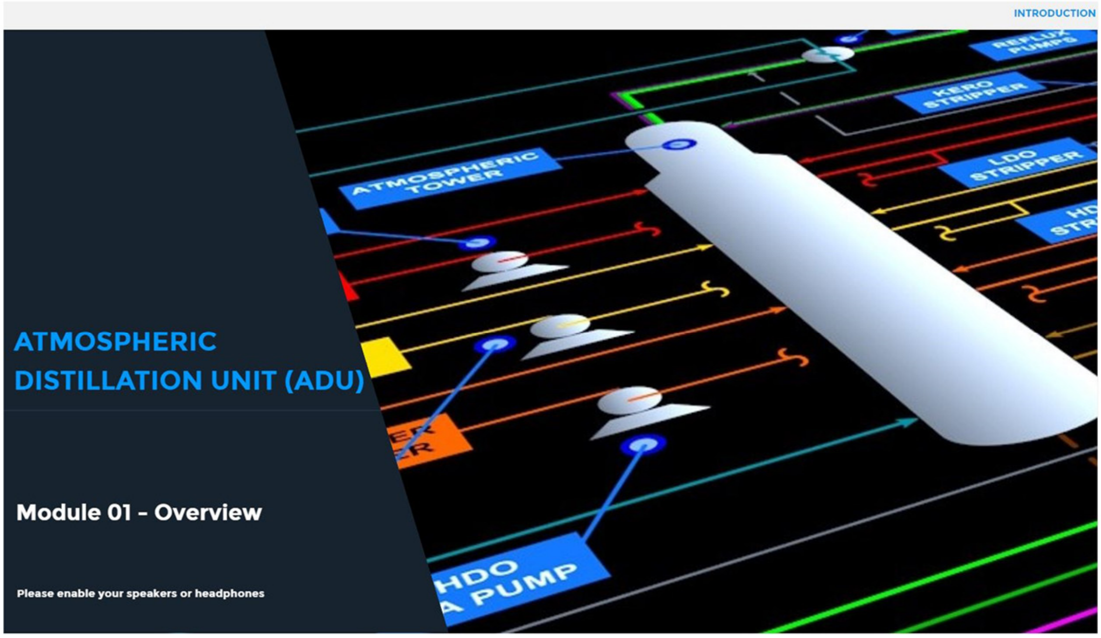
BU MEASUREMENT & ANALYTICS

Refinery Process Units

Atmospheric Distillation Unit (ADU) – Module 1: Overview



Welcome to Atmospheric Distillation Unit Module 1, Overview.

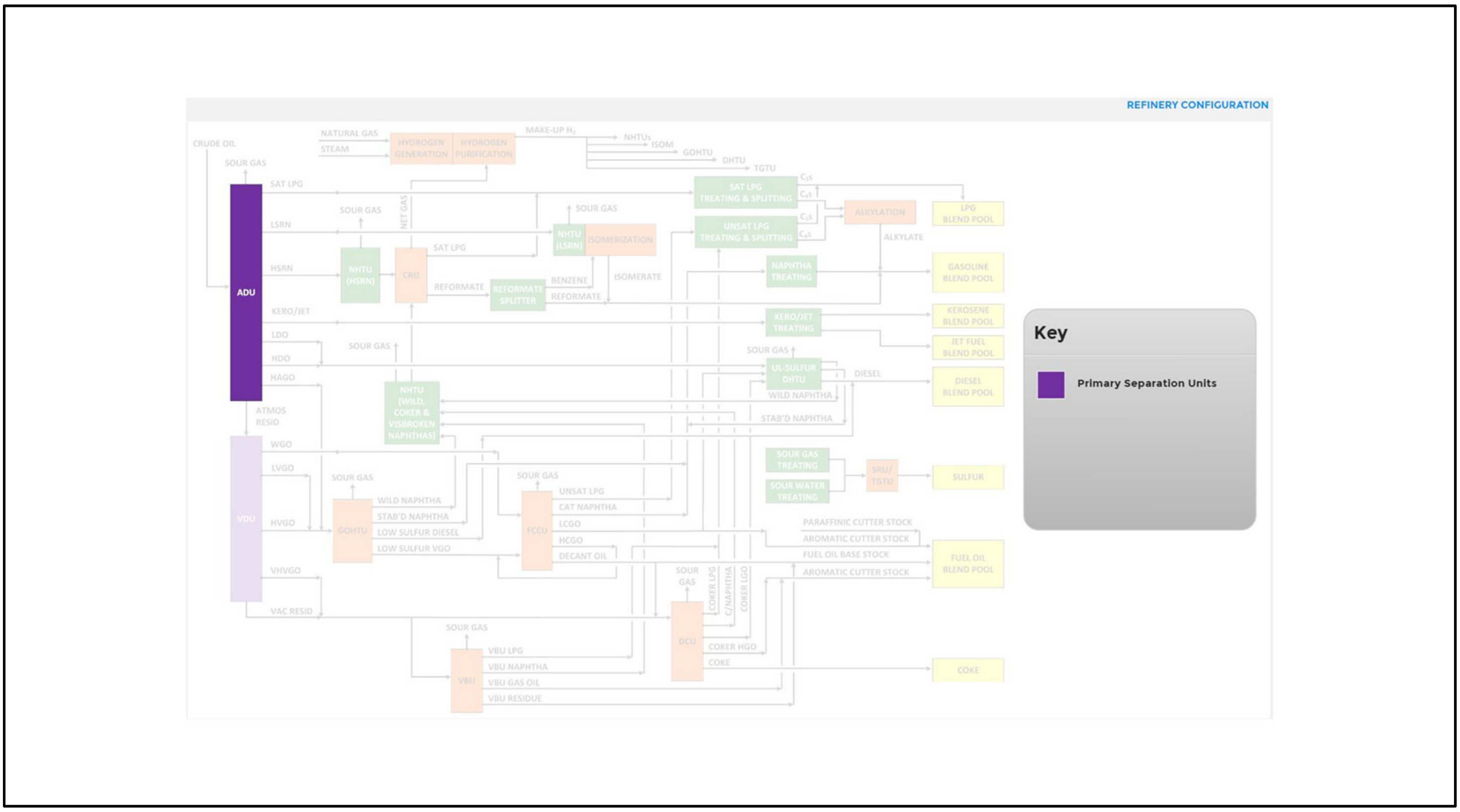
For the ADU Overview, upon completion of this module, you should:

Understand the role of the ADU within the refinery configuration

Be familiar with terms used to describe crude separation processes and feed, intermediate and product streams

Be aware of some major constraints on ADU operation

Let’s start with a brief introduction.

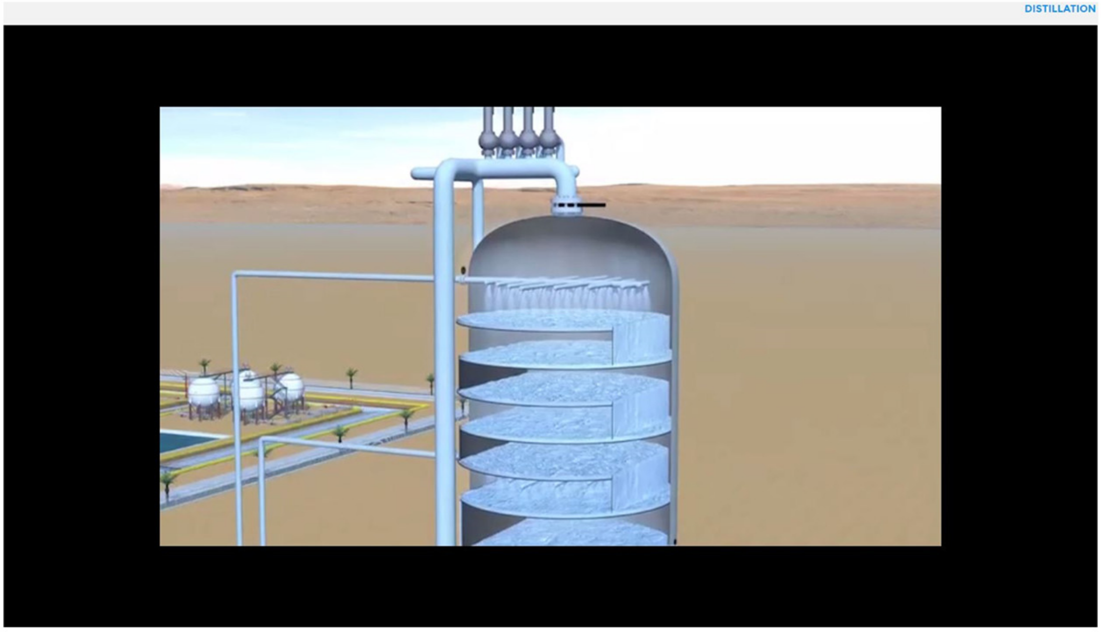


Here we have the overall refinery configuration diagram that we showed you in the Introduction Module.

