KLM Technology Group

Practical Engineering Guidelines for Processing Plant Solutions

Standards, Solutions, Software

KLM Technology Group
Practical Engineering Solutions

Based in USA since 1995, KLM is a technical consultancy group, providing specialized services and equipment to improve process plant operational efficiency, profitability and safety.

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Training

Today we are discussing - Introduction To Petroleum Refining

We also offer training classes in;

1. **Advanced Petroleum Refining for Technical Professionals**
2. **Advanced Crude Unit Troubleshooting**
3. **Refining for Operations**
4. **Troubleshooting for Operations**
5. **Refinery Catalytic Processes**
6. **Refining for Non Technical Professionals**

As well as other process units and equipment groups. Most of the courses are 3 to 5 days. The course descriptions may be found on the website.

www.klmtechgroup.com/training

Kolmetz Handbook of Process Equipment Design

In 2007 we began writing the Kolmetz Handbook of Process Equipment Design. There are multiple chapters for Petroleum Refining design in the Handbook. We have over 50 individual chapters on a wide range of subjects.

Each chapter is 70 to 160 pages including design and sizing guidelines.

The handbook may be found here;

www.klmtechgroup.com/Engineering_Design_Guildelines.htm

Some of the Refining Chapters include;

1. General Distillation Tower Design – 93 Pages
2. Refinery Desalter Unit – 67 pages
3. Refinery Crude Tower – 164 Pages
4. Refinery Vacuum Tower – 136 Pages
5. Refinery FCC Units – 98 Pages
6. Hydrotreater Units – 70 Pages
7. Refinery Catalytic Reformer – 90 Pages
8. BTX Extraction Units – 75 Pages
9. Refinery Furnace – 185 Pages
10. Other Chapters – Reboilers, Flares, Tanks, Waste Treatment

Introduction to Refining

We are going to cover Introduction to Refining in Two Parts

Part One we will cover;

1. **Crude Unit Properties**
2. **Atmospheric Crude Towers**
3. **Vacuum Towers**
4. **DAO Towers**
5. **Coker Units**

We are going to cover Introduction to Refining in Two Parts

Part Two we will cover;

1. Hydro De Sulphurization Units
2. Refinery Catalytic Reformers
3. Refinery FCC Units
4. Refinery Alkylation Units
5. Refinery Isomeration Units

Origins of the Petroleum Industry

- Bitumen seeping to the surface used as building material, lining water cannels, sealing joints in boats and lighting in the middle East as far back as 3,000 BC.

- Petroleum encountered when digging salt wells in China 200 BC and used for lighting and fuel.

- Petroleum industry developed in Eastern Europe in early 19th century – shafts dug by hand

Origins of the Petroleum Industry

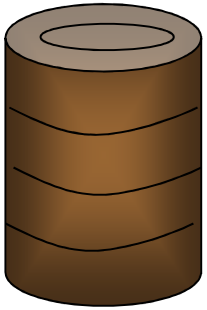
- Primitive oil industry in Pennsylvania in mid 19th century gathering surface oil.
- Processes developed for the production of lighting fluid termed “kerosene in 1854.
- First scientific investigation into the properties of petroleum carried out by the American Chemist Benjamin Sillman Jr in 1855.

Origins of the Petroleum Industry

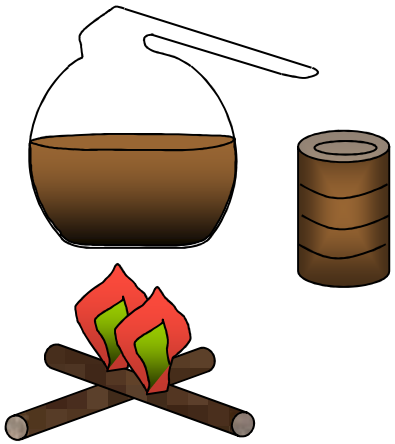
- Around 1830 the Chinese method of salt boring or drilling imported into Europe and United States.
- Salt-boring technique adapted to drill the first oil well by Edwin Drake in Titusville, Pennsylvania in 1859.
- Oil transported in barrels with volume standardized to 42 gallons in 1866 (after the size of barrels used for herrings in England) – still used as standard.

Origins of the Petroleum Industry

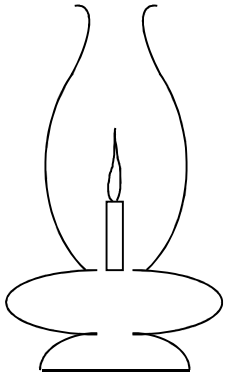
In the earliest days of the oil industry they distilled oil to get kerosene for lamps



Crude Oil



Pot Still

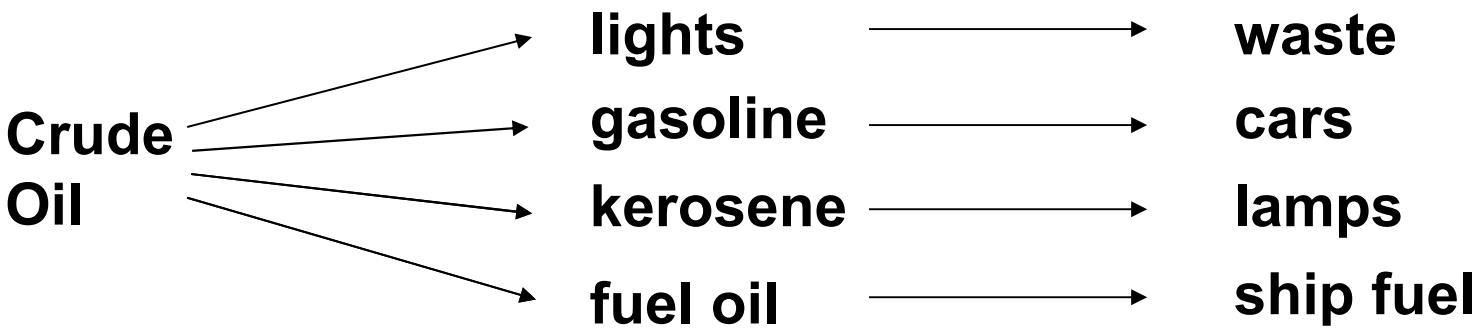


19th Century Lamps

The lighter and heavier fractions were thrown away – typically in a waterway

Origins of the Petroleum Industry

Later, when automobiles created a market for gasoline, the lighter fractions became more valuable



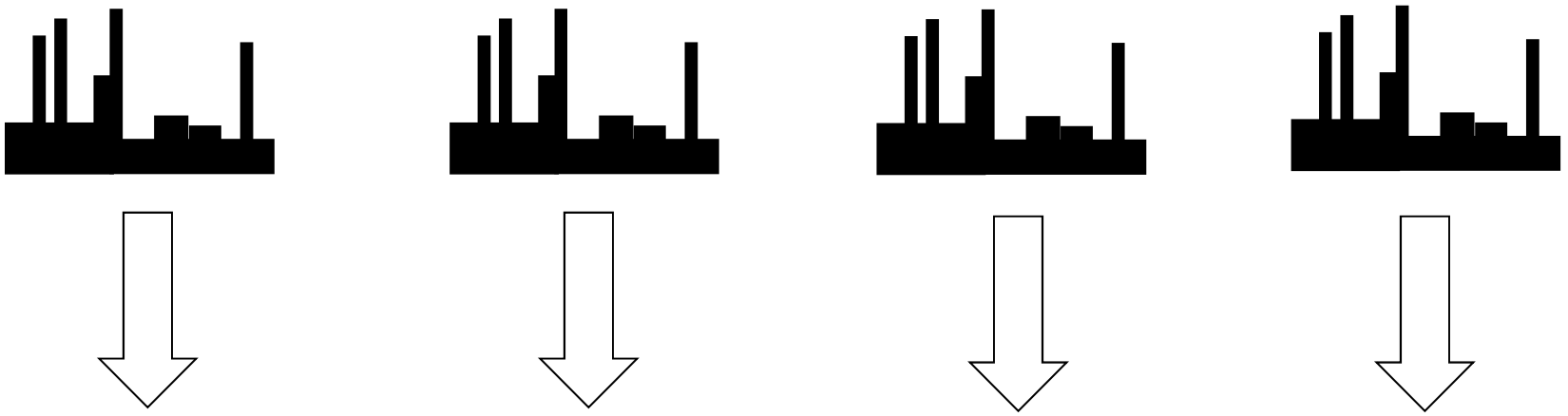
Origins of the Petroleum Industry

- Over the years 1920 – 1960, processes were developed to convert low value fractions into high value products
- Processes were also invented to improve the product properties
- Petrochemicals (chemicals from petroleum) grew rapidly from mid 20th century
- The refinery therefore evolved from a simple boiling operation into the complex plant we see today

Refinery Products

Fuel gas	→	Fuel or chemical feedstock
Liquified gases	→	
Gasoline	→	Motor transportation
Naphtha	→	Chemical feedstock
Jet fuel	→	Aviation fuel
Diesel fuels	→	Motor, railroad and marine transportation
Fuel oils	→	Industrial fuel
Lubricating oils	→	Machine lubrication
White Oils	→	Electrical insulation, lubrication and pharmaceuticals
Waxes	→	Coatings, polishes, candles and pharmaceuticals
Bitumen (asphalt)	→	Road making and waterproofing
Petroleum coke	→	Fuel, electrodes, or for metal manufacture

For different range of products:



And for different feed types

light
low sulphur
oil

heavy
high sulphur
oil

Refinery Overview

- **Refining is the second largest chemical industry only superseded by ammonia production. Refining contains almost every unit operation and is a challenging, yet rewarding occupation.**

- **A refinery is an organized and coordinated arrangement of unit operations designed to provide physical and chemical changes to petroleum crude oils.**

Refinery Overview

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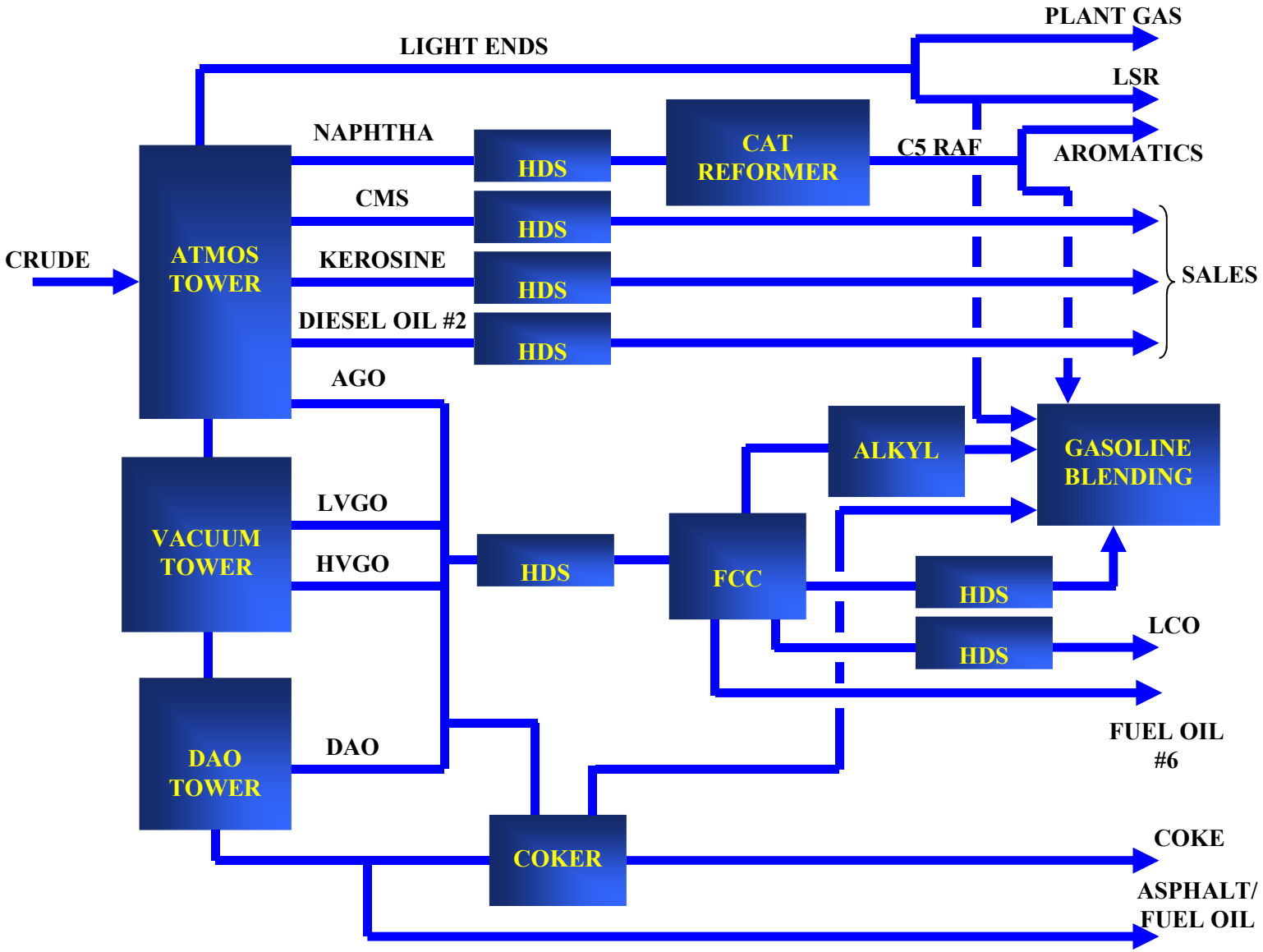

