

Course 288
Petroleum Refining
2017

PROCESSES

SEPARATION AND TREATMENT

The National Air
Compliance Training
Program

The Mobil logo is centered in the upper half of the image. It features the word "Mobil" in a stylized, bold, sans-serif font. The letter "M" is blue, the "o" is red, and the "bil" is blue. The logo is set against a dark, almost black background.

TORRANCE REFINERY

Petroleum Refining Process

- Separation
- Treatment
- Conversion
- Blending



Types of Separation Processes

- Desalting
- Flashing
- Steam Stripping
- Atmospheric Distillation
- Vacuum Distillation
- Saturated Gas Plant

Desalting

PURPOSE: To remove entrained salts, solids, and water that could affect downstream operations



Desalting

- MECHANISM: Vigorously mix crude oil and water, then separate the two phases by gravity and applying an electrical field

Electrostatic Desalter



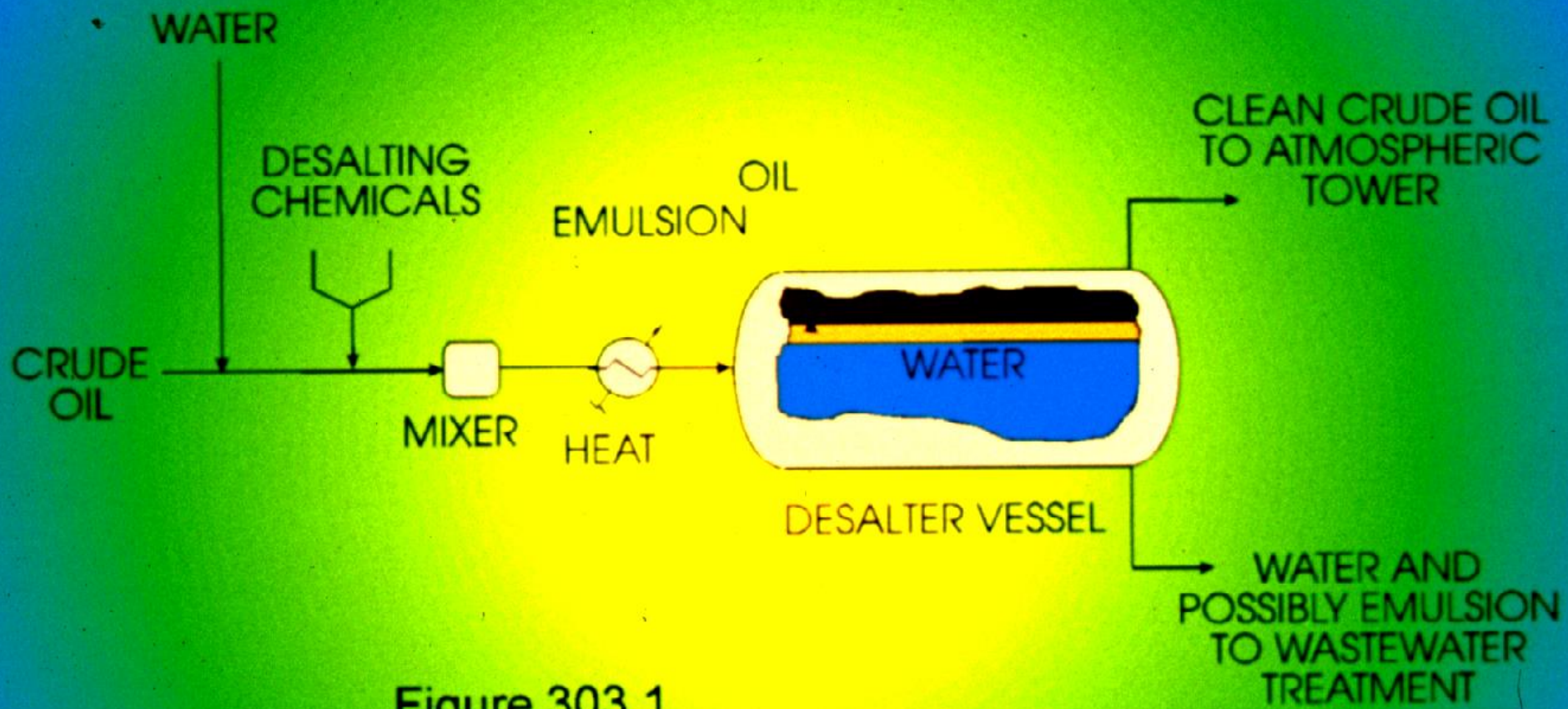


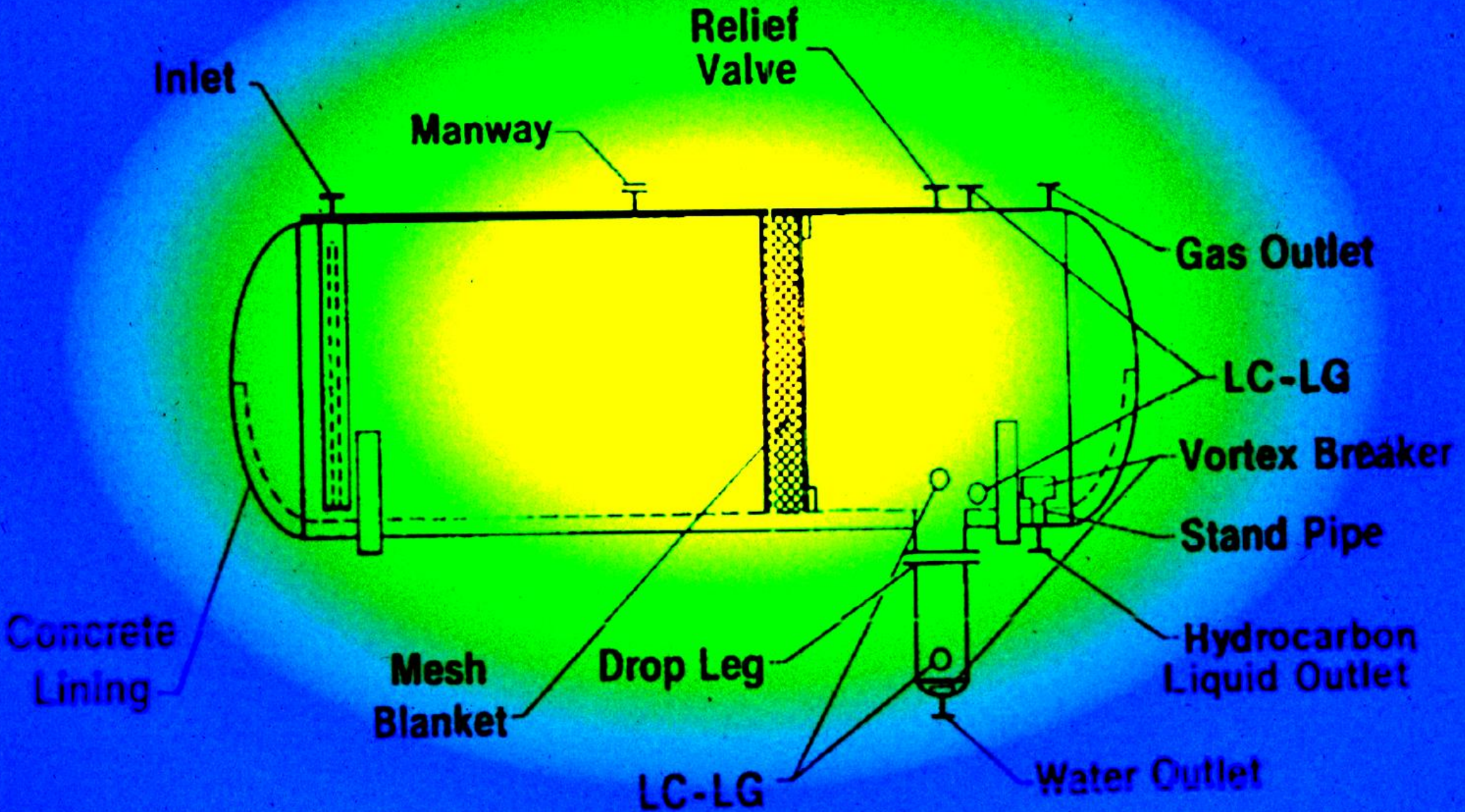
Figure 303.1
Crude Desalter

Flashing

- **PURPOSE:** Separating light and heavy constituents in the crude oil and other process streams.
- **MECHANISM:** Greatly reduce the pressure in the stream thereby separating the liquids from the vapors



