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REFINING INDUSTRY

Industry Release R-104-00

Residuum / Gas Oil Hydrotreating

Residual Hydrotreating

Introduction

Residual and gas oil (VR/AR/VGO/AGO) hydrotreating processes are applied by refiners to produce low sulfur fuel oils, and to prepare feeds for VR or GO FCCs, RFCCs, visbreakers, and delayed cokers. Hydrotreaters upgrade residual oils by removing impurities and sometimes unintentionally produce lighter product oils through cracking of heavy molecules in the feed. They have also performed very well in removing nitrogen, carbon residue, nickel, and vanadium from the oil, and cracking heavy VR molecules into VGO, distillates, and naphtha products. The amount of impurities removed depends on the feed and on the product specifications desired by the refiner. Commercially demonstrated capabilities include sulfur removal percentages over 95%, metal removal over 98%, nitrogen removal over 70% and cracking of vacuum residue as high as 60% liquid volume commercially demonstrated. These types of units typically operate at more severe conditions (higher pressure and temperatures) than a typical middle distillate hydrotreater. The conditions a hydrotreater operates are a function of feedstock. Table 104.1 (below) shows typical operating ranges for the different types of Hydrotreaters.

Table 104.1
Typical Hydrotreating Operating Conditions

Process	Temp. °F (°C)	Pressure psig (barg)
Distillate Hydrotreating	500-750 (260-400)	200-800 (14-56)
Gas Oil Hydrotreating	650-800 (345-425)	1000-2500 (70-175)
Residuum Hydrotreating	650-800 (345-425)	2000-3000 (140-210)

Process Chemistry

Chemical reactions in a hydrotreater reactor take place in the liquid phase. The residual feed is saturated with hydrogen gas, which makes the molecules absorb on the catalyst surface where the reaction takes place. This exothermic reaction allows the breakdown of molecules in the feed that contains sulfur, nitrogen, and heavy metals (Vanadium and Nickel). Some examples of these molecules are shown in Figure 104.1 (page 2).

Desulfurization is the most common of hydrotreating reactions. Hydrocarbon molecules containing sulfur comes in a multitude of forms, and varies in levels of difficulty when attempting to separate sulfur from the base molecule. Dibenzothiophene molecules are very difficult to separate due to the ring structure, attached on both sides. Figure 104.2 (page 2) is a graphic representation of the reaction that occurs in the hydrotreating process to desulfurize the dibenzothiophene molecule . This reaction produces the by-product of hydrogen sulfide, which must be removed in a downstream separation process to complete the reaction.

Denitrification begins with the aromatic ring being saturated to naphthlene. The saturation step puts the molecule in equilibrium and sets the rate at which the reaction occurs. Hydrocarbon molecules containing nitrogen are classified into two main categories; basic nitrogen (typically a six-member ring) and neutral nitrogen (typically a five-member ring). Since nitrogen compounds are much more complex than sulfur compounds, denitrification is much more difficult than desulfurization. Figure 104.3 (page 2) is a graphic representation of the reaction that occurs in the hydrotreating process to remove nitrogen from a quinoline molecule. This reaction produces the by-product of ammonia, which must be removed in a downstream separation process to complete the reaction.

Demetallization as the name infers, is the removal of metals which include nickel and vanadium. If these metals are not removed, they can be poisonous to downstream catalytic units and pose environmental problems. Vanadium is much easier to remove compared to nickel, however, both require a porous catalyst to allow passage of the large molecules that contain the metals. In the past, a refiner would operate a hydrotreater until the catalyst had used up it's capacity to absorb heavy metals. The modern hydrotreater has special catalyst or swing reactors to process crudes with high metal content, producing longer unit run-times since the reactors can be switched.

