Process Overview

This *Process Overview* workshop describes the process you will be working with in this course.

Approximate Length

Two hours.

Prerequisites

- Workshop 1 – Course Overview

Learning Objectives

Upon successful completion of this module, you will be able to

- Name main pieces of equipment of the Distillation unit
- Identify unit streams, and byproducts
- Describe process flows
- Describe process chemistry
- Describe key control objectives and process variables

Process Diagrams

The following diagrams are linked from the course landing page and should be used as reference for this workshop:

- Overview

Process Description

The simulation model consists of two distillation towers, a Debutanizer and Depropanizer in series. The first tower, the Debutanizer, receives a light feed and a heavy feed at a fixed temperature. The Debutanizer separates C5 and heavier hydrocarbons from C4 and lighter hydrocarbons. The bottom product is sent to storage and the overhead product is sent to the second tower. The second tower, the Depropanizer, separates C3 from C4 hydrocarbons.

Feed Flow to Debutanizer (T-100)

A heavy and a light feed available from separate sources and fixed pressures are blended in desired ratios and fed to the Debutanizer T-100. The following table lists the composition, temperature, pressure, and flow control of both feeds.

Variables	Heavy Feed	Light Feed
Temperature	244◦F	80◦F
Pressure	206.0 psig	277.0 psig
Flow	Controlled by FC01	Controlled by FC02
Composition (mol %)		
C_6+	43.19	0.0
C_5	18.64	6.57
C_4	18.14	26.49
C_3	19.57	64.79
C_2	0.46	2.15
C_1	0.0	0.0
H_2O	0.0	0.0

Debutanizer (T-100)

The Debutanizer column consists of 42 trays (also known as "plates"). The operating objective is to remove butanes (C4) and lighter hydrocarbons from the feed and make on specification overhead product. Therefore, the overhead product has a design composition specification of 1 mole % C5, to ensure all lighter components are removed. The blended feed is introduced near the middle of the Debutanizer on tray 23. This tray, also known as the feed-tray, divides the column into two parts. The top segment of the tower (above the feed plate) is known as the rectification section, and the bottom is known as the stripping section.

Debutanizer Reboiler (E-100)

Liquid flowing down through the column is extracted from tray 1 and fed to the
Debutanizer reboiler. This is a thermosiphon type reboiler (also known as "Natural
Circulation Reboiler"), where heat is supplied from a high-pressure steam source in order to generate vapor. The boilup flow is then returned to the bottom of the Debutanizer tower, where it then flows upward counter currently with the liquid coming down. The Debutanizer bottoms product, which is primarily C5 and heavier hydrocarbons, is transferred to storage tank 1.

Debutanizer Condenser (E-110)

Vapor moving up the column exits the top and enters the Debutanizer condenser. This overhead flow is condensed using eight available fans in the condenser. Some of the overhead flow bypasses the condenser to control the pressure in the downstream reflux drum.

Debutanizer Reflux Drum (D-100)

The condensed overhead flow is then collected in the Debutanizer reflux drum. Some of this liquid hydrocarbon is returned to the top of Debutanizer column using pumps P62 and P-63. This recycled liquid is called reflux flow. Liquid is also removed from the reflux drum through pumps P-68 and P-69, and is known as "top product" or distillate. There is also a "minimum flow spillback" that returns liquid to the reflux drum through 11FV28. Excess pressure in the drum is released to either flare or the compressor interstage drum (not simulated).

Feed Flow to Depropanizer (T-200)

The Debutanizer distillate becomes the feed to the Depropanizer column and enters the
Depropanizer feed/bottoms exchanger (E-250). The feed is pre-heated by the Depropanizer bottoms product as it passes through this exchanger before entering the adjacent tower. The composition of the feed is primarily C3 and C4.

Depropanizer (T-200)

The Depropanizer column consists of 40 trays. The operating objective is to remove butanes C3 and lighter hydrocarbons from the feed and make on-specification overhead product. The overhead product of the Depropanizer has a design composition specification of 1 mole % C4, to ensure removal of all lighter

components. The distillate feed enters the Depropanizer tower on tray 20.

Depropanizer Reboiler (E-220)

Liquid flowing down through the column is extracted from the bottom of the tower and fed to the Depropanizer reboiler. This is a thermosiphon type reboiler, where heat is supplied from a high-pressure steam source to generate vapor. The boil up flow is then returned to the bottom of the Depropanizer tower. The Depropanizer bottoms product, which is primarily C4 and heavier hydrocarbons, flows to the Depropanizer feed/bottoms exchanger (E-250) where it is cooled by the incoming feed. The bottoms flow is further cooled as it passes through the C4 product cooler (E-240), before being stored as product.

Depropanizer Condenser (E-210)

Vapor moving up the column exits the top and enters the Depropanizer condenser. This overhead flow is condensed using six available fans in the condenser. Some of the overhead flow bypasses the condenser to control the pressure in the downstream reflux drum.

