Petrochemical Technology

Feedstocks for Petrochemicals

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Gas:

Natural gas, Associated Gas, Gas condensate, Refinery off gas

- **Associated Gas or Associated Petroleum Gas** (**APG**) is a form of natural gas which is found with deposits of petroleum, either dissolved in the oil or as a free "gas cap" above the oil in the reservoir.

- **Gas condensate** is a hydrocarbon liquid stream separated from natural gas and consists of higher-molecular-weight hydrocarbons that exist in the reservoir as constituents of natural gas but which are recovered as liquids in separators, field facilities, or gas-processing plants. Typically, gas condensate contains hydrocarbons boiling up to $C_{8.}$

Light Liquids:

Natural gas liquids, Naphtha, Reformate, Kerosene

Natural-gas condensate, also called **Natural Gas Liquids (NGL)**, is a low-density mixture of hydrocarbon liquids that are present as gaseous components in the raw natural gas produced from many natural gas fields.

Heavy Liquids:

Residuum, Low sulphur heavy stocks, Fuel oil, etc.

All feedstocks require certain type of purification.

Maximum purification is required for gaseous feedstocks as they are obtained either from a field or from a process.

Natural gas production in 2022-23: 34.45 BCM

NG Consumption: 59.97 BCM

Typical Composition of Bombay High Gas:

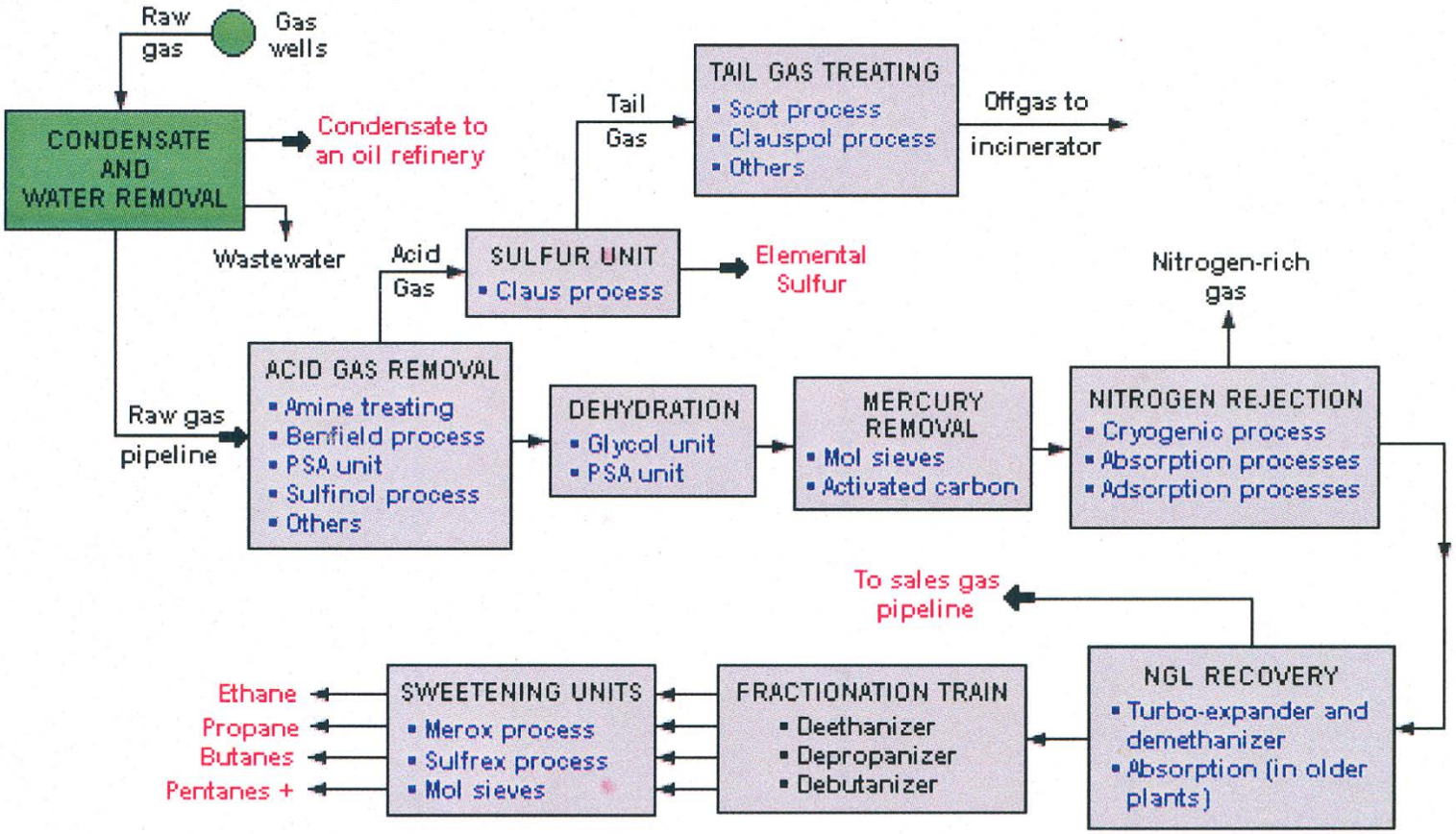
CH_4: 78.48; C_2H_6: 7.24; C_3H_8: 4.59; C_4H_{10}(i- & n-): 1.95; C_5^+: 0.5; CO_2: 6.45; H_2S+RSH: 0.78; N_2+O_2: 0.01

