

# CONTROL VALVES AND LNG: COMMON,

Stephen James, Baker Hughes, USA, addresses the importance of control valves to the LNG supply chain.

# YET

# CRITICAL

**T**he LNG industry stands as a cornerstone in the global energy landscape, with control valves serving as indispensable components in its supply chain. The journey of LNG entails numerous stages, each necessitating precise control and regulation of fluid flow. Control valves emerge as essential elements, enabling efficient operations and maintaining safety standards across LNG liquefaction plants, transportation vessels, and receiving terminals. Understanding the diverse applications and types of control valves in the LNG

industry is paramount for proper control valve selection and long-term operational reliability that optimises operations and upholds the integrity of the various steps in the LNG process.

## LNG liquefaction

LNG liquefaction is a complex and pivotal process within the LNG supply chain, serving as the foundation for the entire industry. This process occurs at LNG liquefaction plants, strategically located near natural gas reserves or major pipeline



# COVER STORY

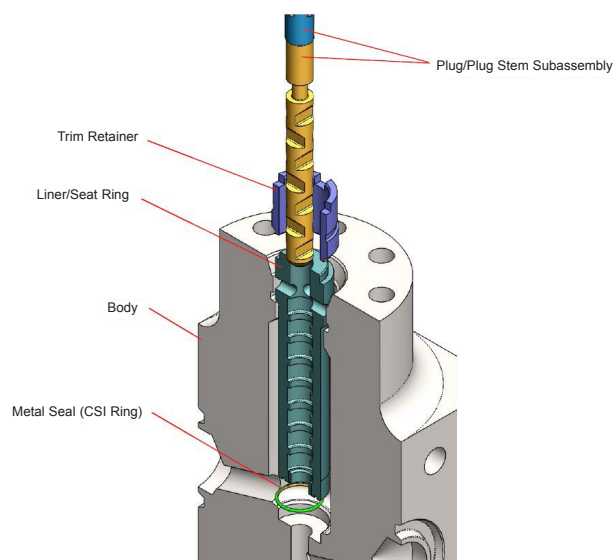
networks. The primary objective of LNG liquefaction is to convert natural gas from its gaseous state to a liquid form, enabling efficient transportation and storage. This transformation involves several intricate steps, each requiring meticulous control and regulation, with control valves playing a crucial role in ensuring the smooth operation and safety of the liquefaction process.

At the heart of LNG liquefaction is the need to reduce the volume of natural gas while maintaining its energy density, making it economically viable for long-distance transportation.

This reduction in volume is achieved through the application of cryogenic temperatures, typically around  $-162^{\circ}\text{C}$  ( $-260^{\circ}\text{F}$ ), at which point natural gas transitions into a liquid state known as LNG.

The liquefaction process can be broadly categorised into three main stages: pretreatment, refrigeration, and condensation. During the pretreatment stage, raw natural gas undergoes purification to remove impurities such as water, carbon dioxide ( $\text{CO}_2$ ), and sulfur compounds ( $\text{H}_2\text{S}$ ). This purification step is

essential to prevent corrosion and contamination within the liquefaction equipment. Specialised control valves with unique material combinations are utilised in the pretreatment stage of the LNG plant. During this phase it is common to remove CO<sub>2</sub> and H<sub>2</sub>S with an amine contactor. The letdown valve at the bottom of the amine contactor needs specially selected materials such as duplex stainless steel or high nickel alloys to combat corrosion from the process fluid. In addition to the material selection, a proper valve design will utilise multi-stage trim to prevent cavitation and also have a gradual expansion in



**Figure 1.** Multi-stage anti-cavitation valve with customised trim used in acid-gas removal systems.



**Figure 2.** Compressor anti-surge control valves couple large capacity with precise, high-speed control.

the trim flow area to prevent choking due to off-gassing during the pressure reduction. The result is a specially engineered valve suitable for the rigours of the application: corrosion, cavitation, and off-gassing.

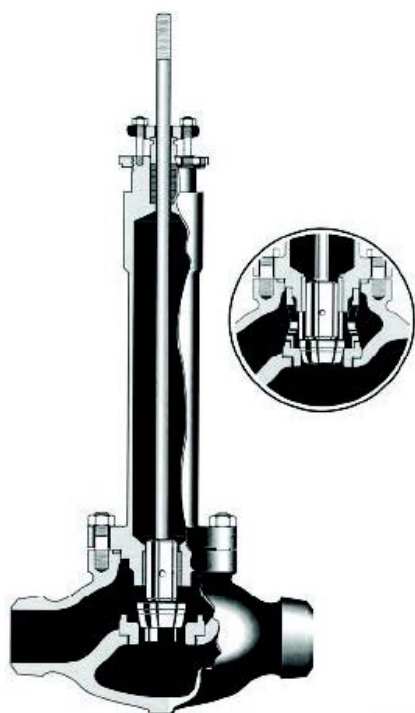
Once purified, the natural gas enters the refrigeration stage, where it is cooled to cryogenic temperatures using a series of refrigeration cycles. These refrigeration cycles rely on the use of cryogenic refrigerants, such as propane or ethylene, to achieve the required temperature reduction. Control valves are deployed throughout this stage to regulate the flow of refrigerants, control pressure levels, and maintain precise temperature conditions within the liquefaction equipment. Some of the most critical control valves in this stage are those associated with turbomachinery protection. Compressor anti-surge control valves modulate flow to protect compressors from surge conditions that could lead to equipment damage or failure, safeguarding the integrity of the LNG trains. The compressor anti-surge valve is high capacity while also having very fast opening and response times, typically no more than 1 – 2 secs. Due to the high pressure drop ratios of the application, noise and vibration need to be mitigated using advanced valve trims based on pressure drop staging, frequency shifting and velocity management. High rangeability, often more than 100:1, is also required for when the valves are used at low capacity during compressor start-up. The cumulative requirements lead to specific valve designs tailored to each piece of turbomachinery.