You'll recall the color coding:

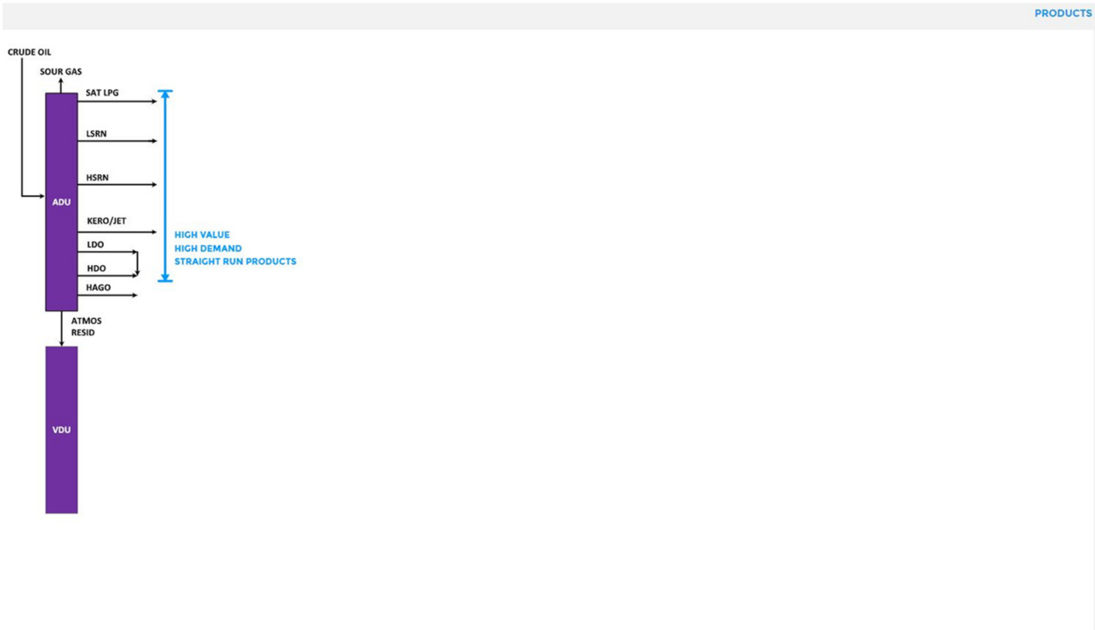
- Primary Separation Units are purple
- Secondary Conversion Units are orange
- Tertiary Treating Units are green
- Export Products are yellow

Our focus here will be on the ADU, the first of the two Primary Separation Units.



The ADU makes extensive use of distillation to separate crude oil into gas, light/middle/heavy distillate and residue products.

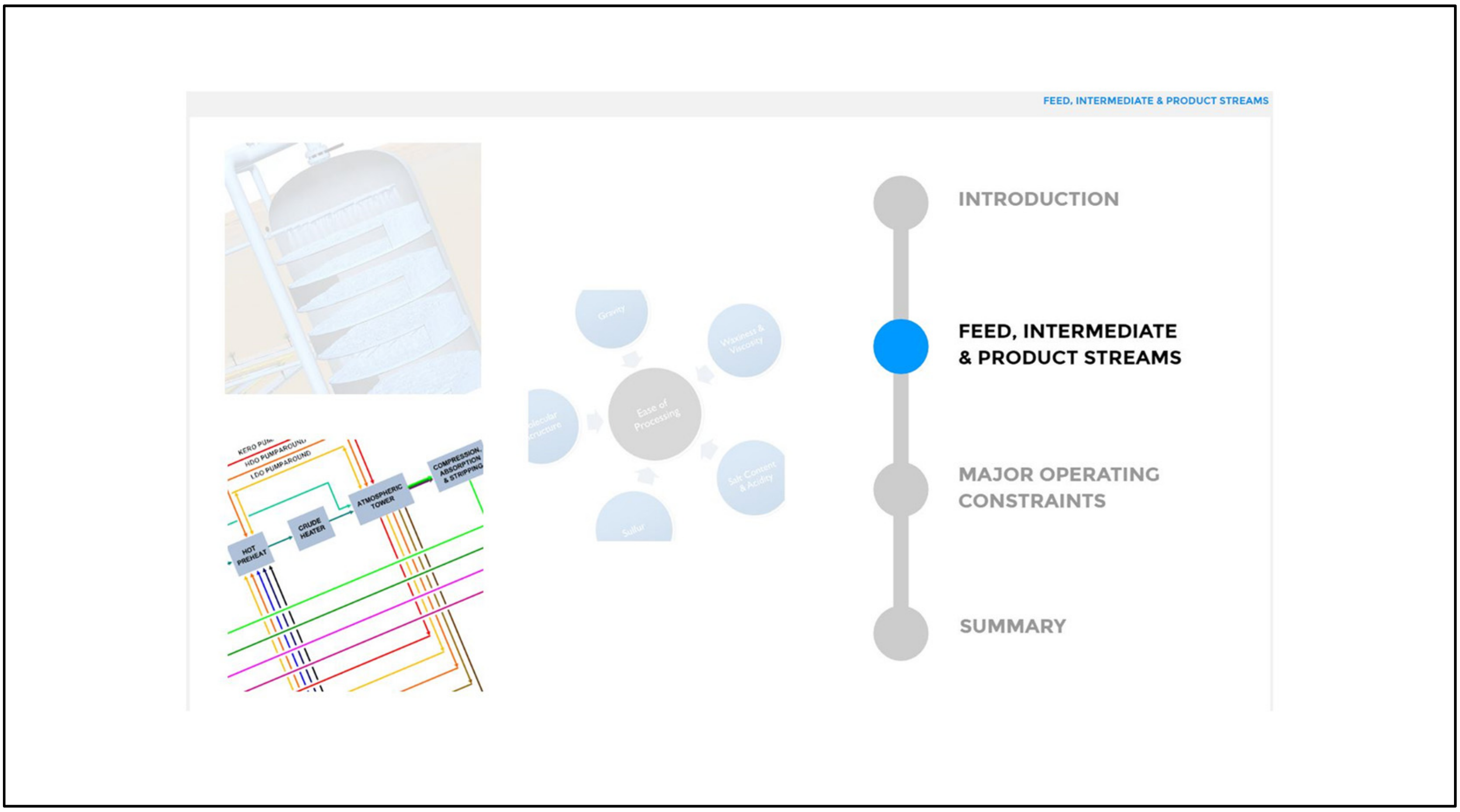
Distillation uses the transfer of heat between ascending vapor and descending liquid over trays or packing to achieve separation. Heat is added at the base of the tower and removed at the top.



