BS ISO 28921-1:2013

BSI Standards Publication

Industrial valves — Isolating valves for low-temperature applications

Part 1: Design, manufacturing and production testing

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National foreword

This British Standard is the UK implementation of ISO 28921-1:2013.

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A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Part 1: **Design, manufacturing and production testing**

Robinetterie industrielle — Robinets d'isolement pour application à basses températures —

Partie 1: Conception, essais de fabrication et de production

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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 28921-1 was prepared by Technical Committee ISO/TC 153, *Valves*, Subcommittee SC 1, *Design, manufacture, marking and testing*.

ISO 28921 consists of the following parts, under the general title *Industrial valves — Isolating valves for low-temperature applications*:

— *Part 1: Design, manufacturing and production testing*

— *Part 2: Type testing*

Introduction

The purpose of this part of ISO 28921 is the establishment of basic requirements and practices for design, fabrication, material selection and production testing of valves used in low-temperature services. The intention is to provide requirements for design, material selection and valve preparation for valves to be used in low-temperature service.

Industrial valves — Isolating valves for low-temperature applications —

Part 1: **Design, manufacturing and production testing**

1 Scope

This part of ISO 28921 specifies requirements for design, dimensions, material, fabrication and production testing of isolation valves for low-temperature applications.

It applies to gate, globe, check, butterfly and ball valves and can be used for other valve types used in low-temperature services.

This part of ISO 28921 covers isolation valves for use in cryogenic temperature service where the design low-temperature service is –50 °C down to –196 °C.

This part of ISO 28921 does not apply to valves for cryogenic services, designed in accordance with ISO 21011, used with cryogenic vessels.

Where the requirements of this part of ISO 28921 vary from those given in the valve product standards, the requirements of this part of ISO 28921 apply.

This part of ISO 28921 covers valves with body, bonnet, bonnet extension or cover made of metallic materials.

It covers valves of nominal sizes DN: 10; 15; 20; 25; 32; 40; 50; 65; 80; 100; 125; 150; 200; 250; 300; 350; 400; 450; 500; 600; 650; 700; 750; 800; 850; 900,

corresponding to nominal pipe sizes NPS: 3/8; 1/2; 3/4; 1; 11/4; 11/2; 2; 21/2; 3; 4; 5; 6; 8; 10; 12; 14; 16; 18; 20; 24; 26; 28; 30; 32; 34; 36,

and applies to pressure designations:

— PN 16; 25; 40; 100; 160; 250.

— Class 150; 300; 600; 800; 900; 1 500.

NOTE PN 250 and Class 1 500 in sizes DN > 100 and NPS > 4 are not covered in this part of ISO 28921.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable to its application. 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 5209, *General purpose industrial valves — Marking*

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

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

ISO 10631, *Metallic butterfly valves for general purposes*

ISO 14313, *Petroleum and natural gas industries — Pipeline transportation systems — Pipeline valves*

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*

EN 12516-1, *Industrial valves — Shell design strength — Part 1: Tabulation method for steel valve shells*

EN 12516-2, *Industrial valves — Shell design strength — Part 2: Calculation method for steel valve shells*

EN 12516-3, *Valves — Shell design strength — Part 3: Experimental method*

EN 1515-1, *Flanges and their joints — Bolting — Part 1: Selection of bolting*

EN 13480-2, *Metallic industrial piping – Part 2: Materials*

API 607, *Fire Test for Quarter-turn Valves and Valves Equipped with Nonmetallic Seats*

API 6FA, *Specification for Fire Test for Valves*

ANSI/ASME B16.34, *Valves Flanged, Threaded and Welding End*

ASME B31.3, *Process Piping*

ASME, *ASME Boiler and Pressure Vessel Code, Section VIII*

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 pipework system, which is used for reference purposes, comprising 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

[SOURCE: ISO 6708:1995, definition 2.1]

3.2
nominal pressure
PN
numerical designation relating to pressure that is a convenient rounded number for reference purposes, and which comprises the letters PN followed by the appropriate reference number

Note 1 to entry: It is intended that all equipment of the same nominal size (DN) designated by the same PN number shall have compatible mating dimensions.

Note 2 to entry: The maximum allowable pressure depends on materials, design and working temperature, and is to be selected from the tables of pressure/temperature ratings given in the appropriate standards.

[SOURCE: ISO 7268:1983, Clause 2, modified.]

3.3
NPS
alphanumeric designation of size for components of a pipework system, which is used for reference purposes, and which comprises the letters NPS followed by a dimensionless number indirectly related to the physical size of the bore or outside diameter of the end connections

Note 1 to entry: The number following the letters NPS does not represent a measurable value and is not intended to be used for calculation purposes except where specified in the relevant standard.

3.4
Class
alphanumeric designation used for reference purposes related to a combination of mechanical and dimensional characteristics of a component of a pipework system, which comprises the word "Class" followed by a dimensionless whole number

Note 1 to entry: The number following the word Class does not represent a measurable value and is not intended to be used for calculation purposes except where specified in the relevant standard.

3.5
cold box
enclosure that insulates equipment from the environment without the need for insulation of each individual component inside the enclosure

3.6
valve body or bonnet extension
extended valve body or bonnet extension that locates the operating mechanism and packing away from the cold media in the valve

Note 1 to entry: The body/bonnet extension allows the formation of a vapour barrier between the liquefied gas in the valve and the packing.

3.7
vapour column
portion of body/bonnet extension that allows for the formation of an insulating column of vapour

3.8
vapour column length for non-cold box application
distance between the bottom of the packing box and the top of the lower stem guide bushing or the beginning of the bonnet extension
See Figure 1.

3.9
length of bonnet extension for cold box applications
length measured from the centre-line of the valve flow passage up to the bottom of the packing chamber
See Figure 1.

3.10
cold working pressure
CWP
maximum fluid pressure assigned to a valve for operation at a fluid temperature of –20 °C to 38 °C

3.11
cryogenics
science of materials at low temperature

3.12
test gas
minimum 97 % pure helium or nitrogen mixed with 10 % helium

4 Requirements

4.1 Materials

4.1.1 General

Materials in contact with cold process fluid or exposed to low temperatures shall be suitable for use at the minimum design temperature specified by the purchase order. Galling, friction heating, galvanic corrosion and material compatibility with the fluid shall also be considered in the selection of materials.

