Hydrocarbon Recovery

Chapter 12

Based on presentation by Prof. Art Kidnay

COLORADO SCHOOL OF MINES

Reasons for Hydrocarbon Recovery

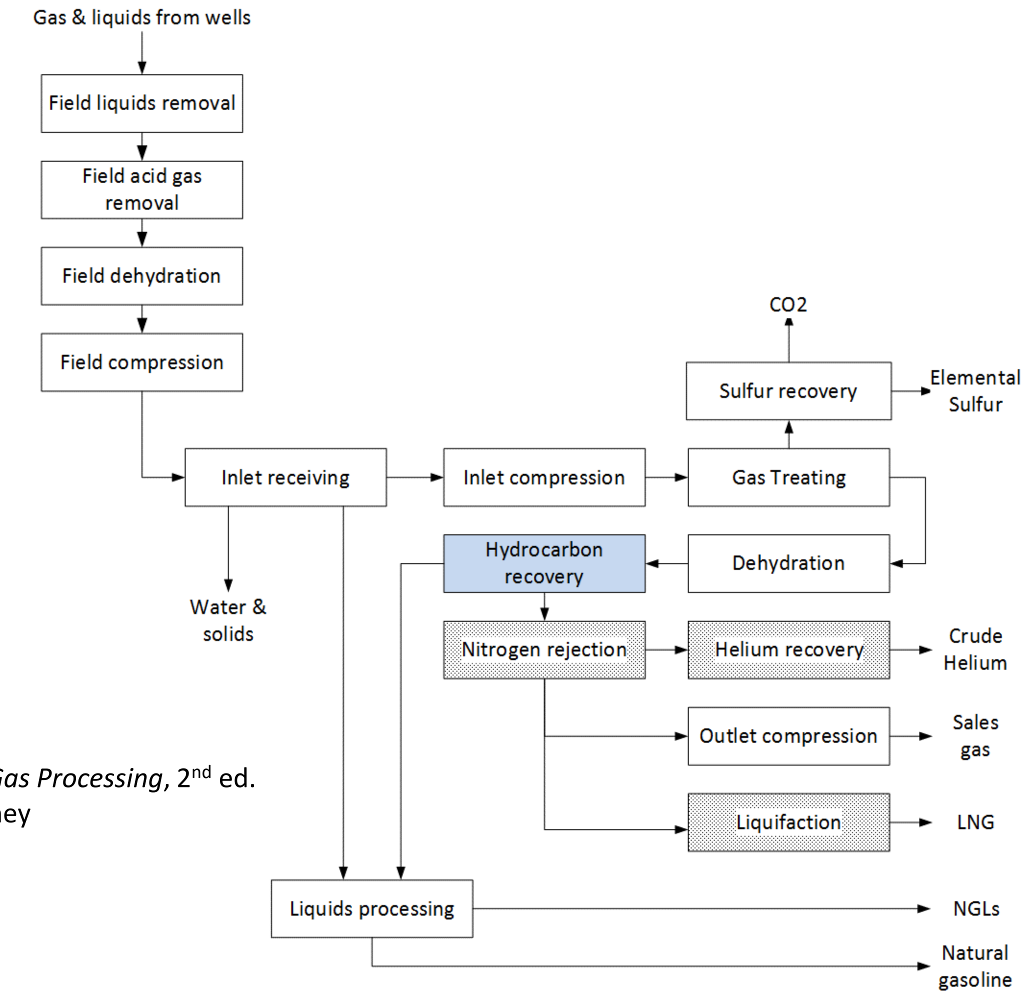
Field Operations

- Reduce liquid content of high GPM gases in gathering systems
- Eliminate or reduce potential for condensation (dew-pointing)
- Reduce Btu content of gas for use in engines (fuel conditioning)

Plant Operations

- Reduce Sales gas Btu content to spec (950 to 1150 Btu/scf)
- Eliminate possible condensation
- Recover valuable C_2^+ liquids

Plant Block Schematic



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

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Topics

Fundamentals

- Retrograde Condensation

Process Components

- Refrigeration System
- Turboexpansion
- Heat exchange
- Gas-Liquid Separators
- Fractionation

Recovery Processes

- Dew Point Control and Fuel Conditioning
- Low C2+ Recovery
- High C2+ recovery

Fundamentals

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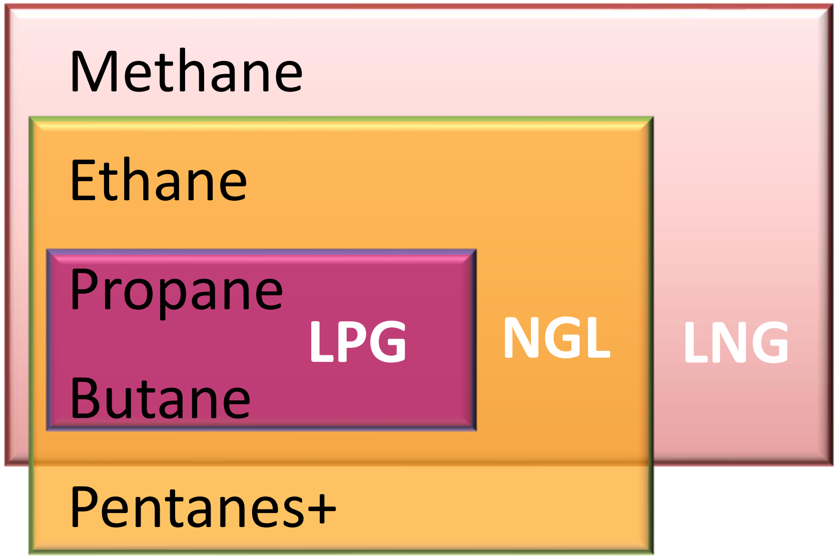
Reminder – Liquids Composition

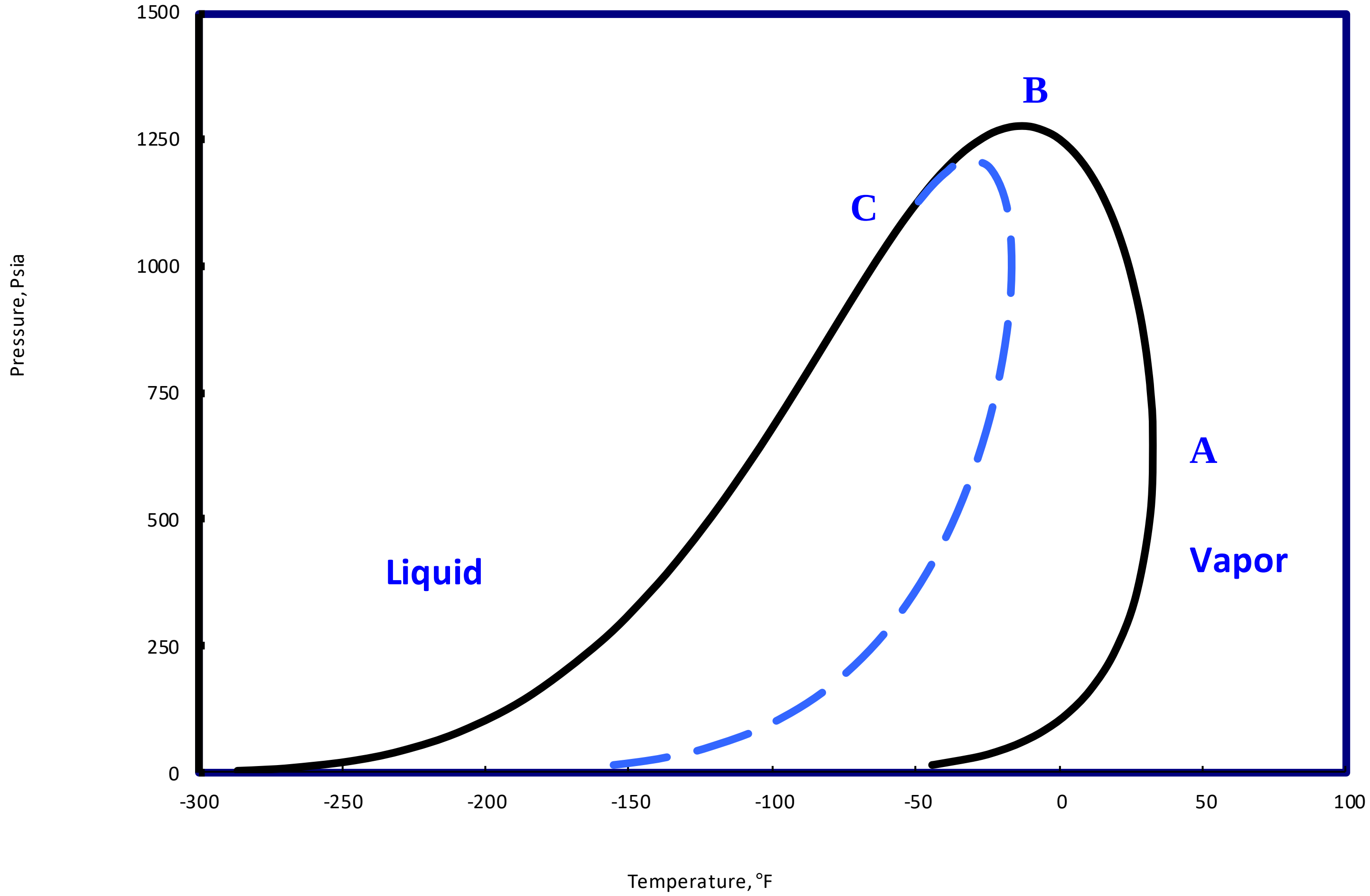
What are Natural Gas Liquids (NGL vs LPG vs LNG)?



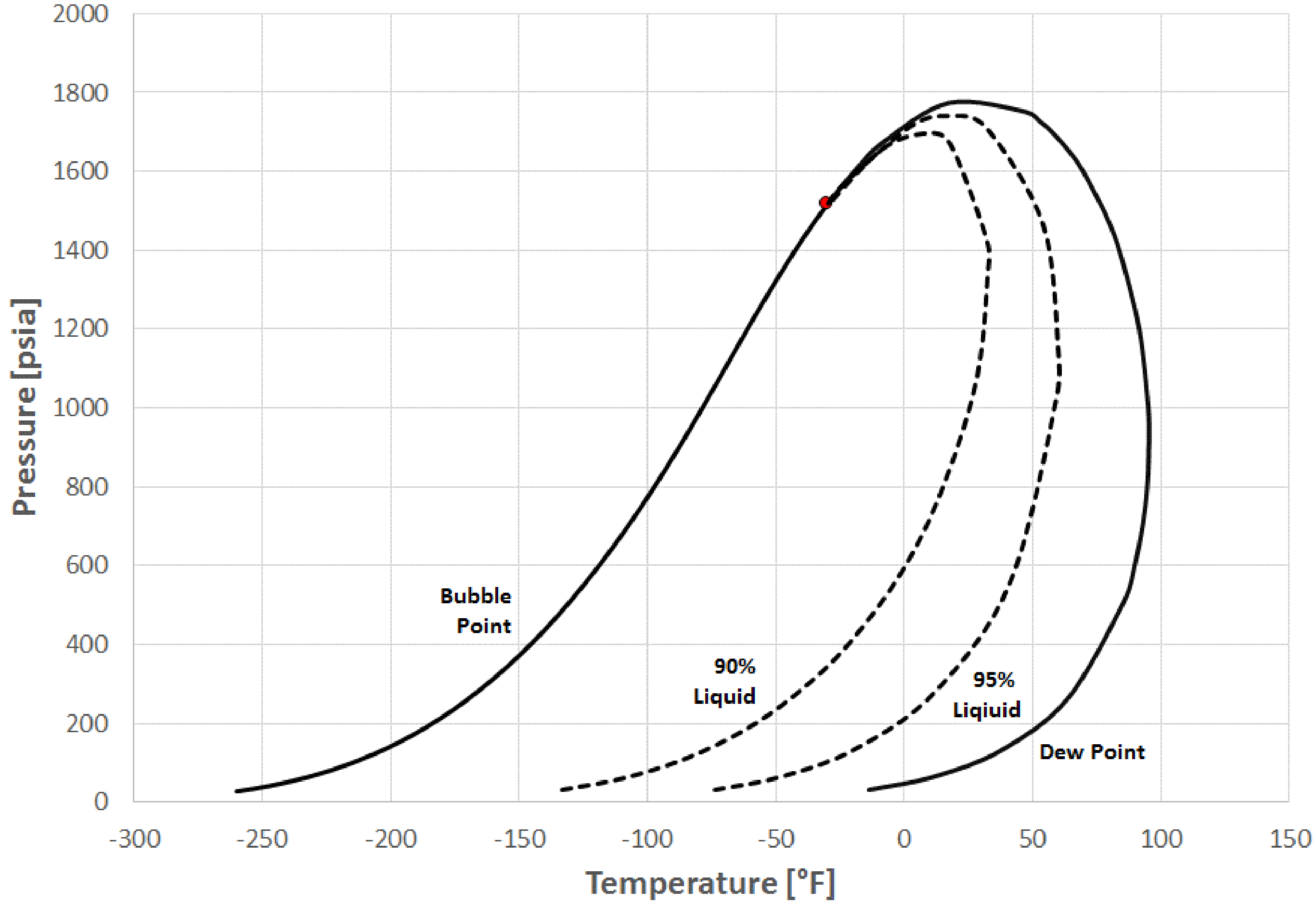
What is the GPM of a gas?