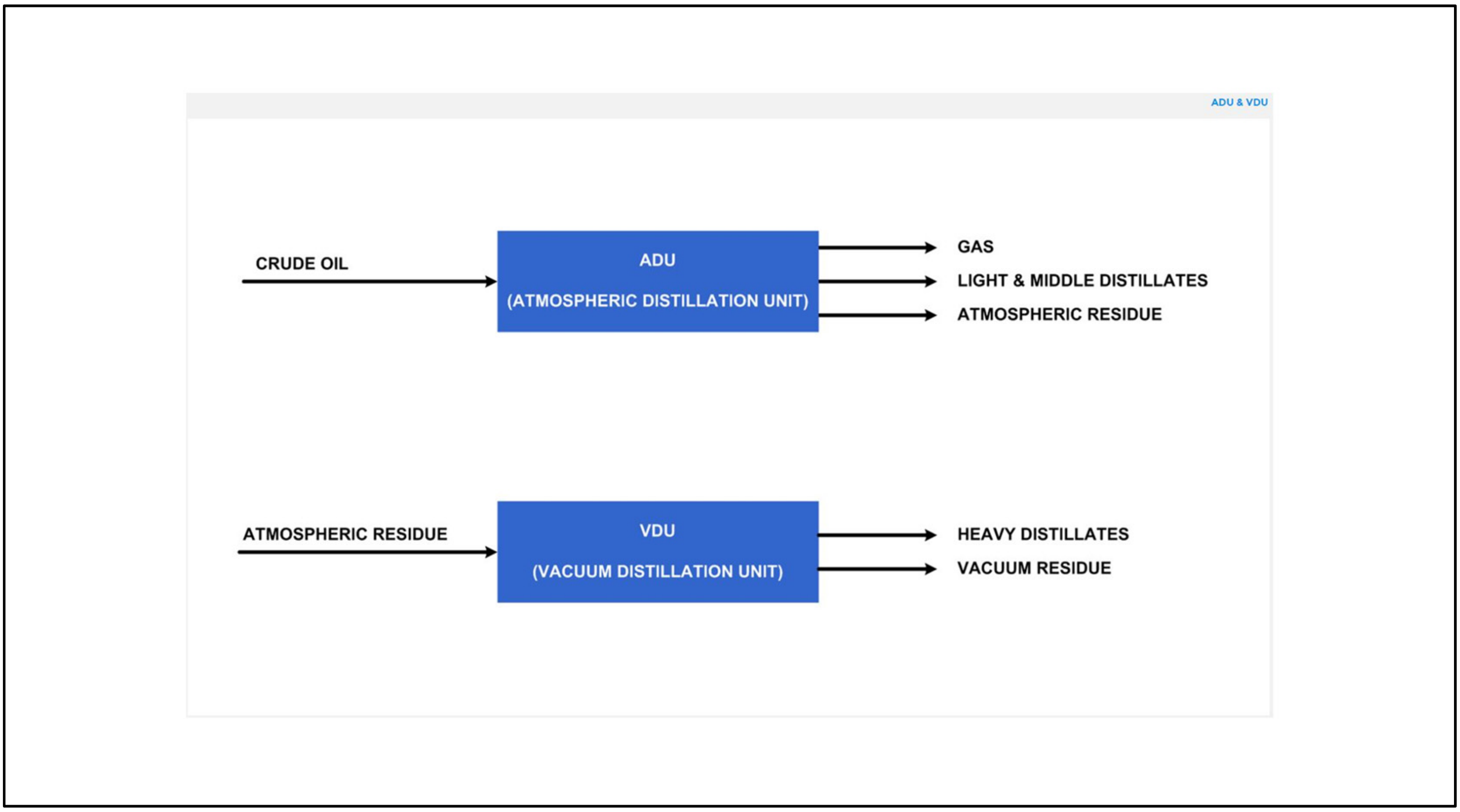
The Atmospheric Distillation Unit (ADU) is a primary separation unit that fractionates crude oil into a by-product of sour gas and liquid products in the form of Liquefied Petroleum Gas (LPG), Light Straight Run Naphtha (LSRN), Heavy Straight Run Naphtha (HSRN), Kerosene and Jet Fuel, Light Diesel Oil (LDO), Heavy Diesel Oil (HDO), Heavy Atmospheric Gas Oil (HAGO) and Atmospheric Residue (which is commonly abbreviated to Atmos Resid).

The LPG (also referred to as Saturated LPG or Sat LPG to distinguish it from unsaturated and unstable LPGs produced by cracking), LSRN, HSRN, Kerosene, Jet Fuel, LDO and HDO are high-demand, high-value straight run products that with further conversion and/or treating form the base stocks for the product blend pools.

Atmos Resid from the ADU passes to the Vacuum Distillation Unit (or VDU).

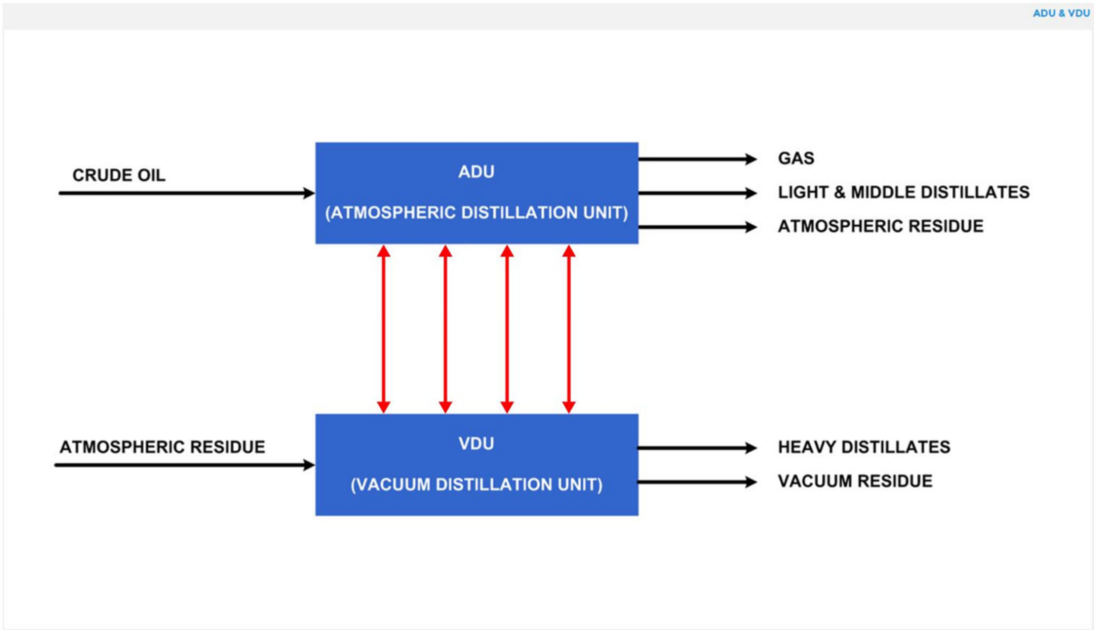


Moving on, we'll look at the feed, intermediate and product streams associated with Atmospheric Distillation.

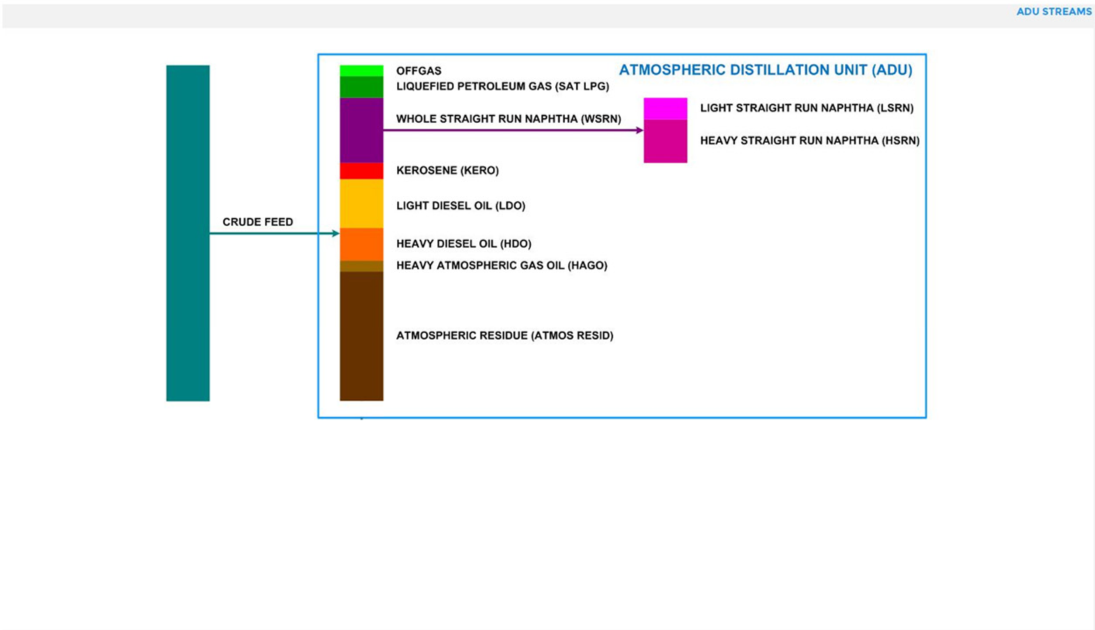


So, we know that an Atmospheric Distillation Unit (or ADU) separates crude oil into gas, light and middle distillate and atmospheric residue fractions.