4.1.2 Metallic materials

4.1.2.1 Pressure-retaining boundary

For material suitability at low temperature, use ASME B31-3 or EN 13480-2.

Body, bonnet, bonnet extension and cover, and other parts of the pressure retaining boundary, shall be selected from materials listed in ASME B16-34 or EN 12516-1 for Class-designated valves or EN 12516-1 for PN designated valves.

4.1.2.2 Bolting

Unless otherwise specified by the purchaser, bolting for assembling shell pressure-retaining components shall be selected from materials listed in ASME B16-34 for Class-designated valves or EN 1515-1 for PN-designated valves.

If low-strength bolting, such as non-strain hardened austenitic stainless steel, for example ISO 3506-1 grade A1-50 and A4-50 or ASTM A320 and ASTM A193 grade B8 Class 1 is being used, the design shall comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 or 2.

4.1.2.3 Internal metallic parts

Internal metallic parts, e.g. stem, wedge, disc, seats, back seat and guide bushings, shall be made of materials suitable for use at the entire design temperature range.

4.1.3 Internal non-metallic materials

Valve parts, e.g. packing, gasket, seatings and other non-metallic valve parts exposed to low temperature, shall be capable of functioning at the entire design temperature range.

4.2 Design

4.2.1 General

Unless otherwise specified in the purchase order, valves shall have a bonnet extension that protects the stem packing and valve operating mechanism from the low-temperature fluid that could otherwise damage or impair the function of these items.

This part of ISO 28921 shall be applied in conjunction with the specific requirements of a valve product standard, such as ISO 10434, ISO 10631, ISO 14313, ISO 15761 and ISO 17292 or other recognized standards, such as API, ASME or EN, based on an agreement between the purchaser and the manufacturer.

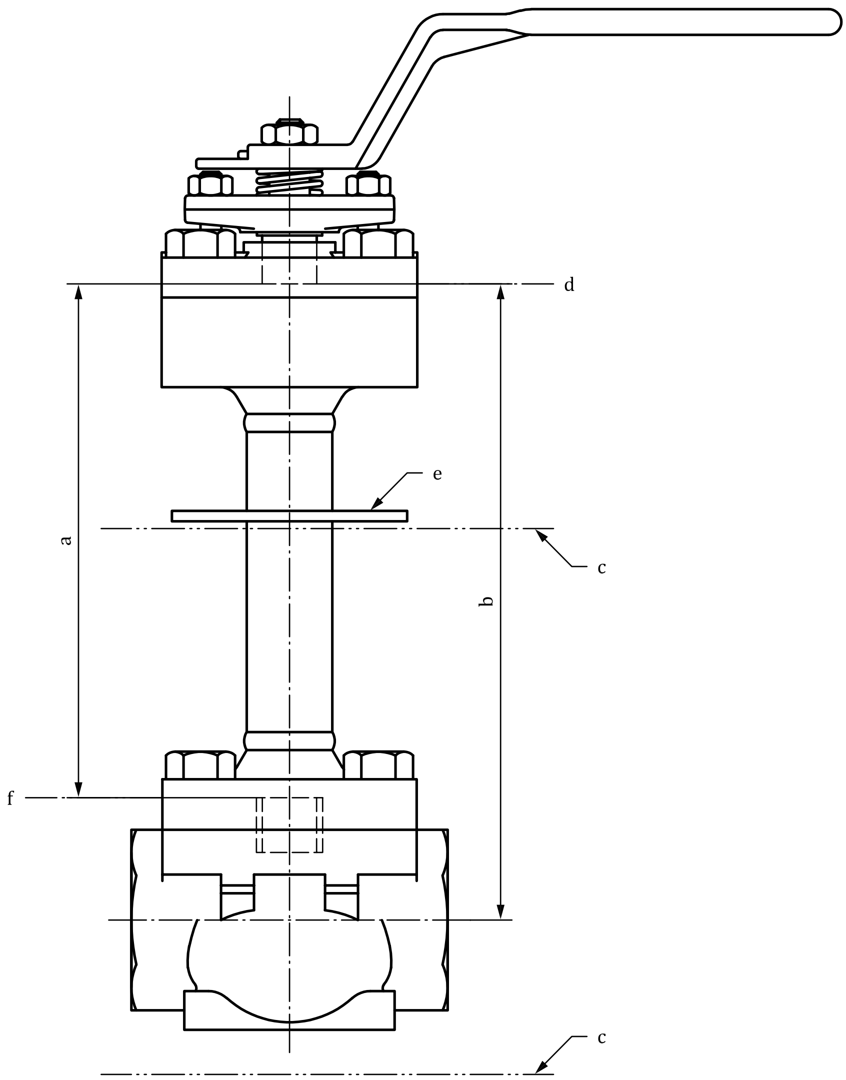
4.2.2 Body/bonnet wall thickness

The minimum valve body and bonnet wall thickness shall meet the requirements of ASME B16-34 or EN 12516-1 for Class-designated valves and EN 12516-1, EN 12516-2 or EN 12516-3 for PN designated valves. The pressure rating of the valve at or below service temperatures −50 °C shall not exceed the pressure rating at room temperature for the applicable valve body material and appropriate Class or PN designation.

4.2.3 Body and bonnet extension

4.2.3.1 The length of the extension shall be sufficient to maintain the stem packing at a temperature high enough to permit operation within the temperature range of the packing material.

4.2.3.2 The minimum vapour column length or bonnet extension shall be in accordance with Table 1 or Table 2 and Figure 1, unless otherwise specified in the purchase order.



a Minimum vapour column length for non-cold box application (see Table 1).

b Extension for cold box application (see Table 2).

c Outline of cold box enclosure.

d Bottom of the packing chamber.

e Optional drip plate.

f Top of stem guide or bonnet.

