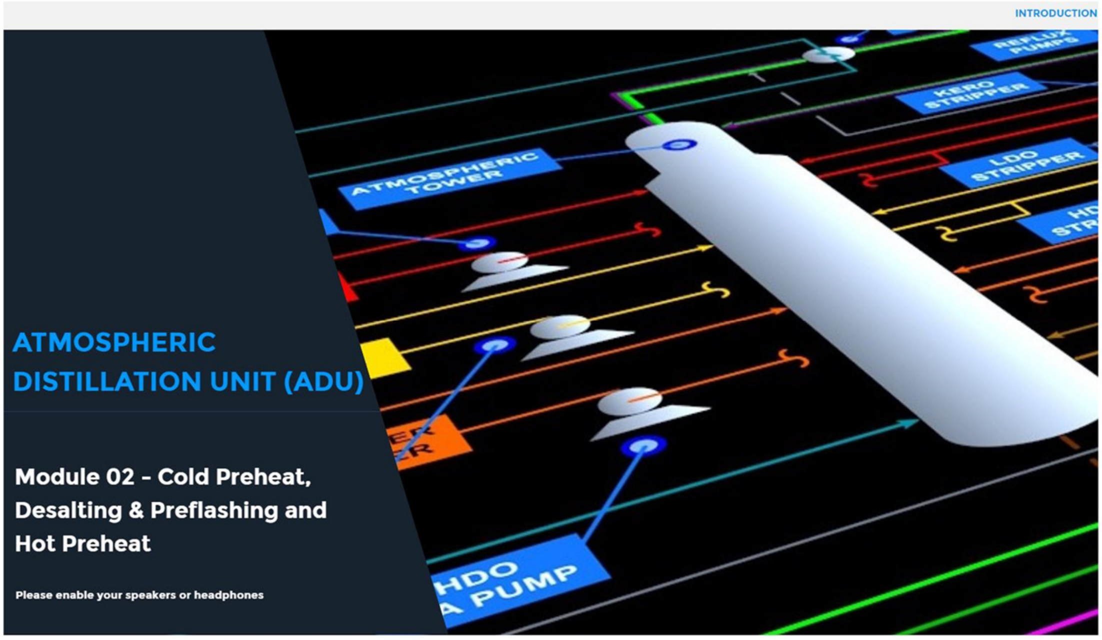
BU MEASUREMENT & ANALYTICS

Refinery Process Units

Atmospheric Distillation Unit (ADU) – Module 2: Cold Preheat, Desalting & Preflashing and Hot Preheat



Welcome to Atmospheric Distillation Unit Module 2 – Cold Preheat, Desalting & Preflashing and Hot Preheat.

For the Cold Preheat, Desalting & Preflashing and Hot Preheat unit operations, upon completion of this module, you should be able to:

Describe the process flow

Name the principal items of equipment

Describe their function

Understand the principles of operation, in particular, variables critical to successful and efficient desalting operations

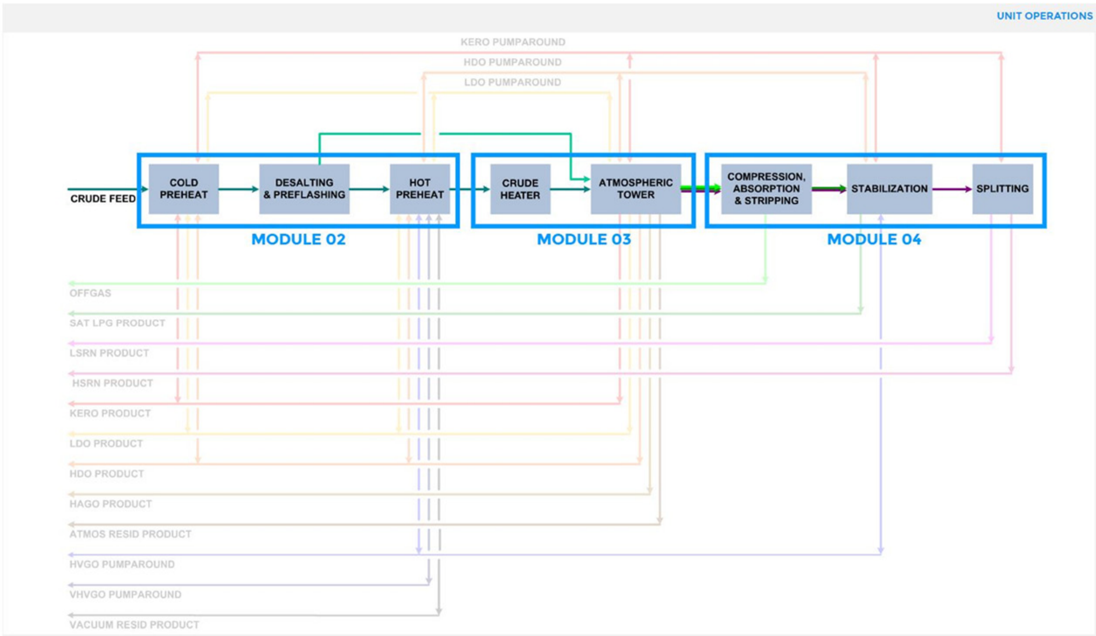
And recognize their internal components

Additionally, you should be able to demonstrate an awareness of:

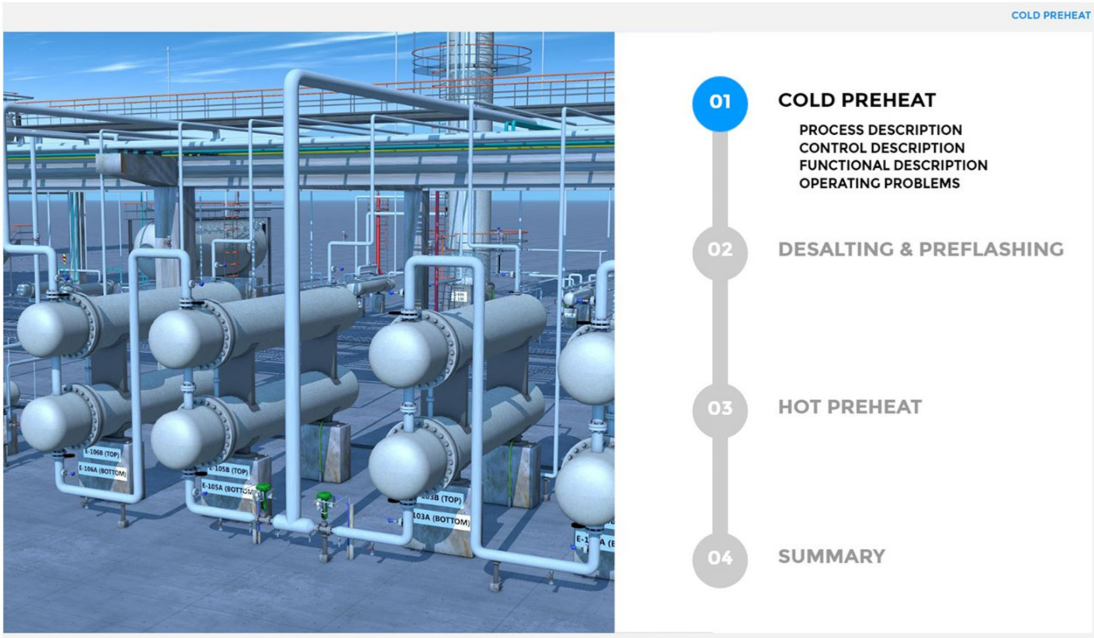
Important process variables and how they're controlled

Major operating constraints

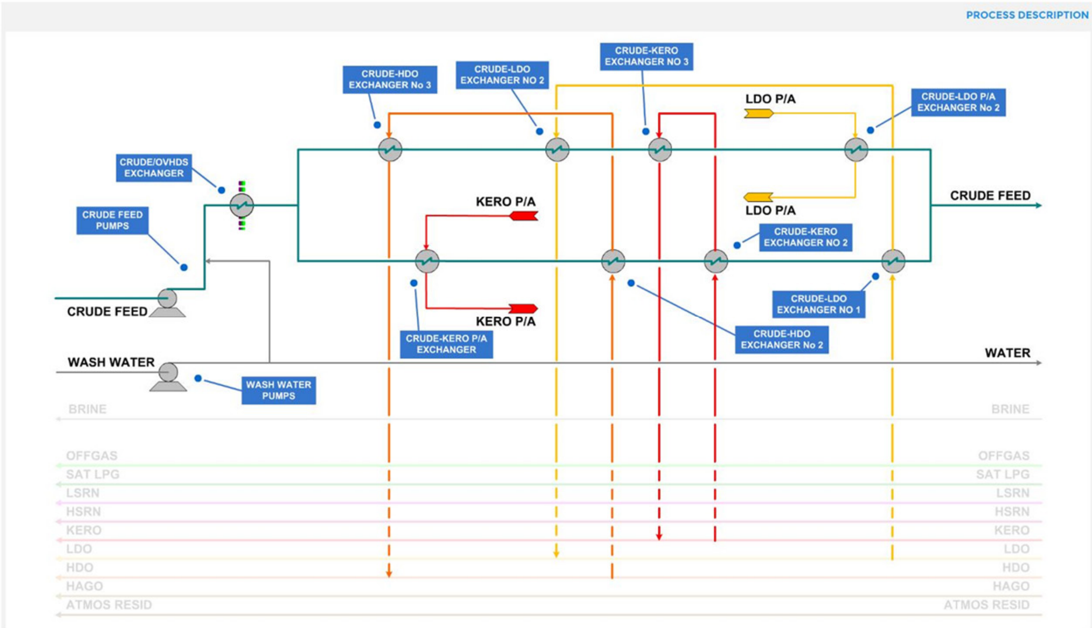
And typical operating problems



Here’s the overall block flow diagram for the ADU that we introduced in module 1. You’ll recall that the ADU has 8 distinct unit operations - we’ve divided these into topics which will be covered in ADU Modules 2, 3 & 4.