A Vacuum Distillation Unit (or VDU) separates atmospheric residue into heavy distillate and vacuum residue fractions.

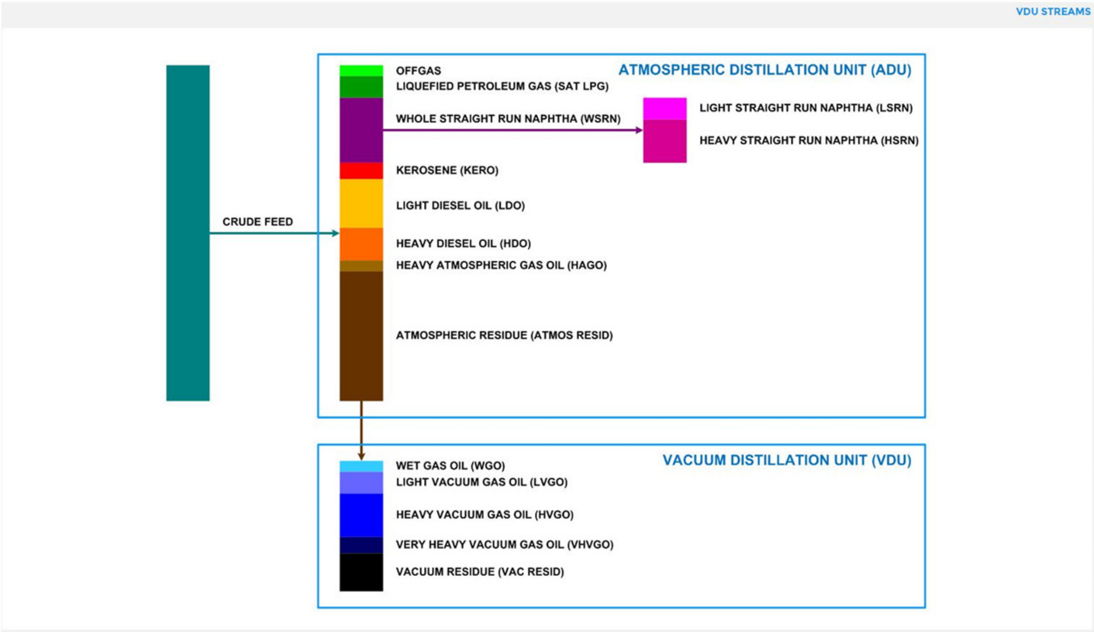


Although the ADU and VDU are separate process units, for the purpose of efficient utilization of energy their heat recovery systems are often integrated. Integration takes the form of indirect heat exchange between hot VDU pumparounds/products and cold ADU crude feed.

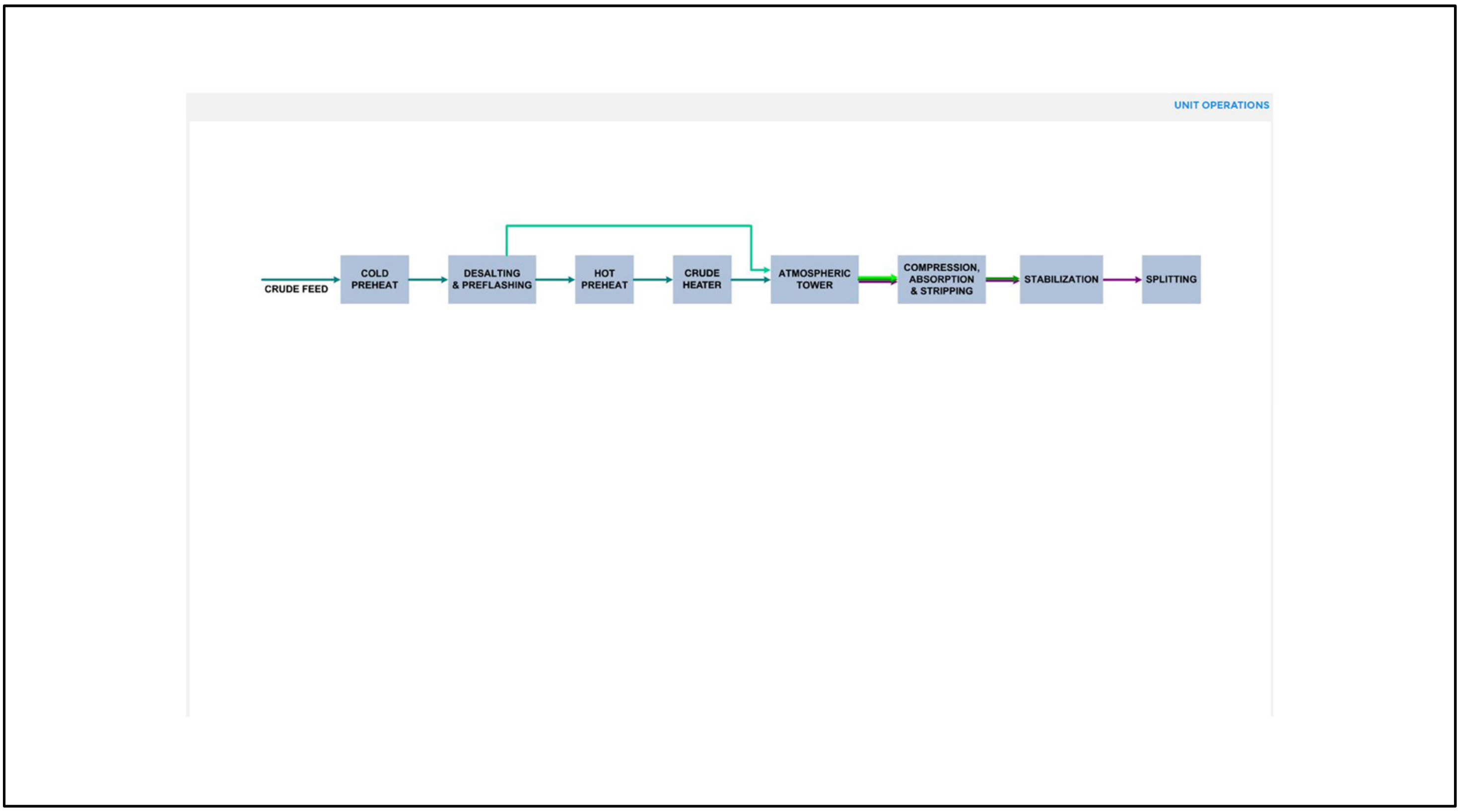


This diagram shows the ADU feed, intermediate and product streams. Please familiarize yourself with the color-coding of these streams and the abbreviations as we'll be using them throughout the program.

