Training Material

Common Parts of a Valve

Many parts are common to all valve types. This topic will take a look at these parts and describe the purpose and function of each part.

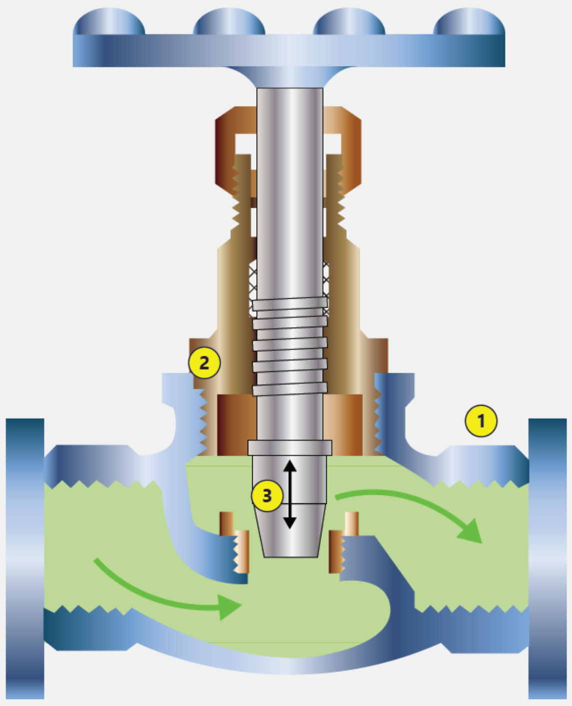
Common Parts of a Valve

The graphic below shows the parts that almost all valve types have in common:

1. The **valve body (shell)** is the outer covering of a valve. It is the structure that holds all valve parts together. The valve body connects to inlet and outlet piping through threaded, flanged, or welded joints. Depending on the application, a valve body can be made from metals, alloys, or plastics. The arrows on the body indicate the direction of flow.

2. The cover of the valve body is called the **bonnet**. The bonnet is made of the same material as the valve body, and it is commonly connected to the body by a threaded, flanged, or welded joint.
   The attachment of the bonnet to the body is considered a pressure boundary. The weld joint or bolts that connect the bonnet to the body are pressure-retaining parts, and can be a potential source of leakage.

3. The **closure member (closure device)** is the physical barrier between the fluid flowing through the valve and the valve itself. The closure member opens, closes, or throttles flow through the valve. *Valves are often named according to the type of closure member they use.* There are three main types of closure members: gate, ball, and plug.



Example: Valve Illustration

Valves

6

Basic Operator Training

- Made for new operators
- Fundamental knowledge
- 16 Courses
- Graphics-driven
- Includes assessments
- Can be delivered online or in-person

Boiling and Pressure

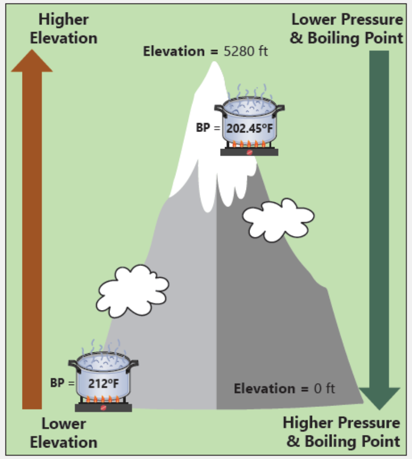
The boiling point strongly depends on **pressure**. If the substance is exposed to a higher pressure, boiling will start at a higher temperature.

Conversely, lowering the pressure will reduce the boiling point temperature.

This can be explained by the concept of **vapor pressure**: the boiling point is reached when the pressure of vapor bubbles is high enough that vapor can escape the liquid. In other words, the pressure of the vapor bubbles is equal to the surrounding pressure.

At high elevations, water boils at a much lower temperature than 212°F because the atmospheric pressure is lower.

This same principle is utilized by pressure cookers; at higher pressure, boiling occurs at a higher temperature, which in consequence speeds up cooking.



Boiling Point (BP) and Pressure

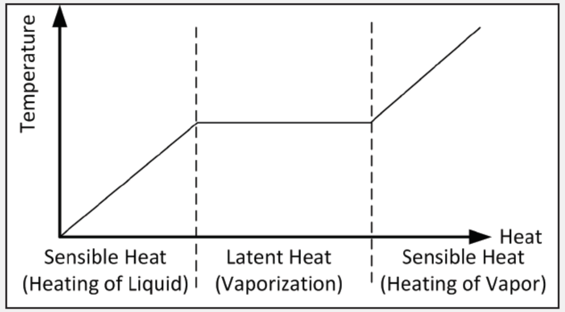
Heat and Phase Changes

Heat supply that creates a change in temperature, such as when the water temperature is raised to bring water to boiling, is called **sensible heat**.

When all liquid is vaporized and more heat is supplied (and only then), the vapor temperature increases; this is also sensible heat.

Heat supply that generates a phase change, such as when water vaporizes or condenses, is called **latent heat.** The temperature remains constant.

The graphic shows how sensible heat supply causes changes in temperature, while latent heat supply does not change temperature.