Refinery Overview

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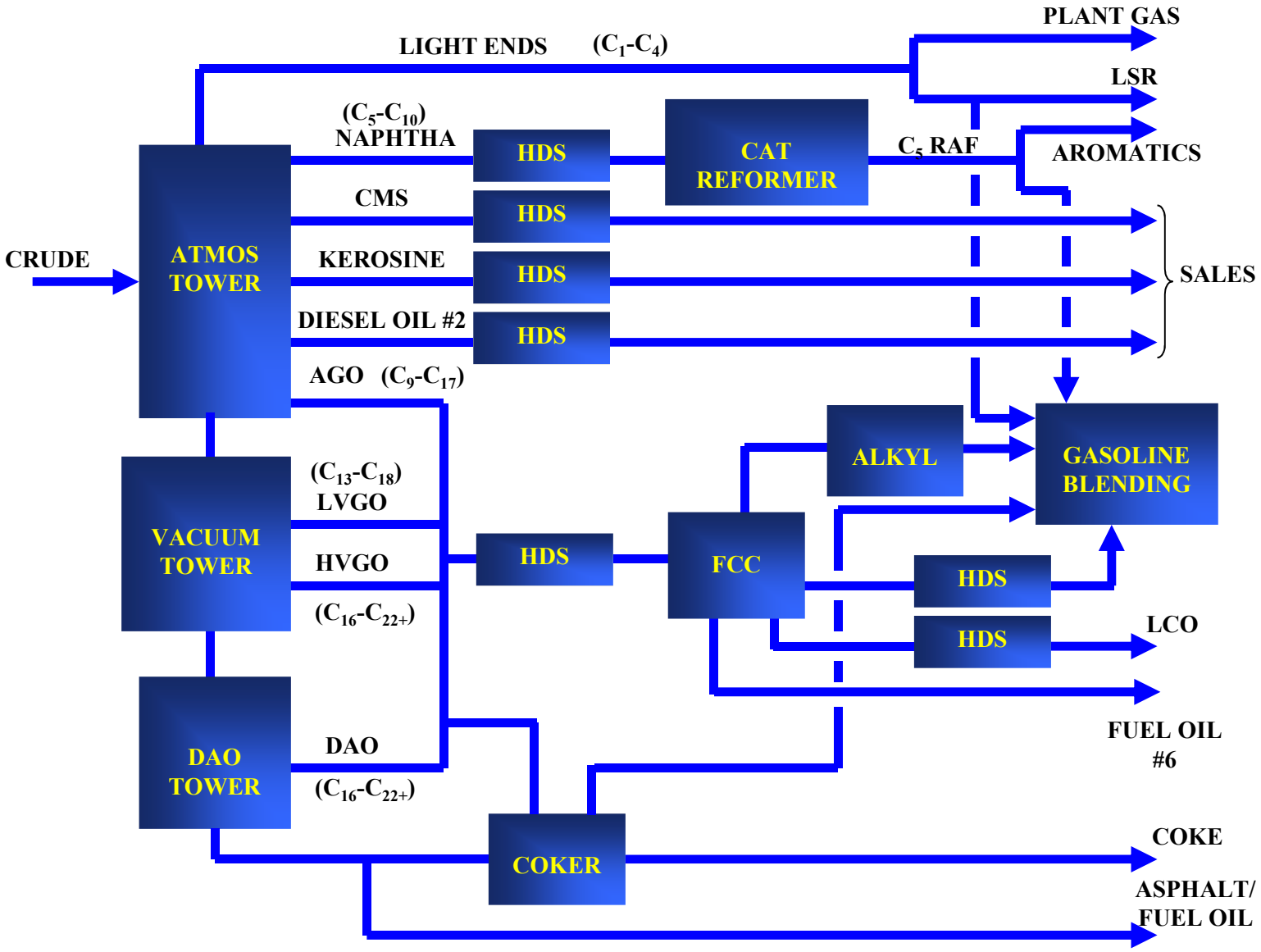

Petroleum

- Petroleum is not an element or even a compound, but is a complex mixture of a number of related chemical compounds generally called hydrocarbons.

- In its natural state, it varies in appearance from whitish clear liquid of very light consistency through brownish or greenish color all the way to a black, heavy asphaltic, almost solid material.

- Hydrocarbons are the basic and most important family of the organic class of compounds.

Crude Oil Types

- Thousand of different hydrocarbon and other chemicals from very light components to compounds as heavy as C80.
- May be found singularly or associated with natural gas.
- It will be noted that as the number of carbon atoms increases, the material becomes heavier and boiling point and specific gravity increases.
- Above 17 carbon atoms, the compounds are solid at room temperature and atmospheric pressure.

Refinery Overview

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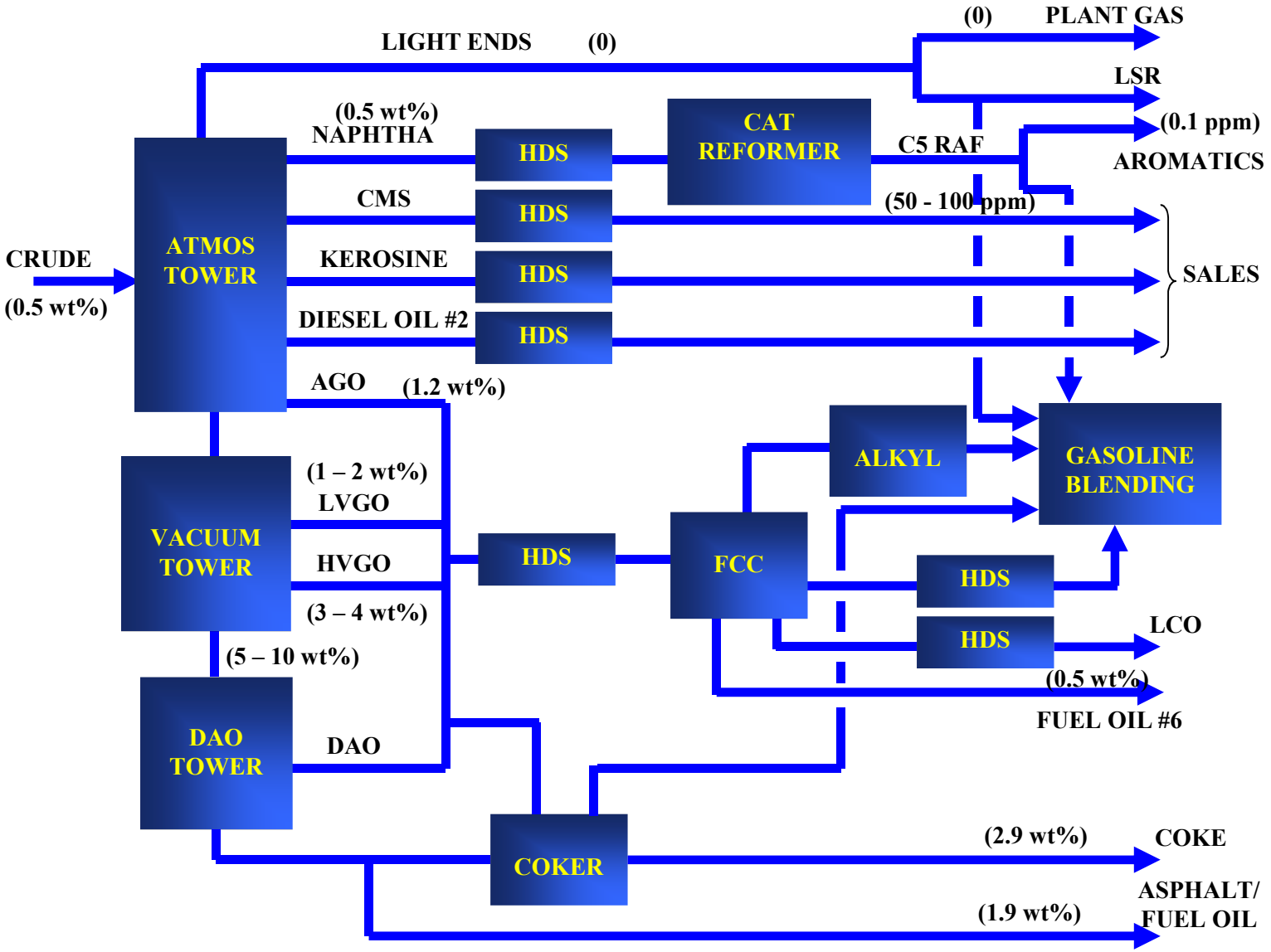

Crude Oil Types

Sulfur Content

- High sulfur crudes are more difficult to refine and may require special equipment.
- Sweet Crude < 0.5 wt% sulfur
- Sour Crude > 2.5 wt% sulfur

Houston Refinery

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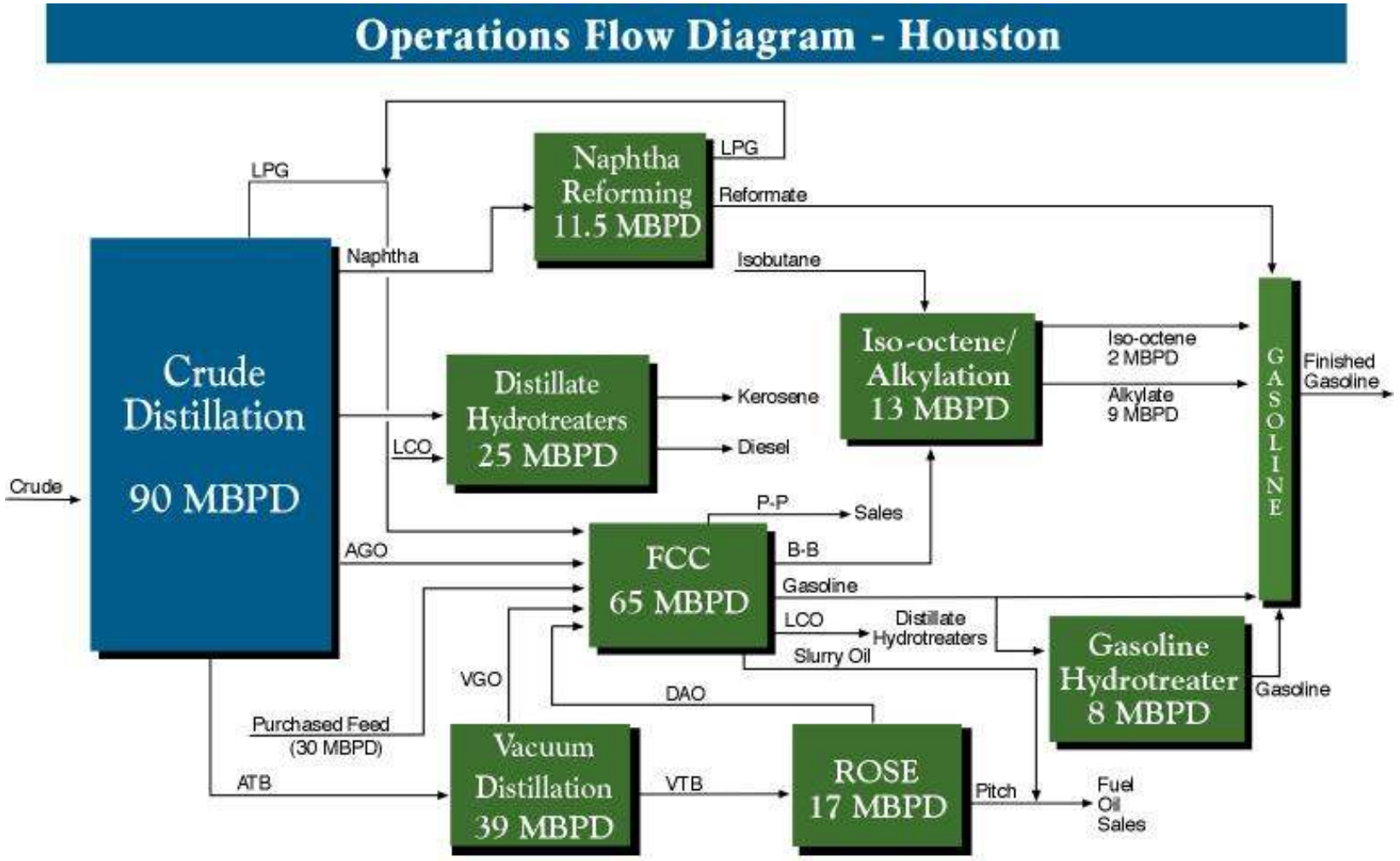