Low Pressure Flash Drum

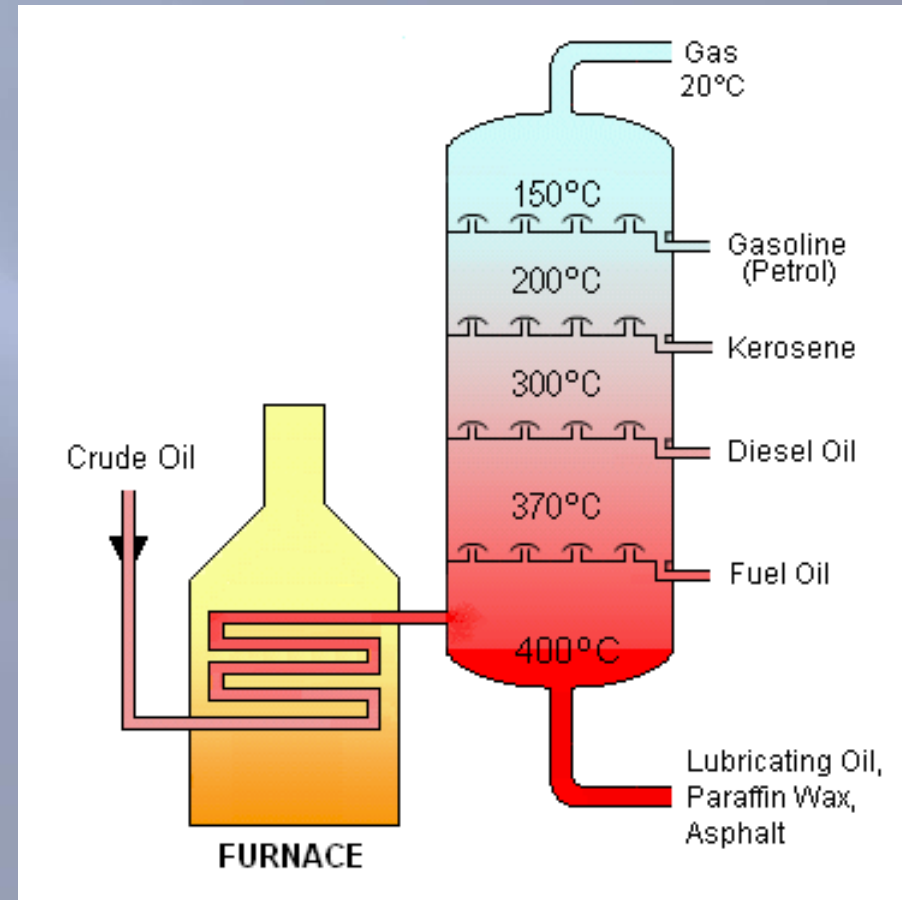


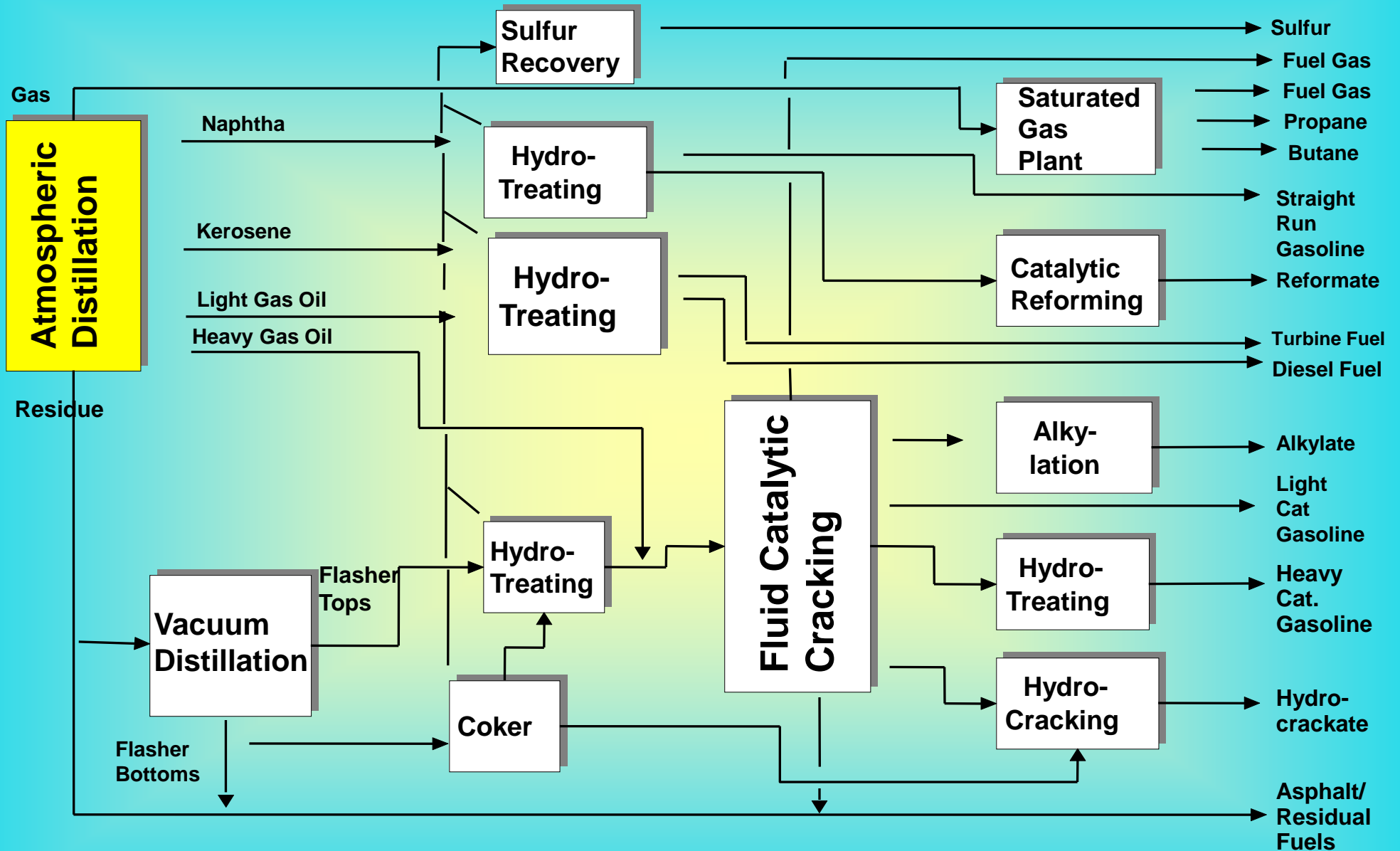
Steam Stripping

- PURPOSE:
 - To lower the boiling point of hydrocarbons and to add heat to the process.
 - Also used to remove H_2S and NH_3 from sour water

Atmospheric Distillation

- **PURPOSE:** To separate the crude petroleum into various fractions which then can be refined into final products





Atmospheric Distillation

MECHANISM: Heat up the crude to around 700 F , which is then fed into a distillation column composed of a series of bubble trays, which then separates the crude oil into product streams having specific boiling point ranges

ATMOSPHERIC DISTILLATION CUTS



Naphtha

Kerosene

Atmospheric
Residuum

Heavy
Naphtha

Atmospheric
Gas Oil

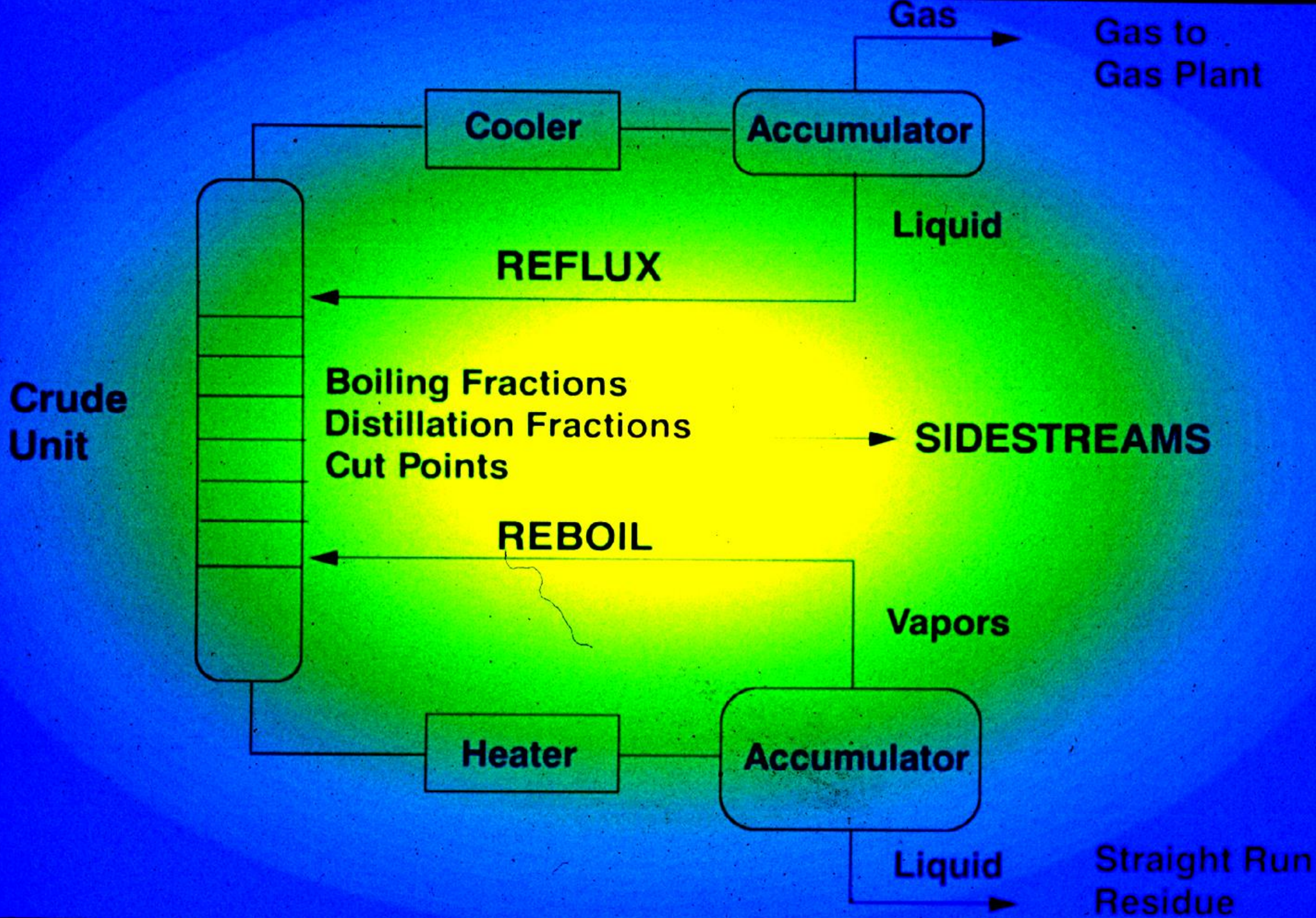
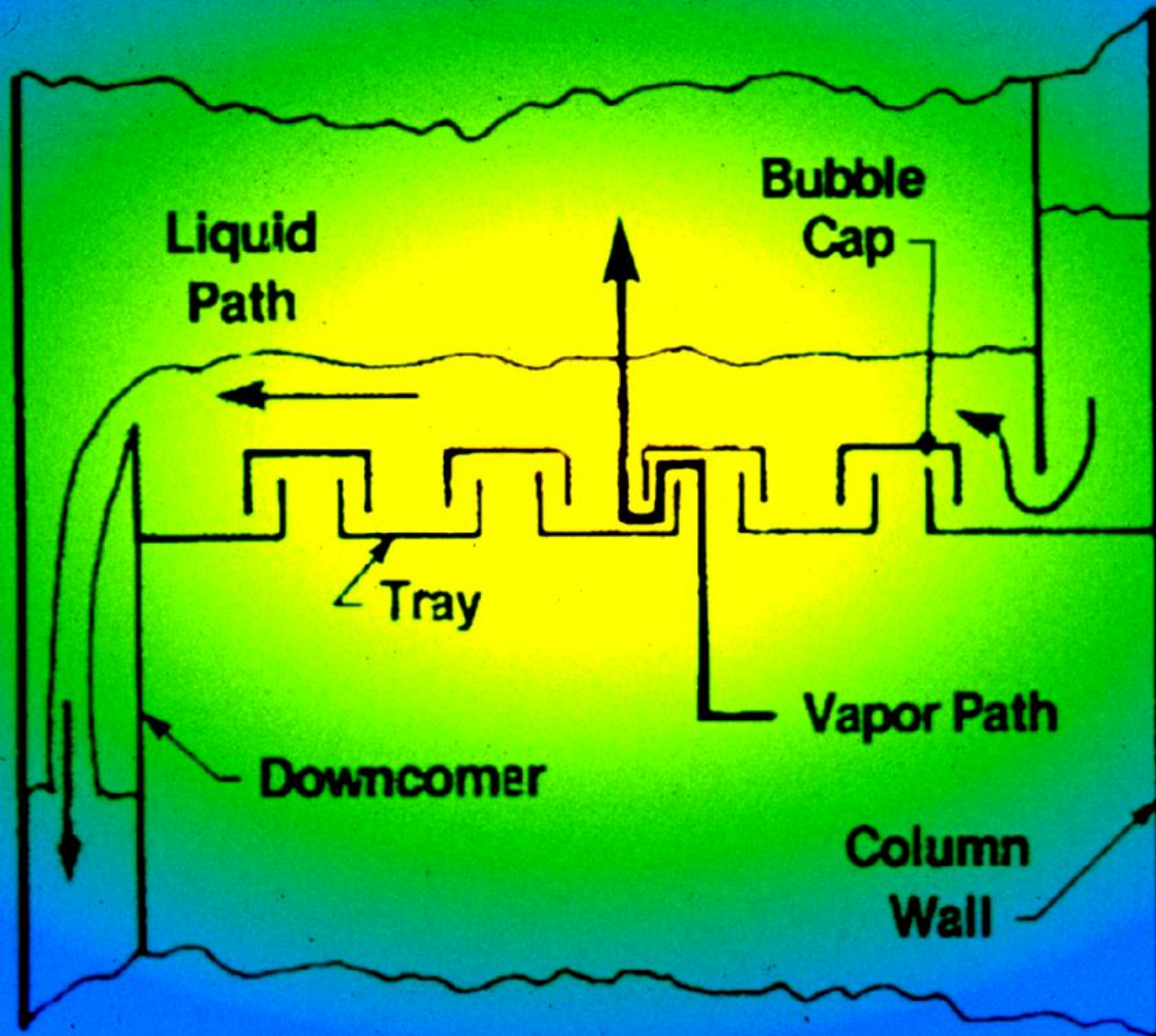
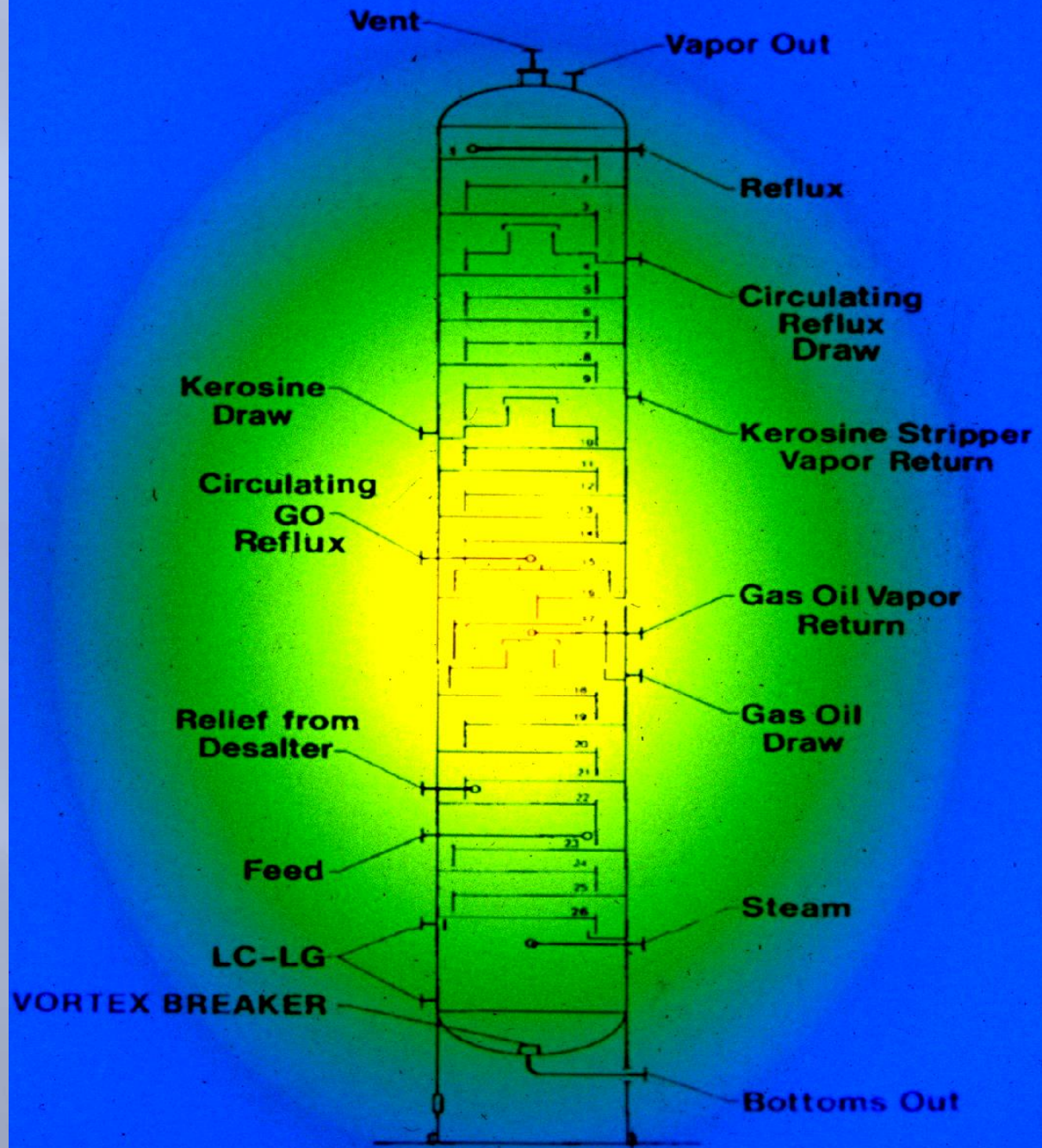
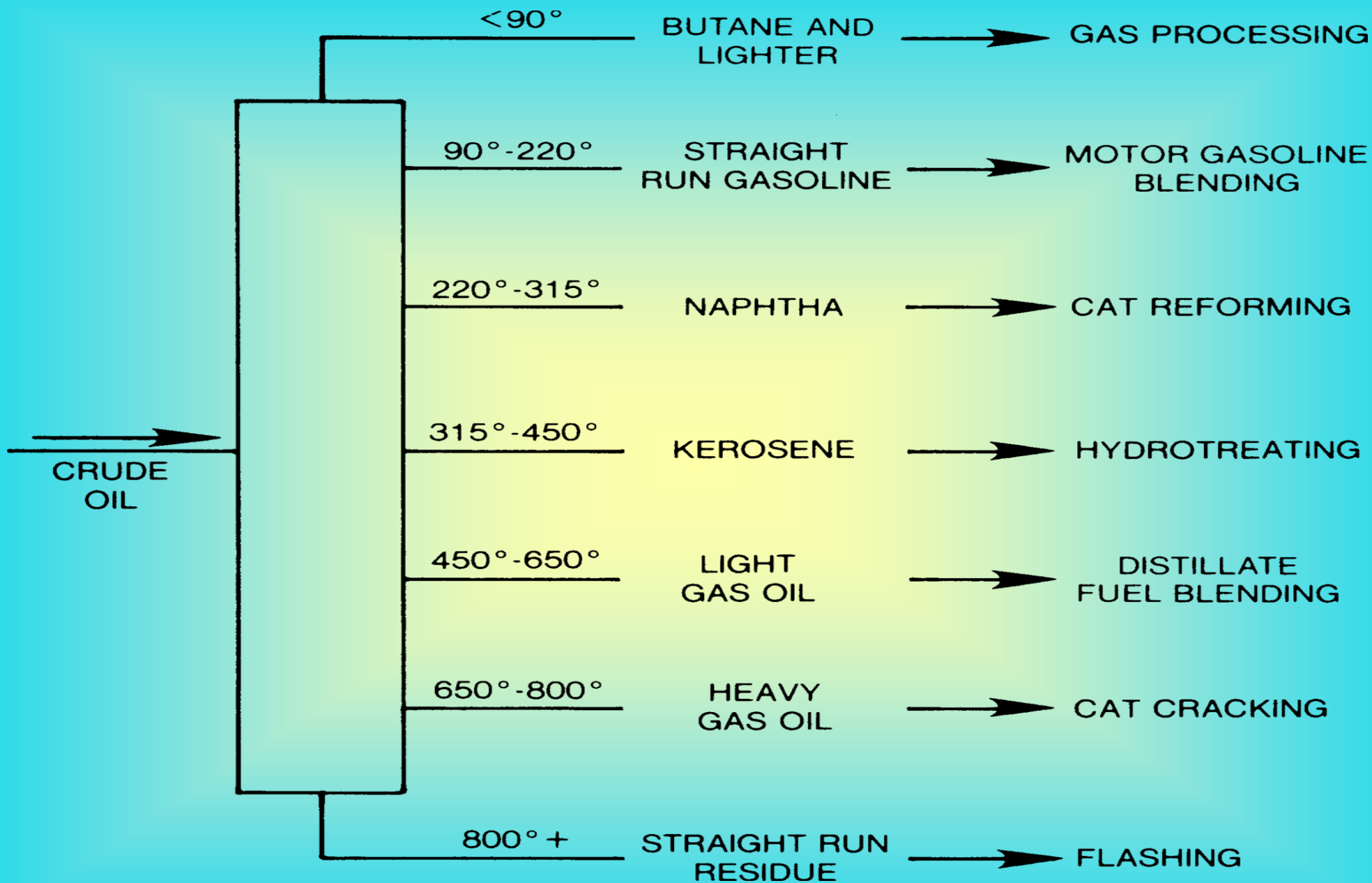