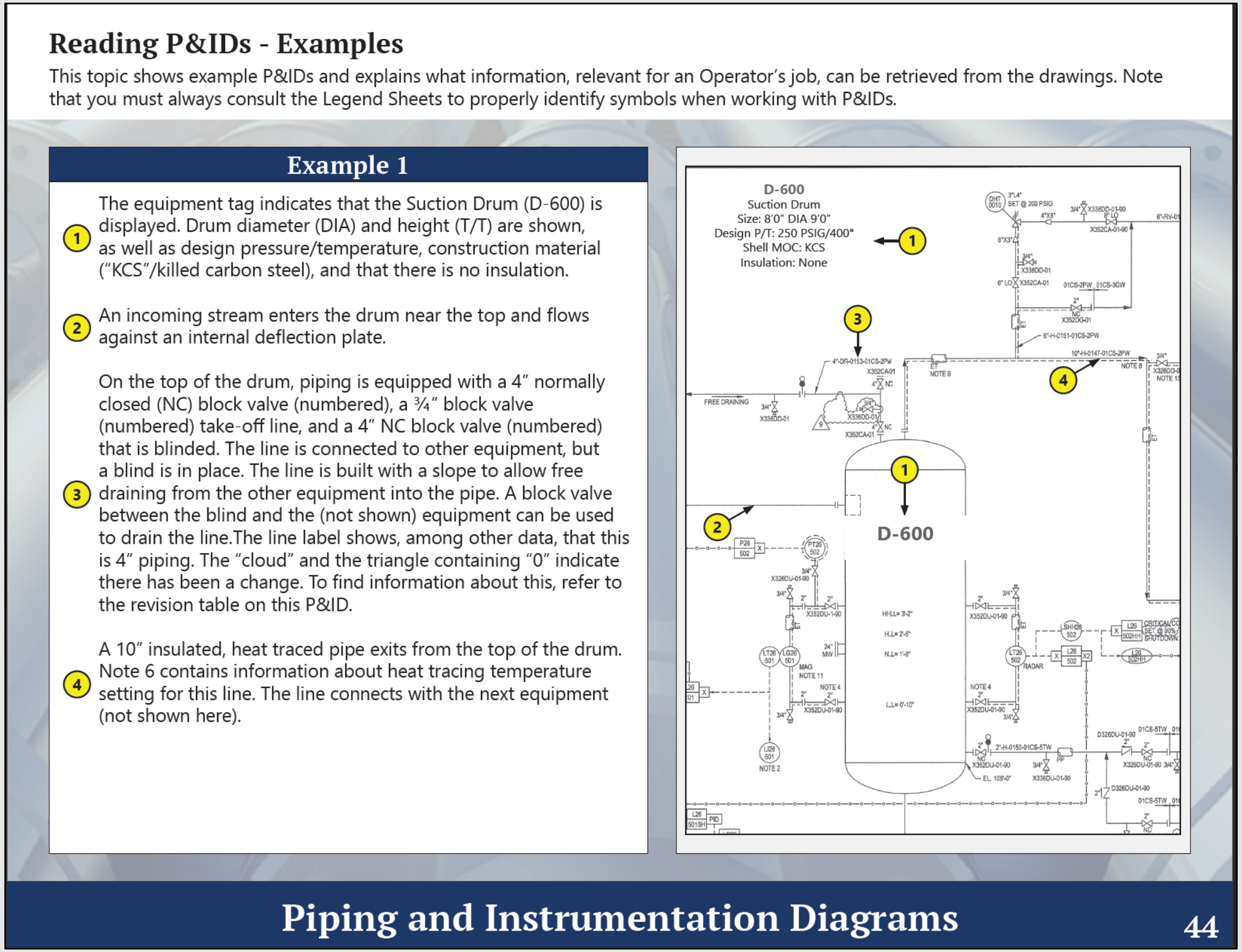


Sensible and Latent Heat

Distillation Principles 8

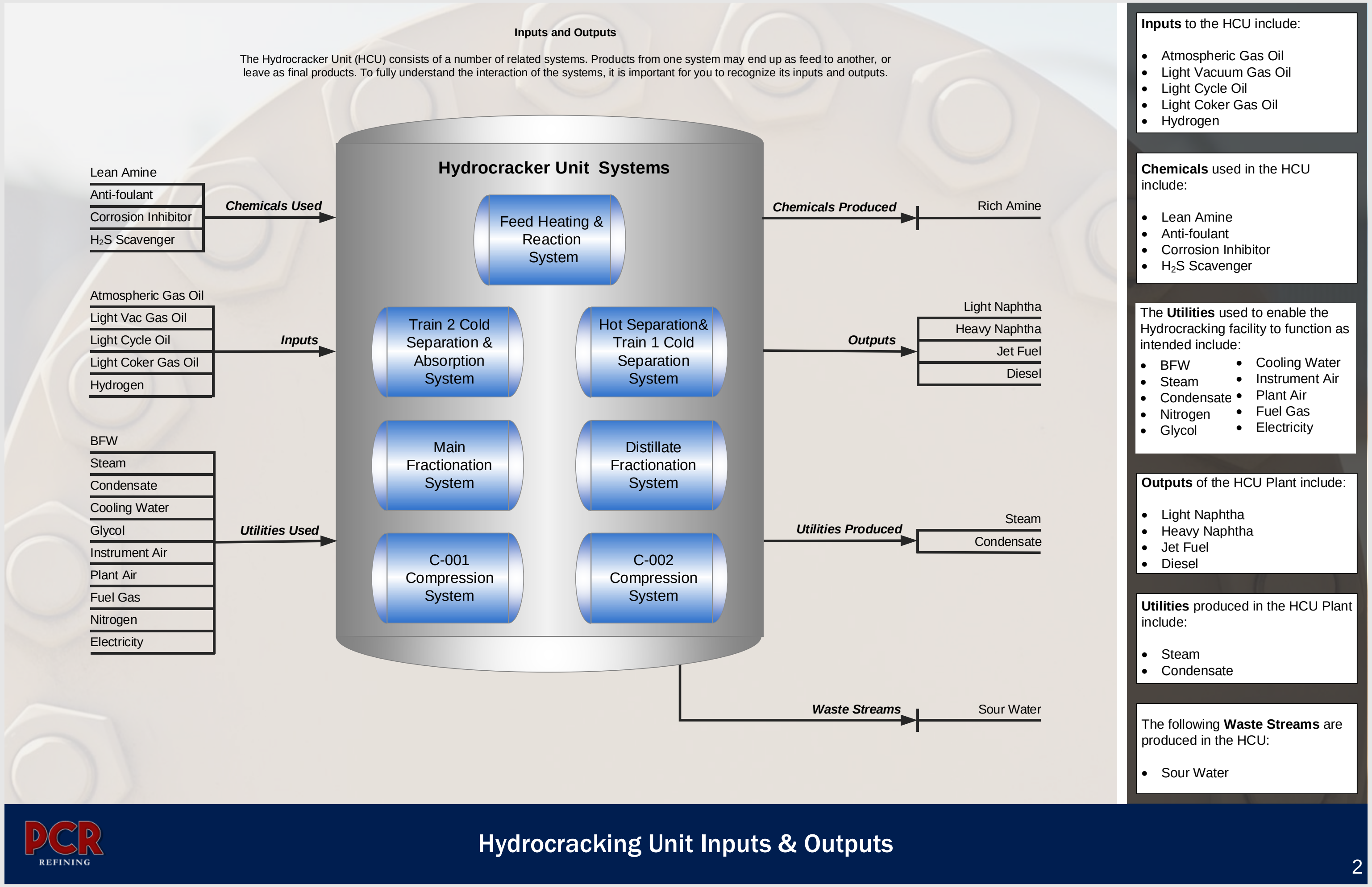
Basic Operator Training

- Made for new operators
- Fundamental knowledge
- 16 Courses
- Graphics-driven
- Includes assessments
- Can be delivered online or in-person



Basic Operator Training

- Made for new operators
- Fundamental knowledge
- 16 Courses
- Graphics-driven
- Includes assessments
- Can be delivered online or in-person



Facility/Unit Overview

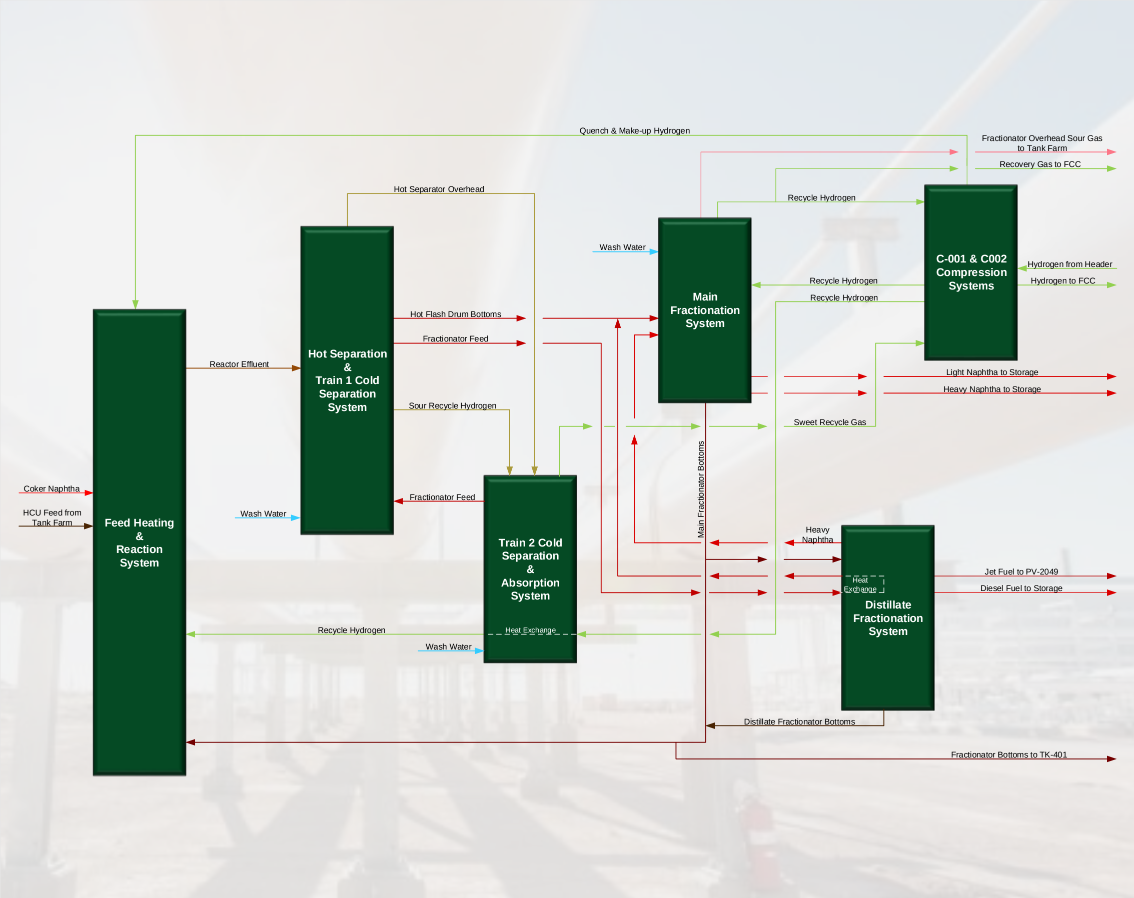
- Brief overview of the facility
- Inputs and outputs
- Types of equipment
- Simplified process flow
- Material and physical hazards
- General safety and health considerations associated with the facility

Facility/Unit Overview

- Brief overview of the facility
- Inputs and outputs
- Types of equipment
- Simplified process flow
- Material and physical hazards
- General safety and health considerations associated with the facility

Facility/Unit Overview

- Brief overview of the facility
- Inputs and outputs
- Types of equipment
- Simplified process flow
- Material and physical hazards
- General safety and health considerations associated with the facility



In the **Feed Heating and Reaction System**, feed is pumped to the high pressure reaction circuit, mixed with hydrogen, then heated to the temperature necessary for reactions to proceed. Due to the unit's high capacity, two parallel reactor trains are used. The feed is first pretreated for sulfur and nitrogen removal, as well as for olefin saturation. This is done primarily to protect the downstream hydrocracking catalyst. Pretreater effluent flows through the Hydrocracker to convert higher molecular weight feed components to more valuable, lighter products. Reactions in both the Pretreater and the Hydrocracker occur at a high temperature and pressure in a hydrogen-rich atmosphere, and in the presence of catalyst.

In the **Hot Separation & Train 1 Cold Separation System**, the process begins to separate reaction products from reaction byproducts and recycle gas. This Hot HP Separator collects the heavier hydrocarbon material that will be sent to the Main Fractionator via the Hot Flash Drum. The process stream from the top of the Hot HP Separator is cooled, then again splits into two trains for cold separation. In this system, the Train 1 stream is cooled to condense water and hydrocarbon liquid so that it can be separated from the hydrogen-rich recycle. Recovered hydrocarbon liquid is cooled and routed to the Main Fractionator.

In the **Train 2 Cold Separation & Absorption System**, the Train 2 stream from the cooled Hot HP Separator vapor is further cooled to condense water and hydrocarbon liquid so that it can be separated from the hydrogen rich recycle. It is separated in 2 stages. The recovered hydrocarbon liquid is cooled, then mixes with the Train 1 flow to the Main Fractionator. Hydrogen-rich vapors recovered from Train 1 and Train 2 are treated with amine to remove H_2S and increase purity of the stream so that it can be recycled to the Reactors.

In the **Main Fractionation System**, feed recovered in the Hot Separator and in the Low Pressure Separators is separated into valuable products through the process of distillation. There are two side draws on the Main Fractionator: heavy and light naphtha. Each naphtha draw is routed to a stripper for light ends removal. Light and heavy naphtha are cooled in a series of Heat Exchangers and flow to storage The Fractionator bottoms is routed to the Distillate Fractionator for further fractionation. A portion of the bottoms is recycled to the Feed Surge Drum for additional product conversion.

In the **Distillate Fractionation System**, Main Fractionator Bottoms is separated through distillation to yield more valuable products. The Distillate Fractionator also has two draws: jet fuel and diesel. Each of these draws is routed to a steam stripper for light ends removal. Distillate product is routed to storage. Jet Fuel is sent to dryers to remove water to reduce haze point. Overhead is condensed and separated to recover heavy naphtha product. Distillate Fractionator Bottoms is also recycled to the Feed Surge Drum for additional product recovery.

In the **C-001 and C-002 Compression Systems**, various hydrogen streams recovered within the unit are compressed so that hydrogen can be returned to the high pressure reaction system. Each system includes a six-cylinder reciprocating compressor. Cylinders 1A and 2A compress sweet recycle hydrogen from the Recycle Absorber to provide hydrogen feed and quench gas to the reactors. Cylinders 1C and 2C compress Main Fractionator overhead vapor, which is sent to the FCC Unit. The D cylinders compress makeup hydrogen from the #1 Reformer. Discharge mixes with hydrogen feed from the HDS. The combined stream is compressed in the E and F cylinders, and supplies hydrogen to both reactor trains.

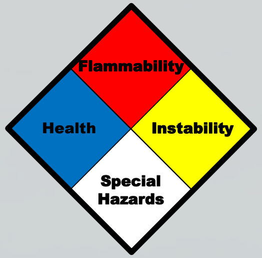
PCR REFINING

Simplified Process Flow

Facility/Unit Overview

- Brief overview of the facility
- Inputs and outputs
- Types of equipment
- Simplified process flow
- Material and physical hazards
- General safety and health considerations associated with the facility

Material Hazards



The NFPA diamond is broken into four colored sections, each representing a specific hazard. Health, Flammability, and Instability are rated numerically, and Special Hazards are identified with symbols or abbreviations.