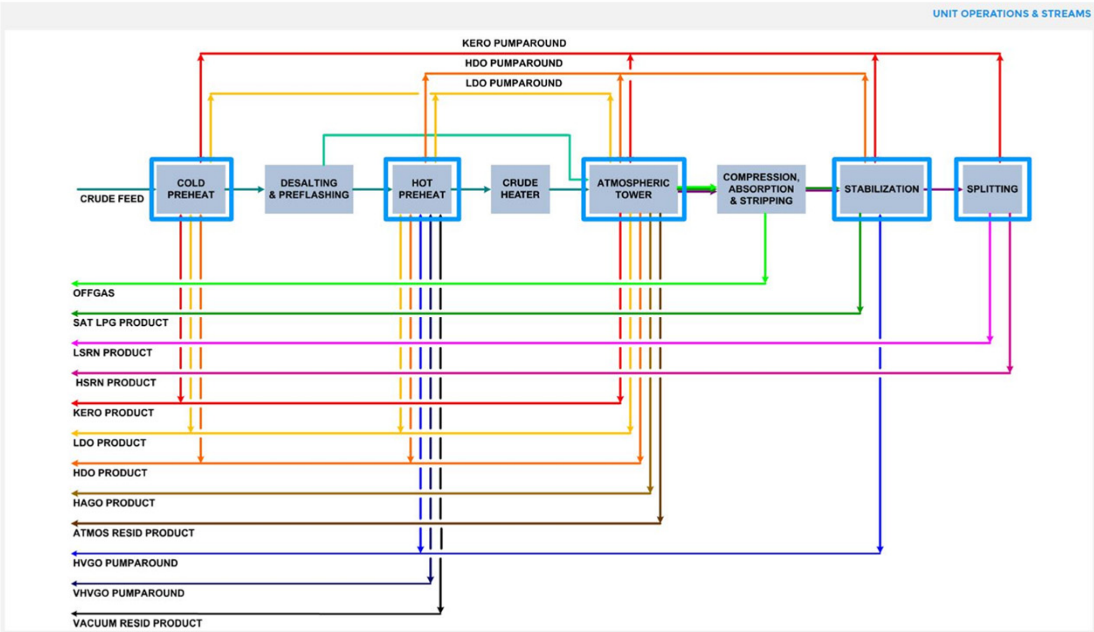
Please click NEXT when you are ready to move on.



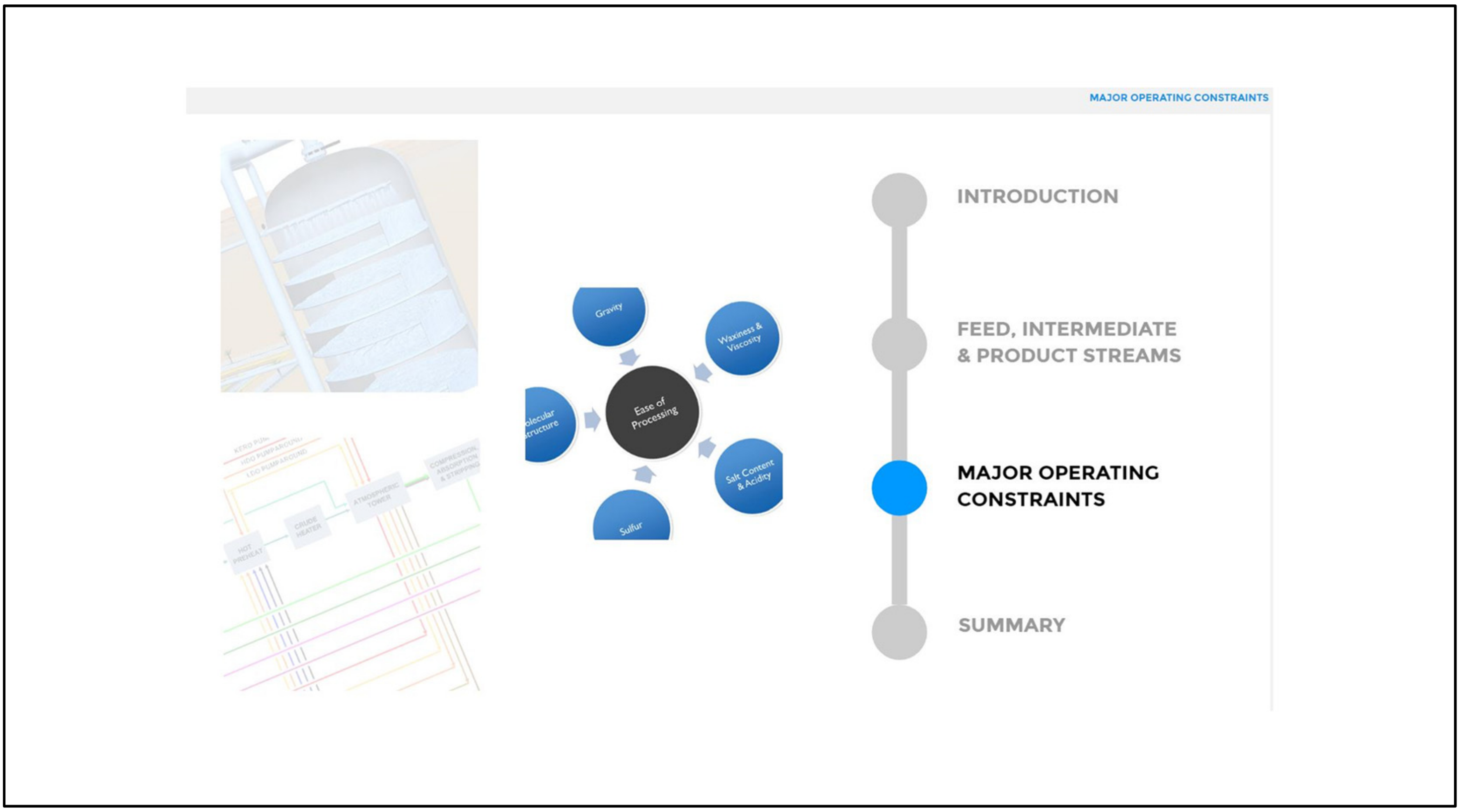
This diagram shows the VDU product streams - these are significant because HVGO, VHVGO and Vac Resid are used in ADU-VDU heat integration.



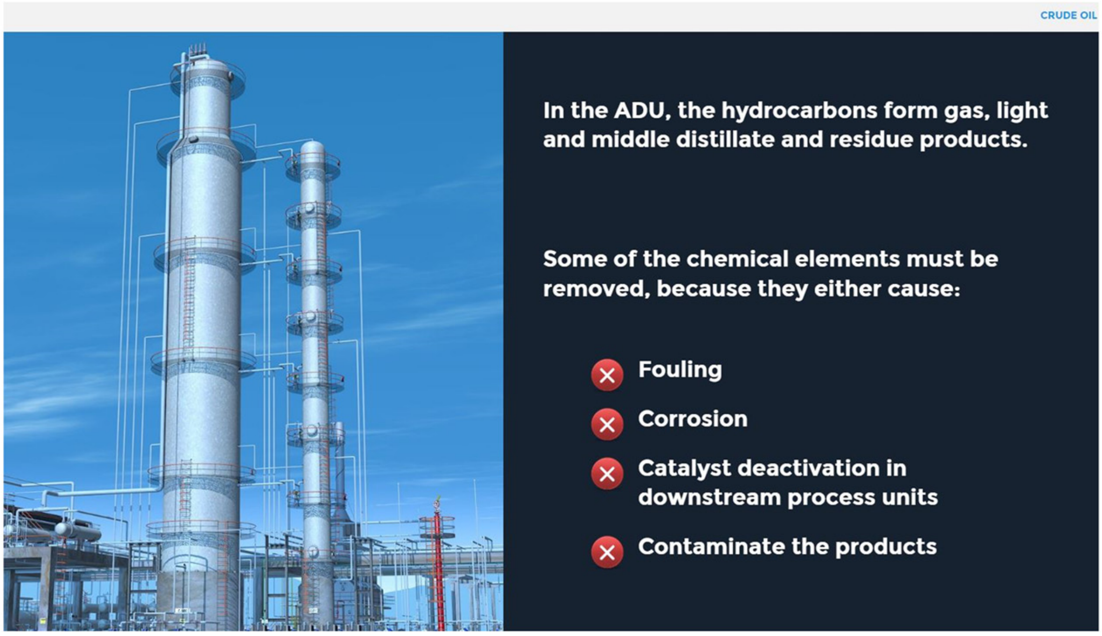
These are the unit operations that take place in the ADU. Don't worry about their function for now, we'll be explaining that in detail in the modules that follow.



