Problem Statement

TICHE Design Competition Year 2022-2023

"Next Generation of Ethane Recovery Unit"

Rational

Natural gas is a mixture of gasses, which is primarily composed of Rich hydrocarbon as Methane, Ethane, Propane, LPG and heavier hydrocarbons. It also contains small amounts of impurities or Non-hydrocarbon gasses such as nitrogen, carbon dioxide, hydrogen sulphide and a trace amount of water.

In Thailand, natural gas is commonly distributed to Gas Separation Plant (GSP) to separate various hydrocarbon components of natural gas, thus adding value to gas from the Gulf of Thailand. Regarding our separated hydrocarbon product, Methane (C_1H_4) is one of the energy sources in power plants and cities via pipelines. Ethane (C_2H_6), propane (C_3H_8) and LPG (mixture of C3 and C4 component) from gas separation plants are feedstocks of petrochemical plants for producing ethylene and propylene. C5+, which C5 and heavier are included, is one of the feedstocks of refinery plants to blend into gasoline as well as petrochemical plants.

The purpose of this study is to design the Next Generation of Ethane Recovery Unit, **only Ethane Recovery Unit** by focusing on a high ethane recovery rate (At least 97.5% Ethane recovery) to recover Ethane and heavier hydrocarbons from Methane with low operating consumption.

Remark : Ethane Recovery is calculated by this below formula

$$\%Ethane\ Recovery\ = \frac{Moles\ of\ Ethan\ \ at\ Bottom\ Demethanizer\ (Battery\ Limit\ 3)}{Moles\ of\ Ethane\ in\ Treated\ Gas\ (\ Battery\ Limit\ 1)}\ x\ 100$$

Basis of Design

A. Feed Gas Capacity and throughput

Ethane Recovery Unit (ERU) is designed for an overall throughput of 390 MMSCFD (dry basis) at inlet ERU (**Battery Limit 1 as shown in Picture 1**).

Parameter	Flowrate	Pressure	Temperature
Inlet Ethane Recovery Unit	390 MMSCFD	42 barg	20 degC

B. Feed characteristics (**Treated Gas Composition at Battery Limit 1**)

Component	%mol
Methane	80.36
Ethane	9.23
Propane	5.06
i-Butane	1.27
n-Butane	1.09
i-Pentane	0.35
n-Pentane	0.22
n-Hexane	0.23
CO2	0.00
N2	2.19
Total	100

Product Specification and Battery Limit

Methane Product (**Battery Limit 2 as shown in Picture 1**)

	Wobbe Index	Operating Pressure	Operating Temperature
Methane	1220-1340 BTU/SCF	44 Barg	≤ 50 degC

Ethane plus Product (**Battery Limit 3 as shown in Picture 1**)

	Mole fraction Ratio of C1/C2	Operating Pressure	Operating Temperature
Methane	<1.50 e-002	≥ 30	≤ 50 degC

Process Description

The Next-Generation Gas Separation plant is designed to recover Ethane, Propane, LPG and NGL from natural gas. This gas plant comprises of the Gas Treatment Section, Cryogenic Section (Ethane Recovery Unit) and Fractionation Section to perform their functions as :

Gas Treatment Section

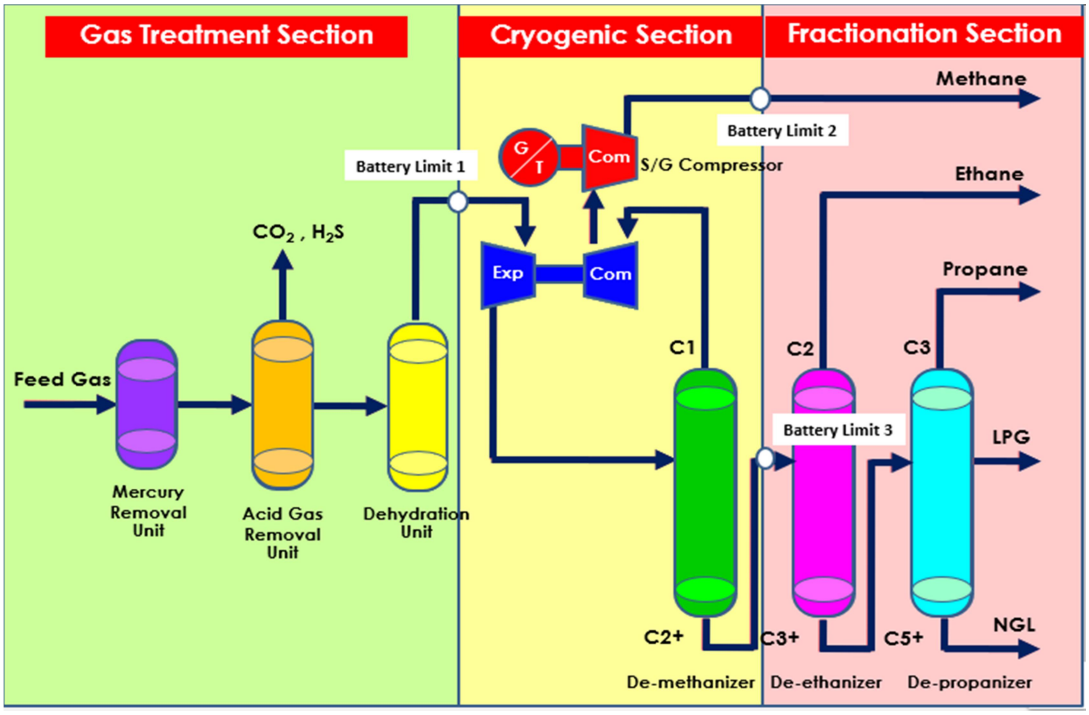
The purpose of a Gas Treatment section is to remove the impurities from natural gas such as Mercury (Hg), Acid Gas (CO_2,H_2S) and Water (H_2O) before sending the treated gas to Cryogenic Section (Ethane Recovery Unit) as shown in **Picture 1.**