Numbers in the three colored sections range from 0 to 4, with the following definitions:

0 = Minimal 1 = Slight 2 = Moderate 3 = Serious 4 = Severe

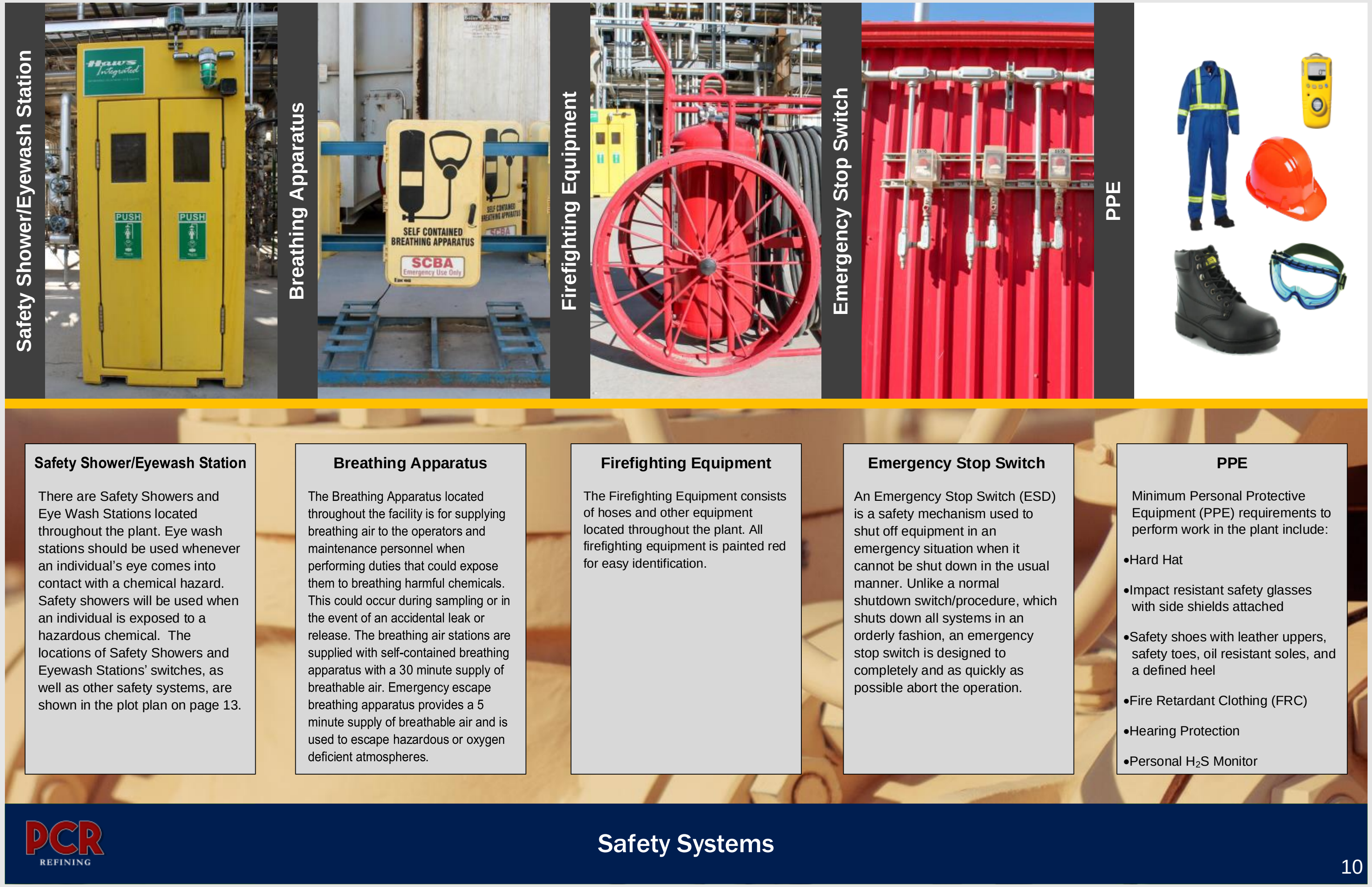
4: Highly toxic, may be fatal on short term exposure
3: Toxic, full protective suit and breathing apparatus required
2: Breathing apparatus and face mask must be worn
1: Breathing apparatus may be worn
0: No precautions necessary
4: Extremely flammable gas or liquid (Flash point below 73 °F)
3: Flammable (Flash point 73-100 °F)
2: Combustible, requires heating to ignite (Flash point above 200° F)
1: Slightly Combustible
0: Will not burn under normal conditions
4: Explosive at room temperature
3: May detonate if shocked, or heated under confinement, or mixed with water
2: Unstable, may react with water
1: May react if heated or mixed with water
0: Normally stable, does not react with water

Oxidizer	OXY	Corrosive	COR
Acid	ACID	Use No Water	$\overline{W}$
Alkali	ALK	Radiation	☢

Material	MSDS Number CAS Number(s)	NFPA Ratings	Major Hazards	Special PPE/Controls	Location
Hydrogen	**MSDS:** # **CAS:** 1333-74-0	4 0 0	Flammable gas that burns with an almost invisible flame. Asphyxiant. Primary route of exposure is inhalation.	Ventilate the area to keep concentrations of hydrogen from building up. A supplied air respirator should be worn when concentrations are unknown. Spark-proof tools should be used to control ignition sources.	Multiple processes
Nitrogen	**CAS:** 7727-37-9	0 0 0 SA	Simple asphyxiant	Maintain O_2 levels above 19.5%. Use positive pressure NIOSH approved air supply.	
Fuel Gas	**CAS:** 74-98-6 115-07-1	4 1 0	Extremely flammable gas. Vapors are heavier than air. May explode violently.	Keep away from heat/sparks. Provide local ventilation, where possible, to minimize worker exposure and prevent explosive concentrations.	
Hydrocarbons C_2 – C_5	**CAS:** By Stream	4 1 0	Highly Flammable	Chemical goggles are recommended. Wear chemical resistant gloves when handling. Wear approved respirators if allowable limits are exceeded.	
Hydrocarbons C_6^+	**CAS:** By Stream	3 1 0	Flammable	Chemical goggles are recommended. Wear chemical resistant gloves when handling. Wear approved respirators if allowable limits are exceeded.	
Hydrogen Sulfide	**CAS:** 7783-06-4	4 4 0	Flammable gas. Toxic at high concentrations.	If concentration is above allowable limits, ventilate the area. A supplied air respirator or SCBA should also be worn.	
Ammonia	**CAS:** 7764-41-7	1 3 0	Strong alkali. Colorless gas or liquid with a pungent odor.	Provide adequate ventilation. Wear chemical goggles, face shield, rubber gloves, and protective clothing when handling. Avoid breathing mist or vapors.	
Sour Water	**CAS:** 7783-06-4 7732-18-5 7647-14-5	1 2 0	Clear to yellow-brown liquid with a foul odor of rotten eggs. Explosive concentrations can build up in poorly ventilated areas.	If the concentration is above allowable limits, ventilate the area. Supplied air respirator or SCBA should be worn.	

PCR REFINING

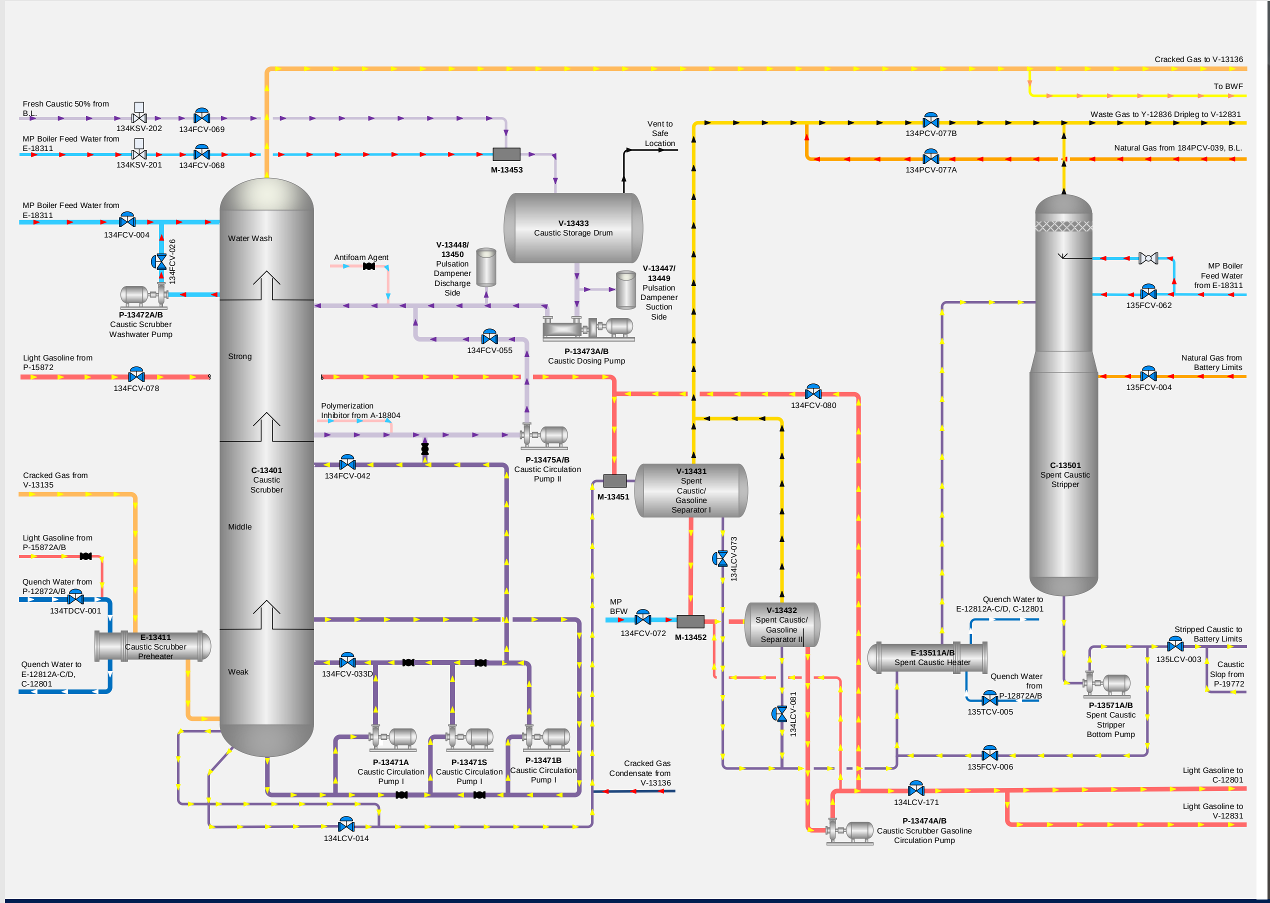
Material Hazards



Facility/Unit Overview

- Brief overview of the facility
- Inputs and outputs
- Types of equipment
- Simplified process flow
- Material and physical hazards
- General safety and health considerations associated with the facility

System Module



Overview:

Between the 4th and 5th stages of cracked gas compression, a caustic solution is used as a scrubbing medium to remove acid gases from the cracked gas stream. This occurs in a multi-stage scrubbing tower, where a chemical absorption process occurs to remove H_2S and CO_2 from the gas.

Light gasoline is used to extract heavy hydrocarbons from the spent caustic. The gasoline and caustic phases are separated in two separation vessels, with a water wash between separation stages.

When the scrubbing medium is spent, it must be disposed of in a safe and environmentally friendly manner. Prior to disposal, heavy hydrocarbon components are removed from the spent caustic in a stripping tower.

Caustic Scrubbing System

2

- Process flow description
- Unit is broken into Systems
- System drawing based on client P&IDs
- Overview of why System is important to the Unit
- Nodes identify important aspects in the subsystem and their purpose

Cracked Gas from Caustic Scrubber Inlet Separator flows through the shell side of The Caustic Scrubber Preheater. It is preheated by quench water that flows through the tube side of the exchanger.

