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Upgrading of the C_3 Stream Separation Units of an Ethylene Plant

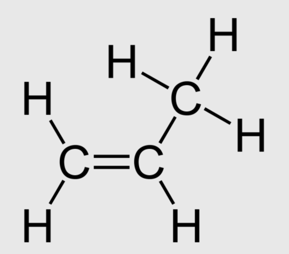
Introduction

The purpose of this project was to design a C_3 upgrading stream for an ethylene plant located in Goldboro, NS.

Ethylene Quick Facts:

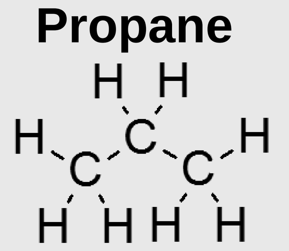
- Polyethylene is the most used plastic worldwide
- Approximately 60% of ethylene (C_2H_4) produced is used to manufacture polyethene [3]
- Ethylene plants produce several valuable co-products, two of which are propylene and propane

Propylene



- Used as an intermediate in the production of acetone, isopropanol, propylene oxide, etc.
- Two-thirds of the propylene produced globally are used in plastics [5]

Propane



- Primarily used as fuel
- Propane can be used to produce ethylene

The following design was developed using a 2-stage approach, objectives are separated accordingly:

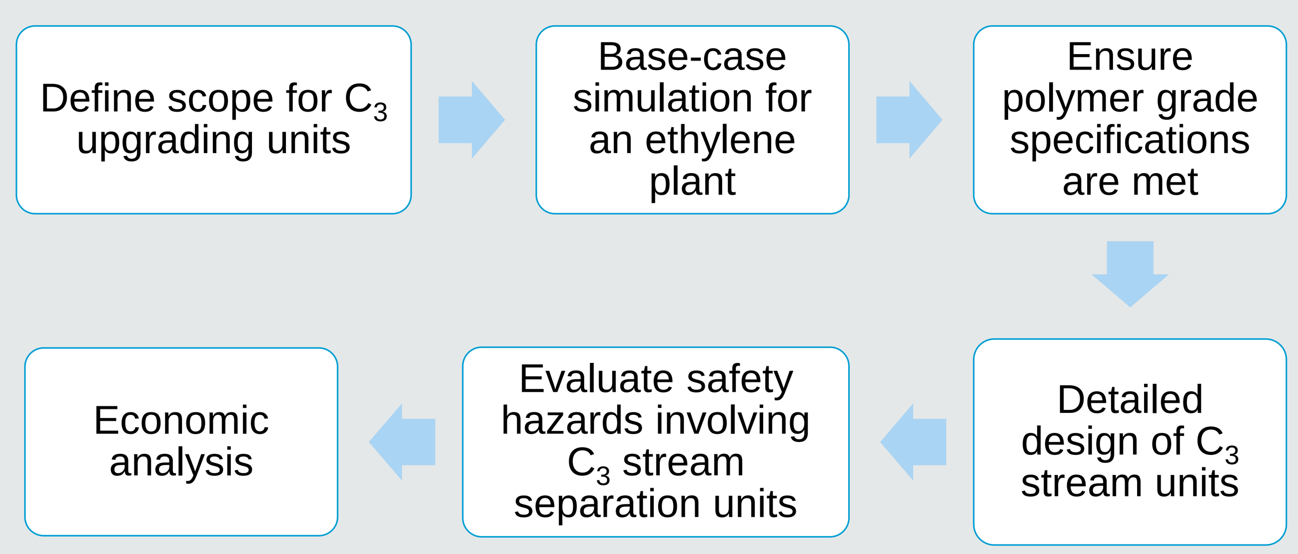
1. Ethylene Plant Simulation

- Simulate operations of an ethylene pant to produce 1000 kMTA of polymer-grade ethylene
- Using ethane feedstock
- Polymer grade ethylene – 99.9 wt% ethylene [7]

2. Detailed Design of C_3 Upgrading Stream

- Utilize the bottoms stream of T-101 to simulate upgrading of the C_3 stream of an ethylene plant
- Produce polymer grade propylene – 99.5 wt% propylene [7]
- Produce commercial propane [1]
- Evaluate potential hazards involving C_3 stream units
- Perform an economic analysis.

