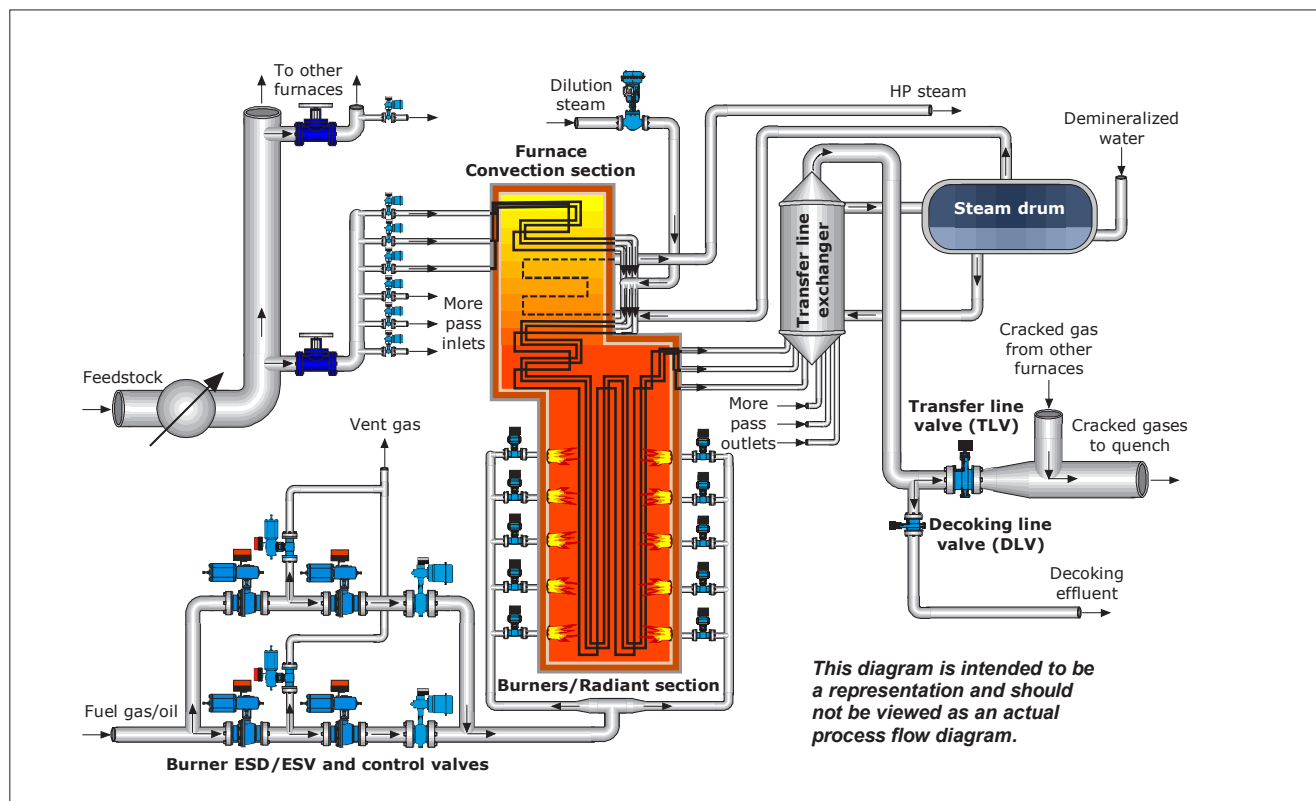


## Steam cracking – Cracking furnaces



### Process overview

Ethylene is a basic building block of the chemical industry, and is the link between chemical companies and petroleum refiners. An ethylene plant is often called an olefin plant, because of the fact that the end products are olefins. The ethylene or olefin plant will yield mostly ethylene, but will also break the feedstock into a number of other usable by-products, including propylene, butadiene and gasoline.

The initial process is cracking, which means that the feedstock is heated to the point that the energy transfer from heat is enough to “crack” the molecules into several smaller molecules. The feedstock is diverted to multiple furnaces and then further divided between multiple passes before entering the furnace.

