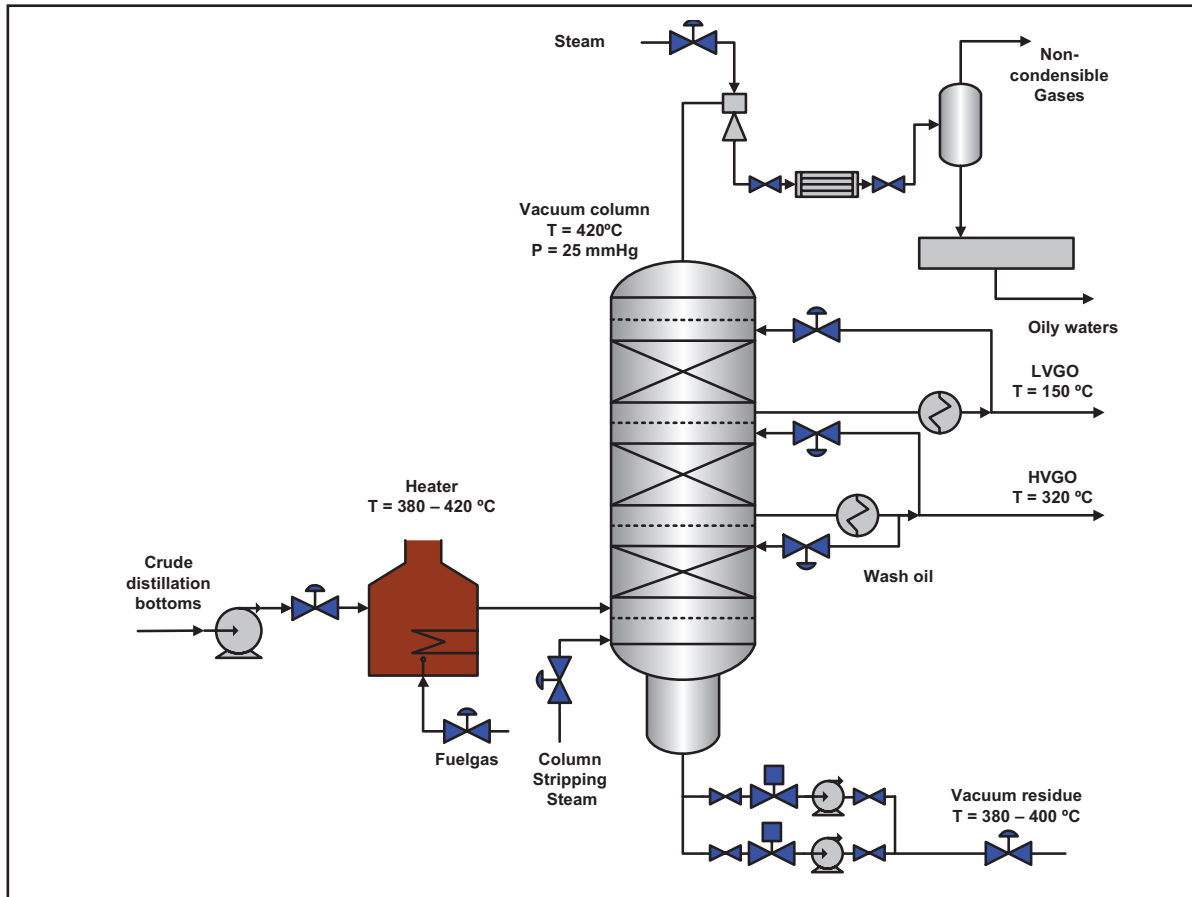


# Vacuum distillation



## Process overview

Hydrocarbons should not be heated to too high temperature due to cracking reactions that take place above about  $400\text{ }^{\circ}\text{C}$ . Coke deposits on piping and equipment increase maintenance costs and reduce process unit run-time. Therefore crude distillation bottom (residue) is further processed in a vacuum column to recover additional distillates, light and heavy vacuum gasoils as feedstock to cracking units or lube-oil processing. Three types of vacuum towers are used: dry (no steam), wet without stripping and wet with stripping.