Figure 104.1
Typical Petroleum Molecules with Sulfur, Nitrogen, and Vanadium

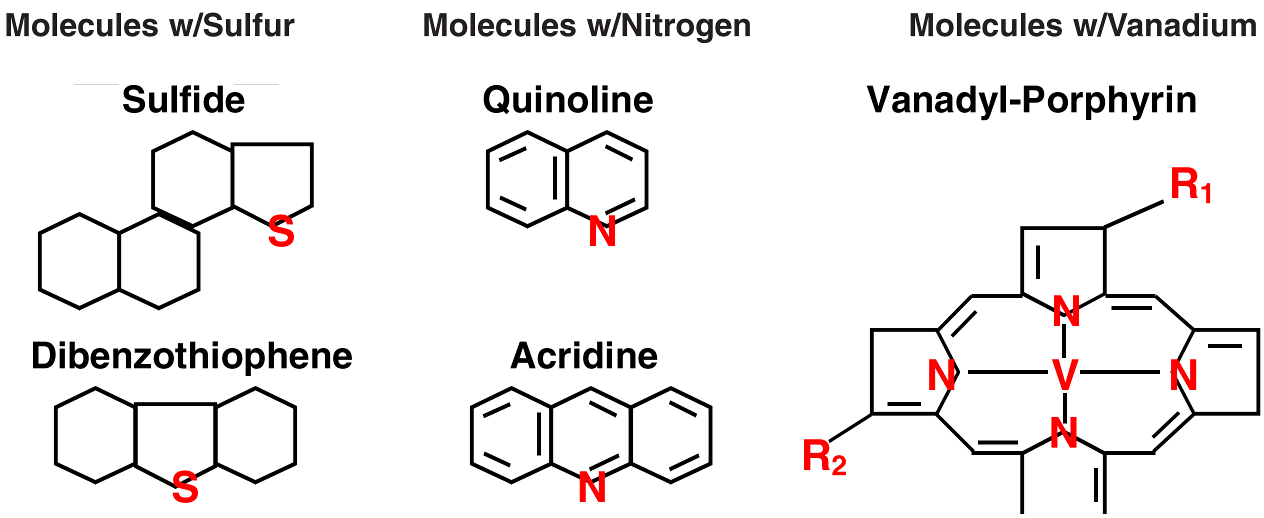


Figure 104.2
Desulfurization of Dibenzothiophene

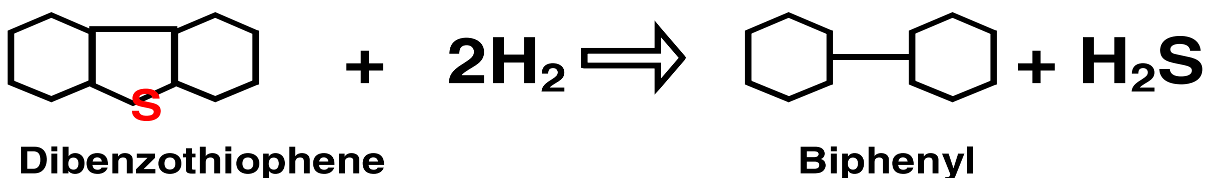
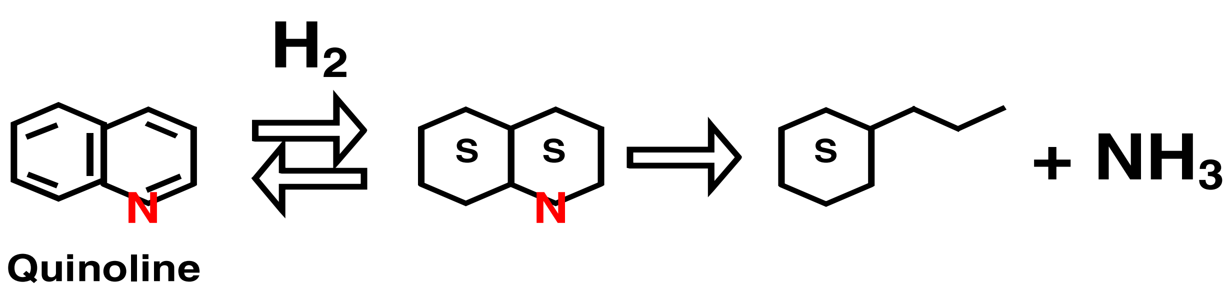


Figure 104.3
Denitrification of Quinoline



Process Description

A typical residual or gas oil hydrotreater is illustrated in Figure 104.4 on page 8. This schematic should be referenced in conjunction with the following process descriptions.

Feed Charging & Preheating

The process begins with the feed being preheated in the Bottoms/Feed Exchanger. The feed then enters a Feed Surge Drum and is then routed into the Charge Pumps. The Charge Pumps pressurize the feed based on the reaction pressure. The feed is then combined with makeup hydrogen and recycle-hydrogen gas, which has been exchanged with the Hot Separator Overhead Exchanger. The mixture of hot recycles hydrogen and feed is exchanged with reactor effluent for preheating purposes. The Charge Heater completes the final heating to reaction temperature before the process enters the single or combination reactors.

Catalytic Reaction

If heavy concentrations of metals exist in the feed then a guard reactor will proceed the main reactor. Swing reactors, or online catalyst removal systems, are used in some instances to reduce unit downtime due to catalyst changeout. Quench gas is introduced in the main reactor prior to feed entry into each bed to prevent reactor overheating. Quench gas is supplied by the recycle compressor. Hydrotreating reactions occur on the catalyst removing impurities such as sulfur, nitrogen, vanadium, and nickel. The reactor effluent is cooled in the exchange with unit feed before entering the Hot-High-Pressure Separator.

High Pressure Separation

The Hot Separator cuts the heavy and light reaction products and recovers the hydrogen flashed off during the letdown from the reactor. The heavy product liquid is let-down in pressure and sent to the Fractionator, Stripper or a combination of both. The light product liquid is cooled and injected with wash water to absorb ammonia (NH_3) and hydrogen sulfide (H_2S). The mixture is further cooled before entering the Cold-High-Pressure Separator by the Recycle Gas Exchanger and fin fan (HHP Separator Cooler). The Cold Separator isolates the vapor, sour water, and light hydrocarbons. The light hydrocarbons are letdown to the fractionator, stripper or combination of both. The sour water is letdown to a sour water flash drum and proceeds to a recovery unit for removal of the H_2S and NH_3.

