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ISO 28921-1

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Industrial valves — Isolating valves for low-temperature applications —

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

Reference number
ISO 28921-1:2022(E)

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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.

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).

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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 153, *Valves*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 69, *Industrial valves,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 28921-1:2013), which has been technically revised.

The main changes are as follows:

— extension of the scope to include sizes DN 950 to 1 800, NPS 38 to 72, and pressure designations PN 400 and Class 2 500;

— addition of a new terminological entry for shell (3.14);

— addition of a new terminological entry for drip plate (3.15);

— exclusion of safety valves and control valves;

— in 5.2, addition of type test requirement in accordance with ISO 28921-2;

— update of Annex A giving the test procedure for production testing of valves at low temperature.

A list of all parts in the ISO 28921 series can be found on the ISO website.

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.

Introduction

The purpose of this document 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 document specifies requirements for design, dimensions, material, fabrication and production testing of gate, globe, ball/plug and butterfly valve design types used as isolation valves and check valves for low-temperature applications.

This document is applicable to isolation valves for use in low and cryogenic temperature service where the design low-temperature service is -50 °C down to –196 °C.

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

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

This document is applicable to valves with body, bonnet, bonnet extension or cover made of metallic materials.

This document is applicable to:

— 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; 950; 1 000; 1 050; 1 200; 1 350; 1 400; 1 500; 1 600; 1 650; 1 800,

— corresponding to nominal pipe sizes NPS: ⅜; ½; ¾; 1; 1 ¼; 1 ½; 2; 2 ½; 3; 4; 5; 6; 8; 10; 12; 14; 16; 18; 20; 24; 26; 28; 30; 32; 34; 36; 38; 40; 42; 48; 54; 56; 60; 64; 66; 72,

and applies to pressure designations:

— PN 16; 25; 40; 100; 160; 250; 400,

— Class 150; 300; 600; 800; 900; 1 500; 2 500.

NOTE Not all type and size combination are available in all pressure ratings.

This document does not apply to safety valves and control valves.

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 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, *Industrial valves — Metallic butterfly valves*

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 15848-1:2015, *Industrial valves — Measurement, test and qualification procedures for fugitive emissions — Part 1: Classification system and qualification procedures for type testing of valves*

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

ISO 28921-2, *Industrial valves — Isolating valves for low-temperature applications — Part 2: Type testing*

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

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 12516-4, *Industrial valves — Shell design strength — Part 4: Calculation method for valve shells manufactured in metallic materials other than steel*

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, *Standard for Fire Test of Valves*

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

ASME B31.3, *Process Piping*

ASME *Boiler and Pressure Vessel Code, Section VIII*

3 Terms and definitions

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

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

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

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

3.1
DN
nominal size
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, 2.1, modified — Notes to entry removed.]

3.2
PN
nominal pressure
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)* (3.1) 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 — The phrase “and which comprises the letters PN followed by the appropriate reference number” has been added.]

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

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

3.7
extended bonnet
bonnet extension that locates the operating mechanism and packing away from the cold media in the valve

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

3.8
vapour column
portion of body/bonnet extension that allows for the formation of an insulating column of vapour

3.9
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

Note 1 to entry: See Figure 1.

3.10
bonnet extension length for cold box application
length measured from the centre-line of the valve flow passage up to the bottom of the packing chamber

Note 1 to entry: See Figure 1.

3.11
CWP
cold working pressure
maximum fluid pressure assigned to a valve for operation at a fluid temperature of −20 °C to 38 °C

3.12
cryogenic
science of materials at low temperature

3.13
test gas
minimum 97 % pure helium or nitrogen

3.14
shell
pressure containing envelope of the valve normally comprised of the body and when included in the design a bonnet or cover and the body bonnet or body cover joint excluding sealing parts

3.15
drip plate
plate attached to the *extended bonnet* (3.7) to prevent condensation from entering the insulation layer

3.16
obturator
movable component of the valve whose position in the fluid flow path permits, restricts or obstructs the fluid flow

3.17
DBB valve
double block and bleed valve
single valve with two seating surfaces that, in the closed position, provides a seal against pressure from both ends of the valve with a means of venting/bleeding the cavity between seating surfaces

Note 1 to entry: This valve does not provide positive double isolation when only one side is under pressure.