In the convection section, the feedstock is mixed with dilution steam in order to reduce coking and improve end product yield. This mixture is pre-heated using high pressure steam before entering the radiant section.

The radiant section has several burners which raise the temperature of the feed to 750-850 °C (1380-1560 °F), ensuring a high enough temperature for cracking to occur. It is important that the residence time is kept short to prevent further reactions from occurring, which would decrease desired product yield.

After exiting the furnace, the cracked gases quickly enter the transfer line exchanger where they are indirectly cooled to prevent further reactions from occurring.

Hereafter the cooled gases are quenched with oil and/or water. This is followed by product fractionation, which includes distillation, and other processes for separating recoverable products.

## Cracking furnace valves

The cracking furnace section of a steam cracker includes valves for controlling the supply of feedstock, with each pass having its own control valve.

The fuel gas/oil section has two isolation emergency shutdown (ESD) valves and an emergency safety vent (ESV) valve located between these, in what is called a “double isolation and bleed” setup. A control valve follows the second ESD valve. At least one ESD shut-off line is present, but most modern safety regulations require redundant lines to ensure operation in case of a malfunction. Finally there are also separate shut-off valves for each burner.

In addition, dilution steam is also on flow control. There may either be a single valve present controlling the total flow of dilution steam, or each pass may have a control valve of its own.

Following the transfer line exchanger, a transfer line valve (TLV) and a decoking line valve (DLV) are present, one of which is open and the other one closed depending on whether the furnace is in operation or is being decoked.

## Feedstock supply

An ethylene steam cracker can accept a variety of feedstock. Naphtha, ethane, propane, gas oil, etc. can be cracked to produce ethylene. The choice of feedstock can depend on the cracker furnace construction, the availability of the particular feed, its current market price and the desired end products. The amount of the particular feedstock required depends on the desired product yield.

The process system in an ethylene cracker must supply the correct amount of raw materials to produce the desired end product. The feedstock supply valve must be able to control this as accurately as possible, taking into account that in some cases the feedstock can be a liquid and sometimes a gas. This makes it one of the most important control valves. As the flow rate difference between low flow and full capacity can be huge, some ethylene producers use separate valves for each case. Fire-safe design is also often a requirement as the feed can be volatile. Depending on the feedstock, cavitation or high noise may also be an issue. Typically the temperature is 120-150 °C (250-300 °F), the upstream pressure 6-10 barG (85-150 psig) and the downstream pressure 2 barG (30 psig).

## Neles solution for feedstock supply

We offer two types of valves which are well-suited for feedstock supply. The selection of valve type depends on the type of feed and piping layout.

Especially in the case of a gas feed, **Neles GB or GU-series globe valve** with a VD spring diaphragm actuator and an ND9000™ intelligent valve controller offers an excellent option for the application ensuring accurate control.

- **Best possible control accuracy**, increasing desired product yield
- **Wide rangeability**, allowing flow to be adjusted with changing capacities and feedstock
- **A variety of trims available**, including the Tendril design, reducing noise and eliminating cavitation
- **Easy maintenance** – Top entry construction for easy access, valve assembly is simple and self-guiding
- **Predictive maintenance** is made possible with the online diagnostics provided by the ND9000

**Neles Finetrol™ eccentric rotary plug valve** with a Quadra-Powr™ X spring-return diaphragm actuator and an ND9000 intelligent valve controller is well suited for supply control of both liquid and gas feeds. It provides an economical high-performance solution for the application.

- **Single valve solution**, due to wide rangeability eliminating the need for split range control
- **Improved energy efficiency**, as reliable control reduces process variability
- **Compact size**, easing the allocation of space for the valve in the piping design
- **Fire-safe approved**, ensuring secure operation
- **Cavitation and noise reduction**, with the patented Q-Trim™ design



Neles Finetrol rotary plug valve

## Fuel gas/oil control

The burners create the heat required to crack the feedstock. They are also used during decoking, though the temperature requirement is lower in this case and therefore not all burners are in operation. Steam crackers can use a variety of fuels to feed the burners, depending on the most economical or practical fuel available at the time, and can range from natural gas to crude oil. Especially modern crackers are capable of taking advantage of various fuels to feed the burners.