Recycle Gas Scrubbing

The hydrogen rich gas overhead is sent to a High-Pressure Efficiency Separator for any additional removal of light hydrocarbons. The light hydrocarbons are letdown from the efficiency separator to the Fractionator, Stripper or a combination of both. The overhead vapor proceeds to the High-Pressure Amine Contactor for final removal of H_2S through contact with a lean amine solution. Rich amine is letdown to the Rich Amine Surge Drum for processing in the Amine Recovery Unit (ARU). The ARU sends lean amine to the unit. The amine booster pumps increase the pressure before the process enters the High-Pressure Amine Contactor.

Makeup & Recycle Hydrogen Compression

The overhead vapor enters the Recycle Compressor Knockout Drum for removal of any remaining liquids from the gas stream before entering the compressor. A makeup compressor provides additional hydrogen to the recycle stream since some hydrogen is consumed during the reaction phase. The recycle compressor is typically a single or double-stage centrifugal type, and the Makeup Hydrogen Compressor is a two-stage reciprocating type. The makeup compressor receives hydrogen from a hydrogen plant.

Fractionation, Stripping, or Combination of Both

Refinery operating schemes and product slates will dictate the configuration downstream of the high-pressure separation. In our example, the light products from the separators enter a stripping column for removal of remaining H_2S, and separation of light and heavy products. The light products leave in the overhead line and are cooled in an overhead fin fan (Stripper Overhead Cooler) before entering the Stripper Reflux Drum. Product pumps draw wild naphtha from the Reflux Drum for additional processing in other units (CCR, FCC, etc.), or for sale to petrochemical plants. Some naphtha is returned at a controlled rate to the Stripping Column as reflux. Sour water is letdown from the Reflux Drum and sent to the SWS unit. The overhead gas from the reflux proceeds to a Low-Pressure Sour Gas Coalescer for removal of any remaining water vapor before it enters the Low-Pressure Amine Contactor. Lean amine is contacted with the sour gas to remove any remaining H_2S. The overhead gas is used as refinery fuel gas or sold on the product slate. The rich amine is collected from the bottom of the contactor in a Rich Amine Surge Drum before being sent to the ARU. The heavy hydrocarbons fall to the bottom of the Stripping Column where medium pressure steam is introduced to flash off any additional light hydrocarbons. Pumps draw off the bottoms of the Stripping Column for exchange with feed entering the unit, and for production of low-pressure steam in the Bottoms Steam Generator. The bottoms are cooled in a series of fin fans (Product Coolers) before being sent to either product storage, fuel oil blending, gas oil blending or cat cracking.

Metallurgy

Main Process Stream

The majority of the valving required will be carbon steel construction. If H_2S is present in the product stream, NACE approved trim materials and stressed relieved bodies should be specified as a minimum. The main process will experience high temperatures with H_2S and large amounts of hydrogen. In these cases, hydrogen embrittlement and temper embrittlement are a concern, but 2 ¼% Cr - 1% Mo (chrome-moly) steel can be specified for temperatures not exceeding 500° F. Stainless steel, such as 347 SS or 321 SS, should be specified for higher temperature applications.

Sour Water/Amine

The high-pressure sour water will contain H_2S and NH_3. Trim materials constructed of Inconel and duplex alloys have performed exceptionally well in these applications. Amine service can be handled with 316 SS, Stellite, or 316 SS hardfaced trim materials. High-pressure amine letdown service should be serviced with the same materials as the high-pressure sour water.

General Control Valve Requirements

Table 104.2 lists all of the equipment tag numbers referenced in Figure 104.4. Each tag number has an associated service description along with some basic product line information. The specific size and pressure rating requirements will be dependent upon the capacity, feedstock, and licensor. Body material and equipment model recommendations are listed, however, sizing of each application should be performed to verify details of valve and instrument specifications.

Feed Charging & Preheating

Applications in the early stages of the process will require high-pressure body designs, therefore 900-2500# body ratings are typically used depending on the type of feedstock (See Table 104.1). The High-Pressure Charge Pumps will require recirculation protection. Multi-step valves should be specified for these applications with the number of stages dependent upon specific pressure drop conditions. If feedstock temperatures are over 450° F, then metal-to-metal unbalanced designs should be used. Teflon-based seals should be avoided under these conditions. Feedstocks are usually dirty and have entrained particulates; therefore cage guided and drilled hole multi-step valves should be avoided at all costs.

The recycle hydrogen injection valves located before the Feed/Effluent Exchangers will control recycle hydrogen that has been preheated by the Recycle Gas Exchanger. Temperatures will fluctuate from 450-600° F depending on the feedstock. These valves should be specified with double packing designs. If extension bonnets are specified, then Teflon packing can be applied (as opposed to applying double Grafoil packing).