Most Common Impurities of Gaseous Feedstock

Water vapour: Forms crystalline hydrates ($CH_4.7H_2O$, $C_2H_6.7H_2O$, etc.)
- stable solids below 19 ^oC
Removed by passing through drying agents

Mechanical (suspended) impurities: Clay, dust, catalyst particles, tar droplets, etc.
Mostly removed by washing with water
Suitable solvent required for removal of tar and heavy oils

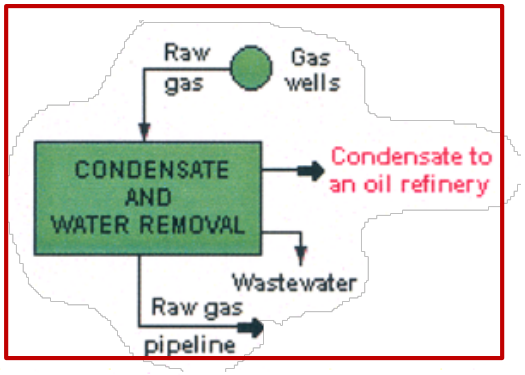
Chemical impurities: CO_2, COS, H_2S, RSH, NH_3, etc.
Mostly removed by absorption

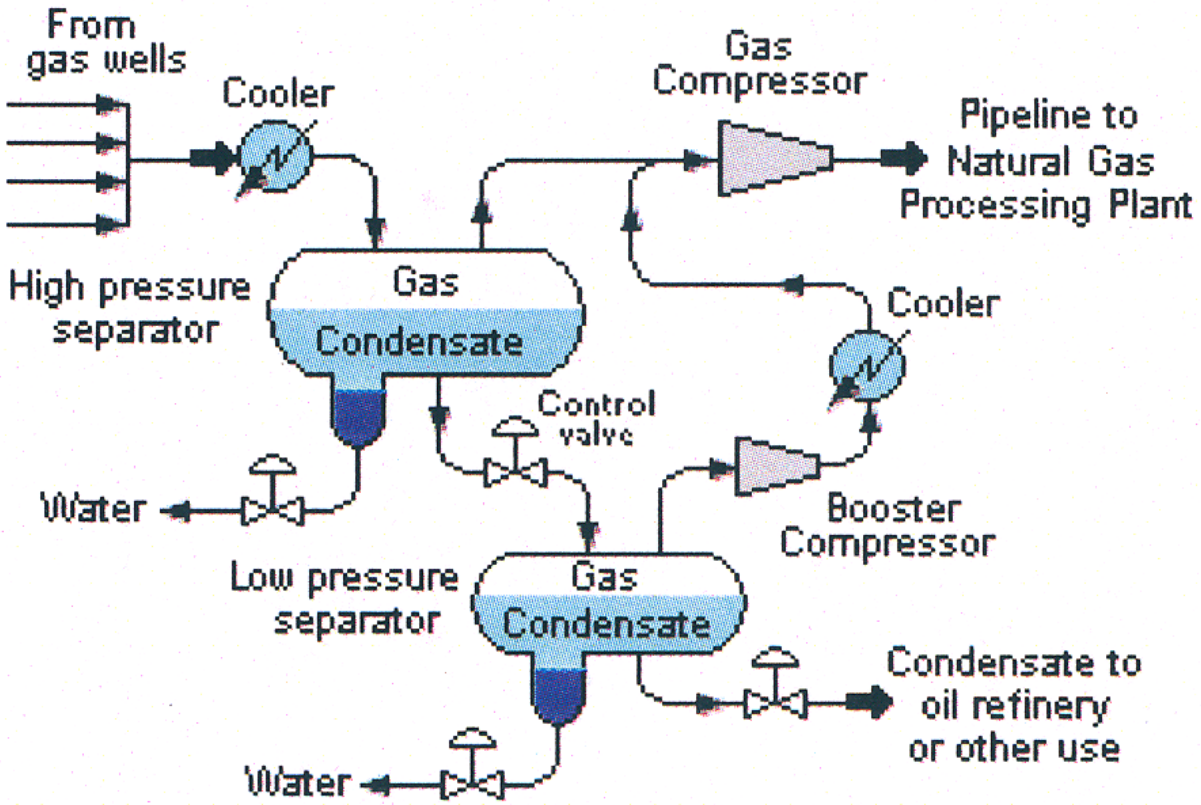


LEGEND:

- Located at gas wells — Located in gas processing plant
- Red Indicates final sales products — Blue Indicates optional unit processes available
- Condensate is also called natural gasoline or casinghead gasoline
- Pentanes + are pentanes plus heavier hydrocarbons and also called natural gasoline
- Acid gases are hydrogen sulfide and carbon dioxide
- Sweetening processes remove mercaptans from the NGL products
- PSA is Pressure Swing Adsorption
- NGL is Natural Gas Liquids