Figure 1 — Valve with extended bonnet

Table 1 — Minimum vapour column length for non-cold box extension

Valve size range DN	Minimum vapour column length mm				Valve size range NPS
	Minimum design temperature °C				
	minimum	maximum	minimum	maximum	
	–196	–110	–109	–51	
DN ≤ 25	200		100		NPS ≤ 1
32 ≤ DN ≤ 65	250		125		1 ¼ ≤ NPS ≤ 2 ½
80 ≤ DN ≤ 125	300		150		3 ≤ NPS ≤ 5
150 ≤ DN ≤ 200	350		175		6 ≤ NPS ≤ 8
250 ≤ DN ≤ 300	400		200		10 ≤ NPS ≤ 12
350 ≤ DN ≤ 400	450		250		14 ≤ NPS ≤ 16
450 ≤ DN ≤ 650	500		300		18 ≤ NPS ≤ 26
700 ≤ DN ≤ 850	600		400		28 ≤ NPS ≤ 34
DN 900	700		500		NPS 36

Table 2 — Minimum bonnet extension length for cold box applications

Valve size DN	Minimum bonnet extension length mm		Valve size NPS
	Rising stem valves[a]	Quarter-turn valves	
DN ≤ 25	450	400	NPS ≤ 1
32 ≤ DN ≤ 65	550	500	1 ¼ ≤ NPS ≤ 2 ½
80 ≤ DN ≤ 125	650	600	3 ≤ NPS ≤ 5
150	760	610	6
200	865	660	8
250	1 120	710	10
300	1 150	810	12
350	1 200	850	14
400	1 300	850	16
450	1 400	900	18
500	1 500	950	20
600	1 600	1 000	24
650	1 700	1 050	26
700	1 800	1 100	28
750	1 900	1 150	30
800	2 000	1 200	32
850	2 100	1 250	34
900	2 200	1 300	36

[a] For globe valves, bonnet extension is shown up to DN 300 – NPS 12 only.

4.2.3.3 In case of a bonnet extension made of material having lower pressure/temperature rating than the body, then the extension thickness shall be increased proportionally to meet the pressure/temperature rating of the body at all applicable temperatures. The minimum wall thickness shall be in accordance with ASME B16-34 for Class-designated valves or EN 12516 for PN designated valves.

4.2.3.4 Bonnet extension tube thickness shall take into account pressure stresses as well as operating torque, stem thrust and bending stresses induced by operating devices, such as handles, gears or actuators.

4.2.3.5 Stem to extended bonnet clearance should be minimized to reduce convective heat loss except there shall be sufficient clearance to avoid interference during operation.

4.2.3.6 Valves specified to be in gas service shall be capable of operation with the extended bonnet in any position, unless otherwise limited by the manufacturer.

4.2.3.7 Valves specified to be in liquid service, other than cold box applications, shall be capable of operation with the extended bonnet at or above 45° above the horizontal position (see Figure 2).

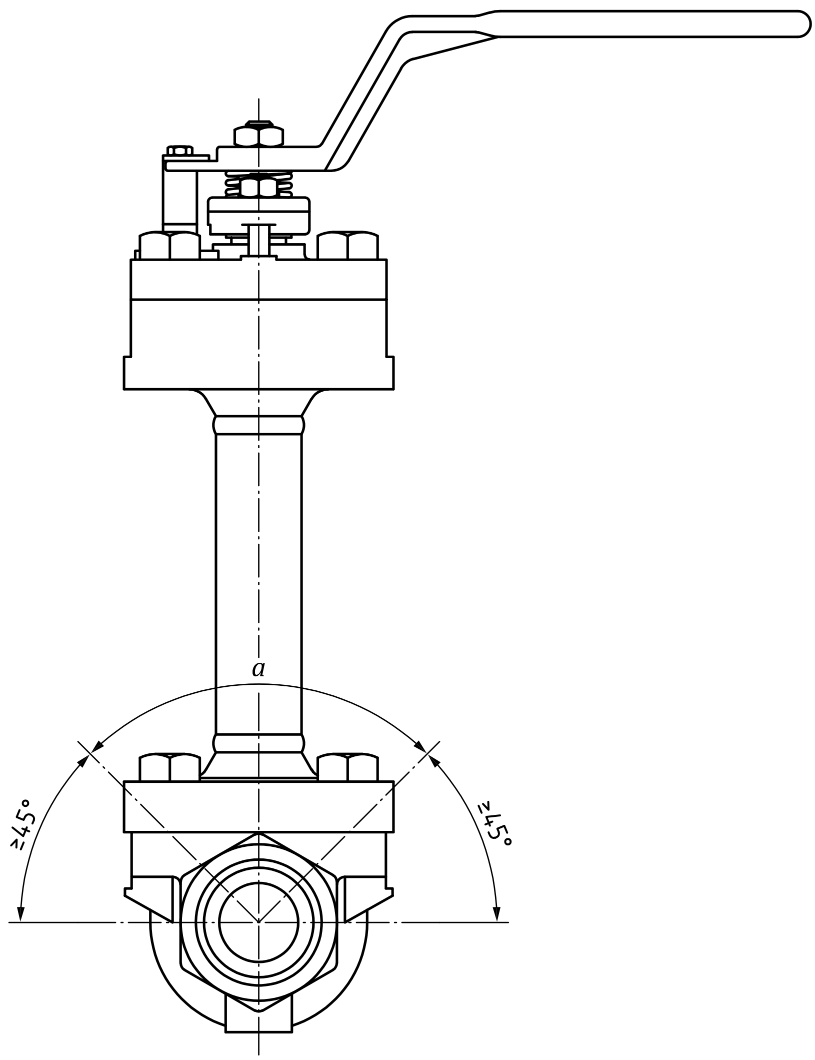


Figure 2 — Recommended bonnet orientation for non-cold box installation

4.2.3.8 Valves specified to be in cold box applications, equipped with extended bonnet, for applications with liquids, shall be capable of operating with the stem oriented 15° to 90° above the horizontal plane (see Figure 3).