The main feed flow control valves may require bi-directional shutoff if automated isolation valves are not included on the pump discharge lines. Shutoff in the reverse direction prevents backflow from the reactor and possible damage to the Charge Pumps. The temperature trim valves used for bypassing the process around the Feed/Effluent Exchangers requires high capacity designs. Typically, swing thru butterfly valves are specified for this application based on capacity and economic reasons. All valve designs should be specified to the latest revision of NACE for wetted parts.

Pilot and fuel gas lines to the heater may require double block and bleed valve arrangement for safety purposes. These valves should be specified for tight shutoff (ANSI Class VI).

Reactor

The most popular reactor designs are fixed bed trickle configurations. Control valves for each quench gas line can be specified as an unbalanced design. If sizes exceed 1 ½", the balanced designs should be investigated to minimize actuator requirements. In some applications, swing reactors are used for high metal content feeds. Additional valving (not shown in the schematic) is required for switching of the reactors. Three-way or swing thru butterfly valves have been applied for these types of configurations.

High Pressure Separation

The high-pressure separation section generally includes a hot and cold separator. In some configurations, a Low-Pressure Separator receives the letdown from the hot and cold separator before entering stripping or fractionation. The level letdown valves on the separators witness high pressure drops, and are the most critical valves within this section. In the hot separator case the fluid temperatures are much higher and will require an alloy body design depending on temperature. Multi-step valves should be utilized in these applications (Hot Separator, Cold Separator, & Sour Water Letdowns). The number of stages will depend on the pressure drop conditions. Typically, redundant control valves are utilized for these applications, but in cases where single control valves with manual bypasses are used, the recommendation is to use a manual bypass construction the same as the control valve. Cage-guided designs are not recommended in this section of the unit due to coke formation and catalyst fine carry over from the reactor. The Cold Separator is designed to allow all overhead gas to flow through a high-pressure scrubbing section before entering the Recycle Compressor. Redundant reactor/separator depressurizing valves are located in this line for depressurizing the unit in emergency cases or during shutdowns of the unit. These valves will see high-pressure drops and associated noise and vibration, but only for short periods of time. A standard valve is recommend except where noise is a concern. A multi-step low noise valve should be applied under those conditions. These valves are typically specified with a fire safe requirement for the actuation and instrumentation. A backup nitrogen bottle should be supplied in the event of air loss in the plant to ensure fail safe function.

Recycle Gas Scrubbing

The hydrogen rich gas overhead from the Cold Separator is sent to a high-pressure scrubbing section before entering the Recycle Compressor. The level letdown and amine booster pump recirculation valves should be specified as multi-step designs. The number of stages will depend on the pressure drops. The manual bypass valves around the level control valves should be of the same construction as the control valves. Since amine, NH_3, and H_2S are present in the gas and liquid streams, it is recommended that Inconels, Stellites, Duplex alloys, or combination of these materials be used for valve trim construction for corrosion resistance.

Makeup & Recycle Hydrogen Compression

The Makeup and Recycle Hydrogen Compressors will require recycle protection valves in the event of surge or over pressure conditions. These valves should be designed to open within 1-2 seconds to avoid damage to the compressors. A single stage low-noise trim will usually provide sufficient acoustic operation, but pressure drop conditions may dictate the use of two stages. Liquid let-downs on the Knockout Drums may require multi-step valves depending on the pressure drop conditions.

Fractionation, Stripping, or Combination of Both

This section is a low-pressure section, where the majority of valve applications can be handled by more economical rotary constructions. The sour water and boiler feedwater applications are the exceptions and will require top-guided unbalanced globe type constructions.

General Relief Valve Requirements

Overpressure protection devices will vary in pressure rating depending on their location in the unit. All safety relief valves (SRVs) in the reactor, separator and compressor sections will require 900-2500# body ratings depending on the feedstock. The low-pressure fractionation or stripping section will require 300# designs. Modulating pilots can be used in the separator and compressor sections to reduce the amount of blowdown of hydrogen and recycle gas to the flare header. The low temperatures will allow for soft seat construction in the main base and pilot seating areas. All conventional valves should be fitted with a bellows due to the variable backpressure in the low-pressure header. The modulating pilot valves used in the high-pressure section will be relieving to a high-pressure flare header and may require higher-pressure outlet connections. All pressure relief devices should be designed to meet ASME Section VIII code requirements. Depending on unit capacities, the Fractionator or Stripper may have multiple relieving requirements, including an external fire sizing case. The majority of safety relief valve applications will require carbon steel bodies, but may also include applications for chrome-moly (C5) or alloy (321/347 SST) construction depending on pressures and temperatures of the process fluid. Safety relief valve wetted parts should be designed for the latest revision of NACE and Higher temperature applications may also require the use of Inconel or 347 SS trim materials. All of the possible safety relief valve requirements may not have been identified in the example presented within our schematic. These other valves will also vary based on the configuration and operation of the specific hydrotreating unit.