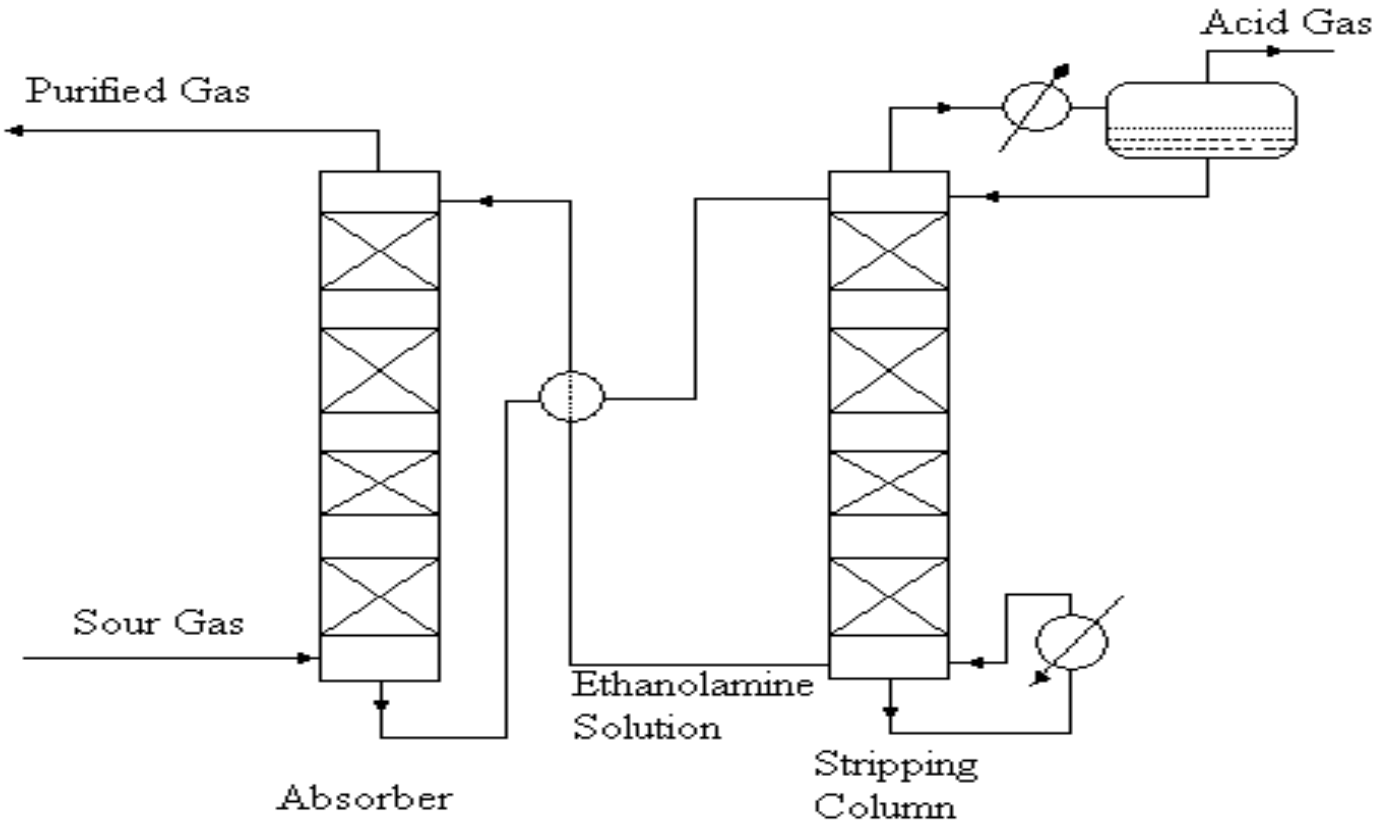
Schematic Flow Diagram for the Processing of Natural Gas





Schematic Flow Diagram of the Separation of Condensate from Raw Natural Gas

Amine Treating Unit (ATU)



***Girbotol Process**: Girbotol* from *Gir*dler Corporation, Louisville, Kentucky, company where the process was developed + Robert R. *Bot*toms *born* 1890 American chemist that devised the process + English *-ol*