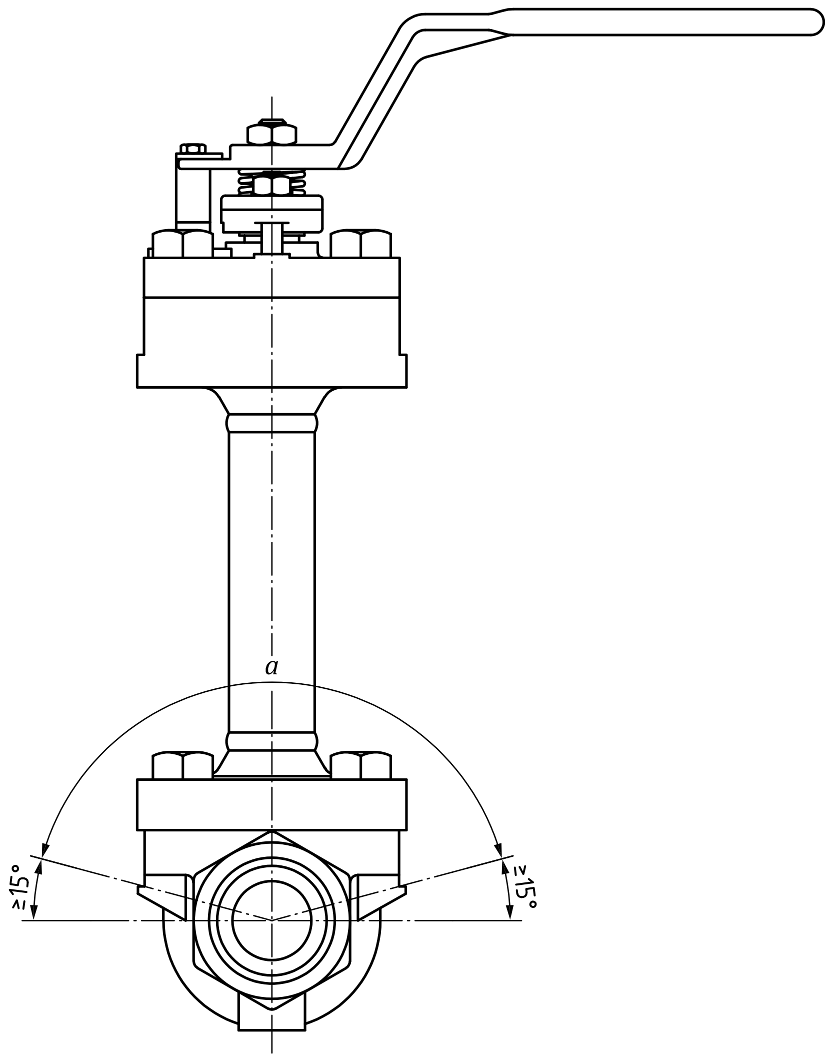


Figure 3 — Recommended bonnet orientation for cold box installation

4.2.3.9 A stem guide shall be applied at the lower end of the extended bonnet.

Where necessary, an additional guide may be provided to the upper end of the extension. It shall be located below the packing and designed so as not to interfere or otherwise damage the stem or the packing during normal valve operation.

The guide can be separate or integral with the bonnet extension.

4.2.3.10 If specified on the purchase order, the extension shall be provided with an insulation collar/drip plate. The collar/drip plate may be welded to the bonnet extension or of the clamp-on design. The clamp-on type shall have the bolting on the upper side to enable easy adjustment. Any gap between the bonnet and the collar/drip plate shall be sealed to avoid condensation entering into the insulated area.

4.2.3.11 The extended bonnet may be cast, forged or fabricated. Fabricated extensions shall use full penetration welding except for valves using pipe extension DN 50 (NPS 2) or smaller, where partial penetration V-groove welding, fillet type welding or full-strength threaded joint with seal weld may be used. When the bonnet extension is made to a tubular specification, the material shall be seamless. The requirements of ASME B16-34 or EN 12516 shall be met for welds to body/bonnets parts.

4.2.4 Stem

4.2.4.1 Gate and globe valve stems shall have a diameter to length ratio that precludes buckling while under compressive loading, required to fully seat the valve.

4.2.4.2 Backseats, when utilized, may be at the bottom or at the top of the body/bonnet extension. Backseats at the bottom of the extension may increase the risk of pressure build-up in the body/bonnet extension cavity if the valve is backseated and allowed to warm to ambient temperatures. In all cases, the valve manufacturer shall provide a means of protection against cavity over-pressurization.

4.2.4.3 The stem shall be sized in such a way that it is able to transfer the required torque and thrust to the valve and fully seat and unseat the closing element against pressure. Consideration shall be given to any additional stresses resulting from the operational loads. During the stem calculations, the highest valve rated temperature shall be used to establish the allowable material stress.

4.2.4.4 The stem shall be of one-piece construction and it shall be designed so that the stem seal retaining fasteners alone do not retain the stem.

4.2.5 Seats and seating surfaces

Metallic seating surfaces in metal seated valves shall have edges equipped with a radius or chamfer as necessary to prevent galling or other damage during operation.

4.2.6 Provision for internal pressure relief

4.2.6.1 Double seated valves shall be designed to prevent the build-up of body cavity pressure due to thermal expansion or evaporation of trapped liquid in excess of 1,33 times the valve rated pressure. Valves with backseat primary stem seal or stem guide at the bottom of the extension shall be designed to relieve excessive pressure in the bonnet when warmed up to ambient temperature.

4.2.6.2 Unless otherwise specified, pressure relief shall function as follows:

— for upstream sealing valves, relief shall be to the downstream side of the closing member;

— for downstream sealing valves, relief shall be to the upstream side of the closing member.

For gate valves, pressure relief shall be achieved by the use of a relief hole, located so as to relief excess cavity pressure to the upstream side of the valve when the valve is closed.

Where valve size permits, the pressure relieving hole shall be a minimum of 3 mm in diameter and visible through the valve end-connection when the valve is closed. Where valve size does not permit a 3 mm hole, a smaller hole diameter may be used.

