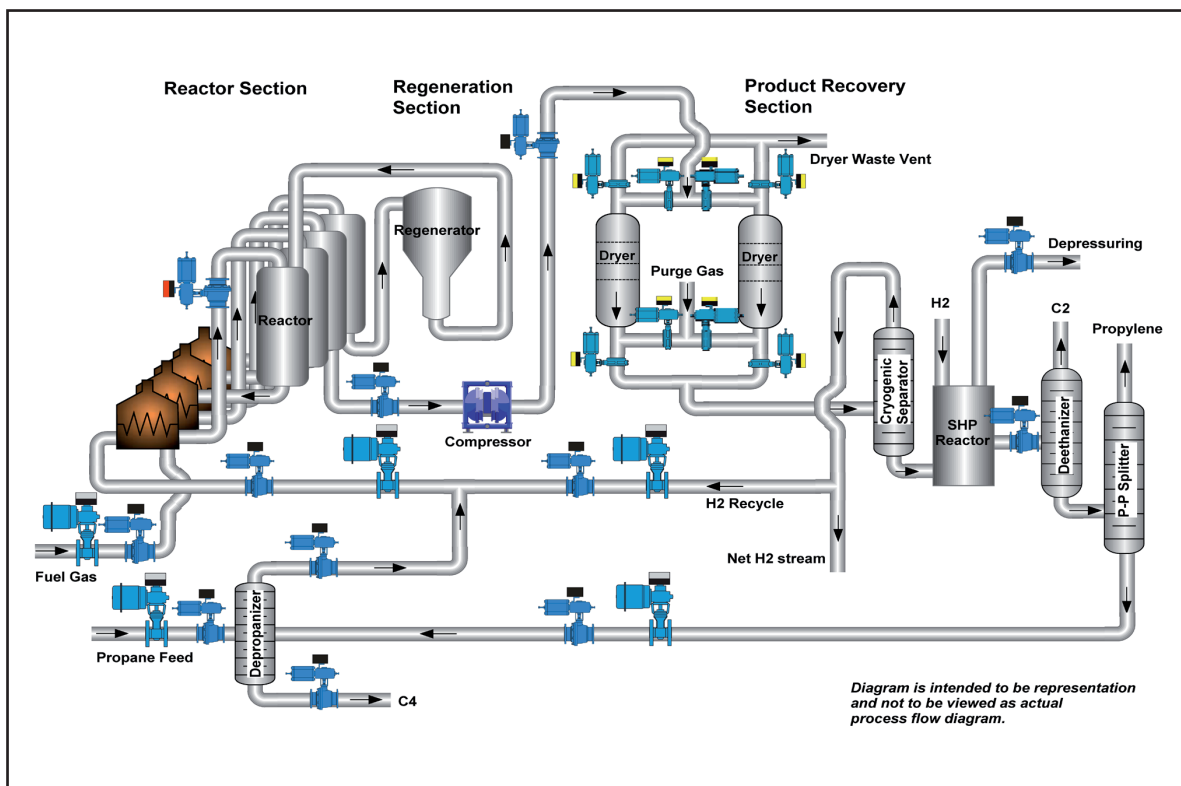


# Propane Dehydrogenation – Reactor and product recovery section applications



## Process overview

The propane dehydrogenation process, known as PDH, is used to supply polymer-grade propylene from propane to meet the growing propylene market, independent of a steam cracker or FCC unit. It provides a dedicated, reliable source of propylene to give more control over propylene feedstock costs.

The process consists of a reactor section, product recovery section and catalyst regeneration section. Hydrocarbon feed is mixed with hydrogen-rich recycle gas and is introduced into the heater to be heated into the desired temperature (over 540 °C) and then enter the reactors to be converted at high mono-olefin selectivity. Several interstage heaters are used to maintain the conversion through supplying heat continuously since the reaction is

endothermic. Catalyst activity is maintained by continuous catalyst regenerator (CCR) or shutting down reactors one by one and regenerating the reactor by the regeneration air, the continuous catalyst regenerator is where the catalyst is continuously withdrawn from the reactor, then regenerated, and fed back to the reactor bed.

Reactor effluent is compressed, dried and sent to a cryogenic separator where net hydrogen is recovered. The olefin product is sent to a selective hydrogenation process where dienes and acetylenes are removed. The propylene stream goes to a de-ethanizer where light-ends are removed prior to the propane-propylene splitter. Unconverted feedstock is recycled back to the depropanizer where it combines with fresh feed before being sent back to the reactor section.

## Propane dehydrogenation Challenges

The propane dehydrogenation process provides a dedicated, reliable, independent source of high-quality propylene. Valves play an important role in ensuring proper propane dehydrogenation process performance. Reliable and accurate control, on-off and ESD valve performance is vital during production 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. Proper valve performance in reactor, regenerator, dryer, recovery system improves the accuracy of throughput control and adversely affects to the plant performance and also the downstream processes.

**Maintenance costs** – Valves play an extremely important role in successful propane dehydrogenation performance. Poorly performing valves in the process must be serviced because they will have a direct impact on the efficiency of the process.

