Course 288
Petroleum Refining
2017

PROCESSES

SEPARATION AND TREATMENT

The National Air Compliance Training Program


Mobil
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

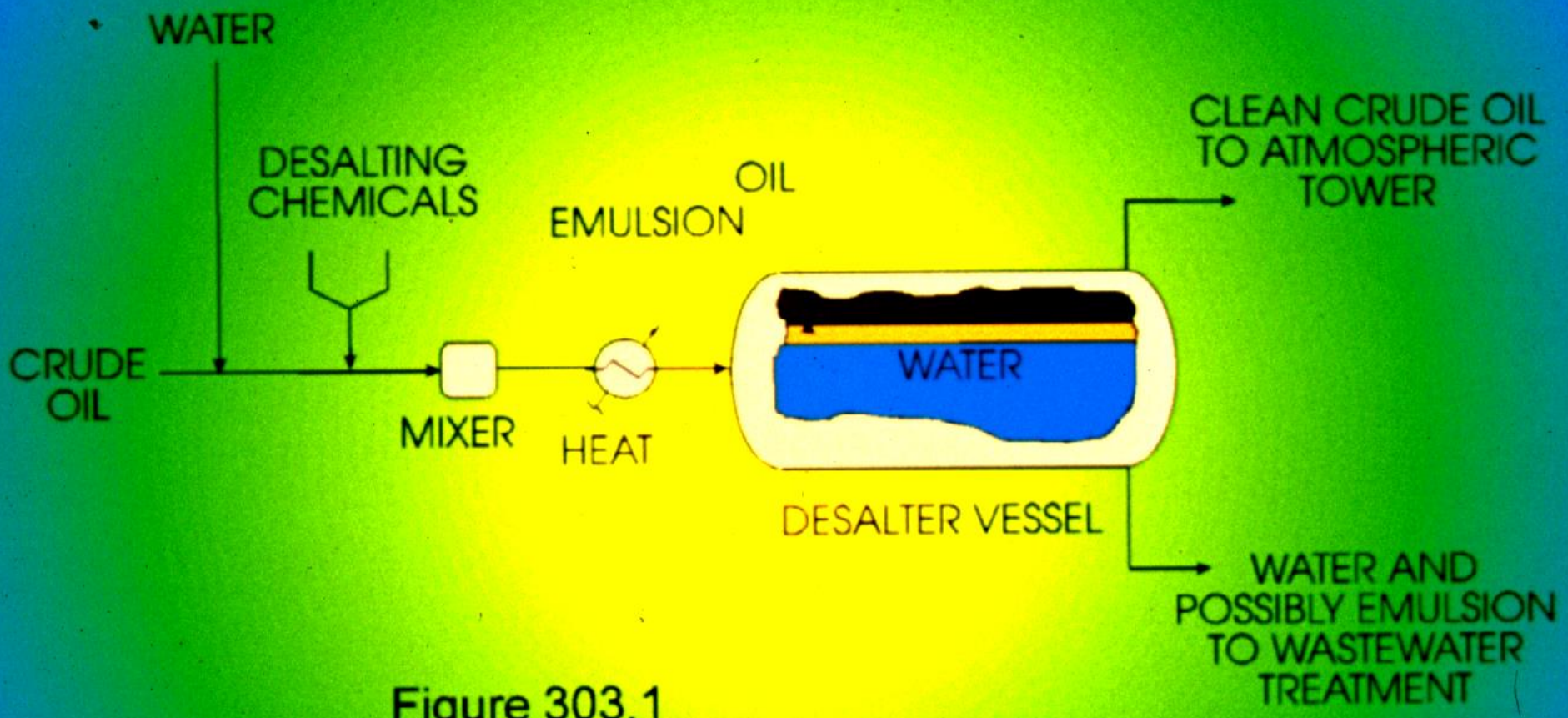
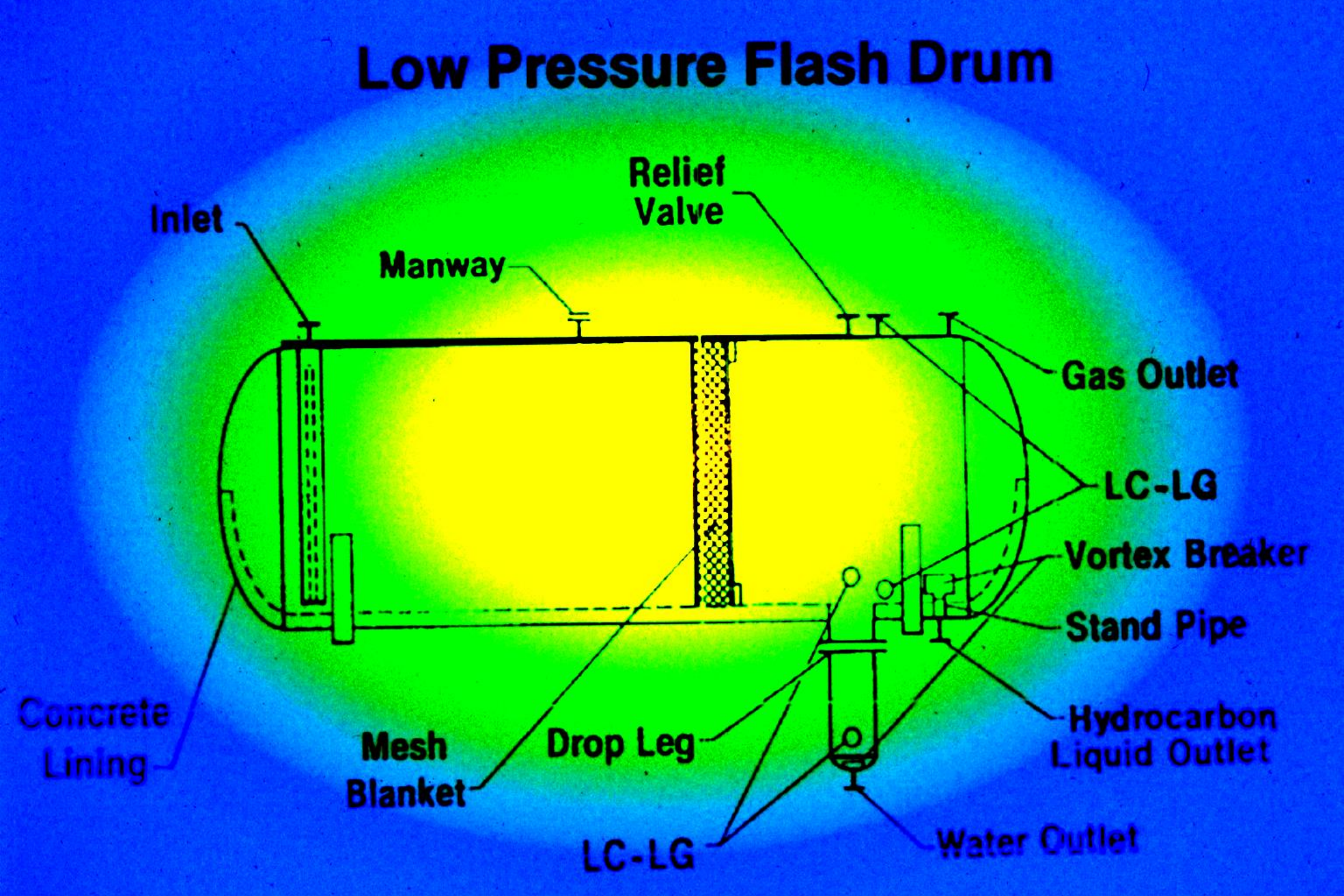


