
연구회: 정보제공 (1) NGL Recovery Process

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조정호

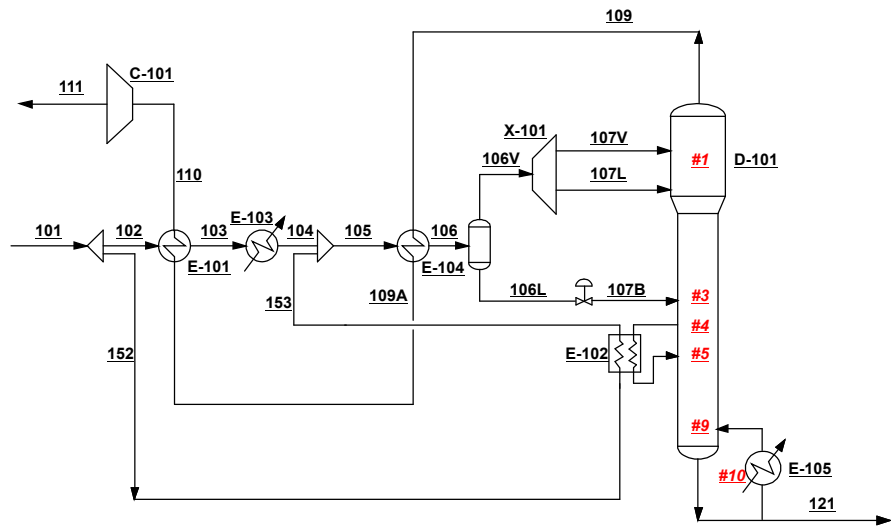
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NGL Recovery Process Problem

- In this problem you will design the Turbo-Expander Gas Plant shown in Figure 1.
- The purpose of this process is to recovery NGL from a natural gas feed. This is accomplished by cooling the natural gas stream through a combination of combined heat exchangers and expander to a temperature low enough to condense the heavier compounds from the gas stream and then final separation of methane and lighter from NGL is done in demethanizer.

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Schematic Diagram for NGL Fractionator



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Process Description

- Gas is dehydrated usually by molecular sieve.
- Gas is partially chilled by back-exchange with residue gas.
- Gas is further chilled by refrigeration system
- Gas is further chilled demethanizer overhead gas.
- Extremely low temperature stream is obtained by letting-down the pressure using turbo-expander.
- Ethane & heaviers are obtained by fractionation.

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Feedstock Information

Component	Mole%
1. N2	1.61
2. CO2	0.20
3. C1	84.80
4. C2	8.86
5. C3	3.05
6. IC4	0.49
7. NC4	0.53
8. IC5	0.12
9. NC5	0.09
10. NC6	0.25
Temperature, F	85.0
Pressure, psig	753.0
Flow, lb/hr	312,674

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Product Specifications

- C1/C2 molar ratio: 0.0119
 - Methane molar flow divided by ethane molar flow at demethanizer bottom stream
- Ethane recovery at DeC1 column bottom: 75%
 - 75% or higher ethane recovery ratio at demethanizer bottom stream is required.

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Determine the Followings....

- Demethanizer Top Pressure
 - If it is too low, compressor power consumption will be increased.
 - If it is too high, additional refrigeration duty will be increased.
- Natural Gas Feeding Temperature to the Flash Drum
- Maximize the Side Reboiler Duty and Minimize the Refrigeration Duty

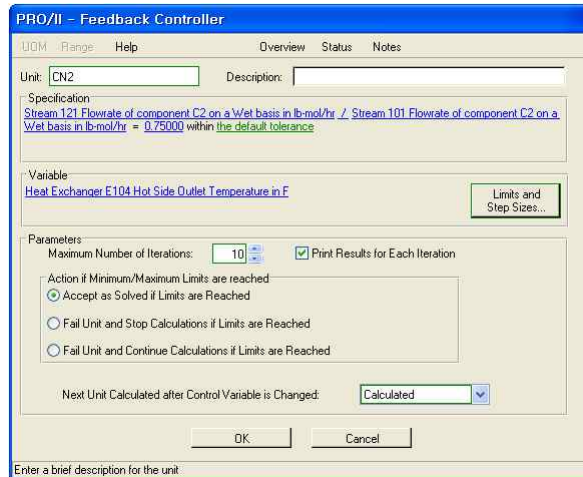
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Thermodynamic Model