Claus Process

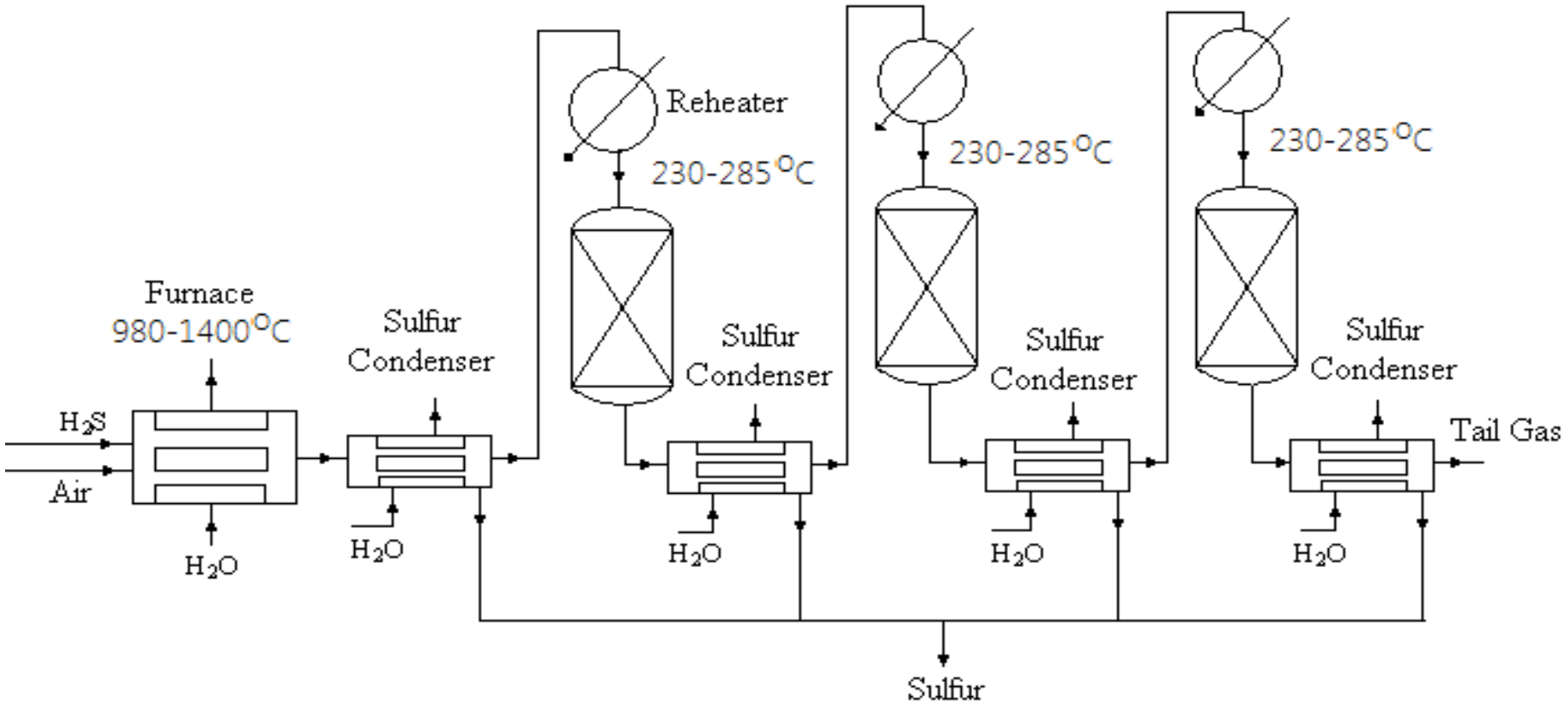
Thermal Stage

$H_2S + 3/2O_2 = H_2O + SO_2 + \Delta$

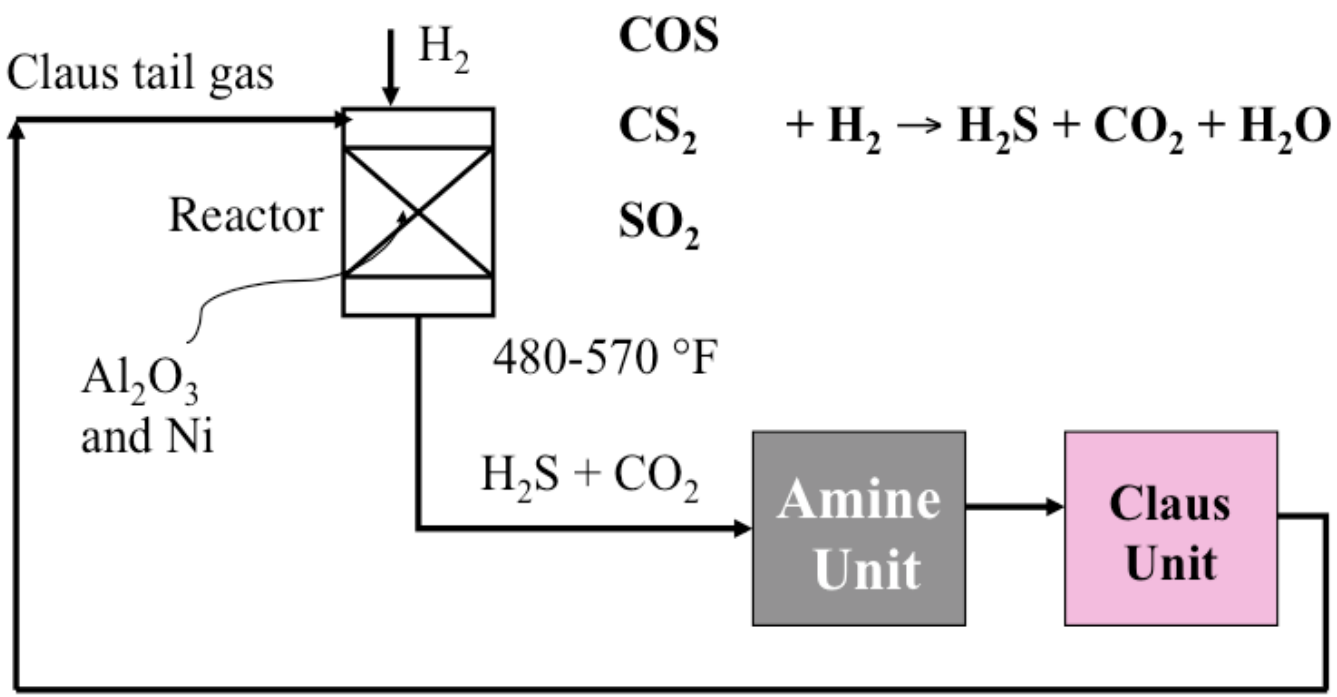
$2H_2S + SO_2 = 2H_2O + 3S + \Delta$

Catalytic Stage

$2H_2S + SO_2 = 2H_2O + 3S + \Delta$



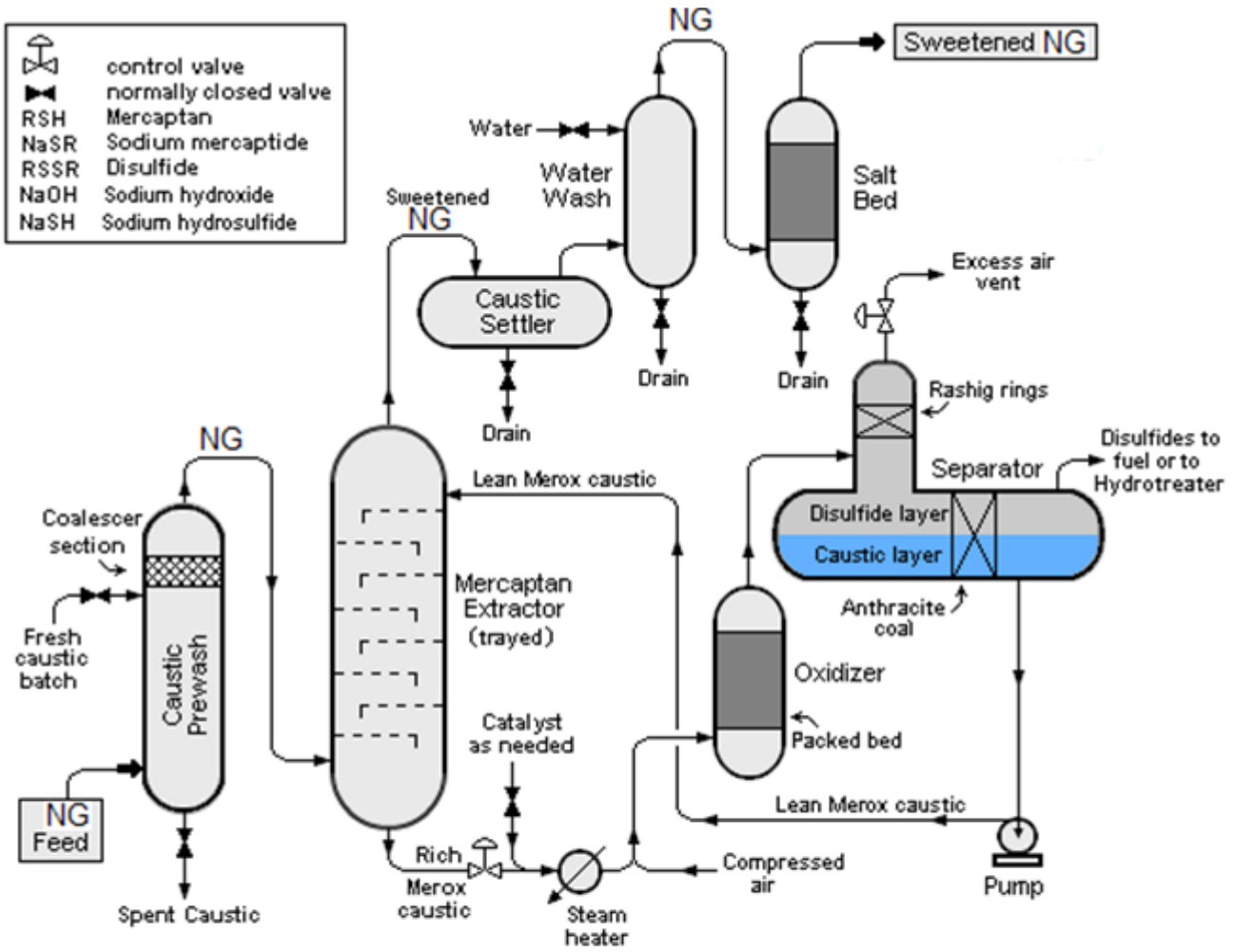
Sulfur Recovery -SCOT Process



Claus +SCOT Recover greater than 99% of S.

The Shell Claus Off-gas Treatment (SCOT) Process

MerOx Process



CHEMICAL REACTIONS IN MEROX TREATING

Caustic Prewash:
$NaOH + H_2S \rightarrow NaSH + H_2O$

Extraction:
$2RSH + 2NaOH \rightarrow 2NaSR + 2H_2O$

Overall Mercaptan Conversion:
$4RSH + O_2 \rightarrow 2RSSR + 2H_2O$

Regeneration:
$4NaSR + O_2 + 2H_2O \rightarrow 2RSSR + 4NaOH$

Catalyst: Cobalt phthalocyanine monosulphate

Liquefied Natural Gas (LNG)

[-163^{o}C close to atmospheric pressure (3.6 psig)]

LNG takes 1/600th volume of NG

LNG is transported in cryogenic vessels or cryogenic road tankers

Compressed Natural Gas (CNG)

NG at 20-25MPa pressure at ambient temperature
(Compressed to <1% of its volume at STP)