Figure 303.1
Crude Desalter

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

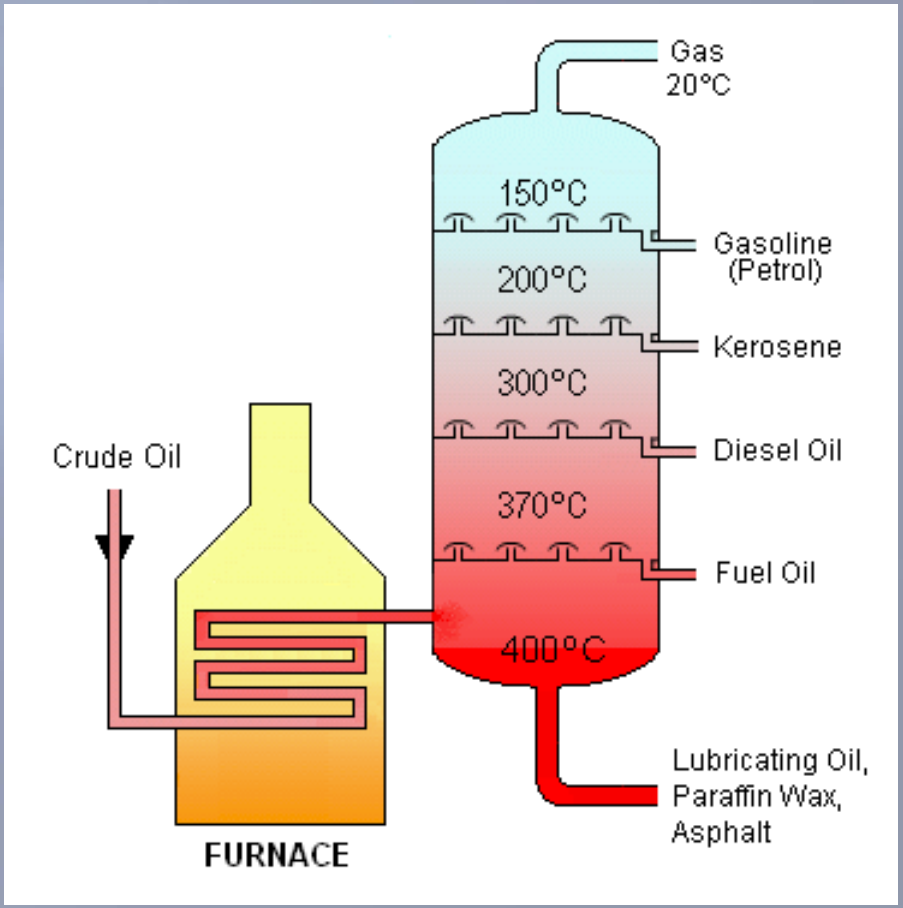


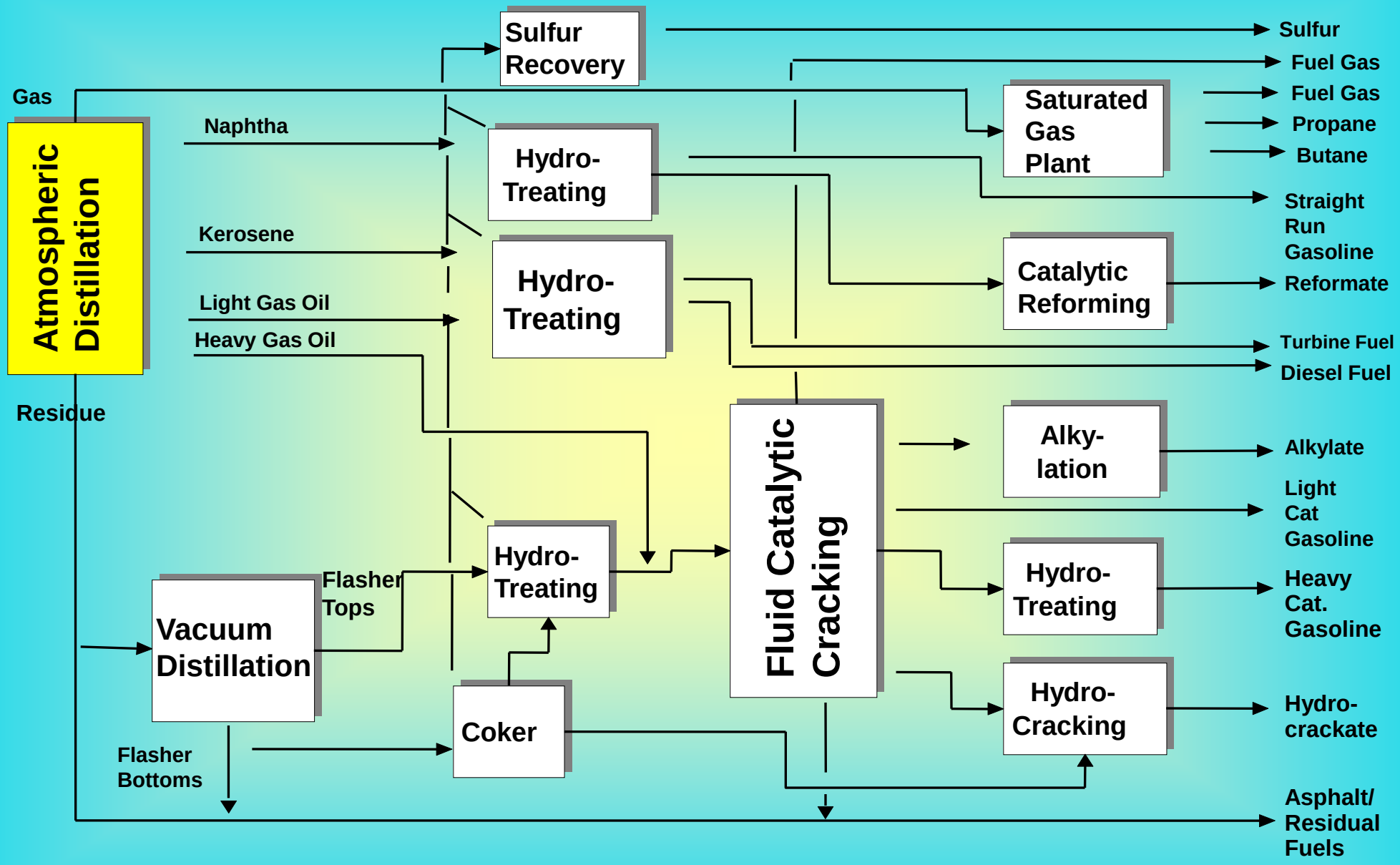
Steam Stripping

- 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

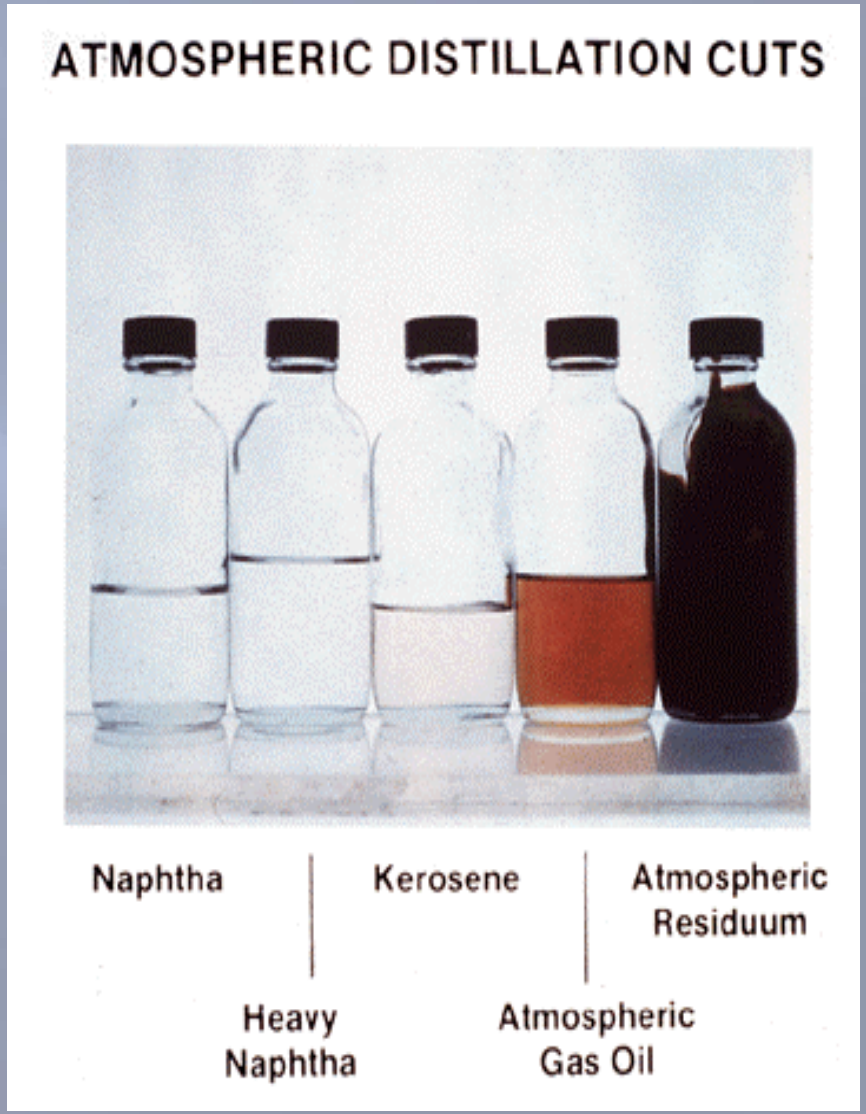
- PURPOSE: To separate the crude petroleum into various fractions which then can be refined into final products




Sulfur Recovery
Sulfur
Fuel Gas
Gas
Saturated Gas Plant
Fuel Gas
Propane
Butane
Naphtha
Hydro-Treating
Straight Run Gasoline
Atmospheric Distillation
Kerosene
Hydro-Treating
Catalytic Reforming
Reformate
Light Gas Oil
Heavy Gas Oil
Turbine Fuel
Diesel Fuel
Residue
Fluid Catalytic Cracking
Alky-lation
Alkylate
Light Cat Gasoline
Hydro-Treating
Flasher Tops
Hydro-Treating
Heavy Cat. Gasoline
Vacuum Distillation
Coker
Hydro-Cracking
Hydro-crackate
Flasher Bottoms
Asphalt/ Residual Fuels

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



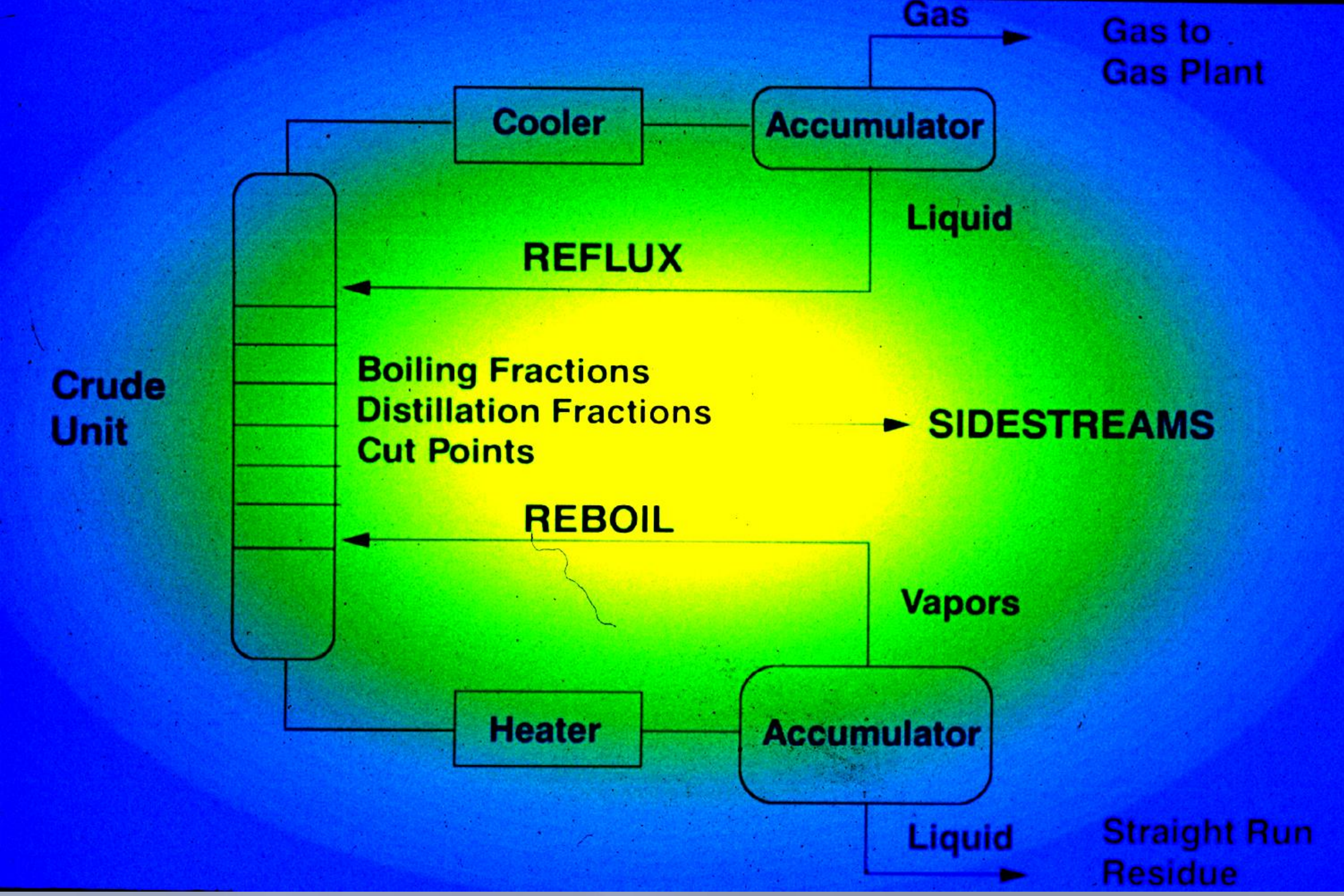
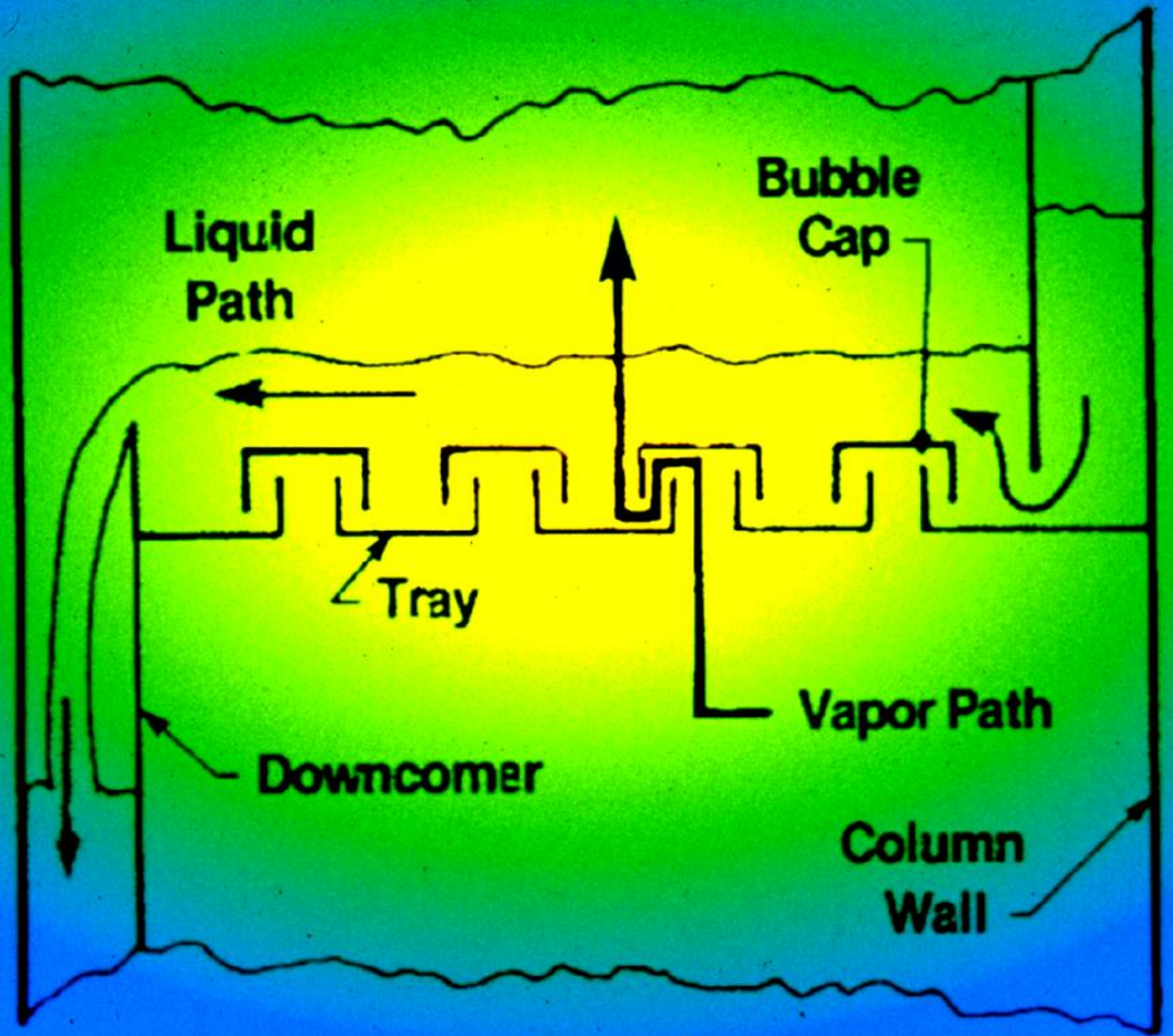
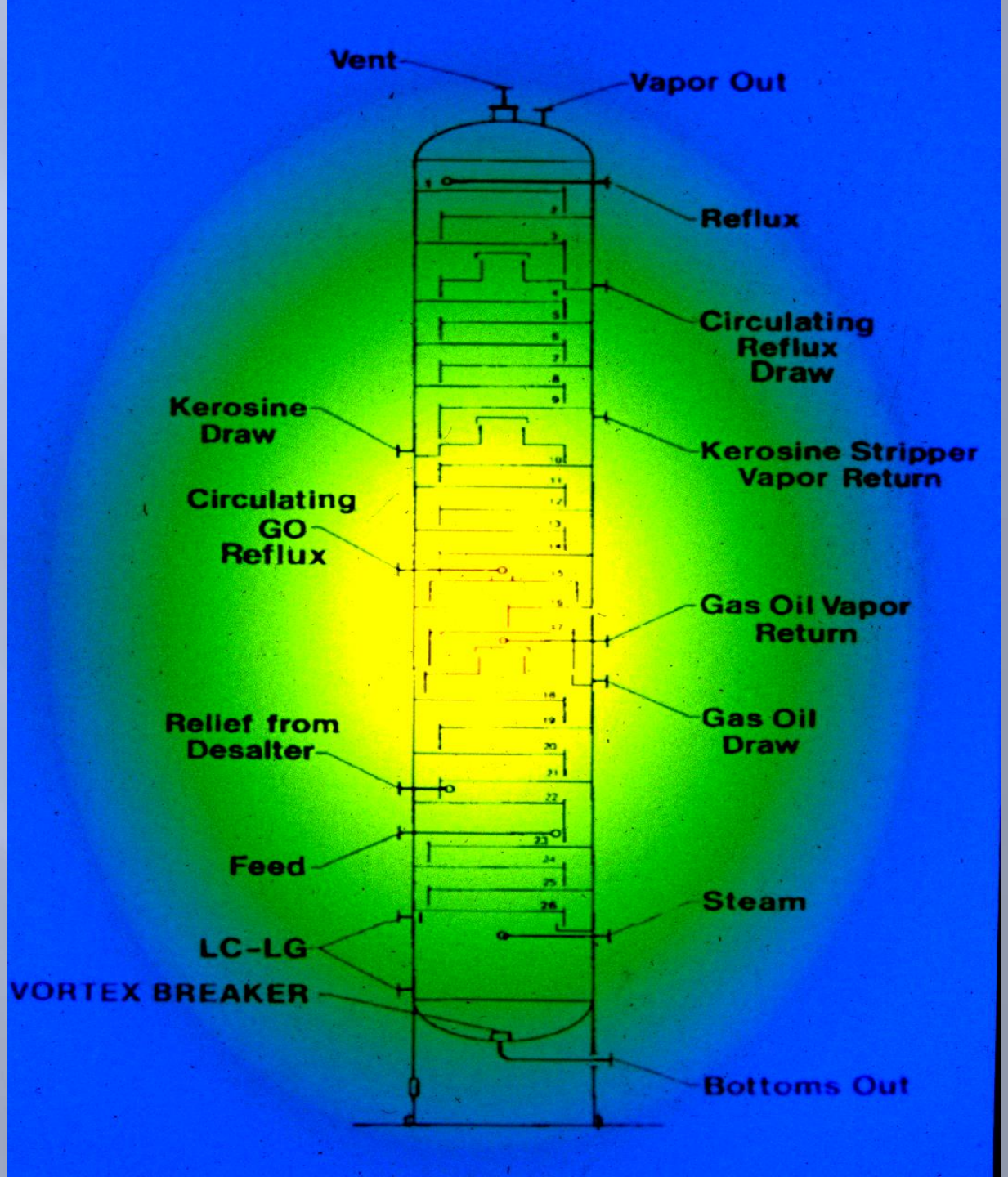
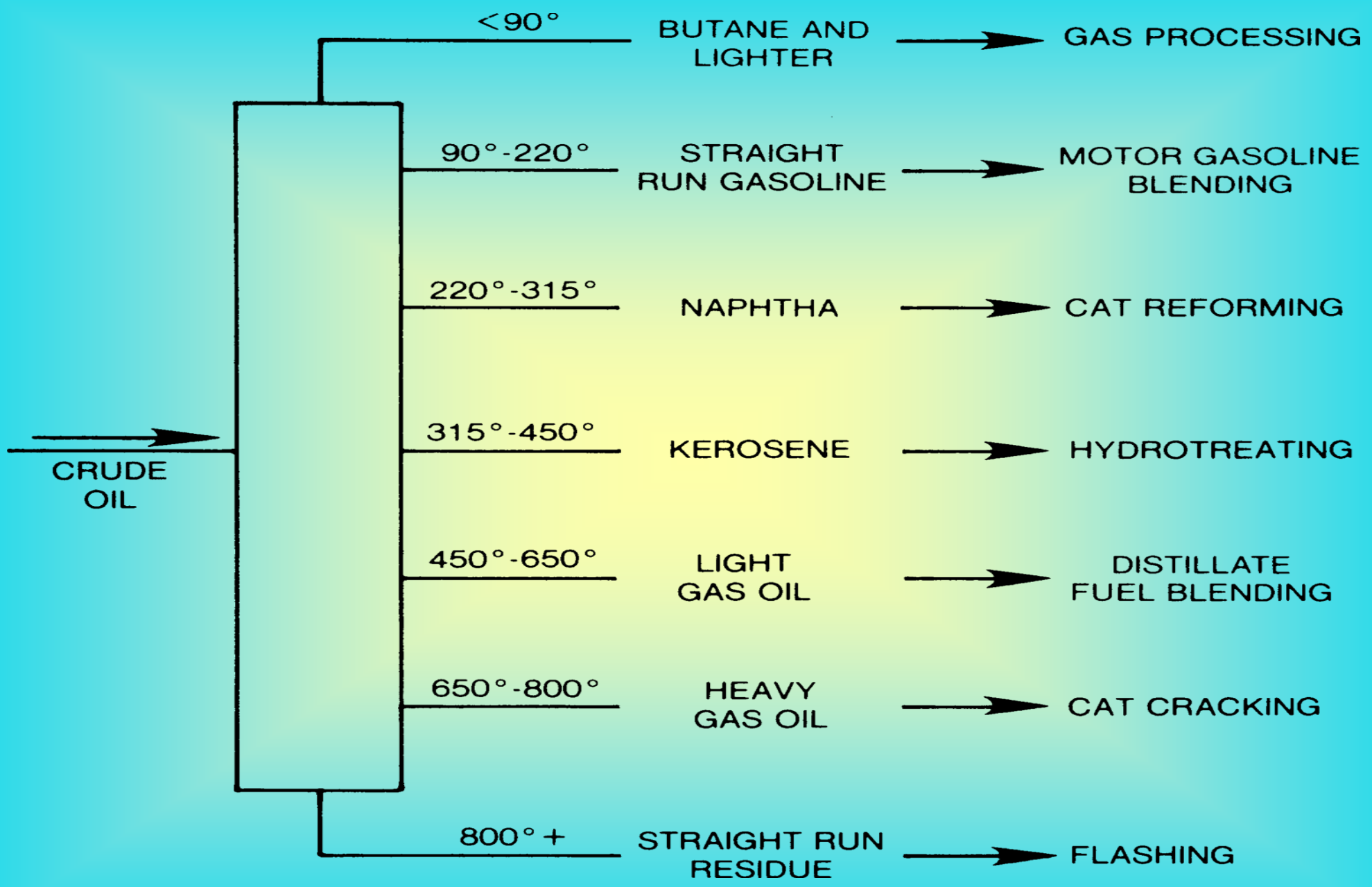