Crude Oil Types

Density

- May be know as light, intermediate or heavy depending on the actual mixture of hydrocarbons. One of the best know crudes is West Texas Intermediate (WTI).
- Light crudes are easier to process into high value products.
- Heavy crudes are more difficult to process and make less high value products

Crude Oil Types

West Texas Intermediate Crude Yields

LPG	1.5%
Naphtha	25.5%
Kerosene	10.5%
Gas Oil	21.0%
Fuel Oil	41.5%

Basic Petrochemical Flow Scheme

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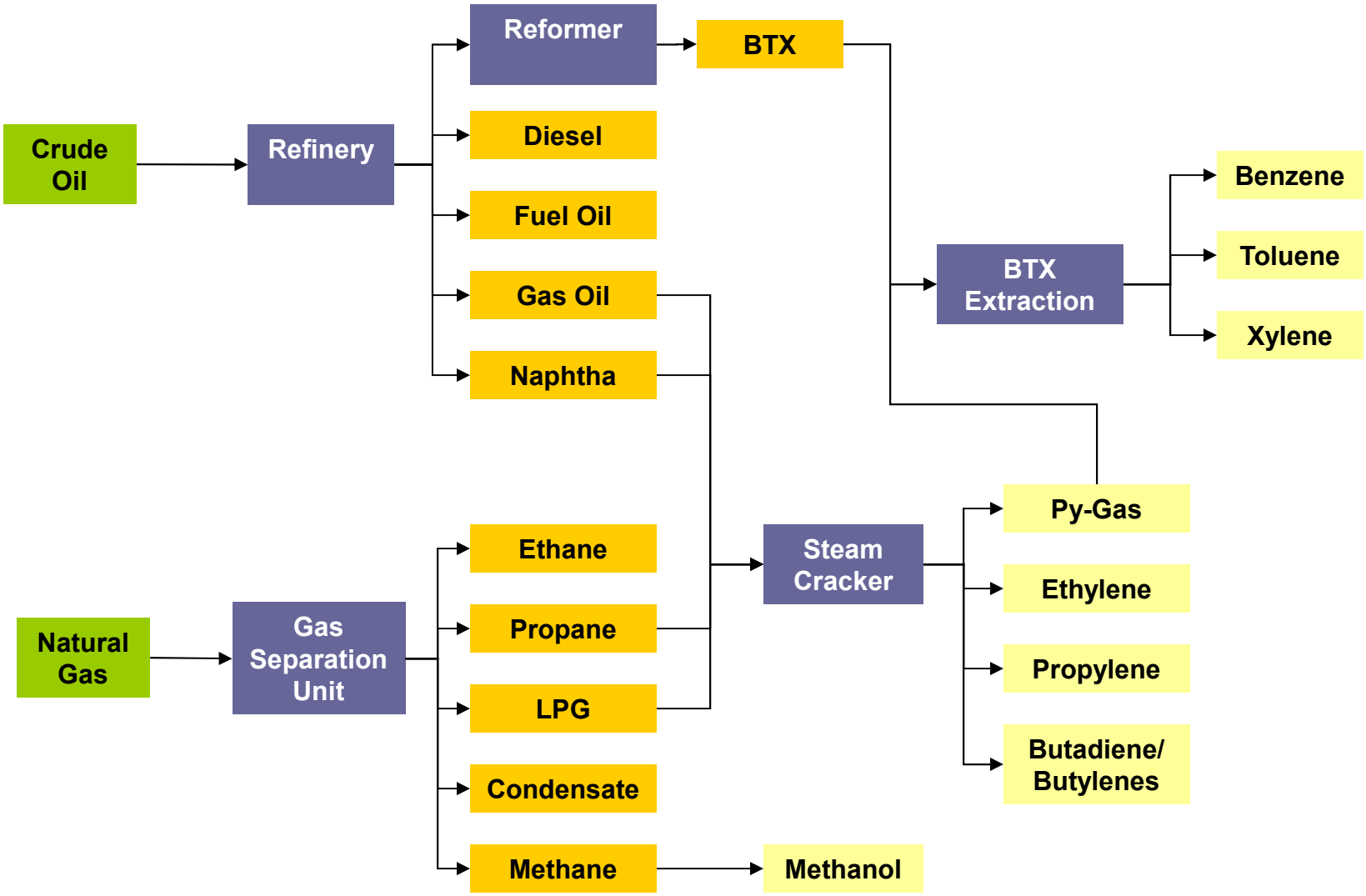

Refinery Overview

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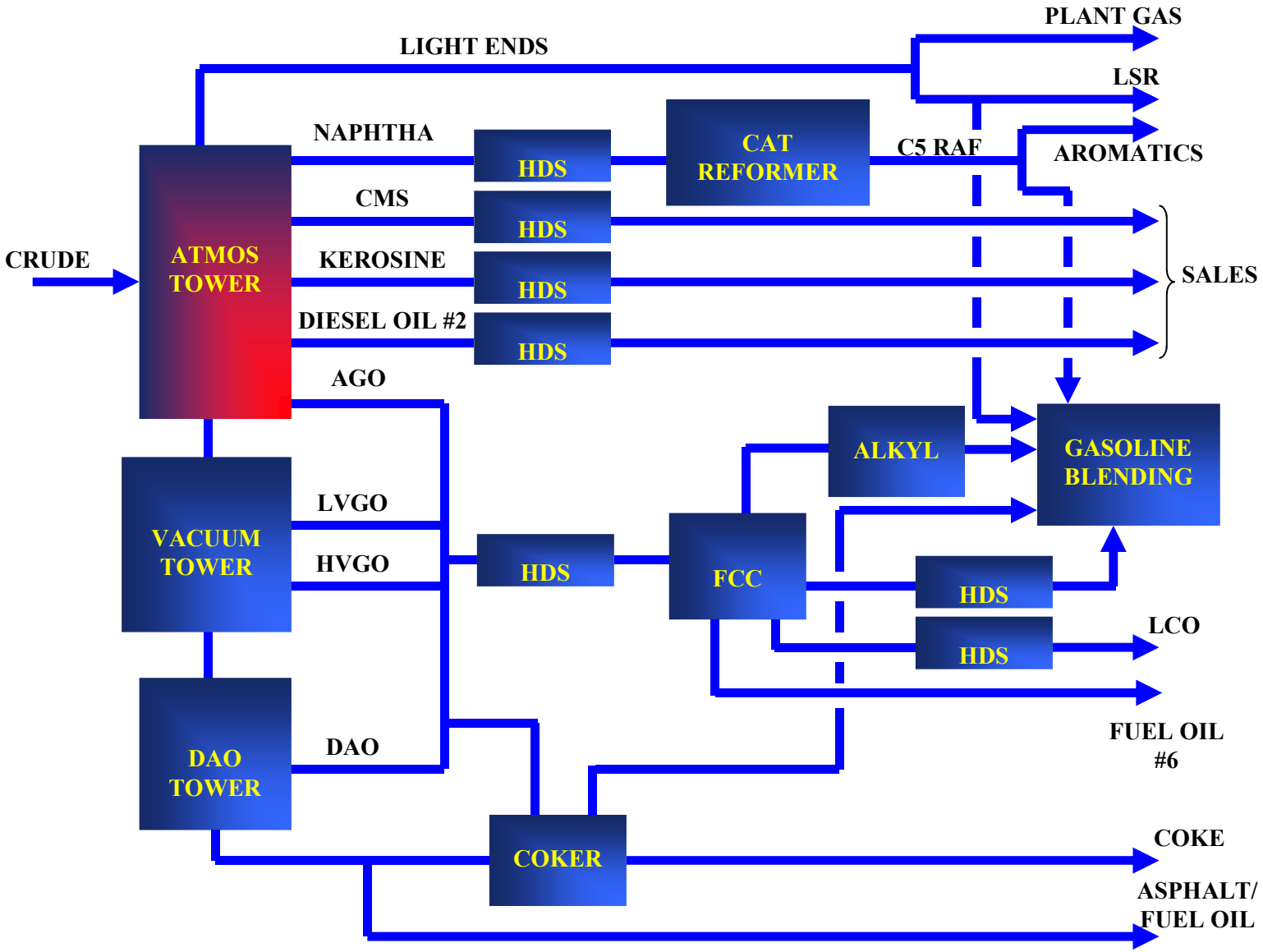


Crude Tower

The function of a atmospheric / crude tower is to distill (separated with heat) the lighter and more valuable portions of the crude.

The crude should be processed safely, economically, environmentally and reliably. This is a very difficult task. Reliably means to be able to run and process more than four years and you really want five years.

Crude Tower

If you go research there are over many people who list themselves as crude unit designers. But there is only a very small group that I actually trust.

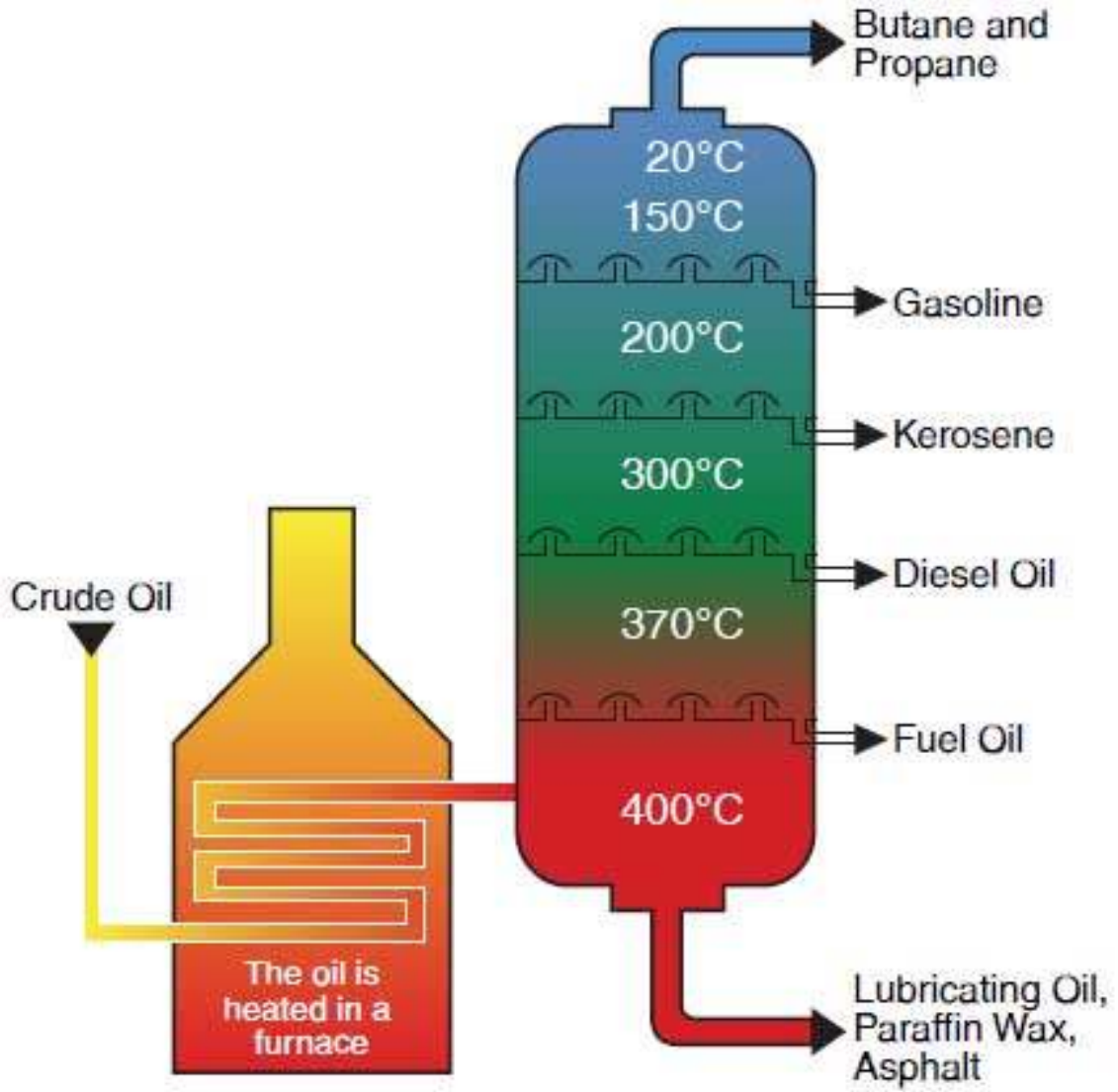
The first question you might want to ask a “crude unit expert” is how many running towers have you designed and commissioned. A good answer might be ten to twenty. Many of this group have only one, and it most likely did not function well.