General Instrumentation & Regulator Requirements

Level Instruments

All level sensing transmitters have been identified as displacement types in Table 104.2. D/P transmitters have been successfully applied, but displacement types are definitely recommended on interface applications. Chamber ratings and materials will vary from high to low pressure depending on location of the equipment. Inconel displacers are recommended for high temperature, dirty, and sour fluid applications. Measurement lengths will vary and depend on vessel sizes and fluid residence times.

Electro-Pneumatic Postioners

Standard electro-pneumatic positioners are recommend for the majority of valve applications. Smart positioners are recommended on quench gas applications due to the criticality and preciseness required. Electronic characterization will enable the system to more accurately control setpoint and provide exceptional repeatability.

Regulators

Self-contained regulators with soft seats are recommend for pilot gas control. Although not shown in Figure 104.4, the Recycle and Makeup Compressors will require regulation of lube oil. Compressor size and design will dictate self contained or externally connected regulator devices.

Conclusion

We have attempted to explain the hydrotreating unit operation in as much detail as possible, but these units will vary in operation based on the particular process licensor and/or local refinery configuration. Equipment recommendations are made based on a typical hydrotreating unit, and should cover 95% of the applications with the equipment specified. Individual equipment should be sized and selected according to each type of hydrotreating unit and its particular configuration. This process document has identified the diversity in equipment selection for this type of process unit, and shows the importance of engineering evaluation in the selection of control valves, relief valves, regulators, and instrumentation.