3.18
DIB valve
double isolation and bleed valve
single valve with two seating surfaces, each of which, in the closed position, provides a seal against pressure from a single source, with a means of venting/bleeding the cavity between the seating surfaces

Note 1 to entry: This feature can be provided in one direction or in both directions: DIB-1 (both seats bidirectional) or DIB-2 (one seat unidirectional and one seat bidirectional).

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 Shell

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

The material of body, bonnet, bonnet extension and cover, and other parts of the shell, shall be selected from the following:

a) low alloy and austenitic stainless-steel materials listed in ASME B16.34 or EN 12516-1 for Class-designated valves or EN 12516-1 for PN-designated valves;

b) nickel alloy materials listed in ASME B16.34 for Class-designated valves;

c) copper alloy materials listed in EN 12516-4 for Class- and 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, for example, stem, wedge, disc, ball, plug, 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, for example, packing, gasket, seats 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 document 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.

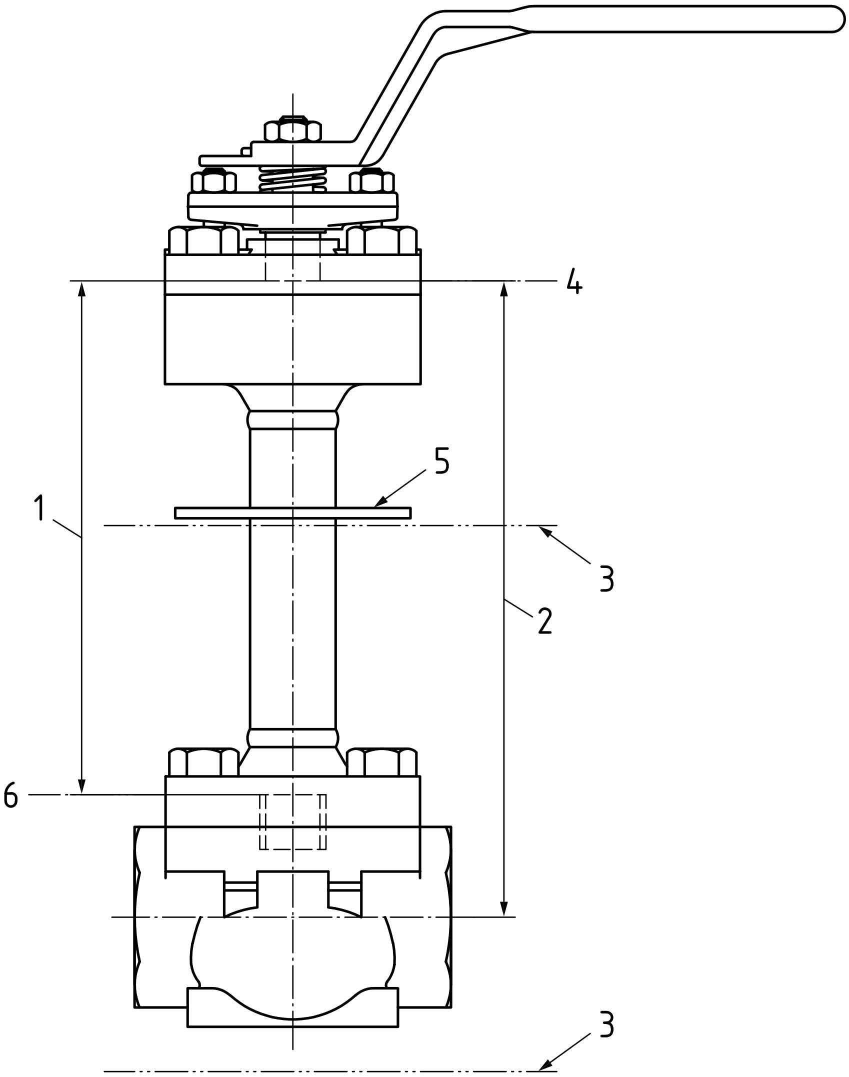
4.2.2 Body/bonnet wall thickness

The minimum valve body and bonnet wall thickness shall meet the requirements of ASME B16.34 or EN 12516-1 or EN 12516-4 for Class-designated valves and EN 12516-1 or EN 12516-2 or EN 12516-4 for PN-designated valves. The pressure rating of the valve at or below service temperatures –50 °C shall not exceed the cold working pressure (CWP) for the applicable valve body material and appropriate Class or PN designation.

4.2.3 Valve body extension and extended bonnet

