption) or a liquid in contact with the gas (absorption).

## LIQUIDS CONTENT

Gas composition plays a critical role in the economics of gas processing. The more liquids, usually defined as  $C_2^+$ , in the gas, the “richer” the gas. Extraction of these liquids produces a product that may have a higher sales value than does natural gas.

To quantify the liquids content of a natural gas mixture, the industry uses GPM, or gallons of liquids recoverable per 1,000 standard cubic feet (Mscf) of gas. (In metric units, the quantity is commonly stated as  $m^3$  of liquid per 100  $m^3$  of gas.) The term usually applies to ethane and heavier components but sometimes applies instead to propane and heavier components. Determination of the GPM requires knowledge of the gas composition on a mole basis and

the gallons of higher hydrocarbons. Note that ethane is not a liquid at 60°F (15.5°C), so the value is a hypothetical value accepted throughout the industry.

### Parameters Controlling NGL Separation

A change in phase for NGL recovery and separation always involves control of one or more of the following three parameters:

- Operating pressure, P
- Operating temperature, T
- System composition or concentration, x and y

*To obtain the right quantities of specific NGL constituents, a control of the relevant parameters has to be carried out:*

1. For separation using ESA, pressure is maintained by direct control. Temperature, on the other hand, is reduced by refrigeration using one of the following techniques:

- (a) Compression refrigeration
- (b) Cryogenic separation; expansion across a turbine
- (c) Cryogenic separation; expansion across a valve

2. For separation using MSA, a control in the composition or the concentration of the hydrocarbons to be recovered (NGL); y and x is obtained by using adsorption or absorption methods.

The *efficiency* of condensation, hence NGL recovery, is a function of **P, T, gas and oil flow rates, and contact time**. Again, absorption could be coupled with refrigeration to enhance condensation.

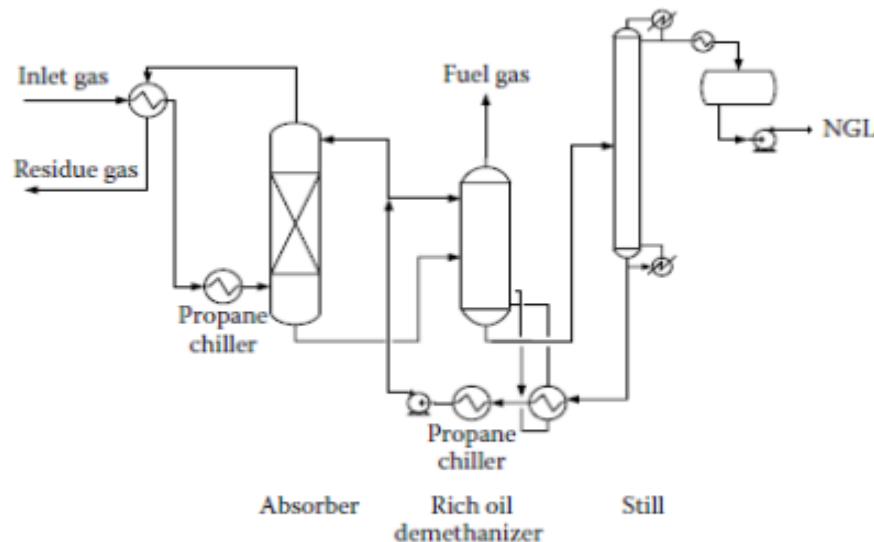
## Absorption Process

The absorption unit, Fig. 13, consists of two sections:

- Absorption
- Regeneration
- ◆ An upflow natural gas stream is brought in direct contact, countercurrently with the solvent (light oil in the kerosene boiling range) in the absorber.
- ◆ The column—a tray or packed one—operates at about 400–1000 psia and ambient or moderately subambient temperatures.
- ◆ The rich oil (absorbed NGL plus solvent) is directed to a distillation unit to separate and recover the NGL, whereas the lean oil is recycled back to the absorber.
- ◆ In addition to natural gasoline,  $C_3/C_4$  could be recovered as well in this process.
- ◆ Provision is made to separate ethane from rich oil using a deethanizer column. Ethane recovery, however, is quite small. This process is being phased out.
- ◆ This process allows for the recovery of around 75 percent of butanes, and 85 - 90 percent of pentanes and heavier molecules from the natural gas stream.