Residual Hydrotreating

Table 104.2 - Equipment Recommendations

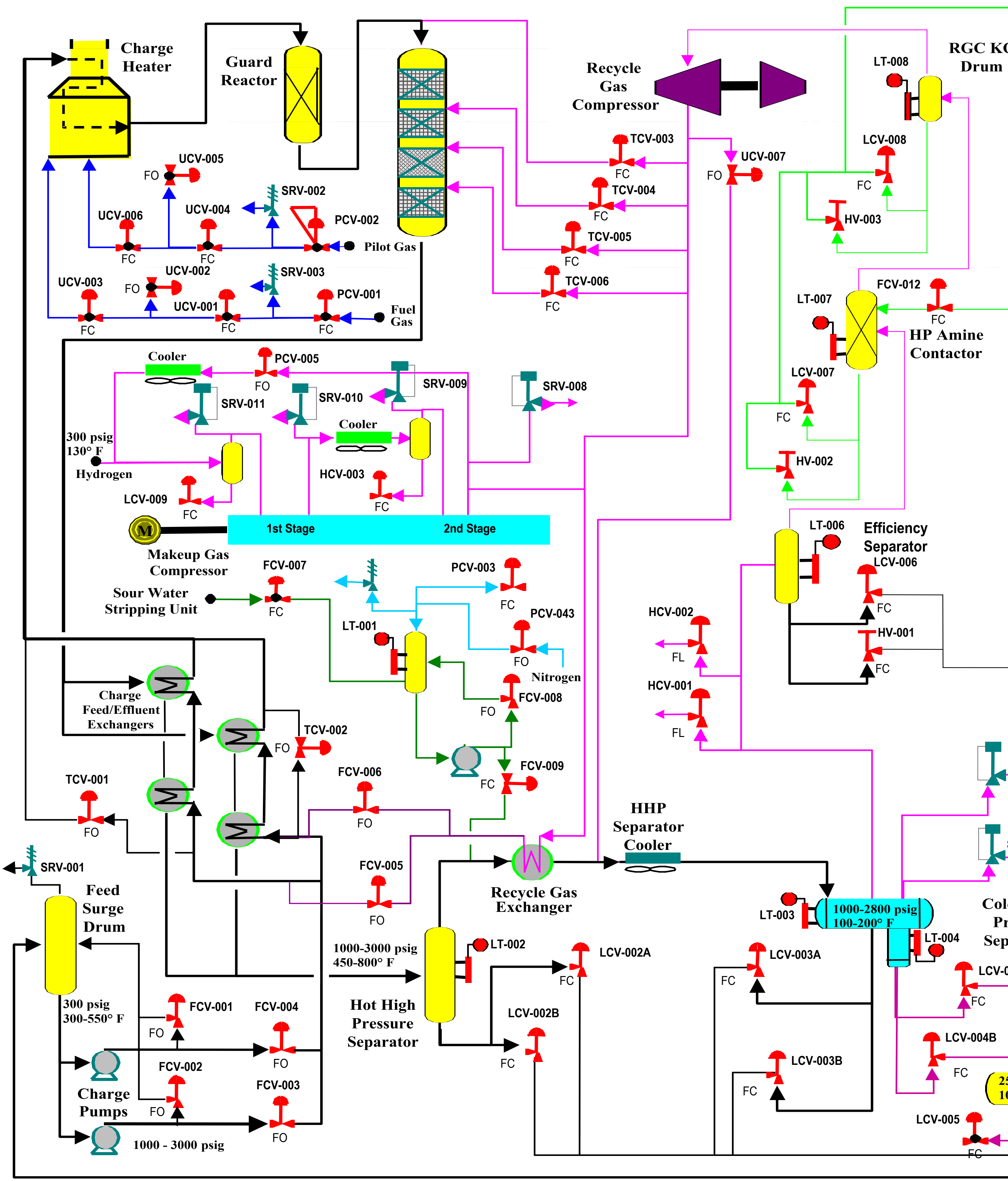
Tag Number	Service Description	Size Range	Rating Range	Body Material	ANSI Class Shutoff	Equipment Models	Brand
FCV-001	Charge Pump Recirc Pump A						Masoneilan
FCV-002	Charge Pump Recirc Pump B	2-8"		Carbon Steel	V	78200/18200	
FCV-003	Feed Heater Flow Control	4-12"				10000/21000	
FCV-004	Feed Heater Flow Control		900-2500#		II-V		
FCV-005	Hot Hydrogen Injection into Feed	3-8"		Stainless Steel		10000/41400	
FCV-006	Hot Hydrogen Injection into Feed						
FCV-007	SWS Water to Water Injection Drum	1-2"	300#		IV	35002	
FCV-008	Washwater Pump Recirc		1500-2500#			78200	
FCV-009	Washwater Injection	1-1.5"			V	21000	
FCV-010	Lean Amine Booster Pump Recirc	1-3"				78200/SE36	
FCV-011	Lean Amine Booster Pump Recirc		900-1500#				
FCV-012	Lean Amine to Recycle Gas Contactor	2-8"			II-IV	10000/21000	
FCV-013	Stripper Bottoms Stripping Steam	2-4"	600#			30000 (LO-DB)	
FCV-014	Stripper Reflux	1-3"				35002/30000	
FCV-015	Wild Naphtha to Feedstock/CCR		300#	Carbon Steel	IV	35002/21000	
FCV-016	VGO to Blending/Cat Cracker	4-8"				30000/35002	
FCV-017	Lean Amine to LP Contactor	2-6"				35002/30000	
HCV-001	Reactor Loop Depressurization	6-10"	900-2500#			41400/SE20-VLOG	
HCV-002	Reactor Loop Depressurization				V		
HCV-003	H_2 Makeup Compressor 1st Stage KO	1-1.5"	300#			21000	
HCV-004	LP Coalescer Sour Water Letdown				IV	35002/21000	
HV-001	LCV Bypass on HP Eff Separator	1-2"					
HV-002	LCV Bypass on HP Amine Contactor		900-1500#			78200	
HV-003	LCV Bypass on RGC Knockout Drum						
LCV-002A/B	Hot HP Separator Letdown	2x3-6x8"	900-2500#	SS/Cr Mo	V	77000/3351	
LCV-003A/B	Cold HP Separator Letdown	2-8"	900-1500#			78200	
LCV-004A/B	Sour Water Letdown	1-4"					
LCV-005	Sour Water to SWS Unit		300#		IV	35002	
LCV-006	HP Eff Separator Letdown	1-2"				78200	
LCV-007	HP Amine Contactor Letdown	2-8"					
LCV-008	RGC Knockout Drum Letdown		900-1500#	Carbon Steel	V	78200/SE36	
LCV-009	H_2 Makeup Compressor 2nd Stage KO	1-1.5"					
LCV-010	Reflux Drum Sour Water Ltdn					35002/21000	
LCV-012	Bottoms Stm Generator BFW	1-3"	300#		IV		
LCV-015	Rich Amine to ARU	6-12"				30000/35002	
LT-001	Washwater Surge Drum						
LT-002	Hot HP Separator		900-2500#	SS/Cr Mo			
LT-003	Cold HP Separator		900-1500#				
LT-004	Cold HP Separator Boot						
LT-005	Sour Water Flash Drum		300#				
LT-006	HP Efficiency Separator						
LT-007	HP Amine Contactor	14-32"	900-1500#		N/A	12000	
LT-008	RGC Knockout Drum						
LT-010	Reflux Drum Boot						
LT-011	Main Reflux Drum						
LT-012	Bottoms Stm Generator						
LT-013	LP Sour Gas Coalescer Boot			Carbon Steel			
LT-014	LP Amine Contactor		300#				
LT-015	Rich Amine Surge Drum						
PCV-001	Fuel Gas PRV	2-6"				35002/21000	
PCV-002	Pilot Gas PRV	1"			VI	17	
PCV-003	Vent To HP Flare Header	1-1.5"				35002/21000	
PCV-004	Nitrogen to Surge Drum				IV		
PCV-005	H_2 Makeup Comp 2nd Stage Recycle	1-2"	900-1500#		V	21000 (LO-DB)	
PCV-006	Bottoms Steam Generator Diff Press	3-8"				35002/30000	
PCV-007	Reflux Drum Overhead	2-6"			IV		
PCV-008	LP Amine Contactor Overhead	3-8"				30000/35002	
UCV-001	Fuel Gas Block						
UCV-002	Fuel Gas Block	2-4"	300#				
UCV-003	Fuel Gas Bleed				VI	35002	
UCV-004	Pilot Gas Block						
UCV-005	Pilot Gas Block	1-1.5"					
UCV-006	Pilot Gas Bleed						

Table 104.2 - (cont.)