Distillation is carried out with absolute pressures in the tower flash zone area of 25 to 40 mmHg. To improve vaporization, the effective pressure is lowered even further by the addition of steam to the furnace inlet and at the bottom of the vacuum tower. The amount of stripping steam used is a function of the boiling range of the feed and the fraction vaporized as well as furnace outlet temperatures ( $380 - 420\text{ }^{\circ}\text{C}$ ).

Vacuum towers are much larger in diameter than atmospheric towers, usually 12 – 15 meters. The operating pressure is maintained by using steam ejectors and condensers. The size and number of vacuum device is determined by the vacuum needed and the quality of vapors handled, for 25 mmHg, three ejector stages are usually required. A few millimetres decrease in pressure drop between the vacuum-inducing device and the flash zone will save operating costs. The capacity of the presented vacuum distillation is 80 000 bbl/day (~ 4 million tons/year) with fuel consumption of about 3200 MMBtu/day.

## Vacuum distillation challenges

Refineries today are facing new challenges in order to meet the requirements with respect to environment, health and safety of the plant personnel and the quality of the finished products. With increasing crude oil prices, refineries are processing heavier, lower quality crudes that set new challenges to further develop the processes and maximize the yield of valuable distillates in an energy efficient way. Plant run-time targets are increasing which sets more challenges for equipment reliability and process control.

**Health, Safety, Environment** – Valve leaking poses both an environmental and safety issue due to risk of fire and oil spills, as the sticky residue accumulates on the valve bonnet and refinery ground. ESD and on/off valves must be able to perform their action in a process or equipment failure.

**Top-class products at maximum yield** – The market calls for clean products and high quality. It is important that the process is stable, flexible and under control. Sticking and leaking of control valves reduces the accuracy of throughput control and adversely affects also the downstream processes.

**Maintenance costs** – Poorly performing valves in the process must be serviced because they will have a direct impact on the efficiency of the process. The cost of unscheduled maintenance will be quite high, up to 70% of the cost of a new valve in some applications. Add this to the cost of removing the valve from the line and disruption of the process and the total cost will be much higher.

**Plant run-time** – Refineries are increasing vacuum unit and plant run-time targets since downtime means production losses and is a remarkable cost including maintenance costs. This requires reliable equipment in terms of materials and process control. Vacuum units operate from 1 year to 4-5 years.



## Metso solutions

Metal and soft seated rotary control, on-off and ESD-valves together with application specific intelligent valve controllers and FieldCare valve condition monitoring can answer all these challenges with wide margins of assurance.

**Safety** – Metso Automation rotary stem operation reduces fugitive emissions and protects from leaking. Packing construction meets the latest emission standards. Our products are fire tested and approved to meet the standards. Neles ValvGuard™ partial stroking will ensure that plant emergency shutdown valves will always perform properly when needed.

**Efficiency** - Throughput losses due to sticking and poor control performance will be avoided with high performance rotary valves. Flow through the process unit may be changed as the need arises with rangeability of 150:1 and further with full bore ball valves. Metso Automation's advanced ND9000 digital valve controller ensures higher positioning accuracy and faster response to reduce process variability. Correct valve selection and sizing with Metso Automation Nelprof-program we can assure the best valve performance and process control.

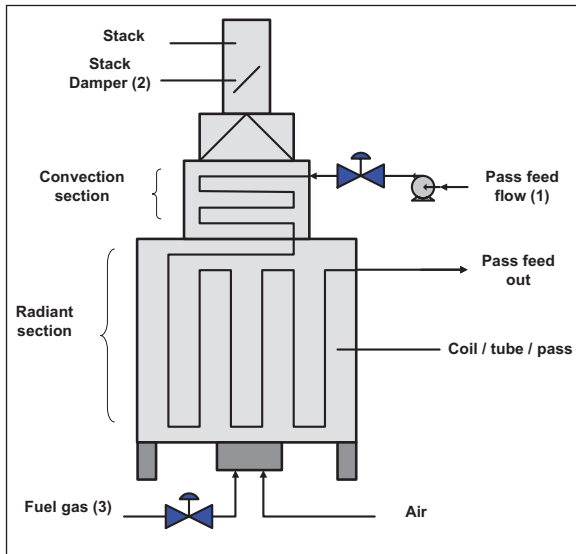
**Availability** – Simple rotary designs, same face-to-face dimensions, and global service network and inventory management will help you to optimize your maintenance activities. Rotary valves have been in service for several years without requiring maintenance and show no sign of leakage.

