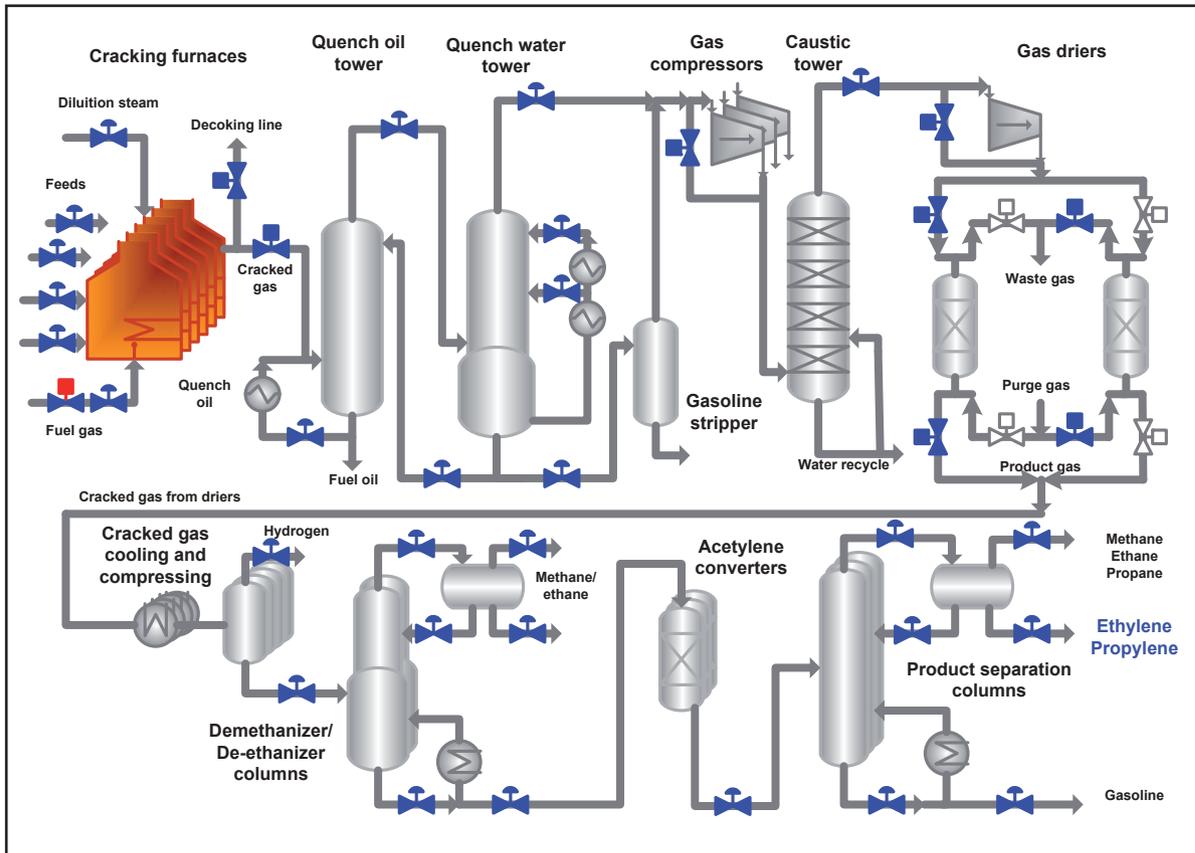


# Steam cracking - furnaces



## 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 and correctly 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 usable byproducts, such as the ones listed above.

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

molecule into two or more smaller molecules. The cracking is done during a short residence time and under a high temperature, followed by a sudden quench. This is followed by product fractionation, which includes distillation, and other processes for separating recoverable products.

The ethylene steam cracker raises the temperature of the feed stock to be cracked to 750-850 °C / 1380-1560 °F, and adds steam to reduce coking and improve the yield of end product.

## Steam cracking challenges

The steam cracking process has high yields with high temperature in the cracking furnaces. Steam cracking furnace valves play an important role in ensuring proper ethylene process performance. Reliable and accurate control, on-off and ESD-valve performance is vital during normal production and frequent furnace decoking operations to ensure total process productivity and safety.