- Gallons of NGL components per 1000 scf (Mscf) of gas
- Either C2+ GPM or C3+ GPM

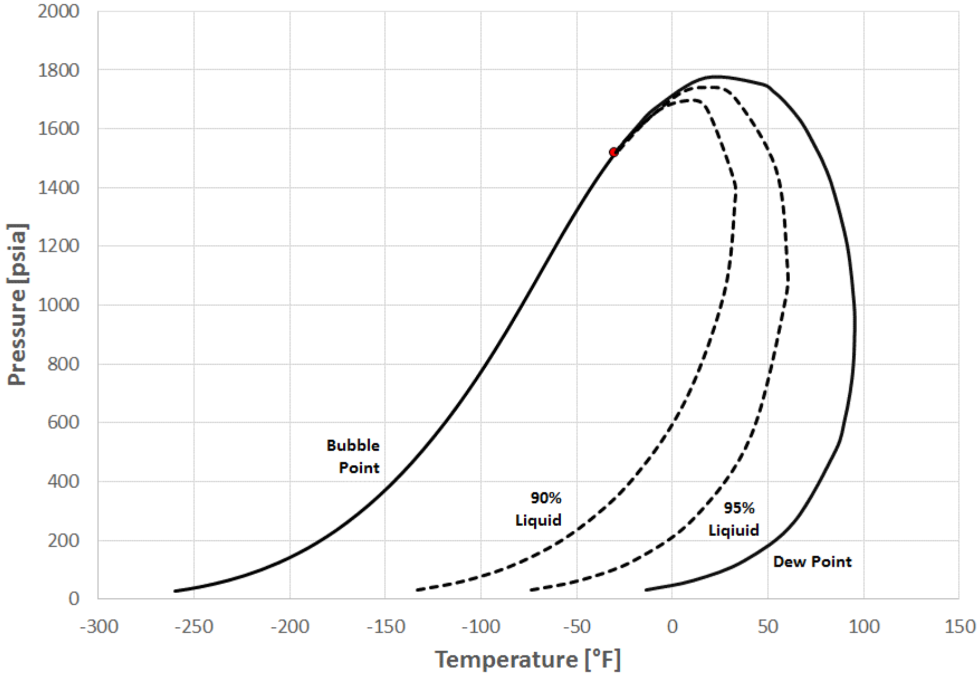
Retrograde Condensation

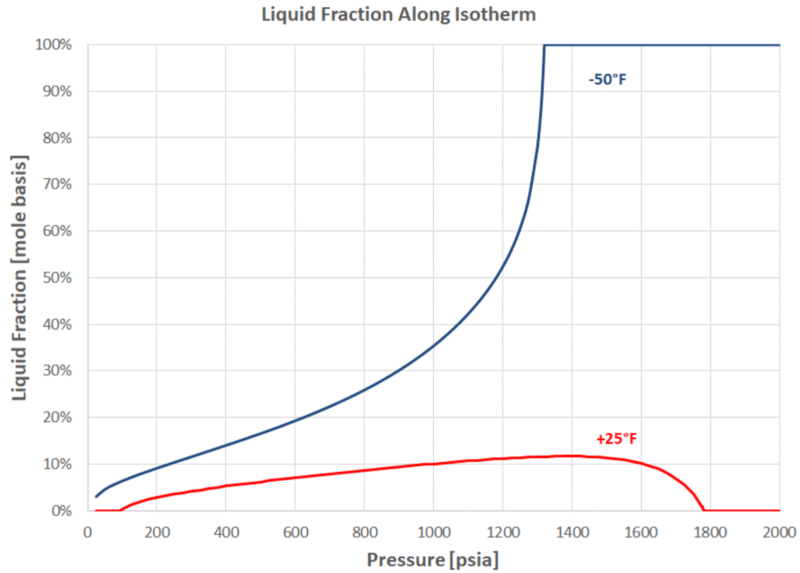


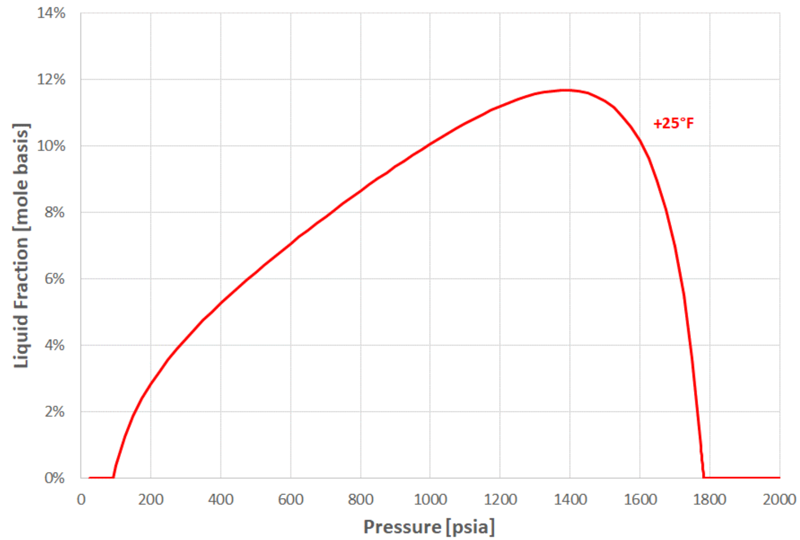
Rich Gas Phase Diagram



Rich Gas Phase Diagram







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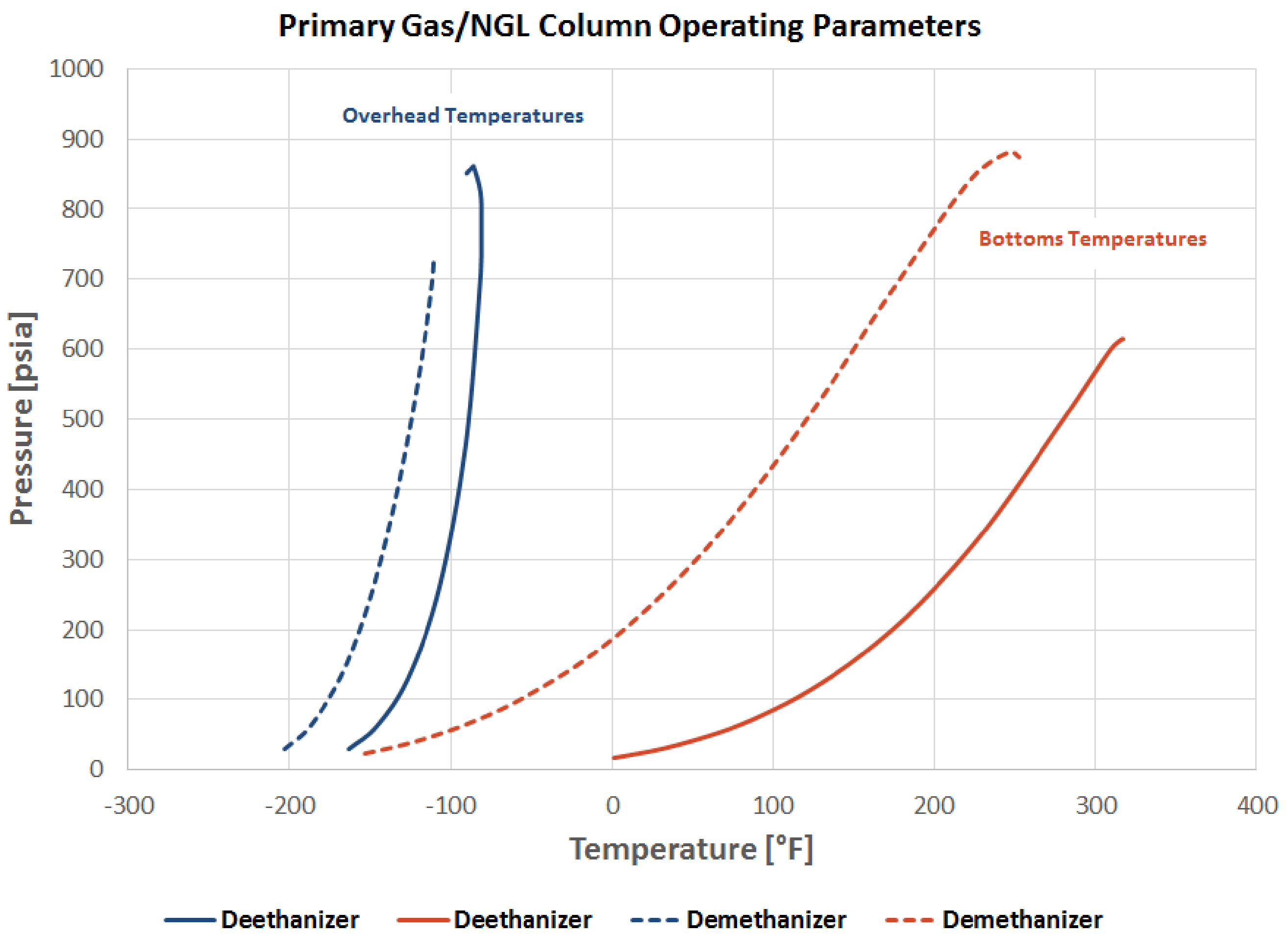
Operating Conditions Depend on Type of NGL Recovery



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Process Components

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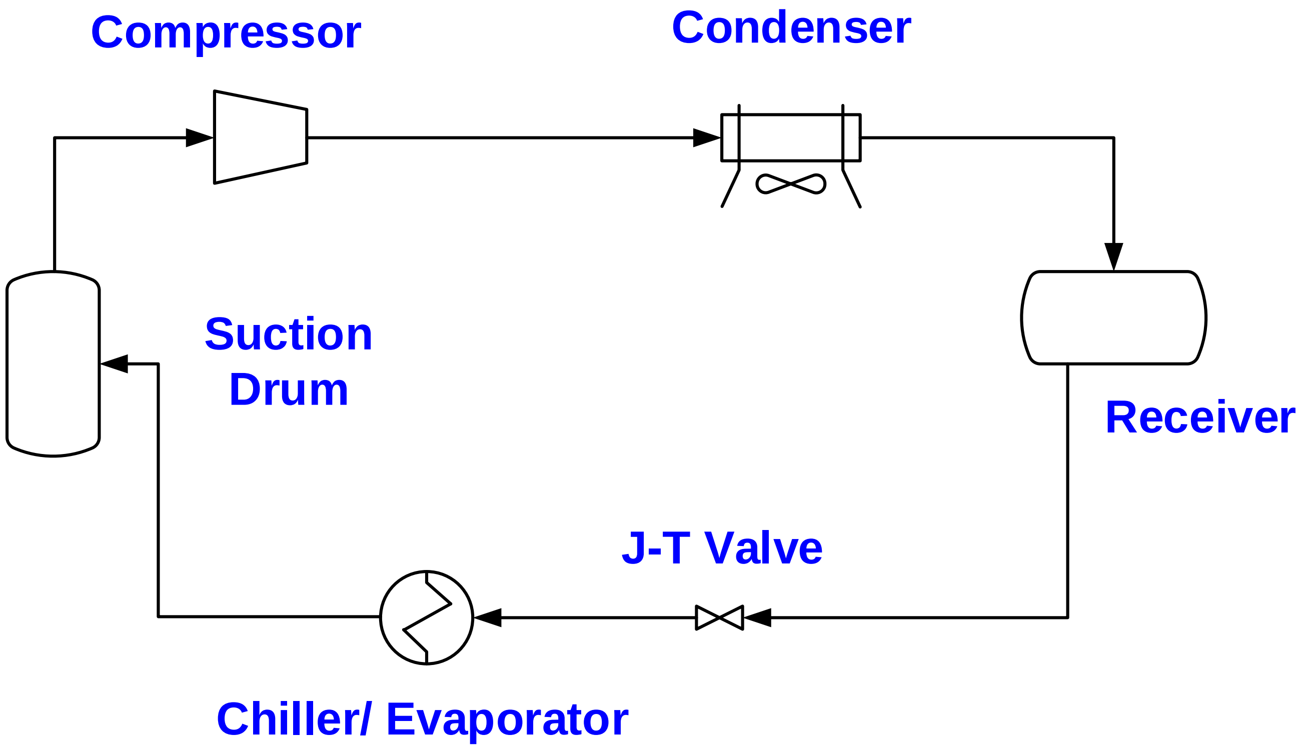
External Refrigeration

When inlet pressures to Hydrocarbon Recovery are too low to provide required cooling by expansion we can obtain additional refrigeration by:

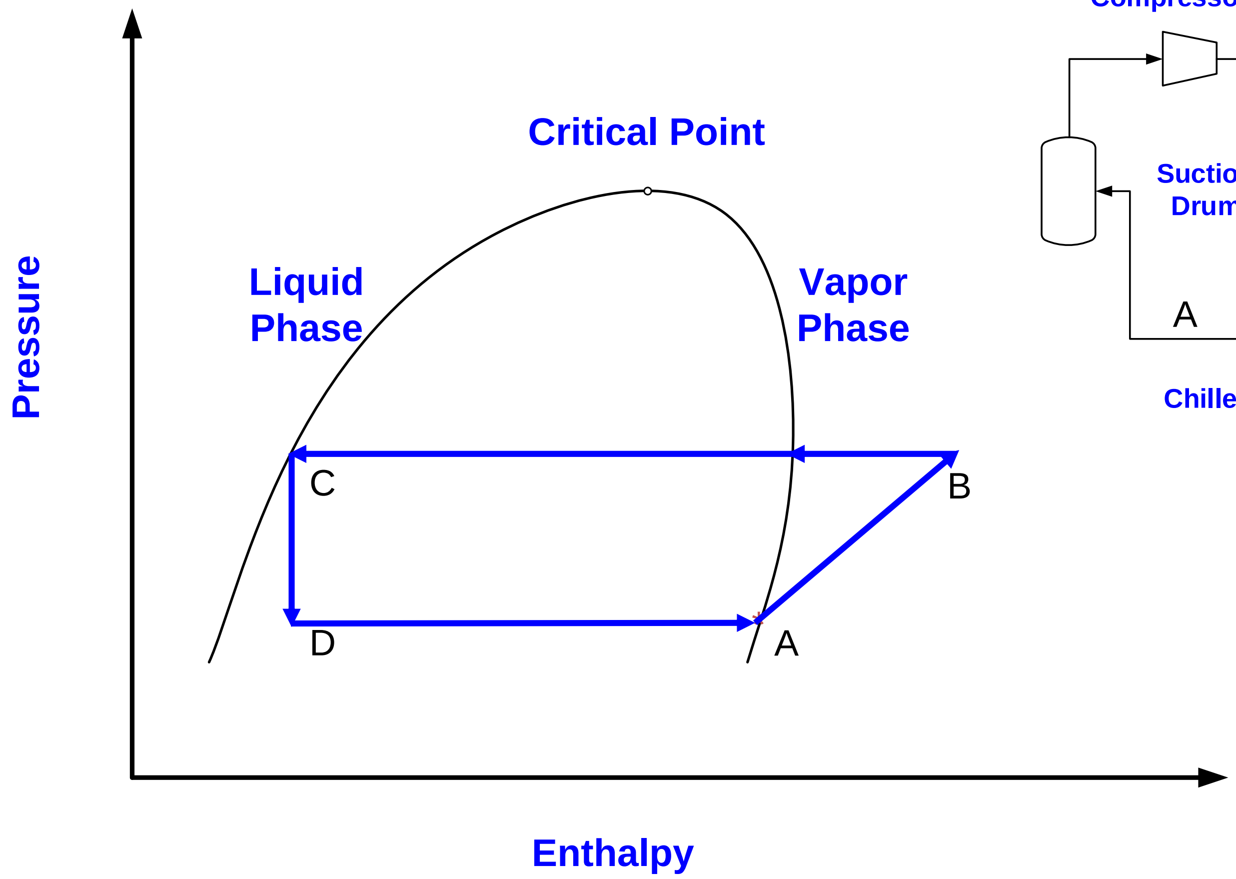
- Compressing inlet gas to higher pressure
- Compressing propane in refrigeration cycle