Diagram of a Typical Tray







Atmospheric Crude Distillation Column

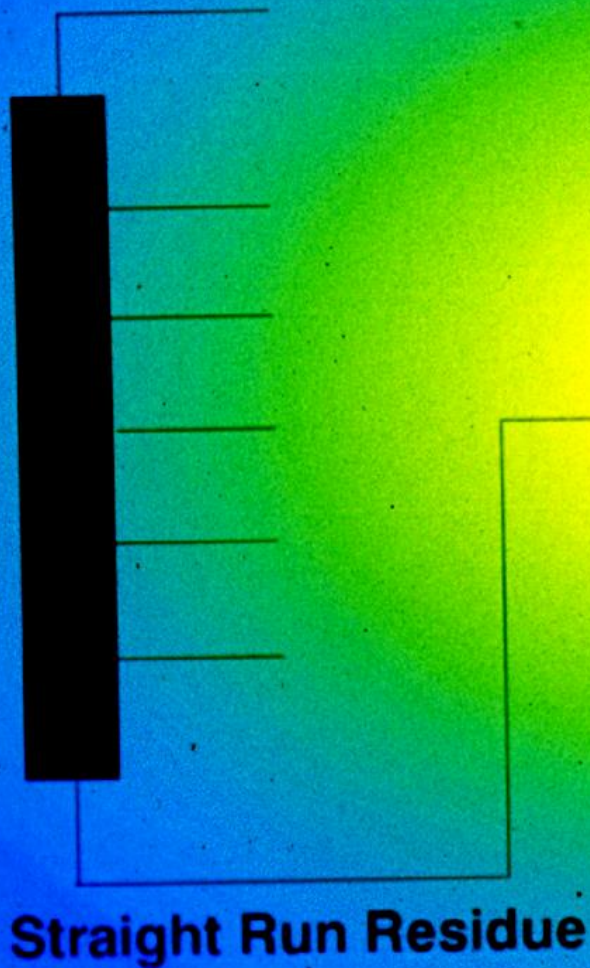


Vacuum Distillation

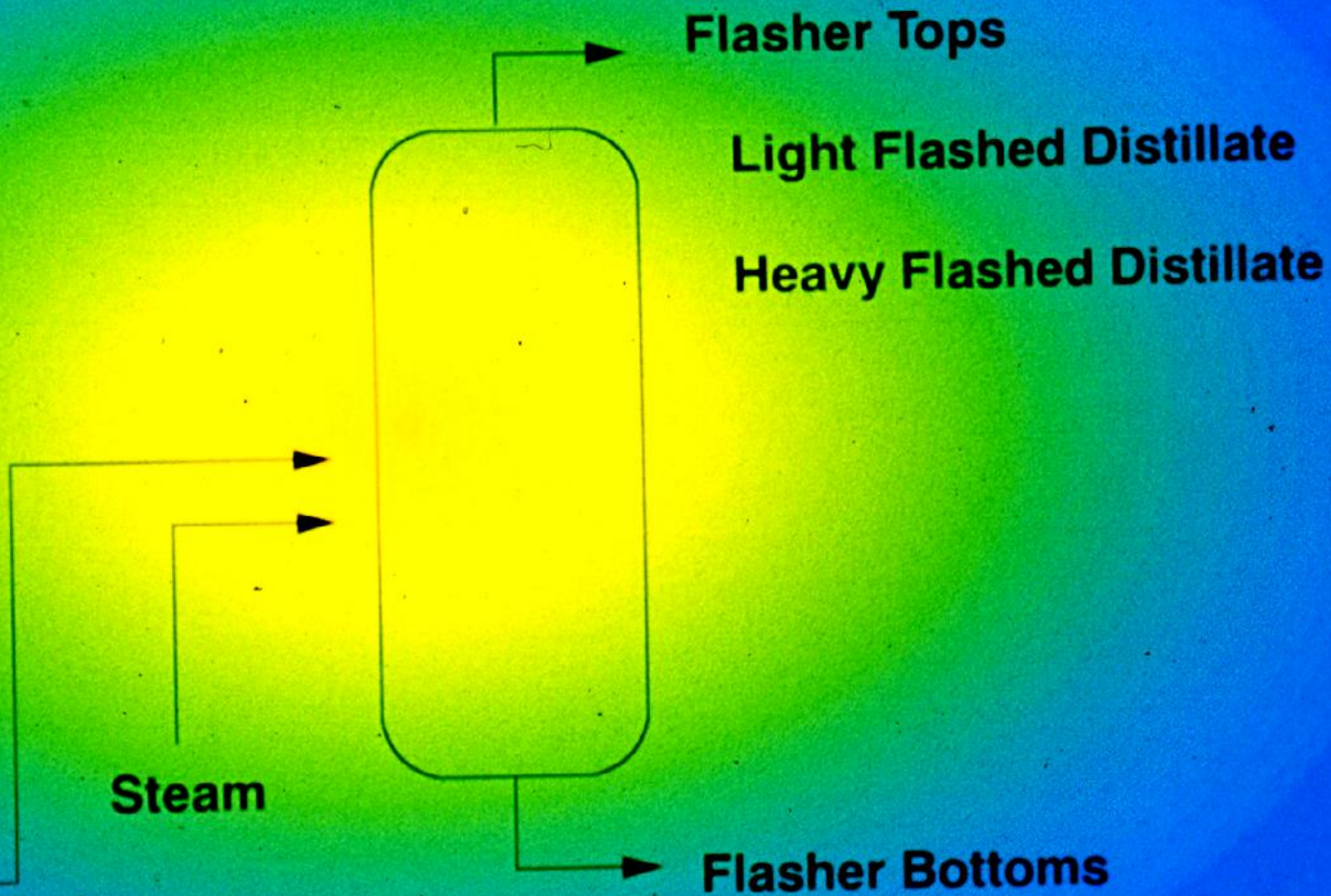
- **PURPOSE:** To distill the heavier components of crude oil (residuum) without raising the temperature to the point that thermal cracking takes place.