The second question might be to ask for a list of people, (more than one) that would recommend them.

All at once the list of “crude unit designers” gets very small. We would be happy to recommend a qualified “crude unit designer” to review your project.

If you have a small project, a P&ID and Distillation Equipment review would be wise. If you have a large project you should bring them in early in the project.

Crude Tower


Butane and Propane
20°C
150°C
Gasoline
200°C
Kerosene
300°C
Diesel Oil
370°C
Fuel Oil
400°C
Crude Oil
The oil is heated in a furnace
Lubricating Oil, Paraffin Wax, Asphalt

Crude Tower

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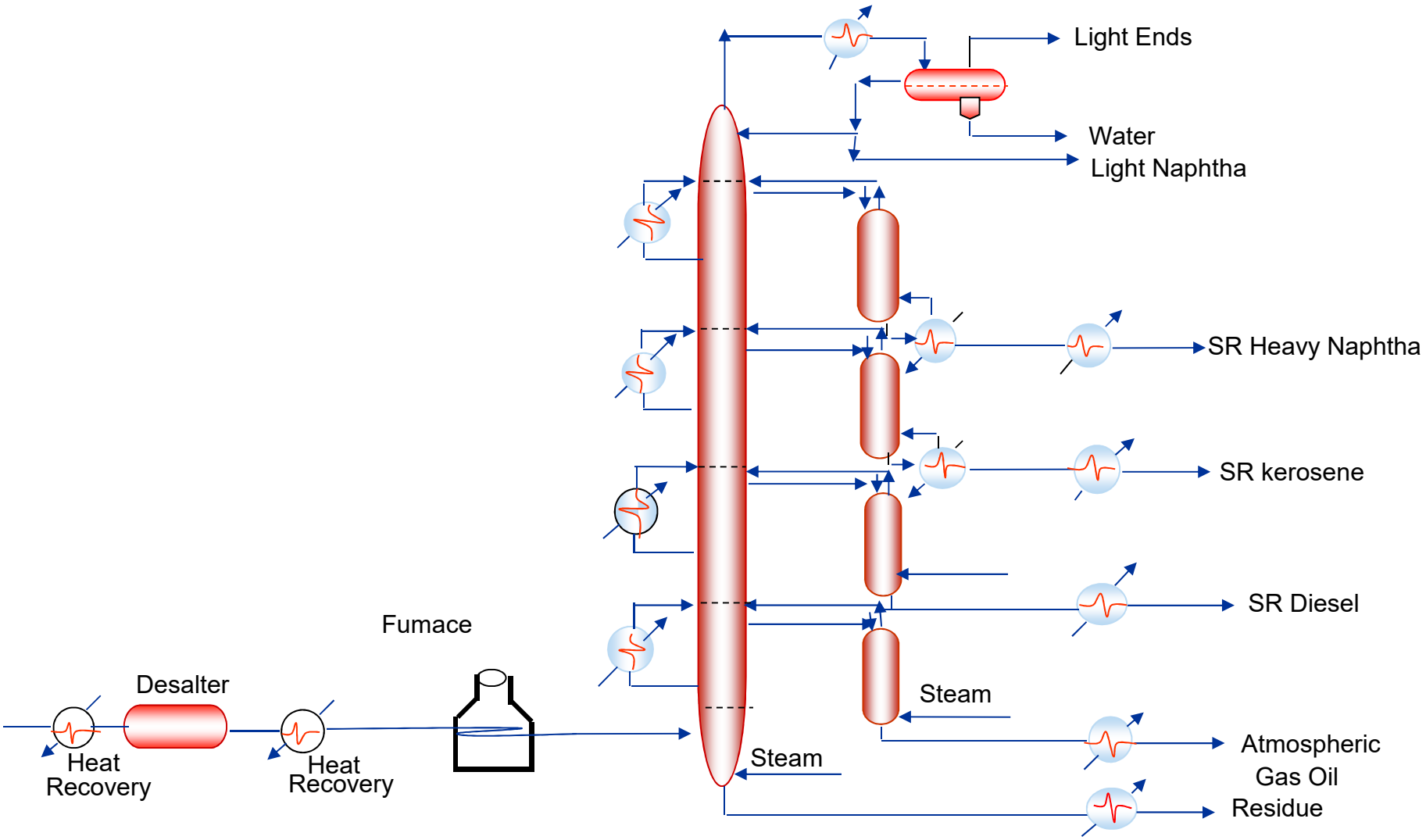

Crude Tower

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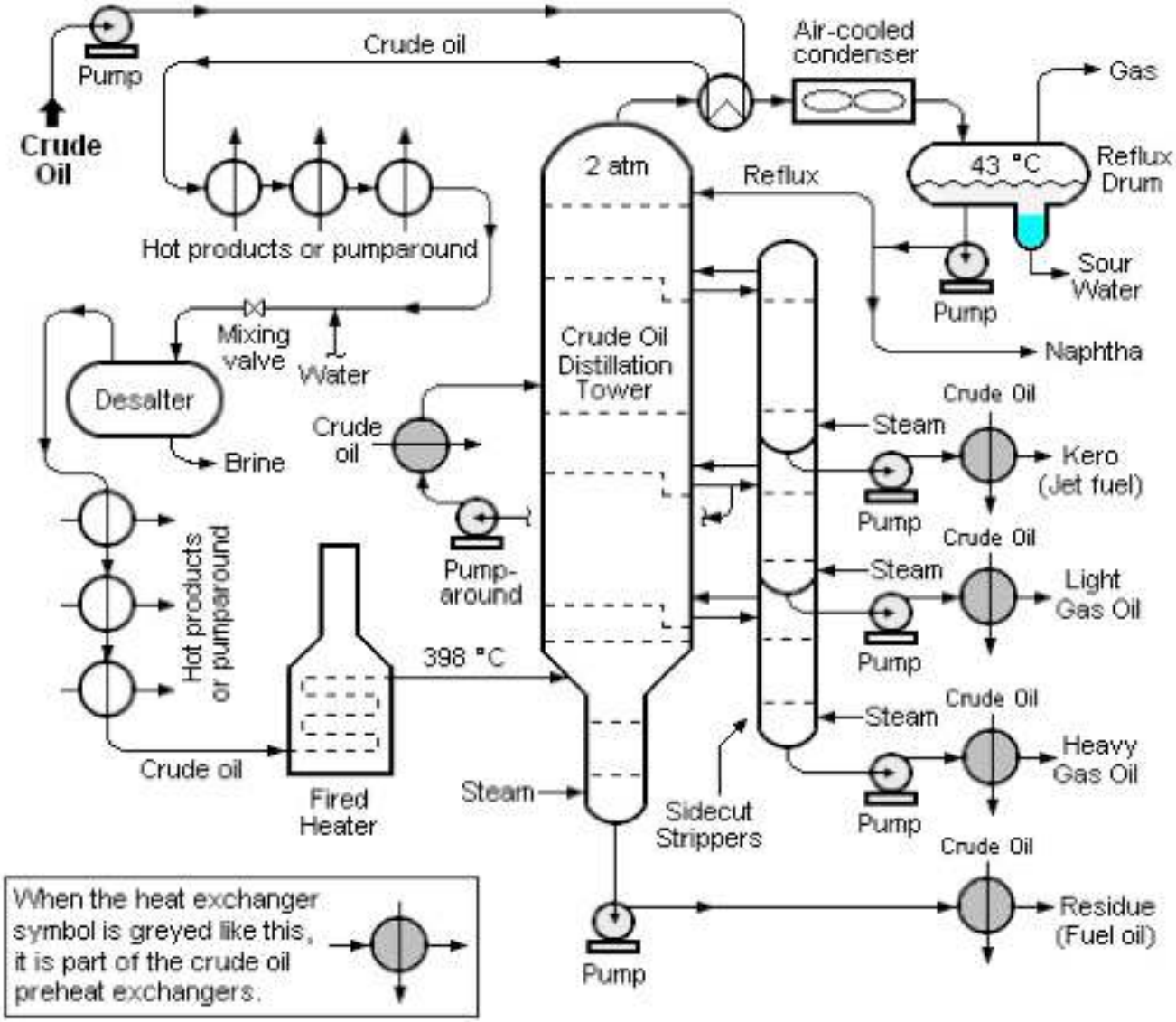
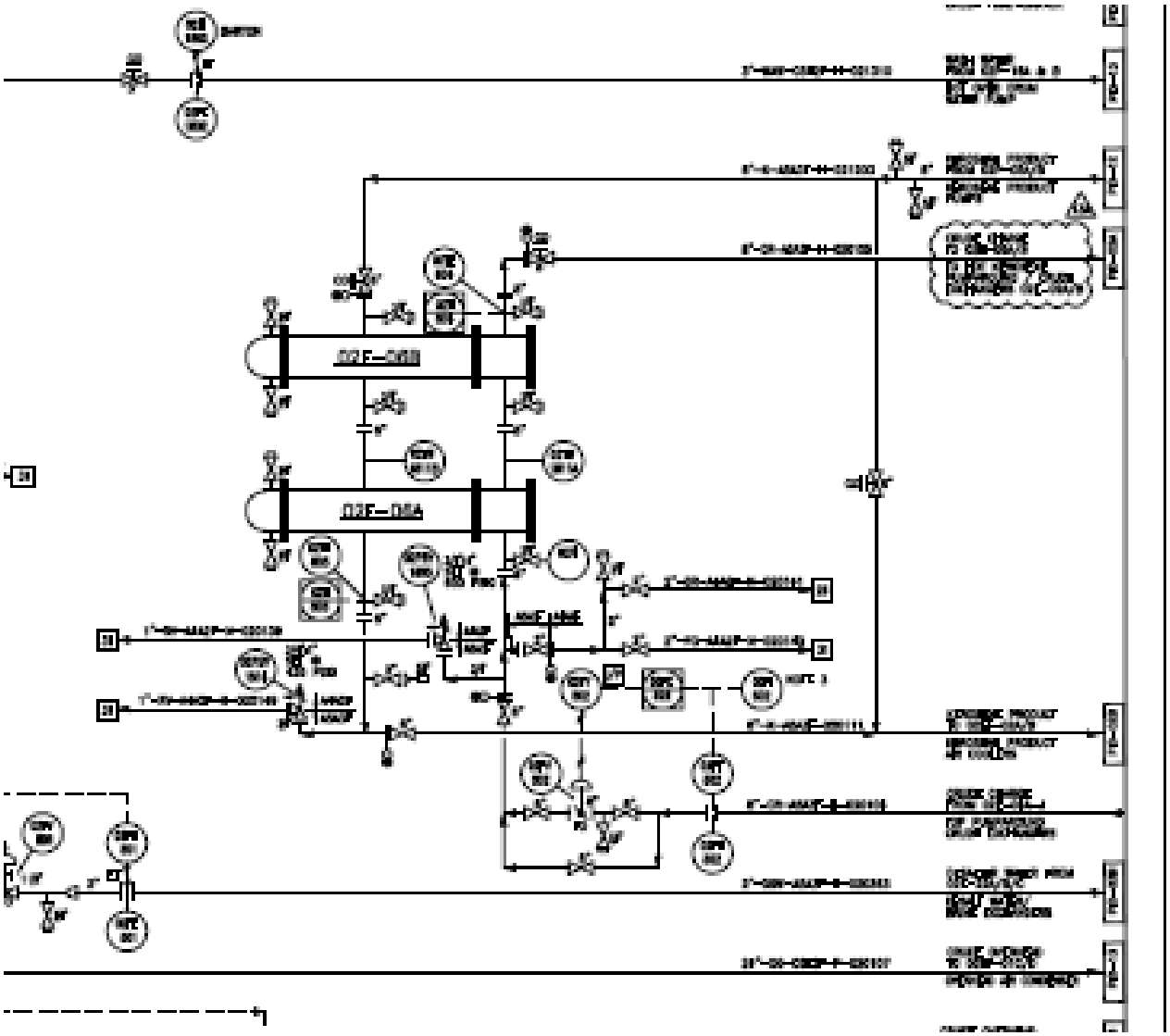


