BIDIRECTIONALITY IN CRYOGENIC BALL VALVES

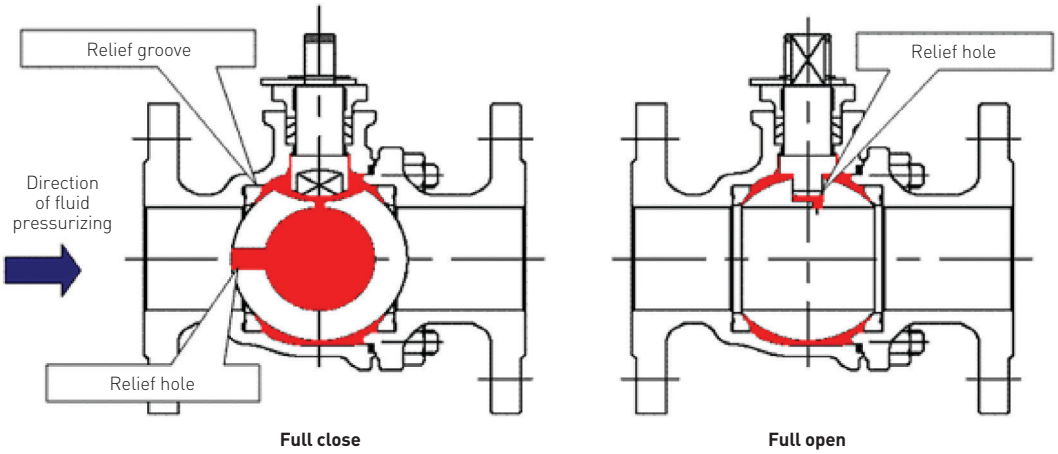
UNDERSTANDING APPLICABLE STANDARDS FOR SAFER SOLUTIONS

Introduction

There is often confusion when the term bidirectional is applied to cryogenic ball valves for liquefied hydrocarbon gases in cryogenic service. There are some vendors that even claim a ball valve with a cavity vent hole in the body or closure element is bidirectional. It is important to understand the difference between a bidirectional and unidirectional cryogenic ball valve and what process safety risks need to be accounted for with various designs that include a trapped cavity and handle fluid that can expand 625X.

A good starting point is with API 6D to better understand the definitions related to unidirectional and bidirectional valves in one of the most referenced design codes.

FIGURE 1
Ball valve with cavity vent hole



Full close **Full open**

API 6D Definitions
Section 3.1.3, Bidirectional Valve: Valve designed for blocking the fluid in both downstream and upstream directions.

Section 3.1.12, Downstream: Side of the valve where there would be no pressure or lower pressure.
Note 1: where the valve is bidirectional, this reference may change side.

Section 3.1.45, Unidirectional Valve: Valve designed for blocking the flow in one direction only.

Therefore, according to API 6D a bidirectional valve is one that can block fluids in both directions and it is noted that the reference of what is upstream and downstream may change. In other words, the functionality of the valve must be the same from both sides.
See Figure 1.

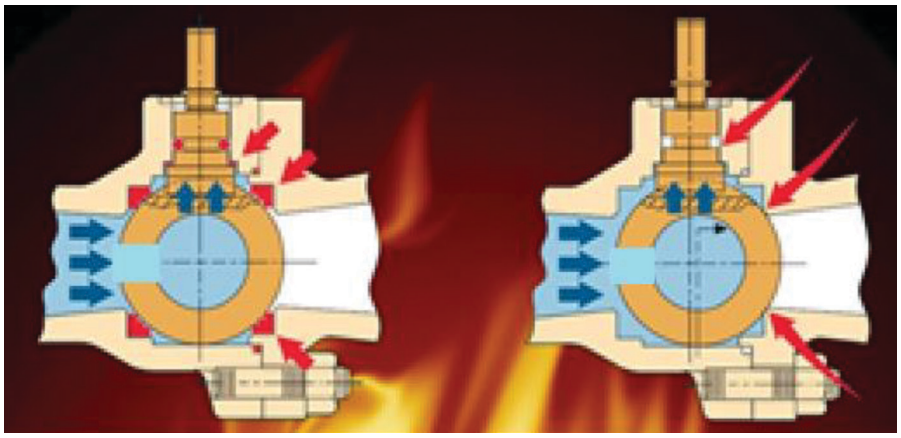
This is an important note because it takes account of the fact that even in the unlikely scenario where a ball valve with a hole in the body or closure element connecting the ball cavity to the upstream could block flow in the reverse direction the functionality is not the same. The valve is not fire safe in the reverse direction.
See Figure 2.

For this reason, API 607 requires non-symmetric valves to define and mark the HP side. This is the direction the valve has been tested for fire safety. A ball valve with a hole on one side to vent the cavity is non-symmetric. Obviously, a valve with a hole through the closure element or body going upstream cannot be fire safe when flowing towards the vent hole. Therefore, the cryogenic ball valve with the vent hole is a unidirectional ball valve as it is designed to block flow from one direction only.
See Figure 3.