- Equation of State Approach:
 - Soave-Redlich-Kwong
 - Peng-Robinson
 - Benedict-Webb-Rubin-Starling

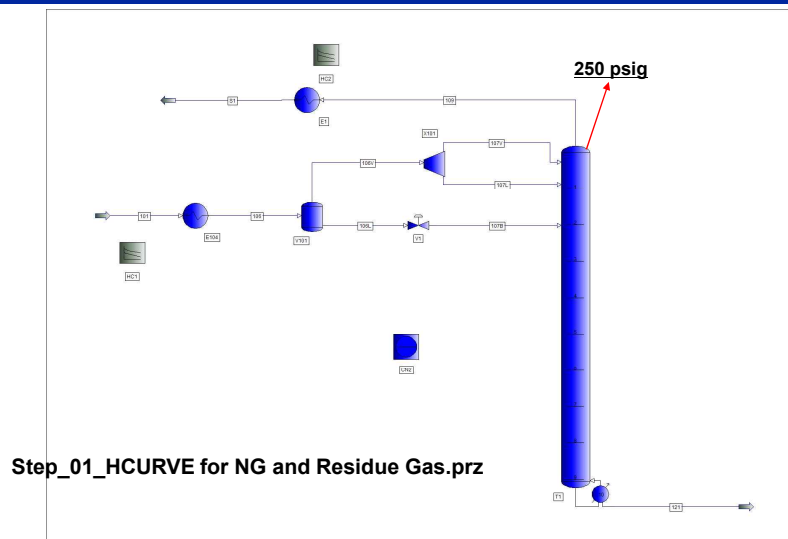
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Step 1: Flash Drum Temperature Estimation at 250 psig of DeC1



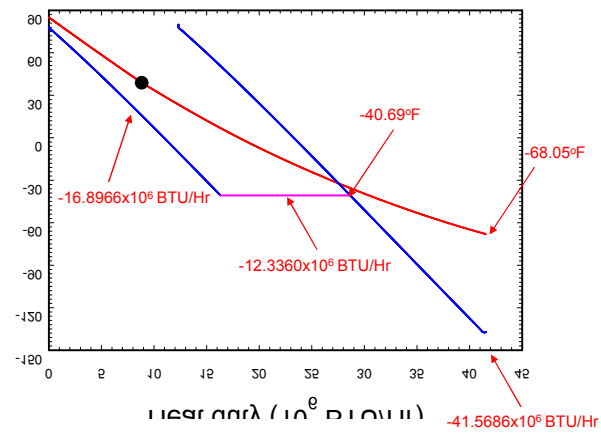
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Flow Sheeting Drawing Using P2



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Step 1: Cooling Curve for Natural Gas Feed Stream



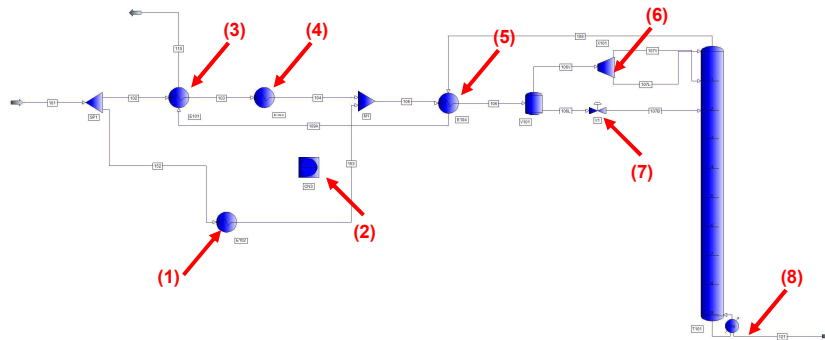
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Step 1: Simulation Results

- Simulation results for step 1 are as follows:
- Natural gas cooling duty: 41.5686 MM BTU/Hr
 - Natural gas cooler outlet temperature: -68.05°F
 - Recovered heat duty for residue gas: 29.2326 MM BTU/Hr
 - Propane refrigeration cycle heat duty: 12.3360 MM BTU/Hr
 - Bottom reboiler heat duty: 11.0272 MM BTU/Hr

