Introduction to Crude Oil Distillation

Crude Oil Distillation

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Introduction to Crude Oil Distillation
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Crude Oil Characterisation

- Crude oil is a complex mixture of hydrocarbons whose composition and physical properties depend on its geographical origin
- Impractical to measure individual species in such a complex mixture, hence crude oil characterised by measuring physical properties such as distillation temperature, density, flash point, pour point, viscosity etc
- Composition and contaminant concentrations determine its value
- Crude oils with high sulphur, naphthenic acid, or in/organic salt content are more difficult to process reliably so are cheaper to purchase
- Crude oil delivered to refinery by ship, pipeline or railcar

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Crude Oil Distillation Process Overview

- The crude distillation unit (CDU) is usually (but not always) the first processing step for crude oil entering the refinery
- Crude oil is separated into several fractions (cuts) with different boiling ranges; offgas, naphtha, kerosene, diesel, gas oil and residue
- The cuts (intermediate products) undergo further processing to make fuel gas, petrol, kerosene, jet fuel, diesel, gas oil, fuel oil and bitumen
- The heart of the CDU is the atmospheric tower which typically contains 20 - 45 trays and runs at 1.0 - 2.5 barg (14.5 - 36.3 psig)
- However the desalter plays a key role in maintaining efficient operation

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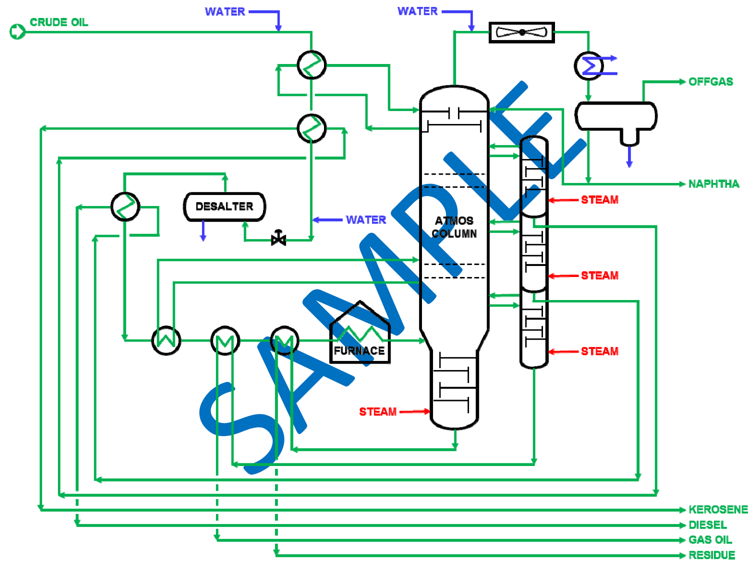
Atmospheric CDU Flowscheme



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Desalting Process Overview

- **Crude oil contains in/organic salts (eg. chlorides) which become corrosive when heated in the presence of an aqueous phase**
- **Desalter is provided to remove most of the inorganic salts and sediments plus excess free water**
- **Water injected into cold crude oil to keep salts in solution as oil passes through preheat exchanger train**
- **More water and demulsifying chemicals injected just upstream of desalter at mix valve**
- **Desalter temperature and water pH are key variables for optimal operation**

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Desalting Process Overview (cont)

- Mix valve dP optimised to ensure good mixing but avoiding emulsion
- Sub-optimal operation can result in salt carryover and/or oil carryunder
- Desalter may be chemical or electrostatic type
- Target 1 ptb salt (as NaCl) in desalted crude
- Note that calcium and magnesium salts are much less soluble in water so removal efficiency for these salts is much lower than for sodium salts
- Excess free water ("brine") is cooled and routed to Benzene Stripper and/or Wastewater Treatment Plant

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Crude Preheat Exchanger Train

- Practically all heat required for crude oil fractionation enters with feed
- Crude oil is preheated by progressively hotter sidecut (liquid product) and pumparound (heat removal) streams
- Raw crude is preheated to 120 - 150 °C (248 - 302 °F) to suit desalter
- Desalted crude preheat exchanger train designed for maximum heat recovery to minimise duty of fired charge heater (approx. 50%/50%)
- Charge heater raises temperature to around 340 - 380 °C (644 - 716 °F)
- Fouling of crude preheat exchangers increases fuel fired at charge heater

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Atmospheric Tower

- Partially vapourised crude oil enters atmospheric tower at "flash zone" near bottom of tower where all but heaviest fractions flash to vapour
- Remaining liquid is atmospheric residue ("atres") with some gas oil
- Stripping steam injected at base of column to aid recovery of the gas oil
- Hot vapours rise up tower, cooling as they ascend, and "pumparound" circuits remove heat to distribute vapour and liquid loads more evenly
- Progressively lighter components condense out and are withdrawn as sidecuts (liquid products)
- Side strippers are used to help vapourise light ends for return to tower