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 length shall be in accordance with Table 1 or Table 2 and Figure 1, unless otherwise specified in the purchase order.



Key

1 minimum vapour column length for non-cold box application (see Table 1)

2 bonnet extension length for cold box applications (see Table 2)

3 outline of cold box enclosure

4 bottom of the packing chamber

5 optional drip plate

6 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 DN	**Minimum design temperature**				**Valve size** NPS
	minimum	**maximum**	**minimum**	**maximum**	
	−196 °C	−110 °C	−109 °C	−50 °C	
	Minimum vapour column length [mm]				
DN ≤ 25	200		100		NPS ≤ 1
32 ≤ DN ≤ 65	250		125		1 ¼ ≤ NPS ≤ 2 ½

Table 1 *(continued)*

Valve size DN	Minimum design temperature				Valve size NPS
	minimum	**maximum**	**minimum**	**maximum**	
	–196 °C	–110 °C	–109 °C	–50 °C	
	Minimum vapour column length [mm]				
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
≥ 950	To be agreed between purchaser and the manufacturer.				≥ NPS 38

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
≥ 950	To be agreed between purchaser and the manufacturer.		≥ NPS 38

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

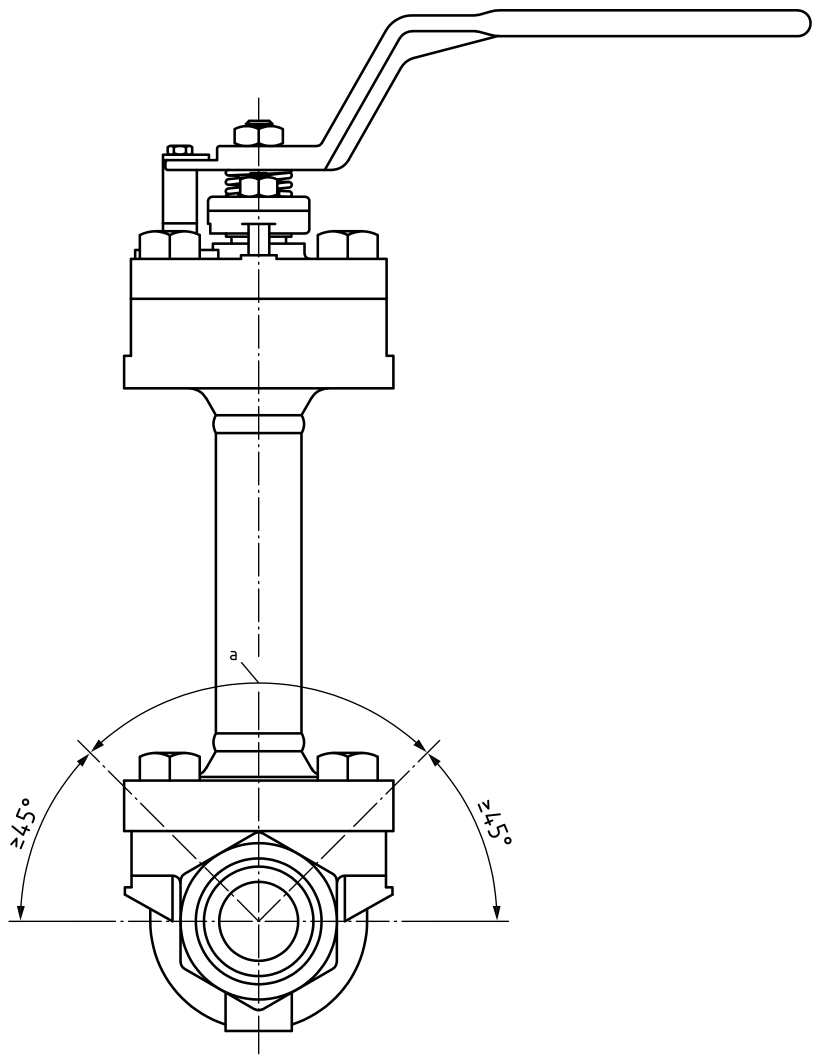
4.2.3.3 In case of a bonnet extension made of a material having lower pressure/temperature rating than the body, then the extension thickness shall be increased proportionally to meet the pressure/temperature rating of the body at all applicable temperatures. The minimum wall thickness shall meet the requirements of ASME B16.34 or EN 12516-1 or EN 12516-4 for Class-designated valves and EN 12516-1 or EN 12516-2 or EN 12516-4 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 that 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).

