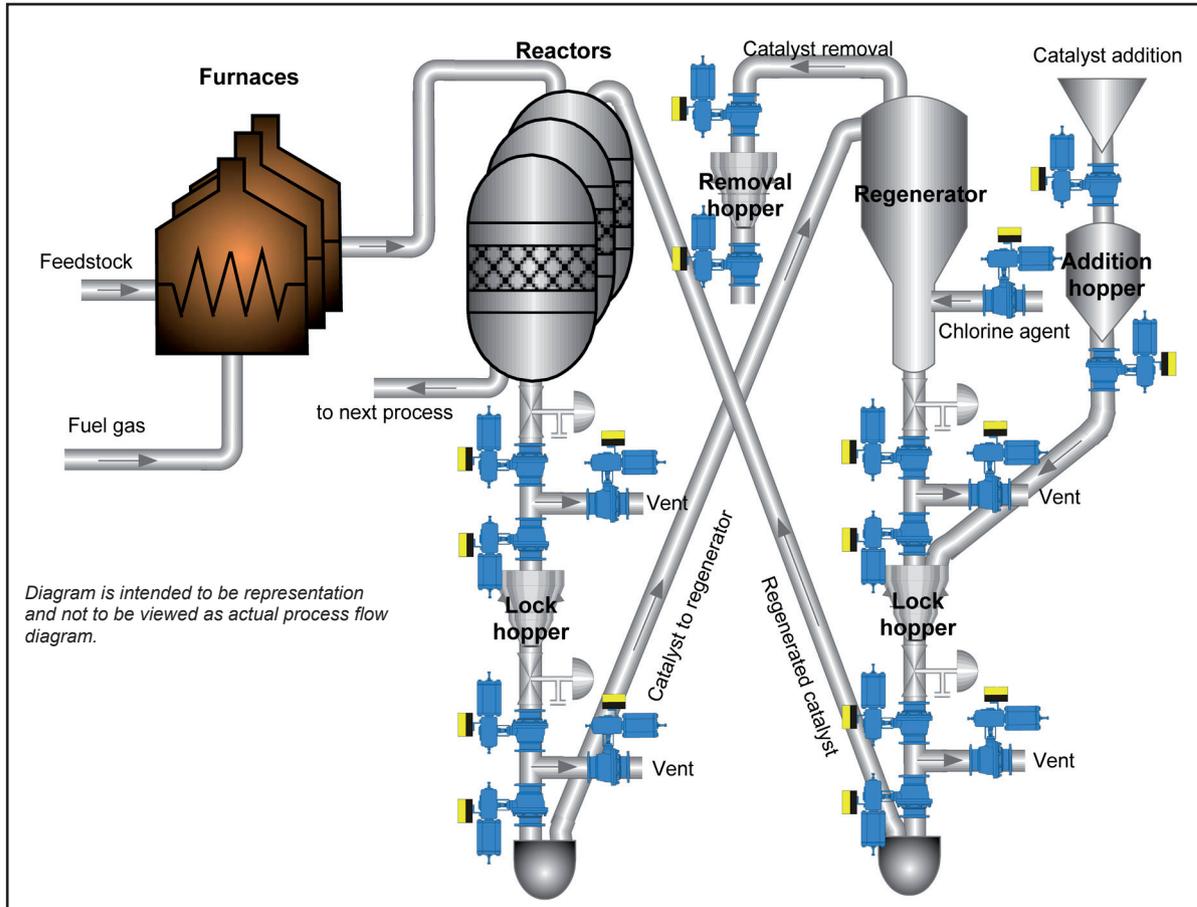


# Propane Dehydrogenation – Continuous catalyst regeneration applications



## 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 propane dehydrogenation process operates at high temperature (around 540°C). Over a period of time, the catalyst becomes coated with coke, a nature byproduct of the process, and requires regeneration. Catalyst

activity is maintained by continuous catalyst regenerator, known as CCR, where the catalyst is continuously withdrawn from the reactor, then regenerated, and fed back to the reactor bed. A series of lock hoppers, typically four complete lock hopper arrangements, are used to move catalyst from the reactor to the regenerator and eventually back into the reactor. The continuous catalyst regenerator makes it possible to manage the high catalyst coking rate to achieve the constancy of the yields.

## Propane dehydrogenation Challenges

The propane dehydrogenation process provides a dedicated, reliable, independent source of high-quality propylene. A constant non-declining yield is important in the PDH economics. The constancy of the yields is achieved by the CCR section, which ensures the reactors are continuously supplied with freshly regenerated catalyst, and product yields are maintained at fresh catalyst levels. Catalyst handling valves play an important role in ensuring proper CCR performance. Reliable and accurate control, on-off and ESD-valve performance is important for total process efficiency.

