Comparison of **Contemporary Cryogenic Valve Standards**

Background

Cryogenic valve standards provide design and performance standards for valves in cryogenic services. Some of the applications where valves are required to operate in cryogenic service include LNG (Liquefied Natural Gas) processing, intake, storage and satellite facilities, gas to liquids, ethylene plants, LPG terminals and industrial-use cryogenic gases.

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Definition(s)

- As per API RP 615, cryogenic service is defined as the lower end of low temperature service (such as liquefied gas) typically between -163 °C to -196 °C (-261 ° F to -320 °F) while low-temperature service is generally defined in the process industry as services that range from -196 °C (-320 °F) up to -30 °C (-21 °F).
- As per MSS SP-134, cold box extension is an enclosure that insulates a set of equipment from the environment without the need for insulation of the individual components inside the cold box while Non-cold box extension is one that is used for valves that are normally individually insulated.

Cryogenic Valve Standards: Applicability and Scope

Cryogenic valve standards that are used in the valve industry include:

1. BS 6364: 1984: Valves for Cryogenic service
2. MSS SP-134: 2012: Valves for Cryogenic Service, including Requirements for Body/Bonnet Extensions
3. ISO 28921-1: 2013: Part 1 - Design, material selection and production testing
4. ISO 28921-2: 2015: Part 2 -Type testing of low temperature valves
5. EN 12567: 2000: Isolating valves for LNG
6. ISO 21011:2008: Cryogenic vessels -- Valves for cryogenic service

With 6 active cryogenic valve standards in the industry, it is important to understand the requirements spelt out in each of these standards. The standards differ in terms of the extension lengths for cold box and non-cold box applications, drip plate design, stem strength guidelines, test sequence, number of cycles, to name a few. Figure 1 shows the scope and applicability of the various cryogenic valve standards.

Design Requirements Covered in Standards:

Some of the design requirements that are covered in BS 6364, MSS SP-134 and ISO 28921-1 include wall thickness, extension length, orientation, stem guiding, drip plate, cavity relief, bolting material and valve installation. MSS SP-134 covers the guidance for stem strength calculations in both linear and quarter turn valves to determine critical load for buckling load failure.

Extension Column:

The purpose of the extension column is The main purpose of the extension column is to reduce the heat influx into the system and to keep the packing away from the influence of cryogenic temperature so that it operates within its Working range. The Layers of vapors in saturated and super-saturated formed below the stuffing box will act as a thermal insulator and this will prevent the loss of the cryogenic liquid.

The standards vary in the way extension lengths for non-cold box and cold box applications are defined (Table 1).

Installation:

The extended bonnet can be in any position for valves specified in gas service. For valves specified to be in cold box applications, with liquids, stem could be oriented 15° to 90° above the horizontal plane. For valves specified to be in liquid service, other than cold box applications, extended bonnet could be at or

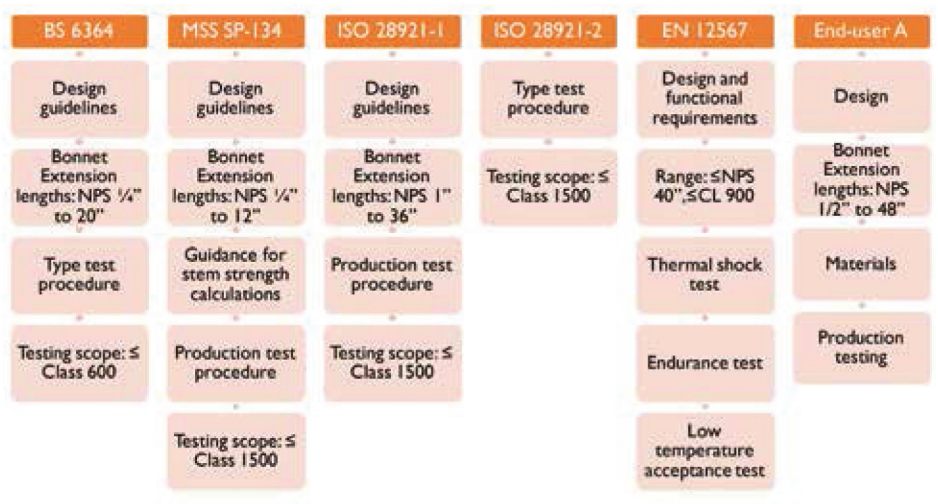

Figure 1 - scope and applicability of the various cryogenic valve standards/specifications

Standards	Non-cold box extension	Cold box extension
BS 6364	Weld to weld	Body centreline to bottom of stuffing box
ISO 28921-1	Top of stem guide bush to bottom of Stuffing box	Body centreline to bottom of stuffing box
MSS SP-134	Body centreline to top of stuffing box	Body centreline to top of stuffing box

Table 1: Extension length definition in standards

above 45° above the horizontal position.

Parameters not specified in the standards but are still important to the valve performance are stabilization treatment of components, hard coating on the sealing surface of obturator and seat, fire safe type testing to API 607/ISO 10497, fugitive emissions (ISO 15848-1) type testing between -196 C and upper design temperature. Material selection is critical in ball valves where seat (PCTFE, PEEK, Devlon etc.) and sealing materials (O ring, PTFE Lip seals, Metal seals) have to be compatible with the service conditions.