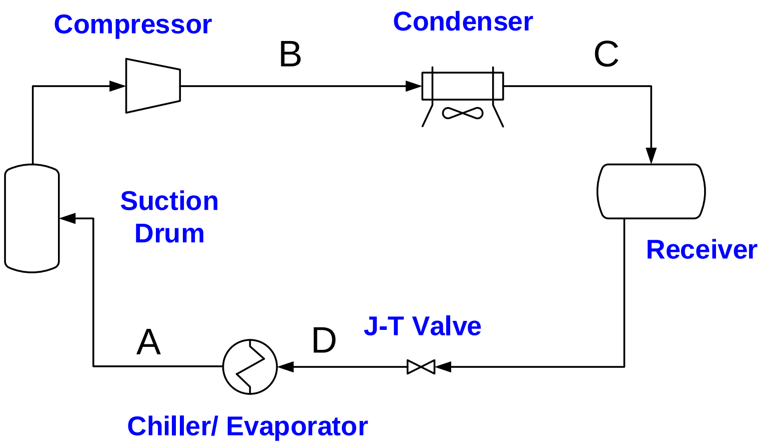
Compressing propane is usually the best choice

Basic Single-Stage Refrigeration System

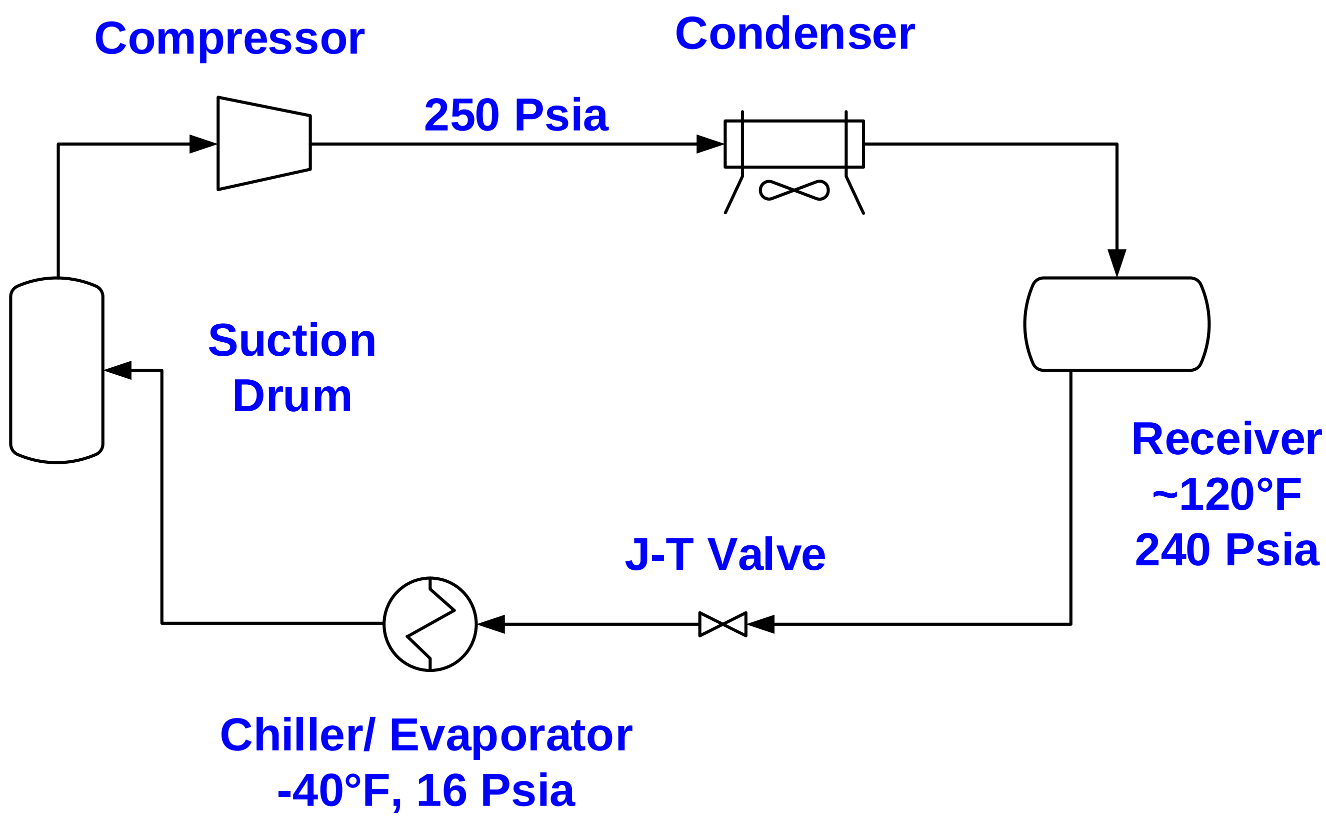


Single-Stage Refrigeration cycle

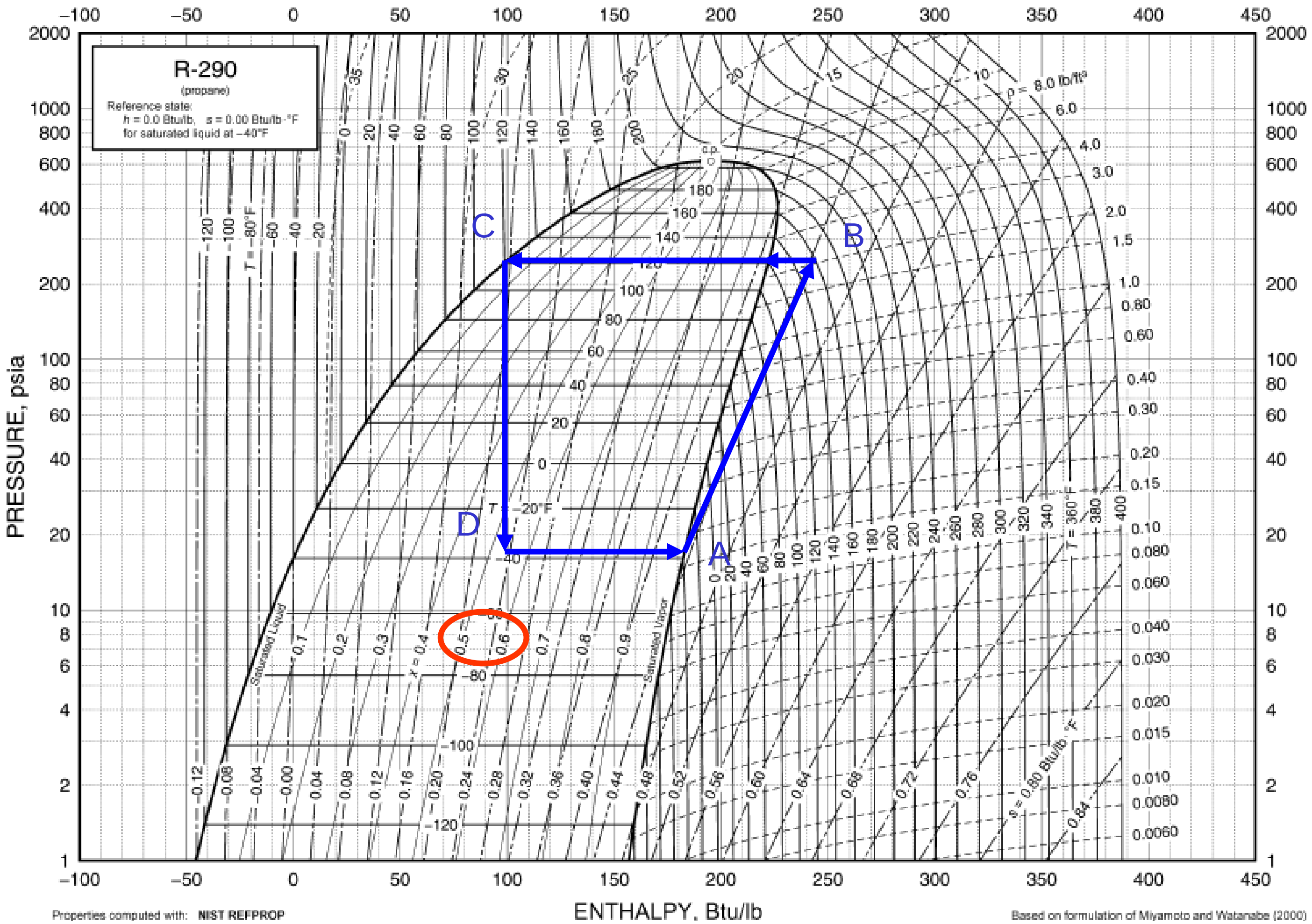




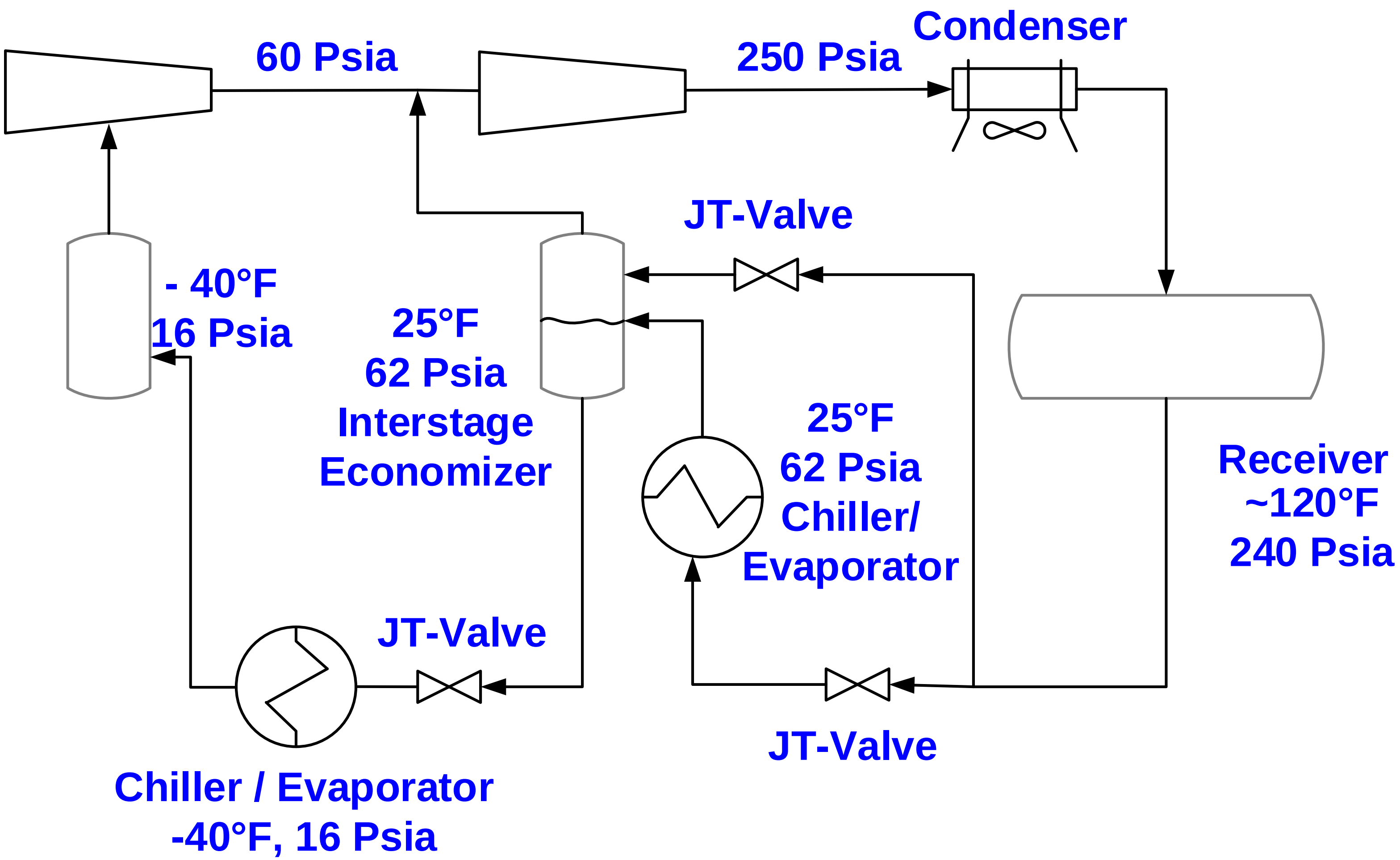
1-Stage Propane Refrigeration System



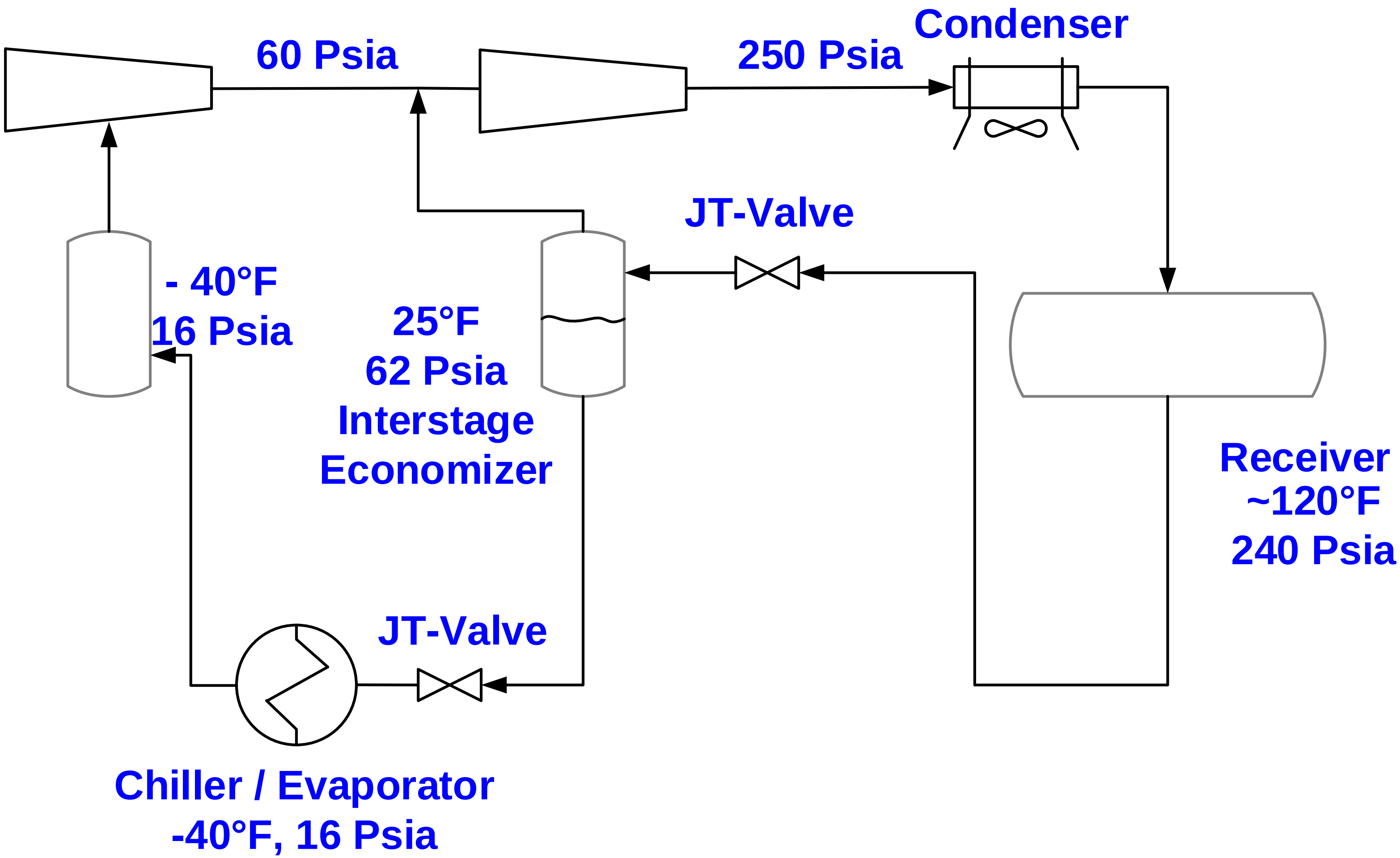
Refrigeration cycle



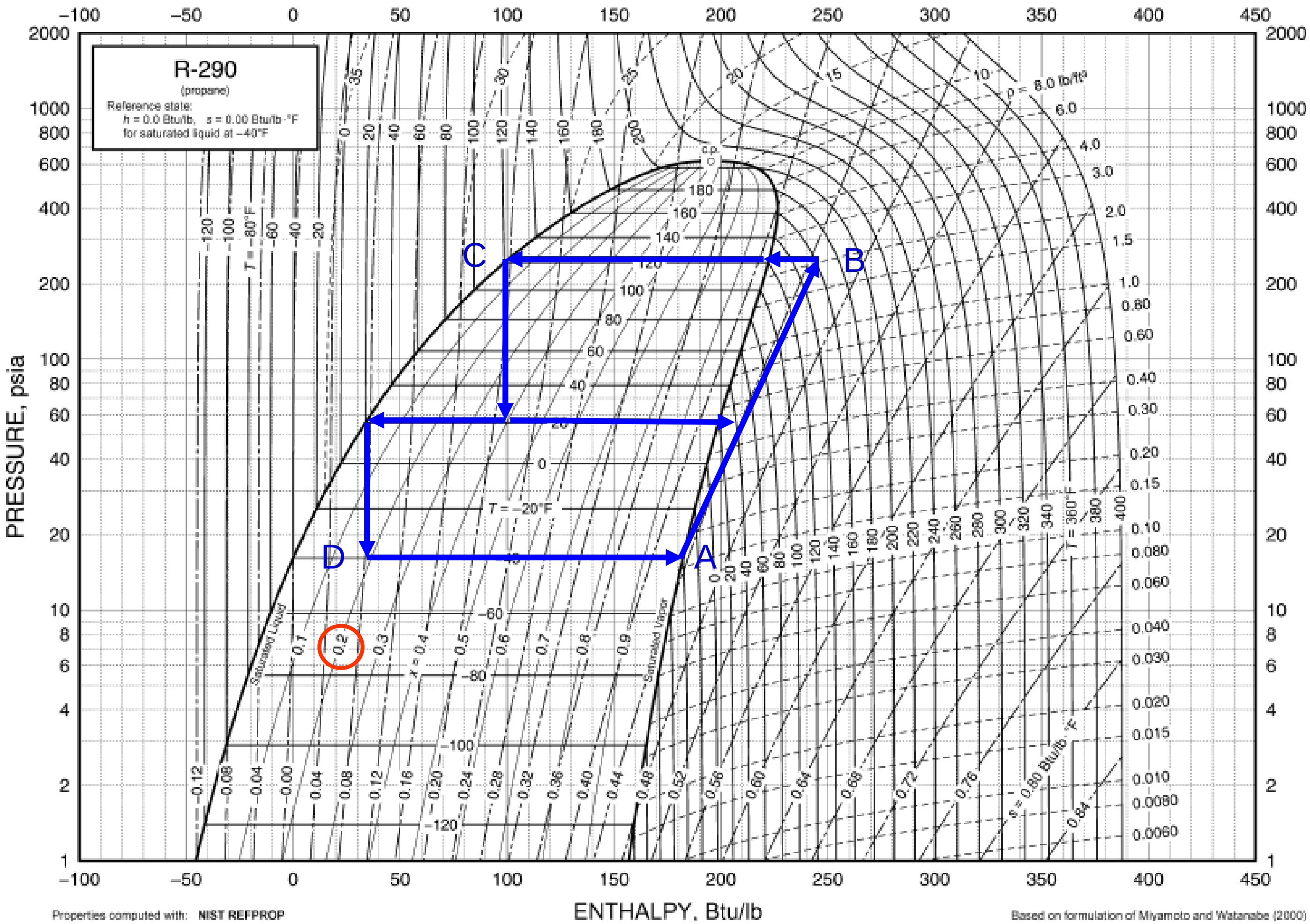
2 Stage C_3 Refrigeration System



2 Stage C_3 Refrigeration System



Refrigeration cycle



Benefits of Staging

Number of Stages	1	2	3
Reduction in Compression Power	0	19%	23%
Reduction in Condenser Duty	0	8%	10%

Condenser Temp = 100°F Chiller Temp = -40°F

Turboexpanders

Provide

- Maximum possible cooling
- Work which can drive compressors

Operate

- Over wide temperature range
- At high speeds, > 15,000 rpm

Require clean gas