The basic absorption process above can be **modified** to improve its effectiveness, or to target the extraction of specific NGLs. In the refrigerated oil absorption method, where the lean oil is cooled through refrigeration, propane recovery can be upwards of 90 percent, and around

40 percent of ethane can be extracted from the natural gas stream. Extraction of the other, heavier NGLs can be close to 100 percent using this process.

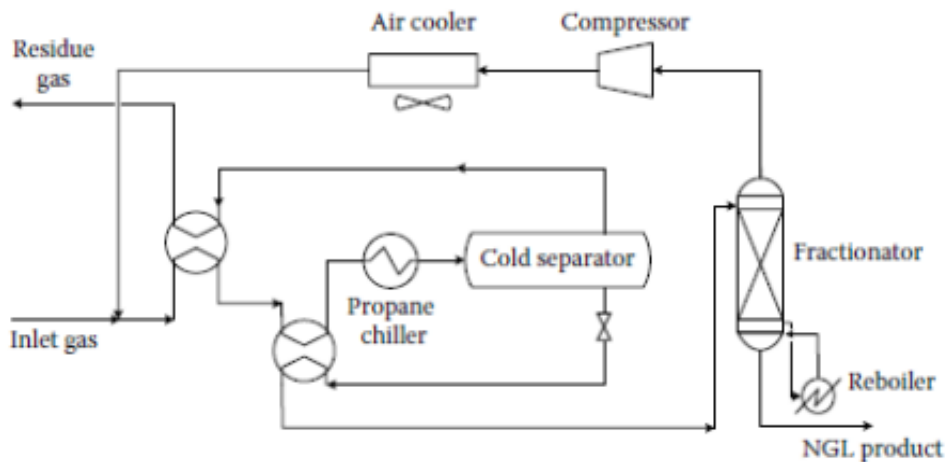


**Figure 13: Refrigerated Lean Oil Absorption Process**

## Refrigeration Process

The production of NGL at low temperature is practiced in many gas processing plants in order to condense NGL from gas streams. As indicated in Figure 14, using *nontoxic and noncorrosive refrigerants* to chill the feed natural gas to a temperature between  $0^{\circ}\text{F}$  and  $-40^{\circ}\text{F}$  using a low level one-component refrigerant system provides external refrigeration.

When using a high-level cascade refrigerant system, a much lower temperature in the range of  $-100^{\circ}\text{F}$  to  $-150^{\circ}\text{F}$  is reached. Liquids are separated from the residue gas at multiple temperatures and then fractionated into final products. Ethane recovery is a strong function of the operating temperatures as is explained next.



**Figure 14: Schematic of Direct Refrigeration Process for Partial Recovery of  $\text{C}_2^+$  Fraction**

The schematic flow diagram above shows one commonly used direct-refrigeration process that employs recycle from a fractionator to maximize liquids recovery. Inlet gas is initially cooled with cold residue gas and cold liquid from the cold separator before going to the propane chiller and to the cold separator. Vapor from the separator is the sales gas, and the liquid goes to a fractionator to strip out light ends and recover liquid product.