Tag Number	Service Description	Size Range	Rating Range	Body Material	ANSI Class Shutoff	Equipment Models	Brand
UCV-007	Compressor Surge Control	2-6"	900-2500#		V	41400	Masoneilan
SRV-001	Feed Surge Drum	2x3-6x8"				1900	
SRV-002	Pilot Gas Line	0.75x1"	300x150#			19000	
SRV-003	Fuel Gas Line	1x1.5"					
SRV-004	Washwater Surge Drum	1x2"				1900	
SRV-005	Cold HP Separator	2x3-6x8"	900-1500x300#			3900 (MPV)	
SRV-006	Cold HP Separator						
SRV-007	Sour Water Flash Drum		300x150#			1900	
SRV-008	H_2 Makeup Comp 1st Stage KO				TSO		Consolidated
SRV-009	H_2 Makeup Comp 1st Stage Disch	1x2-3x4"	900-2500x300#	Carbon Steel		3900 (MPV)	
SRV-010	H_2 Makeup Comp 2nd Stage KO						
SRV-011	H_2 Makeup Comp 2nd Stage Disch						
SRV-012	Stripper	8x10"					
SRV-013	Steam Bottoms Generator						
SRV-014	LP Sour Gas Coalescer	2x3-4x6"	300x150#			1900	
SRV-015	LP Amine Contactor						
SRV-016	Rich Amine Surge Drum	8x10"					
TCV-001	Feed/Effluent Exchanger Bypass	4-12"		Stainless Steel	II	32000/10000/80000	
TCV-002	Feed/Effluent Exchanger Bypass						
TCV-003	Recycle Quench Gas Bed #1		900-2500#				
TCV-004	Recycle Quench Gas Bed #2	1-3"				21000/41400 w/SVI	
TCV-005	Recycle Quench Gas Bed #3						Masoneilan
TCV-006	Recycle Quench Gas Bed #4			Carbon Steel	IV		
TCV-007	MP Steam to Stripper Bottms	1.5-4"					
TCV-008	Bottoms Steam Generator Bypass	3-8"	300#			35002/30000	
TCV-009	Bottoms Steam Gen Temp Ctrl						

Industry Acronyms

AC Absorbent Chamber
AGO Atmospheric Gas Oil
AR Atmospheric Residue
ARU Amine Recovery Unit
ASO Acid Soluble Oils
ASTM American Society for Testing & Materials
B/D Barrels Per Day
B/SD Barrels Per Stream Day
BOC Black Oil Conversion
BPD Barrels Per Day
BPSD Barrels Per Stream Day
BTX Benzene, Toluene, Xylene
CCR Conradson Carbon Residue
CCR Continuous Catalyst Regeneration
CFD Cold Flash Drum
CGO Coker Gas Oil
CHPS Cold-High-Pressure Separator
CO Carbon Monoxide
CO2 Carbon Dioxide
COD Chemical Oxygen demand
COS Oxysulfide
CS Carbon Steel
CS Cold Separator
CT Clay Tower
CV Control Valve
CW Cooling Water
DAO Deasphalted Oil
DCC Deep Catalytic Cracking
DEA Diethanol Amine
DMB Dimethylbutane
DMO Demetallized Oil
EC Extraction Column
FC CV to Fail Closed on Air Failure
FC Flow Controller
FCC Fluid Catalytic Cracking Unit
FI Flow Indicator
FL Fall In Last Position
FO CV to Fail Open on Air Failure
FT Flow Transmitter
FCV Cv for Flow Control Loop
GO Gas Oil
H_2S Hydrogen Sulfide
H_2SO_4 Sulfuric Acid
HAGO Heavy Atmospheric Gas Oil
HC Hand Controlled
HCGO Heavy Coker Gas Oil
HCL Hydrogen Chloride
HCO Heavy Cycle Oil
HDM Hydrodemetallization
HDO Heavy Diesel Oil
HDS Hydrodesulfurization
HF Hydrofluoric Acid
HFD Hot Flash Drum
HHPS Hot-High-Pressure Separator
HS Hot Separator
HSFO Heavy Sulfur Fuel Oil
HSRN Heavy Straight Run Naphtha
HVGO Heavy Vacuum Gas Oil
LAB Linear Alkylbenzene
LC Level Controller
LCO Light Cycle Oil
LDO Light Diesel Oil
LGO Light Gas Oil
LI Level Indicator
LPG Liquid Petroleum Gas
LSFO Low Sulfur Fuel Oil
LSRN Light Straight Run Naphtha
LT Level Transmitter
LCV Cv for Level Control Loop
MCP Methylcyclopentane
MDEA Methyl Diethanol Amine
MEA Diethanol Amine
Mogas Motor Gasoline
MON Motor Octane Number
MP Methylpentane
MTBE Methyl tertiary butyl ether
NACE National Assoc. of Corrosion Engineers
NH_3 Ammonia
NPSH Net Positive Suction Head
PC Pressure Controller
PI Pressure Indicator
POSRV Pilot Operated Safety Relief Valve
PT Pressure Transmitter
PCV Cv for Pressure Control Loop
RC Raffinate Column
RCD Reduced Crude Desulfurization
RCR Ramsbottom Carbon Residue
RFCC Residual Fluid Catalytic Cracking
RFG Reformulated Gasoline
RON Research Octane Number
RV Relief Valve
RVP Reid Vapor Pressure (Gas)
SDA Solvent Deasphalting
SRU Sulfur Recovery Unit
SRV Safety Relief Valve
SWS Sour Water Stripping
TAA Tertiary Amyl Alcohol
TAEE Tertiary Amyl Ethyl Ether
TAME Tertiary Amyl Methyl Ether
TBA Tertiary Butyl Alcohol
TC Temperature Controller
TGC Tail Gas Cleaning Unit
TCV Cv for Temperature Control Loop
VGO Vacuum Gas Oil
VR Vacuum Residue