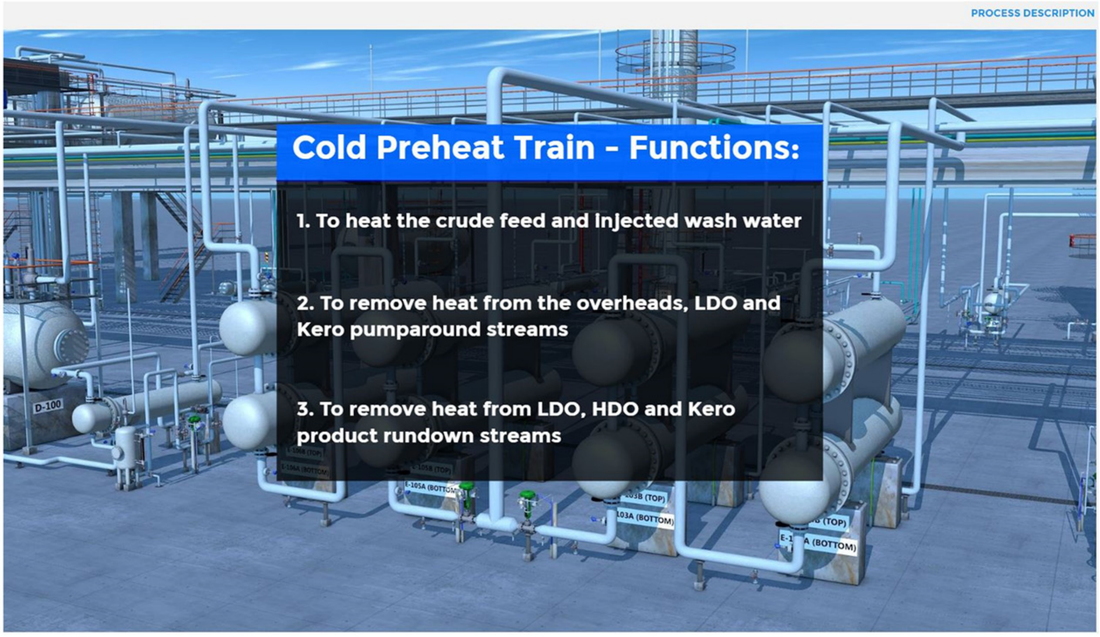
We’ll start with Cold Preheat.



Process Description:

Crude feed from storage is pumped through two parallel trains of heat exchangers. Heat is transferred from hot overheads, product and pumparound streams to the colder crude feed.

Wash water is added to the discharge of the Crude Feed Pumps as a carrier for injection chemicals that help emulsify the crude in preparation for downstream desalting.

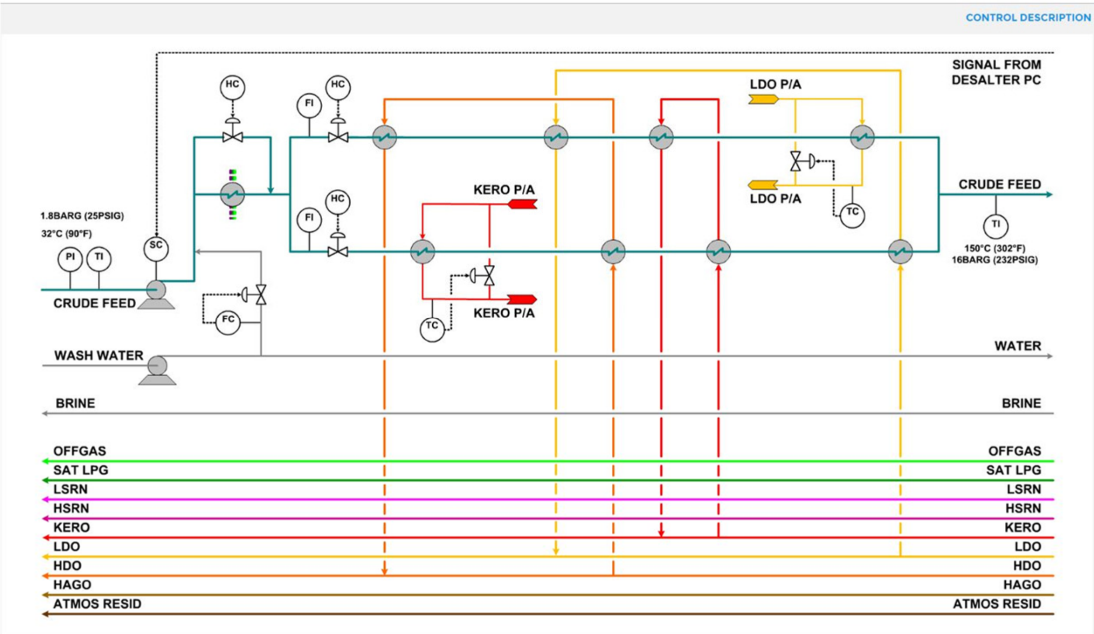


The Cold Preheat train has three functions:

To heat the crude feed and injected wash water to a temperature that ensures efficient operation of the downstream Desalters

To remove heat from the overheads, LDO and Kero pumparound streams, providing reflux for the Atmospheric Tower

To remove heat from LDO, HDO and Kero product rundown streams, satisfying temperature limitations on facilities downstream of the ADU



Control Description:

Crude Feed is received from storage at a temperature of 32ºC (90ºF) and a pressure of 1.8 barg (25 psig). The key control objective is to raise the crude feed temperature to 150ºC (302ºF) and pressure to 16barg (232 psig) ensuring optimal efficiency of downstream desalting operations.

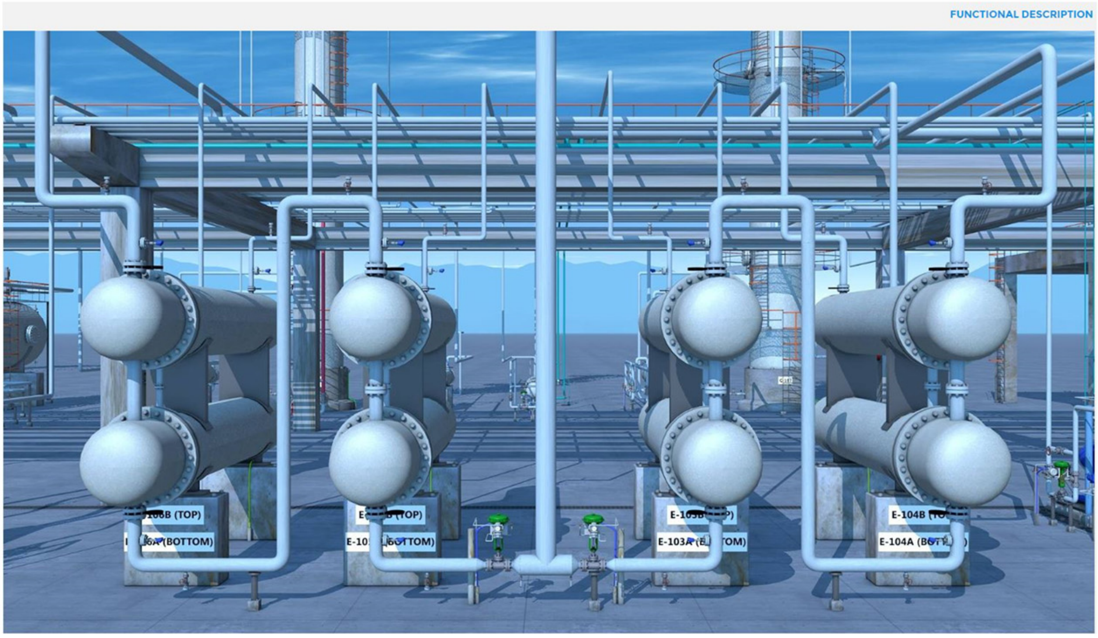
The Crude Feed Pump speed controller (the slave) receives a setpoint from the Desalter pressure controller (the master), keeping the pressure high enough to prevent crude feed vaporization before desalting is complete.

Wash water is injected into the Crude Feed Pump discharge on flow control - the wash water is heated and thoroughly mixed with the crude as it passes through the Cold Preheat train.

A hand controlled tube-side bypass enables the operator to adjust condensation and cooling of the Atmospheric Tower overheads stream.

Hand controllers and flow indicators enable the operator to balance the load on the two trains.

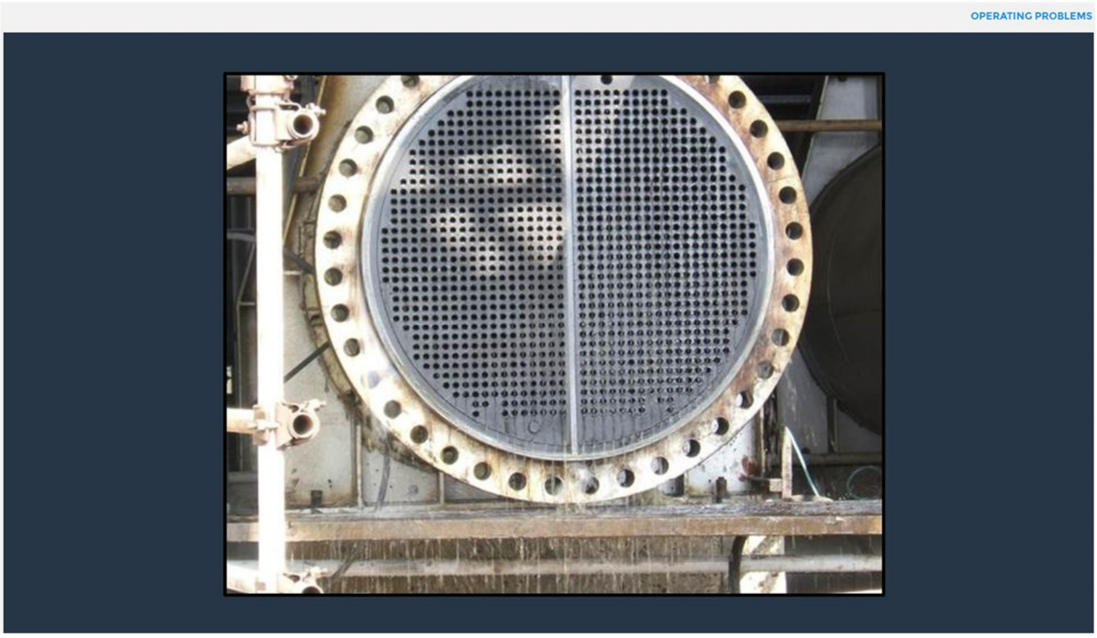
The Kero and LDO pumparound streams returning to the Atmospheric Tower are temperature controlled.