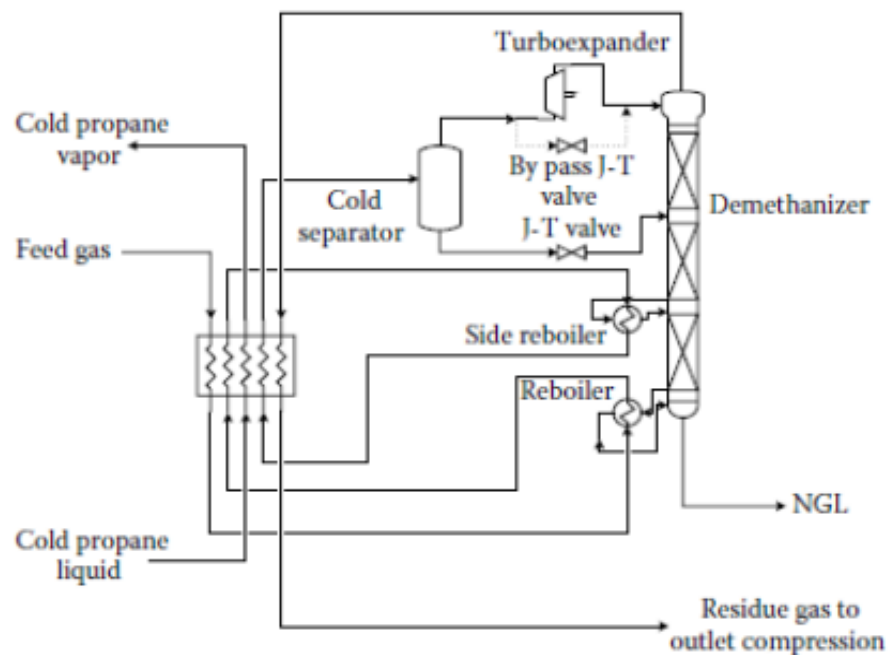
The column operates at a lower pressure than does the cold separator. Because of system pressure drop and because the fractionator runs at the lower pressure, the recycle stream must be recompressed.

## Cryogenic Processes

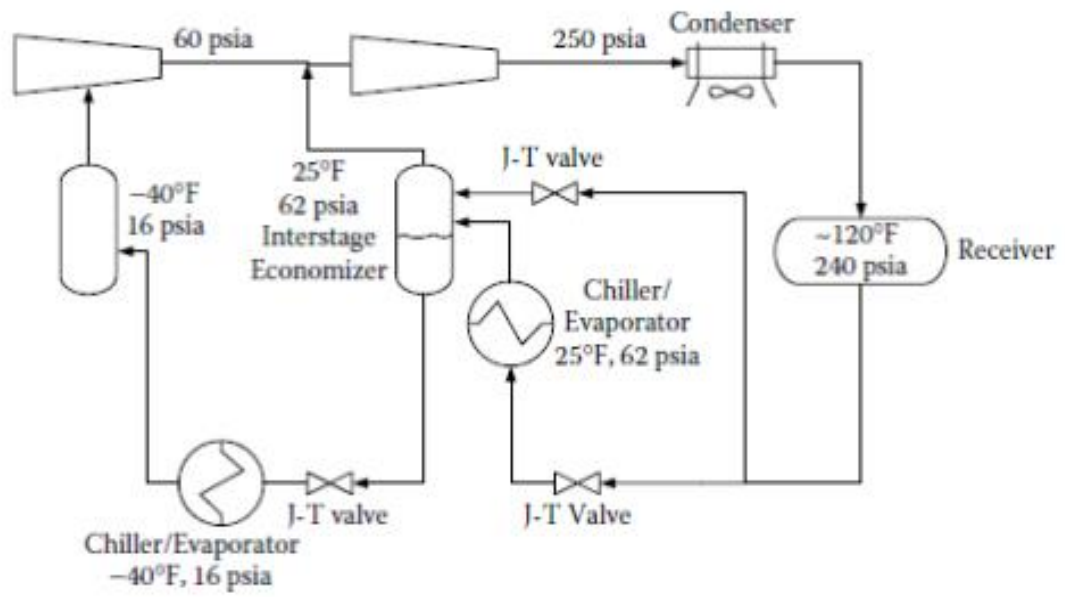
Natural gas liquid could be separated from natural gas using two approaches based on cryogenic expansion (autorefrigeration):

- An expander plant (Fig.15) produces refrigeration to condense and recover the liquid hydrocarbons contained in the natural gas by using a turboexpander. In this process, the enthalpy of the natural gas is converted into useful work, behaving thermodynamically as an approximate isentropic process.
- Expansion across the valve (Fig.16) will lead to a similar result. However, the expansion is described in this case as “isenthalpic.”

Temperatures produced by turboexpansion are much lower than those of valve expansion. The turbo expander process operates at  $-100^{\circ}\text{F}$  to  $-160^{\circ}\text{F}$  and 1000 psia. The process represents a new development in the gas processing industry. Increased liquid recovery (especially ethane) is an advantage of this process.



**Figure 15: Schematic of Cryogenic Separation, Expansion across Turbine**



**Figure 16: Schematic of a Cryogenic Separation, Expansion across Valve**