**Reliability** – Trend data collected by Metso Automation smart valve controllers and analysed by FieldCare configuration and condition monitoring software based on open FDT/DTM technology makes it possible to predict and respond to maintenance requirements and avoid unscheduled downtime. This gives full transparency to the valve performance in process control.



## Heater applications

Energy-efficient heater operations involve proper control, maintenance and monitoring of process fluid outlet temperature, draft, excess air and fuel-firing rate. It is important to keep the flowrates in multipass heaters equal and control flow velocity for optimum residence time. Leaking valves will result in valve sticking and poor control behaviour. 1% fuel savings in a 3 200 MMBtu/day heater saves approximately 70 000 USD/year in fuel cost.



### 1. Heater pass flow control

**Challenge** – Before Metso, some customers had to maintenance their valves every 2 – 6 months because of gland leaks and valve sticking. This reduced heater performance and throughput control, increased risks for health, environment and safety and in some cases caused unscheduled shutdowns, when valve by-pass was not available.

**Metso Solution** – Finetrol eccentric plug rotary valve for mild temperature applications (< +425 °C) and Top 5 rotary valve for high temperature applications (> +425 °C).

**Benefits** – Our customers report remarkable savings in maintenance costs after installing Metso Automation control valves. Oil leaking through gland packing has been avoided, and this obviously improved operator safety in the plant and reduced emissions to environment. Heater efficiency was improved by reducing the tube fouling and fuel consumption. Average saving in maintenance costs on a 4-year process cycle is approximately 38 000 USD/valve.



Metso Finetrol valves at customer heater pass flow control

### 2. Heater dampers automation

**Challenge** – Heater efficiency is measured in accordance of excess O<sub>2</sub> in flue gases. Heater excess O<sub>2</sub> results in poor heater performance as in the use of fuel gas. Damper actuation can have control problems, like hysteresis, overshooting and response time.

**Metso Solution** – Pneumatic B-series actuator, ND9106HNT positioner.

**Benefits** – The heater efficiency can be improved with Metso's reliable full automation solution and service. The system is fully automated and it is possible to predict the maintenance needs. Decreases from 2% to 3% of residual O<sub>2</sub> have been reported. This equals to yearly fuel gas savings of 70 000 USD/year in a vacuum heater.

### 3. Heater fuel gas control

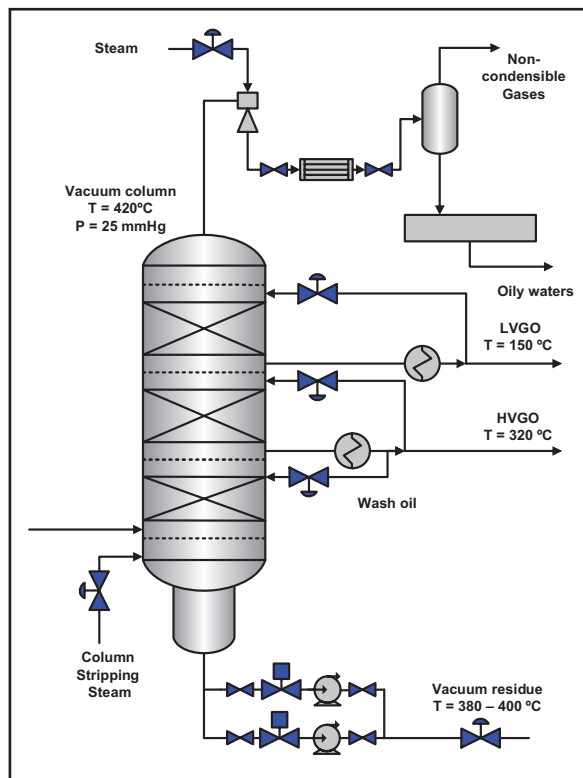
**Challenge** – Reliability and accuracy is required from heater fuel gas control. It has a direct impact on the process performance, since the vacuum feed is heated by fuel gas. A failure in the system may shutdown the whole vacuum unit. There are variations in the fuel composition that have an affect on the heating value.