Cryogenic Testing Procedure

While MSS SP-134 and ISO 28921-1 specify production test procedure for qualifying a cryogenic valve, BS 6364, EN 12567 and ISO 28921-2 specify type test requirements for a cryogenic valve. A typical test sequence for a cryogenic test is - pressure testing prior to cryogenic test, system proving test, valve cavity purging, cooling of the valve, tests at cryogenic/low temperature, warm-up procedure and post-test examination.

EN 12567:

EN 12567 specifies a thermal shock test (Annex A) to simulate the thermal stresses in transient state that are greater than stresses due to static pressure. The thermal shock test consists of the following steps:

1) Valve shall be filled with cryogenic test fluid

2) Valve shall be in partially open position during filling

3) Outer surface exposed to atmosphere

4) Filling of the valve in 5 minutes

5) Valve shall remain filled for 1 hour

6) Valve disassembly and crack detection test

This standard also has an endurance test procedure (Annex B) that calls for 500 or 2000 operating cycles with Liquid Nitrogen inside the valve, periodic seat and shell leakage measurements at incremental pressure values. The parameters that can be assessed during the endurance test are the effectiveness of the cryogenic neck extension, stem and body sealing system, seat leak tightness, wear and tear of drive train components after cycling and checking whether the operating effort doesn't exceed 360 N. An ambient shell and seat test is conducted before and after the endurance test in accordance with EN 12266-1.

Conclusion:

To summarize the current trends in cryogenic valve standards,

- ISO 28921-2 is the new type test standard for cryogenic valves
- MSS SP-134 and ISO 28921-1 are popular production test standards for valves.
- BS 6364, last updated in 1998, is increasingly being replaced by ISO 28921-1&2 in end-user specifications.
- Lastly, EN 12567 offers the industry a test procedure for testing valves to thermal shock and endurance test with Liquid Nitrogen inside the valve simulating real life conditions.

REFERENCES

[1] API RP 615 Valve Selection Guide, Second Edition

[2] MSS SP-134: 2012, Valves for Cryogenic Service, including Requirements for Body/Bonnet Extensions

[3] EN 12567:2000, Isolating valves for LNG

[4] ISO 28921-2: 2015: Part 2 - Type testing of low temperature valves

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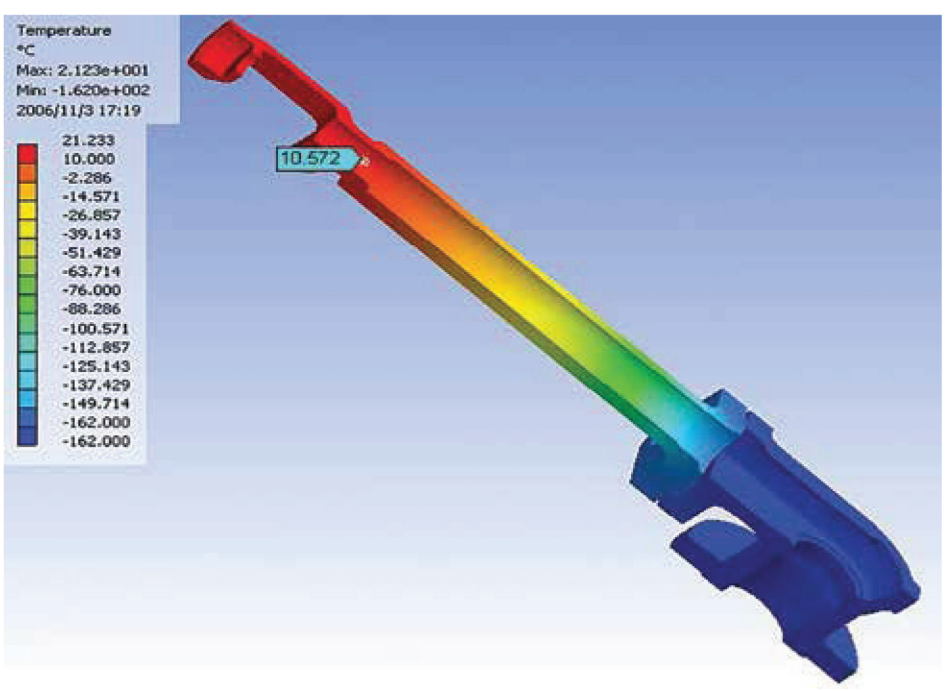

EN 12567 Annex B	ISO 28921-2
Shell/Seat tests as per EN 12266-1	System proving test
Cooling carried out with LN2 inside the valve	Cooling of the valve (outside-in)
Liquid temp shall be lower than -150 deg C	LP seat test 5 cycles, torque measurement, seat leakage
Leakage measurements at 0, 20, 40, 80, 150, 300, 500 cycle	HP seat test- Test in 4 equal increments, seating/unseating torque
Shell leakage tests conducted at 0.25, 0.5, 0.75, 1 x CWP	5 cycles against full DP; measure seat leakage after 1st and 5th cycle followed by 180 cycles at CWP
Seat leakage tests conducted at 0.25, 0.5, 0.75, 1 x CWP	Measure seat leakage, cycle 5 times, measure valve torque
Shell and Seat tests as per EN 12266-1	External leak test: Cycle 5 times; measure effort (<360 N); stem/bonnet leakage (<50 ppm)
Inspecting after disassembly	Disassemble and inspect parts for damage/galling

Table 2: Extension length definition in standards