**Health, Safety, Environment** – Valve leaking poses both an environmental and safety issue due to risk of fire, toxicity and volatility of gases. Emergency shutdown 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 both for liquid and gas feeds. Proper control valve performance in furnace applications improves the accuracy of throughput control and adversely affects to the plant performance and also the downstream processes.

**Maintenance costs** – Steam cracking furnace valves in feed, steam and fuel gas control as well as transfer line and decoking applications play an extremely important role in successful and reliable ethylene plant performance. Poorly performing valves in the process must be serviced because they will have a direct impact on the efficiency of the process.

**Energy** – Energy efficiency and CO<sub>2</sub> reduction is becoming more and more important for petrochemical plants that are looking for ways to reduce fuel gas consumption and CO<sub>2</sub> emission. Proper sizing and selection of process automation equipment, like valves is important to take into account.

## Metso solutions

We are all tuned up to answer these challenges through our steam cracking application experience and product offering for control, safety and automated on/off duty that ensure high valve performance. Our steam cracking furnace valves have proven performance history and are designed for efficient and reliable process operation.

**Safety** – Metso is the only single source emergency shutdown valve supplier who has the experience and knowledge to combine intelligence with most reliable valves and actuators. Technology selections like rotary stem operation and inherently fire safe design ensure that latest emission and fire safety standards can be applied. Reliable valves with Neles ValvGuard™, intelligent SIL3 approved safety valve controller and partial stroke testing device will ensure that plant emergency shutdown valves will always perform properly when needed.

**Efficiency** – Throughput losses 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. Our advanced intelligent digital valve controllers for control, on-off and ESD applications ensure high positioning accuracy and fast response. Correct valve selection and sizing with our 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. The proven performance of Metso valves with long lasting metal seat tightness and shut-off capabilities makes them an ideal solution for control, on-off and critical catalyst handling applications.

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

## Steam cracking applications

### 1. Feedstock supply

**Challenge** – 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 product yield.

Process system in an ethylene cracker must control the correct amount of raw materials for the desired end product. The feedstock supply valve must be able to control this as accurately as possible taking into account that some cases the feedstock can be a liquid and sometimes a gas. Some ethylene producers use two valves, one for the low flow, and one for full capacity.

Process conditions are typically

Fluid: Naphtha, ethane, propane or gas oil  
 Pressure: P1: 6 - 10 bar ,P2: 2 bar  
 Temperature: 120 °C / 250 °F

The feedstock supply valve is one of the most important control valves in the steam cracker. Changing demand and variety of feedstock creates certain challenges for the components. General application demands for the feedstock supply control valve are

- Wide rangeability, for variety of feedstock and cracker capacities
- Fire safe construction often required
- Cavitation or noise reduction for high pressure drops.

**Metso solution** – Finetrol eccentric rotary plug valve for general feedstock supply control with both liquid and gas. RE-series V-port segment valve for high capacity applications and extremely high rangeability needs.

**Benefits** – Ability to use a single valve solution due to wide rangeability – no need for split range control. Reliable control and reduced variability improves heater energy efficiency and heater temperature control and therefore process control of the whole cracker is improved.

The benefits of the valve are:

- Wide rangeability required provided by single valve
- Security with Fire-Safe Approvals
- Cavitation and noise reduction through unique 'Q' pressure reduction trim



Picture 1: Finetrol valve

### 2. Dilution steam supply

**Challenge** – The steam supply to the cracker furnace takes place at a temperature near the transition between saturated and superheated steam. The flowrate of the steam depends on the severity of the feed stock. Steam can also be used for decoking the furnace so rangeability of this valve can also be required.

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 can be optimized, a more accurate control is required. A poor performance of the steam supply valve can lead to excessive fouling of the cracker.

Process conditions are typically

Fluid: Steam  
 Flow: 100 - 50 000 kg/h  
 Pressure 10 bar  
 Pressure drop: 2-7 bar  
 Temperature: 180-200 °C

The dilution steam supply valve has typically following general requirements

- Wide rangeability, for varying cracker capacities and decoking
- Accurate control to minimize fouling
- Noise reduction capabilities

**Metso solution** – Finetrol eccentric rotary plug valve for general dilution steam control with noise reduction q-trim if needed. RE-series V-port segment valve for high capacity applications and extremely high rangeability needs

**Benefits** – Accurate control performance provided by Metso control valves ensures optimum product quality and yield with no additional energy requirements. Valve plays a significant role in control loop, especially when modern crackers are used and steam control needs to be optimized. Better valve performance means increased profit to the cracker.