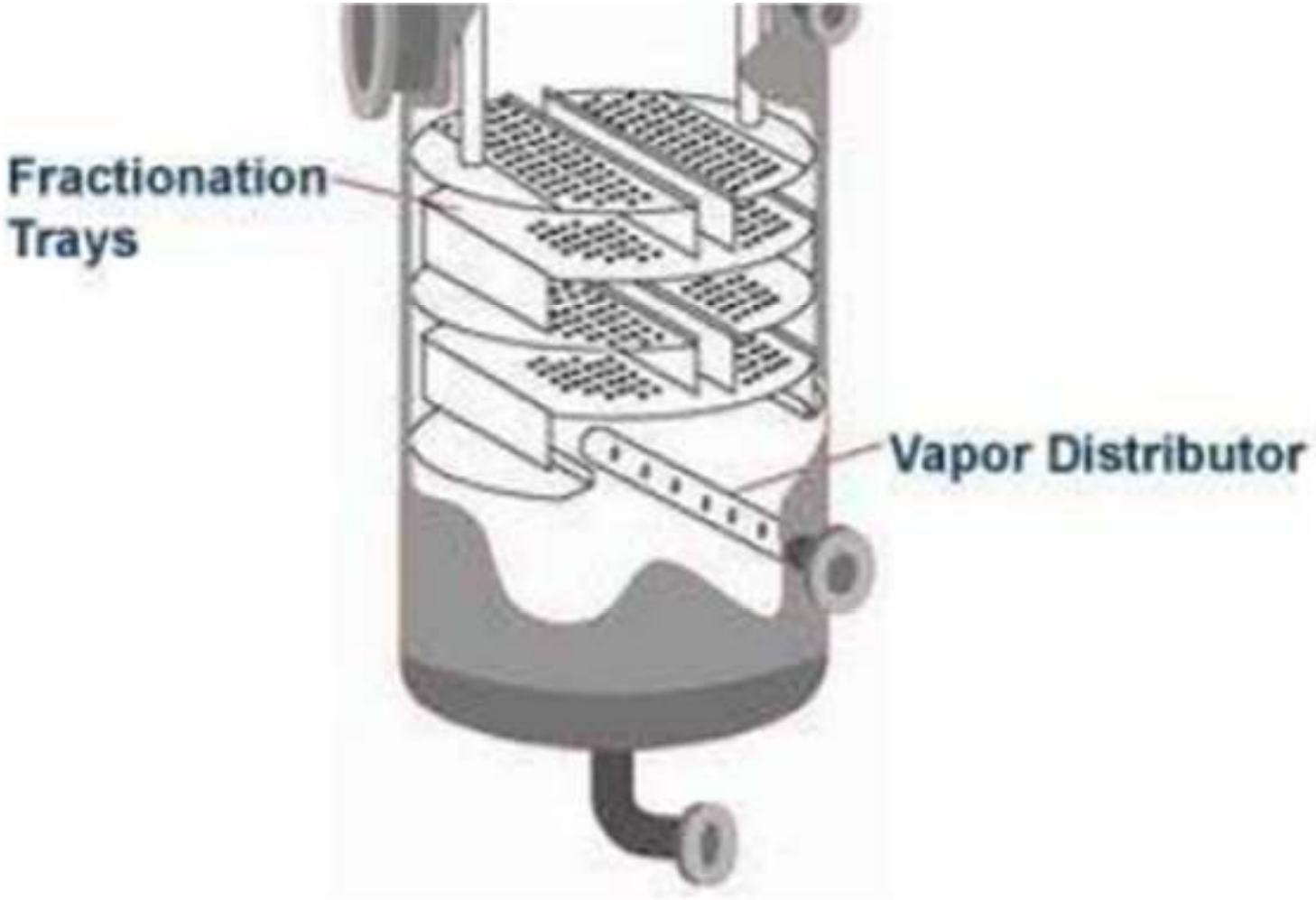
Crude Tower



Crude Tower

In middle is the crude tower, on the right is the vacuum tower

Crude Tower



Crude Tower

Refinery Overview

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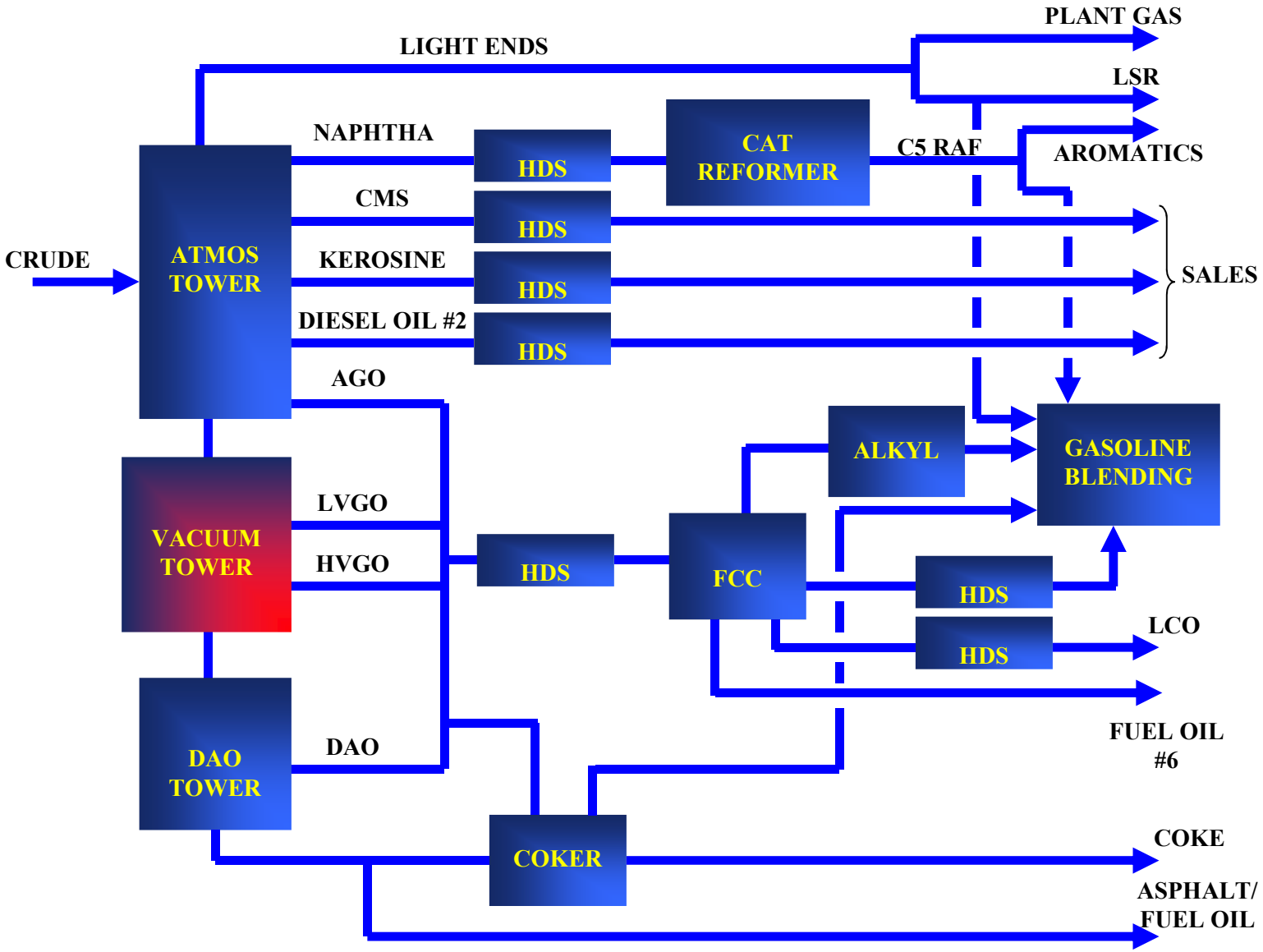


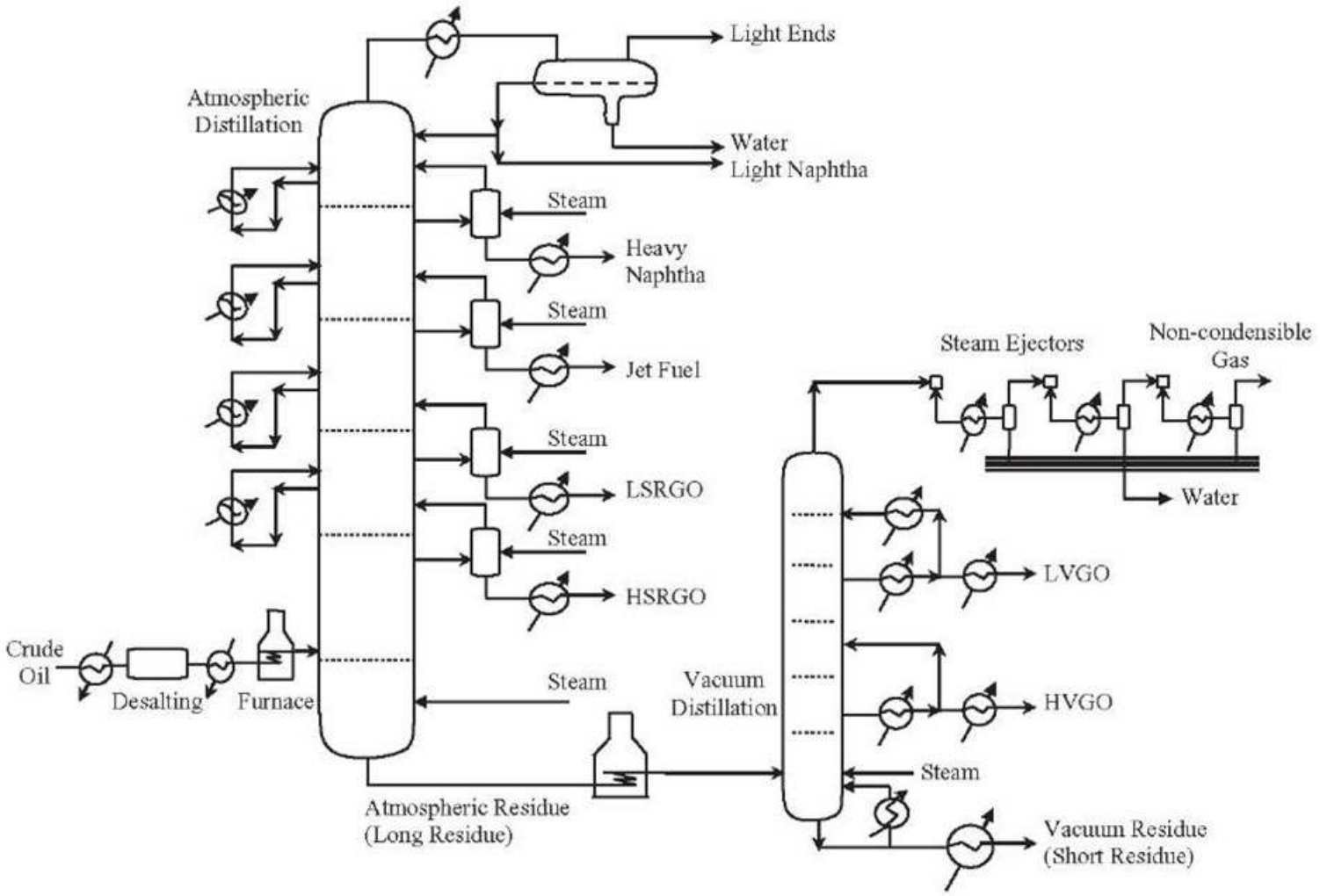
Vacuum Tower

The function of a vacuum tower is to distill (separated with heat) at low pressure some of the remaining more valuable portions of the crude. The crude tower does not remove 100% of the valuable portions so we then process in the Vacuum Tower

The crude again should be processed safely, economically, environmentally and reliably. This is a very difficult task. Reliably means to be able to run and process more than four years and you really want five years.