The different heat generation properties of the fuels require a valve which can regulate the flow accordingly. In addition, the relatively low temperature required during decoking of the furnace demands that the valve is able to control small flows of fuel, as not all the burners are operating. To ensure a more reliable operation, fast reaction to signal changes is required to quickly adjust temperature to account for fouling and switching to decoking. Noise reduction capabilities may also be necessary, especially if fuel gas is being used. Typically the temperature is 40-200 °C (100-400 °F) and the pressure 2-10 barG (30-150 psig).

## Neles solution for fuel gas/oil control

We offer two types of valves which are well-suited for fuel gas/oil control. The selection of valve type depends on the type of fuel and rangeability requirements.

**Neles GB-series balanced cage guided globe** valve with a VD spring diaphragm actuator and an ND9000 valve controller is well suited for the application if there is limited variety in the type of fuel used and good rangeability is required.

- **Minimize leaks**, as the rugged one piece body structure eliminates potential leak paths ensuring that volatile fuel doesn't leave the piping
- **Fugitive emission certified** according to ISO 15848
- **Different inherently characterized trims**, available as equal percentage, linear and quick open
- **Interchangeable trim parts** making it possible to easily change flow characteristics
- **Accurate and sensitive actuator** ensuring fast and proper operation of the valve

If the type of fuel being used varies and/or extremely high rangeability is required, the **Neles RE-series V-port segment valve** together with a Quadra-Powr X spring-return diaphragm actuator and an ND9000 valve controller is the optimal solution.

- **Best possible rangeability**, ensuring that the same valve can be used for various types of fuel and during start-up, full capacity and decoking conditions
- **No potential leak paths** even if subjected to pipe bending forces, as the valve features a one piece body construction
- **Reduced fugitive emissions by design**, as the valve utilizes rotary operation which is inherently less prone to leaks
- **Economical** – Low torque requirements reduce wear and reduces actuator size, resulting in better reliability and a lower cost unit
- **Fire-safe compliant** according to API 607
- **Q-Trim™ design available**, eliminating noise and the potential for cavitation to occur



Neles segment valve

## Burner shut-off and ESD valves

Gas flows into the burners through a series of two ESD valves that have a vent (ESV) between them. The vent is used to prevent pressure build up and flow through the second isolation valve when the system is isolated. The ESD valves automatically shut off the supply of fuel when de-energized by a combustion safety control, safety limit control, or loss of actuating medium. This is followed by burner shut-off valves, some of which are shut during decoking operations.

It is imperative that the ESD valves operate properly even after extended periods of non-operation. Type approvals are also becoming a standard requirement by local authorities. Typical conditions are similar to the control valve.

### Neles solution for burner shut-off/ESD

**Jamesbury™ 4000, 7000 or 9000-series soft-seated ball valves** with a B1-series piston actuator and a ValvGuard™ VG9000 safety solenoid to ensure operability in case of an upset.

For shut-off valves, **Jamesbury 4000, 7000 or 9000-series** valves with a Valv-Powr™ VPVL actuator provide excellent tightness during shut-off.

- **Field proven Xtreme™ seat & Lip-Seal capabilities** in both continuous and on/off (switching) heating
- **Safe and reliable bubble tight shut-off** even after a million cycles and the self-relieving feature (cavity relief) provides safe operation after a long time of non-movement
- **Partial stroke testing capability** with the VG9000 safety solenoid
- **Fire-safe design** acc. to API 607 or ISO 10497
- **Low fugitive emission approvals** by third party authorities
- **Certified up to SIL 3** by third party certifications
- **Gas burner valve type approvals** acc. to EN161, EN264, ISO 23553-1, AGA, FM and CSA



Jamesbury ball valve

## Dilution steam supply

Dilution steam supply to the cracker furnace takes place at a temperature near the transition between saturated and superheated steam. The flow rate of the steam depends on the severity of the reaction.

