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Cryogenic vessels – — Valves for cryogenic service

Récipients cryogéniques– — Robinets pour usage cryogénique

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see ~~www.iso.org/directives).~~ www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see ~~www.iso.org/patents).~~ www.iso.org/patents).

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This document was prepared by Technical Committee ISO/TC 220, *Cryogenic vessels*~~.~~, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 268, *Cryogenic vessels*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 21011:2008), which has been technically revised.

The main changes ~~compared to the previous edition~~ are as follows:

— Update of the Scope to change upper end of size from DN 150 to DN 200;

— Clarification of the use of pressure units;

— Revision of the type approval tests;

— Revision of ~~Clause 7,~~Clause 7, “Marking”.

— Revised formula in ~~Annex A~~Annex A to take into account atmospheric pressure in dead volume at initial condition.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Field Code Changed

Cryogenic vessels ~~–~~ — Valves for cryogenic service

1 Scope

This document 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.

This document is applicable to all types of cryogenic valves, including vacuum jacketed cryogenic valves up to size DN 200.

This document can be used as guidance for larger size valves.

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

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 metallic valves*

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

ISO 10497, *Testing of valves — Fire type-testing requirements*

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/material 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.

ISO and IEC maintain ~~terminological~~terminology databases for use in standardization at the following addresses:

— ~~—~~ISO Online browsing platform: available at ~~https://www.iso.org/obp~~https://www.iso.org/obp

— ~~—~~IEC Electropedia: available at ~~http://www.electropedia.org/~~https://www.electropedia.org/

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

Note 1 to entry: It comprises the letters “DN” or “NPS” followed by a dimensionless whole number or fractional number which is indirectly related to the physical size of the bore or outside diameter of the end connections.

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 1 to entry: The PR of the valve is the lowest PR of any component of the valve.

3.3
PN
Class
numerical designation relating to pressure that is a convenient rounded number for reference purposes, and which comprises the letters “PN” or “Class” followed by the appropriate reference number

Note 1 to entry: ~~It is desirable that~~ All equipment of the same nominal size (DN or NPS) designated by the same PN or Class number ~~has~~should have compatible mating dimensions.

Note 2 to entry: Tables of pressure/temperature ratings in the appropriate standards provide guidance on the maximum allowable pressure subject to materials, design and working temperature.

3.4
rated minimum temperature
lowest temperature for which the valve is rated by the manufacturer

3.5
valve category A
valves intended to be operated with normal frequency (above 20 cycles a year)

Note 1 to entry: See ~~5.1.3.3.~~5.1.3.3.

3.6
valve category B
valves intended to be operated only occasionally, i.e. with a frequency less than or equal to 20 cycles a year

Note 1 to entry: See ~~5.1.3.3.~~5.1.3.3.

3.7
flow coefficient
basic coefficient used to state the flow capacity of a valve under specified conditions

Note 1 to entry: Flow coefficients in current use are K_v and C_v depending upon the system of units.

Note 2 to entry: 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 following relationship~~.~~:

$$K_v = 0{,}865\ C_v$$

Note 3 to entry: The flow coefficient definitions given in ~~3.7.1~~3.7.1 (for K_v) and in ~~3.7.2~~3.7.2 (for C_v) include certain units, nomenclature and temperature values which are not consistent with IEC 60534-1. These inconsistencies are limited to ~~3.7.1 and 3.7.2~~3.7.1 and 3.7.2 of this document, 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.

3.7.1
flow coefficient
***K*v**

special volumetric flow rate calculated in cubic metres per hour (capacity) through a valve, with the valve 100 % fully open, where the static pressure loss across the valve is 1 bar (0,1 MPa)[1], and the fluid is water within a temperature range 5 °C to 40 °C (278 K to 313 K)

Note 1 to entry: The value of *Kv* can be obtained from test results by means of the following formula:

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

where

Q	is the measured volumetric flow rate, in m³/h;
Δp_{K_v}	is the static pressure loss of 1 bar (0,1 MPa);
Δp	is the measured static pressure loss across the valve, in bar (MPa);
ρ	is the density of the fluid, in kg/m³;
~~ρ_W~~ ρ_w	is the density of water, in kg/m³ (1 000 kg/m³).

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

3.7.2
flow coefficient
***C*v**

non-SI valve coefficient ~~which~~

Note 1 to entry: It is in widespread use worldwide.

Note ~~1~~ 2 to entry: 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, with the valve 100 % fully open, when a pressure drop of 0,068 948 bar (0,006 894 8 MPa)[1] occurs. For conditions other than these, C_v can be obtained using the following formula:

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

where

~~Q~~ Q	is the measured volumetric flow rate, in US gallons per minute~~[2]~~ (1 gal (US)/min = 309 x 10-5 m³/s) ;
~~ρ~~ ρ	is the density of the fluid, in pounds per cubic foot~~[3];~~ (1 lb/ft³ = 16,018 kg/m³);

[1] 1 psi = 0,068 948 bar = 0,006 894 8 MPa.
~~[2] 1 gal (US)/min = 309 x 10-5 m³/s.~~
~~[3] 1 lb/ft³ = 16,018 kg/m³.~~

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

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

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

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

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

3.8
bonnet
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 (see Annex C) 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).~~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 toughness 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 shall 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, shall 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~~components of valves, 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 specified in ~~5.1.3.3~~;5.1.3.3;

~~— — be resistant to sunlight, weather and ageing.~~

— ~~—~~be oxygen compatible~~,~~ (if applicable, see ~~4.1.5.1.~~4.1.5.1).

