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Cryogenic vessels — Valves for cryogenic service

Récipients cryogéniques — Robinets pour usage cryogénique

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 21011 was prepared by Technical Committee ISO/TC 220, *Cryogenic vessels*.

Cryogenic vessels — Valves for cryogenic service

1 Scope

This International Standard specifies the requirements for the design, manufacture and testing of valves for a rated temperature of –40 °C and below (cryogenic service), i.e. for operation with cryogenic fluids in addition to operation at temperatures from ambient to cryogenic.

It applies to all types of cryogenic valves, including vacuum jacketed cryogenic valves up to size DN 150.

This International Standard is not applicable to pressure relief valves covered by ISO 21013-1.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5208, *Industrial valves — Pressure testing of valves*

ISO 10434, *Bolted bonnet steel gate valves for the petroleum, petrochemical and allied industries*

ISO 11114-1, *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 1: Metallic materials*

ISO 11114-2, *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 2: Non-metallic materials*

ISO 15761, *Steel gate, globe and check valves for sizes DN 100 and smaller, for the petroleum and natural gas industries*

ISO 17292, *Metal ball valves for petroleum, petrochemical and allied industries*

ISO 21010, *Cryogenic vessels — Gas/materials compatibility*

ISO 21028-1, *Cryogenic vessels — Toughness requirements for materials at cryogenic temperature — Part 1: Temperatures below –80 degrees C*

ISO 21028-2, *Cryogenic vessels — Toughness requirements for materials at cryogenic temperature — Part 2: Temperatures between –80 degrees C and –20 degrees C*

ISO 23208, *Cryogenic vessels — Cleanliness for cryogenic service*

ASME B16.34, *Valves — Flanged, threaded, and welding end*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
nominal size
DN
alphanumeric designation of size for components of a pipe work system, which is used for reference purposes.

NOTE 1 It comprises the letters "DN" followed by a dimensionless whole number which is indirectly related to the physical size, in millimetres, of the bore or outside diameter of the end connections.

NOTE 2 Adapted from ISO 6708:1995.

3.2
rated pressure
PR
maximum pressure difference between the inside and outside of any pressure retaining boundary for which the boundary is designed to be operated at 20 °C

NOTE The PR of the valve is the lowest PR of any component of the valve.

3.3
rated minimum temperature
lowest temperature for which the valve is rated by the manufacturer

3.4
valve category A
valve type which passed the operation simulation test for 2 000 cycles during type approval testing

NOTE See 5.1.3.3.

3.5
valve category B
valve type which passed the operation simulation test for 100 cycles during type approval testing

NOTE See 5.1.3.3.

3.6
flow coefficient
basic coefficient used to state the flow capacity of a valve under specified conditions

NOTE 1 Flow coefficients in current use are K_v and C_v depending upon the system of units.

NOTE 2 Even though the dimensions and units used with flow coefficient K_v differ from those used with flow coefficient C_v, it is possible to relate the two flow coefficients numerically by means of the relationship $\frac{K_v}{C_v} = 0{,}865$.

NOTE 3 The flow coefficient definitions given in 3.6.1 (for K_v) and in 3.6.2 (for C_v) include certain units, nomenclature and temperature values which are not consistent with the parts of IEC 60534 other than IEC 60534-1. These inconsistencies are limited to 3.6.1 and 3.6.2 of this International Standard, and their sole purpose is to illustrate the unique relationships traditionally used in the valve industry. These inconsistencies do not concern any parts of IEC 60534 other than IEC 60534-1.

3.6.1
flow coefficient K_v

K_v

special volumetric flow rate calculated in cubic metres per hour (capacity) through a valve, where the static pressure loss across the valve is 0,1 MPa (1 bar)[1)], and the fluid is water within a temperature range 5 °C to 40 °C (278 K to 313 K)

NOTE The value of K_v can be obtained from test results by means of the following equation:

$$K_v = Q\sqrt{\left(\frac{\Delta p_{K_v}}{\Delta p}\right)\left(\frac{\rho}{\rho_w}\right)}$$

where

Q is the measured volumetric flow rate, in m^3/h;

Δp_{K_v} is the static pressure loss of 0,1 MPa (1 bar);

Δp is the measured static pressure loss across the valve, in MPa (bar);

ρ is the density of the fluid, in kg/m^3;

ρ_w is the density of water, in kg/m^3 (1 000 kg/m^3).

This equation is valid when the flow is turbulent and no cavitation or flashing occurs.

3.6.2
flow coefficient C_v

C_v

non-SI valve coefficient which is in widespread use worldwide

NOTE Numerically, C_v is represented as the number of US gallons of water, within a temperature range of 40 °F to 100 °F, that will flow through a valve in 1 min when a pressure drop of 6 894,76 Pa (1 psi)[2)] occurs. For conditions other than these, C_v can be obtained using the following equation:

$$C_v = Q\sqrt{\left(\frac{\Delta p_{C_v}}{\Delta p}\right)\left(\frac{\rho}{\rho_w}\right)}$$

where

Q is the measured volumetric flow rate, in US gallons per minute[3)];

ρ is the density of the fluid, in pounds per cubic foot[4)];

ρ_w is the density of water within a temperature range of 4 °C to 38 °C (40 °F to 100 °F), in pounds per cubic foot;

Δp is the measurement state pressure loss across the valve, in psi;

$\Delta p_{C_v} = 1 \text{psi}$.