**Atmospheric Column
(Crude Unit)**



Vacuum Flasher



Flasher Tops

Light Flashed Distillate

Heavy Flashed Distillate

Steam

Flasher Bottoms

Vacuum Distillation

- **MECHANISM:** This is accomplished by lowering the pressure in the vessel using steam jet ejectors or vacuum pump



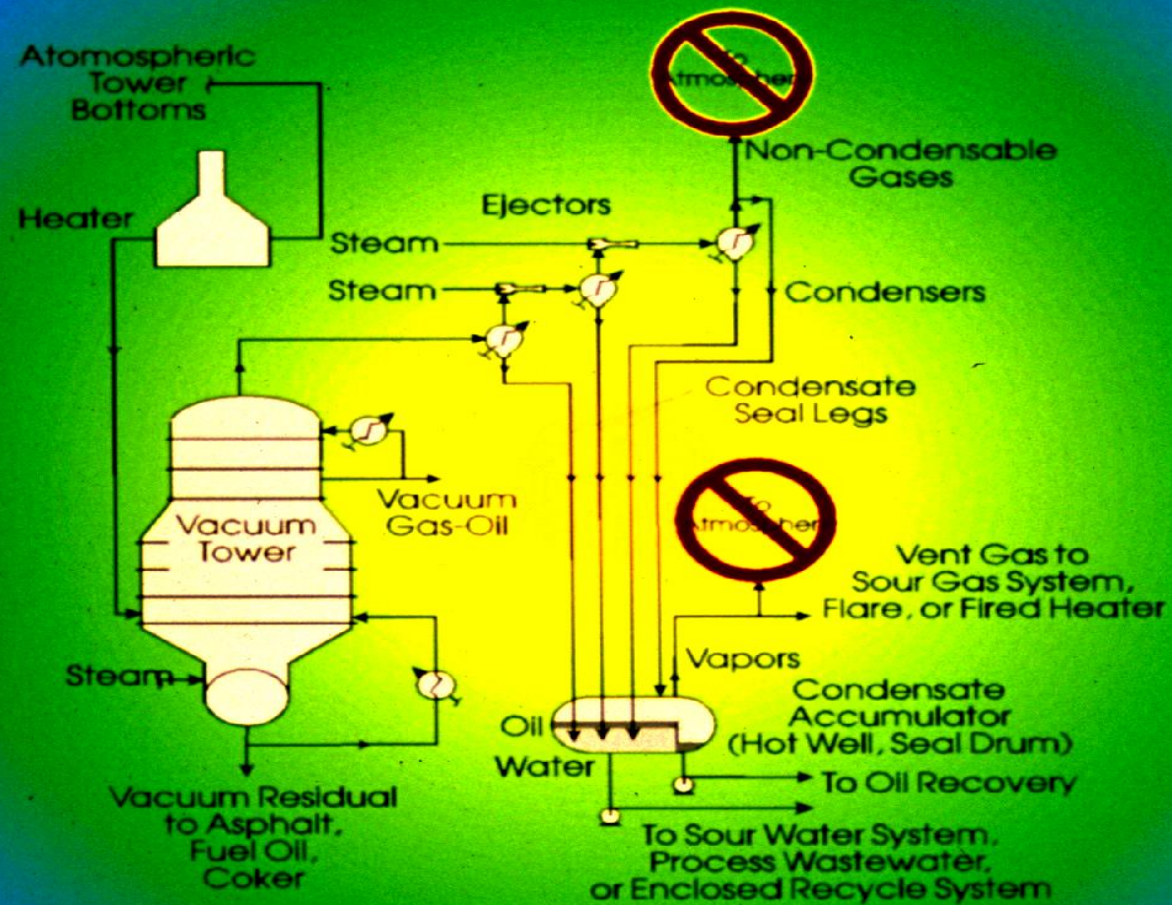


Figure 305.1
Vacuum Distillation Unit



Vacuum Distillation Tower

Two Stage Crude Unit?



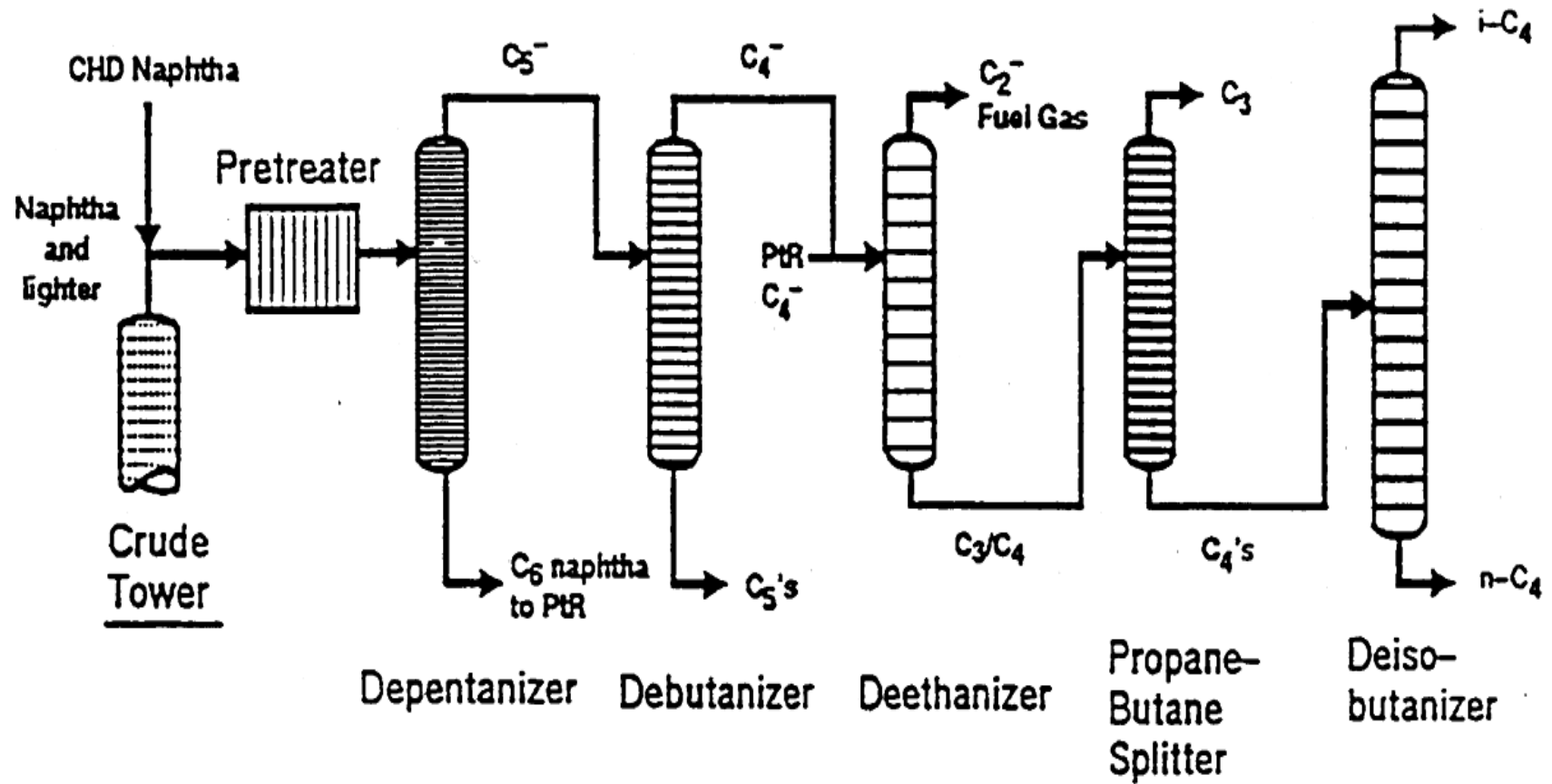
Video Distillation



Saturated Gas Plant

- **PURPOSE:** Separate and clean up mixtures of light hydrocarbons collected from diverse refinery sources into products such as fuel gas, propane, butane.
- **MECHANISM:** Distillation based on vapor pressures.

SATURATED GAS PLANT



Gas Recovery Unit



Boiling Fraction

Product Disposition

Butane and Lighter	→	Gas Processing
Straight Run Gasoline	→	Gasoline Blending
Naptha	→	Catalytic Reforming
Kerosene	→	Hydrotreating
Light Gas Oil	→	Distillate Fuel Blending
Heavy Gas Oil	→	Catalytic Cracking
Straight Run Residue	→	Vacuum Flasher
Vacuum Flasher Tops	→	Lubricating Oil Feedstocks
Vacuum Flasher Bottoms	→	Asphalt Plant, Residual fuel or Coker

Quick Review 3

- Separation
 - Separates constituents
 - Does not manipulate molecular structure
- Processes
 - Desalting
 - Flashing
 - Stream stripping
 - Crude distillation
 - Atmospheric
 - Vacuum
 - Saturated gas plant

Petroleum Refining Process

- Separation
- Treatment
- Conversion
- Blending

Types of Treatment Processes

- Acid and Caustic Washes
- Filtration
- Sulfur Removal - Absorption
- Hydrotreating / Hydrogen Manufacturing
- Sulfur Recovery

Acid and Caustic Washes

- Remove trace contaminants from process streams by contacting with an acid or a base.
 - Acid contaminant - base
 - Base contaminant - acid

Filtration

- Remove solid contaminants from gas or liquid process streams by the use of a filter