Functional Description:

Cold preheat exchangers are usually integrated with the hot preheat exchangers in a side-by-side and stacked arrangement - like the ones pictured here.

Heat exchanger tube bundles have to be periodically removed for cleaning. The open area in front of the exchangers provides maintenance access for tube bundle pullers, cranes and low-bed trucks.



Operating Problems:

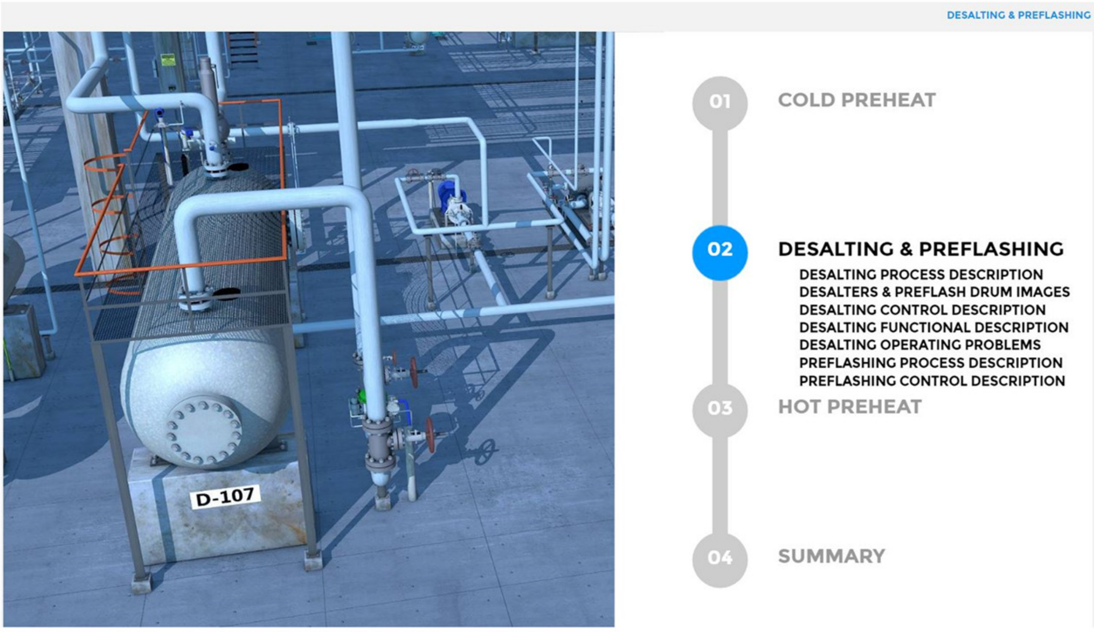
As the crude feed passes through the tube-sides of the cold preheat exchangers, its pressure is at or above 20 barg (290 psig), whereas the pressures of the overhead, pumparound and product streams are significantly lower.

In the event of a leaking tube, crude will contaminate these streams, requiring the exchanger to be taken out of service and repaired, so the operators conduct regular checks on the color of these streams.

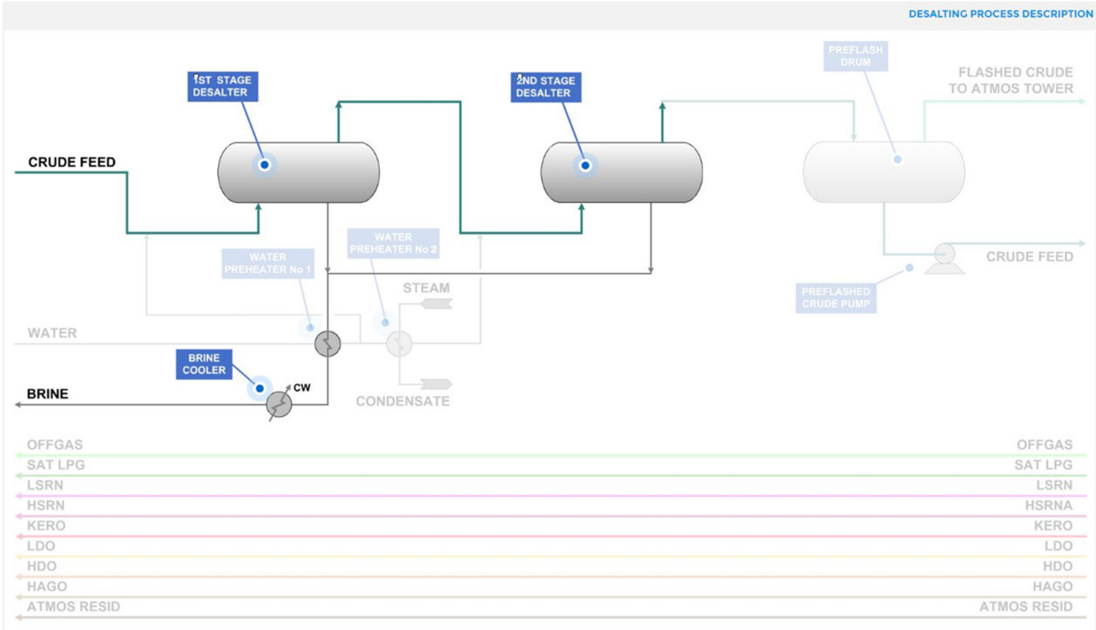
On some ADUs, maintenance is achieved without the need for a plant shutdown by bypassing and isolating the offending exchanger, followed by testing and plugging the leaking tube or tubes.

If on-line maintenance is not possible, the ADU has to be temporarily shutdown.

This picture shows exchanger tubes being leak tested.



Our next topic is Desalting & Preflashing.



Process Description:

Crude feed passes upwards through the two Desalters, which are normally operated in series. The function of the Desalters is to remove impurities such as:

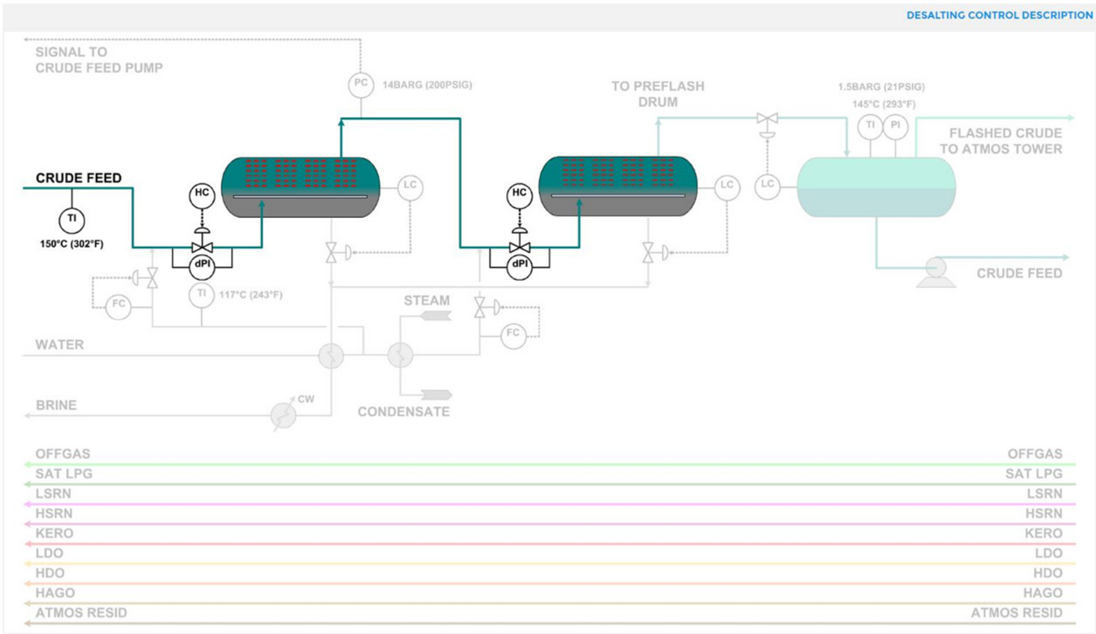
Water

Sodium, calcium and magnesium chlorides

Silt, iron oxides, sand and crystalline salts

Additional water is injected into the crude feed upstream of each Desalter. Water entering the 2nd Desalter is heated, preventing it from having a quenching effect on the inlet crude, causing reduced desalting efficiency. Brine (or salt water) is withdrawn from the bottom of the Desalters and cooled before passing to waste water treatment.

The 2-Stage Desalters are large horizontal vessels (like the ones pictured here), usually located next to the preheat exchangers. The Preflash Drum is similarly sized.