The final stage of the liquefaction process involves the condensation of the cooled natural gas into LNG. This condensation occurs within specialised equipment, where the natural gas is subjected to low temperatures and high pressures, causing it to transition from a gaseous to a liquid state. Control valves play a crucial role in this stage, facilitating the precise control of flow rates while ensuring optimal pressure conditions. One of the most critical control valves in this part of the plant is the turboexpander bypass valve, or Joule-Thompson (J-T) valve. This valve needs to be suitable for low cryogenic temperatures while utilising specially designed multi-stage trims to safely manage the J-T phase change without excessive, damaging vibration. Special consideration needs to be made to the J-T valve, so it is sufficiently large for low inlet and outlet valve velocities.

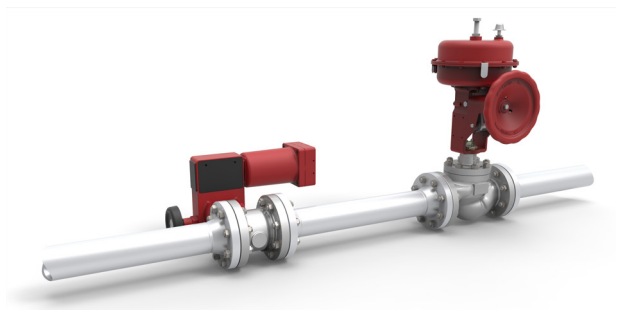
Several types of control valves are commonly used in LNG liquefaction plants, each tailored to meet specific operational requirements and environmental conditions. Among these are triple offset butterfly valves, eccentric rotary control valves, and specialised cryogenic control valves. Triple offset butterfly valves offer precise flow control and tight shutoff capabilities, making them well-suited for cryogenic applications where leakage prevention is paramount. Eccentric rotary control valves provide precise control in a more compact and sustainable design than conventional globe control valves and are ideally suited for managing many general service processes within LNG liquefaction plants. Specialised cryogenic control valves are specifically designed to operate reliably in extremely low temperatures, ensuring the safe and efficient handling of LNG throughout the liquefaction process.

Sustainability is a key consideration in the design and operation of LNG liquefaction plants, with a focus on minimising energy consumption, reducing emissions, and maximising operational efficiency. Sustainable practices encompass various aspects of plant design and operation,

including the selection of energy and material efficient control valves that are certified for low fugitive emission operations. To ensure proper selection of sustainable valve designs, a plant designer or operator should be mindful of valve mass (the



**Figure 3.** Specialised control valves with custom trims are designed to function optimally at cryogenic temperatures commonly found in LNG.



**Figure 4.** Selection of advanced eccentric rotary control valves can provide a more sustainable solution with significant material reduction vs conventional globe control valves.



**Figure 5.** Control valves installed on LNG tankers need to be designed and certified for installation in the harshest of marine environments.

lower, the better) and compliance to fugitive emissions standards like ISO 15848, in addition to anticipated long service life for the selected application. Control valves play a crucial role in these efforts, as they directly influence the efficiency and reliability of LNG liquefaction processes.

## LNG transportation

Following liquefaction, LNG is transported from production facilities to receiving terminals using specialised LNG carriers. The transportation of LNG requires meticulous management of flow, pressure, and temperature to ensure the integrity of the cargo and the safety of the vessel and crew.

Control valves play a critical role in LNG transportation, regulating the flow of LNG within the carriers. In addition to operating successfully as a control valve, they also need to be properly certified for use on a marine vessel and suitably designed for the extreme environments found at sea. Control valves found topsides of LNG tankers are commonly designed with specialised stainless-steel enclosures around critical control components to maintain their integrity at sea.

## LNG receiving terminals

LNG receiving terminals are facilities where imported LNG is received, stored, regasified, and distributed for various applications, such as power generation, heating, and industrial processes. The primary purpose of LNG receiving terminals is to convert LNG back into its gaseous state for use in end-user applications.

The regasification process at LNG receiving terminals involves heating the LNG to return it to its gaseous state. This is typically accomplished using heat exchangers or vaporisers, where the LNG is warmed by exchanging heat with seawater, ambient air, or other sources of heat energy.

Control valves play a crucial role in LNG receiving terminals, regulating the flow of LNG during regasification, controlling pressure and temperature, and ensuring the safe and efficient distribution of natural gas to consumers. Control valve applications in an LNG terminal vary widely. One unique application in LNG terminals is that of high pressure, multi-stage, anti-cavitation, cryogenic control valves for LNG pump recirculation. The combination of high pressure, high-pressure drop ratio, and cryogenic operating temperatures results in this unique control valve design rarely found outside of this industry.

## Summary

Control valves are indispensable components in the LNG supply chain, playing a crucial role in ensuring the safe and efficient operation of LNG liquefaction plants, transportation vessels, and receiving terminals. Ranging from tight shut-off triple offset butterfly valves, to high-speed compressor anti-surge valves, to specialised cryogenic control valves, control valves enable precise control of flow, pressure, and temperature throughout LNG processes. Optimal valve selection balances proper valve suitability, sustainability, and long-term operability. Control valves are common, yet highly critical pieces of equipment needed by LNG operators to enhance the reliability, safety, and sustainability of their operations, contributing to the continued growth and success of the LNG industry. [LNG](#)