Lean Amine Filter System

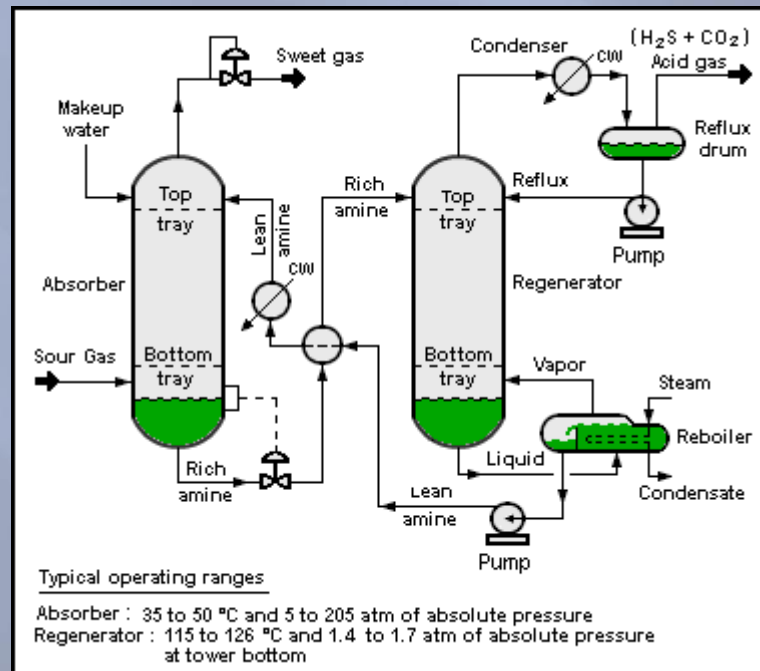
Sulfur Removal - Absorption

- PURPOSE: To remove H_2S from gaseous process streams, usually fuel gas

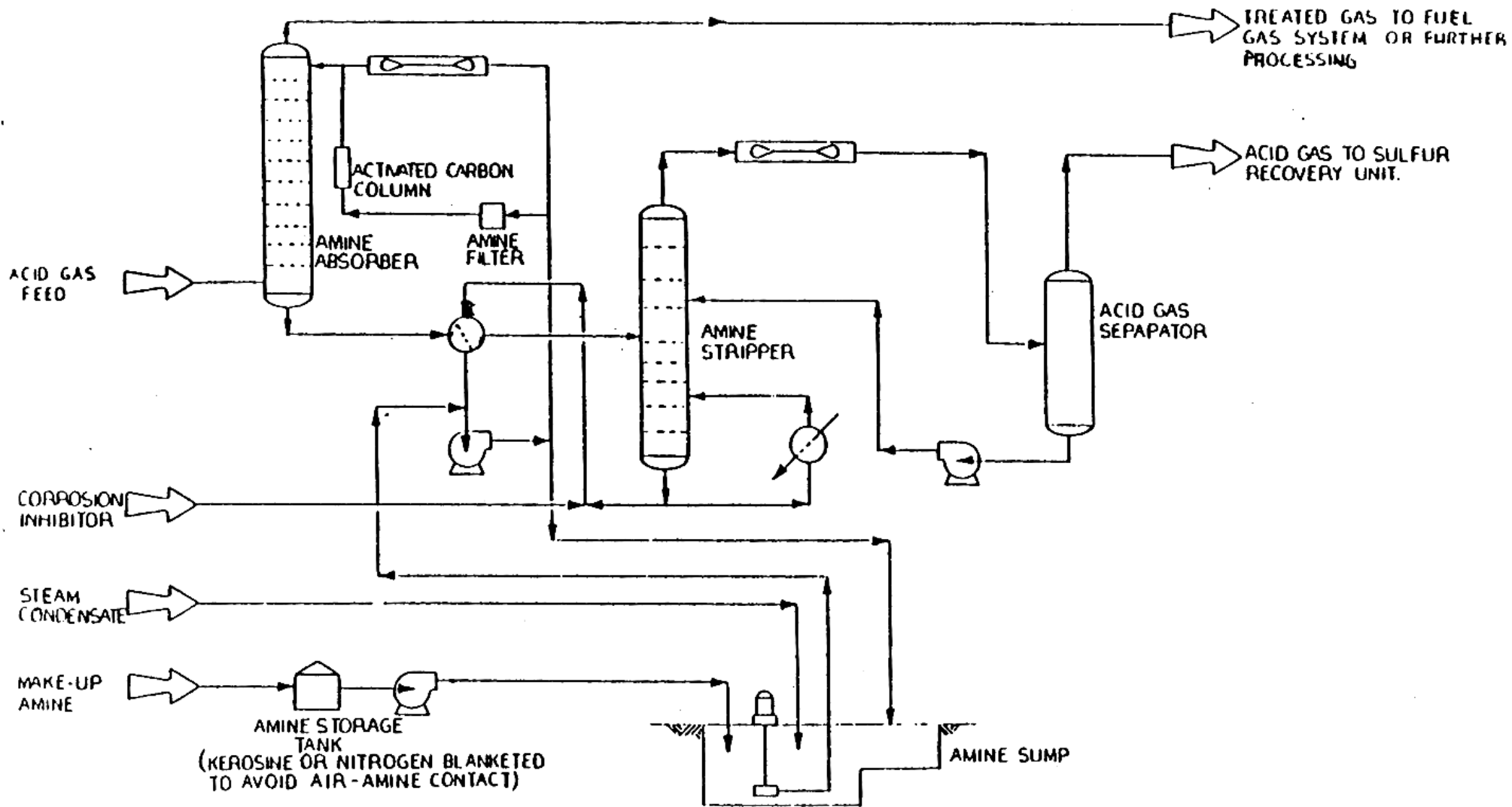


Sulfur Removal - Absorption

- PROCESS: Acid gases are removed by absorption in a alkaline solution using either monoethanolamine (MEA) or diethanolamine (DEA). This process may also be called Scrubbing.