4.2.6.3 For ball valves with polymeric pressure relieving seats, the manufacturer shall demonstrate by type testing that the seats relieve internal pressure at less than 1,33 times the rated pressure at both the minimum and the maximum design temperature.

4.2.6.4 Double seated valves with a pressure-relieving feature, such as a hole through the body or closure member, are unidirectional and the sealing direction shall be clearly marked on the valve in accordance with Clause 7.

4.2.7 Operating means

The maximum continuous force required to manually operate the valve under service conditions, when applied at the rim of the handwheel or lever, shall not exceed 360 N. For valves that are not equipped with gears or manual overrides, the maximum initial force required for valves seating or unseating shall not exceed 1 000 N.

4.2.8 Electric continuity and fire-safe design

Valves with soft seats or soft closing member insert to be used with flammable vapours or liquids shall be designed in such a way that there is electric continuity between the body and stem of the valve. The maximum electrical resistance shall not exceed 10 Ω across the discharge path. To test for continuity, a new, dry valve shall be cycled at least five times, and the resistance can then be measured using DC power source not exceeding nominal 12 V.

When service conditions require that a fire-type test be conducted, this test shall be in accordance with ISO 10497 or API 607 or API 6FA.

5 Testing

5.1 Production testing with low-temperature test

5.1.1 A specified number of valves according to Table 3 shall undergo low-temperature production testing. Prior to the low-temperature testing, all valves shall be ambient-pressure tested as specified in Annex A. After the test, the valves shall be dried and degreased internally unless the shell and seat tests were performed with cleaned valve and dry gas.

5.1.2 The test gas shall be helium. However, for seat testing at temperatures above −110 °C, nitrogen mixed with 10 % helium making up the balance may be used.

5.1.3 The type of coolant shall be liquid nitrogen for testing at a temperature of −196 °C. For temperatures higher than −196 °C, nitrogen gas or dry ice, mixed with heat transfer fluid shall be used, unless otherwise agreed between the manufacturer and the purchaser.

5.1.4 The test temperature shall be in accordance with minimum valve design temperature or as specified by the purchaser. A temporary temperature variation for any thermocouples within a range of ± 5 % and not exceeding ±5 °C are acceptable.

5.1.5 For low-temperature testing at −196 °C or at −50 °C, the test procedure in Annex A shall be used. For other test temperatures, the procedure shall be modified accordingly.

5.1.6 After the test, the valve shall be visually inspected and, if found in satisfactory condition, it shall be thoroughly cleaned, degreased and dried. Disassembly of valve is not required.

5.1.7 All test data shall be recorded. After completion of the testing and final examination, test results shall be documented in a test report. The test report shall include the name of the testing organization, responsible individual, and any purchaser and/or supplier witnesses present during the test. An example of a low-temperature test record is provided in Annex B.

6 Sampling

6.1 Lot requirements

The lot for low-temperature testing, from which the test samples are drawn, is defined as all valves of the same purchase order, manufactured at the same manufacturing plant by the same manufacturer, and of the same valve type, design, size, material (e.g. austenitic, ferritic), pressure class and minimum design temperature.

Additional valves, ordered within a three-month period from the time of the initial purchase order and tested within 6 months of the initial production test, shall be considered part of the same lot.

6.2 Sample size

Unless otherwise stated on the purchase order, the sample size for low-temperature testing shall be in accordance with Table 3. The samples shall be selected at random from each lot and rounded up to the next whole number. As a minimum, one valve shall be tested.

Table 3 — Sample selection for production testing

Lot size	Minimum sample size
X ≤ 100	10 %
101 ≤ X ≤ 1 000	8 %
X > 1 000	5 %

6.3 Lot acceptance

6.3.1 If a test valve does not pass any of the required tests, this shall be cause for rejection of the tested valve and the lot.

6.3.2 If a valve fails any of the test requirements, a component inspection is required. The valve shall be disassembled and critical valve parts, including seats, seals and gaskets, shall be checked for excessive wear, damage and/or permanent deformation.

6.3.3 If retesting is required, valves may be resubmitted for retesting only after the defective valve components have been removed or defects corrected. The number of test valves from the rejected size and type in the lot shall be doubled. Subsequent test failures shall result in rejection of the entire size and type in the lot.

7 Marking, labelling and packaging

7.1 Valve identification marking shall be in accordance with ISO 5209 and valve identification plate shall also include the minimum temperature for which the valve is designed.

7.2 Valves designed for unidirectional capability, or modified to only have unidirectional capability, shall have the sealing direction clearly indicated on the valve body. The indication shall be integral with the body or on a plate securely attached to the valve body. The identification of the unidirectional seat shall be as shown in Figure 4. The identification plate shall not be attached by wire.

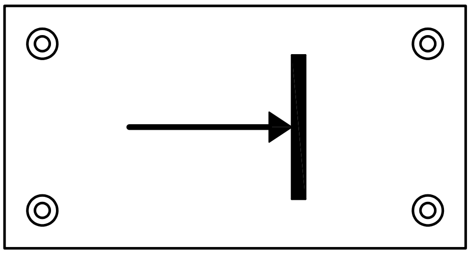


Figure 4 — Unidirectional valve identification plate symbol

7.3 Valves for low-temperature application shall be cleaned to the extent specified in the customer purchase order.

7.4 Valves shall have end connections covered with protective covers.

Annex A
(normative)

Test procedure for production testing of valves at low temperature

A.1 General

The following procedure covers the testing for sealing and operability of valves at one of the following temperatures:

a) valve tests at –196 °C;

b) valve tests at –50 °C;

c) an alternative temperature of between –50 °C and –196°C may be specified based on an agreement between the purchaser and manufacturer.

The test temperature shall be equal to or lower than the minimum design temperature of the valve, provided the materials are suitable.

A.2 Test procedures

A.2.1 Testing flow chart

See Figure A.1.