Design Process



Details of Design

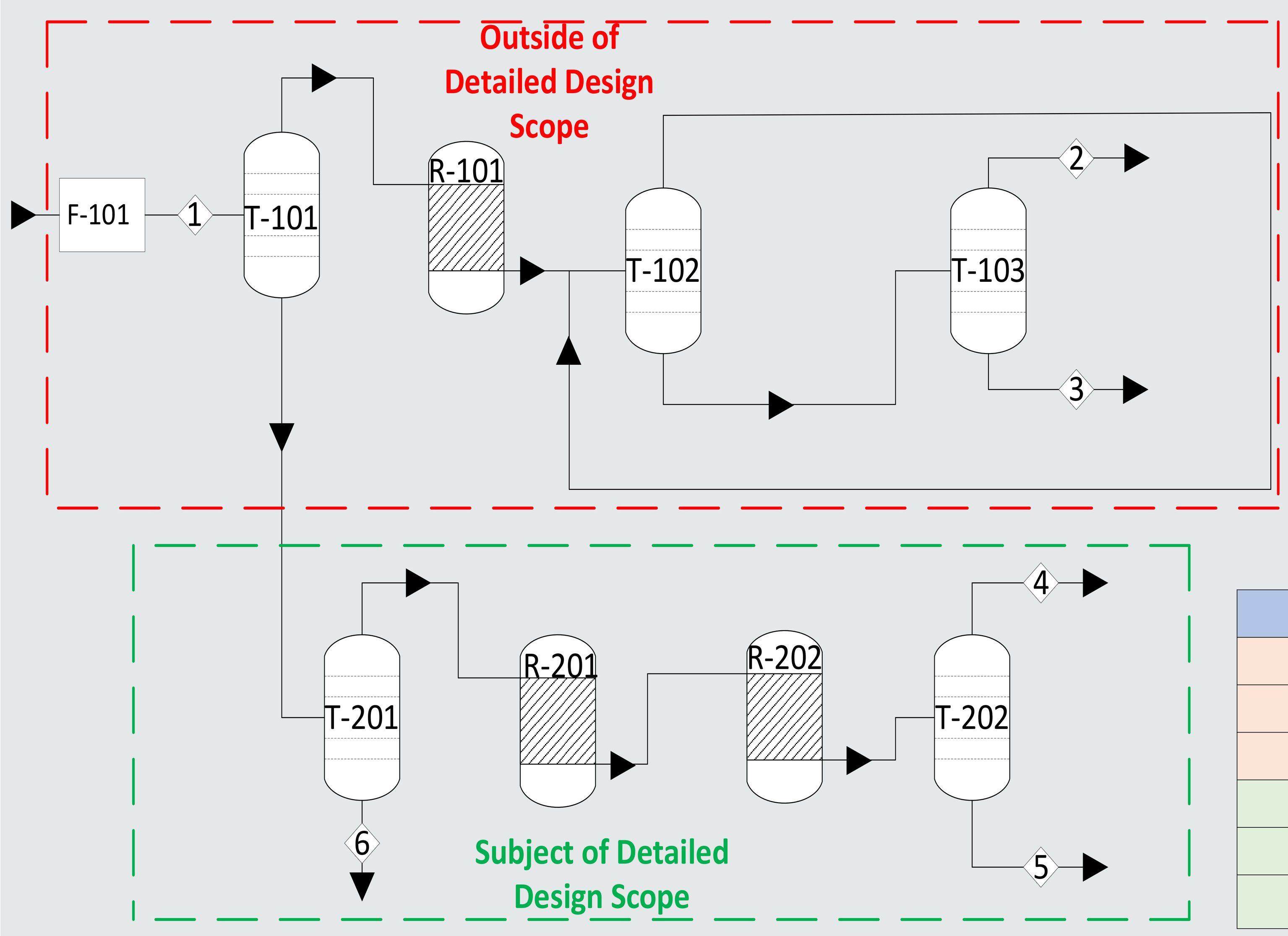


Figure 1 – Ethylene Plant Flow Diagram

Table 1 – Equipment Description

Equipment ID	Equipment Description
F-101	Cracking Furnace
T-101	De-Ethanizer
R-101	Acetylene Reactor
T-102	De-Methanizer
T-103	C2 Splitter
R-201	MAPD Reactor-1
R-202	MAPD Reactor-2
T-201	De-Propanizer
T-202	C3 Splitter

Table 2 – Stream Production Rates

Stream	Description	Production (kMTA)
1	Furnace Outlet	1911.3
2	Ethylene	1040.68
3	Ethane	693.8
4	Propylene	22.67
5	Propane	2.66
6	C_4+	65.07

Table 3 – Reactor Design Parameters

	R-201	R-202
Length (m)	1.56	1.411
Diameter (m)	0.519	0.470
Volume (m3)	0.327	0.245
Operating Pressure (bar)	24	24