Processes for LNG Production

(1) APCI Propane Pre-cooled Mixed Refrigerant Process

(2) Philips Optimized Cascade process

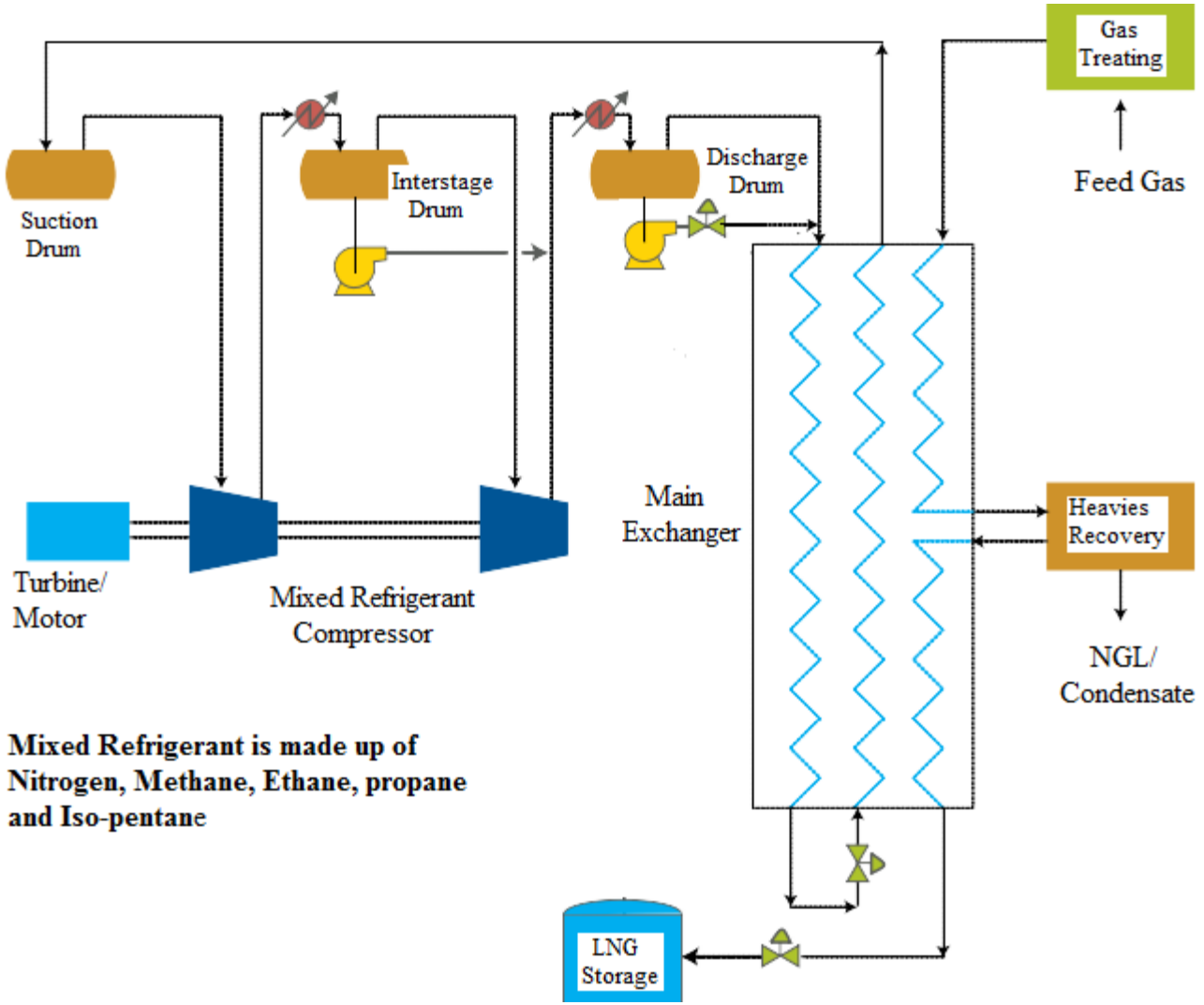
(3) Black & Veatch PRICO Process

(4) Statoil/Linde Mixed Fluid Cascade Process

(5) Axens Liquefin Process

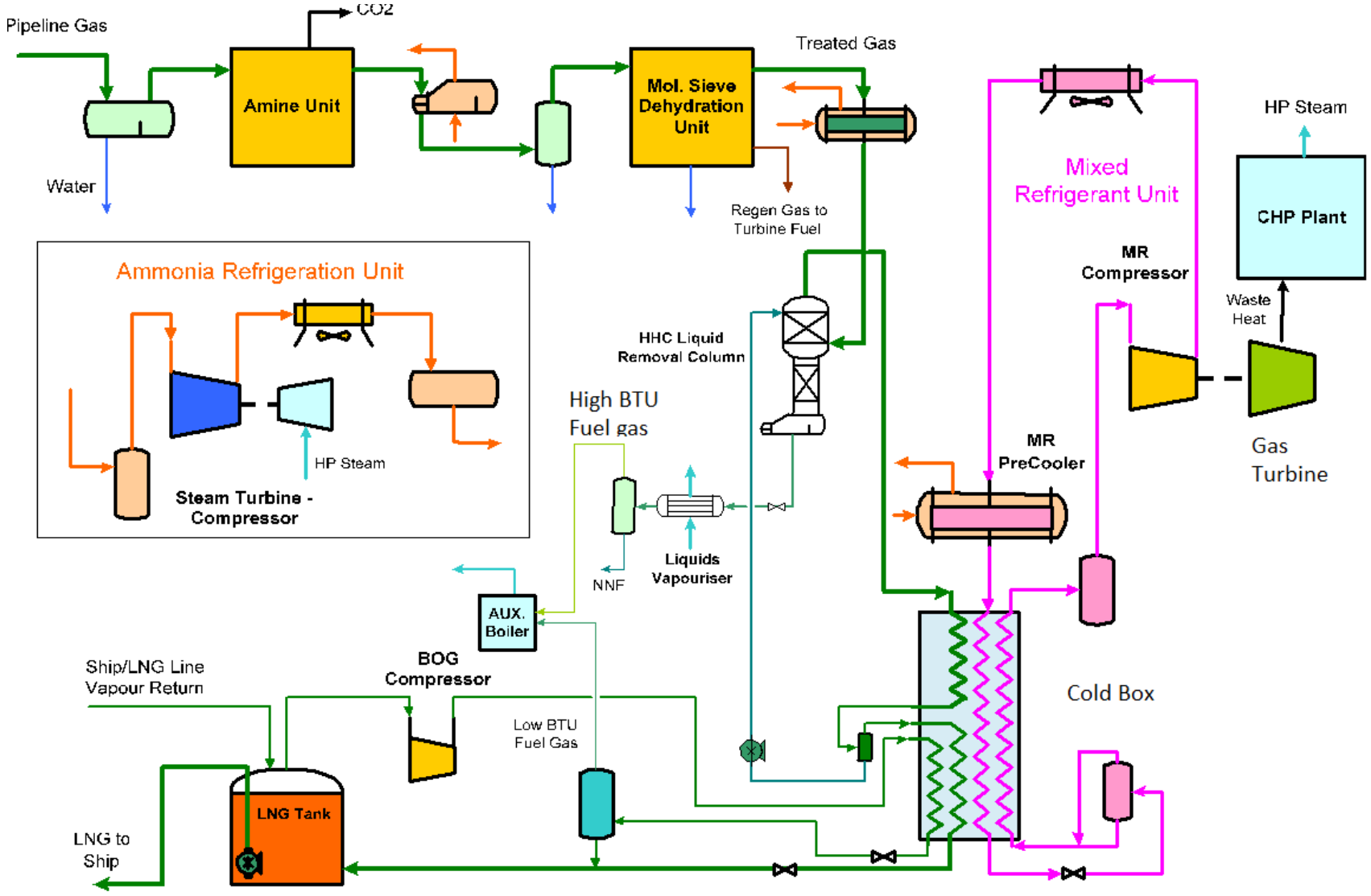
(6) Shell Double Mixed Refrigerant Process