ACID GAS TREATING UNIT

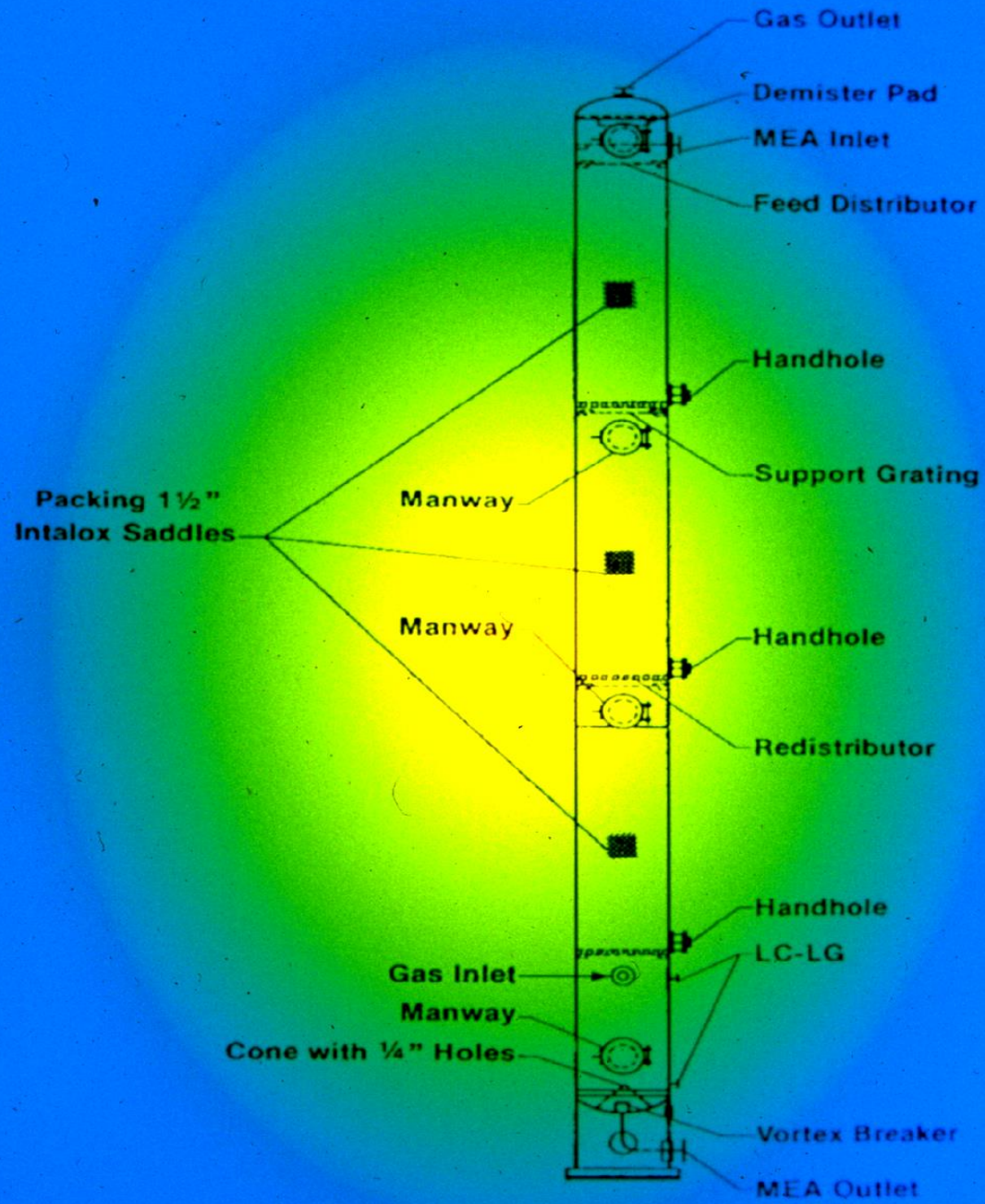


Amine - H₂S Removal Unit



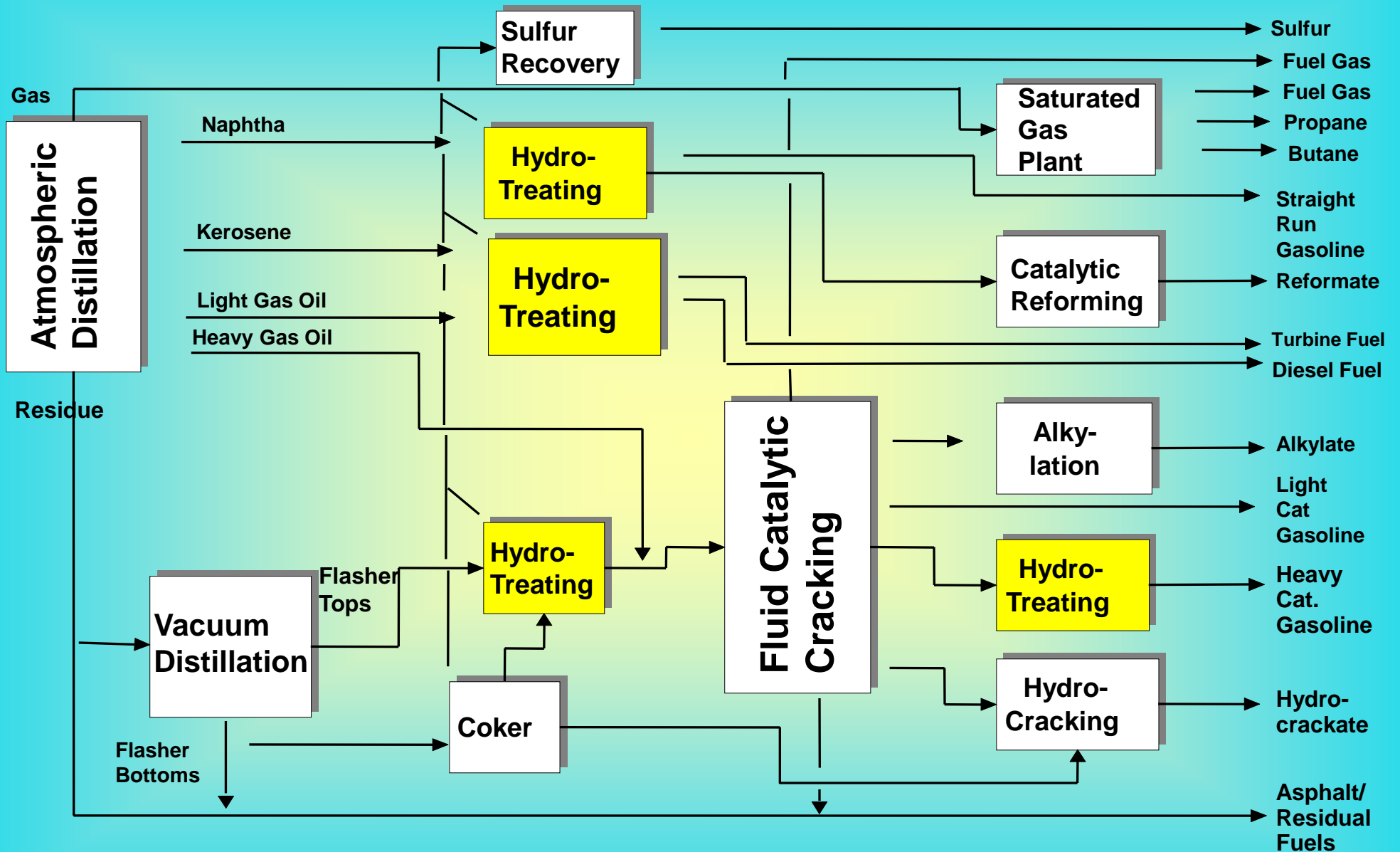
Amine-H₂S Absorber





Hydrotreating

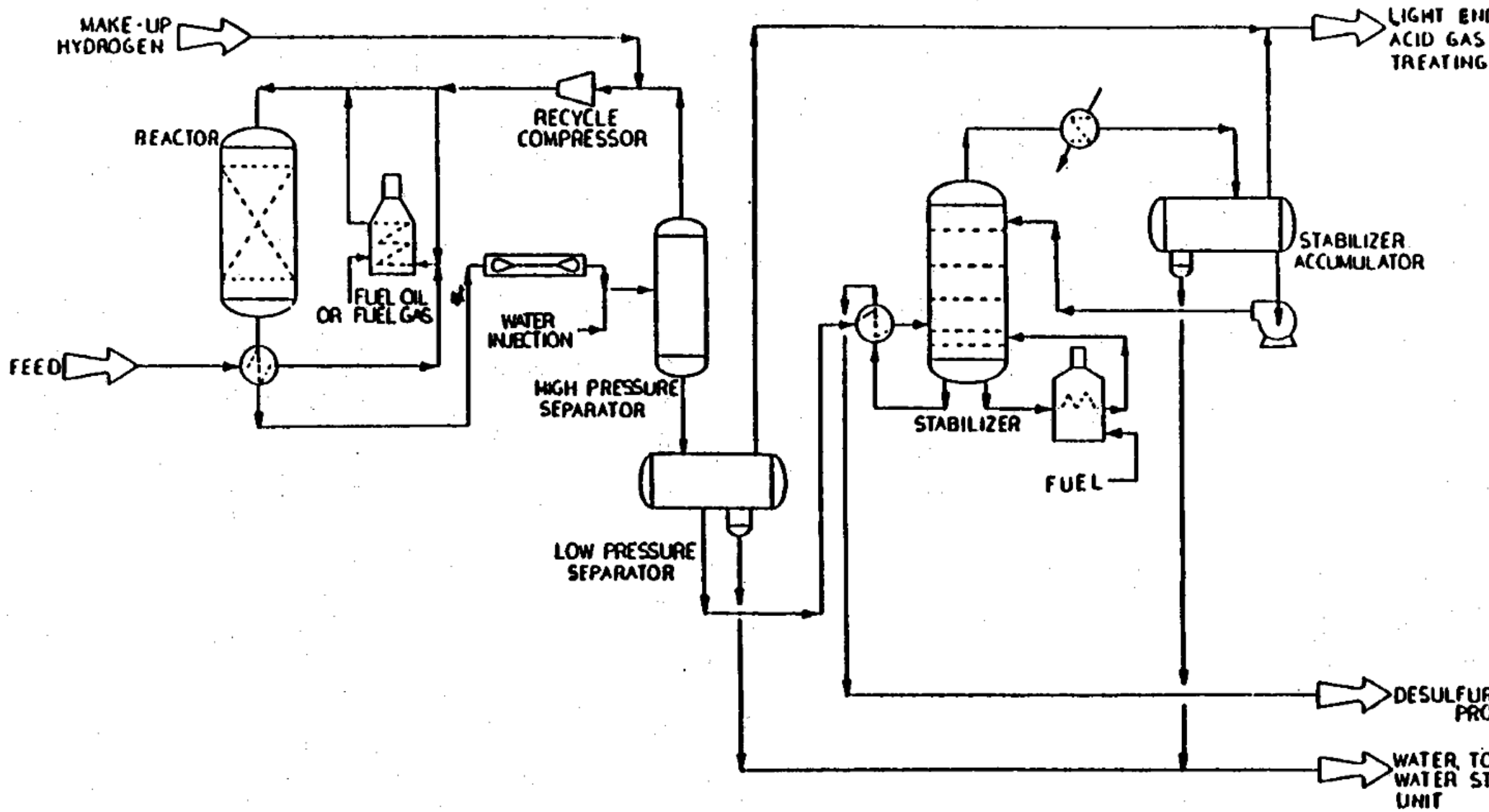
- **PURPOSE:** A process where hydrogen is used to replace contaminants, such as to remove any sulfur, nitrogen, and metallic (nickel and vanadium) contaminants from the process stream, and to saturate olefins and aromatics



Hydrotreating

- **REACTION:** The reaction is accomplished by contacting the untreated petroleum fractions with hydrogen in the presence of a catalyst at a high temperature and pressure

HYDROTREATING UNIT





Hydrotreating Reactor and Pre-Heater

Hydrogen Manufacturing

- **PURPOSE:** The Steam Methane Reforming process creates hydrogen to be used in hydrotreating and hydrocracking.

Hydrogen Manufacturing

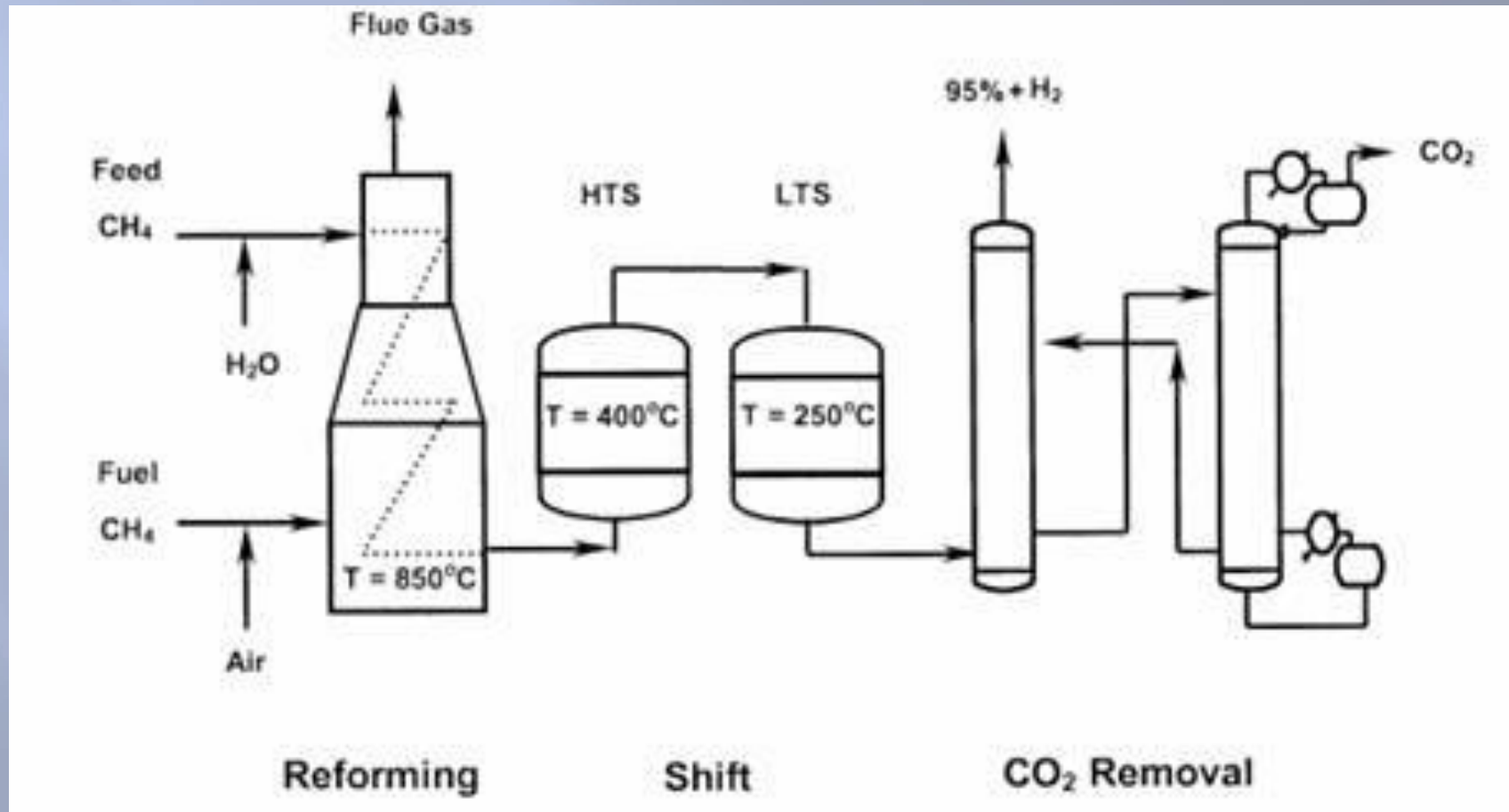
- REACTION: Steam and methane are reacted over a solid bed catalyst in a high intensity reforming furnace. In further processing CO_2 is removed as a by-product. Hydrogen rich product contains small amounts of methane.

Steam Methane Reformer

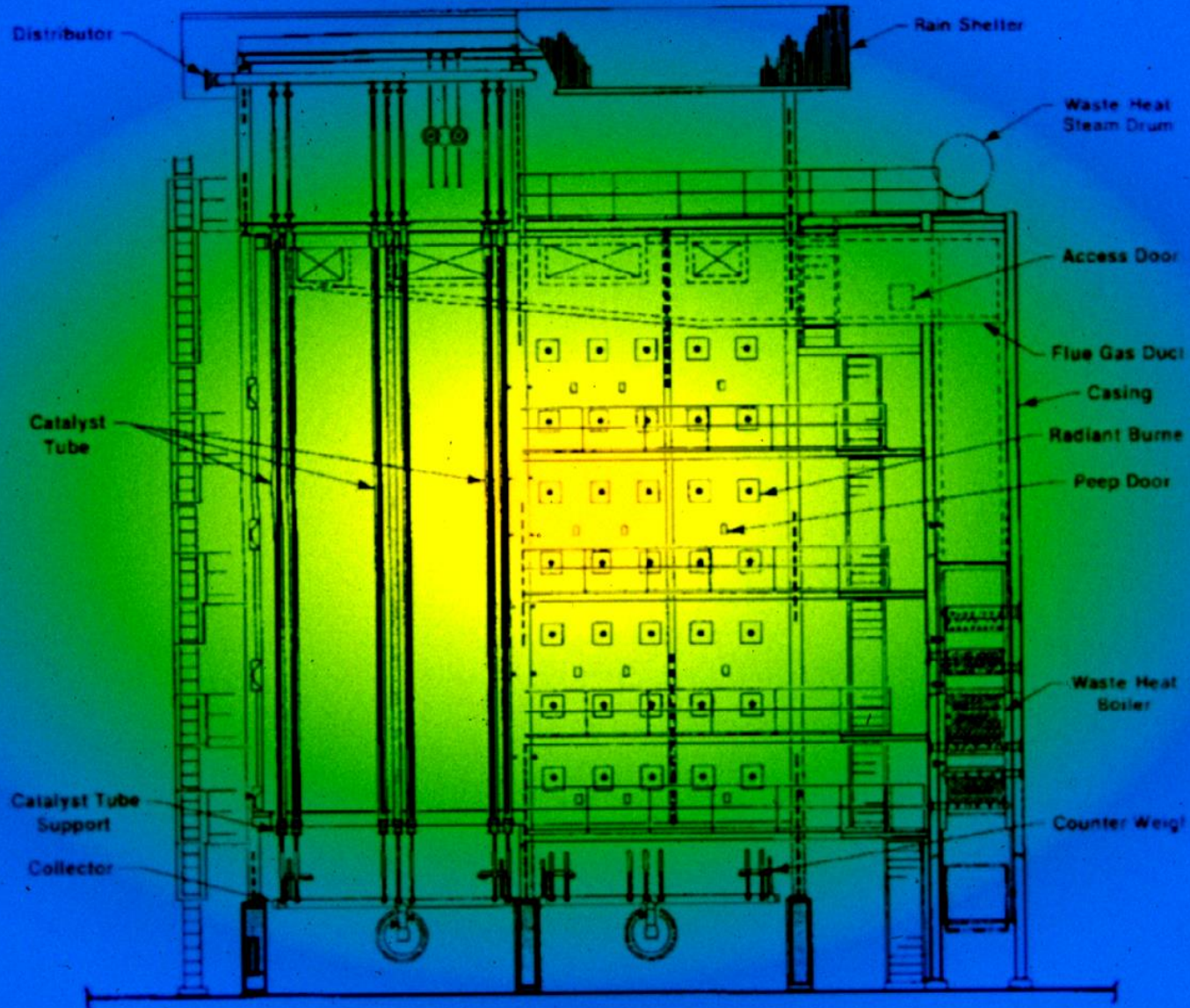
Reformer Reaction
 $\text{CH}_4 + \text{H}_2\text{O} = \text{CO} + 3\text{H}_2$