### 3. Fuel gas / fuel oil control

**Challenge** – Burners create heat required to crack the feed stock. They are also used during de-coking, where relatively lower temperatures are required. The type of fuel, either public utility or internal, depends on the supply and can range from natural gas to crude oil.

Steam crackers can use a variety of fuels to feed the burners, depending on the most economical or practical fuel available at the time. Especially, modern crackers are capable of taking advantage of various fuels to feed the burners. The different heat generating properties of the fuels require a valve which can regulate the flow accordingly. In addition, the relatively low temperature required during de-coking of the furnace demands that the valve be able to control small flows of fuel, as not all the burners would be functional.

Typical process conditions, depending on the type of fuel

Fluid:	Variety of fuels (hydrocarbon liquids and gases)
Flow:	20 Nm <sup>3</sup> /h to 3000 Nm <sup>3</sup> /h (from 5 to 120 burners per furnace)
Pressure	2 - 10 bar
Temperature:	40 - 200 °C

The fuel control valve has typically following general requirements

- Wide rangeability, for varying cracker capacities and variety of fuels
- Fast reaction to signal changes
- Noise reduction capabilities



Picture 2: Segment valve

**Metso solution** – Finetrol eccentric rotary plug valve for general fuel control with noise reduction q-trim if needed. RE-series V-port segment valve for high capacity applications and extremely high rangeability needs. Accurate control can be provided together with QPX Quadra-Powr® spring-return diaphragm actuator and Neles ND9000 intelligent valve controller.

**Benefits** – Reliable control and reduced variability improves heater energy efficiency and heater temperature control and therefore the overall process control. Increased production realized with consistent control throughout the range of different fuel variety.

### 4. Burner shut-off and ESD-valves

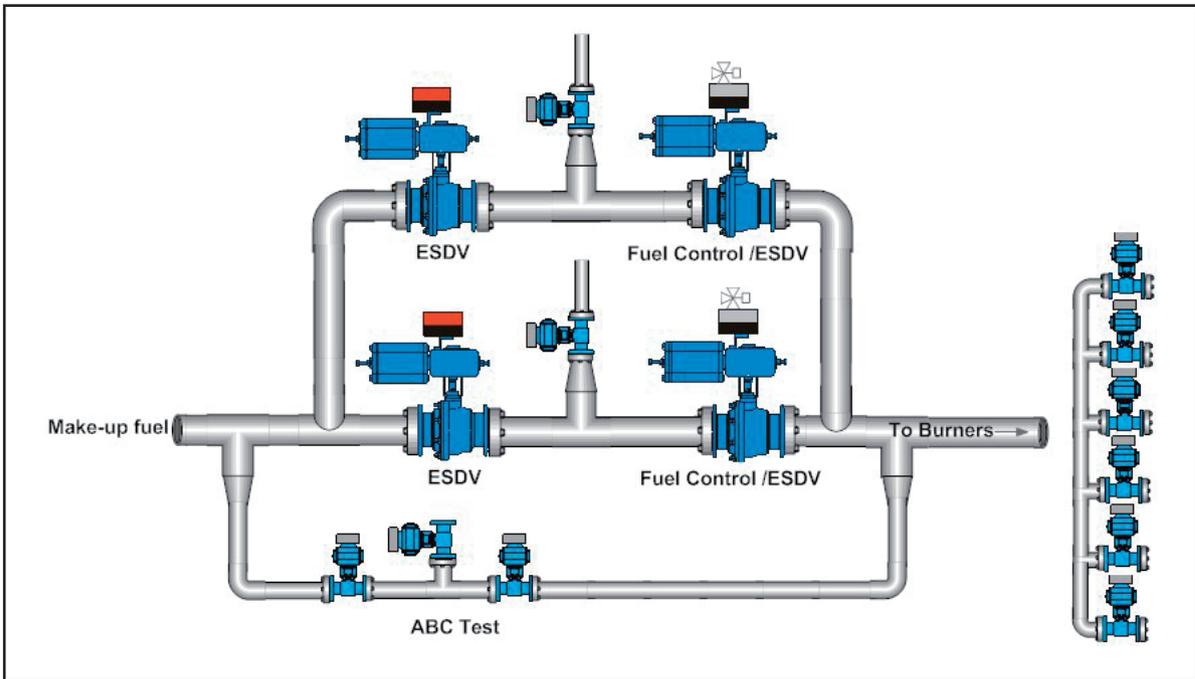
The burner fuel gas system valves consists of isolation ESD-valves (typically 3 – 10”), burner control valves and several burner shut-off valves (typically 1/2 – 3”), one per each burner. ESD-valve automatically shuts off the supply of fuel when de-energized by a combustion safety control, safety limit control, or loss of actuating medium. It is required the use of one, two or three valves (redundancy). Gas flows into the burner through a double series of shut-off valves that have a vent (ESV) between them. The vent is typically about 1/2 the size of the main line and is used to prevent pressure build up and flow through the 2nd isolation valve when the system is isolated. Current terminology for this is Double Isolation and Bleed. Type approvals is becoming more and more typical requirement by the local authorities in different countries.