Control Description:

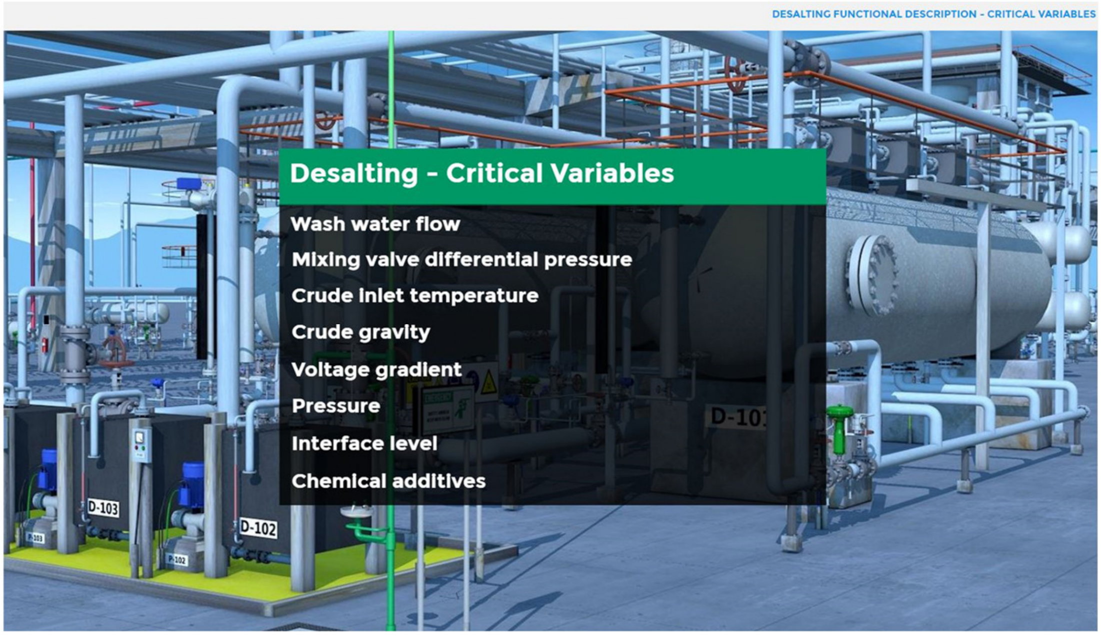
Upstream of each desalter, preheated wash water is injected on flow control into the preheated crude.

The crude and water pass through hand-controlled mixing valves. The induced turbulence across the valves causes the oil-water mixtures to emulsify. Emulsification promotes a high degree of contact between the crude, the water and the impurities.

Upon entering the desalters, turbulence ceases and the emulsions break down to form oil-water interfaces - an electrostatic field causes small water droplets to coalesce into larger ones, assisting oil-water separation.

The Desalter interface levels are controlled by regulating the amount of salt water (or brine) withdrawn from the bottom.

The 1st Stage Desalter pressure is maintained at 14 barg (200 psig) by a pressure controller that adjusts the speed of the Crude Feed Pump.



Functional Description:

The following variables are critical to successful and efficient desalting operations:

Wash water flow

Mixing valve differential pressure

Crude inlet temperature

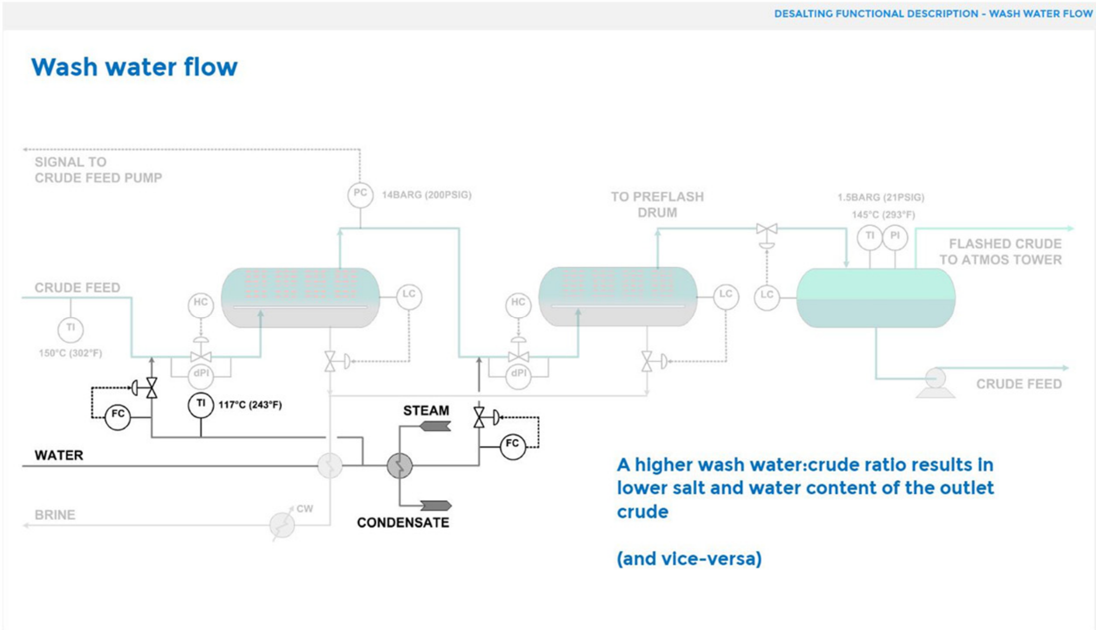
Crude gravity

Voltage gradient

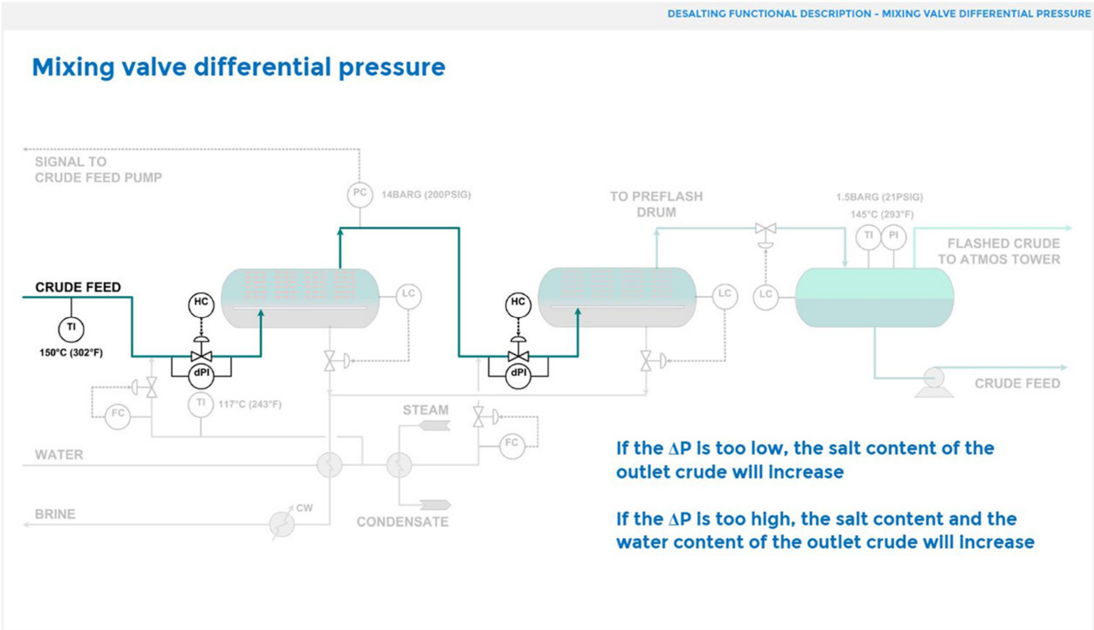
Pressure

Interface level

Chemical additives



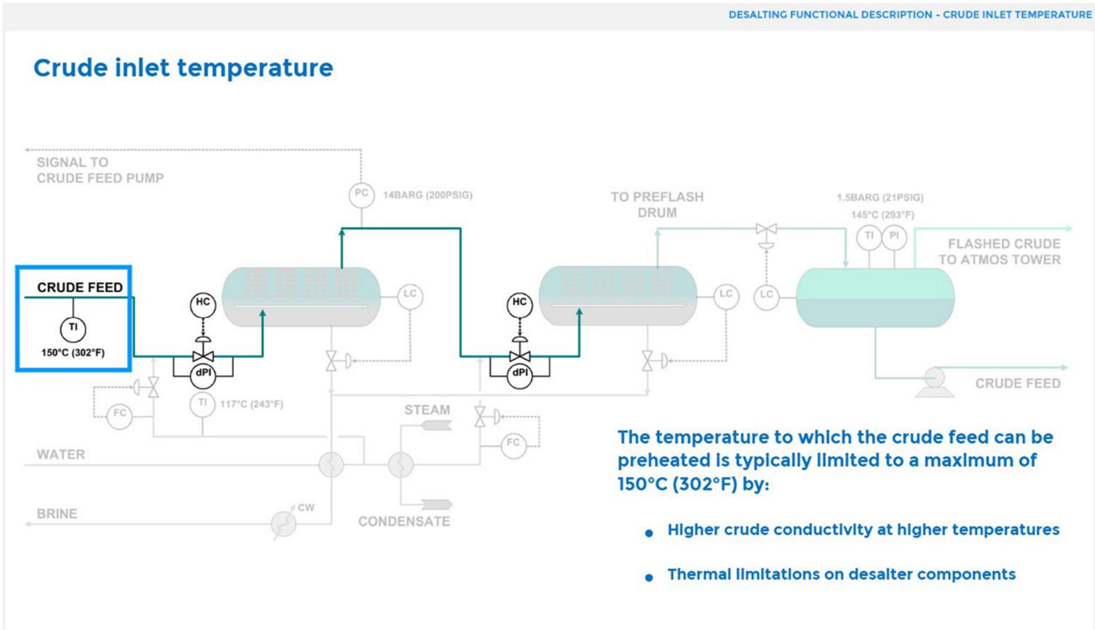
The flow of wash water to each desalter is controlled in proportion to the crude feed rate. A higher wash water:crude ratio results in lower salt and water content of the outlet crude (and vice versa).