Purpose:
The cracked gas stream is preheated to prevent condensation from occurring in the Caustic Scrubber.

1

Preheated cracked gas enters the bottom of the Caustic Scrubber and flows upward through the tower.

Purpose:
C-13401 is a scrubbing tower where acid gases, H_2S and CO_2, are removed from the cracked gas stream by contact with a countercurrent stream of dilute caustic. The scrubber is divided into four sections to maximize caustic utilization and increase process efficiency.

2

The lower three sections of C-13401 are caustic wash sections. Caustic strength decreases down the tower. Each section has its own cycle, requiring fewer trays and resulting in lower pressure drop. The lowest caustic wash section is where the bulk of the acid gas is removed from the cracked gas.

3

Caustic Circulation Pump I provides circulating caustic to the bottom (weak) caustic wash section on flow control. The pump discharges caustic below the towers lowest chimney tray. Caustic falls downward, absorbing H_2S and CO_2 as it contacts the rising cracked gas stream.

4

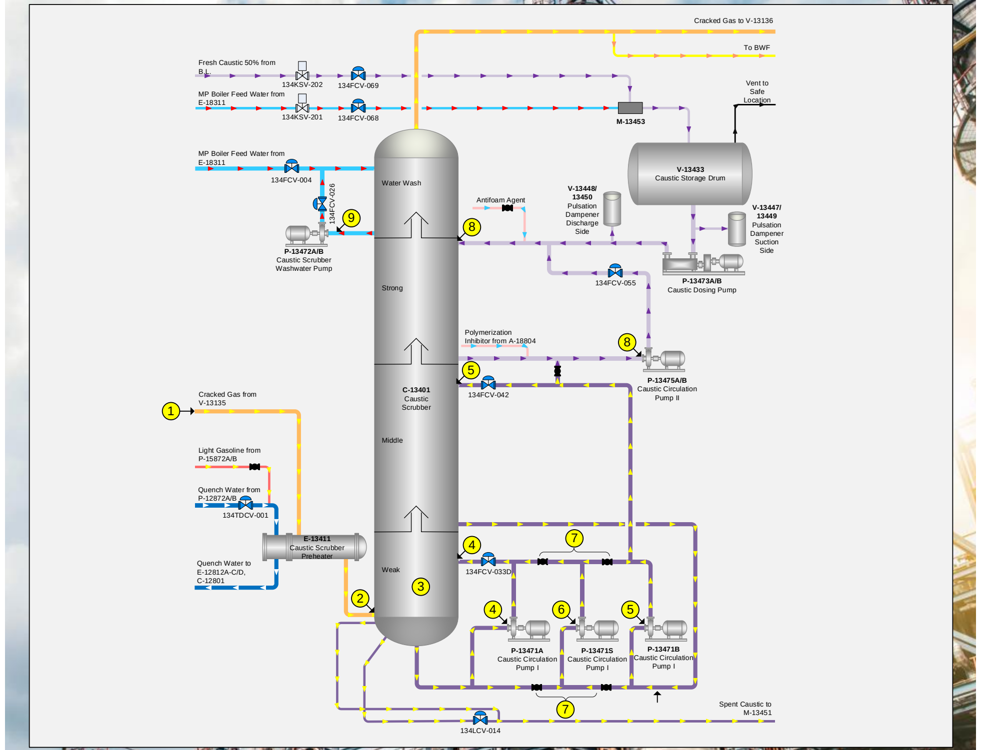
Caustic Circulation Pump I draws caustic from the lower chimney tray and provides circulating caustic to the middle caustic wash section on flow control. Caustic falls downward, absorbing H_2S and CO_2 as it contacts the rising cracked gas stream.

Purpose:
Constant flow of circulating caustic to the middle section provides the column minimum circulating flow, which is higher than the pump minimum flow requirements. Excess caustic flows through the lower chimney tray downpipe to the lower caustic cycle.

5

Overview:

Cracked Gas from the 4th stage discharge of the CGC is scrubbed of acid gases in the Caustic Scrubber. This is achieved as the cracked gas rises through the scrubber and contacts a descending solution of caustic. To increase the efficiency of the process and consequently to minimize fresh caustic consumption, the absorption process in the Caustic Scrubber is divided into three caustic wash sections with a water wash section at the top. Purified cracked gas leaves from the top of the scrubber and flows to the 5th Stage Suction Drum of the Cracked Gas Compressor.



Caustic Scrubbing Subsystem

3

Caustic Circulation Pump P-13471S is a common spare to P-13471A/B.

6

During operation, the respective block valves in the connecting lines at the suction and discharge sides of the pumps P-13471A/B/S are closed, and caustic cycles are separated properly.

7

Caustic Circulation Pump II draws caustic from the middle chimney tray and supplies circulating caustic to the upper (strong) caustic cycle on flow control. Caustic falls downward, absorbing any H_2S and CO_2 not absorbed in the lower two sections as it contacts the rising cracked gas stream.

8

The uppermost section of the column is the water wash section. Boiler feed water is circulated from the upper chimney tray to the top of the tower by Caustic Scrubber Washwater Pump. After passing down the washing trays, the water accumulates on the chimney tray and overflows through the down-pipe to the section below, where it is used for the dilution of the fresh caustic.

Purpose:
The water wash removes any entrained caustic from the gas stream to avoid damage to the downstream compressor.

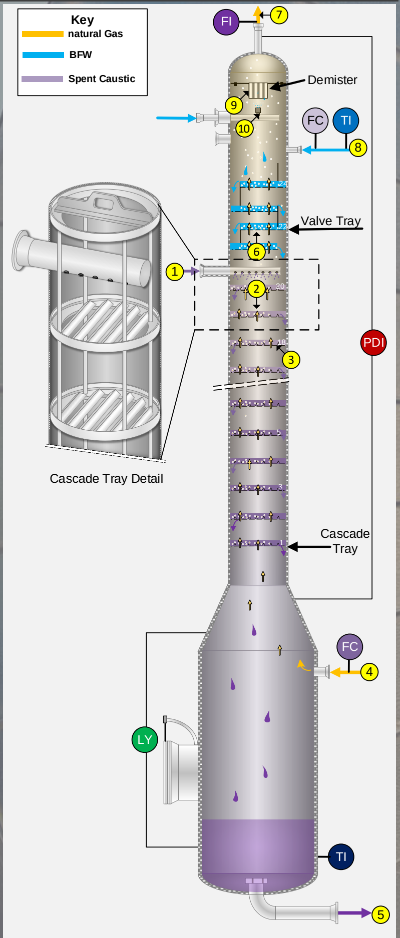
9

Cracked Gas	
Quench Water	
Light Gasoline	
Fresh Caustic	
Spent Caustic	
Condensate	
Chemical Additive	
Blowdown Warm Flare	

System Module

- Process flow description
- Unit is broken into Systems
- System drawing based on client P&IDs
- Overview of why System is important to the Unit
- Nodes identify important aspects in the subsystem and their purpose

Spent Caustic Stripper



Cascade Tray Detail

The Spent Caustic Stripper is a 24 tray stripping column that utilizes natural gas to strip volatile hydrocarbons, such as benzene, from the spent caustic stream. These compounds must be removed from the spent caustic prior to disposal.

How It Works

1. Preheated spent caustic from the Spent Caustic Heater enters the Caustic Scrubber from an inlet distributor near the top of the column. The distributor evenly dispenses spent caustic along the column cross section.
2. The caustic falls downward to tray number 20. Trays #1-20 are cascade cartridge type trays. With cascade trays, liquid falls down the column splashing off the trays with minimum liquid level build up.
3. The purpose of these trays is to increase the amount of contact between the liquid and vapor phases within the column.
4. Natural gas enters into the bottom of the column below the trays and rises upward, countercurrently to the downward flowing caustic. As the gas and liquid streams are contacted, volatile organic compounds are stripped out of the caustic stream and flow upward with the natural gas.
5. Stripped spent caustic accumulates in the bottom of the stripper. It is pumped by the Caustic Stripper Bottom Pump to OSBL for disposal.
6. Natural gas and stripped VOCs continue upward through the column to the water wash section. This section contains 4 valve-type trays.
7. The stripped-off hydrocarbons exit with the natural gas from the top of stripper. They combine with the vent gas streams from Spent Caustic/Gasoline Separator and the Spent Caustic/Gasoline Separator II and are sent to the Quench Tower via the Gasoline Water Separator drip leg.
8. BFW is routed to the top of the column to remove any entrained caustic droplets in the Upper Water Wash Section.
9. A demister is installed above the top tray to avoid entrainment of water droplets in the stripped gas flow.
10. Spray nozzles are provided for flushing the demister in case of plugging. The spray nozzles are pointed upward toward the demister. Flushing should only be performed when the stripper is bypassed.

Monitoring

Monitored Variable	Location	Tag Number
Natural Gas Flow Rate	Board	135 FC-004
Waste Gas Flow	Board	135 FI-064
Column Level	Board	135LY-003
Column Bottom Temperature	Board	135TI-063
Column Differential Pressure	Board	135PDI-001
BFW Flow	Board	135FC-062
BFW Temperature	Board	183TI-045

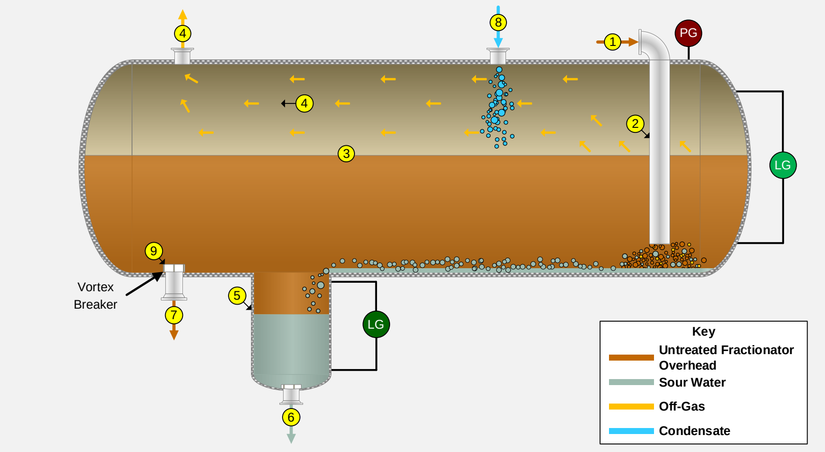
9

Equipment Module

- Overview of each equipment item in a System
- Picture of equipment in the field
- Overview and purpose of each equipment item
- Client specific detailed equipment drawings
- Internal components of equipment
- How it works section
- Monitoring points

Main Column Top Accumulator (V-104)

The Main Column Top Accumulator in the Main Fractionator Overhead System is a three phase, horizontal separator that separates condensed Crude Main Fractionator overhead from sour water and hydrocarbon vapour. This vessel is equipped with a water boot that facilitates phase separation.