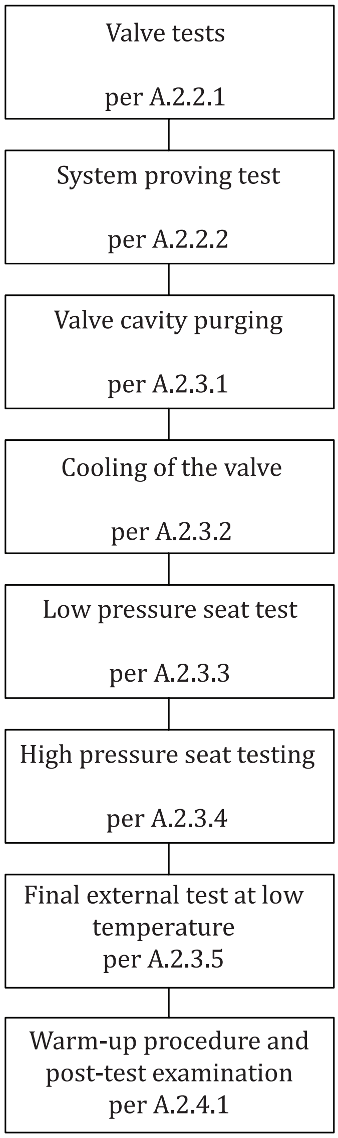


Figure A.1 — Testing flow chart

A.2.2 Ambient temperature test

A.2.2.1 Valve tests

Shell and seat testing shall be in accordance with ISO 5208. The shell test pressure shall be 1,1 x CWP if tested with gas and 1,5 x CWP if tested with alcohol or water. The seat closure test pressure shall be at (6 ± 1) bar.[1)] After each test is complete, the valve shall be thoroughly dried.

A.2.2.2 System proving test

A.2.2.2.1 Test pressure

A system proving test shall be performed at the maximum valve cold working pressure or maximum seat test pressure, whichever is the lower.

1) 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2 (bar is a unit deprecated by ISO).

A.2.2.2.2 Test procedure

For external leakage detection, a soap solution or helium leak detector shall be used. Any detected leakage shall be eliminated. For the seat test, the test procedure shall be in accordance with ISO 5208 except the test pressure shall be limited to CWP. However, for soft seated ball valves of free floating design, the test pressure shall be limited to (6 ± 1) bar.

A.2.3 Low-temperature test

A.2.3.1 Valve cavity purging

A purge of test gas at a supply pressure of (2 ± 0,5) bar shall continuously flow through during cool down. Metal seated valves shall be in a half-open position, while for soft seated ball valves, the closure member shall be in the fully open position and shall only be operated for cavity purging.

A.2.3.2 Cooling of the valve

If the cooling media is liquid, the test valve shall be slowly submerged in the coolant to a depth such that the level of the coolant covers at least the top of the valve body to bonnet joint.

If the cooling media is cold gas, the valve shall be installed in the cooling tank so that the valve body and the body to bonnet joint is exposed to the cold gas. During the valve cooling, the purge of test gas shall be maintained.

A.2.3.3 Low-pressure seat test

When the test valve is at the designated test temperature, the purge of the test gas shall be turned off. The test valve shall be operated to the full open position, and pressurized to (2 ± 0,5) bar with the test fluid.

With the downstream isolation valve open (see Figure A.2) and test gas flowing through the valve, the valve shall be then closed and the (2 ± 0,5) bar pressure shall be re-established. The valve shall be then fully opened and closed five times.

The closing and opening torque shall be measured and recorded during the first and the fifth operation cycle.

After completion of the last open-close cycle and after the pressure and leakage stabilization has occurred, the seat leakage shall be measured and recorded.

A.2.3.4 High-pressure seat testing

The high-pressure seat test shall be performed and recorded in four equal pressure increments, beginning with the first increment at a quarter of the valve allowable cold working pressure or maximum operating pressure when specified. The last increment shall be equal to the allowable CWP. Except for actuated valves where the actuator size is specified and selected for operation at a differential pressure less than CWP, the high-pressure seat test may be reduced based on the specified differential pressure. During each pressure increment, enough time shall be allowed to stabilize the pressure and the test temperature (see A.5). The valve seating and unseating torque shall be measured and recorded during each pressure increment.

A.2.3.5 Final external test at low temperature

After completion of the high-pressure tests, the valve shall be operated five times by opening and closing through its full stroke. The operating force shall not exceed 360 N, except for manual valves, the maximum initial force required for valves seating or unseating shall not exceed 1 000 N.

The test valve shall be partially opened, pressurized to the allowable CWP or specified differential pressure and the designated test temperature shall be re-established.

The test valve shall be pressurized for at least 15 min prior to lifting it from the cooling tank.

After the temperature and pressure has stabilized, the valve shall be closed, removed from the cooling tank and checked for external leakage.

The valve external leakage for the valve stem and the outside perimeter of the bonnet shall not exceed 50 ppmv[2] or 1,78 x 10^{-6} mbar·l·s^{-1} per millimetre stem diameter for the stem, and 1,78 x 10^{-7} mbar·l·s^{-1} per millimetre seal diameter for the bonnet or body joint.

For the measurement of the external leakage, the leakage shall at no time throughout the duration of the test be higher than the above specified limits for more than 10 s.

A.2.4 Warm-up procedure and post-test examination

A.2.4.1 After the external leakage test, the test valve shall be de-pressurized and shall be allowed to warm up to ambient temperature. A forced warming-up is not permitted. Except for soft seated ball valves, for which the closing member shall be in fully open position, the closure member shall be in the half open position.

A.2.4.2 After successful testing, the assembled valve shall be thoroughly cleaned, dried and inspected for ease of operation or any signs of internal binding or galling and packaged in accordance with Clause 7.

A.3 Test temperatures

A.3.1 Ambient temperature

The test is performed at between 5 °C and 40 °C.

A.3.2 Low temperature

A.3.2.1 Test is performed at –196 °C ± 5 °C.

A.3.2.2 Test is performed at –50 °C ± 5 °C.

A.3.2.3 When an alternative test temperature of between –50 °C and –196 °C is specified, all the remaining requirements of this part of ISO 28921 shall be met.