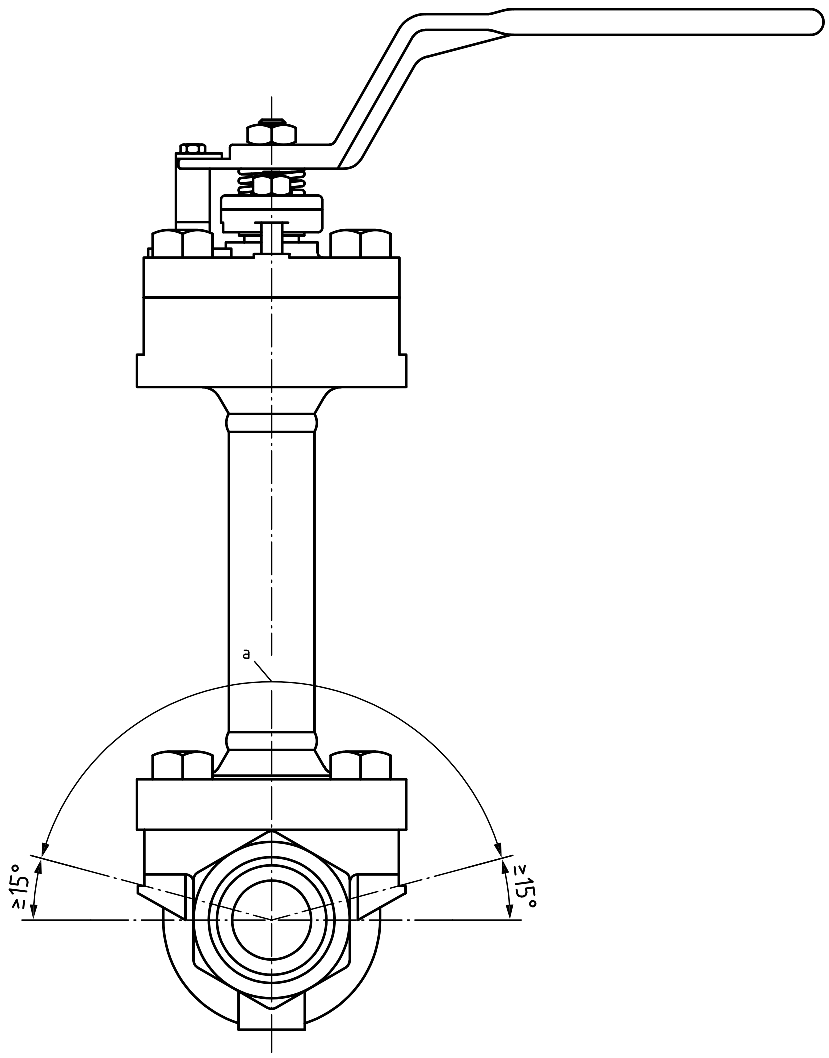


Key

a Vertical plane.