How It Works

1. The Main Column Top Accumulator receives the cooled, condensed effluent from the LP-Tops Condenser through a nozzle located at the top of the vessel.
2. At the inlet of the vessel, momentum change is accomplished by a curved long distributor pipe. The curved inlet causes a rapid change in the direction of the feed. The rapid change in direction causes the feed to disperse into the vessel, minimizing turbulence/swings in the liquid level. The distributor pipe ensures that the vapour and liquid distribution into the vessel is layered.
3. The body of the vessel provides the residence time for the liquid and vapour phases to separate.
4. The off-gas entrained in the feed rises, flowing through the gas space to an outlet at the top of the vessel.
5. V-104 is equipped with a boot. The vessel separates two immiscible liquids: a hydrocarbon liquid phase and an aqueous sour water liquid phase. The denser sour water settles in a boot at the bottom of the vessel. The boot has a much smaller diameter than the main vessel to allow for easier control of the liquid level.
6. Sour water exits from an outlet nozzle located at the bottom of the boot.
7. The hydrocarbon liquid forms a top liquid layer above the sour water phase and exits from an outlet nozzle at the bottom of the vessel.
8. Condensate from the Ejector is discharged into V-104.
9. Vortex breakers, located directly above the liquid outlets, protect the downstream equipment by preventing whrilpooling of liquid, which would allow vapour to flow out with the liquid.

Monitoring

Monitored Variable	Location	Tag Number
Vessel Pressure	Field	75-PG-019
Vessel Level	Field	75-LG-020
Vessel Boot Level	Field	75-LG-021/022

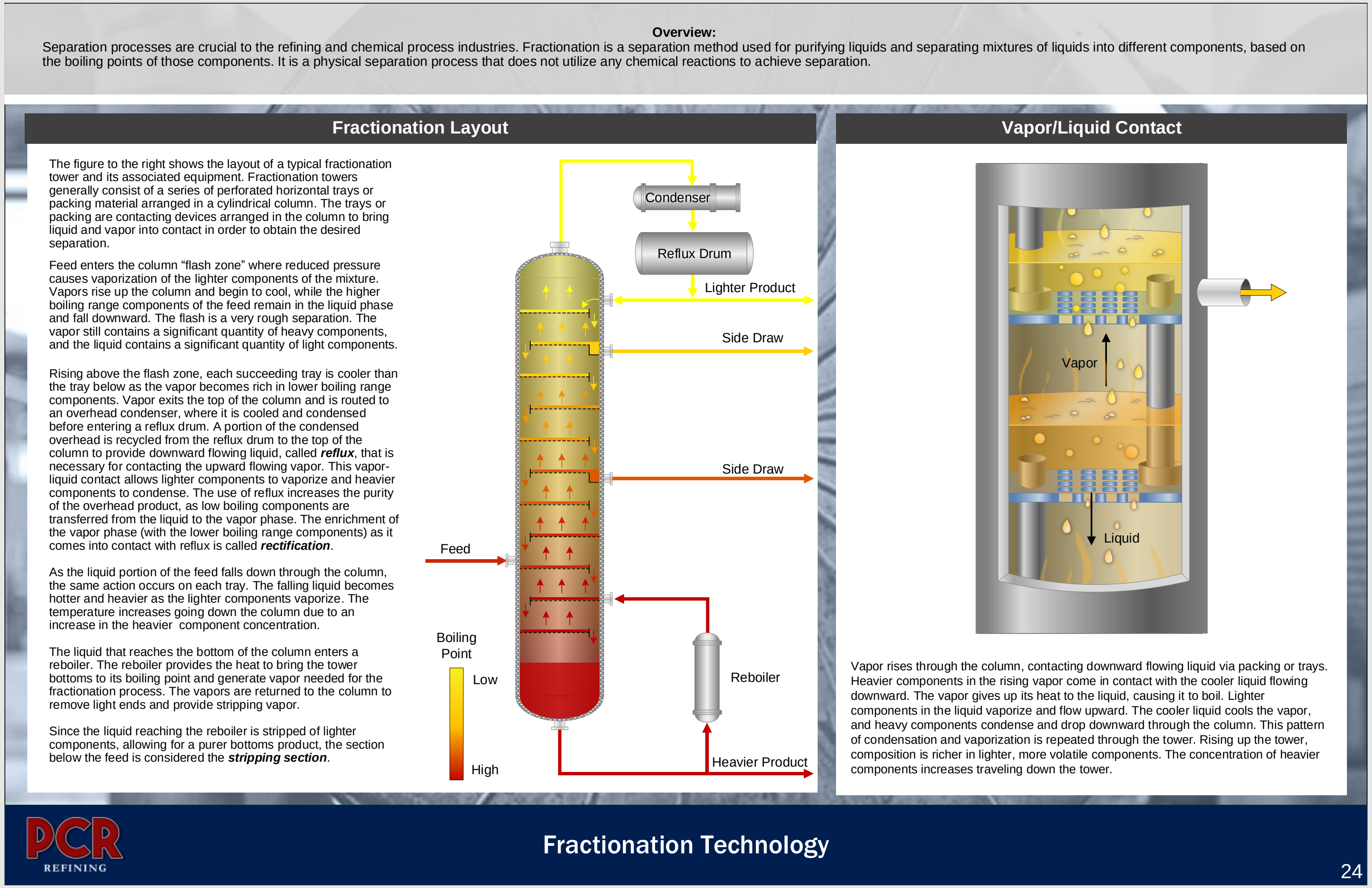
Vessel Information

Vessel	Phases Separated
Main Column Top Accumulator (V-7504)	Off-gas, sour water, hydrocarbon liquid

12

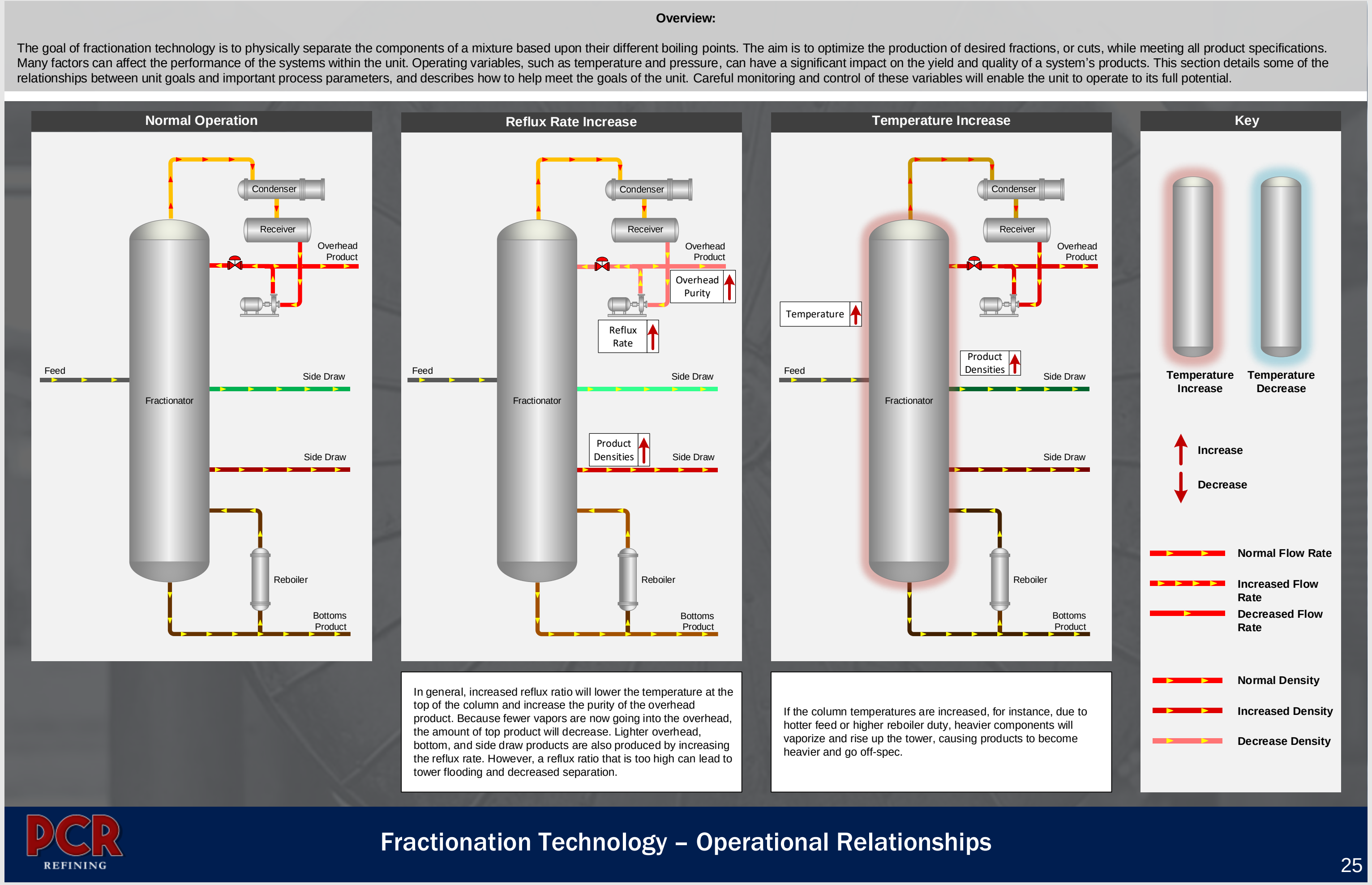
Equipment Module

- Overview of each equipment item in a System
- Picture of equipment in the field
- Overview and purpose of each equipment item
- Client specific detailed equipment drawings
- Internal components of equipment
- How it works section
- Monitoring points



Process Technology

- Chemistry and physics behind major technologies utilized in the facility or unit
- Builds on the knowledge of how system processes work
- Operational relationships
- Example technologies: compression, fractionation, absorption, adsorption, neutralization



Process Technology

- Chemistry and physics behind major technologies utilized in the facility or unit
- Builds on the knowledge of how system processes work
- Operational relationships
- Example technologies: compression, fractionation, absorption, adsorption, neutralization

Process Control Module

- Function and purpose of process controllers under normal operation
- Intro to controls for outside operator
- Detailed description of the components and logic behind each control loop in the system

Controller 840PICA-003 controls the pressure in the EO Buffer Vessel (V-8401). The pressure is controlled using three control valves in a split range configuration. The desired set point is entered into controller 840PICA-003. The pressure is measured by controller transmitter 840PICA-003. In response to a difference between the measured pressure and the set point, 840PICA-003 manipulates control valves PICA-003A/B/C.

If the pressure in V-8401 is very low, controller 840PICA-003 opens control valve 840PICA-003B, allowing nitrogen into the vessel. This will increase the pressure in V-8401 in order to meet the set point.

If the pressure in V-8401 is low, controller 840PICA-003 opens control valve 840PICA-003A, allowing CO_2 to enter the vessel. This will increase the pressure in V-8401 in order to meet the set point.

If the pressure in V-8401 is above the set point, controller 840PICA-003 will open control valve 840PICA-003C. This will vent high pressure gas from the vessel to the Residual Absorber (C-8401) feed in order to meet the set point.