The ΔP across the mixing valve ensures that the wash water is fully distributed throughout the crude:

If the ΔP is too low, the salt content of the outlet crude will increase

If the ΔP is too high, the salt content <u>and</u> the water content of the outlet crude will increase



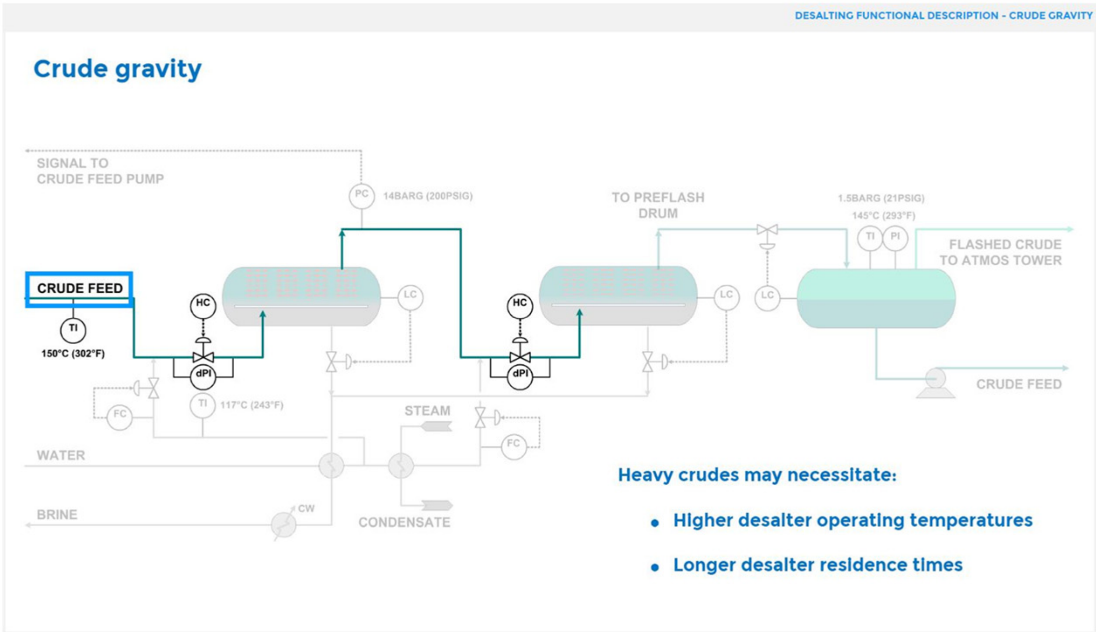
Temperature plays an important role in desalting - maximizing the crude preheat temperature minimizes the crude viscosity - this accelerates the coalescence and settling of water droplets, which improves desalting efficiency.

The temperature to which the crude feed can be preheated is typically limited to a maximum of 150ºC (302ºF) by:

- Higher crude conductivity at higher temperatures, which raises power consumption

- Thermal limitations on desalter components such as insulators and bushings

The second stage wash water is reheated by steam to avoid quenching the second stage desalting temperature.

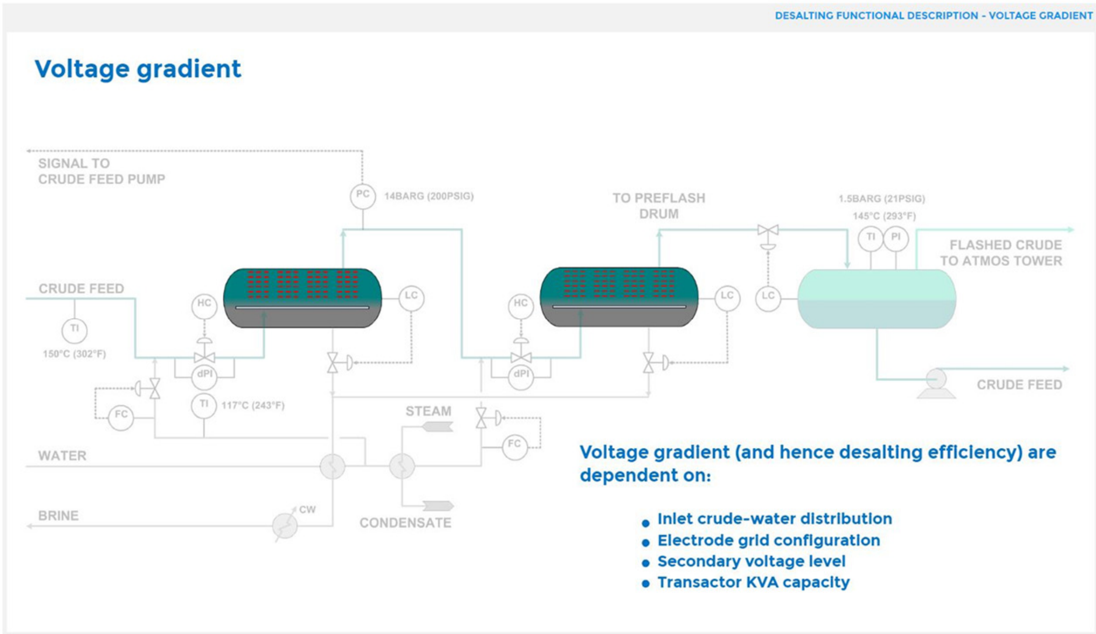


Heavy crudes (which are characterized by increases in specific gravity, viscosity and conductivity) may necessitate:

Higher desalter operating temperatures

Longer desalter residence times

If operation at these conditions becomes uneconomic or prohibitive, restrictions can be overcome by blending a particularly heavy crude with a lighter one.



The voltage gradient between the electrode grids inside the desalter provides the driving force for water droplet coalescence. Voltage gradient (and hence desalting efficiency) are dependent on:

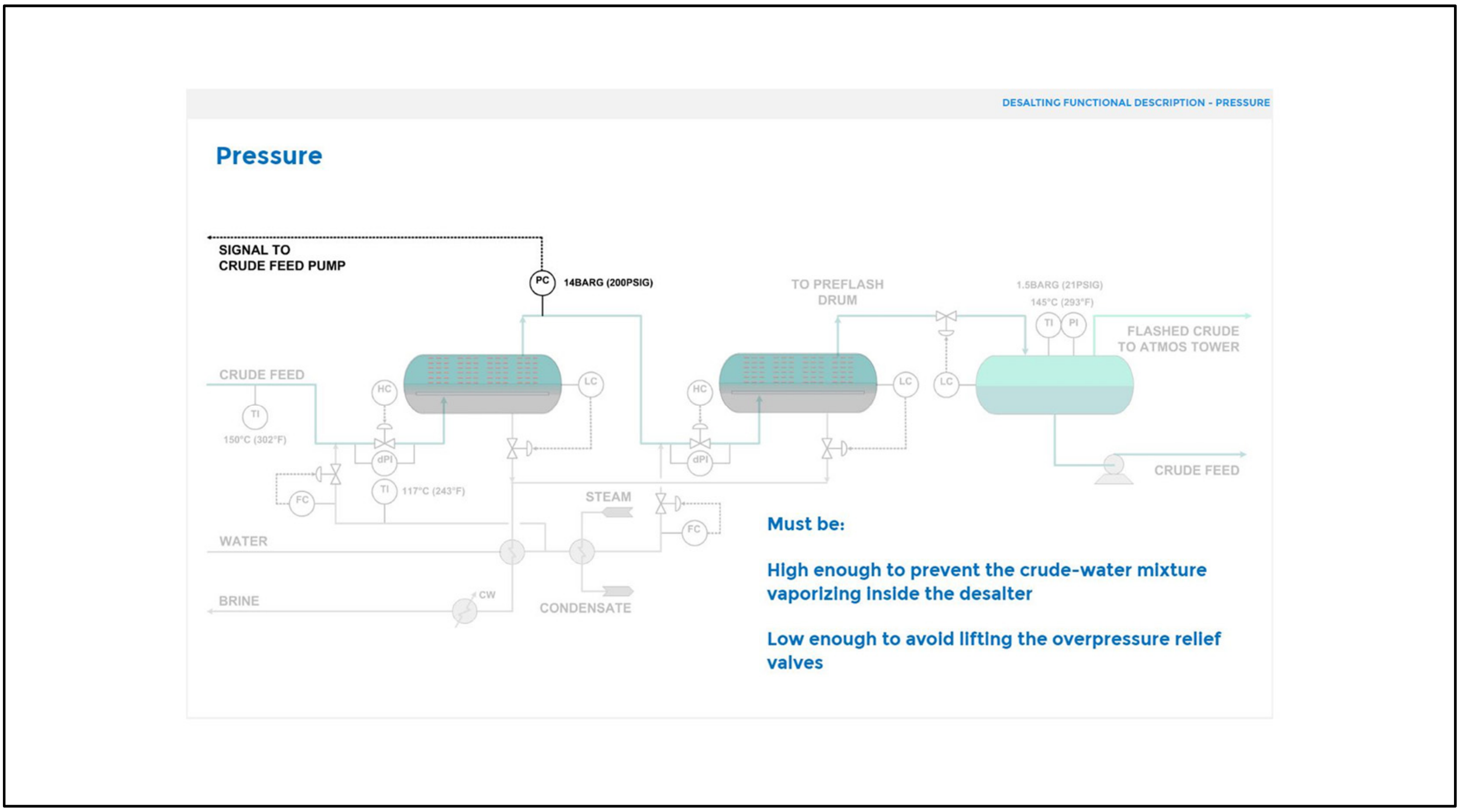
Inlet crude-water distribution

Electrode grid configuration

Secondary voltage level

Transactor KVA capacity

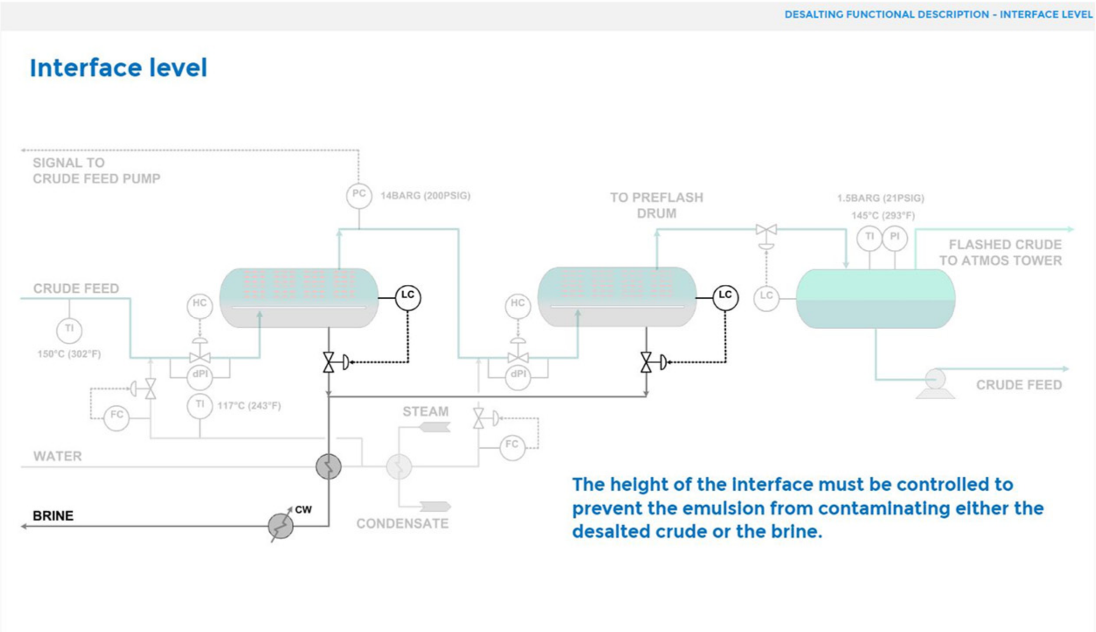
A combination of increasing amperage and decreasing voltage are an indication that the crude may be heavier than normal and difficult to desalt.



Pressure does not affect desalting efficiency, except that it must be:

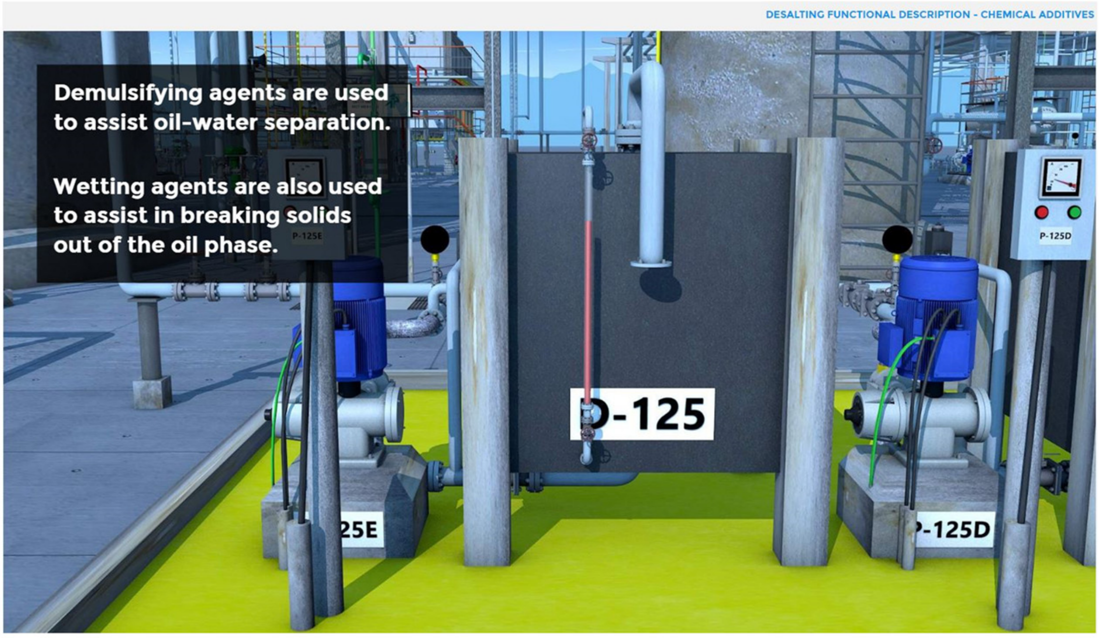
High enough to prevent the crude-water mixture vaporizing inside the desalter

Low enough to avoid lifting the overpressure relief valves



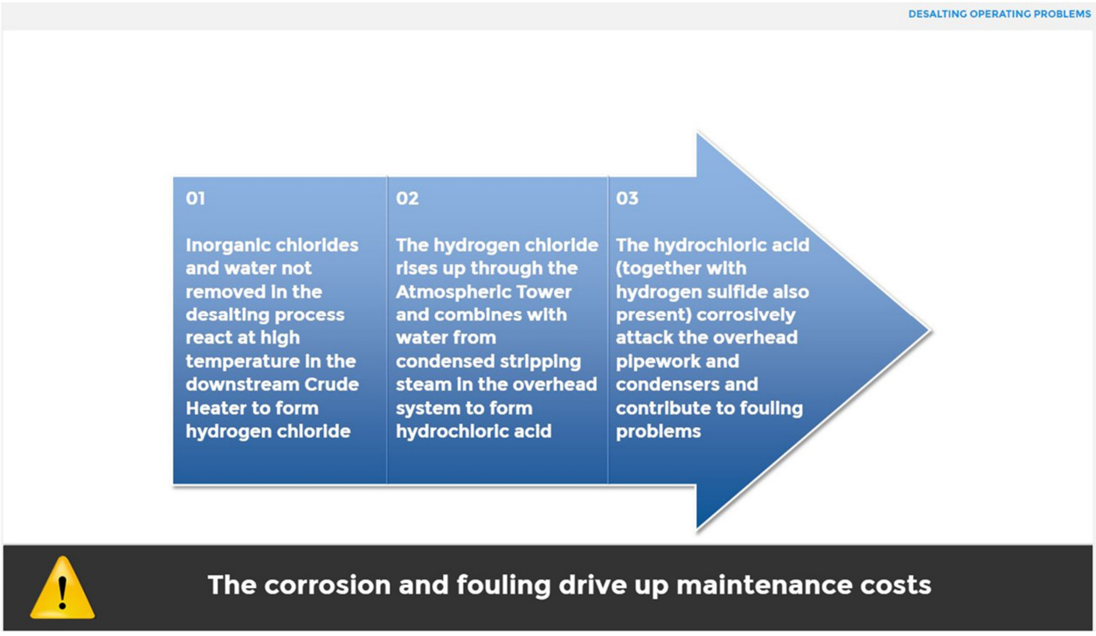
The Desalter interface level is an important variable - the desalters are operated full, with oil at the top and water at the bottom, separated by an emulsified oil-water interface.

The height of the interface must be controlled to prevent the emulsion from contaminating either the desalted crude or the brine.



Many refineries use chemical additives in the desalting process.

Demulsifying agents are used to assist oil-water separation, especially in refineries where the oil content of the brine is limited to very low levels. Wetting agents are also used to assist in breaking solids out of the oil phase.



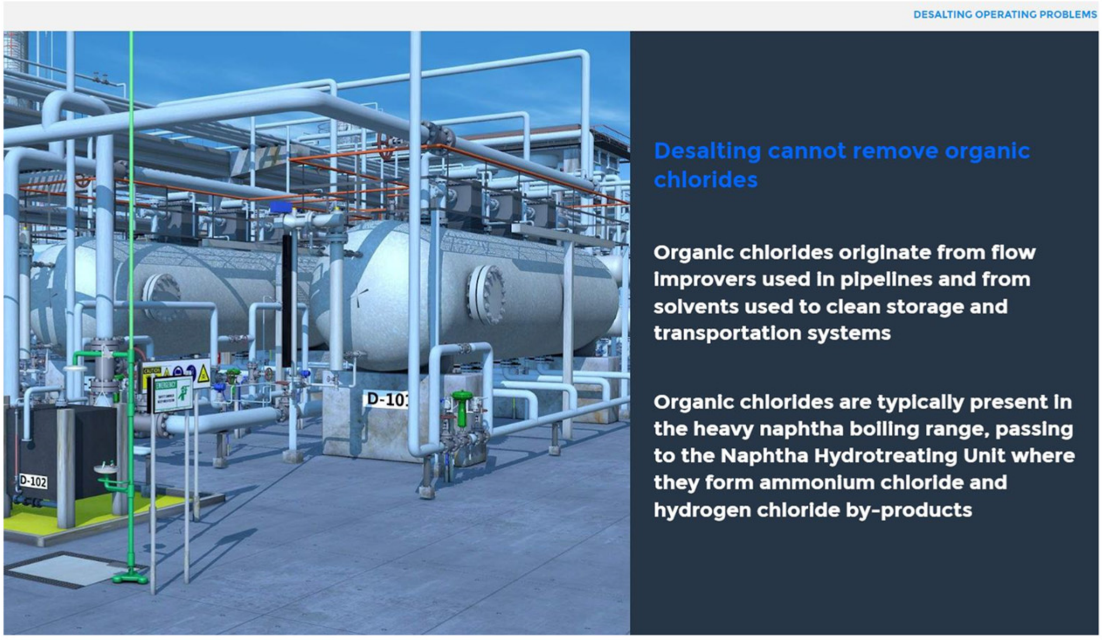
Operating Problems:

If the desalting operation is inefficient, inorganic chlorides and water not removed in the desalting process react at high temperature in the downstream Crude Heater to form hydrogen chloride.

