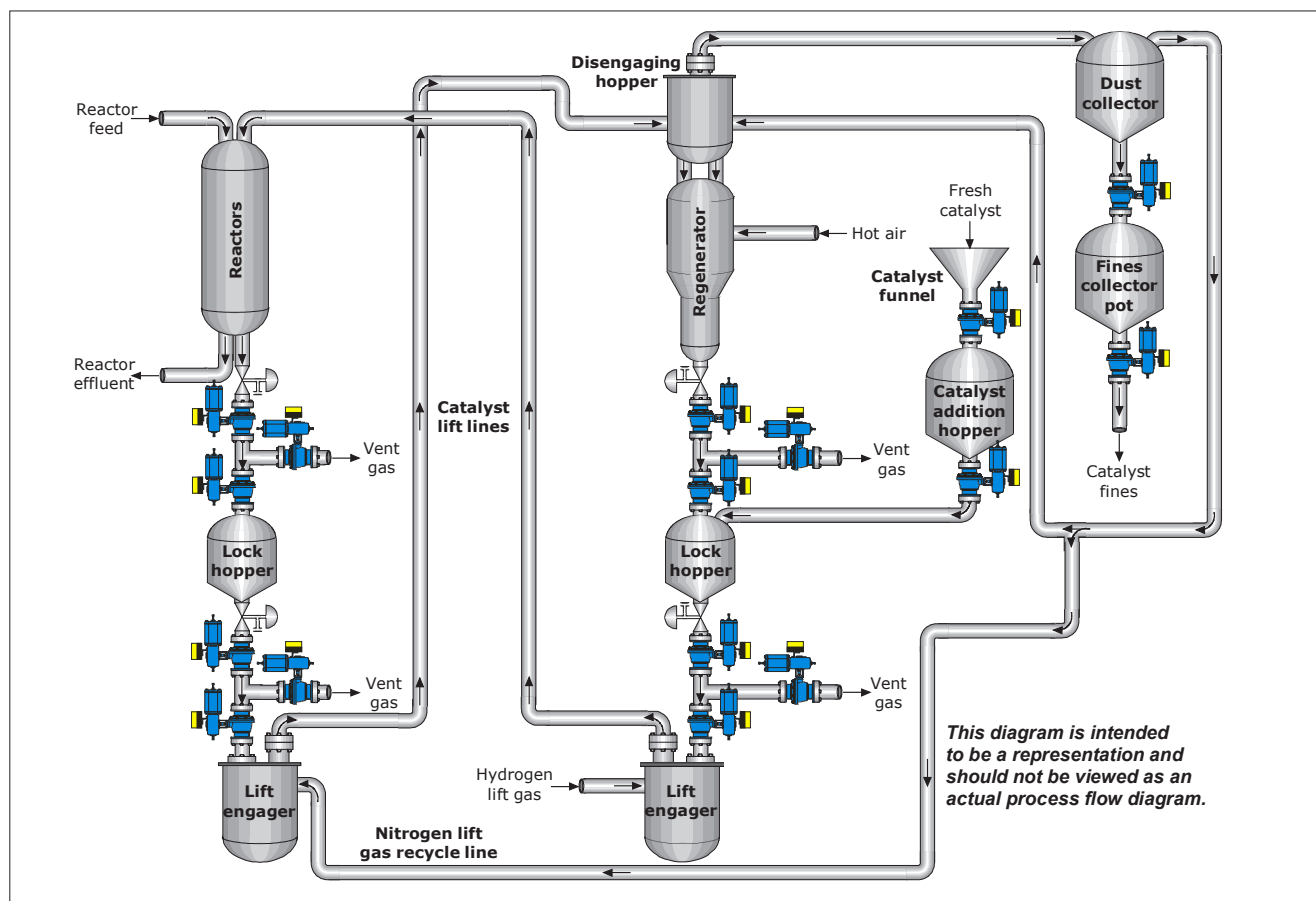


Propane dehydrogenation – Continuous catalyst regeneration



Process overview

Propane dehydrogenation (PDH) is used to produce polymer-grade propylene from propane independent of a steam cracker or fluid catalytic cracking unit. It provides a dedicated and reliable source of propylene to meet the growing market demand for propylene and gives more control over propylene feedstock costs.

A constant non-declining yield is important for PDH economics. Coke is formed as a by-product of the dehydrogenation process which coats the catalyst, decreasing its activity. One method of maintaining catalyst activity is by utilizing continuous catalyst regeneration (CCR), where the catalyst is continuously withdrawn from the reactor, regenerated, and then fed back to the reactor bed.

Catalyst requiring regeneration is gathered in the reactor disengaging zone located below the reactor. 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.

In the first lock hopper, the deactivated catalyst is made inert with nitrogen. Following this, the catalyst enters a lift engager which transports the catalyst into the regenerator, where the coke is burned off the catalyst. The regenerated catalyst is then transported back into the reactor through a series of lock hoppers. Fresh catalyst is also periodically added to replace catalyst that cannot be regenerated due to attrition.

Continuous catalyst regeneration valves

Continuous catalyst regeneration is a quite demanding application for valves. Gas flows with catalyst spheres and dust mean that there is potential for the valves to get stuck due to particle accumulation in cavities. The flow medium is also quite abrasive due to the solids content which may erode valves.

For efficient catalyst regeneration, proper valve performance is crucial. Improperly operating valves may negatively affect regeneration efficiency, which in turn affects the efficiency of the propane dehydrogenation process. Application appropriate valve selection ensures optimal regeneration efficiency, maximizing the throughput of the dehydrogenation process.