Purpose:
The objective of the pressure controller 840PICA-003 is to maintain the pressure in the EO Buffer Vessel.

1

Controller 840FICA-312/313/316 controls the minimum flow rate through the Glycol Unit Feed Pump (P-8401A/B/C). The desired set point is entered into controller transmitters 840FICA-312/313/316, located on the discharge of P-8401A/B/C. In response to a difference between the measured flow rate and the set point, controllers 840FICA-312/313/316 manipulate control valves 840FICA-312/313/316. This adjusts the flow rate through the Glycol Unit Feed Pump in order to maintain the minimum flow requirement.

Purpose:
Minimum flow protection prevents the pumps from cavitating.

2

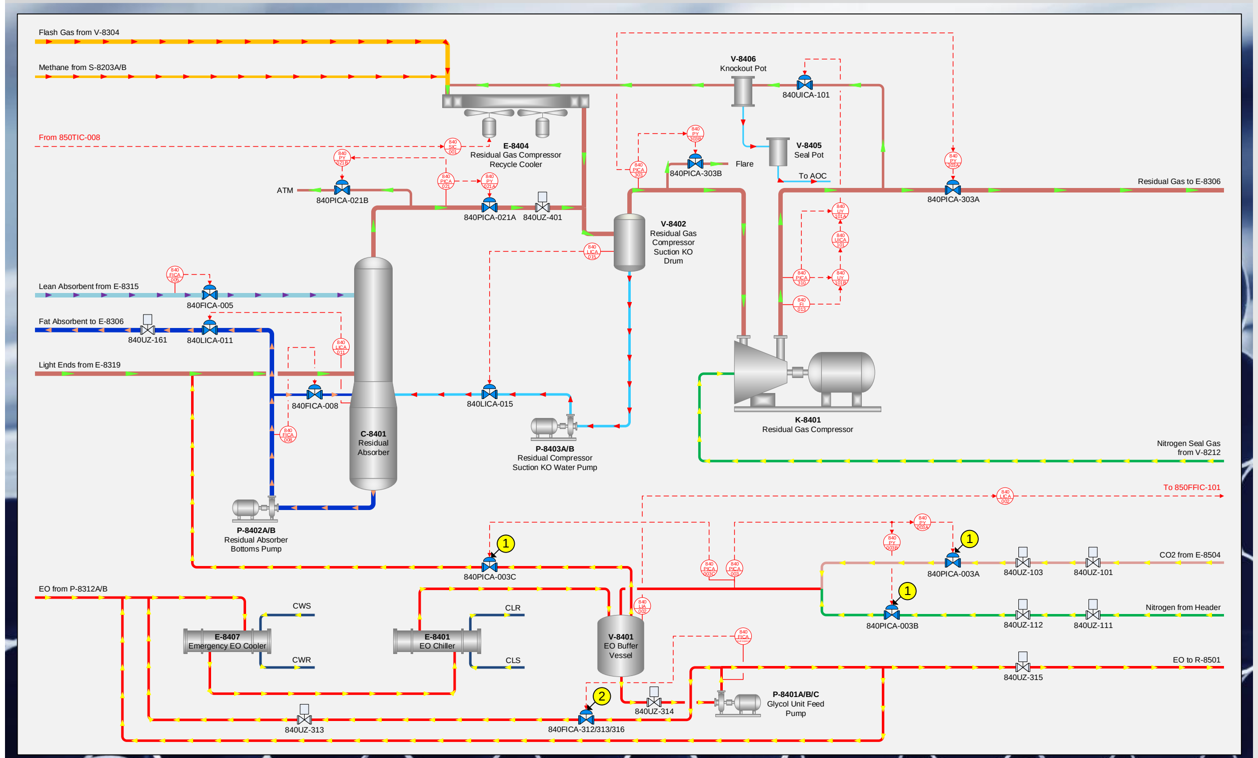
Instrument Signal

Software Link

Connection to Process

Overview:

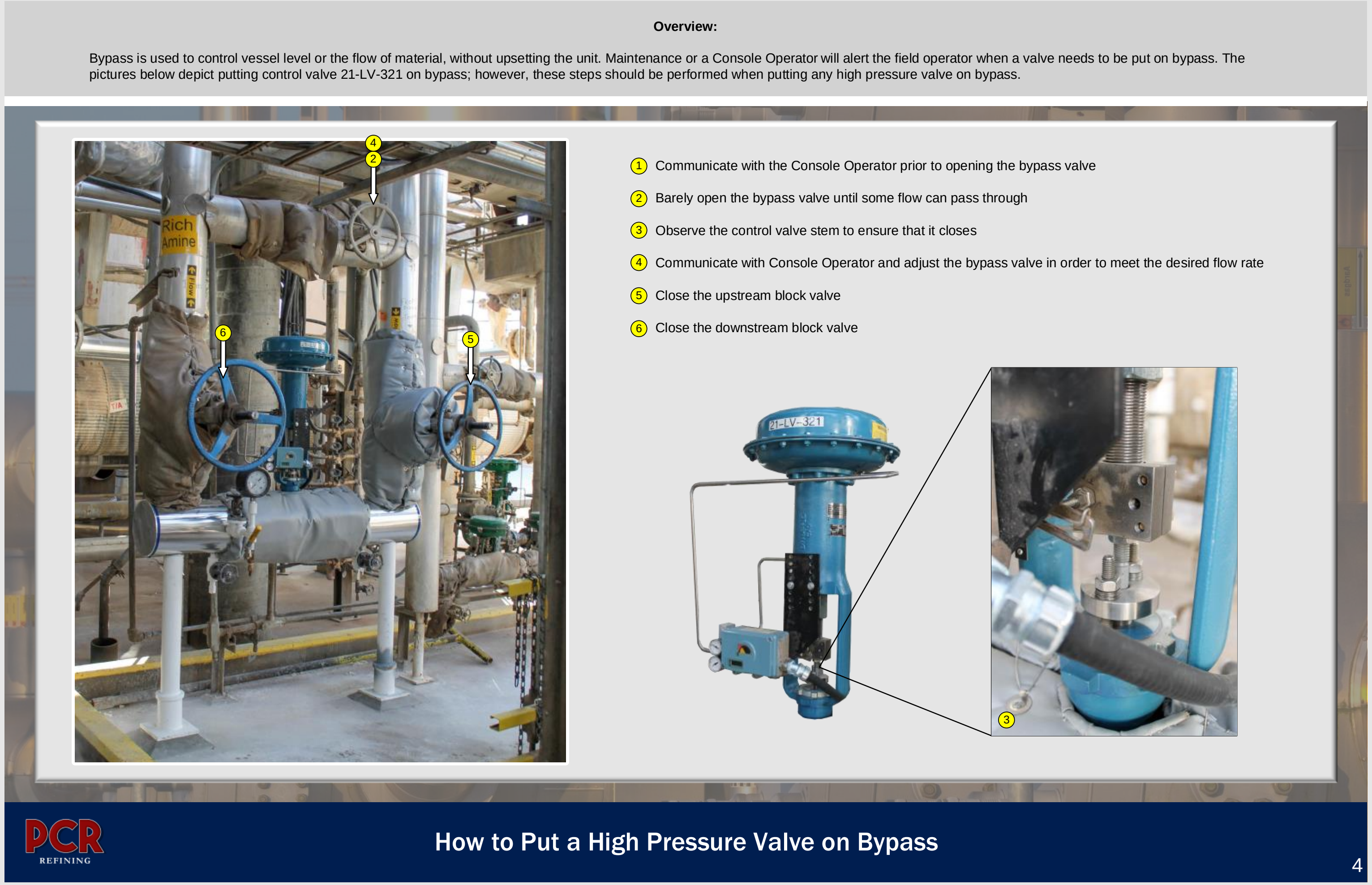
The instruments in the Light End Removal System control the following: pressure and level in the EO Buffer Vessel, minimum flow rate through the Glycol Unit Feed Pumps, feed flow rate to the Residual Absorber, pressure and level in the Residual Absorber, pressure and level in the Residual Gas Compressor Suction KO Drum, discharge pressure from the Residual Gas Compressor, and temperature of flash gas.



PCR REFINING

Light End Removal System

3



Overview:

Bypass is used to control vessel level or the flow of material, without upsetting the unit. Maintenance or a Console Operator will alert the field operator when a valve needs to be put on bypass. The pictures below depict putting control valve 21-LV-321 on bypass; however, these steps should be performed when putting any high pressure valve on bypass.

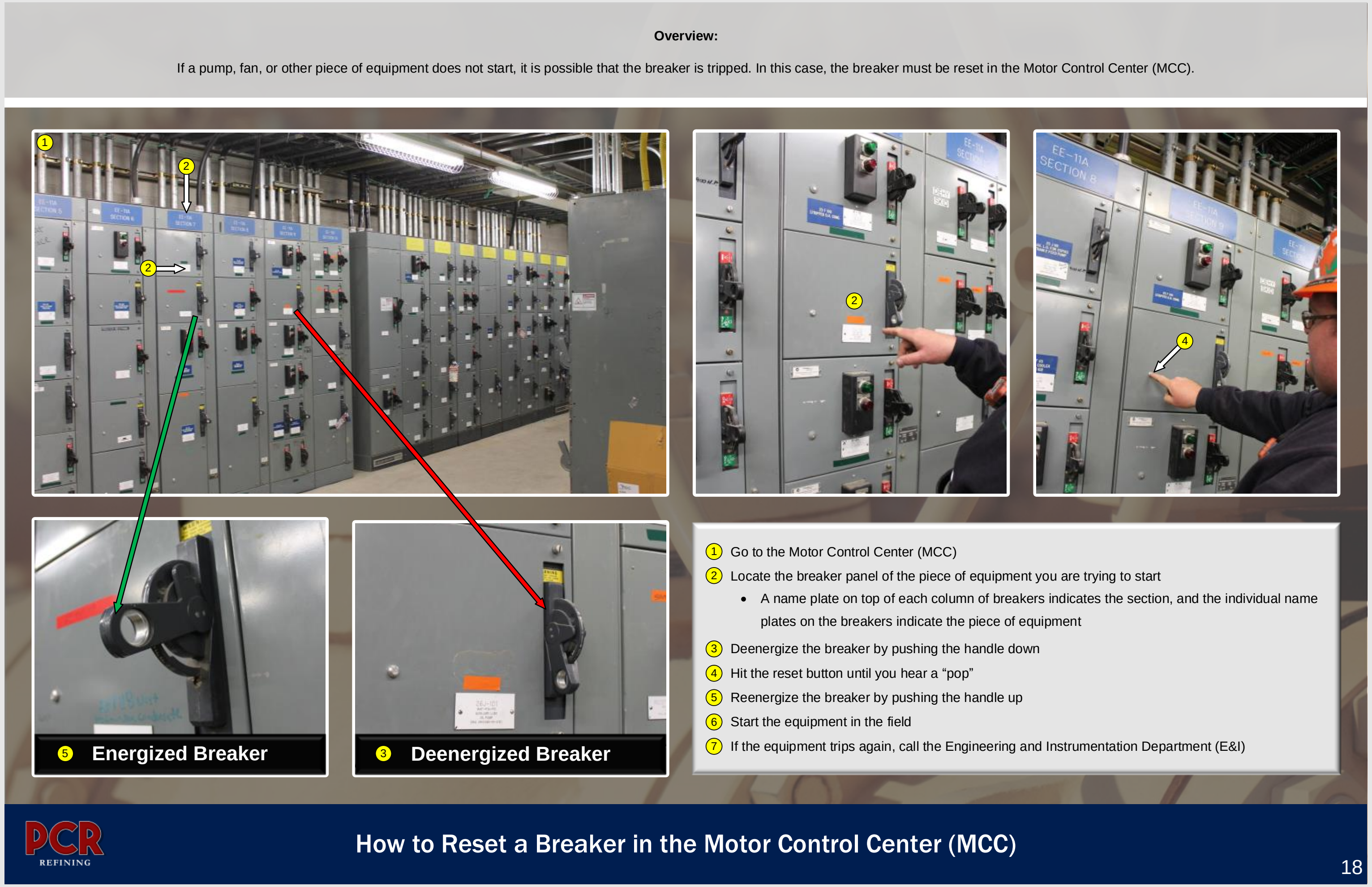
1. Communicate with the Console Operator prior to opening the bypass valve
2. Barely open the bypass valve until some flow can pass through
3. Observe the control valve stem to ensure that it closes
4. Communicate with Console Operator and adjust the bypass valve in order to meet the desired flow rate
5. Close the upstream block valve
6. Close the downstream block valve