**Plant run-time** – Petrochemical plants are looking for longer plant run-times since downtime means production losses and is a remarkable cost including maintenance costs. This requires reliable equipment and process control.

## Metso solutions

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

**Safety** – Metso intelligent valves have been designed to provide market leading safety. Rotary stem operation reduces fugitive emission and protects from leaking. 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. Rotary stem

technology and inherently fire safe design ensure that latest emission and fire safety standards can be applied. Reliable valves with Neles ValvGuard™ VG9000, SIL3 approved intelligent safety valve controller and automatic partial stroke testing device, will ensure that plant emergency shutdown valves will always perform properly when needed. VG9000 provides extensive safety valve testing capabilities, integrated limit switches, market leading pneumatics capacity and online diagnostics on the safety valve performance. With VG9000, plant safety targets can be reached cost-efficiently.

**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 on-off, control and critical catalyst handling applications.

**Reliability** – Valve performance trend data collected by our smart valve controllers and analyzed 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.

## Propane dehydrogenation applications

### 1. Heater applications

Metso heater valves have proven performance history and are designed for efficient and reliable process operation.

#### Heater pass flow control

Problems with this valve can reduce heater performance and throughput control. Severe problems such as gland packing leakage can limit the unit throughput and reduce conversion.

**Metso Solution** – Finetrol eccentric plug rotary valve for moderate temperature service (< +425 °C) and Top entry valve for high temperature (> +425 °C).

**Benefits** – Metso Automation rotary gland systems are inherently more reliable and will not suffer the leakage problems typically associated with conventional globe designs. This is due to a rotary stem does not tend to move process media into gland packing similarly as a rising stem.



Picture 1. Finetrol

#### Fuel gas control

Heaters create heat required to convert the feedstock and to maintain the conversion through supplying heat continuously since the reaction is endothermic.

**Metso solution** – RE-series V-port segment valve with noise reduction Q-trim if needed. Accurate control can be provided together with spring return actuator and Neles ND9000 intelligent valve controller.

**Benefits** – Wide rangeability and high turndown ratio make it possible to use one single valve for start-up and normal operations instead of two valves configuration.



Picture 2. Segment valve

#### Fuel gas burner shut-off and ESD-valves

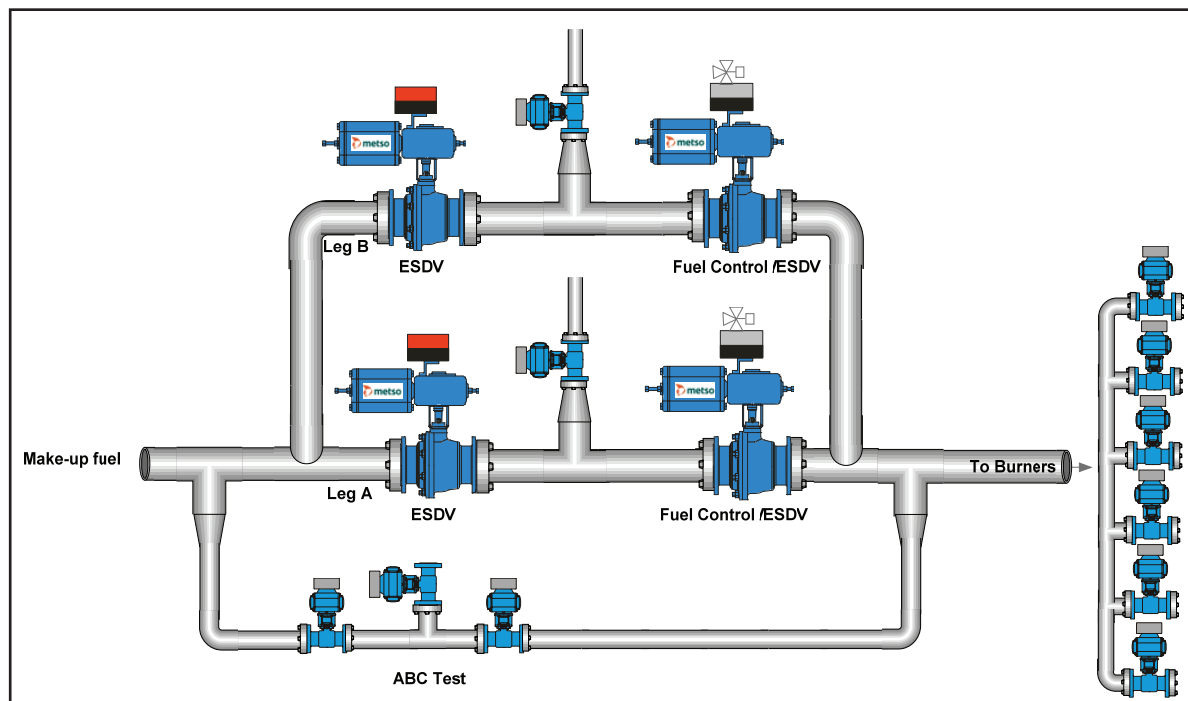
The burner fuel gas system valves consist of isolation ESD-valves (typically 3 – 10”), burner control valves and several burner shut-off valves (typically 1/2 – 3”), one per each burner. ESD-valve automatically shuts off the supply of fuel when de-energized by a combustion safety control, safety limit 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 ½ the size of the main line and is used to prevent pressure build up and flow through the second isolation valve when the system is isolated. Current terminology for this is Double Isolation and Bleed. Type approvals are 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 ValvGuard™ intelligent safety valve controller and partial stroke testing device 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