**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** – Critical valves in catalyst handling lock-hoppers, venting, catalyst withdrawal and addition play an extremely important role in successful catalyst regenerating process 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 application experience and product offering for control, safety and automated on/off duty that ensure high valve performance in propane dehydrogenation processes. Our catalyst handling 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. 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 first intelligent, SIL3 approved safety valve controller and partial stroke testing device Neles ValvGuard™ 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 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.

## Continuous catalyst regeneration applications

### 1. The Lock hopper block and vent valves

The sequence of lock hopper function is as follows:

- Catalyst requiring regeneration is gathered in the reactor disengaging zone.
- Catalyst flow is stopped by a special segmented ball valve located immediately below the disengaging zone and upstream of the two Neles lock hopper block valves. The two valves above the lock hopper are fully open before catalyst is allowed to flow through them.
- The segmented valve is then opened allowing catalyst to flow into the lock hopper.
- When the lock hopper is full the segmented valve is closed. After the flow of catalyst is completely stopped, the two Neles valves are closed, isolating the lock hopper.
- The lock hopper is then inerted with nitrogen. Following this, the two lock hopper block valves located below the lock hopper are opened allowing the inerted catalyst to flow, by gravity, into a lift engager for transport to the next part of the process.
- Catalyst falling from the reactor into the lock hopper contains a fairly large amount of hydrogen. After filling, isolating and inerting the lock hopper, the gases are vented through the lock hopper vent valve. This valve must vent highly abrasive, catalyst-entrained gas while simultaneously achieving Class VI shut off. A special double-seated globe valve previously served this application. This design had one metal seat, intended to resist abrasion damage imparted by the fluid, and one soft seat, intended to achieve the desired shut off classification. This solution has historically been plagued with leakage problems as well as high cost of repair.

#### Metso solution

**Valve type** – Metso utilizes a full-bore design in lock hopper service. All counter bores and transitions in diameter are removed from the waterway of the valve. This causes the valve to look like a piece of smooth pipe to the flowing media in order to eliminate the possibility of pulverizing expensive catalyst. It also minimizes the possibility of internal valve damage by the highly abrasive catalyst. The valve body is constructed of A351 CF8M for the longest possible

life while subjected to the extreme thermal transients associated with this process.

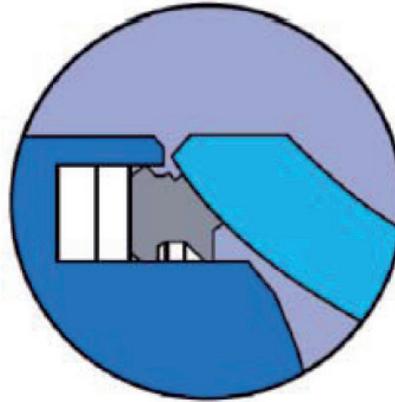
**Ball** – The ball is constructed of A351 CF8M with a Nickel Boron coating. The base material of the valve was chosen to provide for a coefficient of expansion similar to the valve body. This is required to maintain seat to ball tightness as the valves experience a large number of significant thermal transients. The Nickel Boron coating is applied to raise the surface hardness of the ball to Rockwell C68-C70. This is necessary to provide for long component life in this highly abrasive service.

**Seat** – Metso utilizes 316SS seat with Chromium Carbide (CrC) coating for this application. This material combination was again chosen for compatible coefficients of expansion as well as superior abrasion resistance. The seat energizer, perhaps the most important design feature of the valve, is Metso's unique "solids-proof" construction. The seat back cavity is completely filled with a graphite stack. The graphite seat back material achieves two important tasks: 1) it serves as seat energizer. The graphite allows for repeatable valve shutoff despite the extremes in temperature. 2) The graphite stack completely fills the seat back cavity. This eliminates the possibility of catalyst fines accumulating behind the seat. This is extremely important as catalyst fines behind the seat can cause the required torque to increase enough to exceed the maximum output capability of the actuator.

**Controller** – Neles SwitchGuard SG 9000 is an intelligent on-off valve controller that is specially designed to meet challenges of process critical on-off applications. SG 9000 gives the possibility to set the on-off valve stroking times and profiles according to the process needs. Its high pneumatics capacity also gives the possibility to reach fast stroking times without the need for any additional accessories such as volume boosters or quick exhaust valves. In addition, predictive maintenance can be practised with the help of the diagnostics that SG 9000 provides on the on-off valve performance. To simplify the installation, different mechanical or inductive proximity switches can be installed inside the SG 9000 housing. As an option for SG 9000, Metso can also provide traditional control solution based on separate solenoid valve and limit switches.