How to Put a High Pressure Valve on Bypass

4

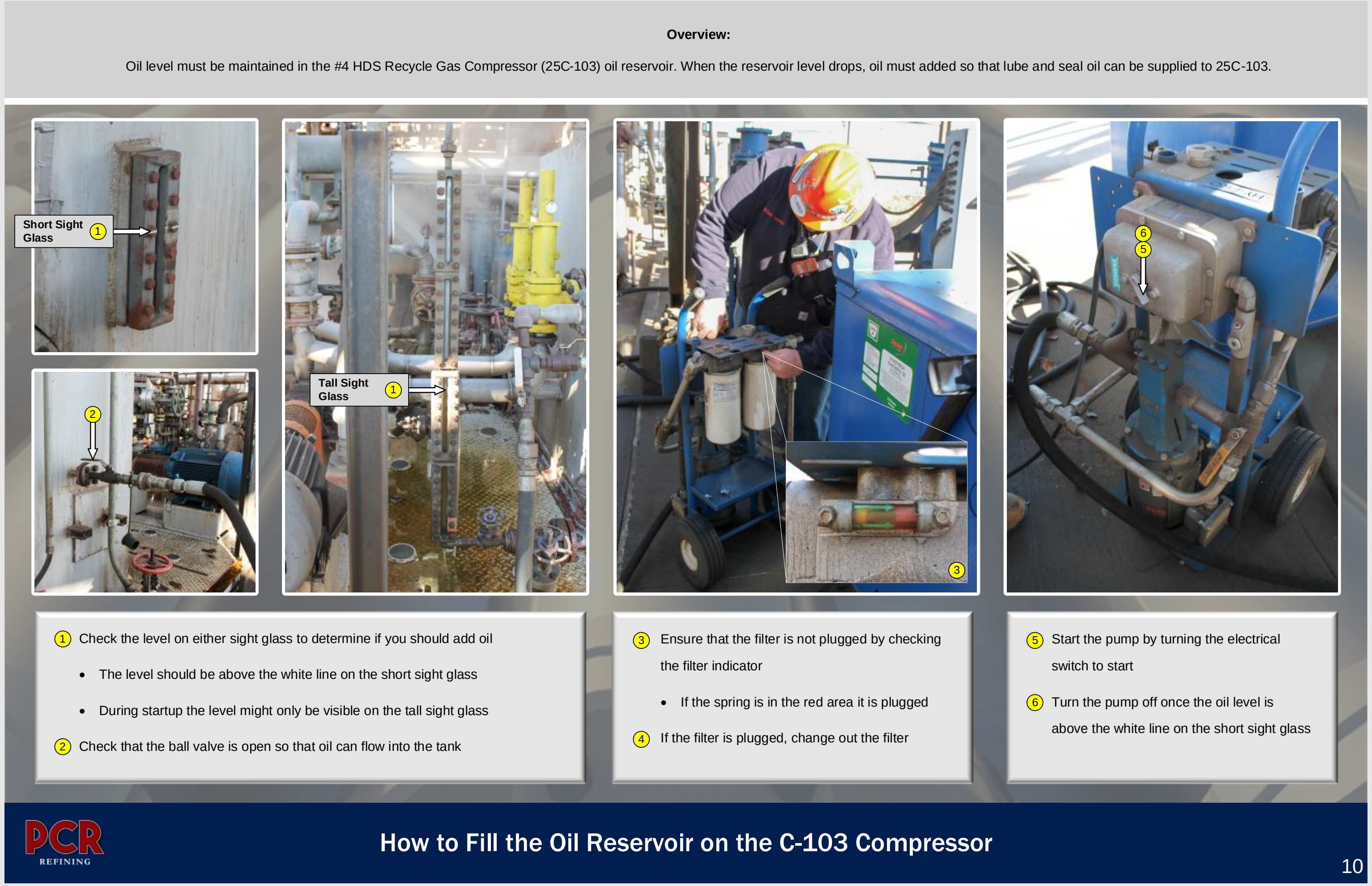
Duties

- Job aid on how to perform specific tasks
- Materials needed to perform the task
- Step-by-step instructions
- Pictures to guide the operator



Duties

- Job aid on how to perform specific tasks
- Materials needed to perform the task
- Step-by-step instructions
- Pictures to guide the operator



Duties

- Job aid on how to perform specific tasks
- Materials needed to perform the task
- Step-by-step instructions
- Pictures to guide the operator

Overview:

A Distributed Control System (DCS) is a complex monitoring and operating system used for most process units. Board Operators use the DCS to remotely start up, monitor, operate, troubleshoot, and shut down a process unit or systems. Board Operators interact with a process unit using DCS Workstations, typically located in a centralized control room. Behind the scenes, complex software connects field-located process monitoring devices and controllers through a central computer to the workstation monitors. The graphics on the workstation monitors display the process in real time and allow the Operator to directly interact with the unit.

Main DCS Components

DCS contain hardware and software. Main parts of the DCS are:

1. DCS Workstations

The Board Operator interfaces with the process through the **DCS Workstation** (Human Machine Interface; HMI). The Workstation is equipped with six monitors, three computer towers, a keyboard, mouse, and printer. The Operator monitors and can adjust the process by accessing controller set points through the workstation.

2. Control Network

The **Control Network** contains the wiring that ensures communication between DCS system parts.

3. Field Control Station (FCS)

Field Control Stations are the “brain” of the DCS. They receive the **inputs**, automatically carry out calculations/algorithms, and generate **output** signals. Inputs and outputs are electric or pneumatic signals. Inputs are measured, calculated, or given by the Operator or the DCS. Outputs are generated by the control modules to adjust control elements.

4. Data Historian

The **Data Historian** is a server that stores process variables, set points, and output values that may be used for trends or compliance.

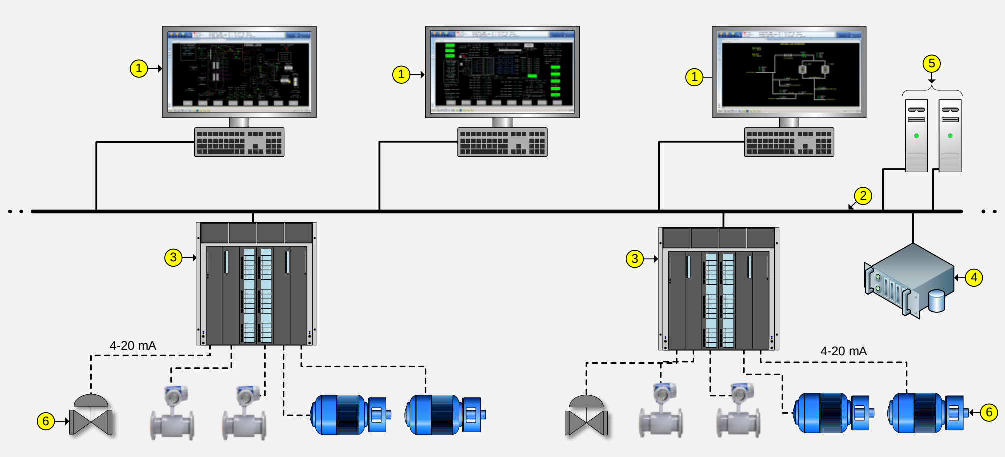
5. Additional Computers

Additional computers are often connected to the DCS for the purposes of advanced process control, alarm management, and other administrative system processes. The DCS is connected to the ethernet to provide information to users not directly involved with process operation, such as Management, Sales, and Accounting.

6. Field Devices

Field Devices consist of transmitters, control valves, switches, motors, and more. These components receive a 4-20 milliamp (mA) signal from the DCS, which represents 0-100% of the range of measurement or control.

Typical DCS Architecture



Workstation

A control room contains multiple workstations. Each station is associated with a part of the process and operated by an assigned Operator.