Depropanizer Reflux Drum (D-200)

The condensed overhead flow is then collected in the Depropanizer reflux drum. Reflux pumps P-66 and P-67 return a portion of the liquid flow back to the top of the column as reflux. Some of the product returns to the reflux drum via 11FV30 as minimum flow spillback. The remaining C3 distillate then flows to the C3 product cooler (E-230), where it is cooled before being stored as product.

Control Description

The model consists of controllers, indicators, hand switches, and hand controllers. The control strategy for both columns (Debutanizer, Depropanizer) and their associated equipment is very similar, with few differences. The model consists of single, cascade, and split range control loops. All controllers provide bumpless transfer when changing modes from manual to automatic and automatic to remote control.

Debutanizer (T-100) Feed Control

11FC01 controls the flow of heavy feed and 11FC02 controls the flow of light feed to the Debutanizer tower. Both feeds are inlet boundaries to the model with fixed temperature, pressure and composition.

Debutanizer (T-100) Level Control

11LC14 and 11FC17 regulate the flow of the Debutanizer bottoms flow sent to storage, and in turn the liquid level in the Debutanizer. They are designed to work as a cascade loop with 11FC17 receiving its setpoint from 11LC14. The bottoms flow is a combination of C_5 and heavier hydrocarbons.

If the level of the Debutanizer bottoms falls below 10%, 11LSD15, the level shutdown interlock trips the shut off valve 11HV39, upstream of flow control valves 11FV17 and 11FV18. To restore flow, 11HS39 is used to reset the shutdown valve after 11LSD15 has returned to normal status (when the level on 11LC14 is greater than 10%). 11FC18 regulates the flow (normally zero) to the off-specification storage tank.

Depropanizer (T-200) Level Control

The Depropanizer bottoms flow rate is controlled by 11LC20, which is cascaded to 11FC22. This product flow is comprised of mainly C_4 and heavier hydrocarbons. Downstream analyzer indicators 11AI16A (C_3) and 11AI16B (C_4) have an analysis time of 150 seconds.

Column Tray Temperature Control

11TC10 controls the Debutanizer tray 2 temperature by providing a remote setpoint to 11FC15. The flow controller regulates the flow of high-pressure steam to reboiler E-100 via steam flow valve 11FV15.

11TC11 controls the Depropanizer tray 3 temperature by providing a remote setpoint to 11FC21. The flow controller regulates the flow of high-pressure steam to reboiler E-220 via steam flow valve 11FV21

Column Overheads Analyzer Control

11AC12 regulates the flow of reflux from drum D-100 to the Debutanizer column, in order to control the overhead composition to 1 mol % of C_5. It is designed to work as a cascade loop by providing a remote set point to 11FC19, which controls reflux valve 11FV19. 11AC12 has an analysis time of 300 seconds.

The Depropanizer analyzer controller 11AC17 is designed to control the composition of the overheads flow to 1 mol % C_4 by cascading to flow controller 11FC23. The final control element 11FV23 draws the appropriate reflux flow from drum D-200 back to the Depropanizer column. 11AC17 has an analysis time of 150 seconds.

Column Overheads Pressure Control

11PC15 controls the pressure in the top of the Debutanizer column by regulating the overheads vapor flow entering the Debutanizer condenser E-110.

11PC18 controls the pressure in the top of the Depropanizer column by regulating the overheads vapor flow entering the Depropanizer condenser E-210.

Reflux Drum Pressure Control

Both reflux drums D-100 and D-200 on the two towers have pressure controllers operating on similar principles. PC16 and 11PC19 control the pressure on D-100 and D200 respectively, by split range action on two valves. PV16A and PV19A valves are reverse acting and PV16B and PB19B valves are direct acting.

The following table illustrates how valves A and B open with the split range signal. Valve
A is the valve on the line bypassing the Debutanizer overhead condensers E-110 and E210. Valve B is on the vapor line exiting reflux drums D-100 and D-200, and is used to release excess pressure.

Signal from PC16/PC19	Valve	Condition
0	A	Fully Open
50	A	Closed
50	B	Closed
100	B	Fully Open

PC16 is used to import non-condensable natural gas from the compressor interstage drum (not simulated) during startup via the bypass line (HC44), in order to backpressure the Debutanizer column. This controller can also release excess pressure to either flare or the compressor interstage drum.

PC19 is used to import non-condensable natural gas from the off-gas unit (not simulated) during startup, in order to backpressure the Depropanizer column. This controller can also release excess pressure to the off-gas unit.

Reflux Drum Level Control

11LC16 controls the level of distillate (top product) in the Debutanizer reflux drum D-100.
It is configured to work as a cascade loop by providing a remote set point to flow controller 11FC20, which controls flow valve 11FV20. This flow is the feed to the Depropanizer tower with a composition of mainly C_3 and C_4.

11LC21 controls the level of distillate in the Depropanizer reflux drum D-200. It is configured to work as a cascade loop by providing a remote set point to flow controller 11FC24, which controls final control element 11FV24. This final product flow has a composition of mostly C_3