The vacuum tower has one of the highest failure rates in distillation

Vacuum Tower

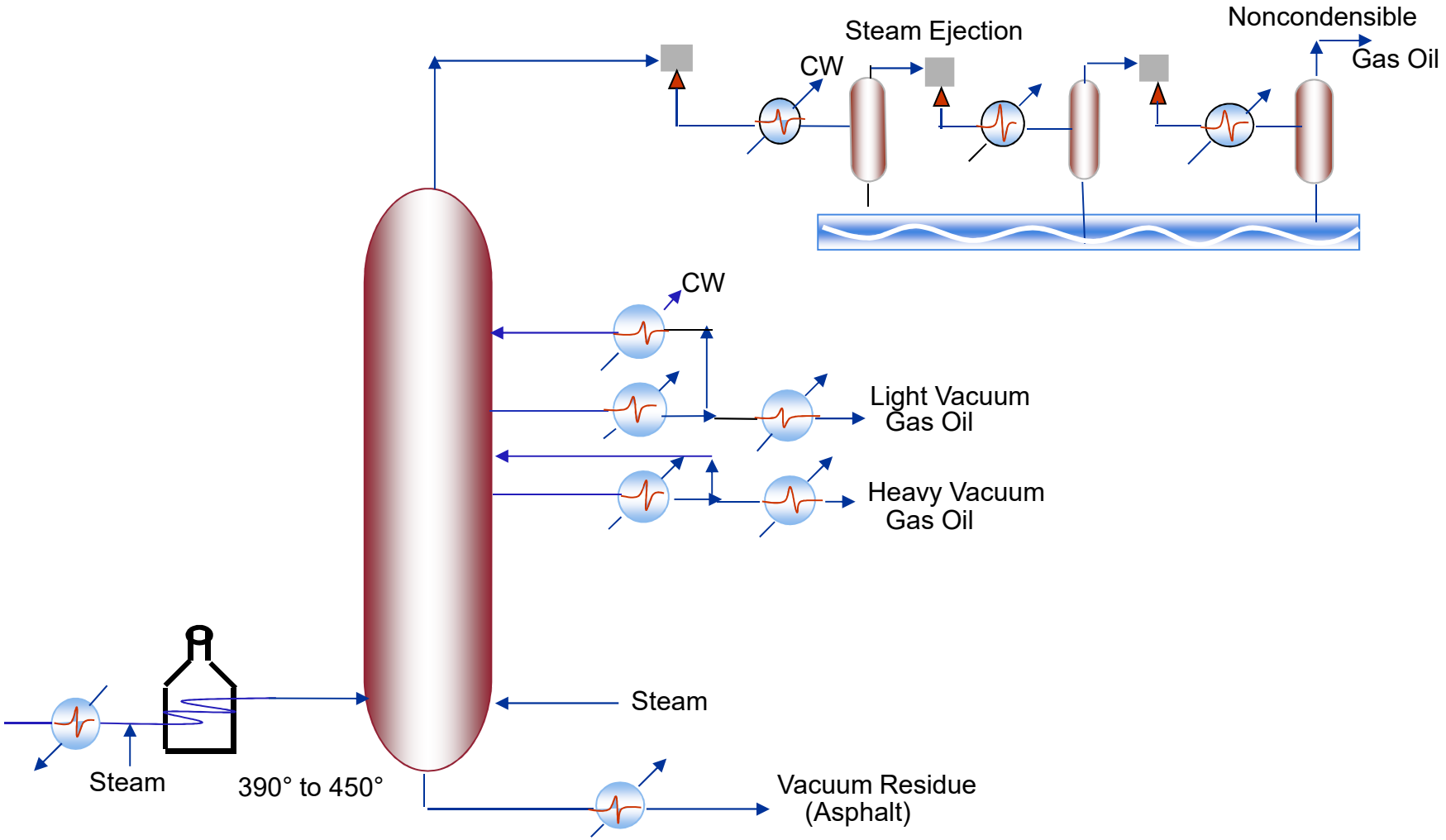


Vacuum Tower

Picture of the Houston Refinery where I worked for 16 years

On the right – crude tower, middle vacuum tower.

Vacuum Tower



Vacuum Tower

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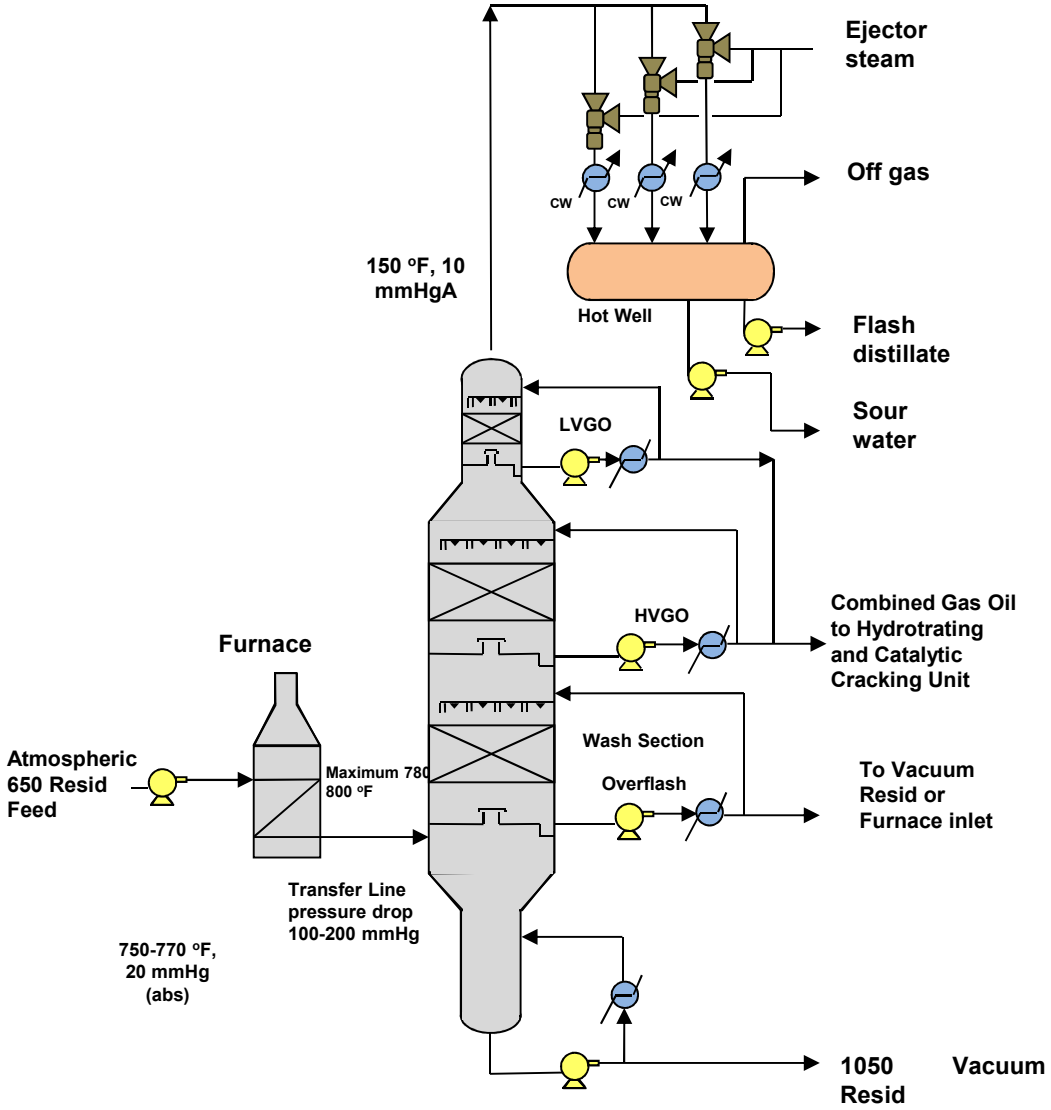
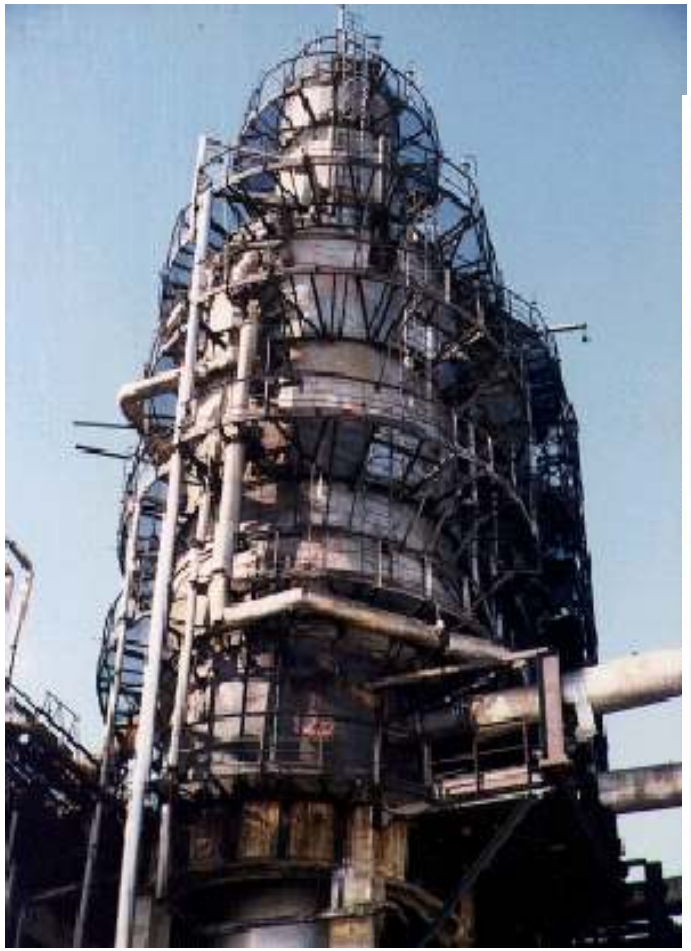


Vacuum Tower



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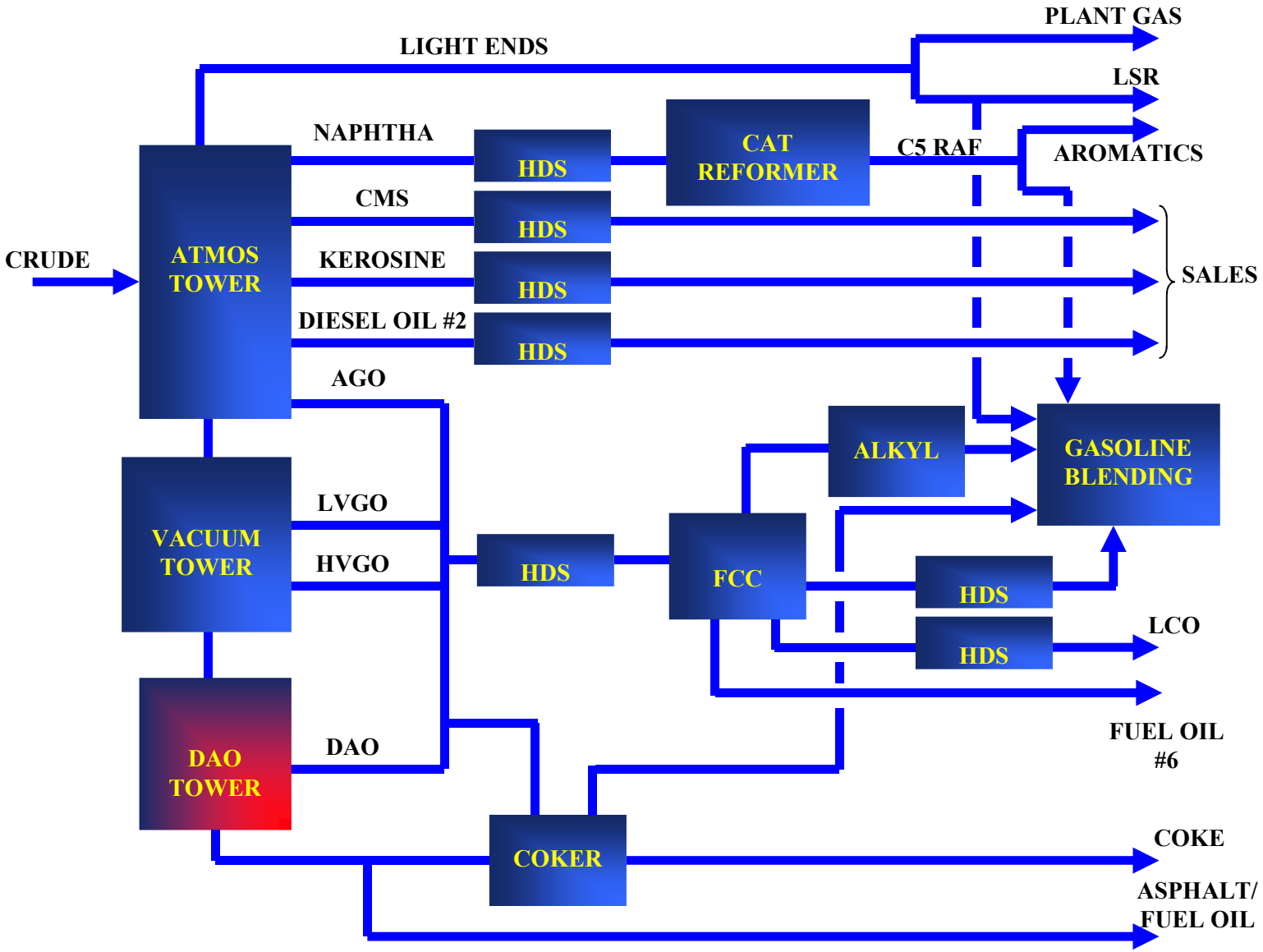