Cryogenic Section or Ethane Recovery Unit

The purpose of a Ethane Recovery Unit is to cool down and condense C2+ products from Methane gas as much as possible. In order to separate and recover C2 plus from Methane gas, the treated gas at **Battery Limit 1** is cooled by Turbo-Expander, external C3 refrigeration or/and exchanged with cold stream using heat exchanger.

Fractionation Section

Ethane plus (C2+) product (**Battery Limit 3**) from Ethane Recovery Unit is then sent to fractionation section, which is composed of De-ethanizer and De-propanizer Column to separate and purify each product such as Ethane, Propane LPG and NGL before transferring to Petroleum customer as shown in **Picture 1.**



Picture 1 : Simplified schematic of overall Gas Separation Plant

Assumption

Revenue

Product	Thai Baht (THB)	Unit
Ethane product	12,000	Per ton
Propane and Butane product	10,000	Per ton
Heavier Hydrocarbon product (C5+)	14,000	Per ton

Expense (Utilities)

Source	Temperature	Pressure	Cost / Unit
Hot Oil (Heat Source) Sensible heat shall be used.	Supply 170 degC Return 130 degC	6 barg	750 Baht / MWh
Propane Refrigerant (Cold Source) Latent heat shall be used.	- 30 degC	0.2 barg	350 Baht / MWh
Electrical Consumption	None	None	5 Baht / kWh

Remark : Plant to be operate for 24 hours/day and 365 days/year

Design Requirement

Designers are requested to design only Ethane Recovery Unit using the information provided above to recover C2+ product (At least 97.5% Ethane recovery). Ration of Revenue per Expense is provided as a guideline for determining the value of the design.

$$Ratio\ of\ \frac{Revenue}{Expense} = \frac{Revenue\ of\ all\ products\ (Tons\ of\ each\ product\ x\ each\ Unit\ rates)}{Total\ Expense\ (Heat\ \&\ Cold\ Source, and\ Electrical\ Consumption)}$$

Design guideline of gas and liquid system

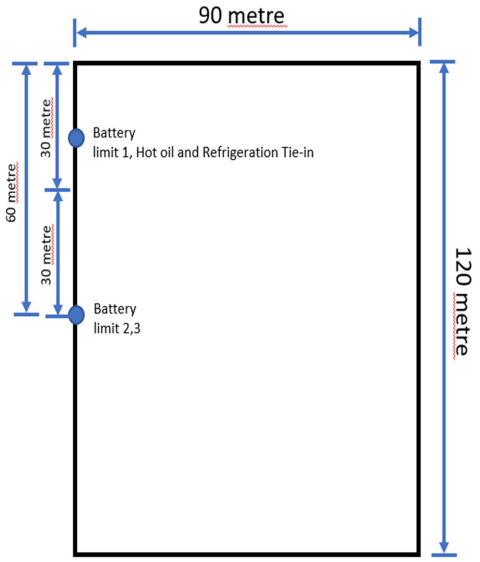
The guidelines shown in the following should be used when calculating the line size of vapor and liquid lines. The guidelines cover most normal situations for systems within unit battery limits.

- Gas velocity : 18.3 m/s
- Liquid velocity : 2.5 m/s

For economic analysis, suggested investment costs in engineering design software are preferable.

Area of Construction

The area of construction of this cryogenic section is located spared area nearby the existing Gas Separation Plant No.6. The dimension of construction area and Battery limit point has been shown in the below picture (W x L = 90 m x 120 m).



Guidance , Keyword : Ethane Recovery Unit, NGL Recovery Plant

Deliverables

The report must have contents in the following order.

1. Letter of Transmittal
2. Cover Page
3. Table of Contents
4. Abbreviations
5. Introduction/ Conceptual Design including block diagram/ Design Basis
6. Design philosophy
7. Control philosophy
8. Process Control System (PCS) and Safety Instrumented System (SIS)
9. Process Flow Diagram
10. Material Selection

11. Process Description
12. Material/Energy Balances
13. Preliminary hydraulic calculation
14. Preliminary Piping and Instrument Diagram
15. Utility Requirements
16. Equipment and control valve data sheet
17. Equipment List
18. Equipment Specification Sheets
19. Preliminary Plot Plan
20. Equipment Cost Summary
21. Power consumption and electrical load list
22. Economic Analysis (NPV, payback period, IRR)
23. Safety, Health, and Environmental Considerations
24. Other Important Considerations (optional)
25. Conclusions and Recommendations
26. Bibliography