Shift Reaction
 $\text{CO} + \text{H}_2\text{O} = \text{CO}_2 + \text{H}_2$

CO₂ Removal
Amine Absorption

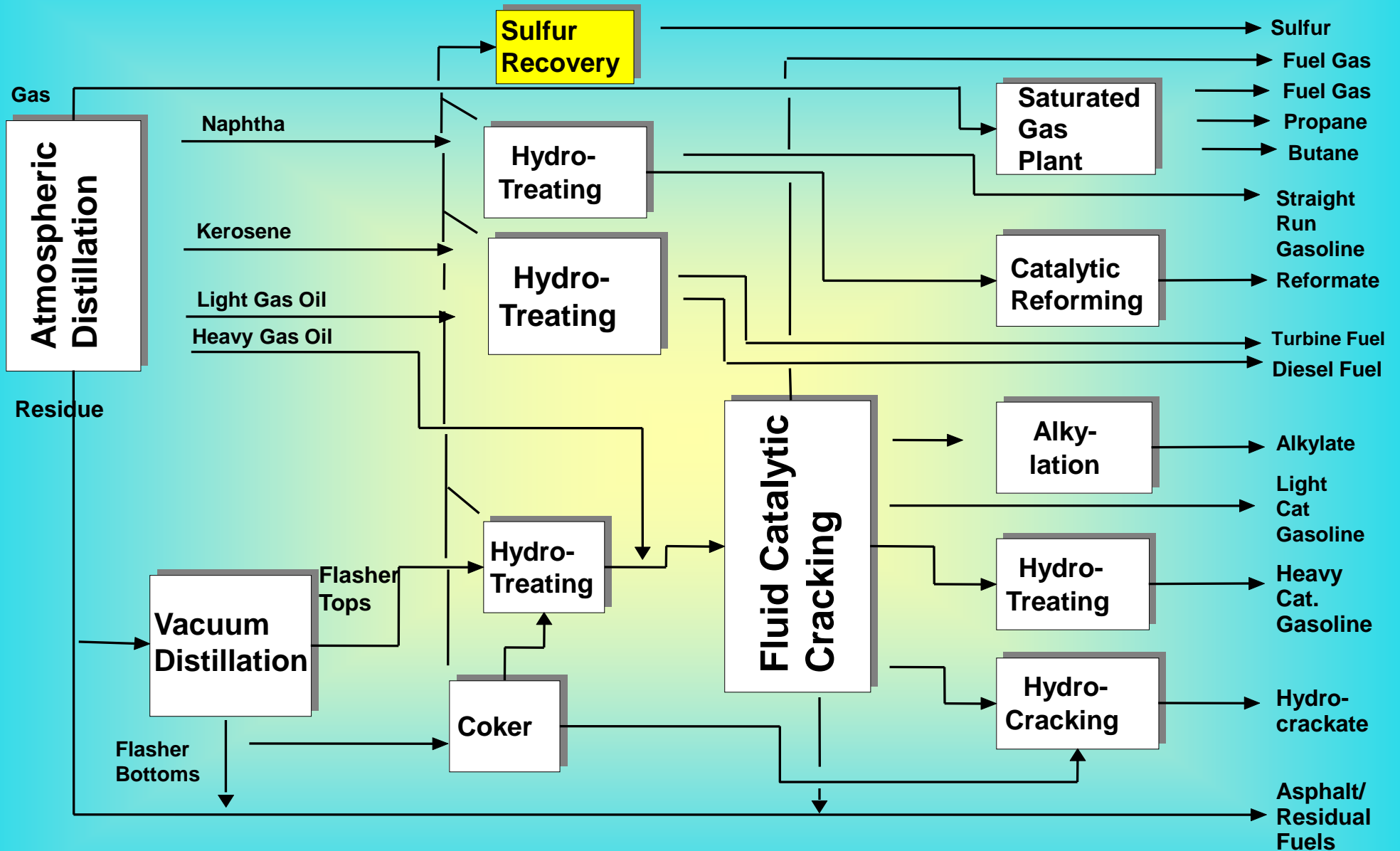


Reforming Furnace



Sulfur Recovery

- **PURPOSE:** To convert the H_2S to elemental sulfur
- **TWO PROCESSES:**
 - (1) Claus Process
 - (2) Tail Gas Treating



Claus Process

- REACTION:
 - H_2S is partially burned with air in a boiler to convert it to SO_2 to create the proper $\text{H}_2\text{S}/\text{SO}_2$ ratio
 - The $\text{H}_2\text{S}/\text{SO}_2$ is then reacted over a catalyst to produce elemental sulfur and water by a shift conversion reaction

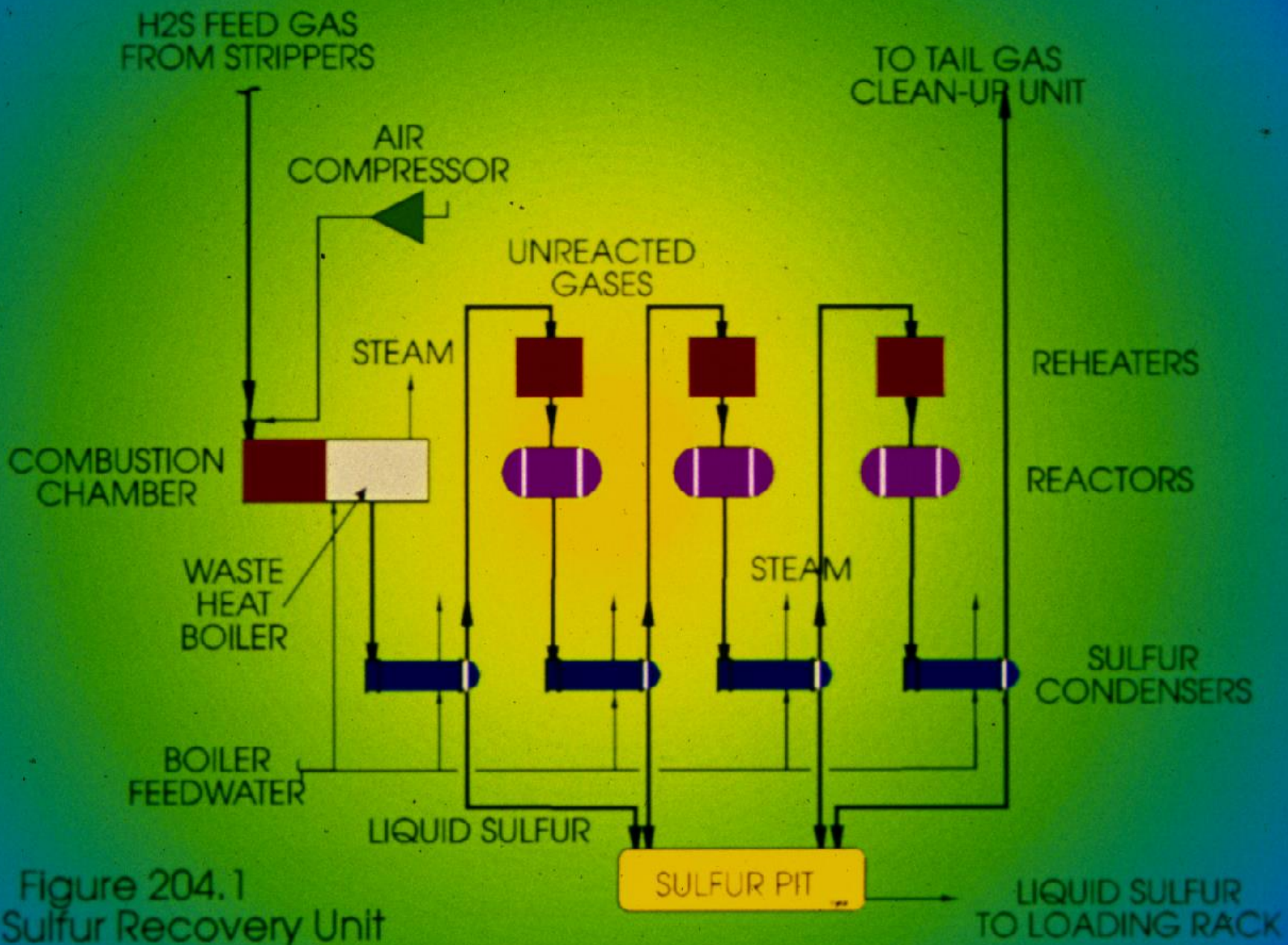
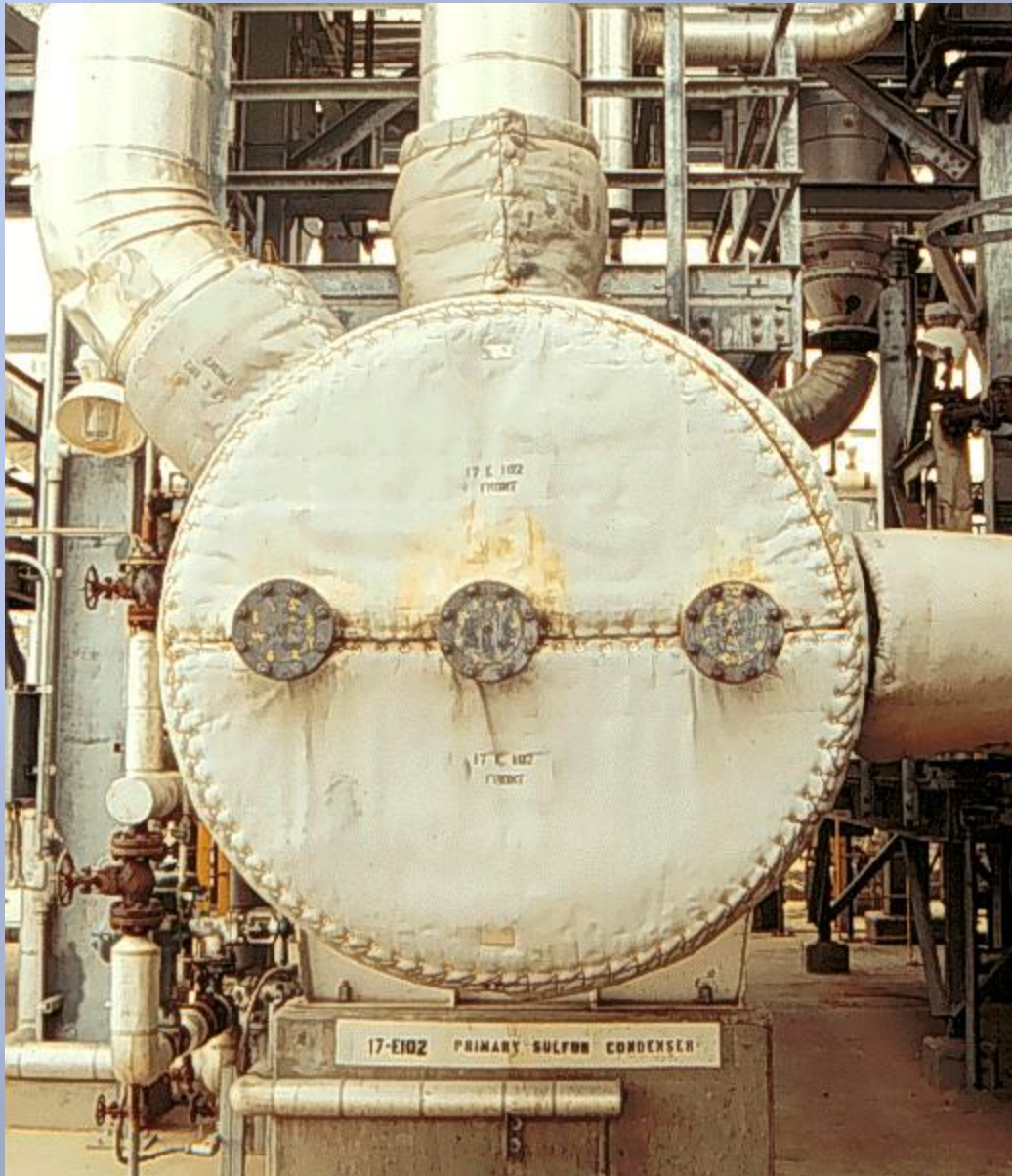