Can handle up to 50 wt % liquid formation provided droplet size less than 20 µm

Methane Expansion – Isentropic vs. Isenthalpic

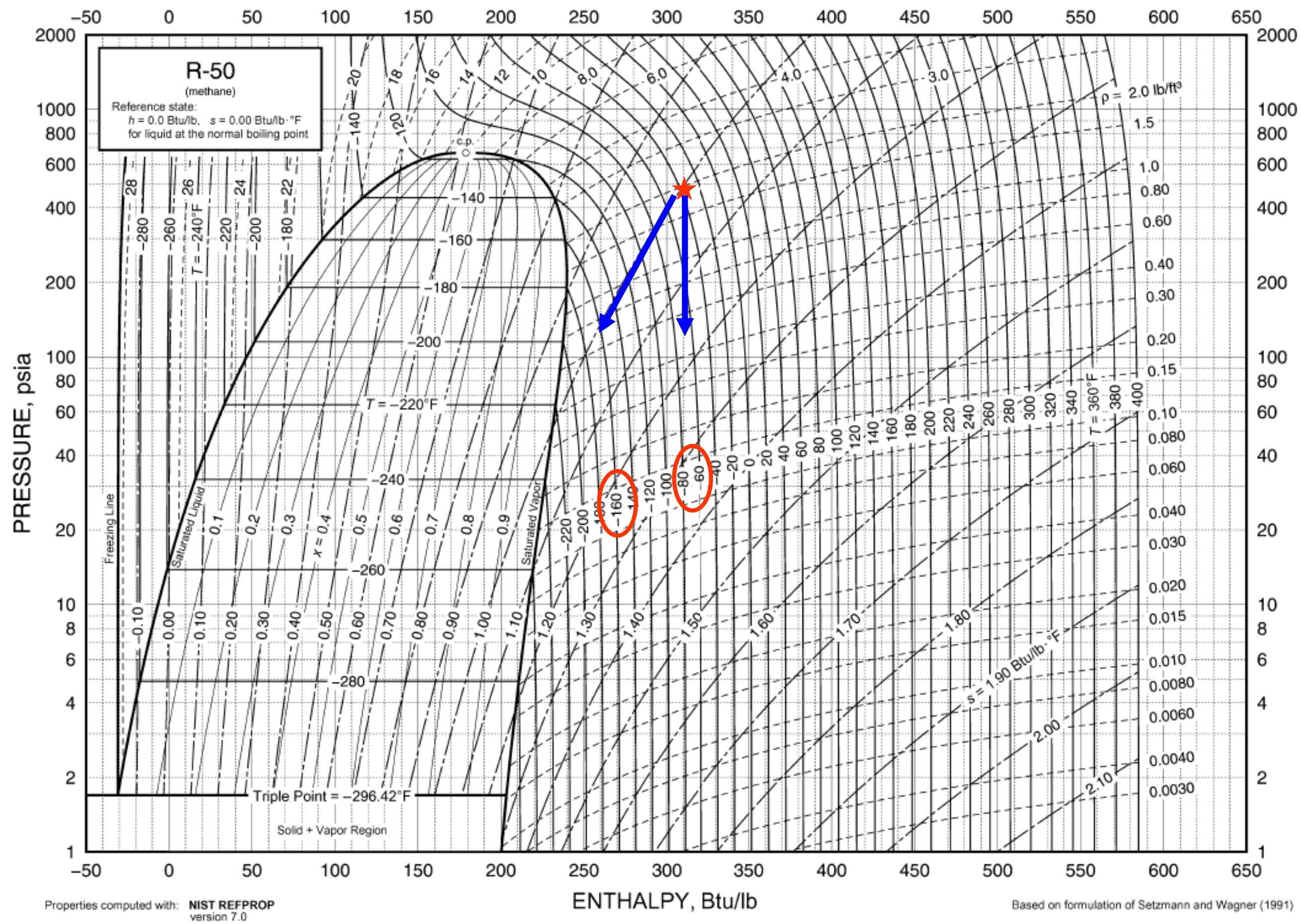


Fig. 19 Pressure-Enthalpy Diagram for Refrigerant 50 (Methane)

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Recovery Processes

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Recovery Processes

Dew Point Control and Fuel Conditioning

- High recovery not needed
- Operating temperatures ~0°F for fractionation

Low C_2^+ Recovery

- < 60% C_2^+ recovery needed
- Operating temperatures ~ -35°F for fractionation

High C_2^+ recovery

- ~ 90% C_2^+ recovery needed
- Operating temperatures ~ -165°F for fractionation

Dew Point Control and Fuel Conditioning

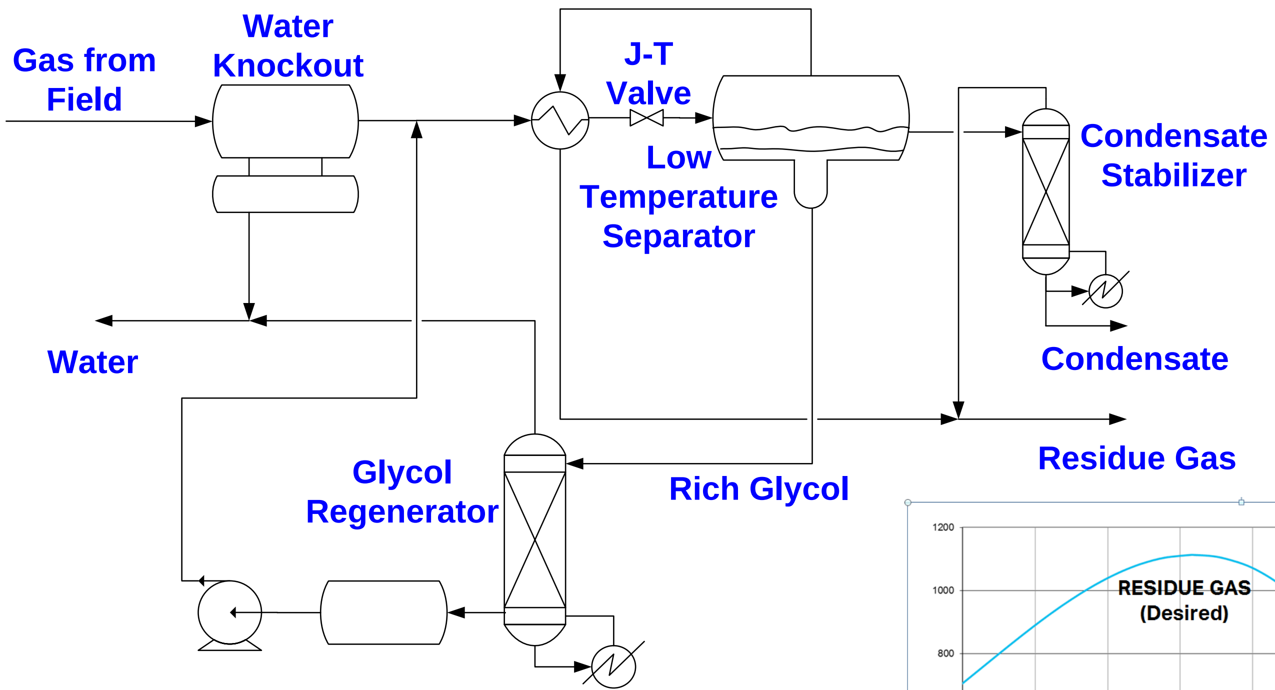
Traditional technology

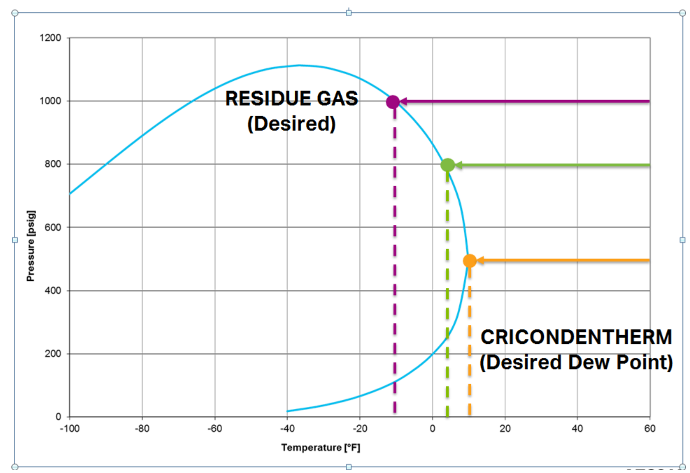
- Low Temperature Separators (LTS or LTX)
  - Standard technology (>60 years old)

