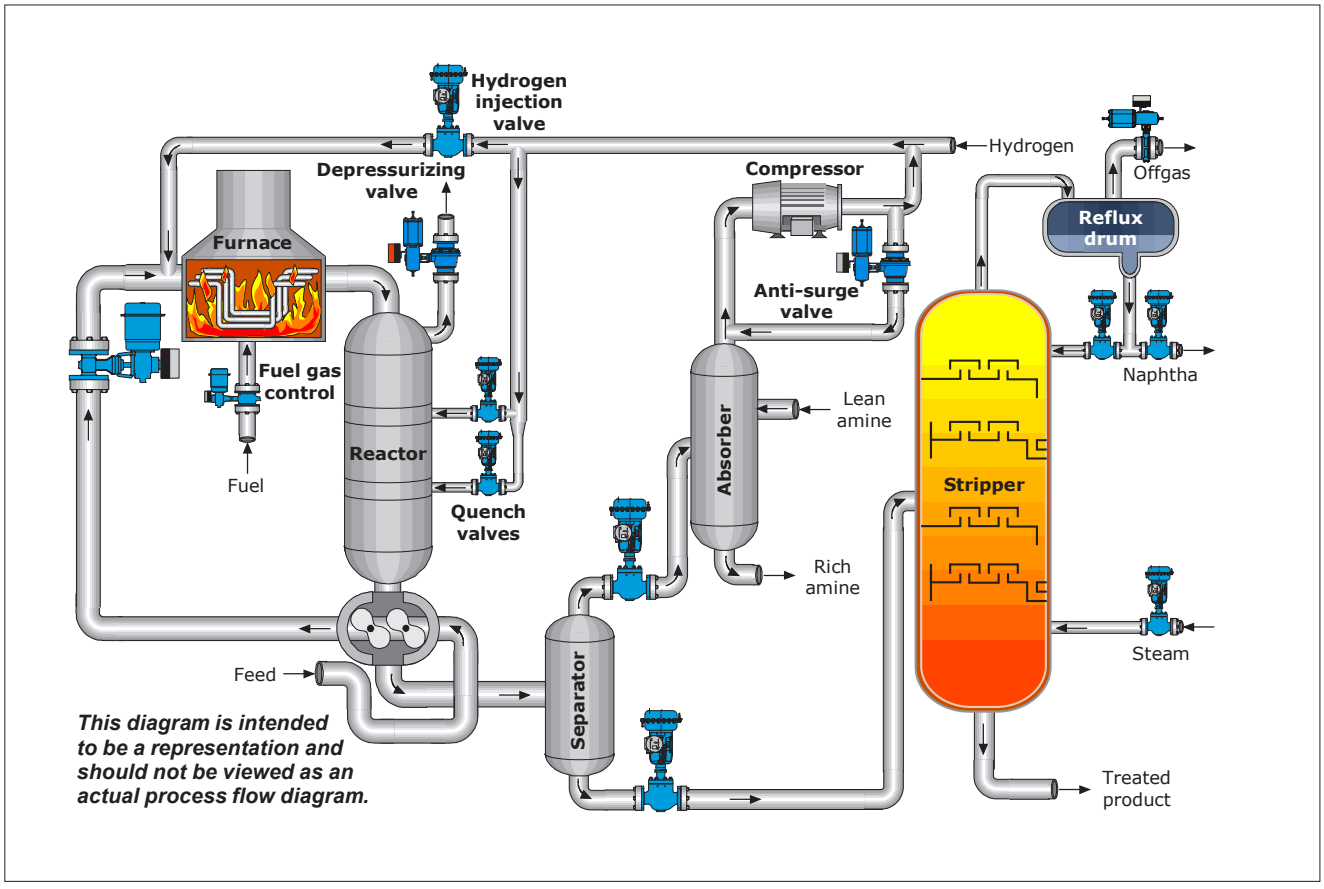
Hydrotreating



Process overview

Hydrotreating is used to remove sulfur and other contaminants including nitrogen, oxygen, aromatics and metal-containing compounds from the feedstock. The process utilizes hydrogen gas for treating and it is mainly used for producing low-sulfur fuels or as pretreatment in processes where these contaminants may poison the catalyst.

The feed is first preheated by heat exchange with the reactor effluent. Hydrogen gas is mixed to the feed and the mixture is then heated to the desired hydrotreating temperature (around 260-430 °C/500-810 °F) before entering the reactor. The feed mixture then passes downward in the hydrogenation reactor packed with various types of catalyst depending on the reactions desired.

Hydrogen reacts with the feed contaminants to produce hydrogen sulfide, ammonia, saturated hydrocarbons and free metals. Metals stick to the catalyst surface; other products leave the reactor with the oil-hydrogen stream. Hydrogen quenches are used for reactor bed temperature control.