ISO 28921-1
ISO28921-1, Design Code for Isolating Valves for Low Temperature Applications states clearly in 4.2.6.4 ;
Double seated valves with a pressure relieving feature, such as a hole through the body or the closure member, are unidirectional and the sealing direction must be clearly marked on the valve in accordance with clause 7 (marking, labelling and packaging).
This is in accordance with code and common sense. A valve with a vent hole on one side of the ball cavity cannot be bidirectional and especially not in a hydrocarbon application requiring fire safety.

FIGURE 2
API 607 fire test

FIGURE 3
Clearly reverse direction not fire safe with vent hole



A: Valve closed and seals intact

B: Valve is closed, seals completely dissipated

Process Safety Risk for Valves with a Vent Hole

Theoretically there is low process safety risk with a valve with a hole for pressure relief if it is recognized to be unidirectional and the valve is installed in the correct direction for venting and fire safety. However, it is frequently found in the field that valves are installed in the wrong direction. There is also risk with a unidirectional ball valve that the operator does not understand the correct functionality of the valve for safe operation.

Self-Relieving Seats

Valves utilizing self-relieving seats can be bidirectional although the venting direction must be marked. These valves also have risk if not installed in the correct direction or operators misunderstand the functionality for safe operation.
See Figure 4.

The greater risk for cryogenic ball valves utilizing self-relieving seats is the gap in API 6D where there is no method defined in a code for validating functionality of the relieving function. API 6D Appendix H.8 defines a procedure for cavity relief testing with water at ambient temperature. However, this procedure does not validate self-relieving functionality for a liquefied gas at cryogenic temperature that can expand 625X.
See Figure 5.

Similarly, low temperature and cryogenic valve design codes BS 6364 and ISO 28921-1 reference self-relieving seats for cryogenic service but neither code offers an appendix procedure for design validation testing. This gap in existing standards gives rise to uncertainty as to how an operator can validate whether conventional ball valves can relieve at the correct pressure, in the correct direction and at sufficient capacity.

Solution

In response to the need for safe and reliable bidirectional cryogenic ball valves, manufacturers have developed torque sealing, single seat "C" ball valves. These ball valves are cavity free, eliminating all cavity expansion risks and are inherently bidirectional.
See Figure 6.

Emerson's AEV™ ²XC™ Cryogenic C-Ball Valve has undergone Design Validation Testing at a 3rd party laboratory witnessed by Shell Global Solutions, proving the ability to block fluid flow from upstream or downstream with no vent direction. Safety is assured with firesafe operation tested in both directions. The AEV ²XC is the state-of-the-art, 3rd party validated and field proven solution for performance, reliability and safe bidirectional isolation of liquefied hydrocarbons at cryogenic temperatures.
See Figure 7.

FIGURE 4
Self-relieving seat trunnion ball valve

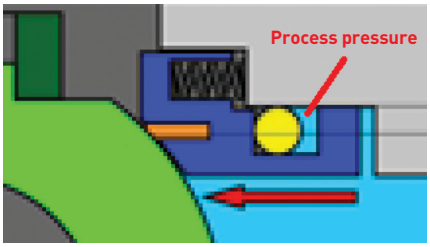


FIGURE 5
LNG vs natural gas volume

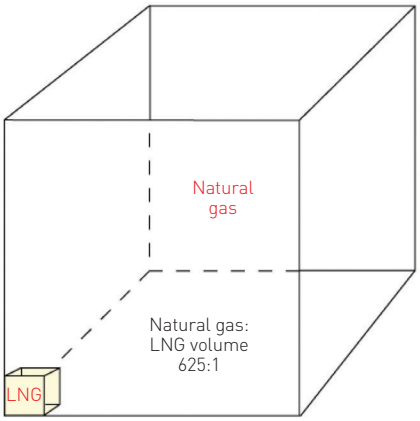
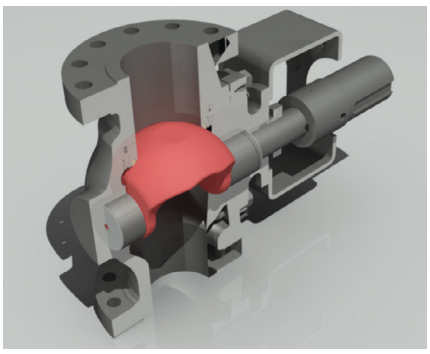


FIGURE 6
Cavity free, inherently safe and bidirectional



Emerson is a leading manufacturer of critical service valves for the Oil and Gas, Petrochemical, Polymer, Refining and Aerospace Industries. Specializing in severe service zero leakage switching valves, cryogenics, high temperatures, high pressures, ESD and HIPPS valves, Emerson's AEV valves can be found anywhere there are extreme conditions.

Designed to
API 6D • ASME B16.34 • EN ISO 10497 • Shell SPE 77/300 • API 608 • BS 6364 • ISO 15848-1 • API 607 • ASME B16.10 • ISO 28921-1

FIGURE 7
AEV ²XC C-Ball Valve after bidirectional cryogenic testing

FIGURE 8
Emerson's AEV facility in Belgium

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