This diagram illustrates how the ADU feed, intermediate, product and pumparound streams together with the VDU product and pumparound streams are heat integrated with the Cold Preheat, Hot Preheat, Atmospheric Tower, Stabilization and Splitting unit operations. As you can see, its complex.



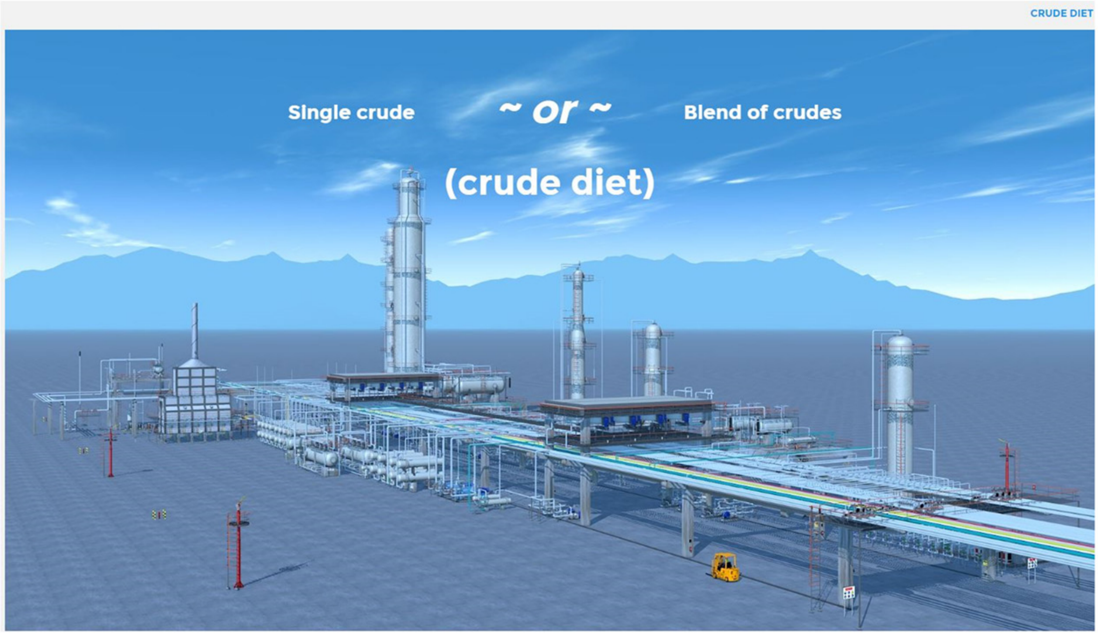
Next, we'll get you up to speed on some major operating constraints on ADU operation.



Crude oil is a complex mixture of hydrocarbons, consisting principally of carbon and hydrogen together with sulfur, nitrogen, oxygen and metallic elements arranged in a variety of molecular structures.

In the ADU, the hydrocarbons form gas, light and middle distillate and residue products.

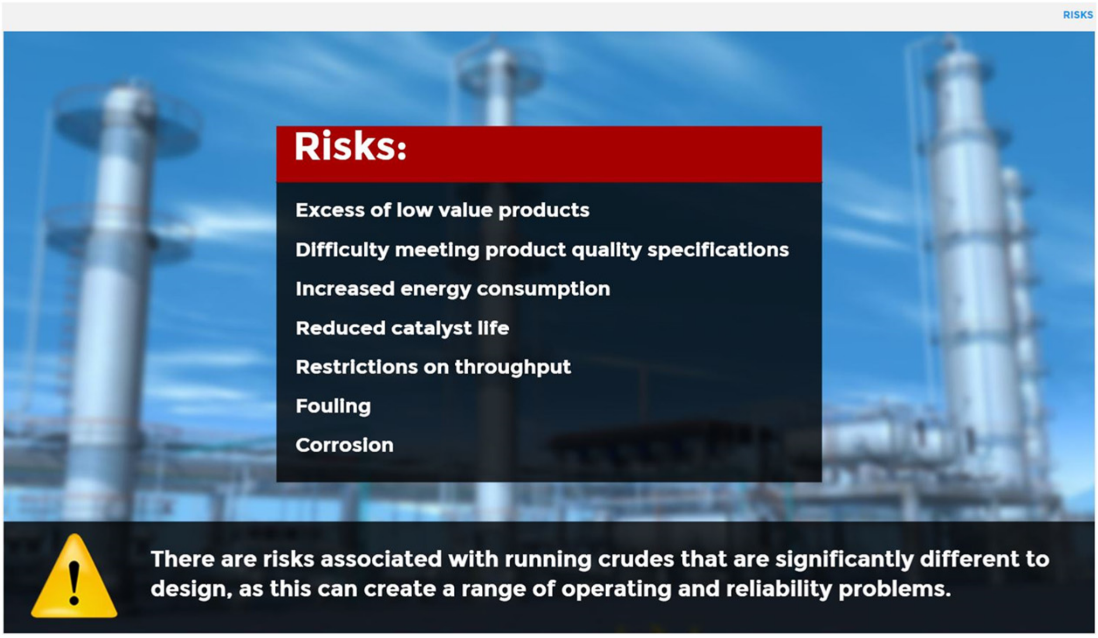
Some of the chemical elements must be removed because they either cause fouling, corrosion and catalyst deactivation in downstream process units or contaminate the products.



In general, refineries are designed to run either a single crude feed or a blend of crude feeds (you may hear this referred to as the ‘crude diet’). From time-to-time, the refiner might find it economically advantageous to run a crude that differs significantly from design - this could be for a number of reasons, e.g.

Distressed crude cargos can sometimes be picked up at discounted prices, offering the refiner an increased profit margin

The refiner might have a surplus of a particular product, e.g. LPG, and want to selectively reduce production by running a crude that gives lower LPG yields