Lock hopper block and vent valves

The lock hopper block valves are located directly beneath a special segmented ball valve, which blocks the flow of catalyst into the lock hopper between regeneration batches. At first the block valves are open, and when the segmented valve opens, catalyst flows into the lock hopper. Once the lock hopper has been filled, the segmented valve and block valves are closed to isolate the lock hopper. Next, nitrogen is fed into the lock hopper to make the catalyst inert. A large amount of hydrogen is also present in the spent catalyst and the gases are vented through the vent valves after the catalyst has been made inert. Finally, the block valves below the hopper are opened and the catalyst flows into a lift engager and transported to the next part of the process.

The lock hopper valves must be able to handle the abrasive catalyst. In addition, the valve shouldn't allow catalyst spheres or dust to get stuck in cavities. The vent valve must vent highly abrasive, catalyst-entrained gas while simultaneously achieving Class VI shut off. These valves must also achieve a stroking time of less than 10 seconds and they are cycled a moderate amount of around 20 000-30 000 times annually.

Neles™ solution for lock hopper valves

Neles full bore metal-seated ball valves. When equipped with Neles pneumatic cylinder actuators and Neles SwitchGuard™ intelligent on-off valve controllers, they offer a proven performance in lock hopper block and vent valve applications.

- **No pulverization of expensive catalyst**, due to a full-bore design, minimizing the possibility of damage by the abrasive catalyst and saving costs
- **Thermal transient resistant**, due to the body and ball being constructed of A351 CF8M, ensuring the longest possible life and seat to ball tightness
- **Abrasion resistance**, by applying a Nickel Boron coating to the ball and Chromium Carbide (CrC) coating for the seat
- **Neles' unique solids-proof seat**, as the seat back cavity is filled with a graphite stack, ensuring that catalyst fines won't accumulate behind the seat increasing the required torque or cause abrasion damage
- **High performance piston actuator** that has been extensively used even in very high cycle applications
- **Application compliant**, as the valve meets licensor process requirements such as UOP specification 671



Neles full bore ball valve

Catalyst addition and fine removal

New catalyst is periodically added to replace the quantity of catalyst that can no longer be regenerated due to attrition. 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. The fine removal valves also operate in a similar manner.

Catalyst friendly design is required to prevent catalyst dust and particles from entering cavities. Tight shut-off, Class VI tightness, is required. Fire safe design is also often required.

Neles solution for catalyst valves

Jamesbury™ soft-seated ball valves with Xtreme™ seats, a B1-series pneumatic actuator, and a SwitchGuard valve controller as an option, have been proven to be the right choice by many refineries and petrochemical plants utilizing continuous catalyst regeneration.

- **Xtreme seat**, a fluoropolymer-based blend, which provides longer life, expanded performance boundaries and greater value
- **Bubble tight shut-off** even after a million cycles, due to the flexible lip seat design which prevents permanent deformation from occurring
- **Cavity relief design**, which diverts the cavity pressure to the least resistance, preventing the valve from being damaged
- **Fire-Tite™ design**, meeting API 607 and BS6755-Part 2 requirements
- **High torque actuator**, allowing the use of a smaller actuator to achieve tight shut-off



Jamesbury ball valve

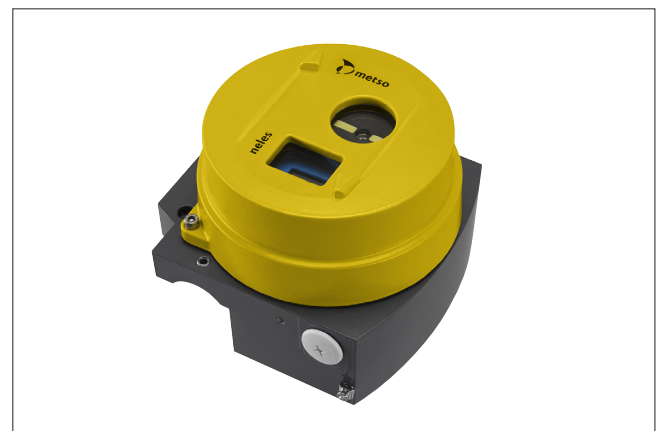
Valve controllers

Neles valve controller SwitchGuard SG9000 offers topmost reliability in severe environmental conditions and provides extensive diagnostics for process critical on-off applications, enabling users to guarantee the availability of PDH-valves.

- **Configure to meet process demands** – the SG9000 gives the possibility to set the on-off valve stroking times and profiles according to the process needs
- **Reach fast stroking times without accessories** such as volume boosters or quick exhaust valves, due its high pneumatics capacity
- **Practise predictive maintenance** with the help of the extensive diagnostics that it provides on the PDH-valve performance
- **Simplify the installation** by installing different mechanical or inductive proximity switches inside the SG9000 housing
- **Comprehensive hazardous area certifications** for intrinsically safe and flameproof applications are available for all valve control instruments

Benefits

- Industry and licensor proven performance
- Valves designed to last for the desired process uptime targets
- Advanced diagnostics capability in the SG9000 allowing problems to be detected in advance
- Reduce catalyst waste as catalyst won't get stuck in cavities
- Save piping and valve costs with compact and lightweight valve solutions
- Reliable catalyst regeneration improving total process efficiency



SG9000 intelligent valve controller

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