Newer technologies

- Membrane System
  - Newer technology (~10 years old)
- Twister
  - Newest technology (~5 years old)

Dew Point Control (No External Refrigeration)





Dew Point Control (With External Refrigeration)

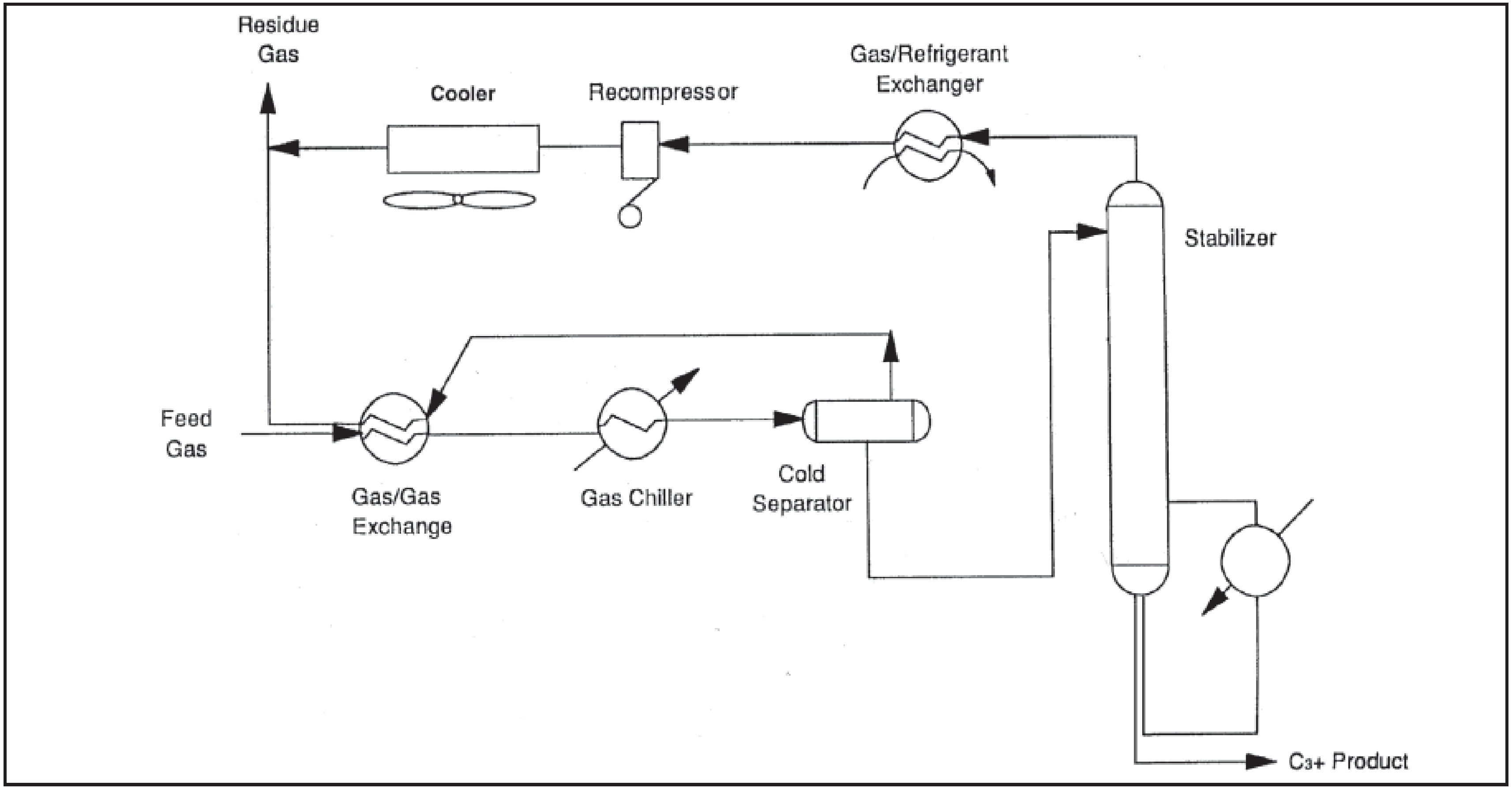
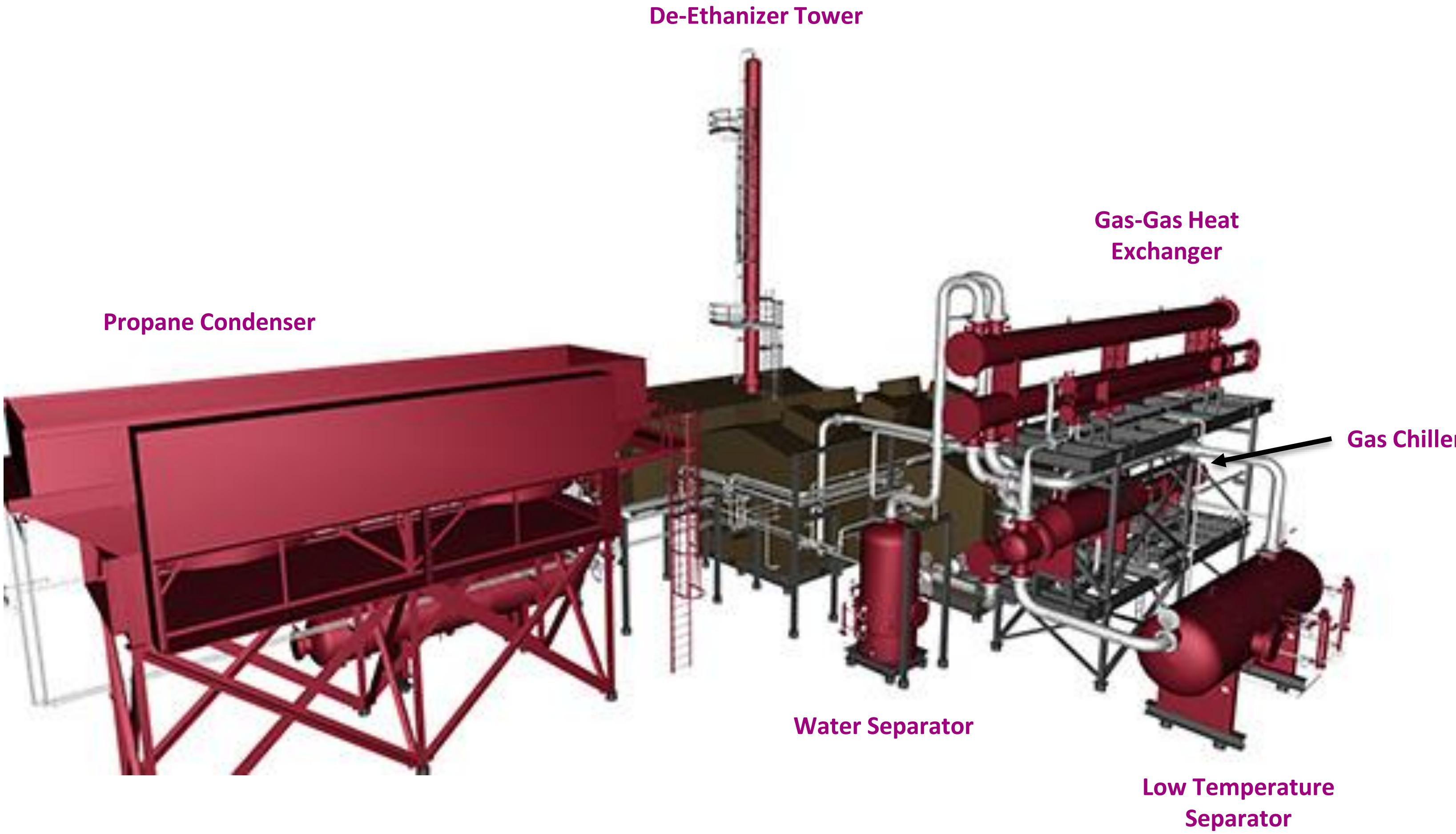


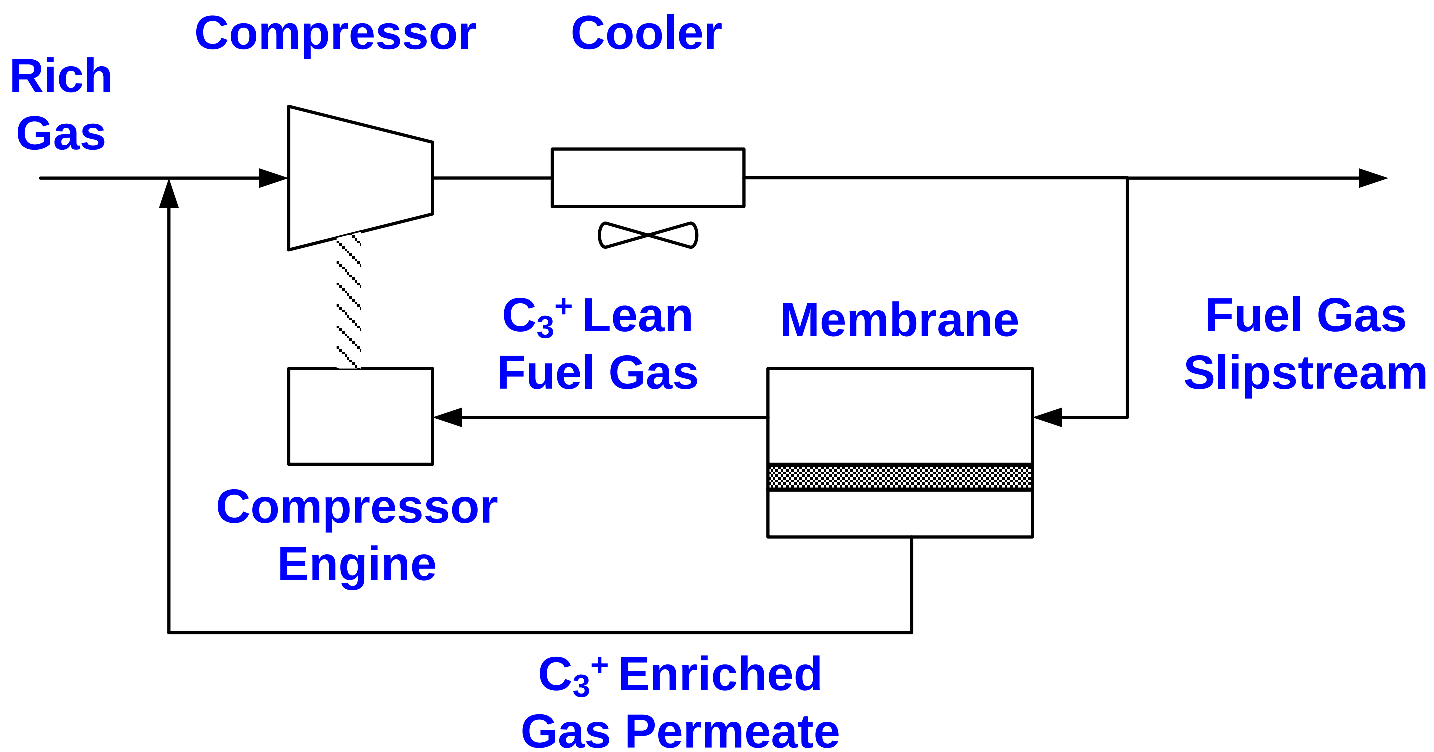
Fig. 16-5, *GPSA Engineering Data Book*, 14th ed.