Residual Hydrotreating

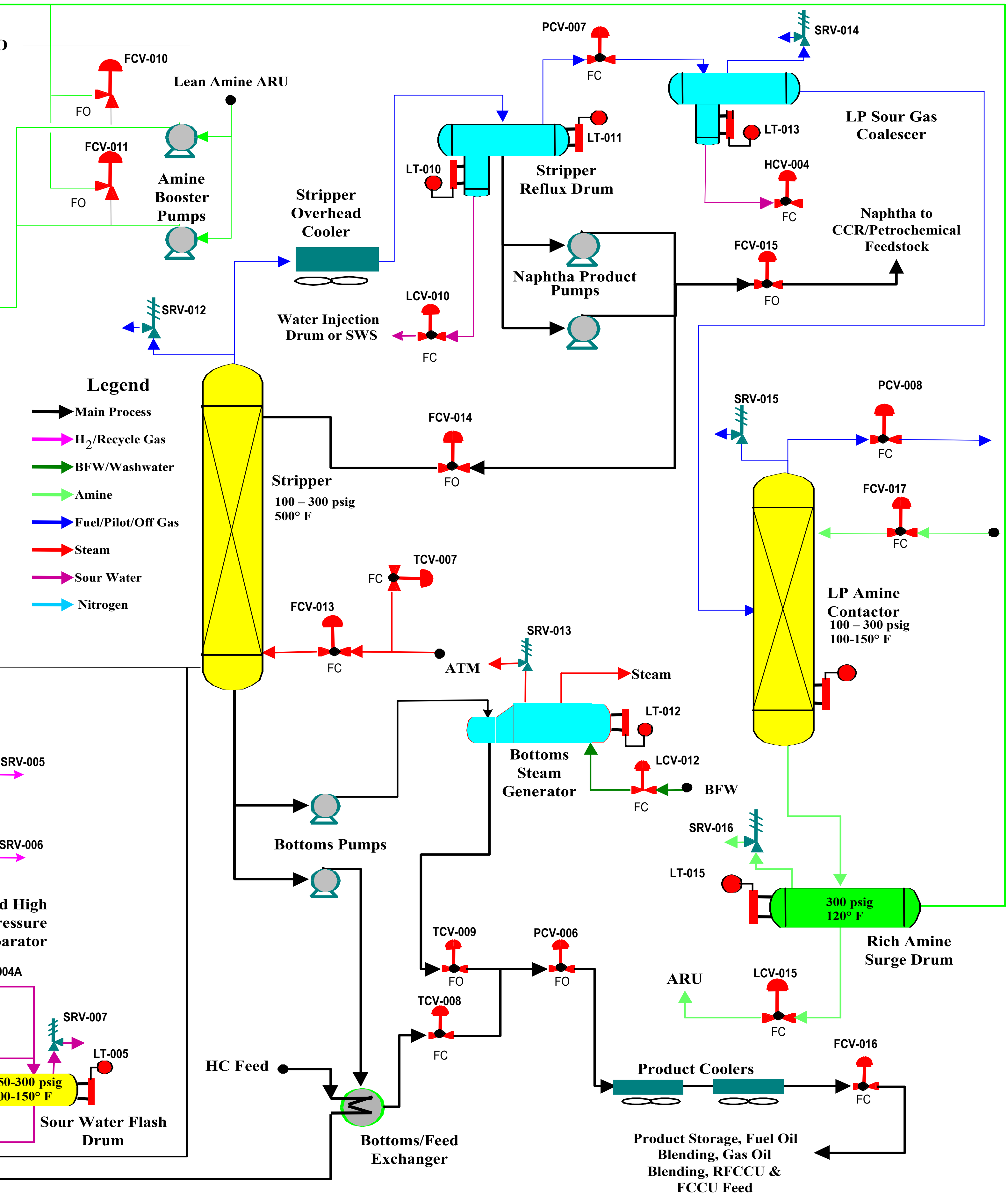


Figure 104.4
Typical Residual or Gas Oil Hydrotreater

Valve & Instrumentation Symbols