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Step 2: Side Heater and Feed Split Steam Heat Exchange



Step_02_Side Heat and Feed Split Steam HX.prz

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Note #1: (1) Connecting Feed Split Stream with Side Reboiler

Heat Exchanger - Specifications

Specification:

Value: x 10⁶ BTU/hr

Relative Tolerance:

Area: ft²

U-Value: BTU/hr-R²-F

Definition

Set Up Definition for Heat Exchanger Duty

Heat Exchanger E102 Duty in x 10⁶ BTU/hr = [Column T101 Duty of Heater SIDEHC1 in x 10⁶ BTU/hr](#)

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Note #2: (2) Connecting Feed Split Stream with Side Reboiler

The screenshot shows the 'PRO/II - Feedback Controller' dialog box. It has a title bar with 'PRO/II - Feedback Controller' and a menu bar with 'UGM', 'Range', 'Help', 'Overview', 'Status', and 'Notes'. The 'Unit' is set to 'CN3'. The 'Specification' is 'Stream 153 Temperature in F = -35.000 within an absolute tolerance of 0.00010000'. The 'Variable' is 'Splitter SP1 Specification on Stream 152'. There is a 'Limits and Step Sizes...' button. The 'Parameters' section includes 'Maximum Number of Iterations' set to 10 and a checked 'Print Results for Each Iteration' option. Under 'Action if Minimum/Maximum Limits are reached', the 'Accept as Solved if Limits are Reached' option is selected. The 'Next Unit Calculated after Control Variable is Changed' is set to 'Calculated'. There are 'OK' and 'Cancel' buttons at the bottom, and a note 'Exit the window after saving all data'.

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Note #3: (3) Specifying Reside Gas Outlet Stream Temperature

The screenshot shows the 'Heat Exchanger - Specifications' dialog box. It has a title bar with 'Heat Exchanger - Specifications' and a menu bar with 'UGM', 'Define', 'Range', and 'Help'. The 'Specification' is set to 'Cold Product Temperature'. The 'Value' is 75.00 F. The 'Relative Tolerance' is 0.000100. The 'Area' is in ft². The 'U-Value' and 'Maximum Allowable U*A' are in BTU/hr-ft²-F. There are 'OK' and 'Cancel' buttons at the bottom, and a note 'Exit the window after saving all data'.

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Note #4: (4) Propane Refrigerator Outlet Temperature Specification

The image shows two overlapping software dialog boxes. The background box is titled "Heat Exchanger - Cold Side Utility" and has tabs for "UOM", "Define", "Range", and "Help". It contains the following fields:

- Use Utility for Cold Side
- Utility Type: Water or Air Inlet and Outlet Conditions
 - Water
 - Air
 - Refrigerant
- Refrigerant Component Selection and Saturation Conditions:
 - Component: C2
 - Saturation Conditions:
 - Pressure: [] psig
 - Temperature: -40.00 F
- Thermo Method for Air Cp Calculation:
 - Ideal Thermo Method
 - Compatible with Simple HX Air Ver. 8.2 and earlier

Buttons for "OK" and "Cancel" are at the bottom, with the text "Exit the window after saving all data" below them.

The foreground box is titled "Heat Exchanger - Specifications" and has the same tabs. It contains the following fields:

- Specification: Hot Product Temperature
- Value: 35.00 F
- Relative Tolerance: 0.000100
- Area: [] ft²
- U-Value: [] BTU/hr-ft²-F
- Maximum Allowable U*A: [] BTU/hr-F

Buttons for "OK" and "Cancel" are at the bottom, with the text "Exit the window after saving all data" below them.

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Note #5: (5) Specifying Reside Gas Outlet Stream Temperature

The image shows a single software dialog box titled "Heat Exchanger - Specifications" with tabs for "UOM", "Define", "Range", and "Help". It contains the following fields:

- Specification: Cold Product Temperature
- Value: -40.00 F
- Relative Tolerance: 0.000100
- Area: [] ft²
- U-Value: [] BTU/hr-ft²-F
- Maximum Allowable U*A: [] BTU/hr-F

Buttons for "OK" and "Cancel" are at the bottom, with the text "Exit the window after saving all data" below them.