The hydrogen chloride rises up through the Atmospheric Tower and combines with water from condensed stripping steam in the overhead system to form hydrochloric acid.

The hydrochloric acid (together with hydrogen sulfide also present) corrosively attack the overhead pipework and condensers and contribute to fouling problems.

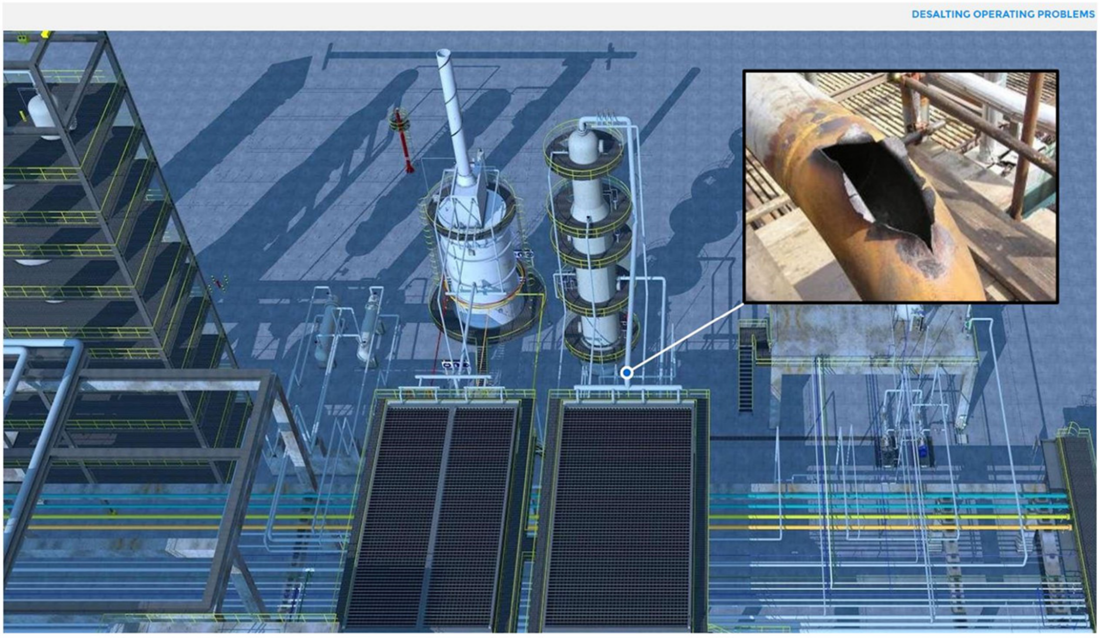
The corrosion and fouling drive up maintenance costs.



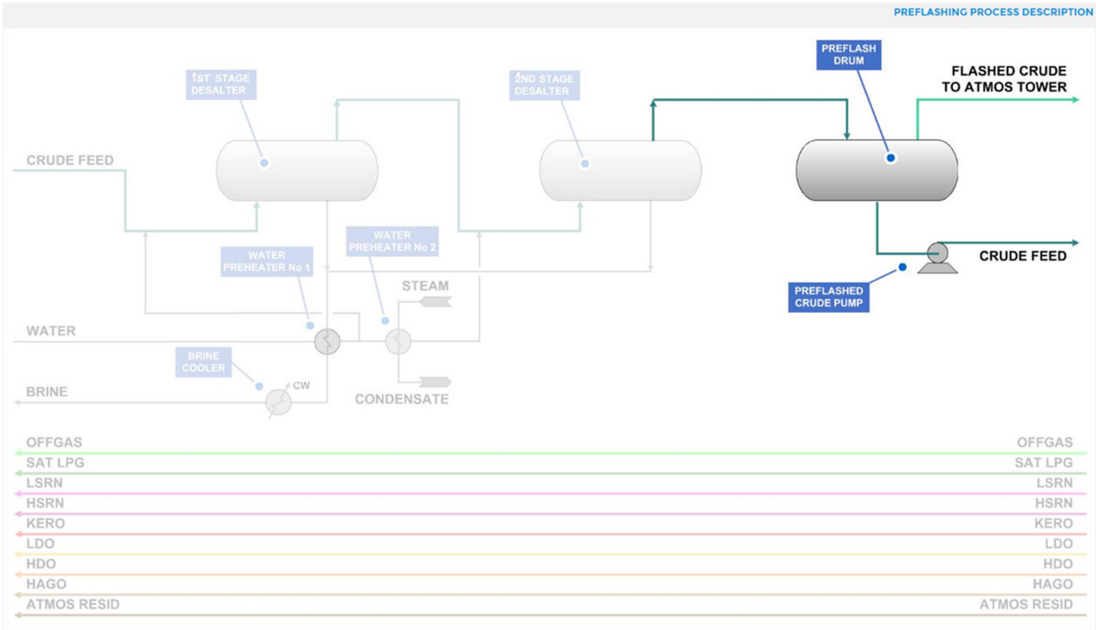
While desalting removes inorganic chlorides, unfortunately it cannot remove organic chlorides.

Organic chlorides originate from flow improvers used in pipelines and from solvents used to clean storage and transportation systems.

Organic chlorides are typically present in the heavy naphtha boiling range, passing to the Naphtha Hydrotreating Unit where they form ammonium chloride and hydrogen chloride by-products that cause corrosion problems and fouling in the reactor effluent piping and equipment.



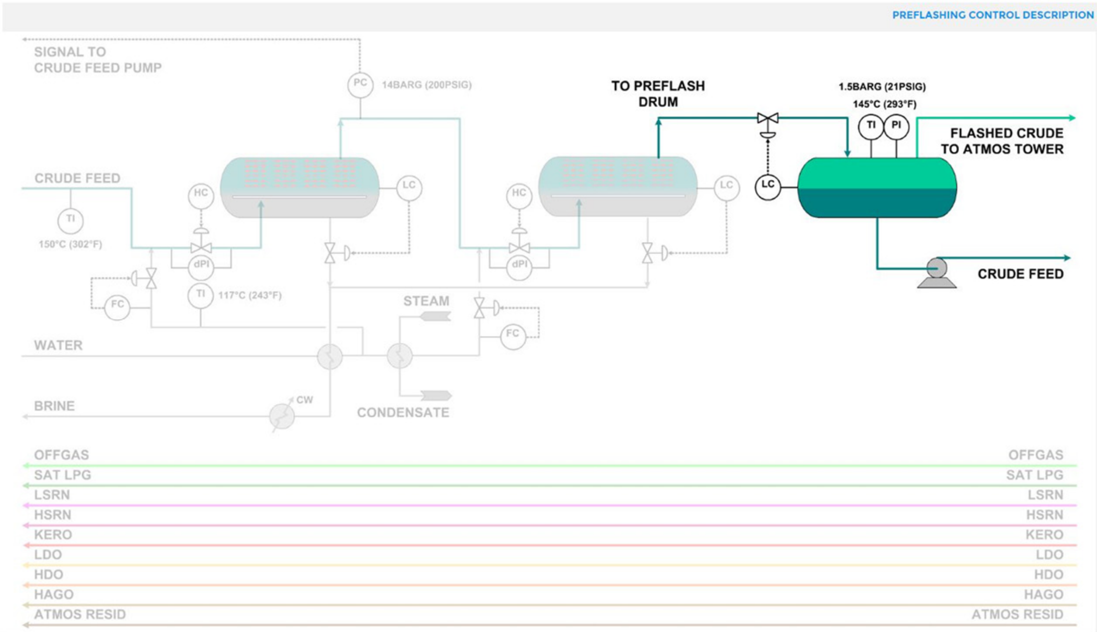
Taken from our NHTU archives, here's an example of the extent of hydrogen chloride and ammonium chloride corrosive attack.



Process Description:

Moving on to Preflashing - desalted crude feed enters the Preflash Drum where a portion of it flashes to vapor. Flashed vapor passes to the Atmospheric Tower and liquid passes to the Hot Preheat train for further heating.

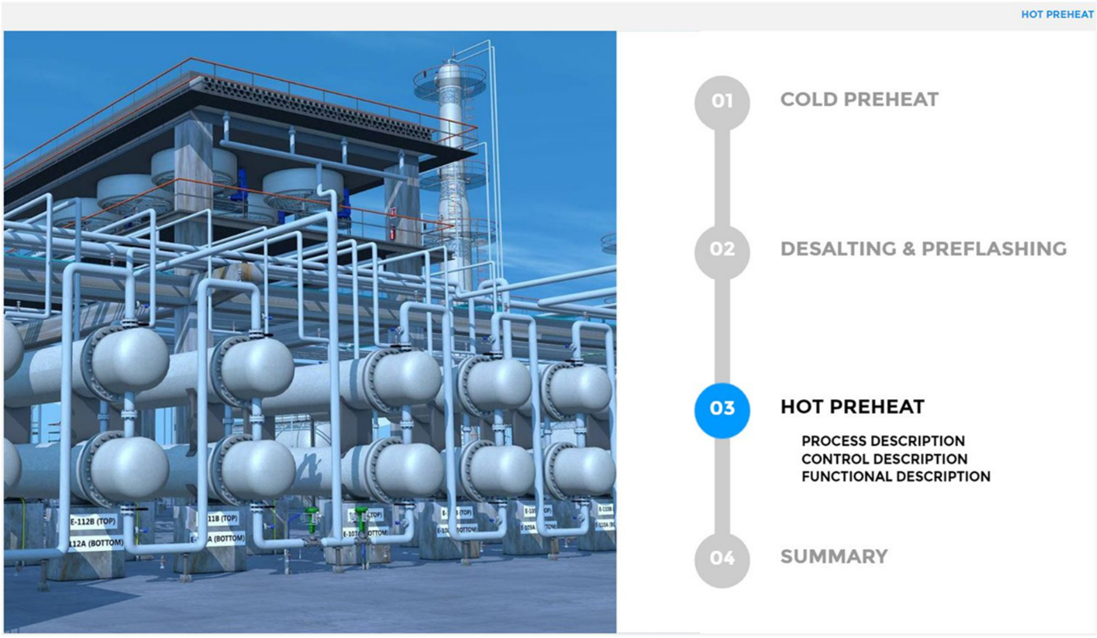
The function of the Preflash Drum is to reduce the load on the downstream Hot Preheat Exchangers and Crude Heater, improving energy efficiency.