The reactor effluent is cooled to around 40-50 °C (100-120 °F) and then enters the high-pressure separator, which separates the liquid hydrocarbon from the reacted contaminants and hydrogen gas. Hydrogen, minus purges, is combined with make-up hydrogen and recycled after acid gases have been absorbed in the amine absorber.

The separator let-down is taken to a fractionator/stripper where the product is stripped of any remaining hydrogen sulfide and light ends.

Hydrotreating valve applications

Valves play an important role in the hydrotreating process. Regular reactor temperature control is performed by valves and usually the emergency system for regaining control of reactor temperature is dependent on several valves. Improperly functioning valves in the vicinity of the reactor could cause a thermal runaway situation.

Valves are also used for providing heat to the process and during various separation stages where inaptly operating valves will negatively affect overall process efficiency.

Hydrogen injection valve

Unreacted hydrogen is recovered in separators following the reactor. This recovered gas is usually scrubbed to remove entrained sulfur before it is combined with make-up hydrogen and injected to the reactor feed or used as reactor quench.

The injection valves are typically subject to very high pressures, around 80-150 barG (1160-2200 psig). There may also be hydrogen sulfide present in the mixture which is corrosive. Furthermore, since hydrogen gas is very flammable, emissions need to be strictly controlled to prevent fire hazards. In some cases, the valve might also need special cleaning to remove moisture and grease to mitigate ignition hazards.

Neles solution for hydrogen injection

Neles linear globe valves provide a compliant and reliable solution for hydrogen injection.

- **Excellent seat tightness** even in high pressure drop applications (tight shut-off, seat leakage class V)
- **Minimize process deviations** with accurate performance of ND controller and actuator
- **Corrosion resistance** ensured with NACE compliant materials
- **Fugitive emission certified** per ISO 15848, ensuring minimized emissions

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.

It is imperative that the safety (ESD) valves operate properly even after extended periods of non-operation. For both shut-off and safety valves, high temperature compatibility and fire safe design are typical valve requirements. Type approvals may also be required.

Neles solution for burner shut-off/ESD

Jamesbury™ soft-seated ball valves with a piston actuator provide excellent tightness during shut-off. The ValvGuard intelligent safety solenoid ensures operability of ESD valves in case of an upset.

- **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** for safety-valves with the ValvGuard™ safety solenoid
- **Fire-safe design** acc. to API 607 or ISO 10497
- **Fugitive emission approvals** by third party authorities
- **Certified up to SIL 3** by third parties
- **Gas burner valve type approvals** acc. to EN161, EN264, ISO 23553-1, AGA, FM and CSA

Jamesbury ball valve

Fuel gas/oil control

The furnaces heat the feedstock into the temperature producing optimal yield of desired products in the reactor. A variety of fuels can be used 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.

The different heat generation properties of the fuels require a valve which can regulate the flow accordingly. In addition, the difference in the amount of fuel required during start-up and actual process conditions requires a valve with good rangeability. To ensure a more reliable operation, fast reaction to signal changes is required to quickly adjust furnace outlet temperature and for 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

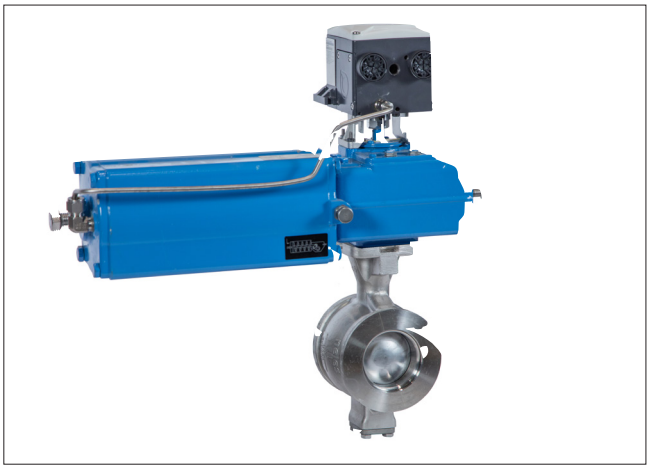
We offer two types of valves which are well-suited for fuel gas/oil control. The selection of valve type depends on the type of fuel and rangeability requirements.

Neles balanced cage guided globe valve with a spring diaphragm actuator and an ND 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 V-port segment valve** together with a spring-return diaphragm actuator and an ND 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 and full capacity 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

Reactor bed quench

The hydrogen quenches are controlled to obtain equal bed inlet and outlet temperatures. This minimizes the catalyst deactivation rate and maximizes product selectivity. The bed inlet temperatures are typically controlled within ±0.5 °C (±1.0 °F) of the desired temperature. As catalyst activity declines during the run, the reactor average temperature is gradually increased to compensate for the lost activity.

This requires a valve with good control accuracy and minimized variability to optimize hydrogen consumption. Rangeability is also needed to compensate for catalyst activity loss. There may be traces of hydrogen sulfide in the media.