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Note #6: (6) Turbo-Expander Outlet Pressure & Efficiency Spec.

PRO/II - Expander

UDM Define Range Help Overview Status Notes

Unit: X101 Description:

Product Phases... Thermodynamic System: Default (SRK01)

Pressure and Work Specifications:

Outlet Pressure: 250.00 psig

Pressure Ratio: psia

Pressure Drop: psia

Work: HP

Relative Tolerance: 0.0010000 Percent

Outlet Temperature Estimate: F

Minimum Outlet Pressure: psig

Adiabatic Efficiency: 85.00 Percent

OK Cancel

Exit the window after saving all data

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Note #7: (7) Joule-Thomson Valve Outlet Pressure Spec.

PRO/II - Valve

UDM Define Range Help Overview Status Notes

Unit: V1 Description:

Product Phases... Thermodynamic System: Default (SRK01)

Operating Parameter:

Pressure Drop: psia

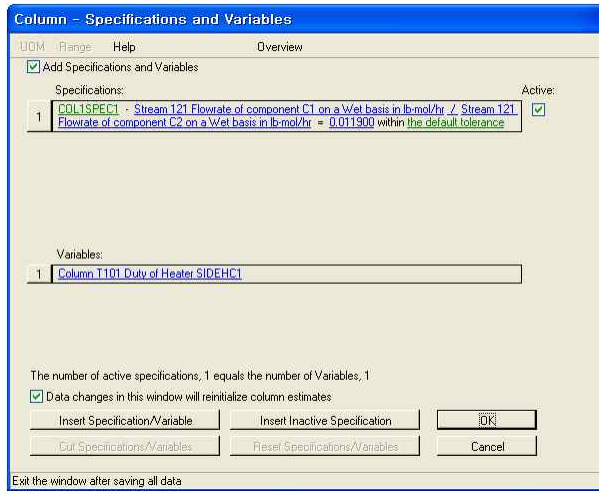
Outlet Pressure: 252.00 psig

OK Cancel

Exit the window after saving all data

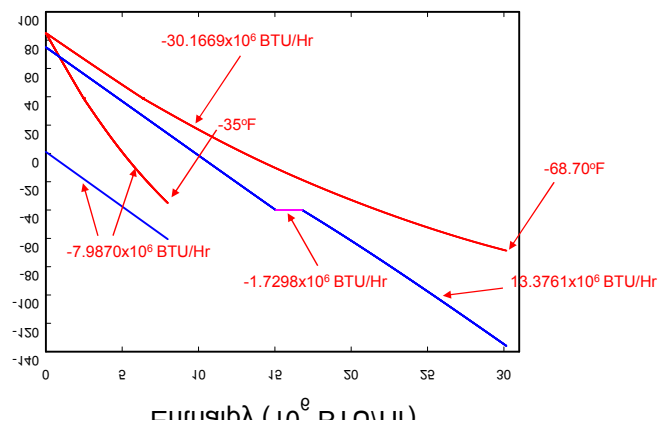
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Note #8: (8) Joule-Thomson Valve Outlet Pressure Spec.



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Step 2: Heat Integration Between Hot & Cold Stream & Refrigerant



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Result Summary for NGL Fractionation Unit

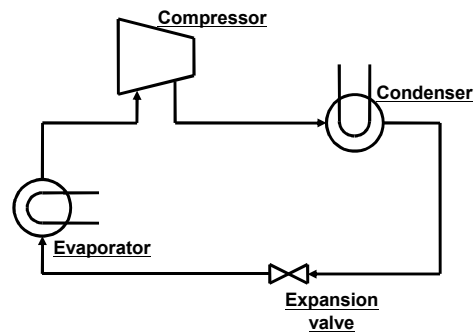
Item	Value
Ethane Flow at Feed (lbmole/hr)	1,449.4863
Ethane Flow at BTMS (lbmole/hr)	1,094.1380
Ethane Recovery %	75.48
C1/C2 Molar Ratio at BTMS	0.0119
Total Cooling Duty (10^6 Kcal/hr) ¹	-41.5686
Total Cooling Duty (10^6 Kcal/hr) ²	-38.1539
C3 Refrigeration Duty (10^6 Kcal/hr) ¹	-12.3360
C3 Refrigeration Duty (10^6 Kcal/hr) ²	-1.7298
Side Reboiler Duty (10^6 Kcal/hr)	-7.9870
Bottom Reboiler Duty (10^6 Kcal/hr)	3.6000