Gas
Gas to
Gas Plant
Cooler
Accumulator
Liquid
REFLUX
Crude
Unit
Boiling Fractions
Distillation Fractions
Cut Points
SIDESTREAMS
REBOIL
Vapors
Heater
Accumulator
Liquid
Straight Run
Residue

Diagram of a Typical Tray



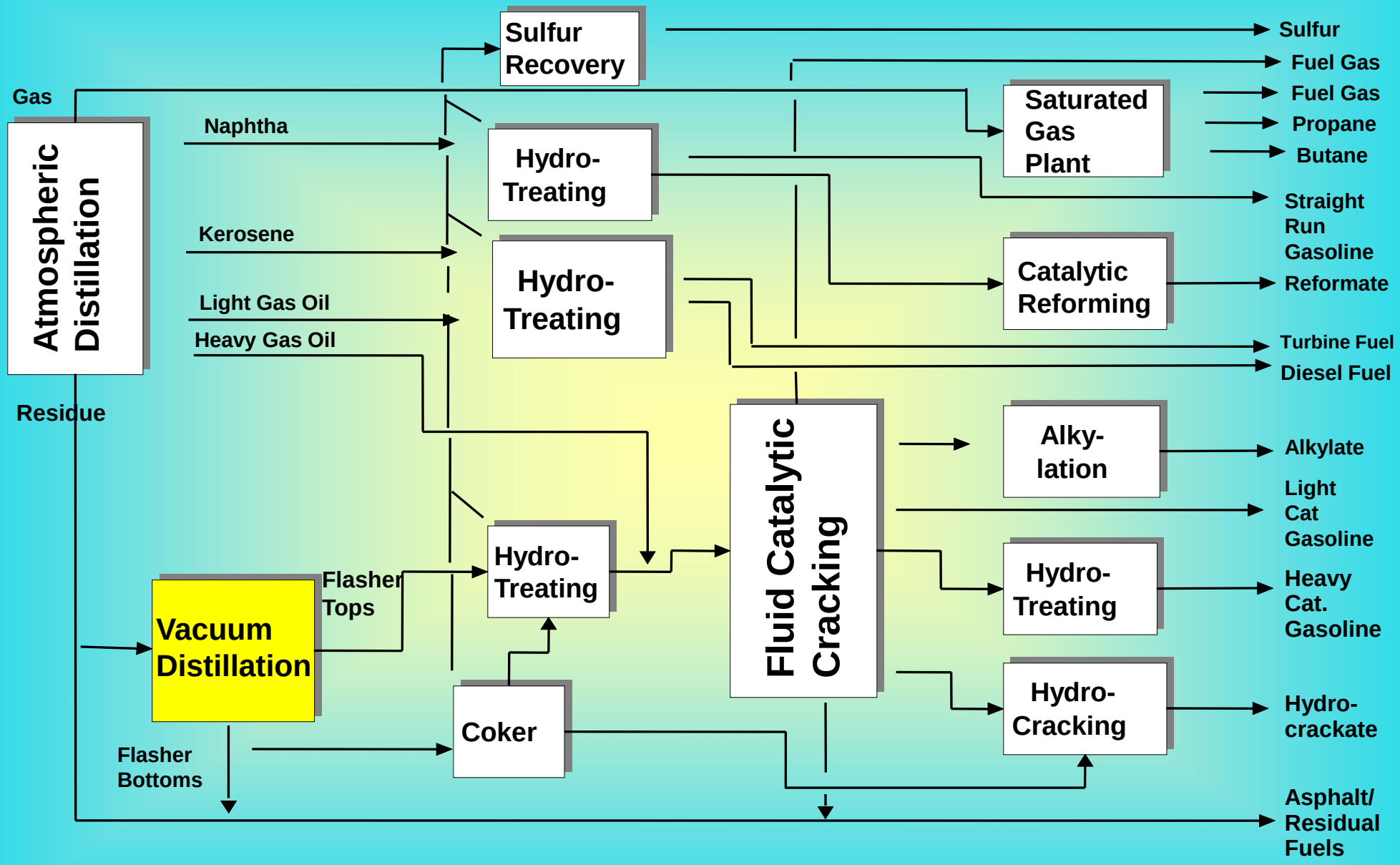

Vent
Vapor Out
Reflux
Circulating
Reflux
Draw
Kerosine
Draw
Kerosine Stripper
Vapor Return
Circulating
GO
Reflux
Gas Oil Vapor
Return
Gas Oil
Draw
Relief from
Desalter
Feed
Steam
LC-LG
VORTEX BREAKER
Bottoms Out

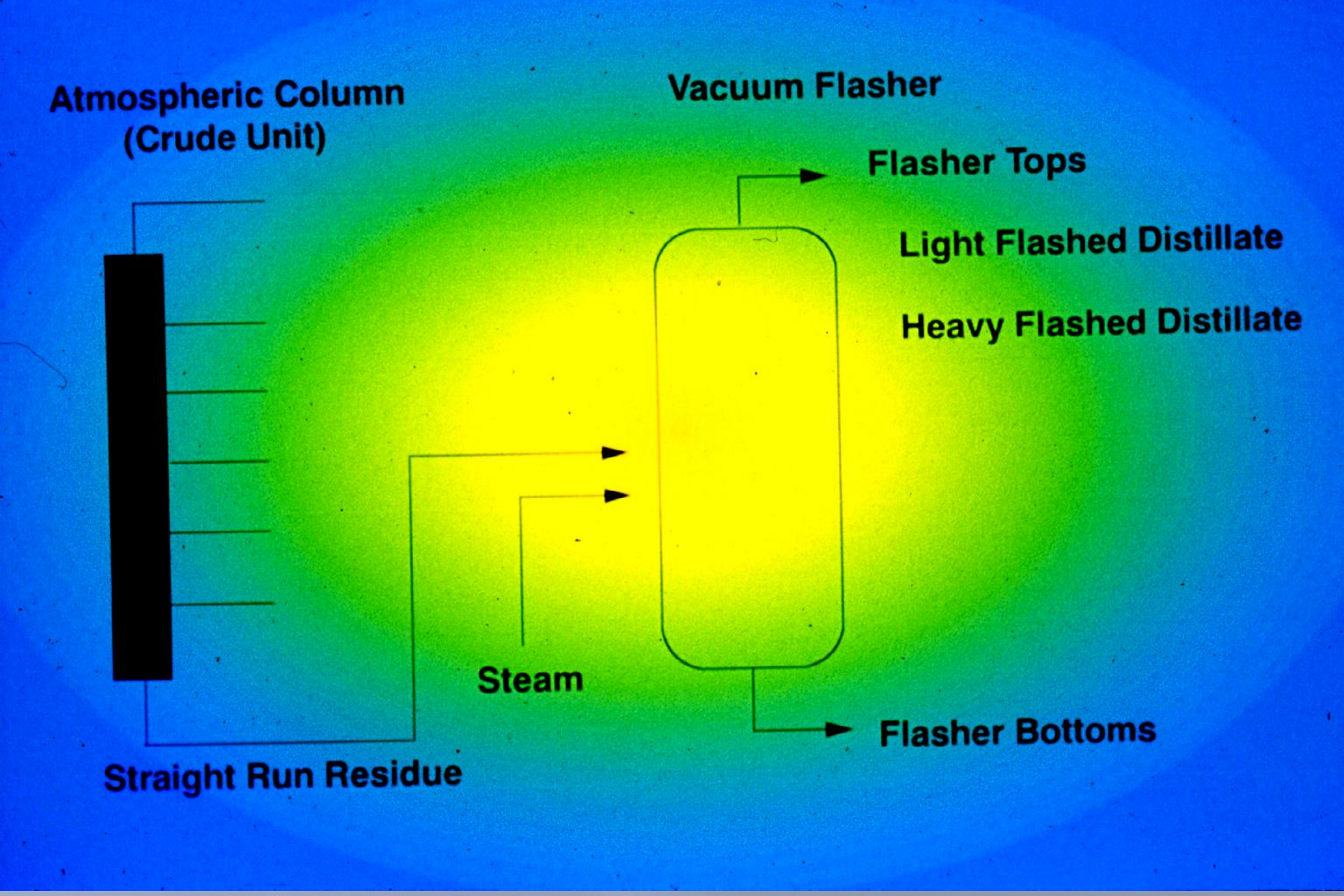

<90°
BUTANE AND LIGHTER
GAS PROCESSING
90°-220°
STRAIGHT RUN GASOLINE
MOTOR GASOLINE BLENDING
220°-315°
NAPHTHA
CAT REFORMING
315°-450°
KEROSENE
HYDROTREATING
CRUDE OIL
450°-650°
LIGHT GAS OIL
DISTILLATE FUEL BLENDING
650°-800°
HEAVY GAS OIL
CAT CRACKING
800°+
STRAIGHT RUN RESIDUE
FLASHING

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.