## 2. SHP Reactor Depressurizing Valve

Selective hydrogenation process, as known as SHP, is used to remove dienes and acetylenes. The SHP reactor depressurizing valves must be able to perform their action in a process upset situation.

High safety integrity and reliability is required from the SHP reactor depressurizing valve, in the case of SHP reactor get overpressure or upset. The valve operation must be fast and reliable. No unnecessary leakage is allowed for safety reasons and to avoid product losses. Tight shut-off, fire safe design, noise reduction capability and matching trim capacity to process conditions are typical valve requirements.

**Metso solution** – Neles metal seated ball valve X series equipped with special capacity Q-trim, pneumatic B-series actuator, and Neles ValvGuard™ intelligent safety valve controller.

### Benefits

- Avoid unnecessary flaring due to long lasting metal seated tightness.
- Emission proofing with rotary technology and standard live loaded packing
- Designed for high performance and reliable operation
- Advanced online diagnostics enabling predictive maintenance

- Availability in fire emergency conditions due to fire proof construction.
- Hidden failures revealed without flaring due to partial stroke testing with ValvGuard.
- Simple valve instrumentation with high safety integrity and reliability provided by ValvGuard.



Picture 4. Neles metal seated ball valve

### 3. Hydrogen Recycle Control Valve

The gas from the cryogenic separator is expanded and divided into two streams: recycle gas and net gas, which are mainly hydrogen. The recycle hydrogen should be controlled accurately to maintain a proper hydrogen-to-hydrocarbon ratio for optimum dehydrogenation reactions in the reactor.

**Metso solution** – Finetrol eccentric rotary plug valve for general hydrogen cycle 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 H<sub>2</sub> cycle control needs to be optimized. Better valve performance means increased productivity to the reactor.



Picture 5. Finetrol

### 4. Product Gas Dryers Valve

The dryers are used to remove trace amount of water formed from the catalyst regeneration and to remove hydrogen sulphide. The valves play an important role in directing the inlet/outlet stream of gas between the dryers columns, hence switching the columns from an adsorption phase into the regeneration phase in a preset sequence. High temperature nature gas or hydrogen (around 250 °C) is used to regenerate the adsorption bed.

**Challenge** – The valves have to withstand fluctuations in temperature while keeping the tightness in both flow directions over years of operation. Care must be taken in material selection and seat construction in order to avoid any wear or particles entering the seat cavities and adhering to sealing surfaces because the molecular sieve beds tend to release dust during the regeneration cycle.

### Metso solution

- Neles X series metal seated ball valve
- Neles triple eccentric disc valve Neldisc for big size
- Mapag high performance triple offset valve BW series with double seat design instead of double gate valve
- Intelligent on-off valve controller Neles SwitchGuard SG9000 as an option.

**Benefits** – Neles X series metal seated ball valve:

- Emission proofing with rotary technology and standard live loaded packing
- Optional bellow seat for improved tightness in high pressure/temperature environment
- Bi-directional tightness
- Long cycle life



Picture 6. Neles metal seated ball

**Benefits** – Neles triple eccentric disc valve Neldisc® for big size:

- Unique full metal seat design assures tightness over long operational periods
- Mechanically induced disc and seat contact, does not rely on differential pressure for tightness
- Bi-directional tightness even in large thermal cycling
- Low friction and wear resistant
- Robust and heavy-duty stem and bearings excellent in thermal cycle and medium with impurities
- Economical for large size, low pressure and single seat applications.





Picture 7. Neldisc

**Benefits** – Mapag high performance triple offset valve BW series instead of double gate valve:

- Double seat design perfectly manage medium with big temperature difference between two sides of the valve meanwhile keep bi-directional tightness
- Rotary technology for low emissions
- Less weight and cost saving compare with double gate valve
- Pressure relief in sealing cavity
- Customized engineering design ability
- Be able to tolerate the piping forces as such eliminating the risk of the valve get stuck



Picture 8. Mapag type BW valve



### Benefits - Intelligent on-off valve controller Neles SwitchGuard SG9000

For a complete valve solution for the driers we offer our Neles SwitchGuard SG9000, intelligent on/off valve controller that is designed to meet the demands of process-critical switching operations, particularly high cycling applications. With SwitchGuard and Neles FieldCare, configuration and condition monitoring software, you can monitor the condition of all the critical switching valves and utilize the unique on/off valve diagnostics to predict occurring valve failures in advance. In addition, with SwitchGuard, exact stroking profiles and times can be set for the switching valves.

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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