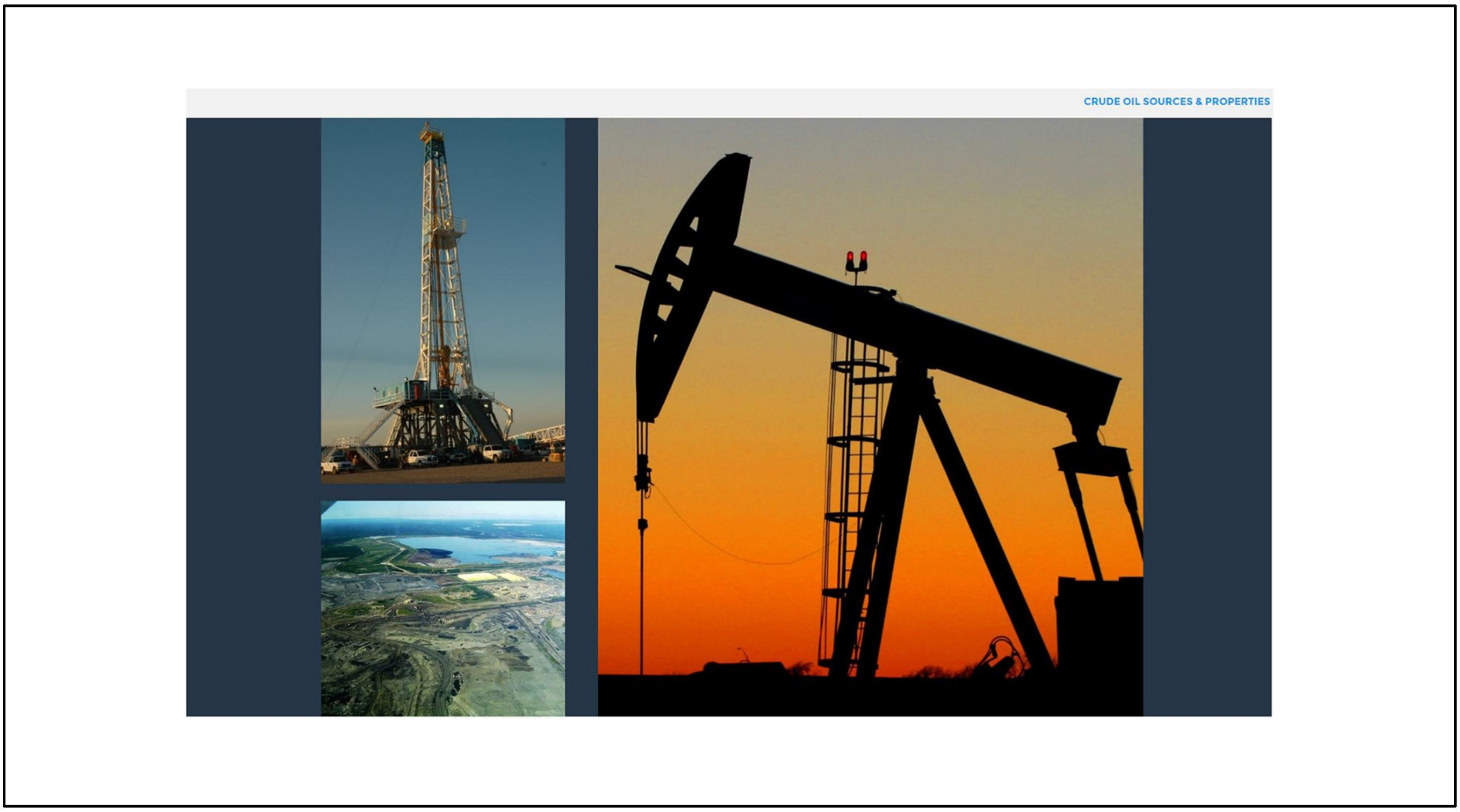
There are risks associated with running crudes that are significantly different to design, as this can create a range of operating and reliability problems such as:

- Excess of low value products
- Difficulty meeting product quality specifications
- Increased energy consumption
- Reduced catalyst life
- Restrictions on throughput
- Fouling
- Corrosion

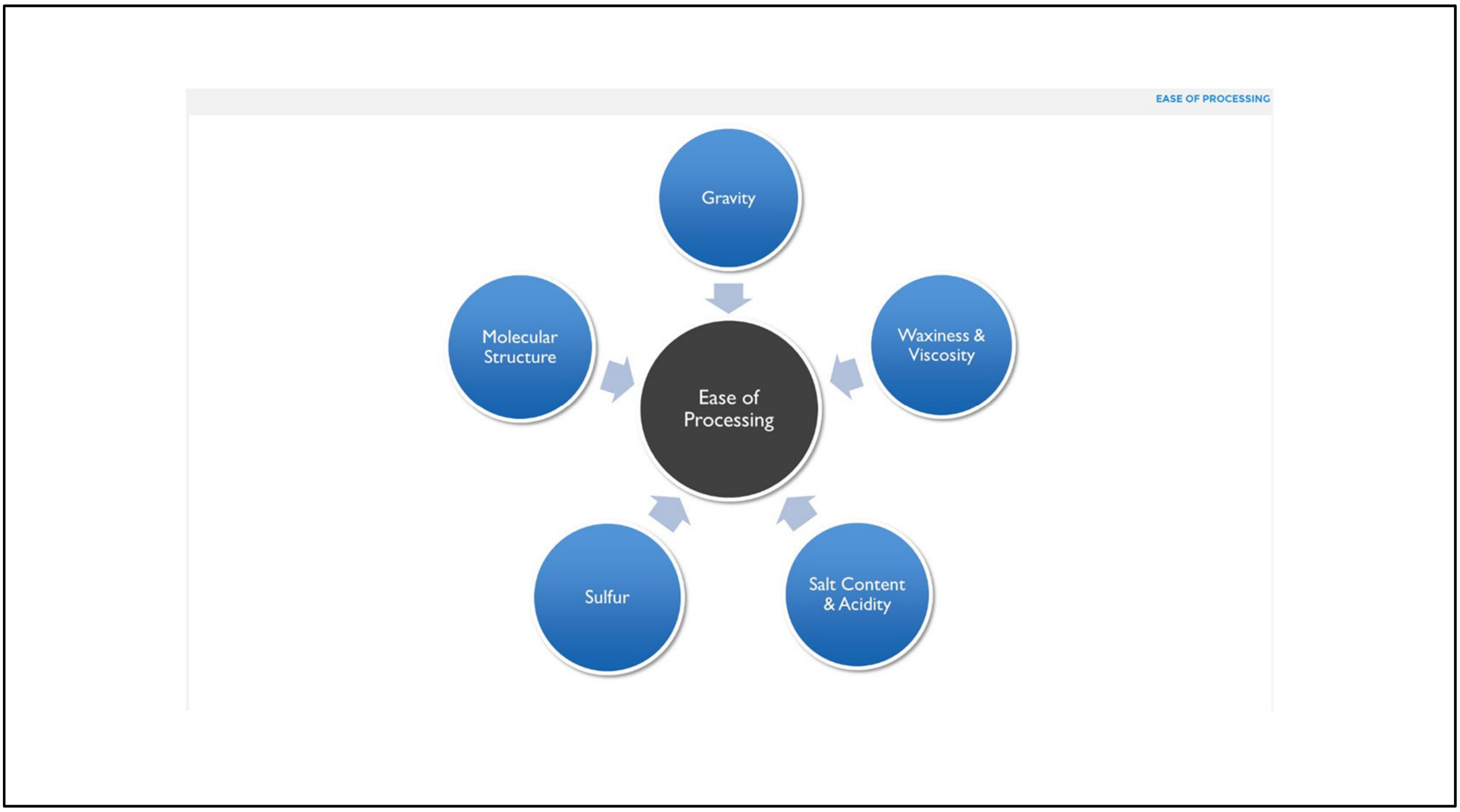
So caution must be exercised - excursions into unknown and uncharted crude territory have been known to end in tears.

Laboratory tests (called assays) provide important information on the crude, helping refiners decide if a certain crude can be run in their refinery and determine operating conditions and expected product yields.

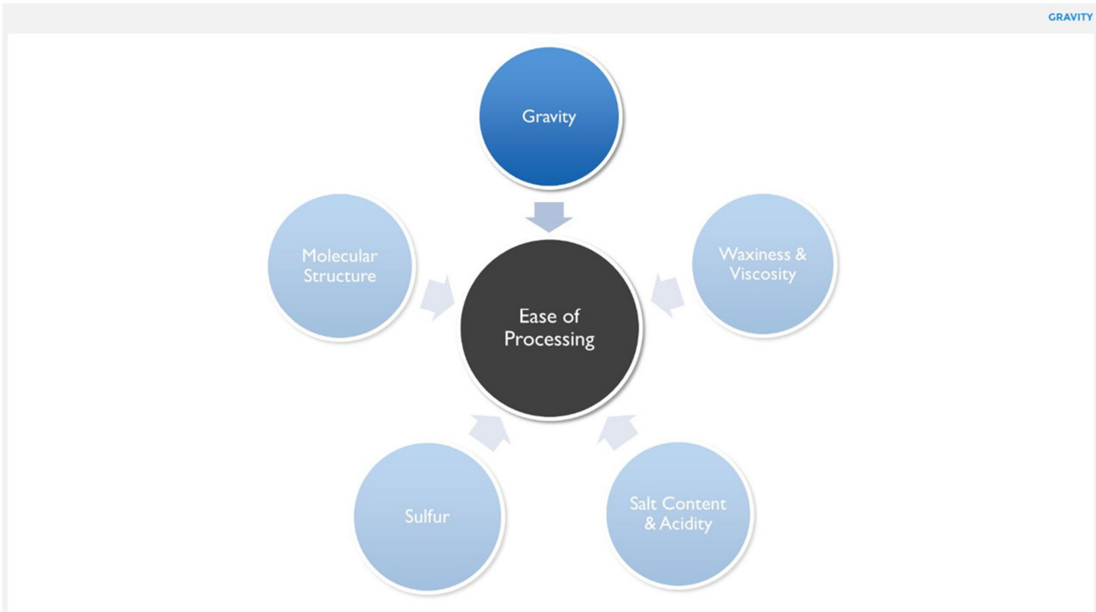
As oil fields are discovered and oil is progressively extracted, crude quality varies with time - crude assays are not performed daily so they can be inaccurate and crude delivered to the refinery can differ significantly from the assay.