#### Metso solution

- Jamesbury® ball valve Series 7000 or 9000
- Neles® piston actuator Series B
- Neles® SIL3 TÜV certified partial stroke safety device ValvGuard® for ESD-applications

#### Highest Safety:

- Bubble tight long term tightness
- Fire-Safe Design acc. API607 or ISO10497
- Lowest fugitive emission by 3rd authority approval up to 2” acc. ISO15848 BH and up to 12” acc. TA-Luft/VDI2440
- SIL 2 or 3
- Gas Burner valve type approvals with EN161/264 type TÜV approved unit



Picture 3: Simplified schematic of Metso valves in burner system

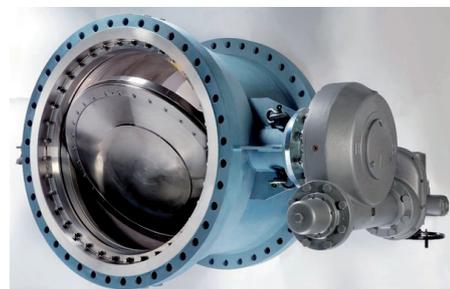
**5. Transfer line and decoking valves**  
 Regular decoking is required for steam cracker furnaces to remove coke from the furnace tubes, typically every 3-4 months/furnace depending on the type of feed and furnace severity. The decoking is typically done by steam/air decoking. When end of run conditions are attained, the hydrocarbon feed is discontinued, the furnace isolated, firing rate in burners adjusted, and controlled amounts of dilution steam and decoke air admitted. Decoking effluent is routed to decoke drums, where the coke fines are separated from the decoking effluent gases. On-line steam/air decoking will allow the furnace and quench exchanger system to operate through several successive cycles. The decoking valves have to withstand high piping forces due to high temperature variations. Downstream process must be protected from fire, high temperature steam and coke to ensure the plant operability and safety, therefore 100 % tightness is essential.

The rotary technology based Mapabloc ensures minimal emission rates and can tolerate the piping forces as such eliminating the risk of the valve get stuck. The construction is designed to withstand high temperature shocks and if needed it can be installed before the quench oil feed. As the closing element is moving freely and not sliding against any seat it can react accurately to any control demand coming from the system. The DCV and TLV are working in synchrony to ensure the fast change of ethylene furnace from production to decoking.

Criteria	Gate Valve	Mapablock
Size	NPS 40 CL 150	NPS 40 CL 150
Face to face	1200 mm (47")	1200 mm (47")
Overall dimension	7490 mm (295")	2450 mm (96")
Weight	11.5 tons (25.300 lb)	3.5 tons (7.600 lb)
Price	100 %*	80 %*

**Metso solution**

Metso’s unique Ethylene Cracker valve, the Mapabloc design, has been successfully used for several steam cracking plants since the late 90’s for furnace isolation decoking valve (DCV) and transfer line valve (TLV) to secure reliable decoking operations. The compact and light weight design allows for reduced capex and opex costs from piping design, transportation and installation to maintenance against the traditionally used linear (gate) valve type.



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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