Sulfur Recovery
Sulfur
Gas
Fuel Gas
Saturated Gas Plant
Fuel Gas
Propane
Butane
Naphtha
Hydro-Treating
Straight Run Gasoline
Kerosene
Hydro-Treating
Catalytic Reforming
Reformate
Light Gas Oil
Heavy Gas Oil
Turbine Fuel
Diesel Fuel
Atmospheric Distillation
Residue
Fluid Catalytic Cracking
Alky-lation
Alkylate
Light Cat Gasoline
Hydro-Treating
Flasher Tops
Hydro-Treating
Heavy Cat. Gasoline
Vacuum Distillation
Coker
Hydro-Cracking
Hydro-crackate
Flasher Bottoms
Asphalt/ Residual Fuels


Atmospheric Column
(Crude Unit)
Vacuum Flasher
Flasher Tops
Light Flashed Distillate
Heavy Flashed Distillate
Steam
Flasher Bottoms
Straight Run Residue

Vacuum Distillation

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

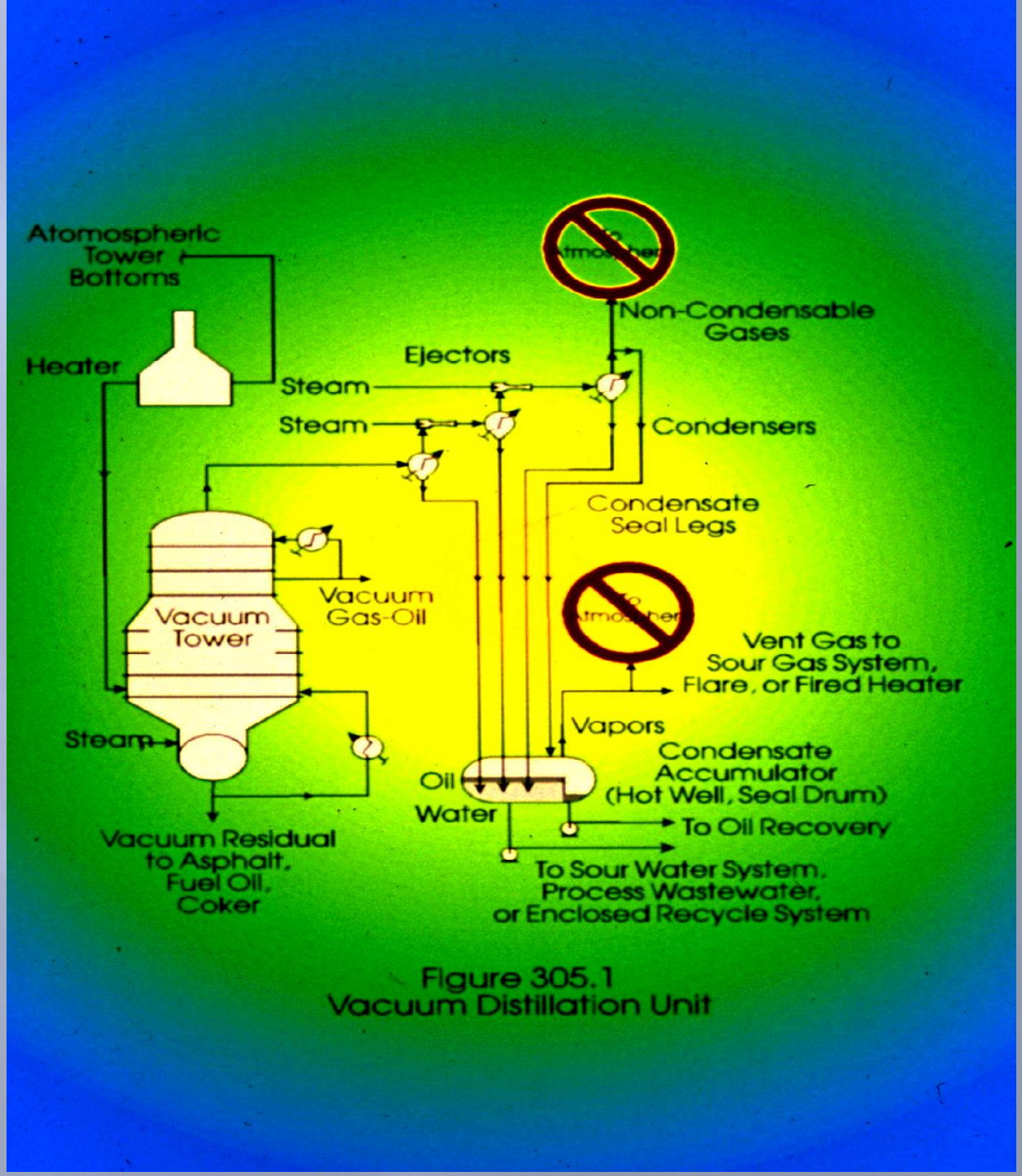


Figure 305.1
Vacuum Distillation Unit

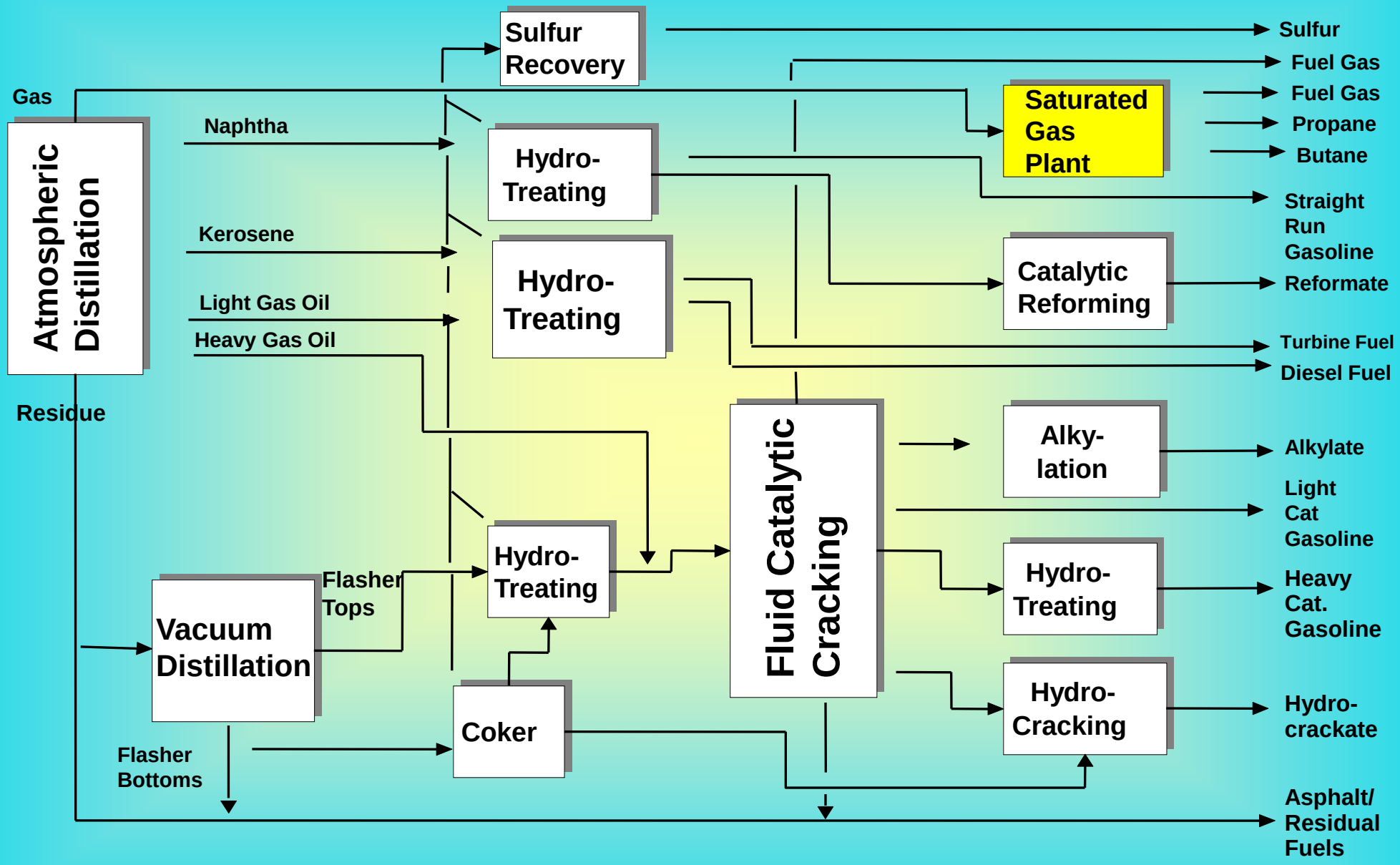
Vacuum Distillation Tower

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.


Sulfur Recovery
Sulfur
Fuel Gas
Gas
Saturated Gas Plant
Fuel Gas
Propane
Butane
Naphtha
Hydro-Treating
Straight Run Gasoline
Kerosene
Hydro-Treating
Catalytic Reforming
Reformate
Light Gas Oil
Heavy Gas Oil
Turbine Fuel
Diesel Fuel
Atmospheric Distillation
Residue
Fluid Catalytic Cracking
Alky-lation
Alkylate
Light Cat Gasoline
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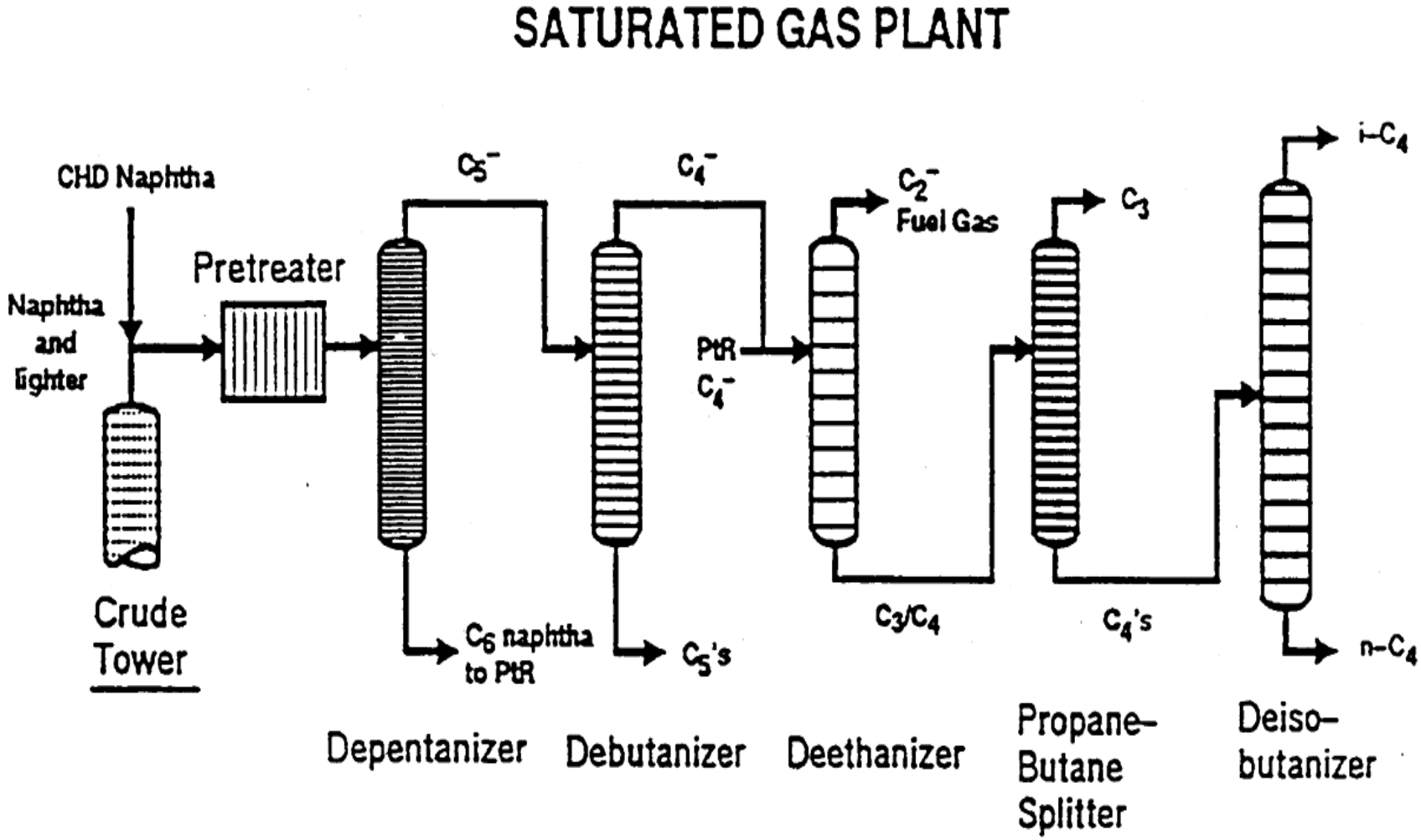
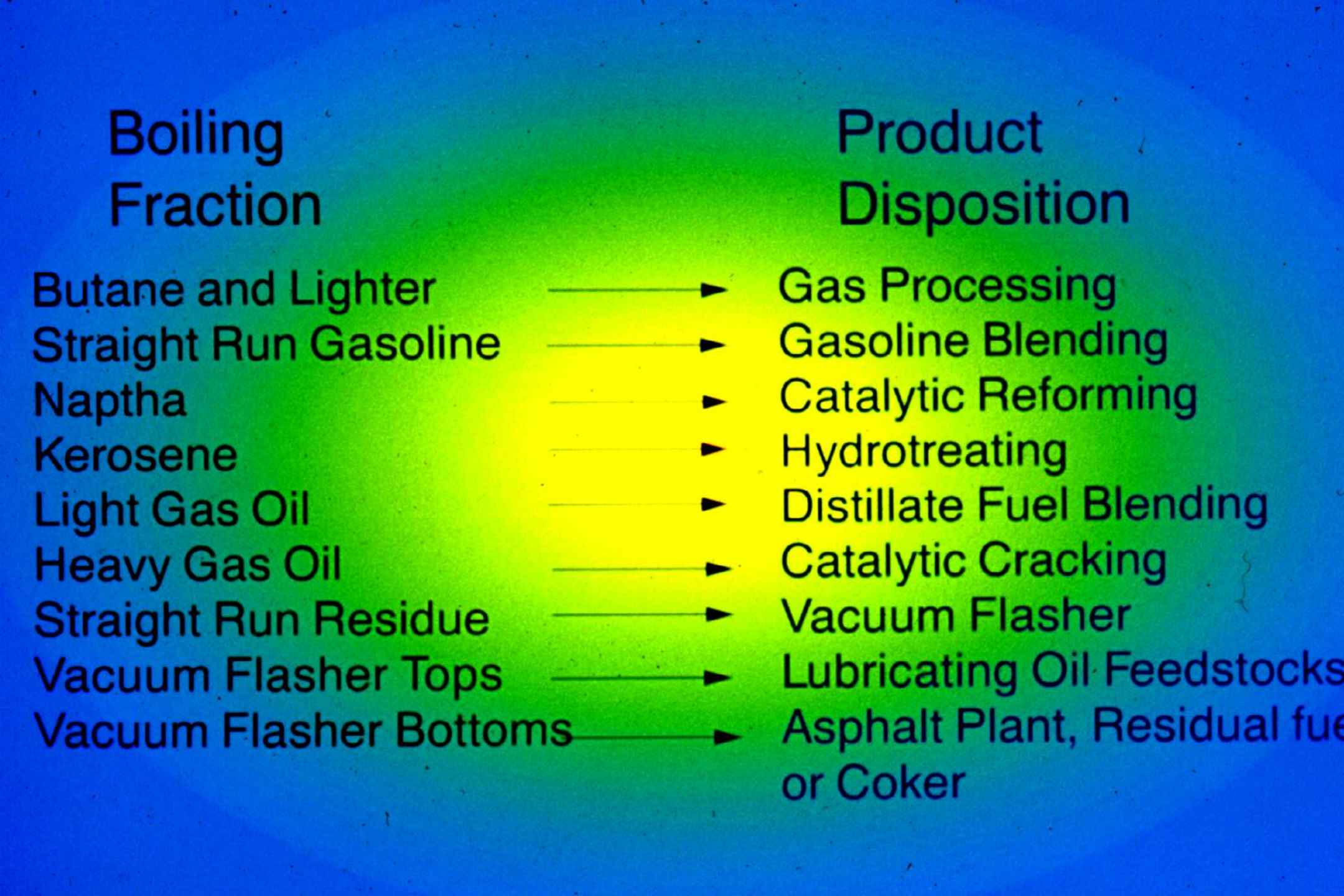
Flasher Tops
Hydro-Treating
Heavy Cat. Gasoline
Vacuum Distillation
Coker
Hydro-Cracking
Hydro-crackate
Flasher Bottoms
Asphalt/ Residual Fuels