(7) OSMR (Optimized Single Mixed Refrigerant) Process

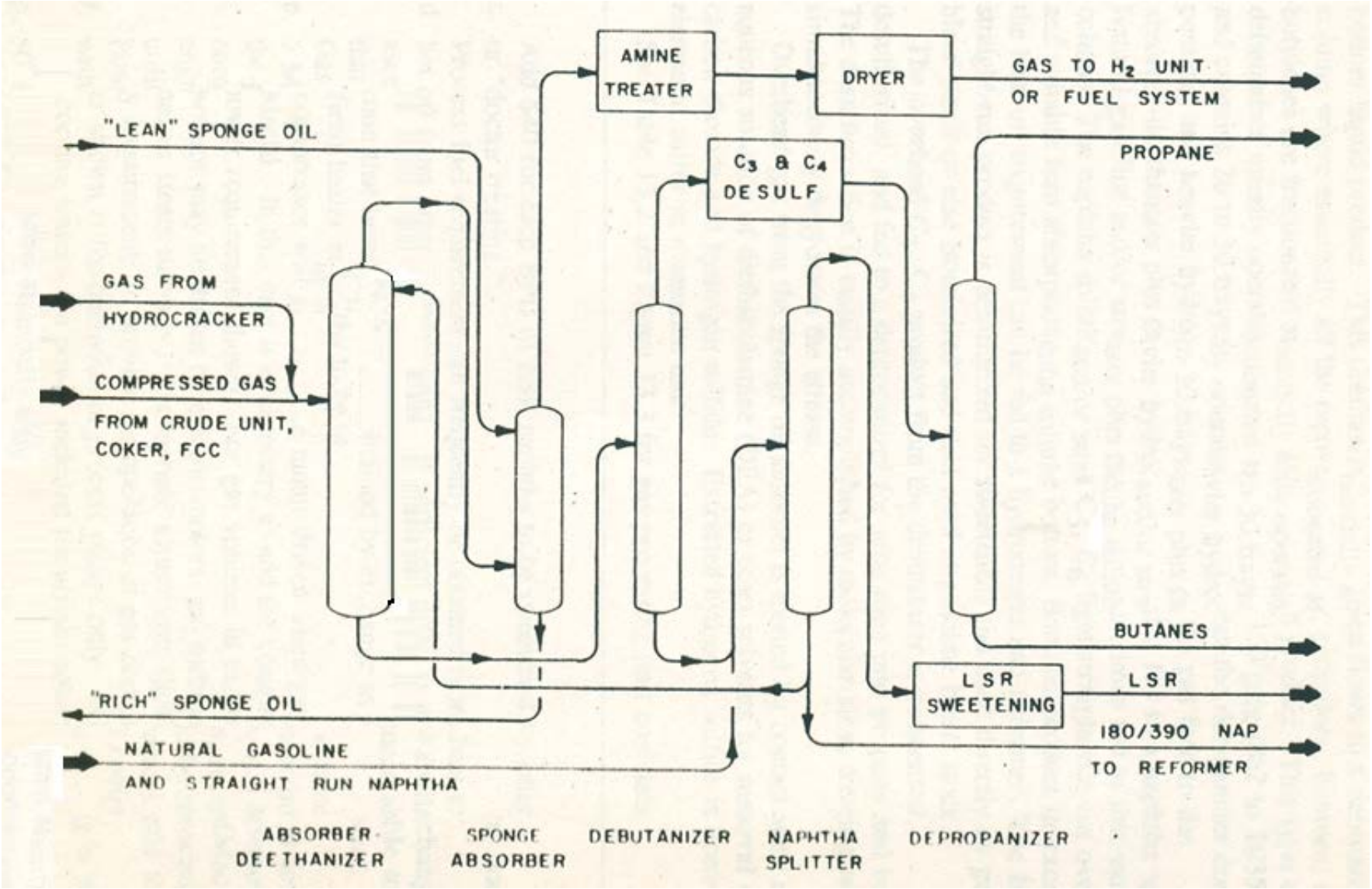


Poly Refrigerant Integrated Cycle Operation (PRICO®) Process

By **Black & Veatch Corpn.**



Optimized Single Mixed Refrigerant (OSMR) Process



Flow Diagram of Refinery Off Gas Processing

Treatment of Liquid Feedstocks

Hydrotreating of Naphtha

Heavy naphtha is catalytically reformed to produce aromatics.