DAO Unit

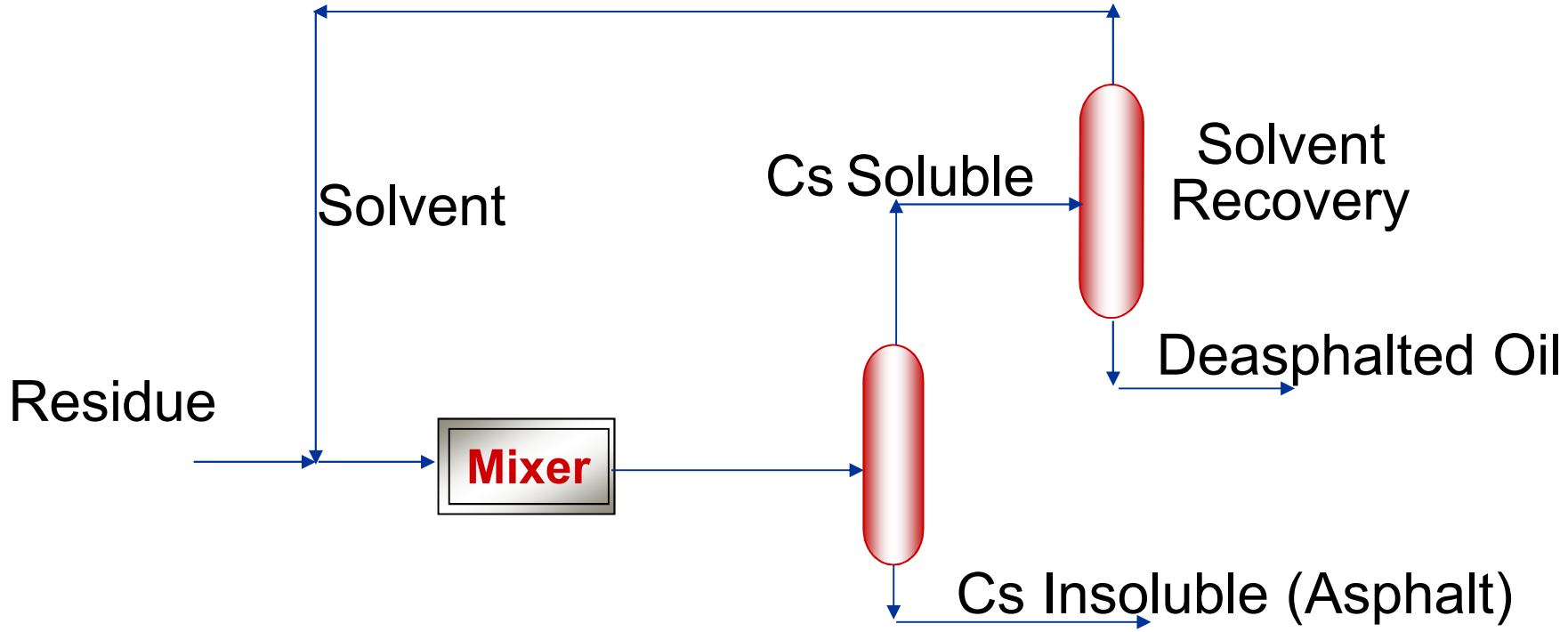
The function of a DAO unit is to remove the remaining higher value products from the asphalt.

The feed is combined with a solvent, and the De Asphaltene Oil is removed by the solvent.

The solvent is the recovered and recycled. The asphalt is then routed to storage.

Solvent De Asphalting

- **Further separation of vacuum residue by distillation without decomposition is difficult**
- **Solvent extraction can be used instead of distillation**
- **De Asphalted Oil (DAO)**



Solvent De Asphalting

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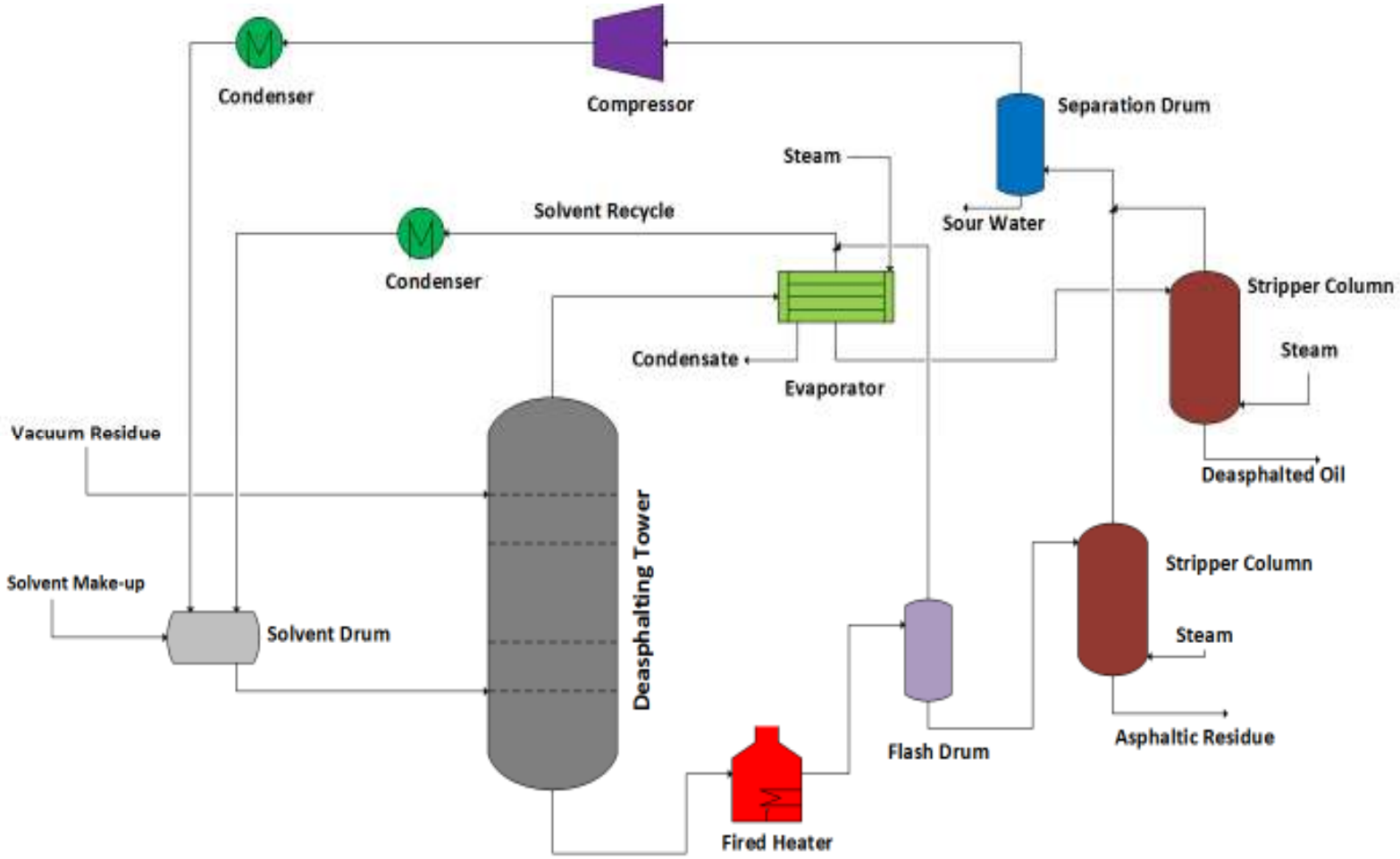

Refinery Overview

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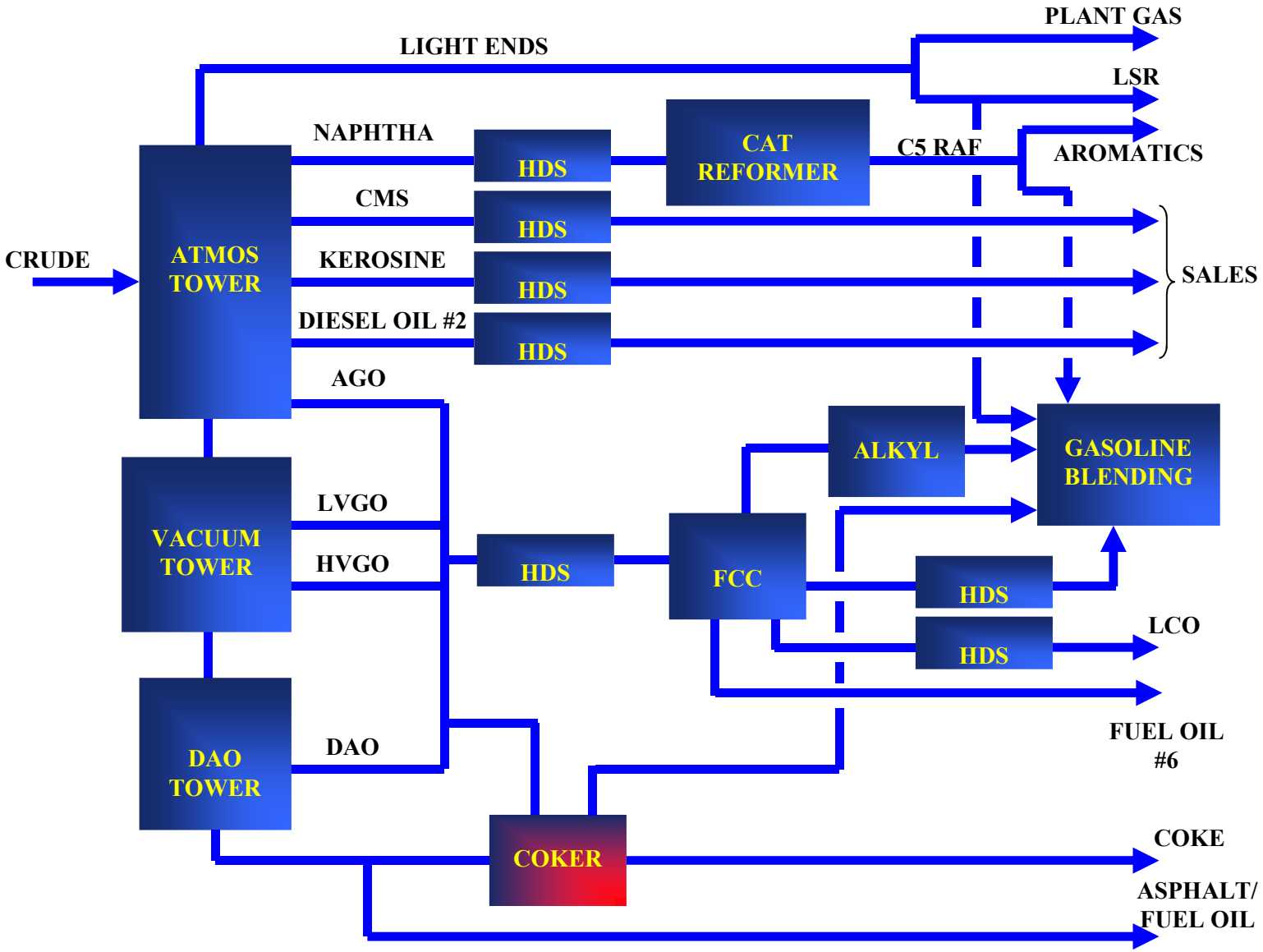

Coker Unit

The function of a coker unit is to crack with heat the asphalt into higher value products

The feed is kept at high temperature for a longer period in a coking drum, producing cracked products and coke.

