Valve Requirements for LNG Installations

Background

The emergence of natural gas as a clean fuel has spurred investments in processing and transportation infrastructure around the globe. It also inspired the development of a new range of cryogenic valves. Natural gas liquefies at -259°F (-162° C) at which point its volume shrinks to around 1/600th of its original volume, making it economically viable to transport over long distances using LNG carriers. Cryogenic valves are used at liquefaction plants and regasification terminals that receive LNG from the carriers.

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Design

Although the design approach for an LNG valve is similar to that for a cryogenic valve, LNG service [1] poses additional considerations such as thermal conditions in steady and transient state, protection against thermal expansion of LNG, protection against icing of sealing device, leak tightness, selection of pressure retaining metal parts and functional test requirements are some aspects of paramount importance.

LNG valves are designed with a gas column (also called extension column), which keeps the stem packing and operator isolated from the influence of cryogenic temperature and allows it to operate within its working range. The gas column length can be optimized by thermal analysis using engineering simulation software. The design of the drive train components including the stem sealing arrangement should ensure that valve is capable of operating with the stem oriented 15° to 90° above the horizontal plane for cold box applications.

Material selection: Austenitic and nickel alloys are the popular materials selected for pressure retaining shell components meeting the impact test requirements. Sealability is of utmost importance in LNG valves and specifying hard coating on seating surfaces (obturator and seat) is recommended to prevent seizing and galling. In triple offset butterfly valves, use of solid seal is preferred for better thermal stability while in trunnion ball valves, thermoplastic lip seals are used to ensure stable operation at low temperatures.

Safety features in design: Valves are designed such that LNG cannot be trapped in any cavity leading to a pressure increase. This is ensured by an arrangement for relieving cavity pressure. In addition, the seals in LNG valves are designed to be intrinsically fire-safe and tested to API 607. The seals are also designed and tested to comply with Fugitive Emissions norms such as API 622 and ISO 15848 Class A/B. Lastly, Safety Integrity Level (SIL) certified valves are selected for shut down applications in LNG service.

Manufacturing

Manufacturing of cryogenic valves requires proper material selection, casting control, precision machining to maintain the tolerances and assembly skills. In addition, large size valves (sizes ≥ 24”) pose several unique challenges in getting the castings right the first time as single piece valve body castings could weigh between 5 to 20 tons.

To enhance integrity of castings, large melting Induction Furnaces (IF), Electric Arc Furnaces (EAF) and ladle refining furnaces can be employed and double ladle pouring technique which allows pouring of more than 20MT liquid metal into the mould within the pouring temperature and time thereby preventing shrinkage and cold shut. In addition, controlling the quenching time is very critical for stainless steel material to avoid crack and to achieve the desired mechanical and corrosion properties.

Specialized manufacturing processes are required including process control of key parameters and dimensions to ensure bubble-tight leak tightness for metal-seated valves at -320°F (-196°C). Thermal stabilization treatment ensures dimensional stability of the body and obturator to avoid distortion during low temperature cycles. In addition, defects due to thermal shock, to a certain extent are prevented by slow thermal stabilization of the components. Dimensional accuracy is better ensured by employing machines such as 5-axis machining centers and special purpose machines for welding of the extension column to ensure concentricity.

Testing

Low temperature cooling tanks are used for tests between -51°F (-46°C) to -320°F

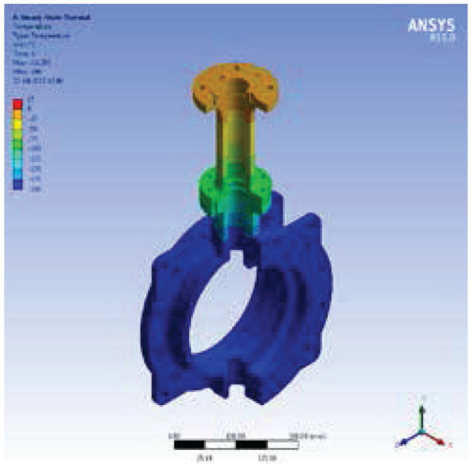
Aspects	BS 6364:1984	MSS SP-134: 2010	ISO 28921-1: 2013	ISO 28921-2: 2015
Testing scope	App A: Prototype test procedure (≤Class 600 ; ≤20")	Production testing ≤ 12", ≤ Class 1500	Production testing (≤ 36", ≤ Class 1500)	Type test* (≤ Class 1500)
Mechanical cycles	20 cycles	5 cycles	5 cycles	200 cycles
Seat leakage in cc/minute (10" Class 600)	1500	1000	750	750

* Size selection shall be at mid-range of the design range, pressureclass shall be selected so that it qualifies all valves of the same and lower pressure rating

(-196°C) using liquid nitrogen with PID controlled valves and fans. At a differential temperature of more than 392°F (200°C), there is an enormous amount of heat transfer leading to a huge loss of liquid nitrogen. To address this issue, cooling tanks that employ super-insulating materials are used to minimize heat loss. Nitrogen bullets are installed in the plants to supply liquid nitrogen to the cooling tanks without manual handling of the liquid thereby ensuring the safety of the operating personnel.

The industry standards for cryogenic valves are BS 6364, MSS SP-134 and ISO 28921, which call for testing with helium at -320°F (-196°C). All these standards have many of the design and testing requirements in common except for differences in scope of the standard, extension column lengths, number of operations during low temperature test and allowable seat leakage values. Typical cryogenic testing consists of an extensive test program with a stringent leakage rate criteria and require the valve operation test as well as seat and shell leakage test to be done at -320°F (-196°C).

Apart from the testing standards mentioned above, the EN 12567 standard specifies thermal shock testing, the purpose of which is to verify that a valve can withstand the transient thermal stresses induced by the cooling down process under operating conditions. According to the procedure, the valve shall be rapidly filled with the cryogenic fluid in 5 minutes after which the valve shall remain filled with the test fluid for a duration of one hour. After returning to room temperature, the valve is disassembled and the pressure retaining parts are examined for defects. These are similar to the conditions the valve will be subjected to during its normal operation.



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References

[1] BS EN 12567:2000, "Isolating Valves for LNG"