DCS Input Signals

Inputs for process control by the Field Control Stations are typically electrical or pneumatic signals. They can, for example, come from:

- Field sensors/transmitters measuring process variables
- Control valve positions
- Run status of pumps, compressors, etc.
- Operator-given values (e.g., set points)
- Programmed Values (PLCs)

DCS Output Signals

Outputs from the Field Control Stations are typically electrical or pneumatic signals. They can, for example, come from:

- Set points
- Start/Stop signals
- Valve positions
- Alarms
- Automated shutdowns and interlocks

PCR REFINING

DCS Overview – Main Components and Architecture

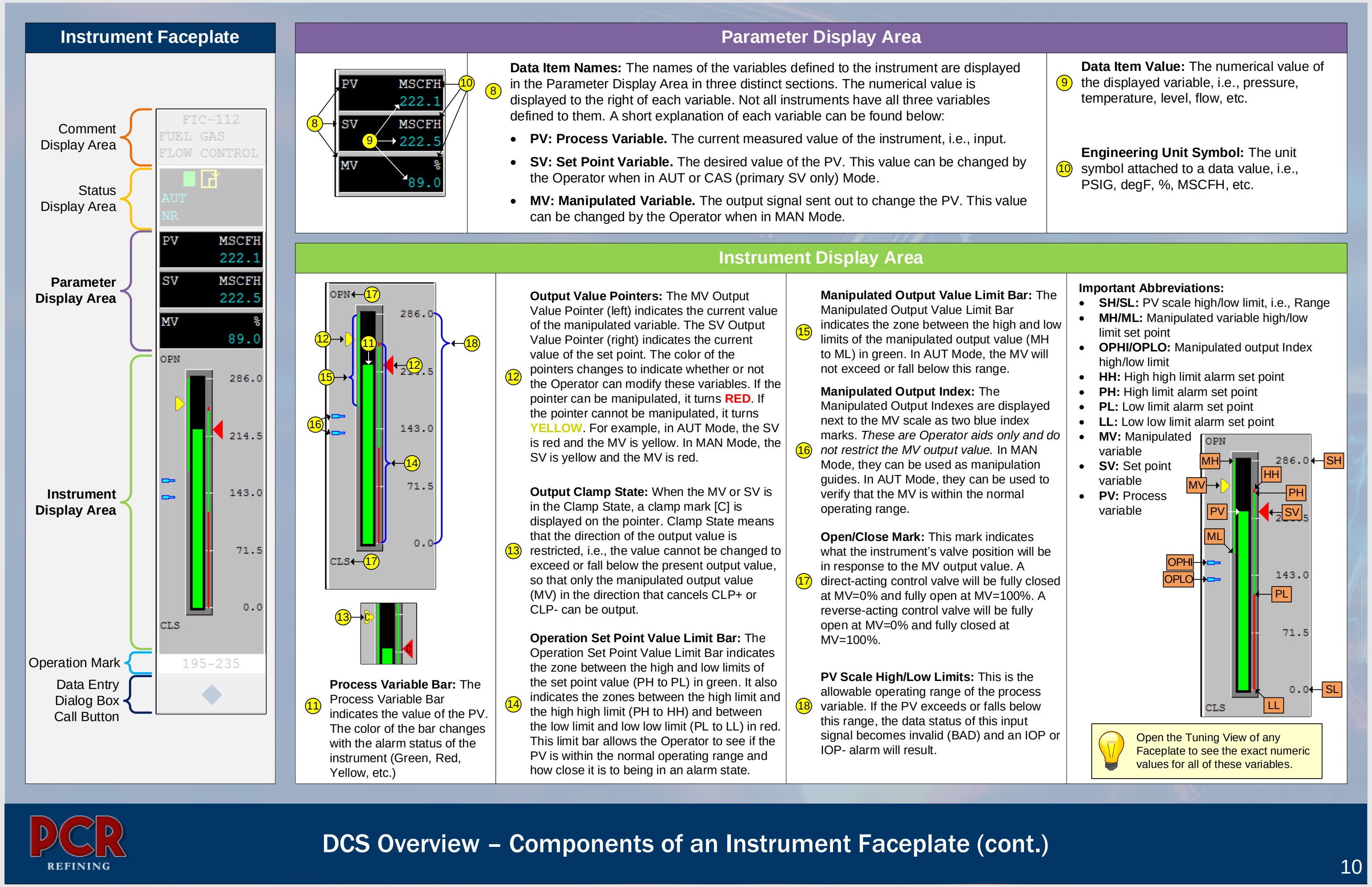
2

Board Operator

- For console/board operator
- DCS Navigation
- Control Objectives
- Trends
- Alarms
- Controller Modes

Board Operator

- For console/board operator
- DCS Navigation
- Control Objectives
- Trends
- Alarms
- Controller Modes



Instrument Faceplate

Comment Display Area — FIC-112 FUEL GAS FLOW CONTROL
Status Display Area — AUT NR
Parameter Display Area — PV MSCFH 222.1; SV MSCFH 222.5; MV % 89.0
Instrument Display Area — OPN 286.0 214.5 143.0 71.5 0.0 CLS
Operation Mark — 195-235
Data Entry Dialog Box Call Button

Parameter Display Area

(8) **Data Item Names:** The names of the variables defined to the instrument are displayed in the Parameter Display Area in three distinct sections. The numerical value is displayed to the right of each variable. Not all instruments have all three variables defined to them. A short explanation of each variable can be found below:

- **PV: Process Variable.** The current measured value of the instrument, i.e., input.
- **SV: Set Point Variable.** The desired value of the PV. This value can be changed by the Operator when in AUT or CAS (primary SV only) Mode.
- **MV: Manipulated Variable.** The output signal sent out to change the PV. This value can be changed by the Operator when in MAN Mode.

(9) **Data Item Value:** The numerical value of the displayed variable, i.e., pressure, temperature, level, flow, etc.

(10) **Engineering Unit Symbol:** The unit symbol attached to a data value, i.e., PSIG, degF, %, MSCFH, etc.

Instrument Display Area

(11) **Process Variable Bar:** The Process Variable Bar indicates the value of the PV. The color of the bar changes with the alarm status of the instrument (Green, Red, Yellow, etc.)

(12) **Output Value Pointers:** The MV Output Value Pointer (left) indicates the current value of the manipulated variable. The SV Output Value Pointer (right) indicates the current value of the set point. The color of the pointers changes to indicate whether or not the Operator can modify these variables. If the pointer can be manipulated, it turns RED. If the pointer cannot be manipulated, it turns YELLOW. For example, in AUT Mode, the SV is red and the MV is yellow. In MAN Mode, the SV is yellow and the MV is red.

(13) **Output Clamp State:** When the MV or SV is in the Clamp State, a clamp mark [C] is displayed on the pointer. Clamp State means that the direction of the output value is restricted, i.e., the value cannot be changed to exceed or fall below the present output value, so that only the manipulated output value (MV) in the direction that cancels CLP+ or CLP- can be output.

(14) **Operation Set Point Value Limit Bar:** The Operation Set Point Value Limit Bar indicates the zone between the high and low limits of the set point value (PH to PL) in green. It also indicates the zones between the high limit and the high high limit (PH to HH) and between the low limit and low low limit (PL to LL) in red. This limit bar allows the Operator to see if the PV is within the normal operating range and how close it is to being in an alarm state.

(15) **Manipulated Output Value Limit Bar:** The Manipulated Output Value Limit Bar indicates the zone between the high and low limits of the manipulated output value (MH to ML) in green. In AUT Mode, the MV will not exceed or fall below this range.

(16) **Manipulated Output Index:** The Manipulated Output Indexes are displayed next to the MV scale as two blue index marks. *These are Operator aids only and do not restrict the MV output value.* In MAN Mode, they can be used as manipulation guides. In AUT Mode, they can be used to verify that the MV is within the normal operating range.

(17) **Open/Close Mark:** This mark indicates what the instrument's valve position will be in response to the MV output value. A direct-acting control valve will be fully closed at MV=0% and fully open at MV=100%. A reverse-acting control valve will be fully open at MV=0% and fully closed at MV=100%.

(18) **PV Scale High/Low Limits:** This is the allowable operating range of the process variable. If the PV exceeds or falls below this range, the data status of this input signal becomes invalid (BAD) and an IOP or IOP- alarm will result.

Important Abbreviations:

- **SH/SL:** PV scale high/low limit, i.e., Range
- **MH/ML:** Manipulated variable high/low limit set point
- **OPHI/OPLO:** Manipulated output Index high/low limit
- **HH:** High high limit alarm set point
- **PH:** High limit alarm set point
- **PL:** Low limit alarm set point
- **LL:** Low low limit alarm set point
- **MV:** Manipulated variable
- **SV:** Set point variable
- **PV:** Process variable

Open the Tuning View of any Faceplate to see the exact numeric values for all of these variables.

PCR REFINING

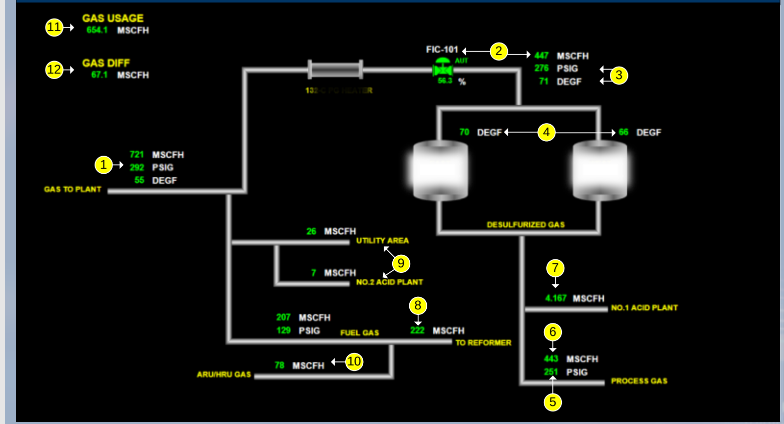
DCS Overview – Components of an Instrument Faceplate (cont.)

10

Board Operator

- For console/board operator
- DCS Navigation
- Control Objectives
- Trends
- Alarms
- Controller Modes

DCS View – Natural Gas Graphic GR0101



Natural gas is feed for the Primary Reformer and is used as fuel gas for the plant. Natural gas mainly contains methane, which reacts with steam in the Primary Reformer to form process gas. **Access this screen using function key #17 on the Operator Keyboard.**

Control Objectives

	Objective	Why it is Important
1	To maintain continuous natural gas supply for the plant	Natural gas is supplied from the pipeline. The Operator is responsible for monitoring and maintaining flow rates and pressure to the users in the plant.
2	To reduce sulfur in reformer feed gas	Sulfur must be removed from Reformer feed gas to prevent catalyst damage. Maintaining conditions in the Desulfurizers is essential for sufficient sulfur removal.

Control Table

	Controller/ Indicator	Process Variable	Final Control Element/ Fail Position	Purpose
1		Natural Gas Supply Flow, Pressure, Temperature	NA	Use to identify if supply problems exist
2		Gas Flow Rate to Desulfurizers	FV-101A FC	Maintain natural gas flow rate by adjusting control valve (faceplate on view CG0101/0110)
3		Gas Pressure/ Temperature to Desulfurizers	NA	Monitor to ensure temperature and pressure for proper operation of Desulfurizer
4		Temperature in 102-D/103-D	NA	Monitor bed temperature to evaluate sufficient desulfurization
5		Gas Pressure to Preheat Coil	NA	Monitor to ensure feed gas flow to reforming section
6		Gas Flow to Preheat Coil	NA	Monitor to ensure feed gas flow to reforming section
7		Desulfurized Gas Flow to No.1 Acid Plant	NA	Monitor to ensure sufficient supply (FI-809A faceplate on view CG0110/ 112)
8		Fuel Gas Flow to Primary Reformer	NA	Monitor to ensure sufficient fuel gas supply for Reformer and if in use to Startup Heaters
9		Fuel Gas Flow to Utilities/No.2 Acid Plant	NA	Monitor to ensure sufficient supply
10		Fuel Gas Flow to ARU/HRU	NA	Monitor to ensure sufficient supply
11		Total Gas Usage for Reformer (Fuel and Process)	NA	Calculated sum process and fuel gas; Use to determine of discrepancies in measurements are present
12		Difference in Gas Use	NA	Calculated difference between gas usage #11 and #1; use to evaluate gas to utilities, #1 and #2 acid plant

PCR REFINING

Control the Process through DCS – Natural Gas Supply

21