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Propane Refrigeration Cycle:

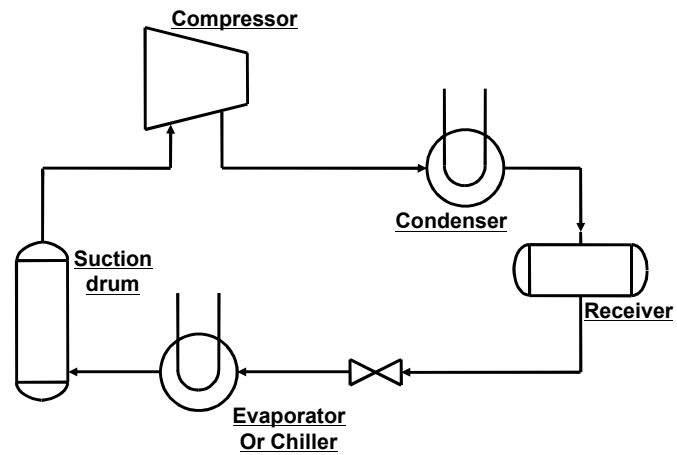
➤ Refrigeration Cycle By Recompressing Vapor:

- Compression
- Condensation
- Expansion
- Evaporation or Chilling



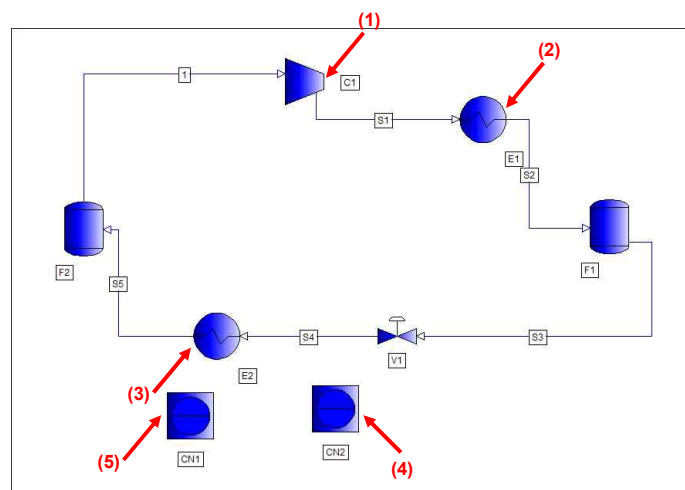
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Actual Refrigeration Cycle Using C3 Refrigerant



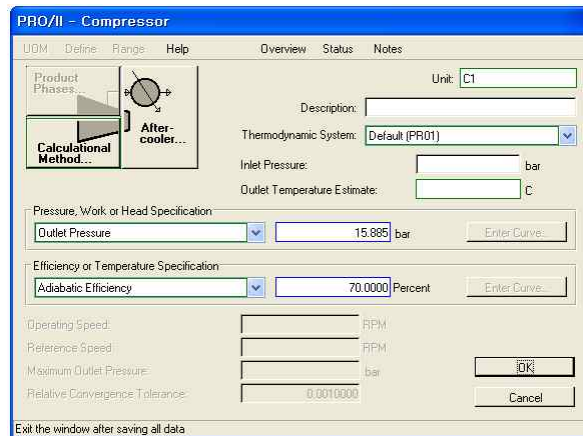
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Simulation of C3 Refrigeration Cycle Using P2



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Note #1: (1) Compressor Outlet Pressure



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Note #1: (1) Compressor Outlet Pressure

- It is related to a bubble point pressure of propane at 113°F.
 - Pressure drop from compressor discharge to condenser outlet stream is 0.5 bar.

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Note #2: (2) Condenser Outlet Liquid Fraction Spec.

Heat Exchanger - Specifications

UOM Define Range Help

Specification: Hot Product Liquid Fraction

Value: 1.0000

Relative Tolerance: 0.000100

Area: m²

U-Value: kcal/hr·m²·K

OK Cancel

Exit the window after saving all data

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Note #3: (3) Evaporator Outlet Vapor Fraction Spec.