It has multiple coke drums where the feed is cracked and then taken off line and the coke is removed.

Coker Unit

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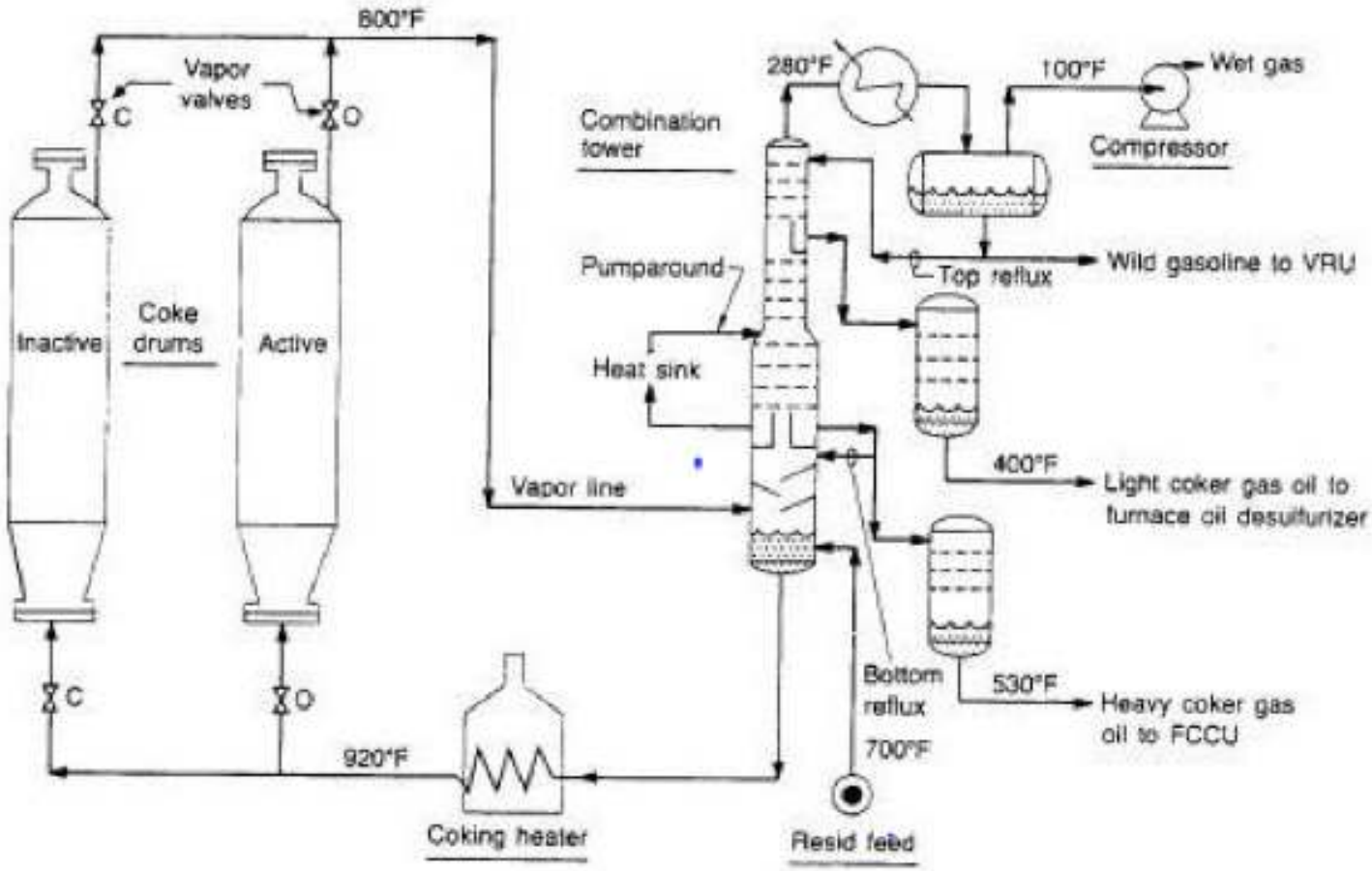

Coker Unit

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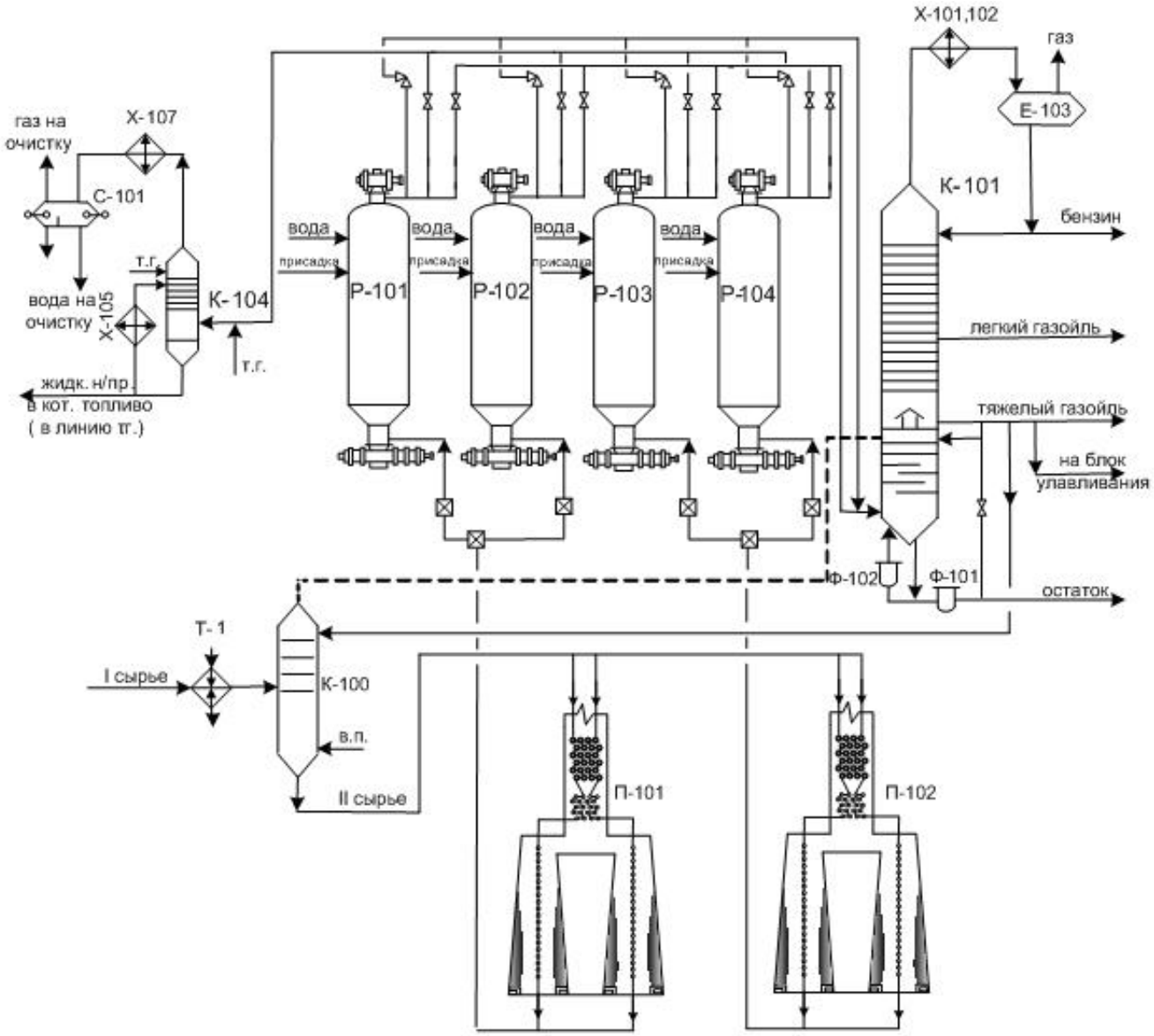

Coker Unit

Refinery Overview

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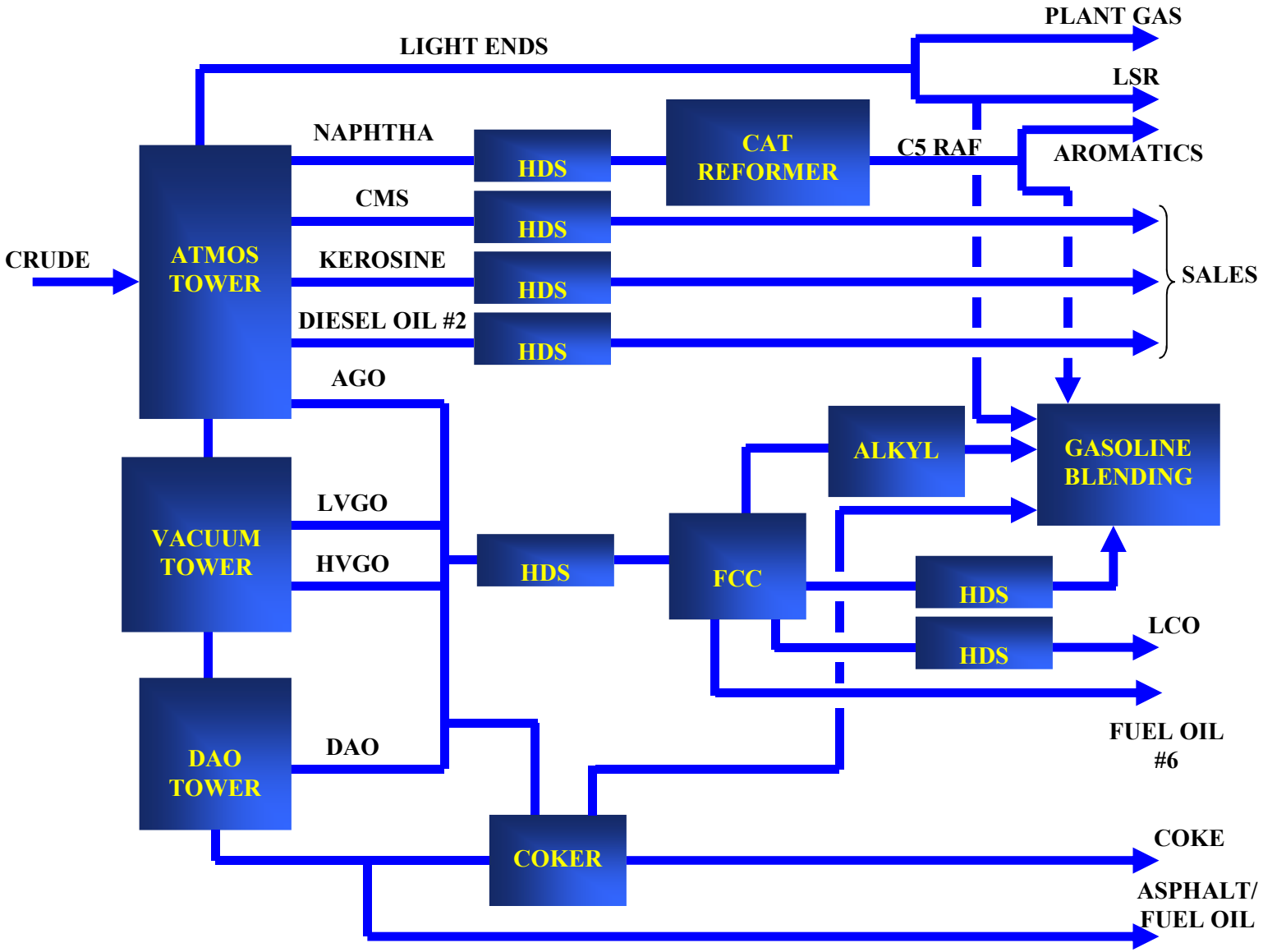

Introduction to Refining

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1. **Crude Unit Properties**
2. **Atmospheric Crude Towers**
3. **Vacuum Towers**
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5. **Coker Units**

Part Two we will cover;

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Thank You