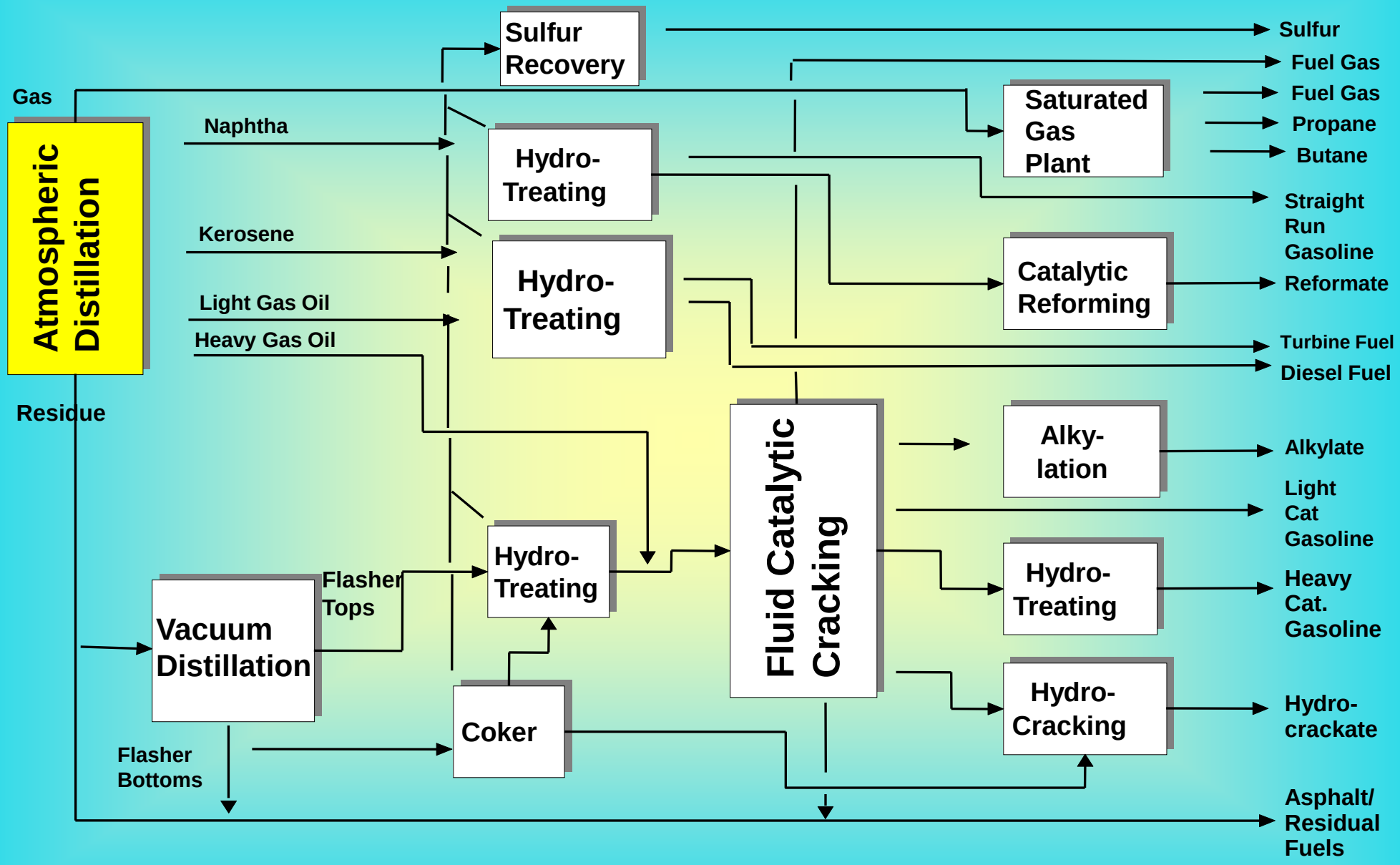

SATURATED GAS PLANT
CHD Naphtha
Naphtha and lighter
Pretreater
Crude Tower
C_5^-
C_6 naphtha to PtR
C_4^-
C_5's
PtR C_4^-
C_2^- Fuel Gas
C_3/C_4
C_3
C_4's
i-C_4
n-C_4
Depentanizer
Debutanizer
Deethanizer
Propane–Butane Splitter
Deiso–butanizer

Gas Recovery Unit


Boiling Fraction
Product Disposition
Butane and Lighter
Straight Run Gasoline
Naptha
Kerosene
Light Gas Oil
Heavy Gas Oil
Straight Run Residue
Vacuum Flasher Tops
Vacuum Flasher Bottoms
Gas Processing
Gasoline Blending
Catalytic Reforming
Hydrotreating
Distillate Fuel Blending
Catalytic Cracking
Vacuum Flasher
Lubricating Oil Feedstocks
Asphalt Plant, Residual fue
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


Sulfur Recovery
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Fuel Gas
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Saturated Gas Plant
Fuel Gas
Propane
Butane
Naphtha
Hydro-Treating
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Atmospheric Distillation
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Hydro-Treating
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Coker
Hydro-Cracking
Hydro-crackate
Flasher Bottoms
Asphalt/ Residual Fuels

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

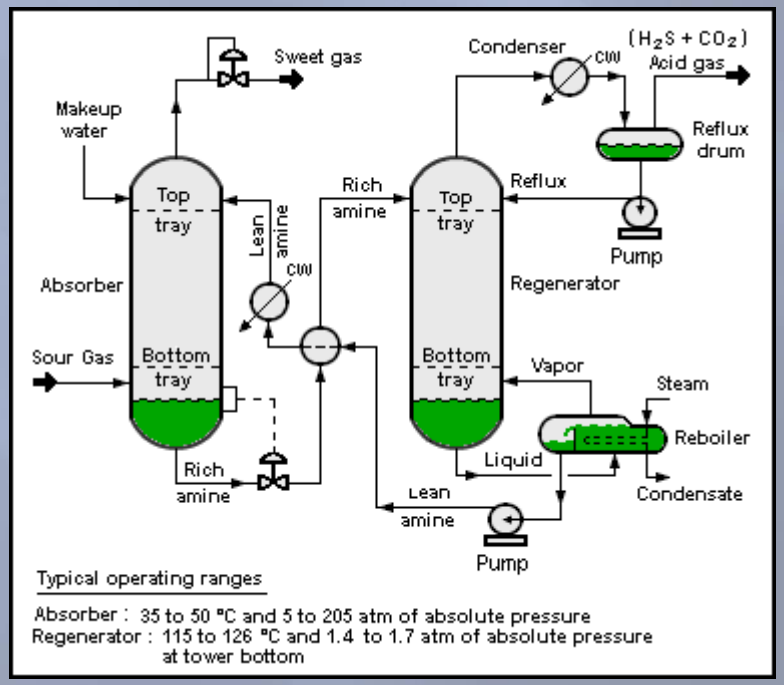
Lean Amine Filter System

Sulfur Removal - Absorption

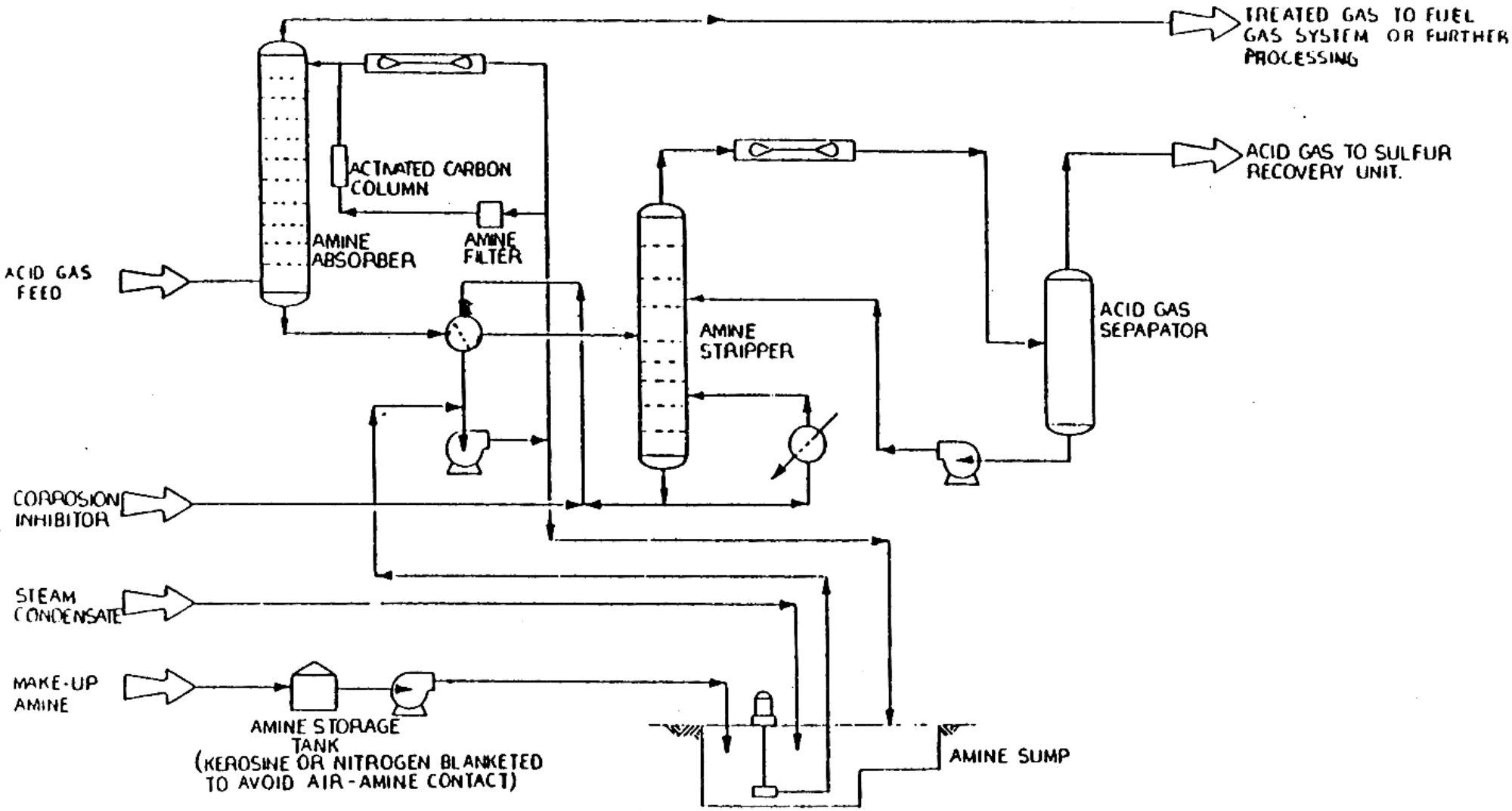
- PURPOSE: To remove H_2S from gaseous process streams, usually fuel gas

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.