This equation is valid when the flow is turbulent and no cavitation or flashing occurs.

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1) 1 bar = 0,1 MPa.

2) 1 psi = 0,068 948 bar = 6 894,76 Pa.

3) 1 gal (US)/min = 309 x 10^{-5} m^3/s.

4) 1 lb/ft^3 = 16,018 kg/m^3.

3.7
bonnet
cylindrical part connecting the valve body to the seal packing chamber

4 Requirements

4.1 Materials

4.1.1 General

Materials shall be in conformance with an internationally recognized standard and compatible with the fluid. Galling, frictional heating and galvanic corrosion shall be considered in the selection of materials. Materials shall also be oxygen compatible, if relevant (see 4.1.5.1).

Materials not listed in an internationally recognized standard shall be controlled by the manufacturer of the valve by a specification ensuring control of chemical content and physical properties, and ensuring quality at least equivalent to an internally recognized standard. A test certificate providing the chemical content and physical property test results shall be provided with the valve.

4.1.2 Metallic materials

Metallic materials to be used in the construction of cryogenic valves shall meet the requirements of ISO 21028-1 or ISO 21028-2 as appropriate for the rated minimum temperature.

These requirements apply only to the valve parts exposed to low temperatures in normal service. Metallic materials which do not exhibit ductile/brittle transition and non ferrous materials which can be shown to have no ductile/brittle transition do not require additional impact tests.

Forged, rolled, wrought and fabricated valve components from raw materials from these processes need not be impact tested if the rated minimum temperature is higher than the ductile/brittle transition range temperatures of the material. Castings meeting the requirements of one of the applicable mandatory Appendices I and IV or II and III of ASME B16.34 for forgings and rolled or wrought material, or conforming to equivalent standards, need not be impact tested if the rated minimum temperature is higher than the ductile/brittle transition range temperatures of the material. When impact testing is required, at least one randomly selected valve body (including bonnet, if applicable) material from each production lot castings shall be impact tested at the rated minimum temperature.

4.1.3 Non-metallic materials

Non-metallic materials are well established only for use in packing and glands and for use for inserts within the plug/stem assembly to provide leak tightness across the seat when the valve is closed. If such materials are to be used for structural parts, they shall have the properties appropriate to the application and conform to ISO 21028-1 or ISO 21028-2, as appropriate to the rated minimum temperature.

Non-metallic materials shall also:

- have mechanical properties that will allow the valve to pass the type approval test for category A valves defined in 5.1.3.3;
- be resistant to sunlight, weather and ageing.

4.1.4 Corrosion resistance

In addition to resistance to normal atmospheric corrosion, particular care shall be taken to ensure that the valve cannot be rendered inoperative by accumulation of corrosion products. Some copper alloys are susceptible to stress corrosion cracking; consequently, careful consideration shall be given before selection of these materials for components under stress.

4.1.5 Gas material compatibility

4.1.5.1 Oxygen

If the rated minimum temperature is equal to or less than the boiling point of air, or if the valve is intended for service with oxygen or oxidizing products, the materials in contact with liquid air or oxidizing products shall be oxygen compatible, in accordance with ISO 21010.

4.1.5.2 Hydrogen

For hydrogen service, see ISO 11114-1 and ISO 11114-2.

4.1.5.3 Acetylene

Metallic materials shall contain less than 70 % copper if specified for use with mixtures containing acetylene.

4.2 Design

4.2.1 General

The valves shall fulfil their function in a safe manner within the temperature range from +65 °C to their rated minimum temperature and the pressure range intended for use.

Minimum wall thickness values for valve bodies shall be from the appropriate valve standards ISO 10434, ISO 15761, ISO 17292 and ASME B16.34. Bonnet thickness of extended bonnet (extended stem) valves are exempted from meeting the minimum wall thickness requirements of these standards. These standards may be used as informative references for design not specifically covered in this International Standard.

4.2.2 Packing gland

Valves can have an extended stem and/or an extended bonnet. The length of the extension shall be sufficient to maintain the stem packing at a temperature high enough to permit operation within the normal temperature range of the packing material.

Valves without an extended stem and/or an extended bonnet shall have a stem packing capable of operating at the specified minimum temperature. The handle shall be designed to remain operable for the duration of the sample valve test, in accordance with Clause 5.

Gland designs incorporating a gland nut with a male or female thread shall be designed in such a way that they will not loosen unintentionally, e.g. when the valve is operated.

4.2.3 Operating positions

Unless otherwise specified by the valve manufacturer, valves with extended stem and/or an extended bonnet shall be capable of normal operation in the liquid service with the valve stem at any position from the vertical to 25° above the horizontal. Loads imposed by actuators shall also be considered.

4.2.4 Cavities

4.2.4.1 Trapped liquid

Cavities where liquid can be trapped and build up detrimental pressures due to evaporation of the liquid during warming up of the valve are not permitted.

NOTE For ball and gate valves, this requirement can be met by the provision of a pressure relief hole or passage or other means, e.g. pressure relieving seats, to relieve pressure in the bonnet and body cavities.