A.4 Test pressures

A.4.1 Low-pressure seat test

The test is performed at (6 ± 1) bar during the seat test according to ISO 5208 and (2 ± 0,5) bar during the low-temperature seat test (see A.2.3.3).

A.4.2 Incremental high-pressure seat test

The actual gas pressure during the seat test shall stabilize within ±1 bar for valves up PN 40 (Class 300) and ±3 bar for higher pressure valves.

A.5 Duration of seat test

The duration of each seat test shall be at least:

— 3 min for valves DN 10 to DN 400; NPS 3/8 to NPS 16;

— 5 min for valves DN 450 or NPS 18 and larger.

2) ppmv means parts per million in volume; 1 ppmv = 1 ml/m^3 = 1 cm^3/m^3 (ppmv is a unit deprecated by ISO).

Each time the test valve is pressurized and after the pressure and temperature have stabilized, there shall be a waiting period prior to the start of seat testing of equal to or longer than the minimum required duration of the seat test.

The same minimum duration applies to the actual seat test.

A.6 Direction of seat test

For globe, gate, ball and butterfly valves, the seat test is conducted in the normal or preferred flow direction for the valve.

For check valves, the seat test is conducted in the reverse flow direction of the valve.

For valves with bidirectional sealing, each sealing direction shall be tested separately unless otherwise agreed to by purchaser.

A.7 Allowable seat leakage rates

The maximum allowable seat leakage shall be in accordance with Table A.1.

Table A.1 — Maximum allowable seat leakage rate per millimetre of nominal seat diameter

<table>
<tr><th rowspan="2">Valve PN — Class</th><th colspan="2">Allowed seat leak
mm³/s x DN</th></tr>
<tr><th>Gate, globe, butterfly and ball valve</th><th>Check valve</th></tr>
<tr><td>PN 16 – Class 150</td><td rowspan="3">50</td><td rowspan="4">250</td></tr>
<tr><td>PN 25 and PN 40 – Class 300</td></tr>
<tr><td>PN 100 and PN 160 – Class 600, Class 800 and Class 900</td></tr>
<tr><td>PN 250 – Class 1 500</td><td>100</td></tr>
</table>

A.8 Test set-up for low-temperature tests

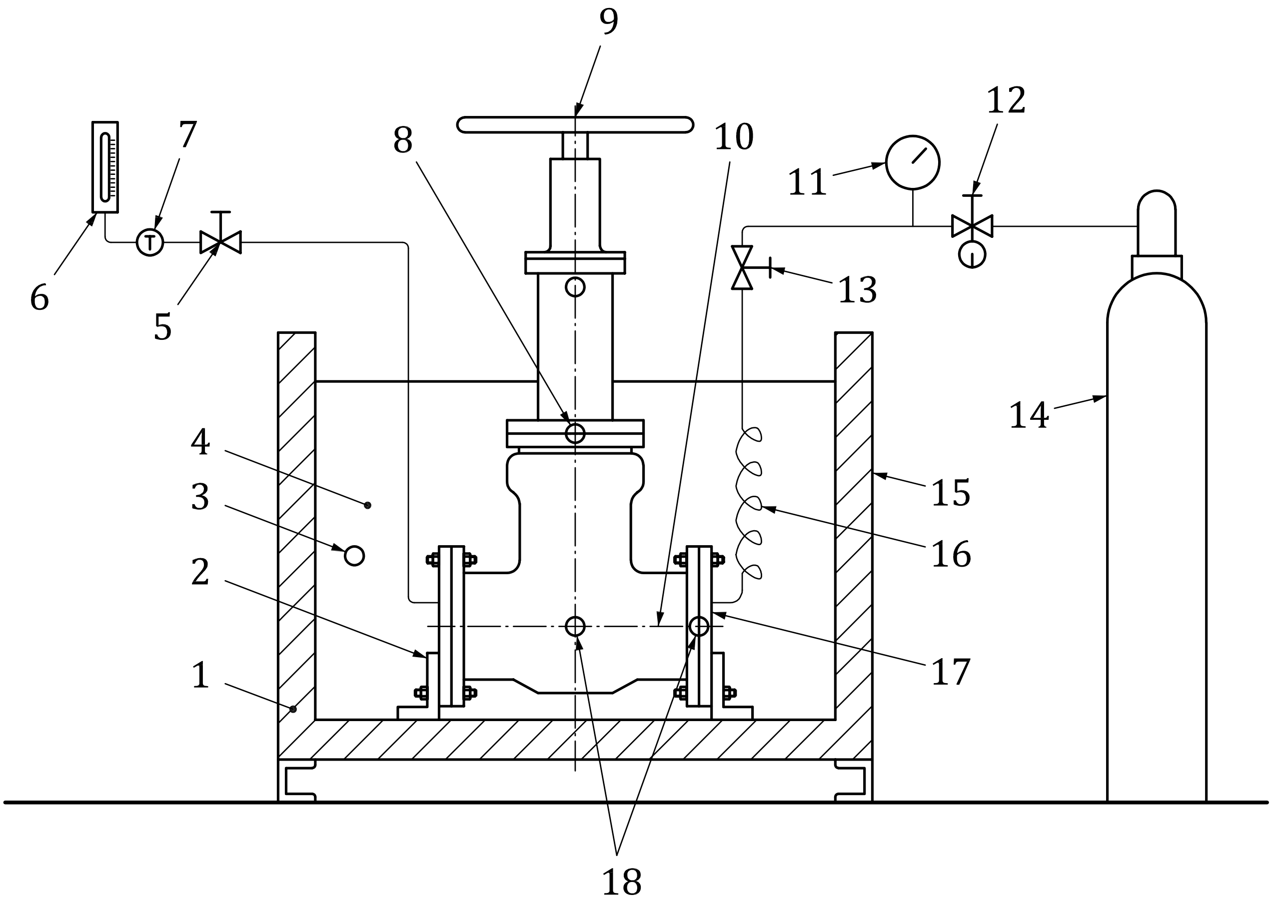
A.8.1 Test equipment

The cooling medium shall be contained in an insulated stainless steel tank that is open on the top. Each test valve shall be blinded with blind flanges that are equipped with support brackets as necessary and small bore tubing connected to the pressurizing media.