Figure 204.1
Claus Sulfur Recovery Unit

Sulfur Recovery - Thermal Reactor



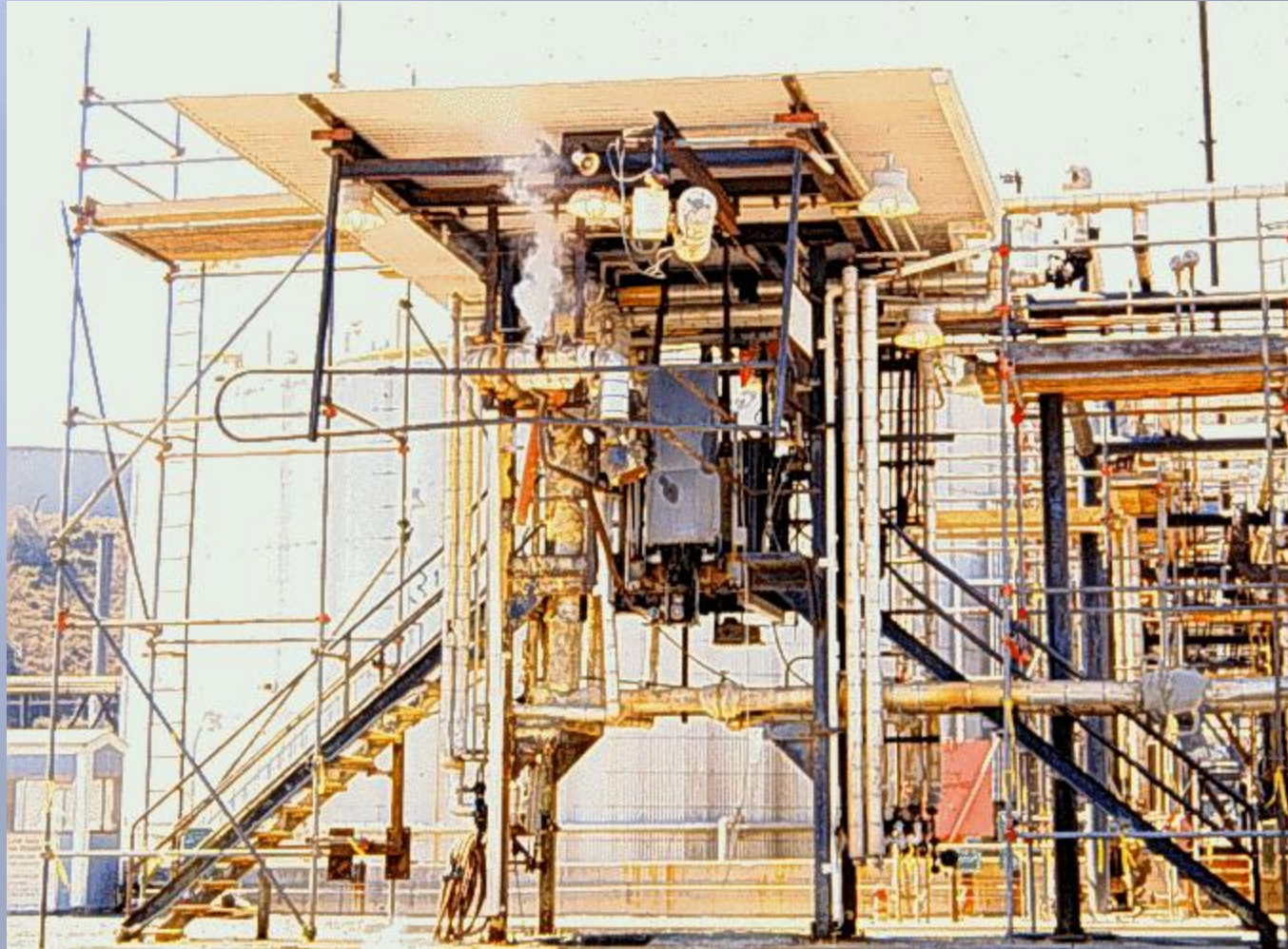


Primary Sulfur Condenser

Molten Sulfur Storage Pit



Molten Sulfur Storage Tank and Loading Rack





Tail Gas Treating Process

- PURPOSE: To remove any traces of H_2S or SO_2 that remain in the tail gas from the Claus Process

Tail Gas Treating Processes

- Beavon Stretford - Reduction
- Wellman-Lord Tail Gas Cleanup - Oxidation

Beavon Stretford

- REACTION: A reduction process that converts all of the sulfur compounds to H_2S . The H_2S is then absorbed in Stretford solution where it reacts to form a froth of elemental sulfur particles.

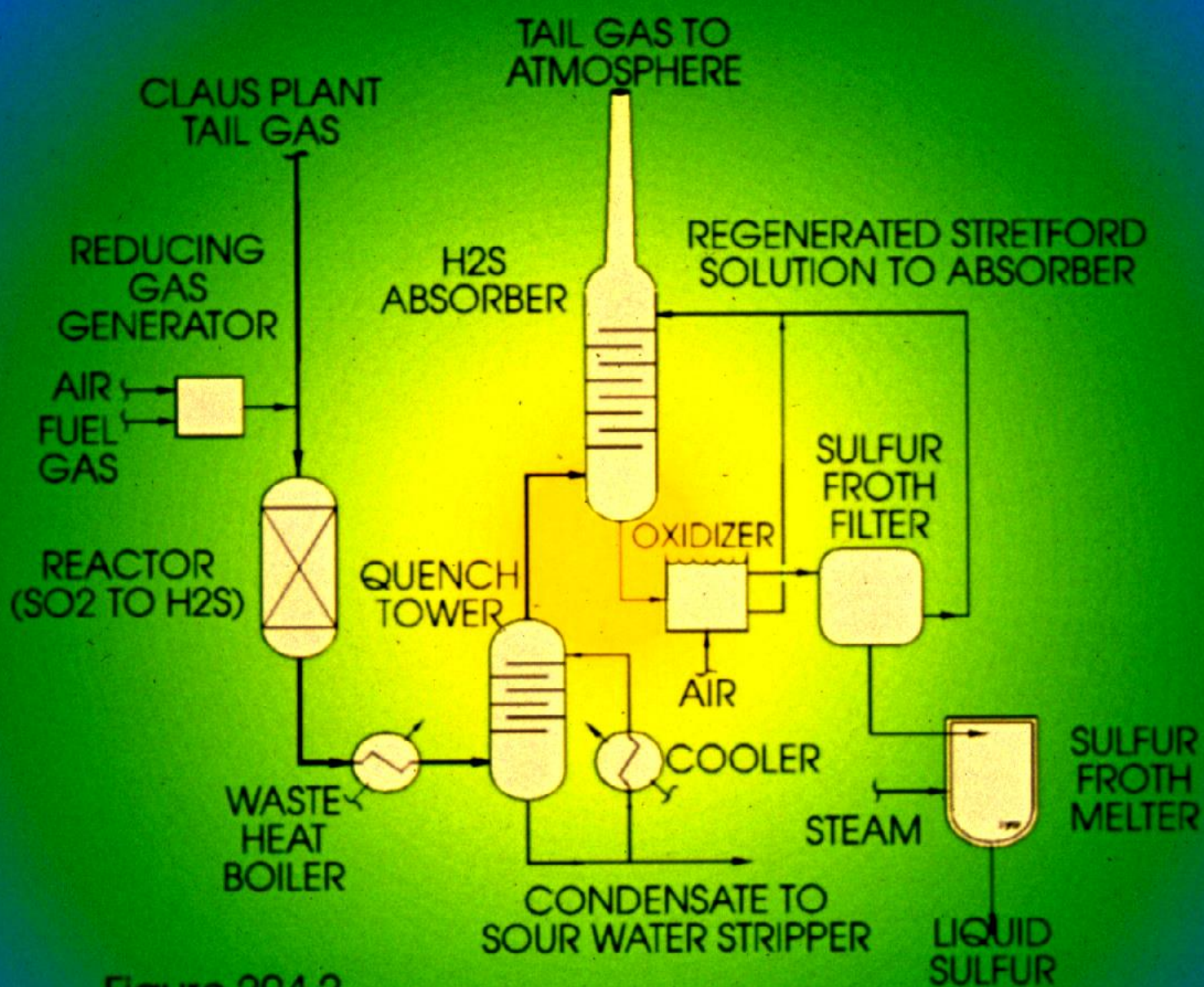


Figure 204.2
Beavon Tail Gas Clean-Up Process

Wellman-Lord Tail Gas Cleanup - Oxidation

- ▣ REACTION: The tail gas stream is incinerated to oxidize sulfur compounds to SO_2 and then is cooled. It then enters an absorption tower and contacts a solution of sodium sulfite forming sodium bisulfite. The SO_2 rich solution is then heated to drive off SO_2 . The SO_2 is then recycled back to the Claus Plant.

Sulfur Recovery - Acid Gas Knockout



Inspection Points

Form: Figure 204.5, Page 204-21/22

- Visible Emissions (VE)
- Odor
- Sulfur Production Rate
- Acid Gas Feed Rate
- CEMs

Odor Sources

- Sour Water Tankage
- Sour Caustic Tankage
- H₂S Absorption Tower
- H₂S Stripping Tower
- Truck Loading Facility
- Sumps



Quick Review 4

- Treatment
 - Remove and/or recover contaminants
- Processes
 - Acid and Caustic Washes
 - Filtration
 - Sulfur Removal - Absorption
 - Hydrotreating / Hydrogen Manufacturing
 - Sulfur Recovery
 - Claus Plant
 - Tail gas treatment