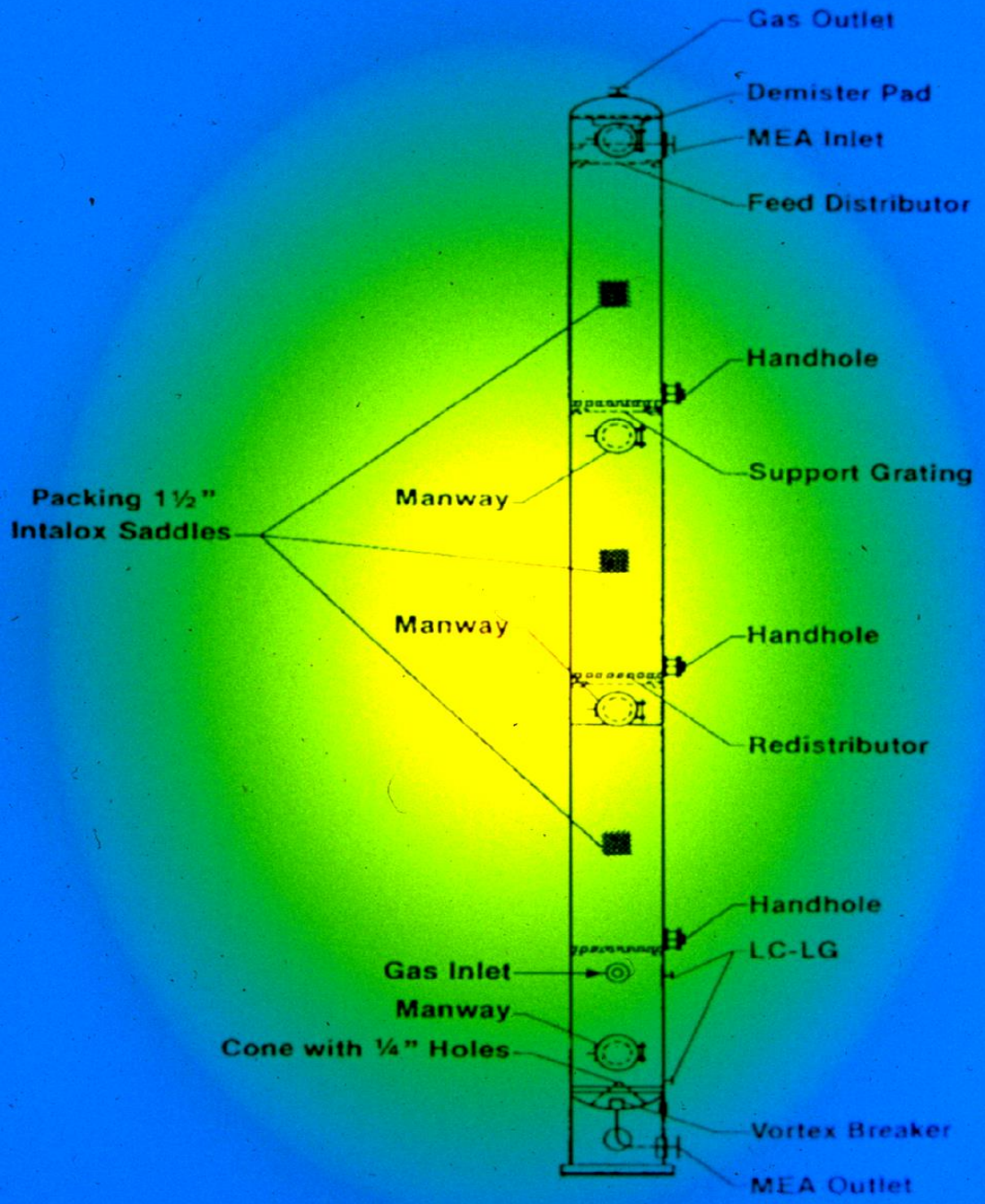


ACID GAS TREATING UNIT



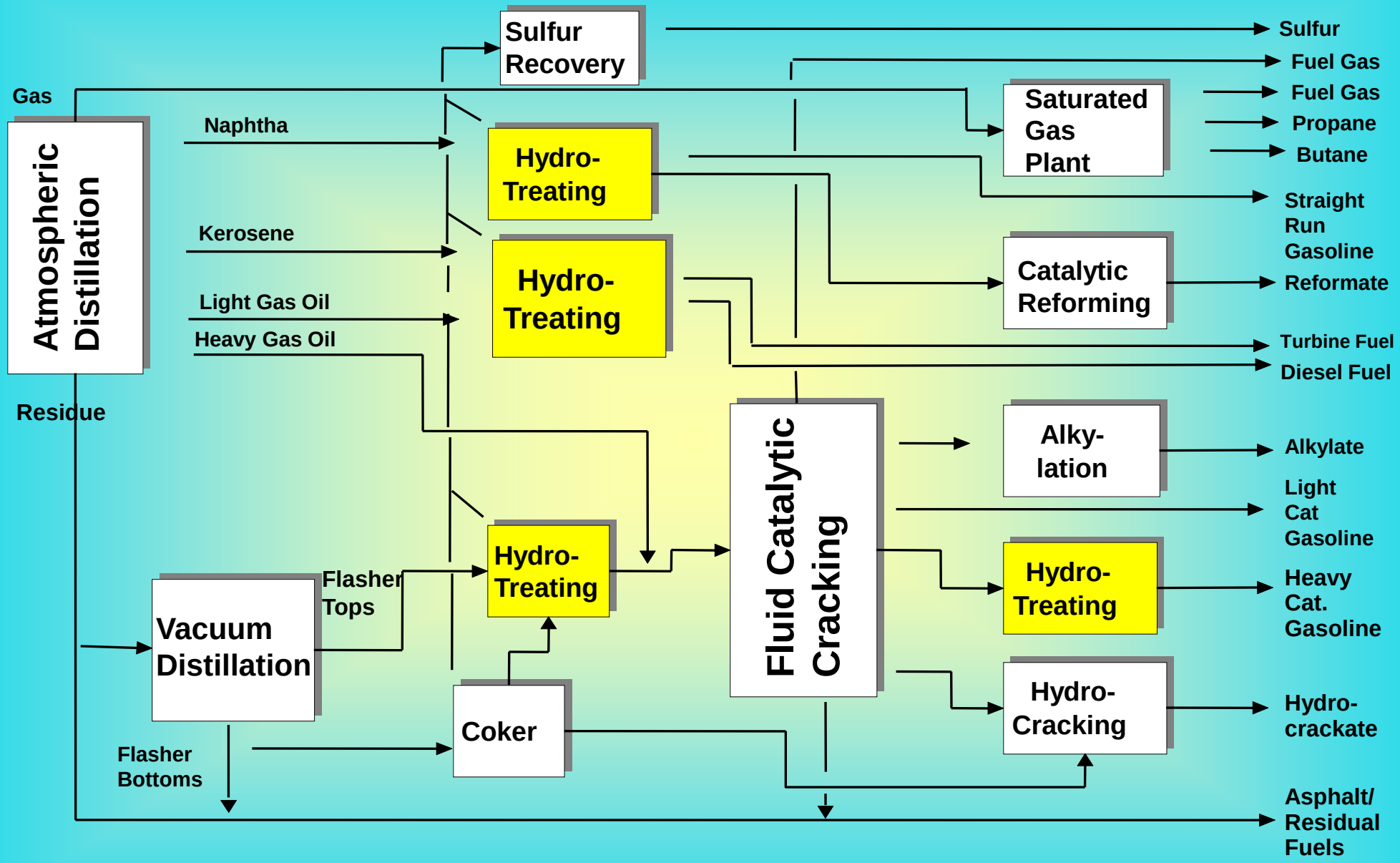
Amine - H_2S Removal Unit

Amine-H_2S Absorber


Gas Outlet
Demister Pad
MEA Inlet
Feed Distributor
Handhole
Support Grating
Packing 1½"
Intalox Saddles
Manway
Manway
Handhole
Redistributor
Handhole
LC-LG
Gas Inlet
Manway
Cone with ¼" Holes
Vortex Breaker
MEA Outlet

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


Sulfur Recovery
Sulfur
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Alkylate
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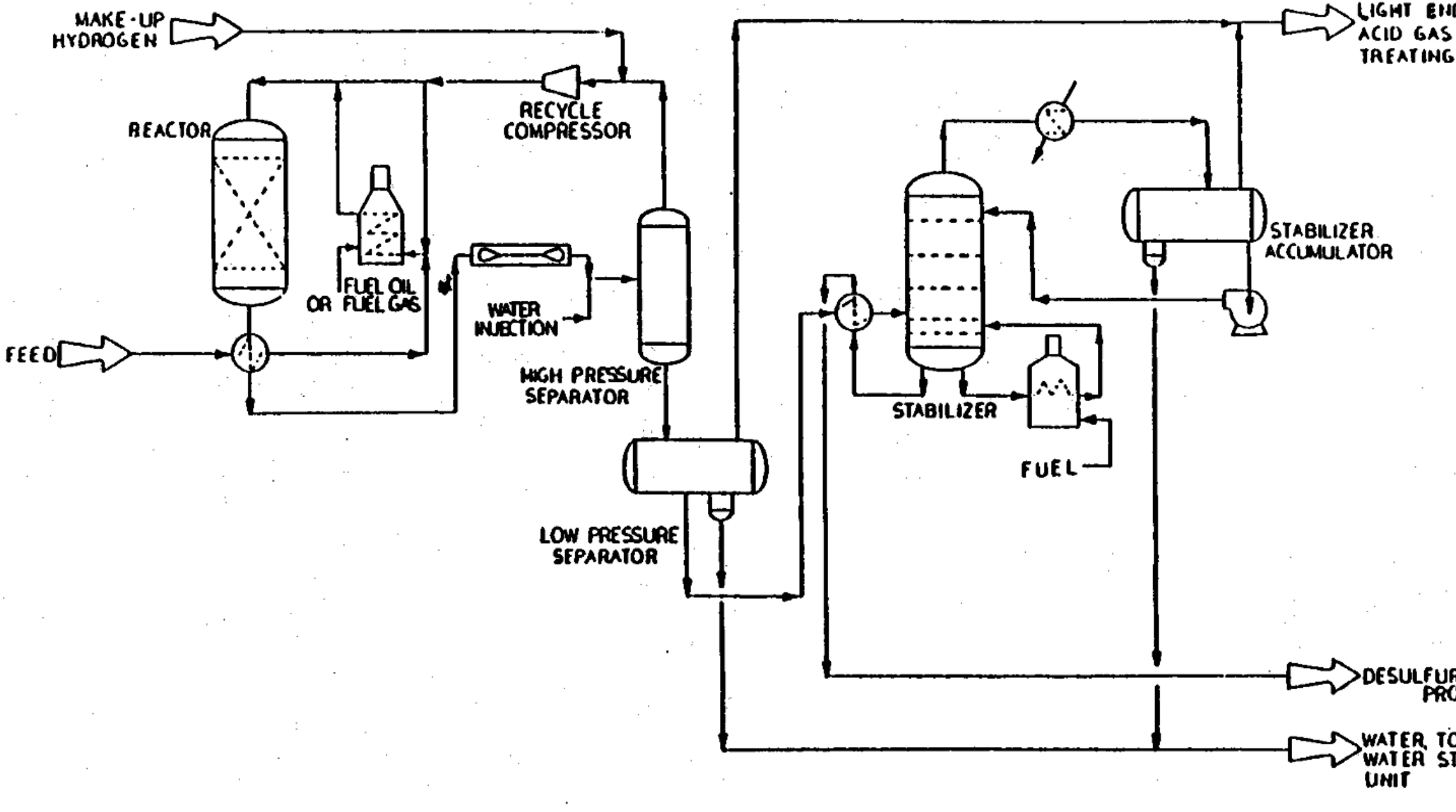
Flasher Tops
Hydro-Treating
Heavy Cat. Gasoline
Vacuum Distillation
Coker
Hydro-Cracking
Hydro-crackate
Flasher Bottoms
Asphalt/ Residual Fuels

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

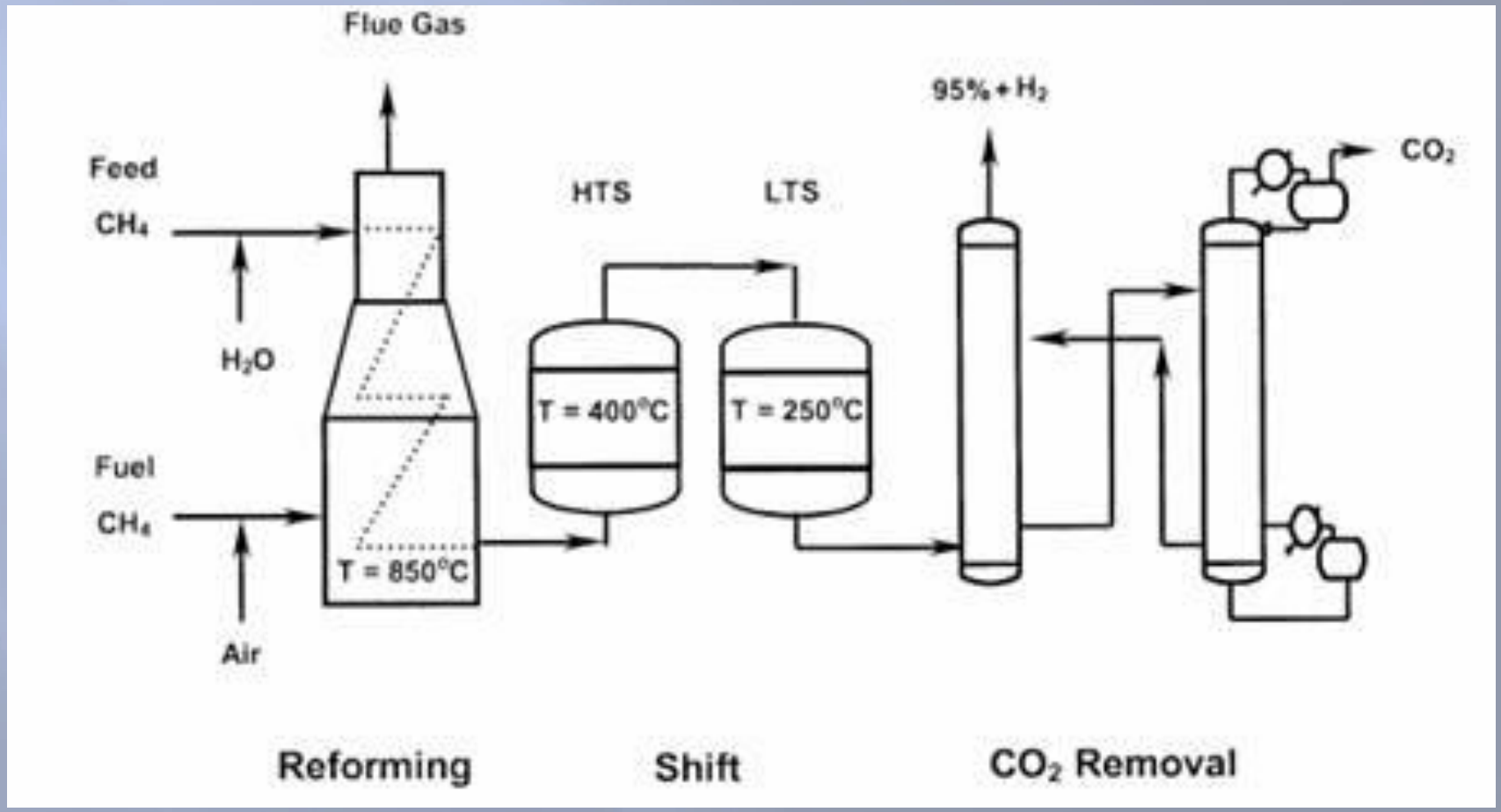
- REACTION: Steam and methane are reacted over a solid bed catalyst in a high intensity reforming furnace. In further processing CO_2 is removed as a by-product. Hydrogen rich product contains small amounts of methane.