Crude oil has many sources throughout the World and depending on the source, its quality varies considerably so we use a number of physical properties to characterize how economic or troublesome it is to process. Let’s take a look at these.



These are the characteristics that typically define the ease or difficulty with which a particular crude can be processed. If an unfamiliar crude has an excess of one or more of these characteristics, this is indicative that it may be necessary to run it as a blend with a less severe crude.



The gravity tells the refiner how light or heavy the crude is... ultra-light and ultra heavy crudes are more difficult to process than intermediates because they give disproportionate yields of light and heavy products that can encroach on pumping and storage limitations and create difficulties meeting product quality specifications.

Heavier crudes often contain higher concentrations of metals, which can poison the catalysts used in the refinery's downstream conversion processes.

Waxiness and viscosity are an indication of the expected flow properties of the crude and its refined products, i.e. how easy these streams are to pump and whether they will solidify and plug lines in cold climates.

Crudes that have a high salt content and high acidity can cause corrosion in processing equipment. Salt is removed by Desalting operations but these become less effective at high salt levels and eventually salt slips past to downstream equipment resulting in corrosion.

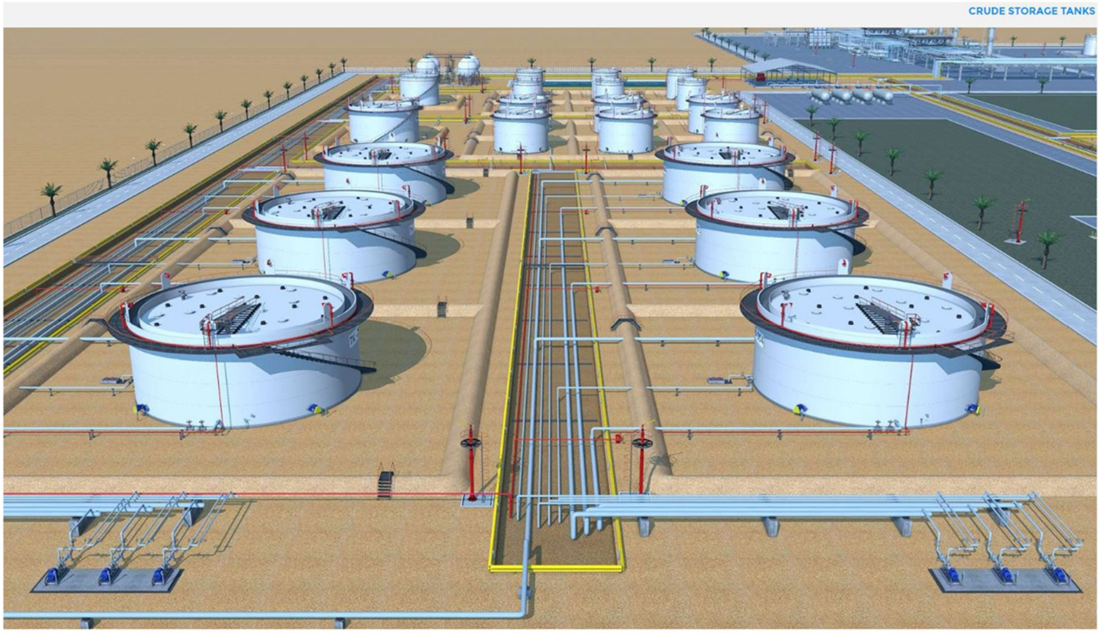
High acidity cannot be removed and has to be diluted by crude blending.

The sulfur content of the crude determines the sourness of the refined products and the amount of sweetening that's required in downstream treating units.

Crudes that are exceptionally high in sulfur can encroach on sweetening constraints... in which case finished products may not meet quality control specifications.

Several of the refining processes convert low value heavy molecules into higher value lighter ones.

Molecular structures vary from crude-to-crude and some are more difficult to convert than others, resulting in production limitations and low yields.



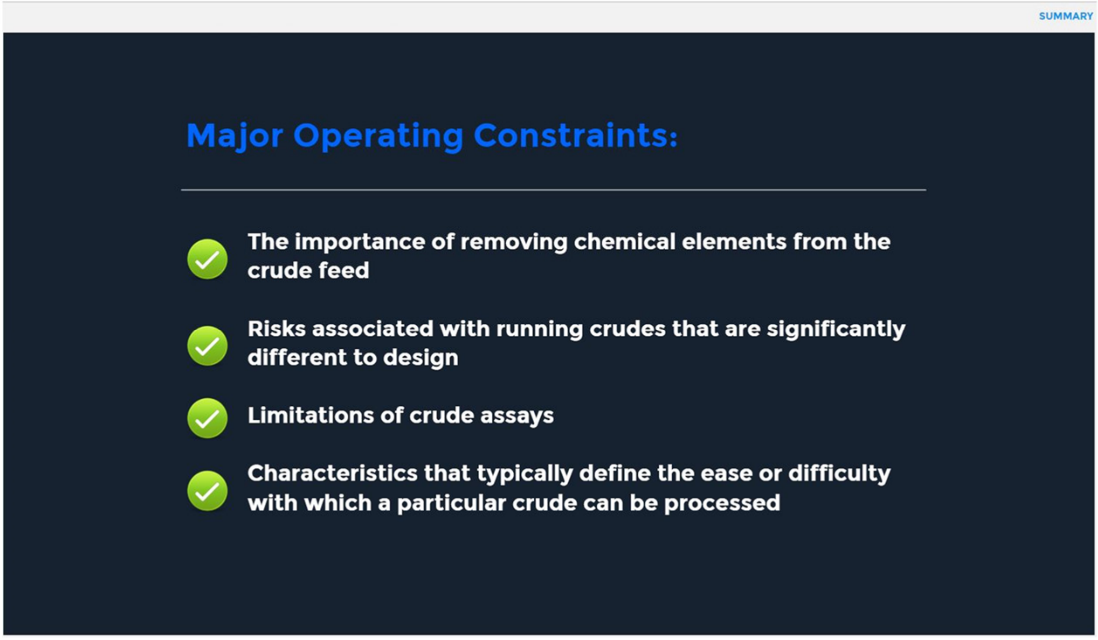
When the crude oil reaches the refinery, it is discharged into crude oil storage tanks.

Before a crude can be run through the ADU, crude receiving tanks must stand for sufficient time to allow any residual water to disengage, accumulate and be drained off - slugs of water can seriously disrupt ADU operation.

When residual water has been drained off, the crude must be thoroughly mixed before processing - this is done by either externally circulating the crude contents using a pump…

…or by turning on the tank mixers.

Crude oil can form stratification layers in tankage, resulting in variations in feed quality that can cause process unit disturbances if the crude is not thoroughly mixed - this is a significant factor when running crude blends.



And that completes ADU Module 01. By now, you should:

- Understand the role of the ADU within the refinery configuration
- Be familiar with terms used to describe crude separation processes and feed, intermediate and product streams
- Be aware of some major constraints on ADU operation – such as:
  - The importance of removing chemical elements from the crude feed because they can cause fouling, corrosion and catalyst deactivation in downstream process units or product contamination
  - Risks associated with running crudes that are significantly different to design
  - Limitations of crude assays
  - Characteristics that typically define the ease or difficulty with which a particular crude can be processed

Your task now is to take the ADU Module 01 Quiz to ensure you have fully understood the material.

If you find the questions challenging, you should consider repeating this module before moving on to Module 02. Good luck!

You can now close this module.