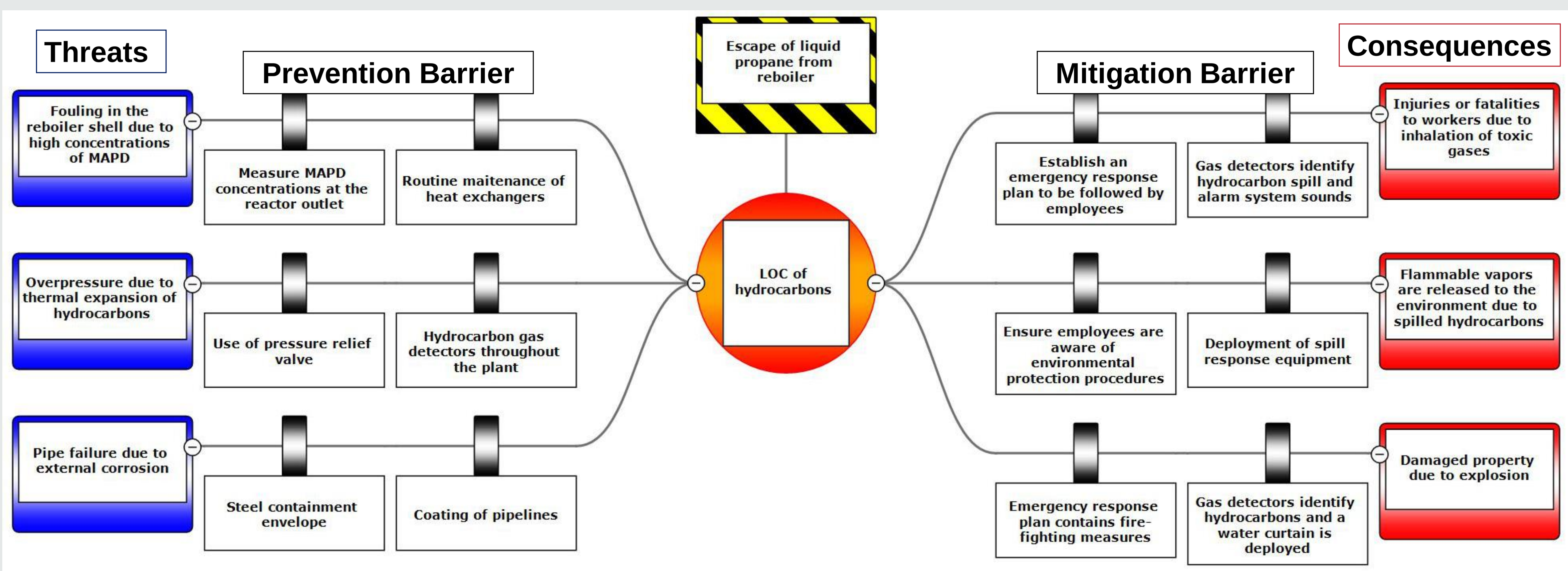
Table 4 – Distillation Column Design Parameters

	T-201	T-202
Height (m)	22.5	60.6
Diameter (m)	1.5	2.14
Number of Trays	28	186
Operating Pressure (bar)	14	8.75
Condenser/Reboiler Size (m^2)	320/27.7	283
Trim Condenser Size (m^2)	-	88.1
Compressor/Pump Drive Power (kW)	0.44	550

Safety Considerations

The figure below is a bowtie analysis which represents potential threats and consequences involving the C_3 upgrading stream.

- Hazard: Escape of liquid propane from reboiler
- Top Event: Loss of Containment (LOC) of hydrocarbons



Economics

Table 5 – Equipment Costs

Equipment	Capital Cost (USD)	Operating Cost (USD)
T-201	$3,007,600	$1,690,730
R-201	$439,760	$9,000
R-202	$335,300	$9,000
T-202	$8,114,050	$1,450,850
Total Annualized Cost (TAC)	$7,125,150	

Separated C_3 Streams Revenue Range :

- Propane - $USD 331,284 - $USD 2,324,800
- Propylene - $USD 9,740,700 – $USD 48,111,000

Mixed C_3 Stream Revenue Range:

- $USD 5,035,990 - $USD 25,217,900

Price ranges based on decade highs and lows [4],[6]

TAC assume 15% interest and 10-year life [2]

Conclusion & Recommendations

- Workable design of C_3 upgrading stream achieved
- Minimum annual revenue exceeds total annualized cost
- Sell propane as product as opposed to recycling to cracking furnace
- Further market analysis required to determine viability of implementing design
  - Profit still made on selling mixed C_3 stream
- Optimization of designed units should be examined
- Analyze the C_{4+} stream for potential refining

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