After insertion into the tank, the valve shall be oriented such that the stem position is vertical. Check valves may be oriented in either the vertical or horizontal disc position.

Thermocouples shall be attached to the valve body, bonnet and end flange, except that the number of thermocouples may be reduced where the size of the test valve makes the use of multiple thermocouples impracticable. However, in all cases, a minimum of one thermocouple, located in the valve bonnet area and one inside the valve are required. A minimum of one thermocouple shall be provided to monitor the temperature of the cooling medium.

A simplified schematic arrangement for immersion cold testing is shown in Figure A.2. Its purpose is to facilitate understanding of the standard test. It is not a required arrangement.



Key

1	insulation	10	thermocouple inside valve
2	support bracket	11	pressure gauge
3	cooling medium thermocouple	12	pressure regulator
4	cooling medium	13	isolation valve upstream
5	isolation valve downstream	14	helium bottle
6	flowmeter	15	tank
7	thermocouple (helium exit temperature)	16	pre-cooling coil
8	thermocouple on body/bonnet flange	17	blind flange
9	test valve	18	optional thermocouple on body and, optionally, on blind flange

Figure A.2 — Test set-up

A.8.2 Cooling of the valve

Cooling begins as the valve is lowered into the test tank and submerged into the cooling medium. The valve temperature, as well as the cooling medium temperature and level shall be continuously monitored and recorded. The test shall begin when the valve temperature is stabilized within the specified test temperature tolerances. See Table A.2.

Table A.2 — Test temperature

Cooling medium	Test valve temperature
Dry ice, mixed with a heat transfer fluid or cooled by nitrogen	Low temperature at –50 °C
Nitrogen gas or other medium by agreement between the purchaser and manufacturer	Low temperature of between –50 °C and –196 °C
Liquid nitrogen	Low temperature at –196 °C
NOTE Valves with a minimum design temperature of between –50 °C and –196 °C may be tested at –196 °C by agreement between the purchaser and manufacturer, provided the valve materials are suitable.	

A.8.3 Test gas

Test gas, see Table A.3, from a charged bottle is used to provide test pressure on the inlet side of the valve.

Table A.3 — Test gas

Test gas	Test valve temperature
Nitrogen mixed with 10 % helium	Low temperature at –110 °C and higher
Minimum 97 % pure helium	Any temperature up to –196 °C

A.8.4 Instruments

All instruments (flowmeter, pressure gauges, torque wrench, etc.) shall be calibrated. Calibration shall remain valid for a maximum duration of six months after the date of test.

A.9 Flowmeters, flowmeter calibration, seat leak and correction factors

A.9.1 Flowmeter

Test valve seat leakage shall be measured at the flowmeter, and shall be at standard atmospheric conditions.

Any type of flowmeter may be used, provided it can be calibrated, for example measuring cylinder, gas flowmeter soap film type or flow rotameter.

Some flowmeters (e.g. electronic mass flowmeters) are not affected by pressure or temperature changes. When such a flowmeter is used, test gas pressure and temperature measurements (as well as correction) at the flowmeter is not required.

A.9.2 Flowmeter calibration

The flowmeter shall be calibrated for the test gas. Alternatively, the flowmeter manufacturer correction factor may be used to relate the calibration gas (typically nitrogen) to the test gas.

A.9.3 Temperature correction

The temperature of exiting test gas shall be measured (before the flowmeter).

Use the perfect gas relationship assuming constant pressure to determine the temperature correction for the flow rate.

$$V_1 \times T_2 = V_2 \times T_1$$

$$Q_1 \times T_2 = Q_2 \times T_1$$

where

V_1 is the test gas volume exiting the flowmeter, in cubic millimetres (mm^3);

V_2 is the test gas volume expressed (corrected) at ambient temperature, in cubic millimetres (mm^3);

T_1 is the test gas temperature exiting the flowmeter, in Kelvin (K);

T_2 is the standard ambient temperature (298 °K), in Kelvin (K);

Q_1 is the test gas flow exiting the flowmeter, in cubic millimetres per second (mm^3/s);

Q_2 is the test gas flow exiting the flowmeter and expressed (corrected) at ambient temperature, in cubic millimetres per second (mm^3/s).

A.9.4 Pressure correction

Measurement of exiting gas pressure (as well as correction) is not required.

NOTE The pressure of exiting gas is near atmospheric and assumed to have negligible effect on leakage measurement.

Annex B
(informative)

Low-temperature test record

Order/item/position:				Test date and number:	
Customer order number:				Valve tag number:	
Project name:				Test temperature	
Valve figure number:				Cooling medium	
Valve type/size/Class:				Test gas:	
Actuator type and handwheel diameter:		mm		Allowed seat leak:	≤ mm³/s
Flowmeter type:				Allowed external leak:	50 ppmv or — 1,78 x 10^{-6} mbar.l/(s.mm dia) for stem — 1,78 x 10^{-7} mbar.l/(s.mm dia) for body

Ambient seat test and system proving test:

Seat test pressure (bar)	Duration of seat test (min)	Seat leak rate (mm^3/s)

System proving test pressure (bar)		Duration (min)		Test result: Pass or Fail	

Low temperature test:

Valve stabilization temperature (°C):		Time:	

Valve stroked 5 times

Record operating torques

Cycle	Opening torque (Nm)	Closing torque (Nm)
1st		
5th		

Low pressure seat test (bar)		Duration (min)		Seat leak (mm^3/s)	

Incremental seat test:

Increment	Pressure (bar)	Duration (min)	Seating torque (Nm)	Unseating torque (Nm)	Measured seat leak (mm^3/s)	Corrected seat leak (mm^3/s)
1st						
2nd						
3rd						
4th						

External leakage tests:

External leakage test pressure (bar)		Duration (min)		Valve body	
		Bonnet joint		Stem seal	

Visual examination or comments:	**PASS (√)**	
	FAIL (X)	

Tested by

Approved by

Customer witness

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