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).



a Vertical plane.

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 or topside of the valve body.

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 12516-1 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 back seated 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 obturator 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 does 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 obturator;

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

For gate valves, floating type ball valves, pressure relief shall be achieved using a relief hole, located 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, 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 obturator, 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 torque, in Nm, to operate the valves manually under service conditions, when applied at the rim of the handwheel or lever, shall not exceed 360 Nm, except for valve seating and unseating when it shall not exceed 500 × *R* as per EN 12570. For a handwheel, *R* is the radius of the wheel, in meters. For a lever, *R* is the length of the lever in meters.

4.2.8 Electric continuity and fire-safe design

Valves with soft seats or a soft obturator 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 Clause 6 shall undergo low-temperature production testing, if requested in the purchase order. 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 closure tests were performed with cleaned valve and dry gas.

5.1.2 The test gas shall be helium. However, for closure test at temperatures above –110 °C, nitrogen may be used, except for final external test at low temperature (A.2.3.5).

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 ±10 % and not exceeding ±10 °C is 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 (Figure B.1).

5.2 Type-testing

In case of a new valve design, the valve shall have been previously type tested in accordance with ISO 28921-2 with satisfactory result.

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 X	Minimum sample size
$X \leq 100$	10 %
$101 \leq X \leq 1\,000$	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. The valve shall be resubmitted for testing following examination in 6.3.2 and repair as in 6.3.3. Additional valves from the previously untested valves equal to the number of the failed valves shall be selected from the lot and also tested. If the repair valve and additional valves pass the required tests, the lot is accepted. Otherwise, the lot is rejected as per 6.3.3.

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. 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.

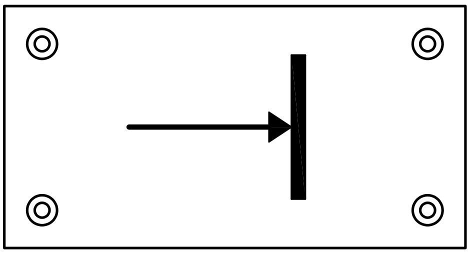


Figure 4 — Unidirectional valve identification plate symbol

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 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.