Example Dew Point Control Package



http://www.enerflex.com/Oil-and-Gas-Solutions/Gas-Processing/Dew-Point-Control/index.php

Membrane for Fuel Conditioning



Twister

Modular, flow dependent

Depends upon pressure ratio, ΔP ~ 20 to 30%

Slip gas is 10 to 15%

Used for dehydration and liquids removal

Is being tested in subsea application

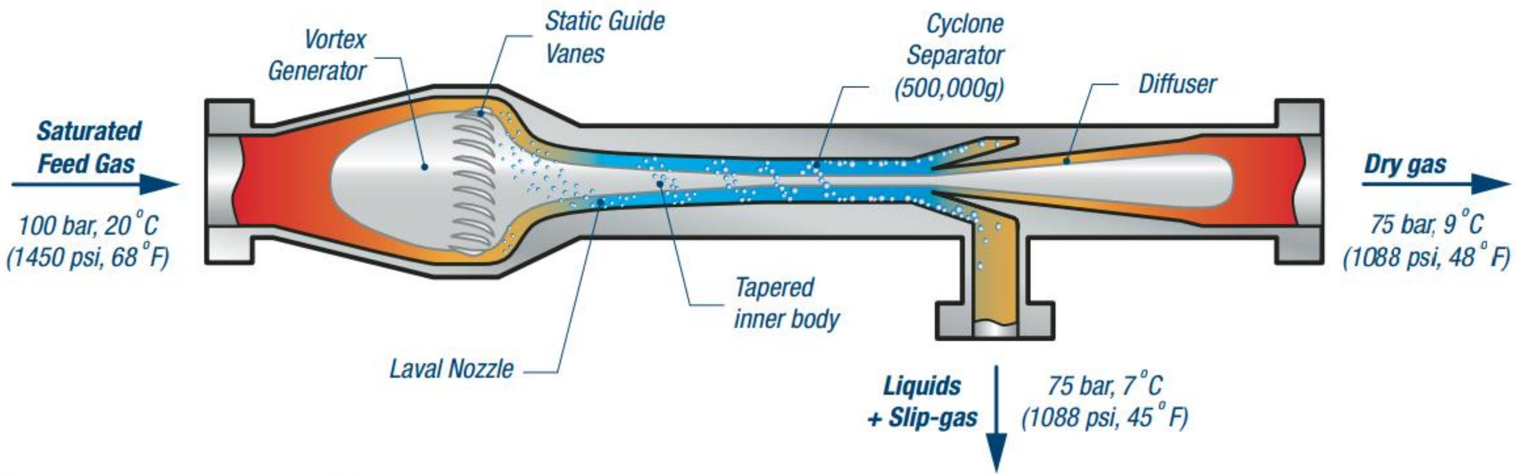


Figure 1 shows a cross-section of a Twister tube with typical process conditions

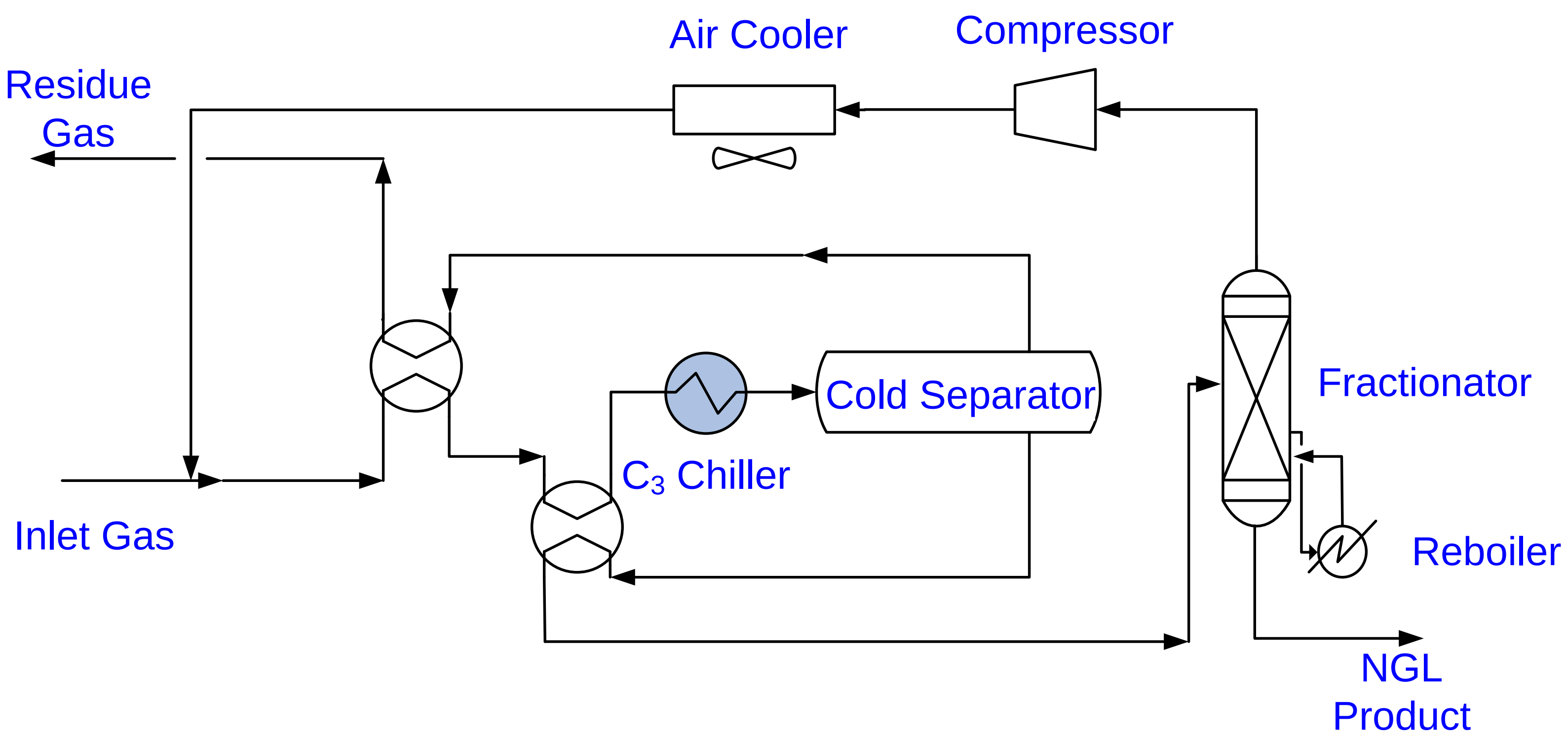
http://twisterbv.com/PDF/resources/Twister_-_How_Does_It_Work.pdf

Low C_2^+ Recovery

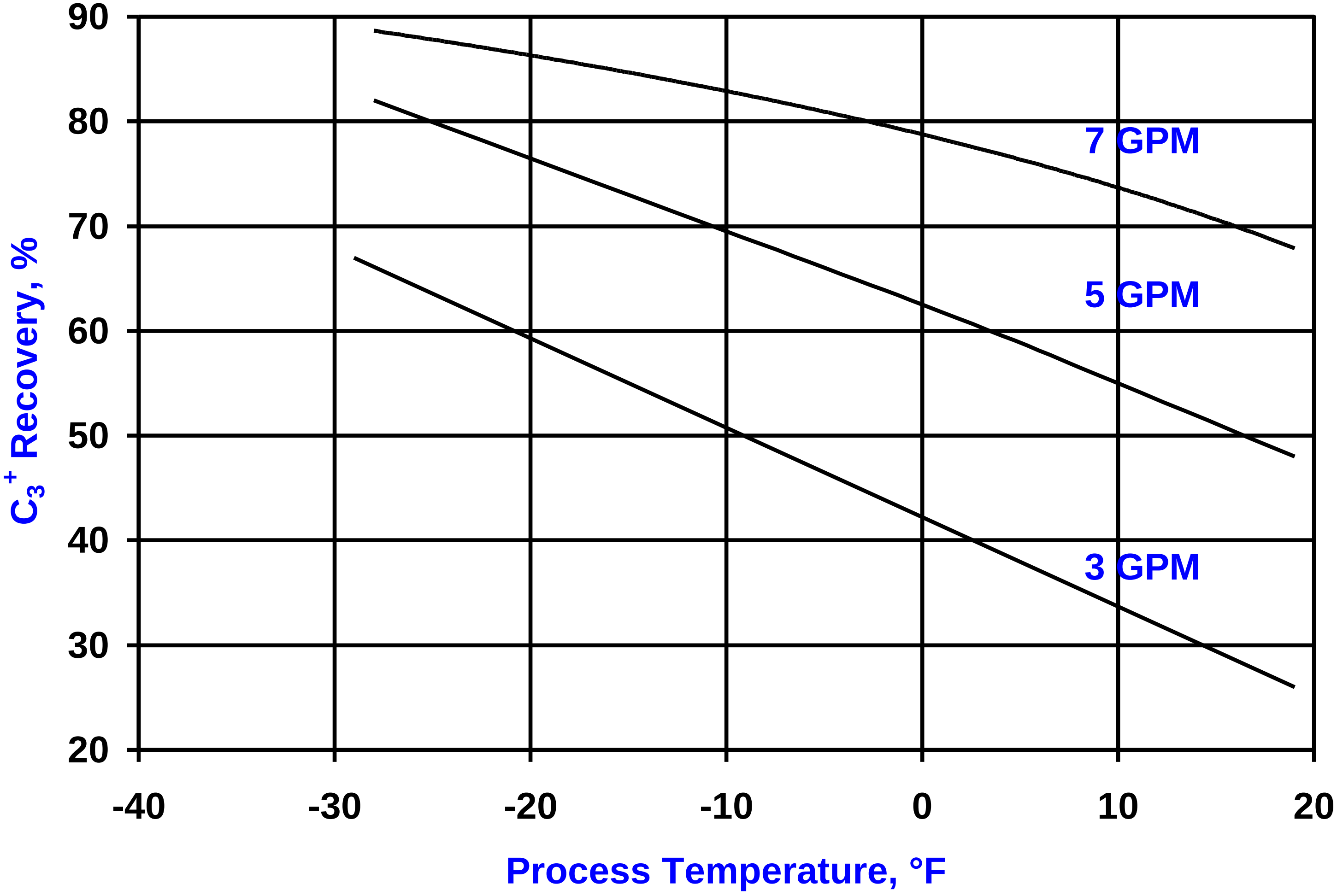
Two major processes

- Refrigerated Lean Oil
  - Lean Oil Absorption first process for liquids recovery
  - Existing plants now use refrigerated system
- Refrigerated Process
  - Simpler than Lean Oil process
  - Lower recoveries