The active material in most catalytic reforming catalyst is platinum. Certain metals, hydrogen sulfide, ammonia, and organic nitrogen and sulfur compounds will deactivate the catalyst. Feed processing, in the form of hydrotreating, is usually employed to remove these materials.

1. Desulphurization:

Mercaptans: $RSH + H_2 \rightarrow RH + H_2S$

Sulphides: $R_2S + 2\ H_2 \rightarrow 2RH + H_2S$

Disulphides: $(RS)_2 + 3\ H_2 \rightarrow 2RH + 2\ H_2S$

Thiophenes: $C_4H_4S + 4\ H_2 \rightarrow C_4H_{10} + H_2S$

2. Denitrogenation:

Pyrrole: $C_4H_4NH + 4\ H_2 \rightarrow C_4H_{10} + NH_3$

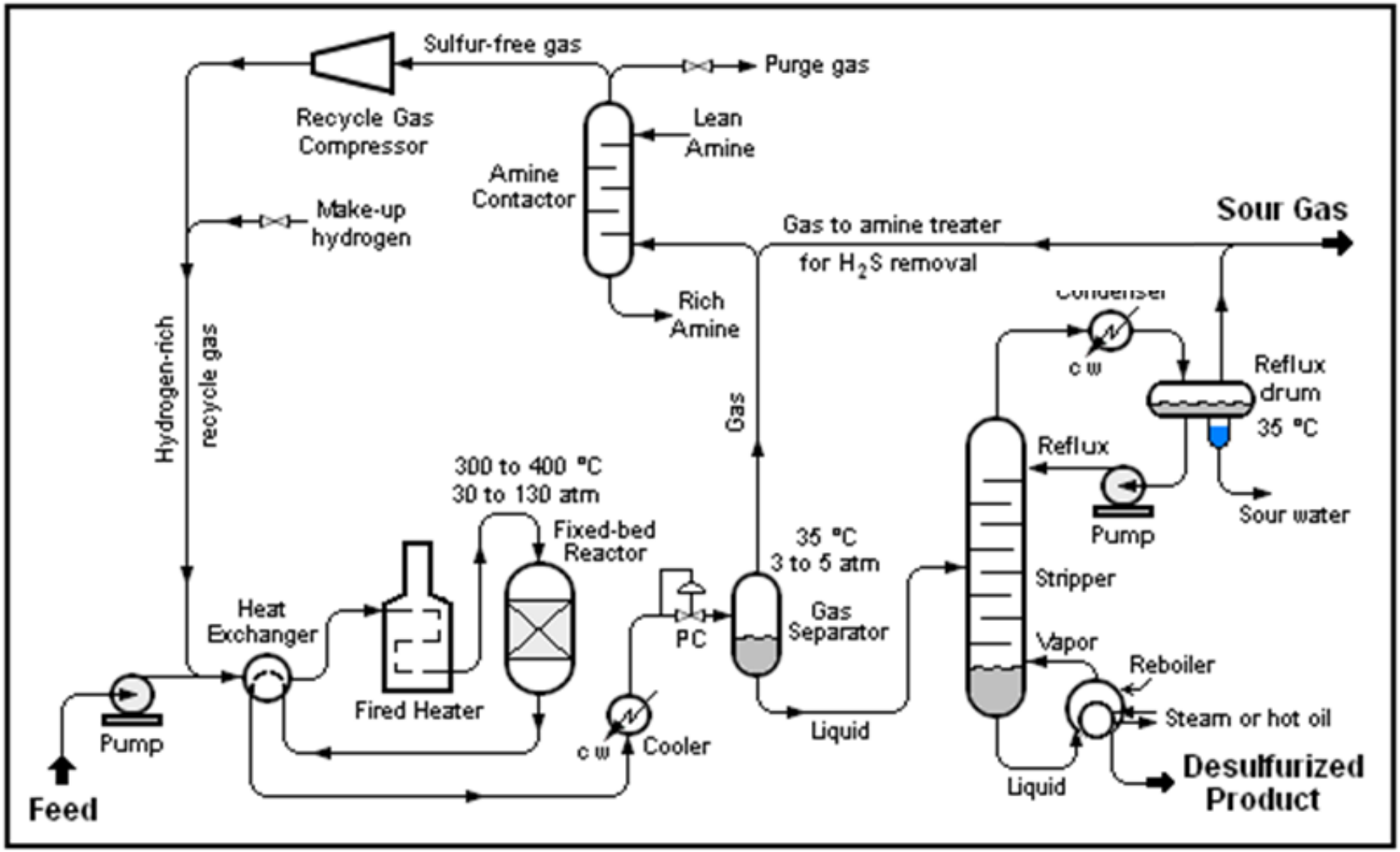
Pyridine: $C_5H_5N + 5\ H_2 \rightarrow C_5H_{12} + NH_3$

Process Conditions:

Temperature: 300 – 400 ^oC

Pressure : 1000 – 3000 psig

Catalyst: Co-Mo/Al_2O_3, Ni-Mo/ Al_2O_3, W-Mo/ Al_2O_3, Ni-Co-Mo/ Al_2O_3



Hydrotreating Process Schematic

Thank you