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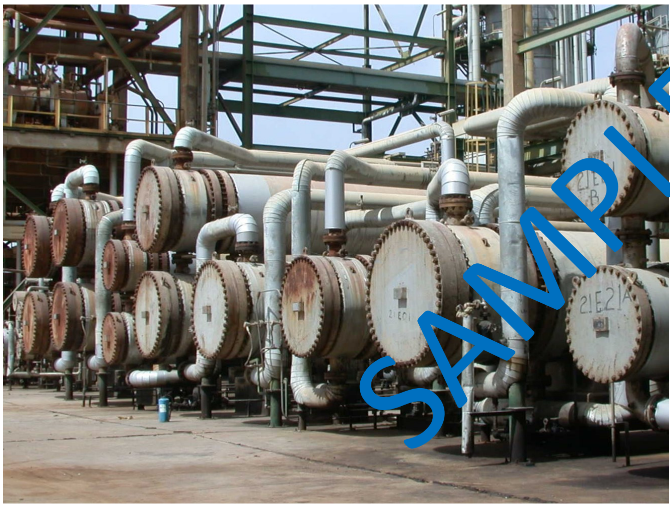
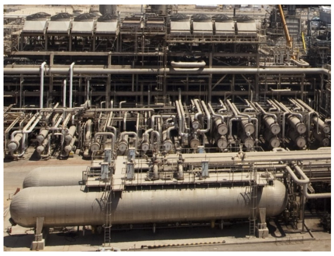
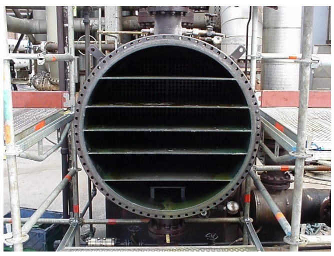
Equipment - Crude Preheat Exchanger Train

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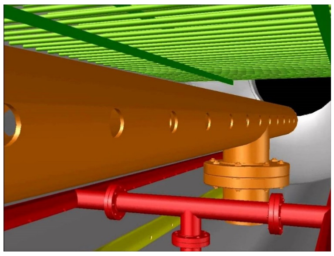
Equipment - Desalter



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Equipment - Crude Charge Heater

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Equipment - Atmospheric Tower

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Key Process Variables

- **Desalter temperature**
  - Affects salt removal efficiency (maximise to bubble point temperature limit)
- **Charge Heater outlet temperature**
  - Sets distillate recovery (maximise to cracking limit)
- **Atmospheric Tower top pressure**
  - Affects vapourisation at charge heater outlet (minimise to condensing capacity limit)
- **Sidecut (product) drawoff rates**
  - Affects product and next heaviest product quality
- **Stripping steam injection rates**
  - Further improves vapourisation (maximise to tower flooding and condensing limit)

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Process Reliability - Crude Preheat Exchanger Fouling

- Asphaltene precipitation and agglomeration is the main cause of crude preheat exchanger fouling (crude oil side)
- Inorganic salts (eg. sodium and calcium chloride) and organo-metallic compounds (eg. nickel and vanadyl porphyrins) also cause fouling

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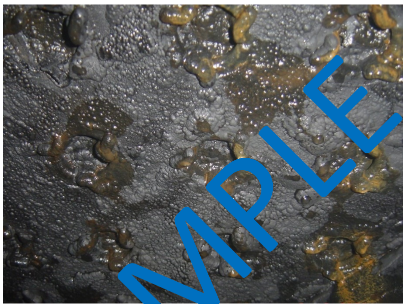
Process Reliability - Atmospheric Tower Fouling



- Top section susceptible to chloride salt deposition and pyrophoric iron sulphide scale accumulation
- Bottom section susceptible to heavy organic compound deposition (eg. waxes and asphaltenes), sludge accumulation and coking

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Process Reliability - Atmospheric Tower Corrosion



- Top section susceptible to chloride corrosion and salt deposition (affects trays, packing, support rings, vessel walls, nozzles etc)
- Bottom section susceptible to high temperature sulphidation corrosion, naphthenic acid corrosion, sludge accumulation and coking

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Process Safety - High Temperature Sulphidation Corrosion



- Major fire at Chevron Richmond CDU on 06-Aug-12 was caused by high temperature sulphidation corrosion of light gas oil sidedraw line
- No fatalities, but 26 injured and ~15,000 people from nearby communities suffered breathing problems, chest pains, sore throats or headaches

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Summary

- Crude oil separated into multiple products (cuts) by fractional distillation
- Best product separation achieved at min pressure and max internal reflux
- Stripping steam injected to increase vapourisation of hydrocarbons
- Crude oil distillation is energy-intensive process (large furnace duty)
- Crude oil preheat exchangers fouled by asphaltene and salt deposits
- Atmos Tower suffers corrosion (chloride at top, sulphidic at bottom)
- Atmos Tower operates above autoignition temperature of some products
- Preflash column sometimes added between desalter and charge heater
- Vacuum Tower added to recover more distillate from atmospheric residue