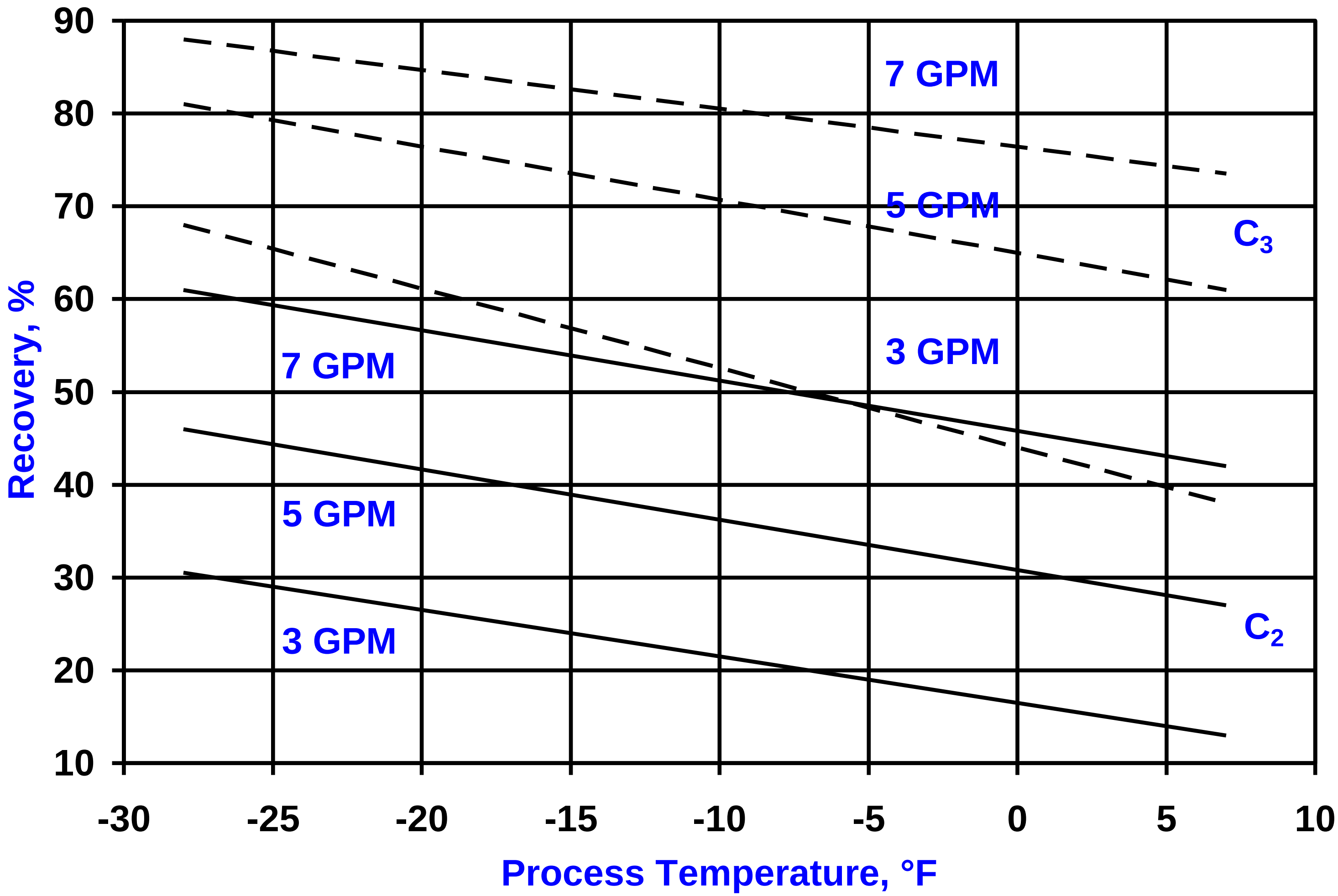
Refrigerated Process



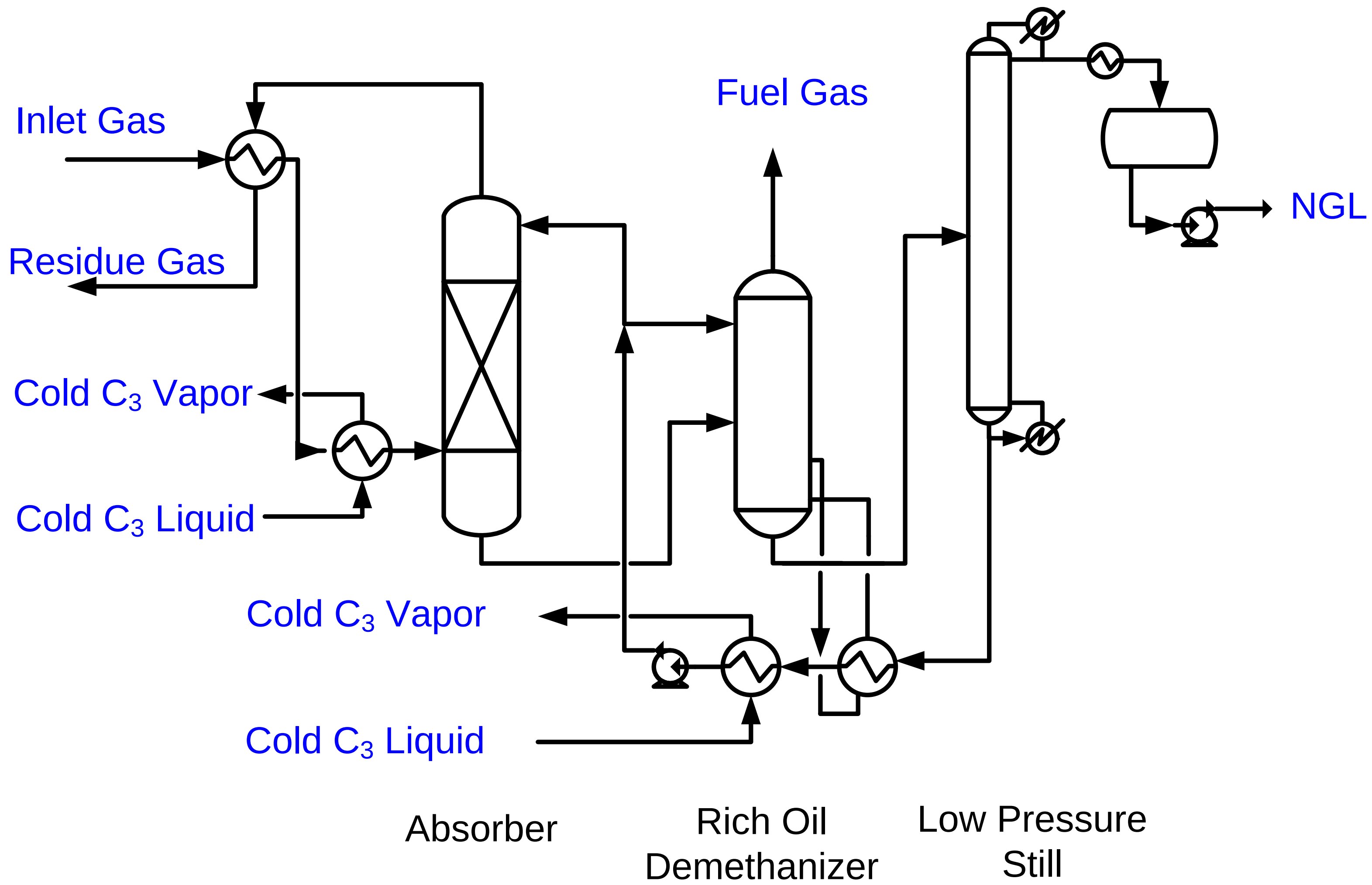
Effect of Composition on C_3^+ Recovery



Recovery Efficiency of C_2 and C_3



Refrigerated Lean Oil



High C_2^+ Recovery

Requires cryogenic separation

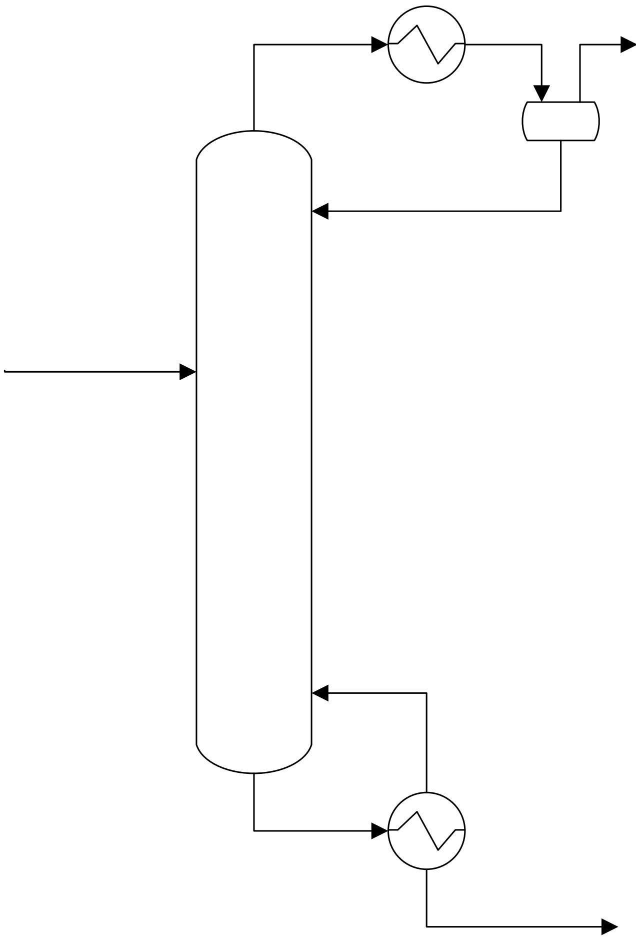
Processes involve:

- Propane refrigeration (unless high inlet gas pressure)
- Multipass heat exchangers (gas-gas)
- Expansion, turbo and JT
- Demethanizer column

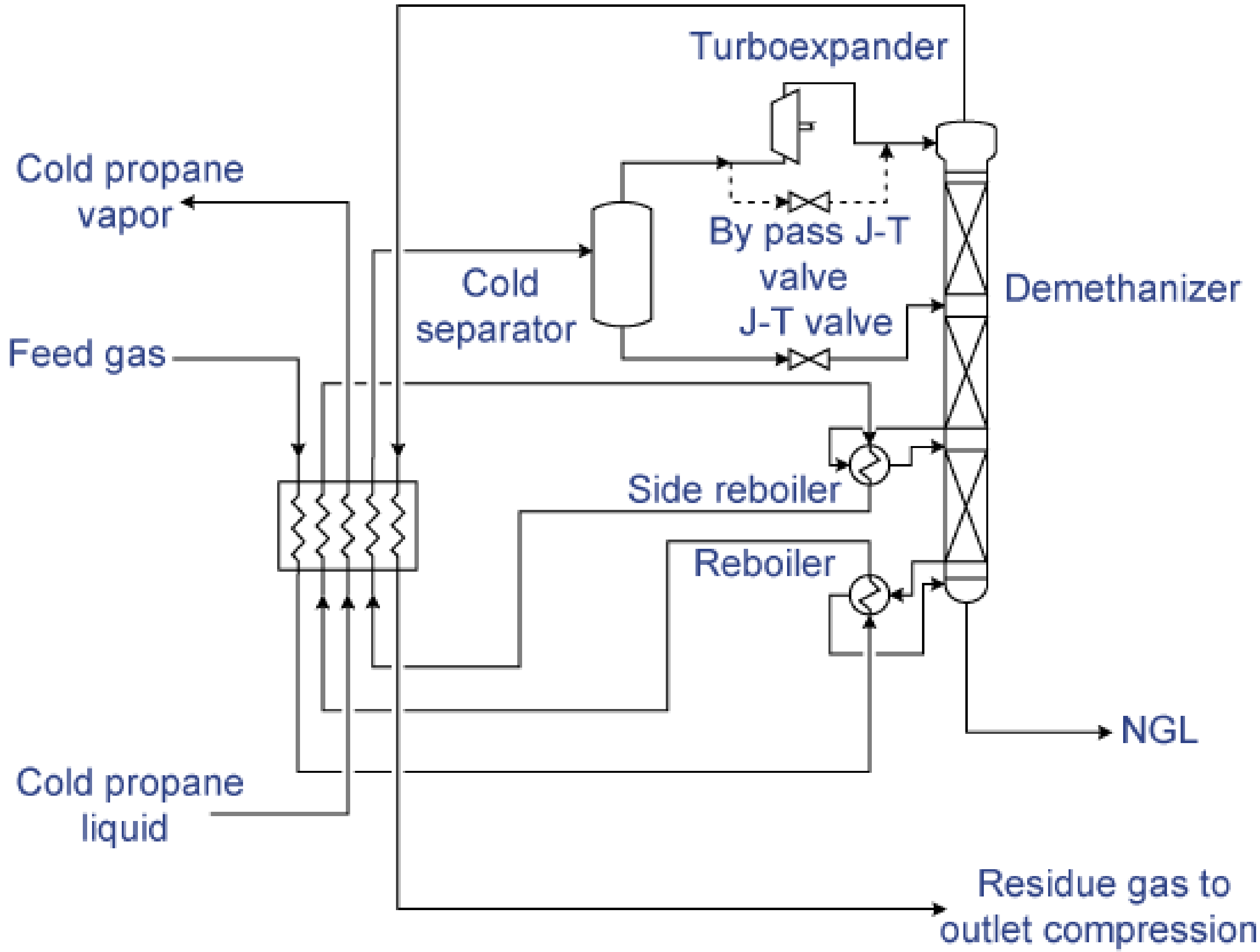
Two processes:

- "1st Generation" – simplest
- Gas Subcooled Process (GSP) – more efficient, higher recoveries and commonly used

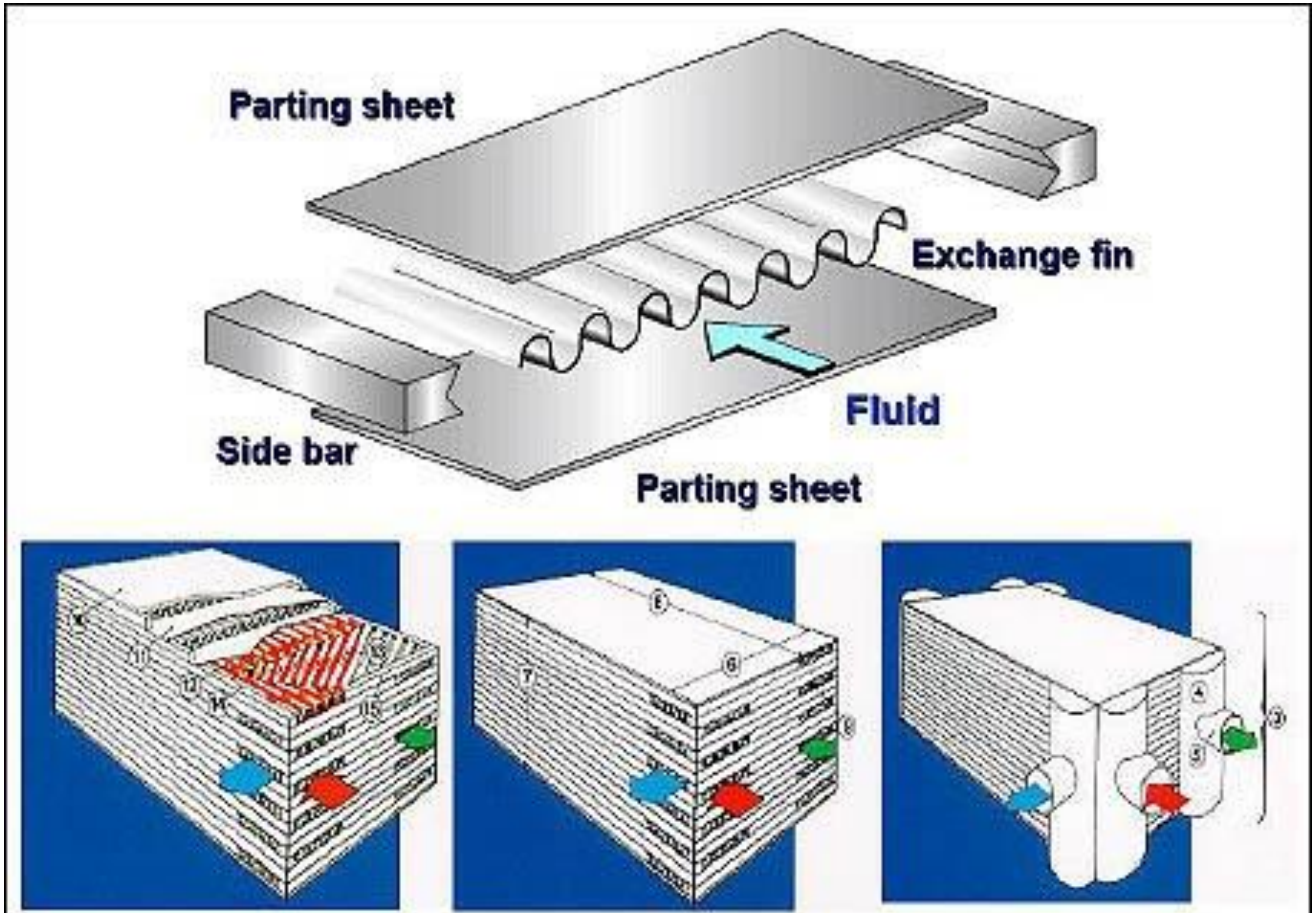
Considerations for Cryogenic Distillation



1st Generation Cryo Process

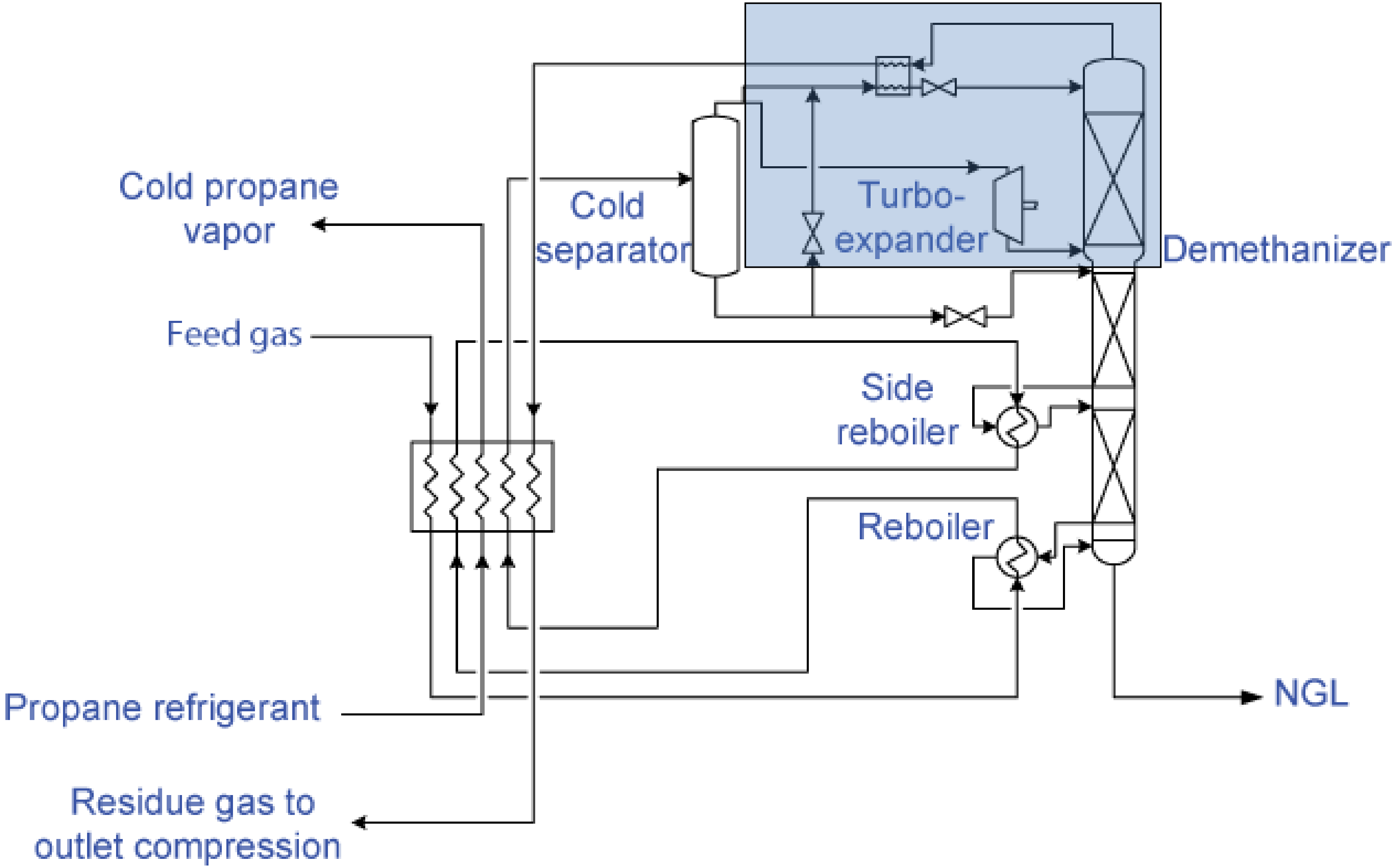


Brazed Aluminum Heat Exchanger – "Cold Box"