Heat Exchanger - Specifications

UOM Define Range Help

Specification: Cold Product Liquid Fraction

Value: 0.00000

Relative Tolerance: 0.000100

Area: m²

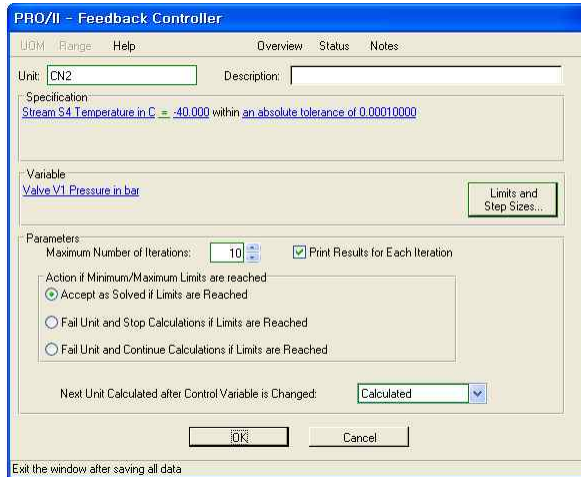
U-Value: kcal/hr·m²·K

OK Cancel

Exit the window after saving all data

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Note #4: (4) Joule-Thomson Valve Outlet Pressure Spec.



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Note #4: (4) Joule-Thomson Valve Outlet Pressure Spec.

Data Review Window - Stream - 'S4'

Property	Value	Units
Stream Name	S4	
Temperature	-40.000	C
Pressure	1.114	bar
Flowrate	370.207	kg.mol/hr

Property Label List Copy Close

Exit the window without saving any data

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Note #5: (5) Refrigerant Circulation Rate Spec.

PRO/II - Feedback Controller

Unit: CN1 Description:

Specification:
Heat Exchanger E2 Duty in x 10⁶ Kcal/hr = 1.7298 within the default tolerance

Variable:
Stream 1 Flowrate in lb-mol/hr

Parameters:
Maximum Number of Iterations: 10 Print Results for Each Iteration

Action if Minimum/Maximum Limits are reached:
 Accept as Solved if Limits are Reached
 Fail Unit and Stop Calculations if Limits are Reached
 Fail Unit and Continue Calculations if Limits are Reached

Next Unit Calculated after Control Variable is Changed: Calculated

OK Cancel

Exit the window after saving all data

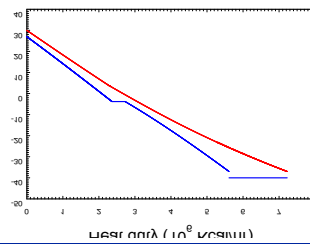
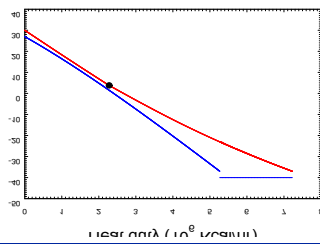
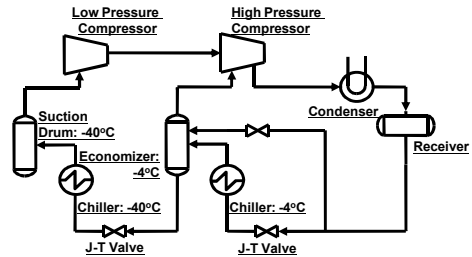
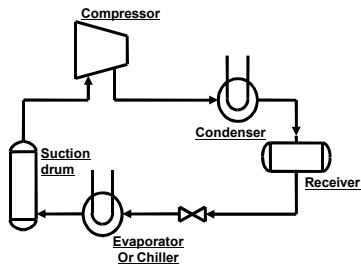
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Result Summary for Refrigeration Cycle

Item	Value
Compressor Power (kW)	1,889
Condenser Duty (10 ⁶ Kcal/hr)	3.4660
Expander Outlet Pressure (bar)	1.114
C3 Circulation Rate (Kg/hr)	37,814
Chilling Duty (10 ⁶ Kcal/hr)	1.7298

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1 Stage Refrigeration vs. 2 Stage Refrigeration



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The End....

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