**Metso Solution** – RE-Series segment valve / Finetrol eccentric plug valve.

**Benefits** – Single valve solution due to wide rangeability – no need for split range control. Reliable control and reduced variability improves heater energy efficiency and crude oil temperature control.

## Column applications

In many refineries, the vacuum units are operated to produce VGOs for hydrocracking or catalytic cracking units. Often, one of the main parameters is to increase the HVGO TBP cut point as much as possible and to maximize product yields. The separation between LVGO and HVGO is not very important. But the wash bed and flash zone are the important parts of the vacuum towers, especially for deep-cut vacuum units. The vacuum produced is limited to the vapour pressure of the water used in the condensers. The operation of a distillation column is a balance between product purity and energy use.



## 4. Overhead vapour – flare valves

**Challenge** – Plant upset or emergency shutdowns require that pressures can be vented safely. This is done by flare valve to flare header. No unnecessary leakage is allowed for safety reasons and to avoid product losses. The valve operation must be fast and reliable. There is a risk of noise at high pressure drops and large sizes.

**Metso Solution** – Neldisc® butterfly valves for low pressure drop and Neles ball valves for high pressure drop applications.

**Benefits** – Metso Automation unique Neldisc® butterfly valves ensure fast and reliable valve operation. HSE-risks including noise are reduced with flow balancing trim. Unique triple offset metal seat design provides tight shut-off over long time periods up to class VI tightness. Comparing to class IV tightness in 8" valve product losses due leaking customers can save approximately 22 000 USD/year.



## 5. Distillate products – stripping and reflux control

**Challenge** – The wash bed removes entrained residue from the vaporized distillates. A poorly operating flash zone increases entrainment that generates black gasoil and fouls the wash bed. Flash zone operating temperature and pressure define throughput and product rates. Reduced variability in a control loop helps to achieve optimum operating conditions.

**Metso Solution** – Finetrol eccentric plug valve.

**Benefits** – With Metso Automation Finetrol valve the product variability is reduced, this provides optimum product quality and yield with no additional energy requirements. Valve plays a significant role in control loop, especially when high loop performance is targeted. 1% increase of total distillate yield means yearly increased production of about 290 000 bbl in an average size (80 000 bbl/day) vacuum distillation. Even a part of this increase with better valve performance means more feed that can be converted to more valuable products.

## 6. Column bottom ESD and on-off valves

**Challenge** – These valves must be able to perform their action in a process upset situation. The most part of the time these valves are either open or closed. The risks are related to the nature of the fluid at the column bottom, there is a risk of coke particles accumulation and valve sticking. The process run-length can be from 1 year to 4-5 years, so extreme reliability is required. In case of failure with these valves, there is a risk of shutdown the entire process. ESD valves are important for the safety of the people operating the plant.

**Metso Solution** – Seat supported X-series ball valves for demanding low pressure service; trunnion mounted D-series ball valves for high pressure service and neldisc butterfly valves for large sizes with ValveGuard partial stroking test for valve performance monitoring.

**Benefits** – Metso Automation metal seated, fire tested rotary valves with ValveGuard performance monitoring are ideal for sticky and coking fluids in the vacuum distillation column bottoms. Thus plant up-time can be maximized and process safety improved with simple and compact solution.



*ESD-valve with ValveGuard ensuring customer process safety*

## APPLICATION REPORT

Optimize your plant safety and vacuum distillation performance, reduce energy and maintenance costs and produce top-class products with Metso Automation intelligent rotary control, on-off and ESD-valves.



*Finetrol eccentric rotary plug valve for general and demanding control applications.*



*Neldisc, high performance butterfly valve for large size applications.*



*T5 top entry control valve for demanding applications.*



*RE-series v-shape segment valve for general purpose control applications.*

The information provided in this bulletin is advisory in nature, and is intended as a guideline only. For specific circumstances and more detailed information, please consult with your local automation expert at Metso.

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