Neles solution for reactor bed quench

Neles globe valves with an ND intelligent valve controller to minimize variability.

- **Wide rangeability** allowing the same valves and piping to be used with rising reactor temperatures
- **Economic benefits achieved** as the ND controller can reduce reactor bed temperature variability
- **Easy maintenance** – Top entry construction for easy access, valve assembly is simple and self-guiding
- **A variety of trims available,** including the Tendril design, reducing noise and eliminating cavitation
- **NACE compliant materials** for corrosion resistance
- **Improved process safety** with the online diagnostics provided by the ND controller, ensuring reactor quench availability

Neles globe valve

Reactor depressurizing

In case of a thermal runaway in the reactor, a safety function is needed to stabilize the conditions. Lowering the reactor pressure also lowers the partial pressure of the hydrogen gas present. This slows down the exothermic reaction, making it possible to regain reactor temperature control. Hydrotreating reactors are usually equipped with a slow and a fast depressurizing system. During an emergency, the slow system is used first to minimize damage to process equipment. If the slow system fails to contain the situation, the fast system is taken into use.

Depressurizing valves are typically required to reduce the vessel pressure to a certain value (e.g. 50 %) of the design level within a set amount of time (from several minutes to almost an hour). As the depressurized gas is usually lead to a disposal system, such as a flare, the capacity of this system usually limits the outlet velocity of the depressurizing valves. Noise reduction capabilities may also be needed.

Neles solution for reactor depressurizing

Neles ball valves with the intelligent safety solenoid ValvGuard as an option provide a reliable and safe solution for reactor depressurizing.

- **Fire-safe construction,** ensuring availability in fire emergency conditions
- **Reduce emissions and product losses** due to long lasting metal seated tightness, rotary stem and live-loaded packing
- **Special capacity trims available** to prevent too fast depressurization
- **Various noise attenuation trims,** providing up to 18 dB(A) noise attenuation where noise levels are to be reduced during depressurizing
- **Possibility for partial stroke testing,** ensuring valve availability

Neles ball valve

Compressor anti-surge valve

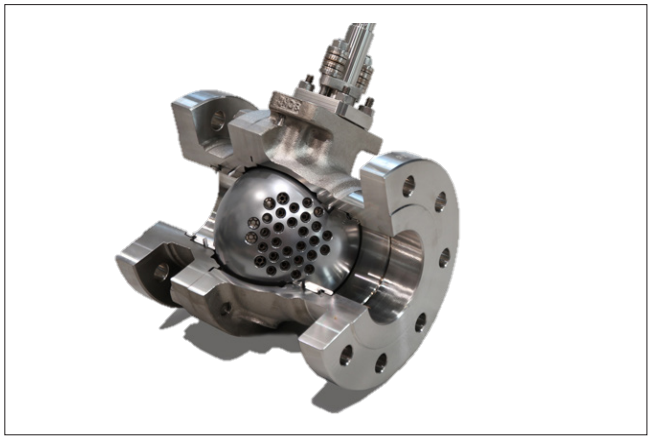
There is a minimum capacity for each compressor, at every speed, below which the operation becomes unstable. This instability is accompanied by a characteristic noise known as pumping or surge. The instability occurs when the pressure at the outlet of the compressor is higher than that produced by the compressor, causing the flow to reverse momentarily. However, the reduction of flow causes the discharge pressure to drop, and the flow returns. This is referred to as surge. The resulting violent oscillation of gas pressure can cause severe and costly damage to the compressor in a few seconds. To avoid this, a bypass valve is installed between the discharge of the compressor and the inlet.

The anti-surge valve must respond quickly, usually in less than one second. It must also be able to pass the capacity of the compressor. Noise and vibration is an issue due to high pressure ratios and volumetric flow. To minimize energy losses, the valve must achieve tight shut-off.

Neles solution for compressor anti-surge

We offer complete solutions for anti-surge on-off and control valves from linear to rotary valves. The exact valve model depends on process conditions and customer preferences.

- **Vibration and noise is eliminated** with special trims and attenuators
- **High capacity designs** ensure quick and sufficient transfer of pressure under surge conditions
- **Quick opening** is achieved by quickly responding double acting piston actuators and appropriate instrumentation
- **Tight-shut off** up to Class V for control valves and Class VI for on-off valves



Ball valve with noise reducing trim

Benefits

- Ensure safety of personnel and equipment with reliable and field-proven safety solutions
- Optimize process efficiency by minimizing process variability with Neles smart controllers
- Save time during commissioning with type approved burner valves
- Know-how to perform application appropriate valve and material selection to maximize valve up-time and reliability
- Improve sustainability by meeting environmental regulations with emission certified valves
- Wide rangeability rotary valves save piping and valve costs by eliminating split-range control

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