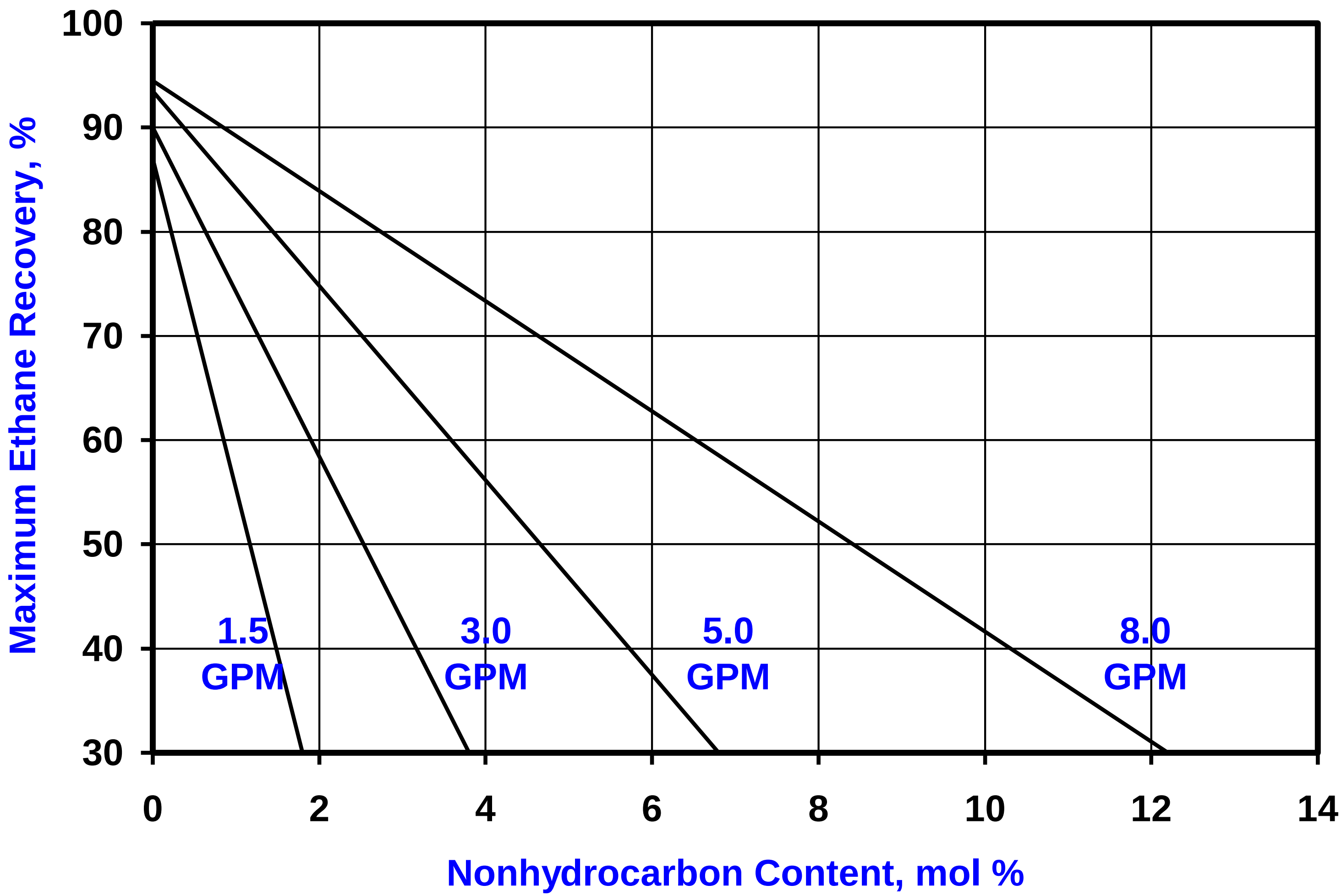


http://hub.globalccsinstitute.com/publications/co2-liquid-logistics-shipping-concept-llsc-overall-supply-chain-optimization/53-co2

GSP Schematic



Effect of Inerts on Max C_2 Recovery



Propane Recovery Processes

FIG. 16-17
Simple Turboexpander Process for Propane Recovery

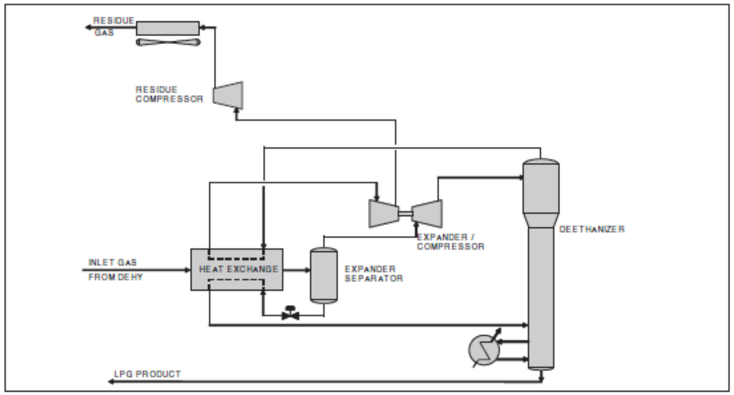


FIG. 16-18
GSP Process for Propane Recovery

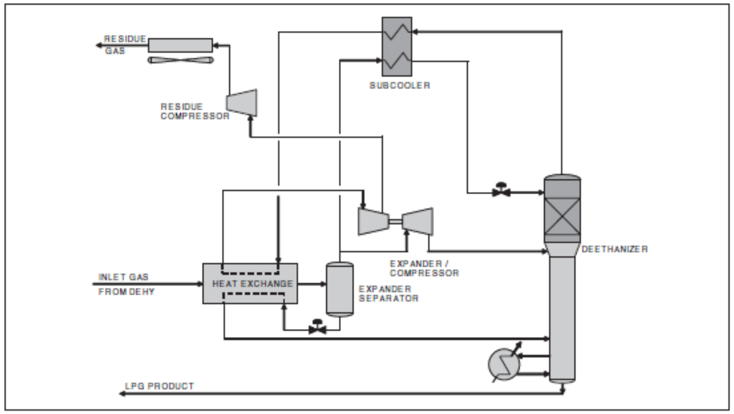


FIG. 16-21
IOR Propane Recovery Process

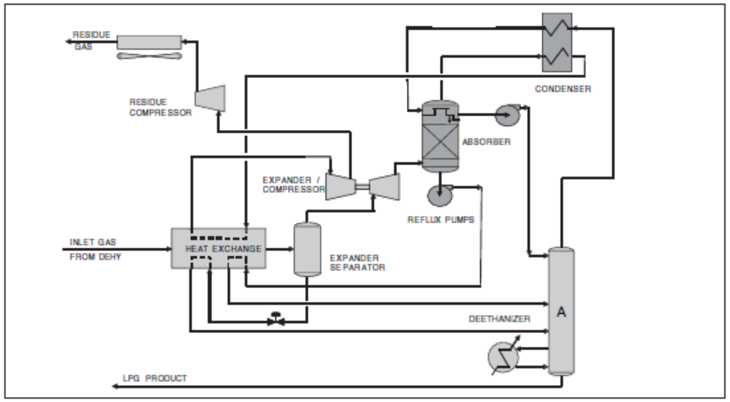
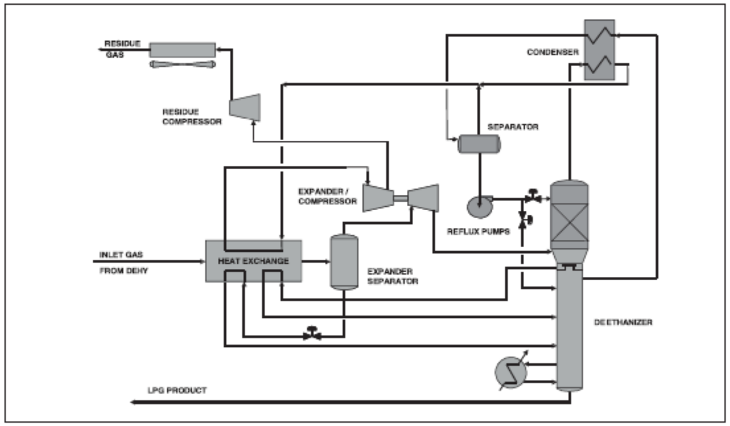


FIG. 16-22
SCORE Propane Recovery Process



GPSA Engineering Data Book, 14th ed.

Ethane Recovery Processes

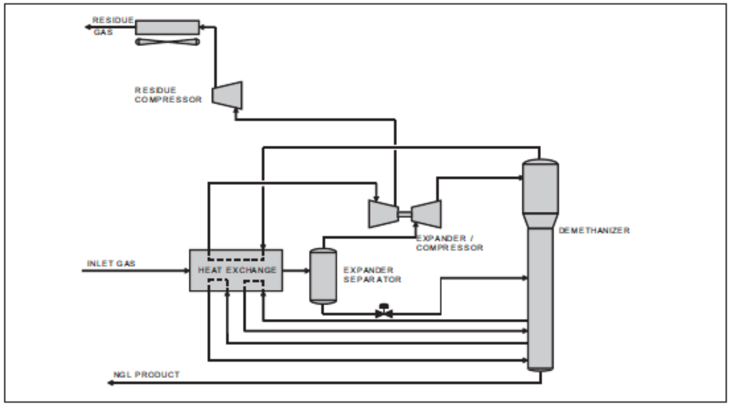


FIG. 16-23
Simple Turboexpander Process for Ethane Recovery

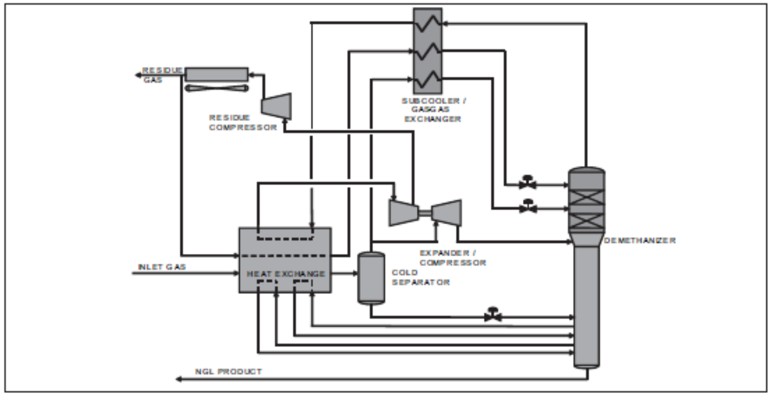


FIG. 16-26
RSV Ethane Recovery Process

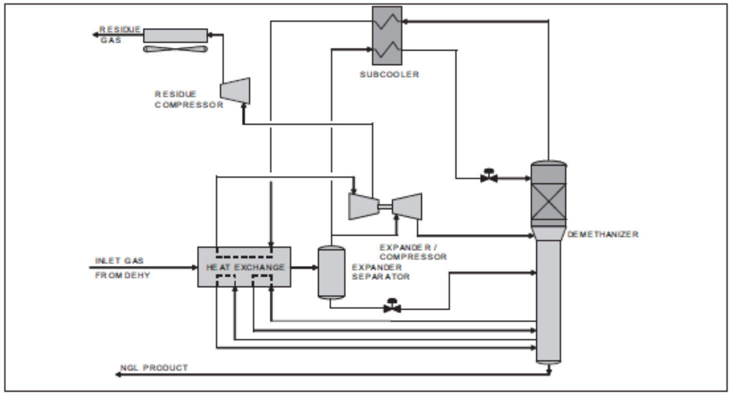


FIG. 16-24
GSP Process for Ethane Recovery

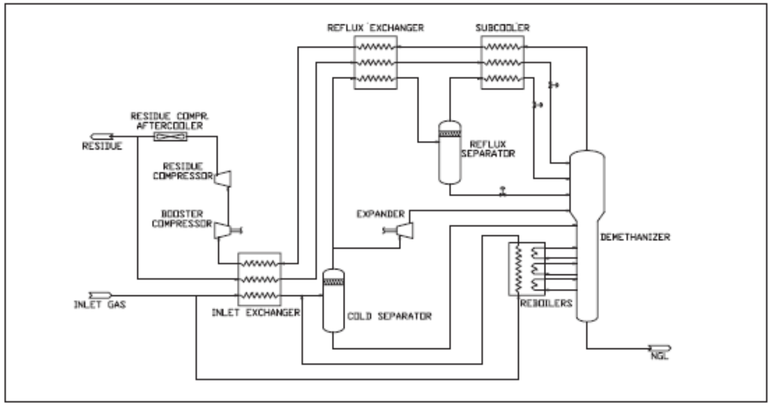


FIG. 16-29
NGL-MAX℠ Ethane Recovery Process

Summary

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Summary

Primary liquids' production from cold separation

- Produced gas at dew point condition at last conditions in contact with hydrocarbon liquid

Lower liquid content of produced gas has a lower dew point requiring lower temperatures

Propane refrigeration loop

- Typical low temperatures to -40°F
- Intermediate pressures reduce compression power & can make chilling temperatures about 10°F