Depending on the technology of the furnace and control systems, the criticality of the steam flow control system can vary. In modern crackers where the furnace process is highly optimized, a more accurate control is required. Poor performance of the steam supply valve can lead to excessive fouling of the cracker. Dilution steam can also be used for decoking the furnace, making good rangeability a requirement of this valve. Steam also often has the tendency to cause high pressure drops and noise, which has to be taken into account when choosing an appropriate valve. Typically the temperature is 180-200 °C (350-400 °F), the pressure 10 barG (150 psig) and the pressure drop 2-7 bar (30-100 psi).

### Neles solution for dilution steam supply

**Neles GB or GU-series linear globe valve** with a VD spring diaphragm actuator and an ND9000 intelligent valve controller for general dilution steam control with a noise reducing trim if needed.

- **Same valve during decoking and operation** due to its wide rangeability allowing the flow to be adjusted accordingly
- **Reliable control**, ensuring that the dilution steam flow is stable preventing excessive fouling of the furnace coils
- **Auto-calibration** is possible by equipping the valve with the ND9000 valve controller
- **Noise reduction** can be achieved by trim design and various noise control components such as silencers and baffle plates
- **Low-friction actuator operation** improving efficiency and control performance



Neles globe valve

## Transfer line and decoking valves

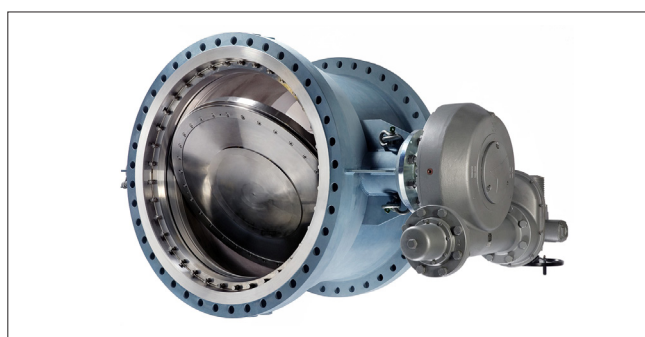
Regular decoking is required to remove coke from the furnace coils, typically every 3-4 months/furnace depending on the type of feed and the reaction severity. Decoking is typically done by steam/air. When end of run conditions are reached, the hydrocarbon feed is discontinued, the furnace isolated, the firing rate in the burners adjusted, after which controlled amounts of dilution steam and decoking air are admitted. The decoking effluent is routed to decoking drums, where the coke fines are separated from the decoking effluent gases.

Decoking valves have to withstand high piping forces due to large temperature variations. The downstream process must be protected from fire, high temperature steam and coke to ensure plant operability and safety, making 100% tightness essential.

## Neles solution for decoking valves

Our unique ethylene cracker valve, the **Mapabloc butterfly valve** design, has been successfully used in several steam cracking plants since the late '90s ensuring reliable decoking operations.

- **Double block and bleed sealing system** giving the valve a safe, extra tight seal
- **Reduced CAPEX and OPEX costs** from piping design, transportation and maintenance, when compared to a traditional gate valve, due to a compact and lightweight design
- **Minimal emission rates**, by utilizing rotary technology
- **Resistant to piping forces**, eliminating the risk of the valve getting stuck
- **Temperature shock resistant**, allowing it to be installed before the quench oil feed
- **Fast change from production to decoking**, as the closing element is moving freely ensuring quick and accurate reactions to system signals



Mapabloc butterfly valve

## Benefits

- Improved process control, reducing downtime and increasing efficiency
- Field proven long term tightness for safe and reliable furnace operation
- Save piping and valve costs with compact and lightweight valve solutions
- Meet noise, emission and fire safety regulations set by local authorities
- Improved cracking furnace efficiency
- Eliminate the possibility of valves getting stuck due to piping forces, temperature variations or coke accumulation
- Highest safety and availability for ESD/ESV applications

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