Steam Methane Reformer

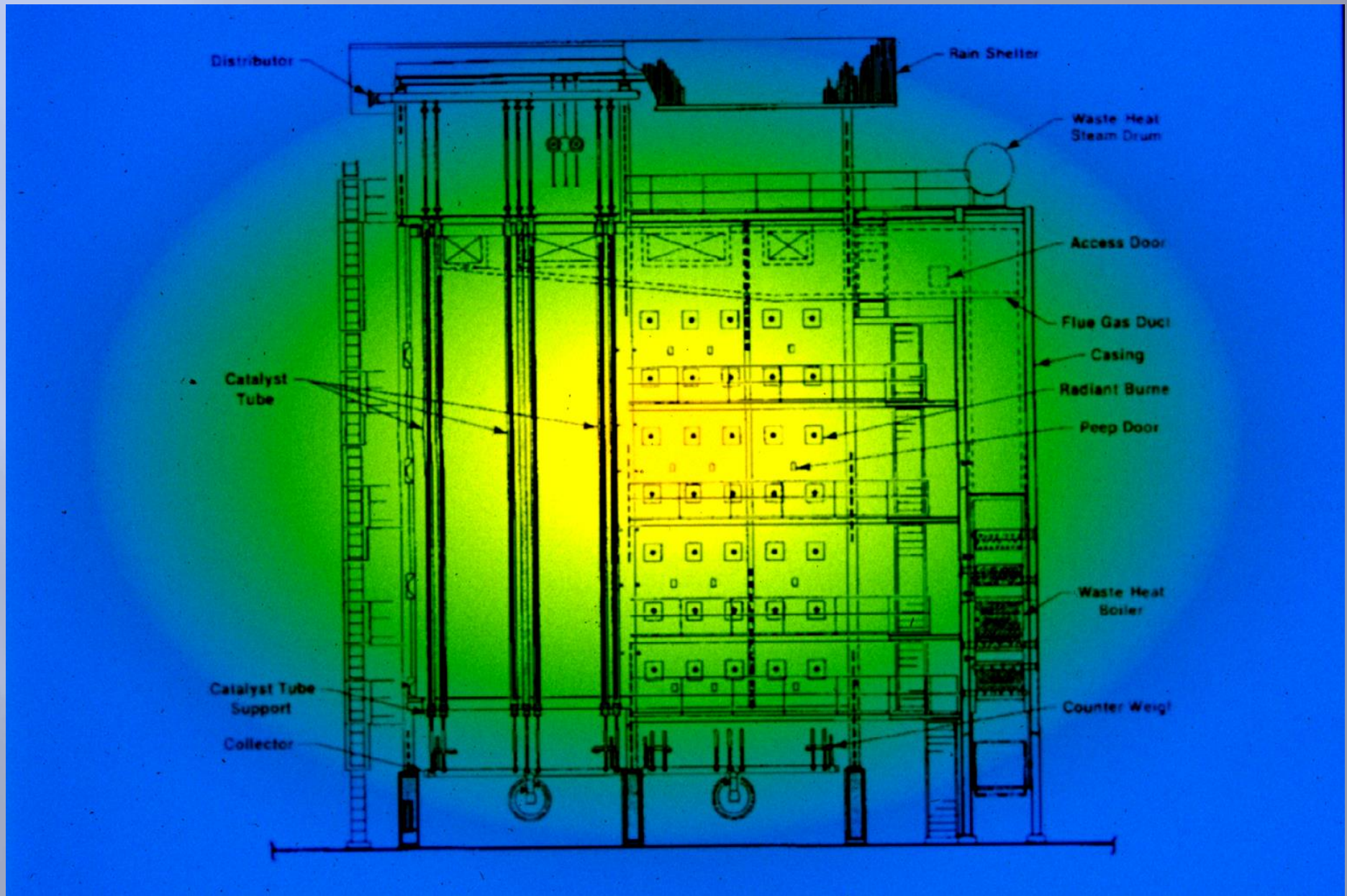
Reformer Reaction
CH4 + H2O = CO + 3H2

Shift Reaction
CO + H2O = CO2 + H2

CO2 Removal
Amine Absorption

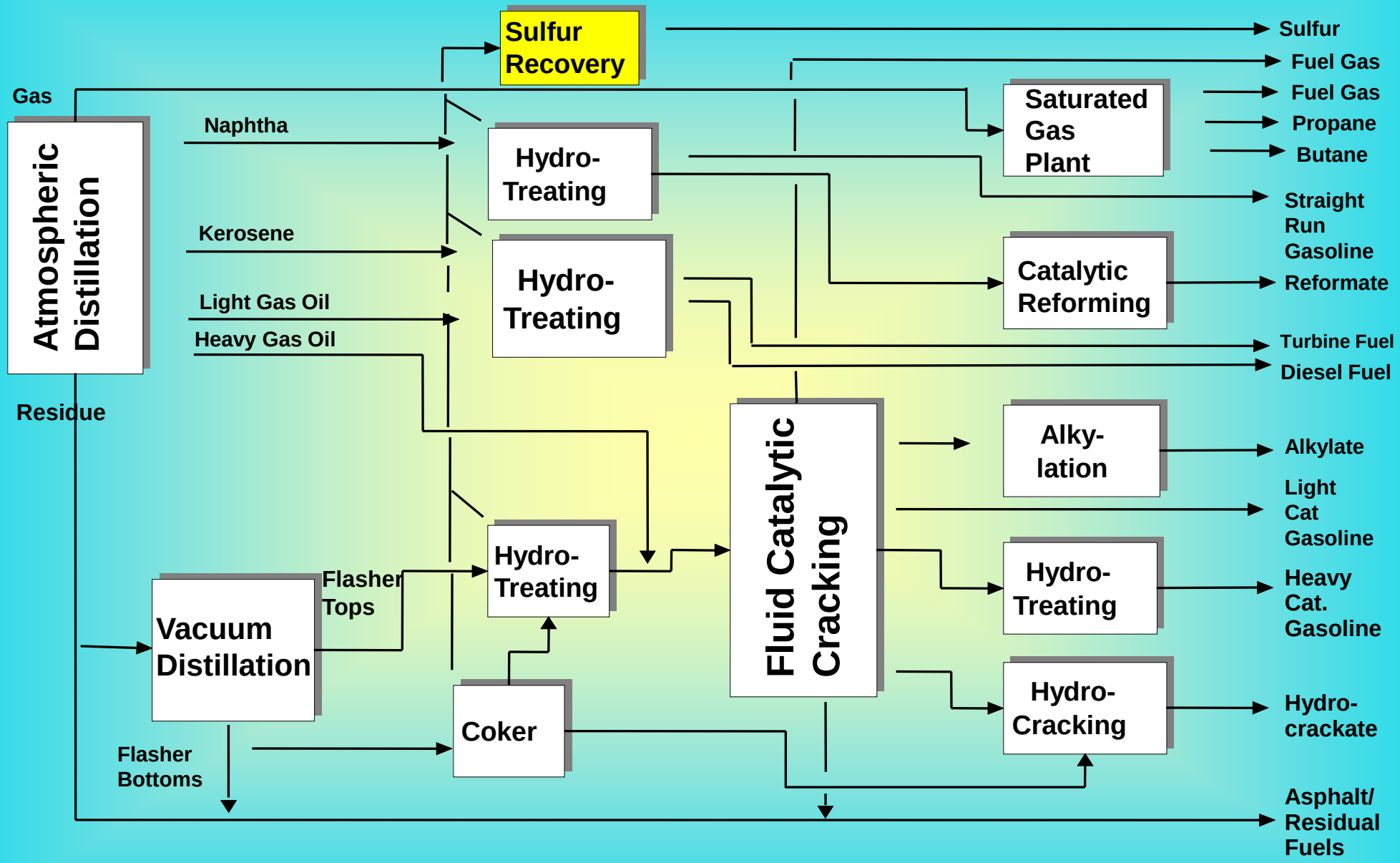


Reforming Furnace



Sulfur Recovery

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


Sulfur Recovery
Sulfur
Gas
Fuel Gas
Saturated Gas Plant
Fuel Gas
Propane
Butane
Naphtha
Hydro-Treating
Straight Run Gasoline
Kerosene
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Asphalt/ Residual Fuels

Claus Process

- REACTION:
  - H_2S is partially burned with air in a boiler to convert it to SO_2 to create the proper H_2S/SO_2 ratio
  - The H_2S/SO_2 is then reacted over a catalyst to produce elemental sulfur and water by a shift conversion reaction

