Design, Specifications and Future Challenges for Cryogenic Valves

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Valve Manufacturers Association of America 2017 Technical Seminar, Exhibits, and Tour
CRYOGENIC SPECIFICATIONS

Timeline

1984

BS 6364, Specification for Valves for cryogenic service

2006

MSS SP-134, Valves for Cryogenic Service, including Requirements for Body/Bonnet Extensions

2013

ISO 28921-1, Industrial valves - Isolating valves for low-temperature applications, Part 1, Design manufacturing and production testing
## CRYOGENIC SPECIFICATIONS

### Applications

<table>
<thead>
<tr>
<th></th>
<th>BS 6364</th>
<th>MSS SP-134</th>
<th>ISO 28921-1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parent Standard</strong></td>
<td>British Standards</td>
<td>ASME B16.34, API Specs, as agreed</td>
<td>ISO standards, as agreed</td>
</tr>
<tr>
<td><strong>Minimum Temp., °F</strong></td>
<td>-320</td>
<td>-425</td>
<td>-320</td>
</tr>
<tr>
<td><strong>NPS</strong></td>
<td>$\frac{1}{2}$ - Parent Standard Limit</td>
<td>$\frac{1}{2}$ - Parent Standard Limit</td>
<td>$\frac{3}{8}$ - 36</td>
</tr>
<tr>
<td><strong>Max. Pressure Class</strong></td>
<td>600</td>
<td>1500</td>
<td>1500</td>
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</tbody>
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CRYOGENIC SPECIFICATIONS

Materials

Valve Body
- BS 6364
  - 300 Series Stainless Steel; Aluminum and Copper Alloys
  - MSS SP-134 and ISO 28921-1
    - Listed in ASME B16.34 and ASME B31.3 (adds Nickel Alloys)

Valve Trim
- Ball - PCTFE seats, Ball same as body
- Gate/Globe/Check - API Trim 12 (316 SS Half Hardfaced)
  - API Trim 16 (316 SS Full Hardfaced)
- Triple Offset Butterfly - 316 SS Disc, Solid Seal Ring

Valve Packing - Graphite
CRYOGENIC SPECIFICATIONS

Extended Bonnets

- Extends valve packing and operator away from cryogenic fluid
- Allows operation in normal working temperature range
- Cast, forged or fabricated with seamless tube
- Minimum extension lengths for non-Cold box/Cold box applications based on valve type, NPS, and temperature (design to worst case)
- ASME B16.34 wall thicknesses
- Stem Design (prevent buckling)
  - MSS SP-134 provides guidance on calculations for stem design
  - ISO 28921-1 requires one stem guide and allows for another
- Minimize clearance between stem OD and extension ID
- Drip plate - prevent condensation from contacting insulation
CRYOGENIC SPECIFICATIONS

Cavity Relief

Gate Valve

Hole in wedge or seat venting to high pressure side (Unidirectional)
CRYOGENIC SPECIFICATIONS

Cavity Relief

Floating Ball Valve

- Hole in ball/seat retainer venting to high pressure side (Unidirectional)
- Self relieving through seats (Bi-directional)
CRYOGENIC SPECIFICATIONS

Cavity Relief

Trunnion Ball Valve

• (2) Single Piston Effect Seats - Vents to low pressure side (Bi-directional)
• (1) Single / (1) Double Piston Effect Seat - Vents through single piston effect seat (Unidirectional)
• (2) Double Piston Effect Seats - External pressure relief (Bi-directional)
CRYOGENIC SPECIFICATIONS

Marking

Typical valve markings *PLUS*

- Valve minimum temperature
- Flow arrow
CRYOGENIC SPECIFICATIONS

Production Testing

• Previously specified by Purchaser → Now minimum sample size required
• Shell and seat testing at room temperature
• System proving test at room temperature
• Cool down with purge gas
• Cycle valve
• Low pressure seat test
• High pressure seat test
• Cycle valve
• External test
• Warm up
FUTURE CHALLENGES

Demand’s Impact on Design

• Higher pressures
  • History has shown that LNG facilities have grown in size resulting in higher pressures

• Larger sizes
  • Sizes continue to increase
  • Availability of large diameter valves
REAL LIFE EXPERIENCES

Installation Issues

Cavity Relief - P&ID
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Installation Issues

Cavity Relief - Operation
REAL LIFE EXPERIENCES

Installation Issues

Cavity Relief - Maintenance
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Installation Issues

Preferred Flow - P&ID
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Installation Issues

Preferred Flow - Operation
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Installation Issues

Preferred Flow - Maintenance
REAL LIFE EXPERIENCES

Valve Issues

• Fortunately no catastrophic failures such as valve casting ruptures
• Leaking valves during production testing (especially modified valves)
• Improper storage
• External debris entering valve body
• Installation - Welded valves
• Dimensional variations
• Operating torque too high
REAL LIFE EXPERIENCES

Valve Issues

Seat/Seal Operational Failure
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Valve Issues

Stem Operational Failure
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Prevention

• Water is not your friend (Avoid, pneumatic test in lieu of hydrotest, other fluids)
• Avoid modifying standard valves to cryogenic valves
• Review non metallic seats/seals closely
• Be aware of changes to service fluid. Changes upstream to feed can impact your facility.