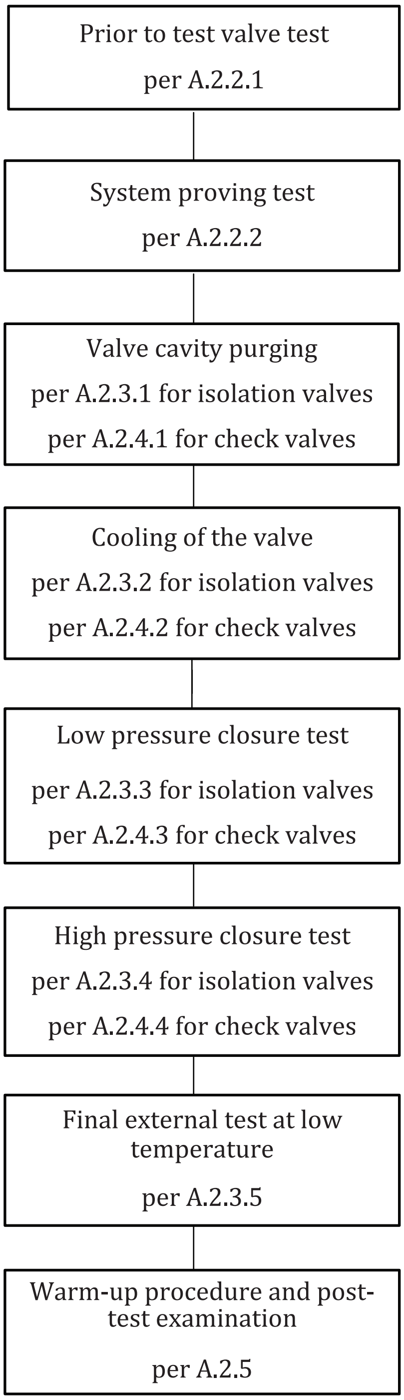


Figure A.1 — Testing flow chart

A.2.2 Ambient temperature test

A.2.2.1 Prior to test

Shell and closure test shall be in accordance with ISO 5208, unless otherwise agreed with the customer. The shell test pressure shall be 1,1 × CWP if tested with gas and 1,5 × CWP if tested with alcohol or water. The seat closure test shall be as per product standard, unless otherwise agreed with customer. 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 CWP. For actuated valves where the actuator size is specified and selected for operation at a differential pressure less than CWP, the closure test of the system proving test shall be performed at specified differential pressure.

A.2.2.2.2 Test procedure

The system proving test consists in performing the valve shell test and the valve closure test with test pressures specified in A.2.2.2.1 in order to ensure that the valve is in suitable condition for the low temperature test to proceed. For external leakage detection, a soap solution or helium leak detector shall be used. In case any leakage is detected, the leakage shall be eliminated.

A.2.3 Low-temperature test

A.2.3.1 Valve cavity purging

Metal seated valves shall be in a half-open position, while for soft seated valves, the obturator shall be in the fully open position and shall only be operated for cavity purging.

To prevent the formation of moisture and ice in the valve during the cooling operation, a purge of test gas at a supply pressure of (2 ± 0,5) bar[1)] (0,2 ± 0,05 MPa) shall continuously flow through during cool down.

Alternatively, the valve may be flushed momentarily and pressurized with test gas to a maximum of 10 % CWP before and during cooling down.

For tests at or close to the temperature of –196 °C, only helium shall be used.

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 and the temperature of the valve body, obturator area (from valve interior) and the stuffing box area shall be monitored by means of suitably located thermocouples.

Once the valve obturator area has reached the test temperature, with the thermocouple readings, the valve shall be allowed to soak at the test temperature for 20 min minimum to ensure that all temperatures have stabilized.

A.2.3.3 Low-pressure closure test

Once the soaking period has finished, the purge of the test gas shall be turned off. The test valve shall be operated to the fully open position and pressurized to (2 ± 0,5) bar (0,2 ± 0,05 MPa) 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 (0,2 ± 0,05 MPa) 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 and shall not exceed 500 N × the radius of the handwheel, in meters, or the length of the lever, in meters.

1) 1 bar = 0,1 MPa =105 Pa; 1 MPa = 1 N/mm^2.

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 closure test

The high-pressure closure test shall be performed in four equal pressure increments, beginning with the first increment at a quarter of the valve allowable CWP or at specified differential pressure, when specified. After the application of the last increment, valve test pressure shall reach the allowable CWP or specified differential pressure. The seat leakage shall be measured and recorded in each of the four increments. In case of actuated valves where the actuator size is specified and selected for operation at a differential pressure less than CWP, the high-pressure closure test shall be performed 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 the first and the fifth operation cycle and shall not exceed 500 N × the radius of the handwheel, in meters, or the length of the lever, in meters.

In case of valves which have seats with bidirectional sealing like, for example, DBB, DIB-1 and DIB-2 valves, all sealings shall be tested.

A.2.3.5 Final external test at low temperature

After completion of the high-pressure closure tests, the valve shall be operated five times by opening and closing through its full stroke. The operating force shall not exceed 360 Nm, except for valve seating and unseating when it shall not exceed 500 × R. For a handwheel, R is the radius of the wheel, in meters. For a lever, R is the length of the lever in meters.