4.1.4 Corrosion resistance

Valve materials shall be resistant to or protected from normal atmospheric corrosion and to the medium that the valve will be exposed to. 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. Careful consideration shall be given to the leak detection fluid that is used for leak checking copper alloys to ensure that the fluid does not cause stress corrosion cracking in copper alloys (e.g. ASTM G186). Susceptibility to intergranular corrosion of austenitic materials or grain boundary attack of nickel-base alloys are among other items requiring attention.

~~nickel-base alloys are among other items requiring attention.~~ NOTE A discussion of precautionary considerations can be found in ASME B31.3:2020, Appendix F; ASME BPVC:2021, Section II, Part D, Nonmandatory Appendix A; and ASME BPVC:2021, Section III, Division 1, Nonmandatory Appendix W.

4.1.5 Gas material compatibility

4.1.5.1 Oxygen compatibility

If the rated minimum temperature is equal to or less than the boiling point of air (approximately – 190 °C at atmospheric pressure), 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 (also called Ethyne)

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

4.1.5.4 Liquefied natural gas (LNG)

The valve shall be designed to take into account the thermal stresses in transient state occurring during the cool down operation.

NOTE Thermal stresses in transient state present the following characteristics:

— ~~—~~They are often much larger than static pressure stresses;

— ~~—~~They increase with an increase in thickness of the valve body.

The valve design shall take into account the effect of thermal stresses during the transient state.

The optional thermal shock test specified in ~~Annex B~~Annex B may be performed on agreement with purchaser/customer. If the optional thermal shock test is performed, the valve design with respect to thermal stresses in transient state shall be accepted provided that the valve passes the thermal shock test.

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. Valves shall be designed to satisfy a pressure rating PR, PN, or Class. Valves shall be selected with a PR (PN or Class) equal to or greater than the maximum allowable pressure (PS) of the equipment with which it is to be used.

Minimum wall thickness values for valve bodies shall be from the appropriate valve standards: ISO 10434, ISO 15761, ISO 17292 or ASME B16.34. Alternatively, the minimum wall thickness may be determined using recognized calculation methods (e.g. EN 16668, AD2000 Merkblatt, or ASME B31.3) for calculating the minimum shell thickness of an equivalent diameter pipe. 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 document.

4.2.2 Packing gland

Valves can have either an extended stem and/or an extended bonnet, or both. 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 either an extended stem and/or an extended bonnet, or both, 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.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 either an extended stem and/or an extended bonnet, or both, shall be capable of normal operation in the liquid service with the valve stem at any position from the vertical to 35° 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.

4.2.4.2 Debris

Cavities susceptible to trapping debris shall be avoided.

4.2.5 Valve bonnet

Valve bonnets may be brazed, welded, bolted, screwed or union type. Union nuts shall be locked to the body. Union type bonnets shall not be used on valves greater than DN 80. Screwed bonnets shall also be secured by a union nut or another device offering equivalent safety. For union bonnet and bolted bonnet valves, the valve manufacturer shall calculate, apply, and indicate the torque value to guarantee the proper sealing of the bonnet gasket.

4.2.6 Securing of gland extension

For bronze or copper alloy valves whose PR is greater than or equal to 100 bar (10 MPa), the gland (bonnet) extensions shall be mechanically secured in the bonnet prior to brazing (e.g. by screwing).

4.2.7 Seat

Valves may have metal/metal or metal/soft seat or insert. Soft seats shall be backed by a secondary metal seat. Soft seat materials shall be adequately supported to prevent cold flow of the seat material.

~~Plugs and/~~Either plugs or soft seats, or both, shall be mechanically secured and locked (e.g. lock tight, tack welded, peening, pinning).

4.2.8 Stem securement

The valve stem shall be secured so that it cannot be blown out of the body in the event of the gland being removed while the valve is under pressure.

4.2.9 Torque

The maximum torque to operate the valves manually under service conditions, when applied at the rim of the hand wheel or lever, shall not exceed 350 × R Nm, except for valve seating and unseating, when it shall not exceed 500 × R Nm. For a hand wheel, R is the radius of the wheel, in metres. For a lever, R is the length of the lever, in metres, minus 0,05 m.

The valve shall be robust enough to withstand 1 000 × R Nm or equivalent in linear force as specified above without damage. A lower value is permitted if there is a limiting torque or stroke device.

Valves intended for actuator operation may have torque or linear force requirements deviating from the above. The sample valve tests shall then be performed using a proper actuator to operate the valve.

4.2.10 Electric continuity and explosion proofness

For valves in oxidising or flammable fluids service, the maximum electrical resistance shall not exceed 1 000 Ω with no more than 28 V d.c. between the ports, in order to ensure electrical continuity to prevent build-up of static electricity.

Any equipment attached to, or associated with, a valve shall be suitable for the stated hazard zone.

4.2.11 Fire resistance

At the request of the purchaser, a fire test shall be carried out in accordance with ISO 10497.

5 Testing

5.1 Type approval

5.1.1 Verification of the design

Valves shall be tested to satisfy a pressure rating PR, PN, or Class. One sample valve shall be tested. It shall be representative of the valves to be produced. If a range of valves of identical design but with different size is to be tested, one sample of the smallest and one sample of the largest shall be tested. The sample valve shall pass the tests as described in ~~5.1.3.~~5.1.3.

The sample valve shall be inspected to ensure that the design satisfies the requirements of ~~Clause 4.~~Clause 4.

5.1.2 Model number

A unique model number shall be assigned to the valve which passes the type approval requirements.