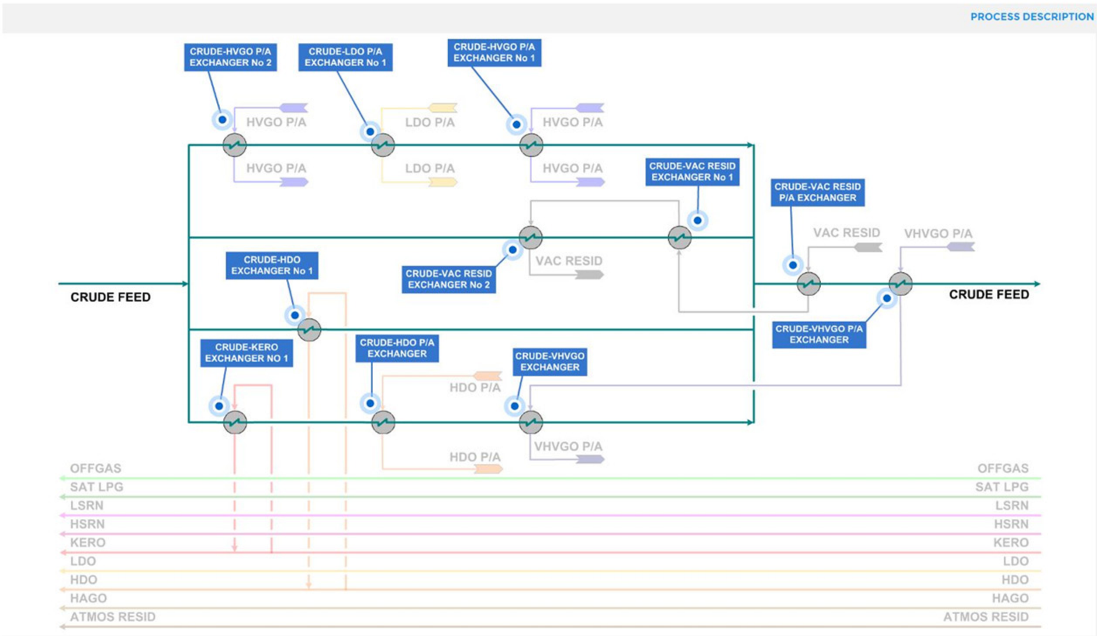
Control Description:

The Preflash Drum level is controlled by regulating the incoming flow of desalted crude. The Preflash Drum operates at a pressure of 1.5barg (21psig), resulting in a pressure drop of around 12 bar (175psi) across the level control valve.

As the crude passes across the level control valve, the sudden reduction in pressure causes a portion of it to flash. The Preflash Drum provides residence time for the vapor and liquid to disengage.



Next, we'll take a look at the Hot Preheat train.



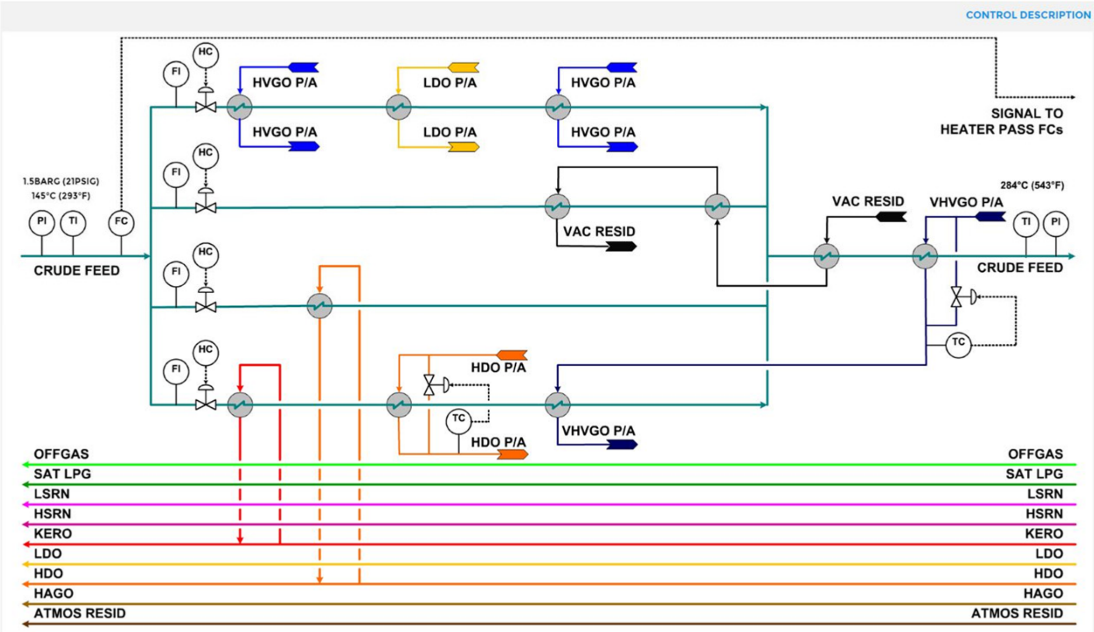
Process Description:

Crude feed from the Preflash Drum is pumped through four parallel trains of heat exchangers. Heat is transferred from ADU and VDU product and pumparound streams to the preflashed crude feed.

The Hot Preheat train has two functions:

To maximize heat uptake by the crude feed, minimizing the amount of heat to be input by the downstream Crude Heater

To remove heat from ADU and VDU pumparound and product streams

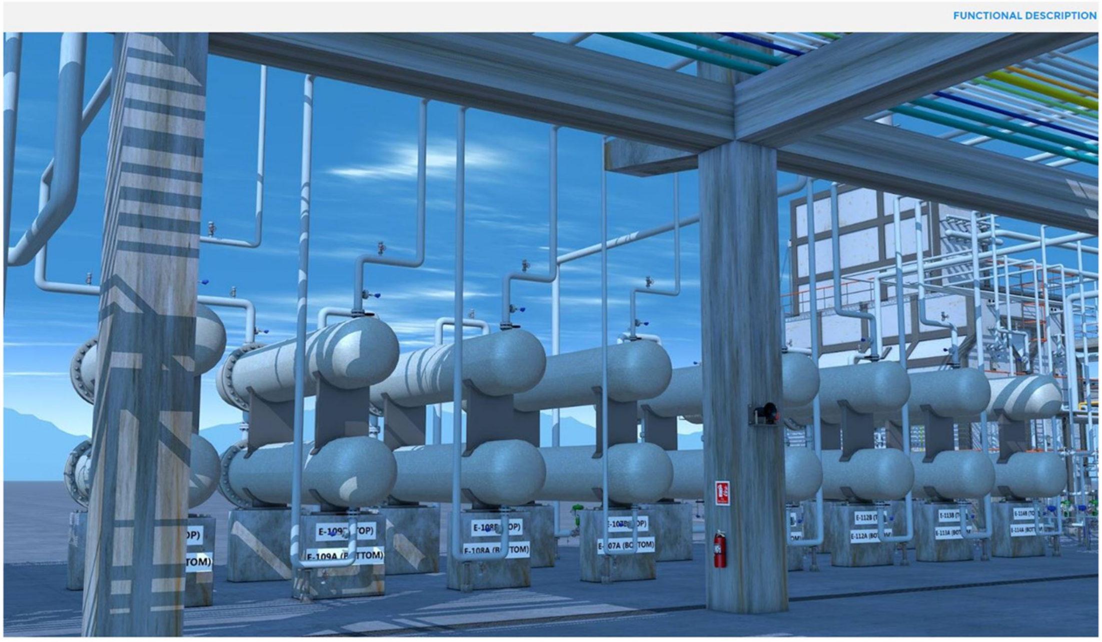


Control Description:

Hand controllers and flow indicators enable the operator to balance the heat duties of the four trains to raise the crude feed temperature from 145ºC (293ºF) to 284ºC (543ºF), ensuring optimal efficiency of the downstream Crude Heater.

The HDO and VHVGO pumparound return streams are temperature controlled.

A combined flow controller (master) sends a setpoint to the four pass flow controllers on the downstream Crude Heater.



Functional Description:

You'll recall that the hot preheat exchangers are typically integrated with the cold preheat exchangers in a side-by-side and stacked arrangement.

And this completes Module 2, in which we have covered the Cold Preheat, Desalting & Preflashing and Hot Preheat unit operations.

To summarize:

The function of the Cold Preheat unit operation is to heat the crude feed and injected wash water to a temperature that ensures efficient operation of the downstream Desalters, while removing heat from the overheads, LDO and Kero pumparound streams and the LDO, HDO and Kero product streams

The function of the Desalting & Preflashing unit operation is to remove impurities from the feed and flash it to vapor to reduce the load on the downstream Hot Preheat Exchangers and Crude Heater

The function of the Hot Preheat unit operation is to maximize heat uptake by the crude feed while removing heat from ADU and VDU pumparound and product streams

For each of these unit operations, you should be familiar with:

Principal items of equipment and their function

Important process variables and associated controls

Principles of operation and the internal components of key items of equipment

Typical operating problems

Your task now is to take the ADU Module 02 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 the next one.

Good luck!

You can now close this module.