*Intelligent seat supported ball valve*



### Valve model example:

#### XA03DWUUS6SLJBDD

- XA Full bore seat supported ball valve
- 03 Valve size, typically 2" to 6"
- D ANSI class 300
- W ANSI B16.5 raised face flange
- UU Full compliance with UOP specification 671
- S6 ASTM A351 CF8M / SS316 stainless steel body construction
- SL SS316/NiBo ball construction
- J Solids proof seat construction
- B CrC coating on seat
- D All graphite seats and packing with metal stem bearings
- D B8 studs and B8M nuts

### Benefits

This demanding application led to the successful development of Metso solution, the Neles X-MBV ball valve. The special end-to-end dimension allows the X-MBV to retrofit in place of a globe valve without piping modification. The Neles J type solids proof seat prevents catalyst dust from getting behind the ball. This precludes the possibility of torque increase or seat back cavity abrasion damage. The materials of construction are selected for maximum resistance to abrasion damage allowing for long valve life. The Neles X-MBV ball valve has been specifically designed to meet the process requirements, such as UOP specification 671. Equipped with Metso pneumatic cylinder actuators and Neles SwitchGuard intelligent on-off valve controller, provides the ideal lock hopper block and vent valve solution.

## 2. The Catalyst addition and removal valves

The catalyst addition system is the point in process where new catalyst is added to replace the quantity of catalyst that is withdrawn and discarded from the system after it can no longer be regenerated. The new catalyst flows by gravity into the system through a catalyst addition hopper at ambient temperature. The new catalyst passes through the first addition valve and into the addition lock hopper. The first valve, above the lock hopper, is then closed and the second valve, below the lock hopper, is opened admitting the new catalyst into the process.

### Valve requirements

- Tight shut-off
- Catalyst friendly design
- Safety interlock system

### Metso solution

The Jamesbury 9150 series soft-seated ball valve with Xtreme seats and pneumatic actuator has been proved to be the right choice by many refineries and petrochemical plants using the continuous catalyst regeneration process. Metso valves equipped with Neles SwitchGuard intelligent on-off valve controller gives the possibility to control the valve opening and closing strokes and also provides diagnostics on the valve performance. A safety interlock system is needed to prevent both the valve above and below the lock hopper from opening at the same time.

**Valve model example:**

**9150 31 3600XTZ**

9150 Full Bore ANSI Class 150 ball valve  
31 Raised face flange, Fire Tite, seat supported  
3600 Stainless steel construction  
XTZ Xtreme seats

**3. Chlorine addition valve**

Spent catalyst enters the top of the regeneration tower where the coke is burnt off the catalyst at high temperature and low oxygen concentration. Catalyst then passes into the chlorination zone. In this area, the catalyst is oxidized at high temperature and high oxygen concentration in the presence of organic chloride injected into the circulating gas to achieve the proper catalyst chloride balance.

**Valve requirements**

- Bubble-tight shut-off
- Inconel® wetted parts
- Low emissions packing and gaskets

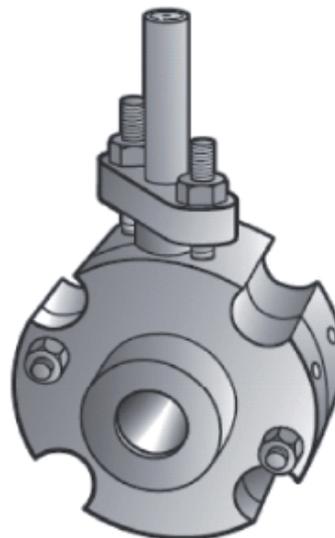
**Metso solution**

The Neles W1 Series valve has been specifically designed to meet the chlorine application requirements such as the UOP specification 671. Equipped with Metso pneumatic cylinder actuators and Neles SwitchGuard intelligent on-off valve controller, it provides the ideal solution for the control of organic chlorides. It provides the ideal solution for the control of organic chlorides. The valve is configured as a wafer style ANSI class 300 full bore ball valve. Depending of the capacity of the CCR, the valve will be supplied as 3/4", 1", or 1 1/2" size. The vast majority of the time the 3/4" valve is supplied. All Inconel construction is used for its metallurgical compatibility with the highly corrosive organic chloride. Teflon seats are provided to provide the bubble tight shut off required.

**Valve model example:**

**W1BU007IIT01-BCM-LS-SV**

W1 Full bore wafer style ball valve  
B ANSI 300 dimensions  
U UOP design and construction testing to UOP 671 specification  
XXX Valve size 3/4", 1", 1 1/2"  
I Inconel 600 body  
I Inconel 600 stem ball  
T Reinforced PTFE seats  
01 TFE seals  
B1C Double acting actuator



*Chloride regeneration isolation valve*

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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