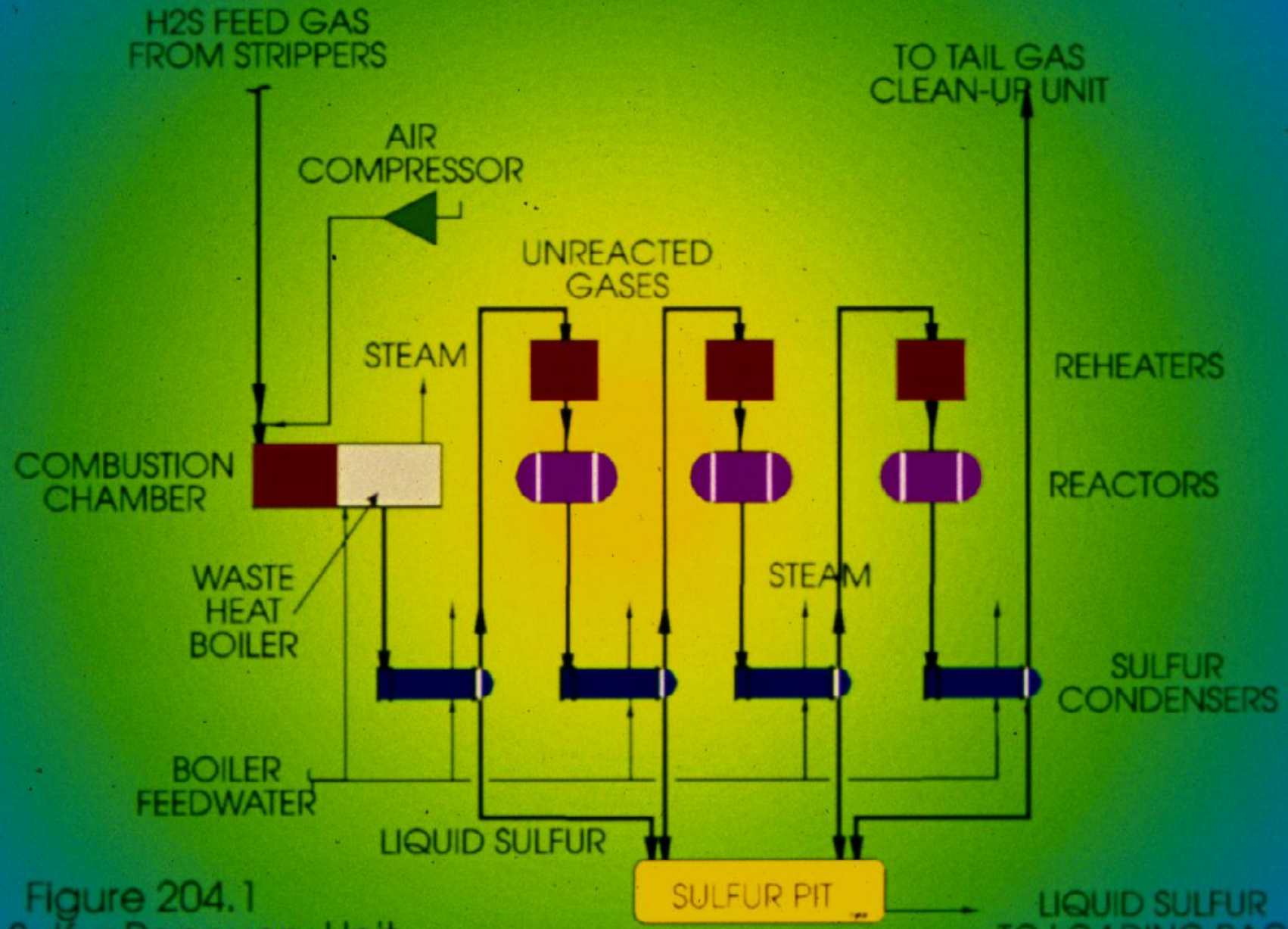
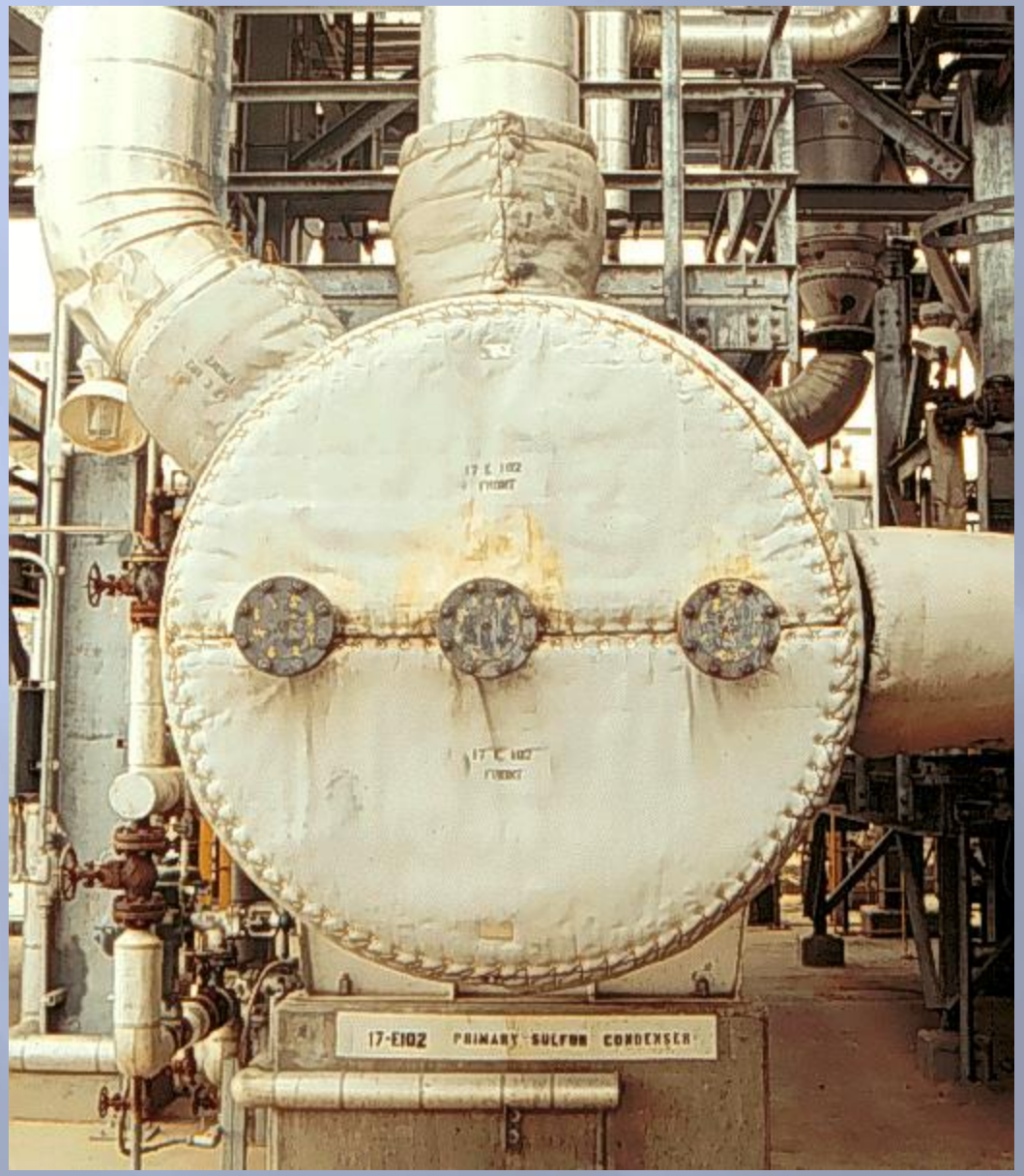


Figure 204.1
Claus Sulfur Recovery Unit

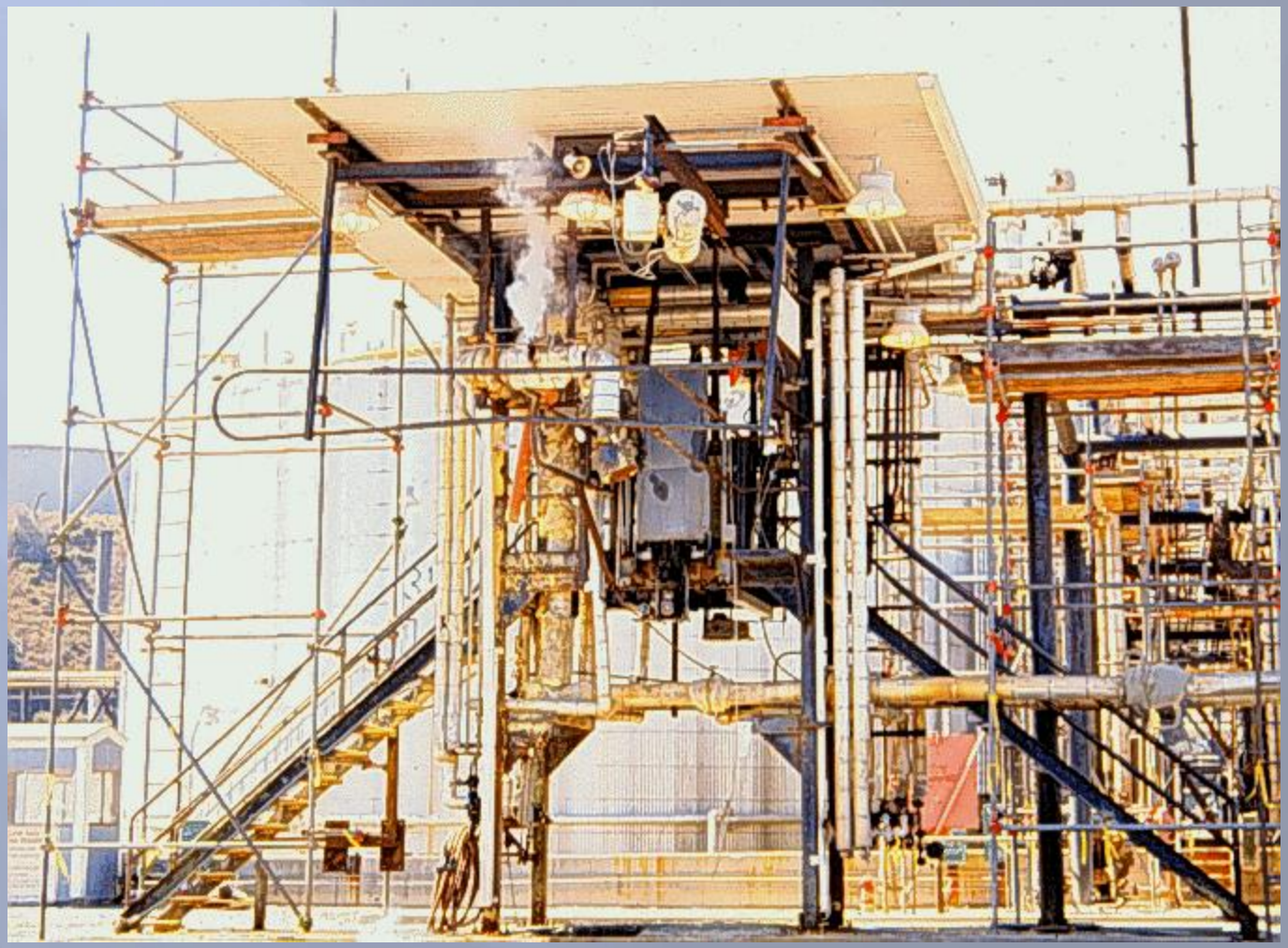
Sulfur Recovery
- Thermal Reactor



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.

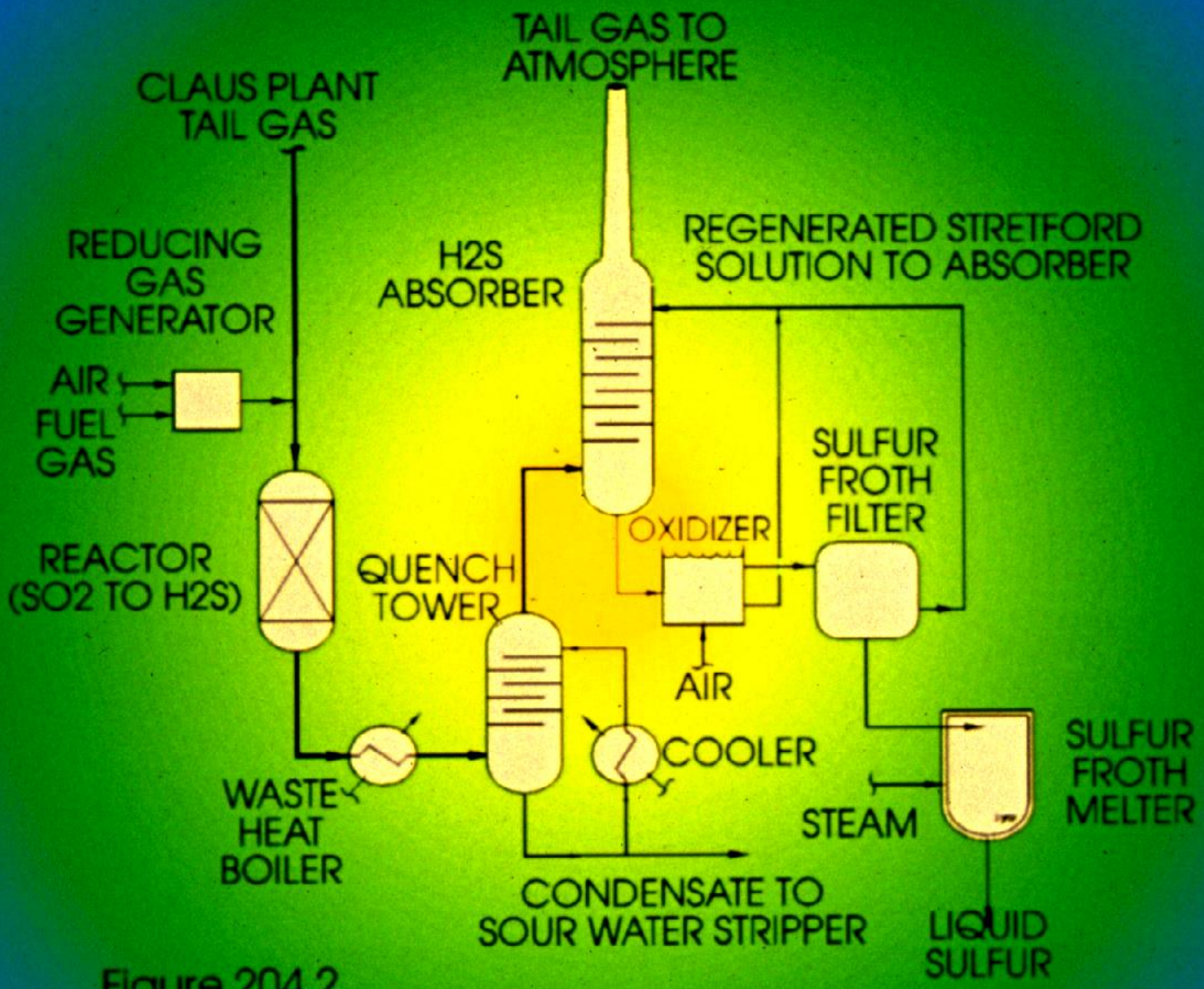


Figure 204.2
Beavon Tail Gas Clean-Up Process

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

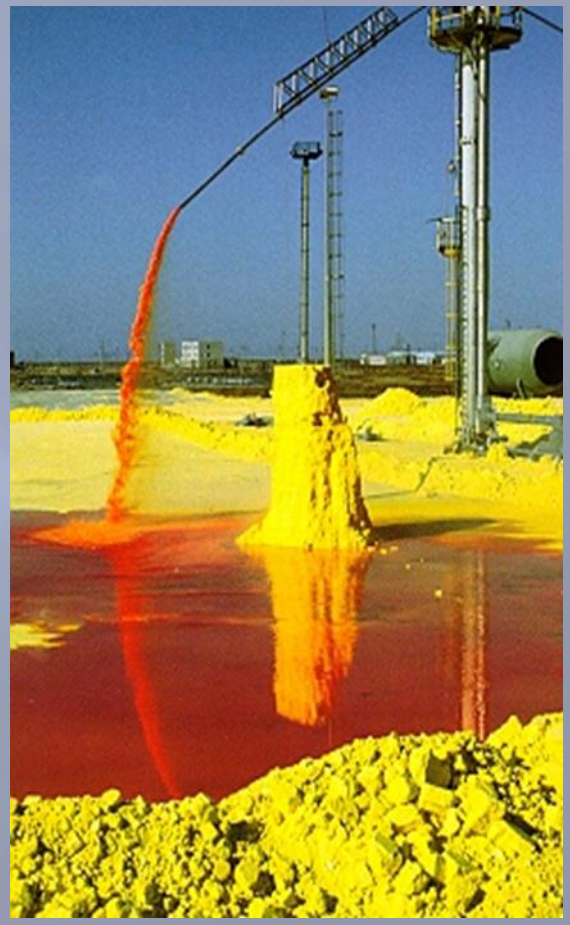
Inspection Points

Form: Figure 204.5, Page 204-21/22

- Visible Emisions (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


QUESTIONS?
COMMENTS?
CONCERNS?