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 $1{,}78 \times 10^{-6}$ mbar·l·s^{-1} ($1{,}78 \times 10^{-7}$ Pa·m^3·s^{-1}) per millimetre stem diameter for the stem, and 50 ppmv for the bonnet or body joint. Bonnet or body joint seals leakage shall be measured using the sniffing method in accordance with ISO 15848-1:2015, Clause B.1. Stem seals leakage shall be measured using the method in accordance with ISO 15848-1:2015, Clause A.2.

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 Low-temperature test for check valve

A.2.4.1 Valve cavity purging

A purge of test gas at a supply pressure of (2 ± 0,5) bar (0,2 ± 0,05 MPa) shall continuously flow through and set-up the valve in the normal flow direction during cool down.

A.2.4.2 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 and the temperature of the valve body, obturator area (from valve interior) and the stuffing box area shall be monitored by means of suitably located thermocouples.

Once the valve obturator area has reached the test temperature, the valve shall be allowed to soak the test temperature for 20 min minimum to ensure that all temperatures have stabilized.

A.2.4.3 Low-pressure closure test

Once the soaking period has finished, with the test fluid flowing through the valve in the normal flow direction, unseat and seat the valve once. Then increase the pressure to (2 ± 0,5) bar (0,2 ± 0,05 MPa) in the non-flow direction with the test fluid flowing in the non-flow direction. After the pressure and leakage stabilization has occurred, the seat leakage shall be measured and recorded.

A.2.4.4 High-pressure closure test

The high-pressure closure test shall be performed in four equal pressure increments, beginning with the first increment at a quarter of the valve allowable CWP or at specified differential pressure, when specified. After the application of the last increment, the valve test pressure shall reach the allowable CWP or specified differential pressure. The seat leakage shall be measured and recorded in each of the four increments. During each pressure increment, enough time shall be allowed to stabilize the pressure and the test temperature (see A.5).

A.2.5 Warm-up procedure and post-test examination

After the external leakage test, the test valve shall be depressurized 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 obturator shall be in fully open position, the obturator shall be in the half open position.

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 ± 10 % and not exceeding ±10 °C.

A.3.2.2 Test is performed at –50 °C ± 10 % and not exceeding ±10 °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 document shall be met.

A.4 Test pressures

A.4.1 Low-pressure closure test

The low-pressure closure test is performed at (2 ± 0,5) bar (0,2 ± 0,05 MPa) (see A.2.3.3).

A.4.2 Incremental high-pressure closure test

The actual gas pressure during the closure test shall stabilize within ±1 bar (±0,1 MPa) for valves up to PN 40 (Class 300) and ±3 bar (±0,3 MPa) for higher pressure valves.

A.5 Duration of closure test

The duration of each closure test shall be at least:

— 1 min for valves DN 10 to DN 50; NPS ⅜ to NPS 2;

— 3 min for valves DN 65 to DN 400; NPS 2 ½ to NPS 16;

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

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 the closure test of equal to or longer than the minimum required duration of the closure test.

The same minimum duration applies to the actual closure test.

A.6 Direction of closure test

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

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

Bidirectional valves shall be tested in both directions. In addition, in case of valves which have seats with bidirectional sealing like, for example, DBB, DIB-1 and DIB-2 valves, all sealings shall be tested.

A.7 Allowable seat leakage rates

The maximum allowable seat leakage shall be in accordance with Table A.1 or Table A.2.

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

<table>
<tr><th rowspan="2">Valve PN — Class</th><th colspan="2">Allowed seat leak
(mm^3/s) × 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 and PN 400 – Class 1 500 and Class 2 500</td><td>100</td></tr>
</table>

Table A.2 — Maximum allowable seat leakage rate per millimetre of nominal diameter (nitrogen)

<table>
<tr><th rowspan="2">Valve PN — Class</th><th colspan="2">Allowed seat leak
(mm^3/s) × 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">25</td><td rowspan="4">125</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 and PN 400 – Class 1 500 and Class 2 500</td><td>50</td></tr>
</table>

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

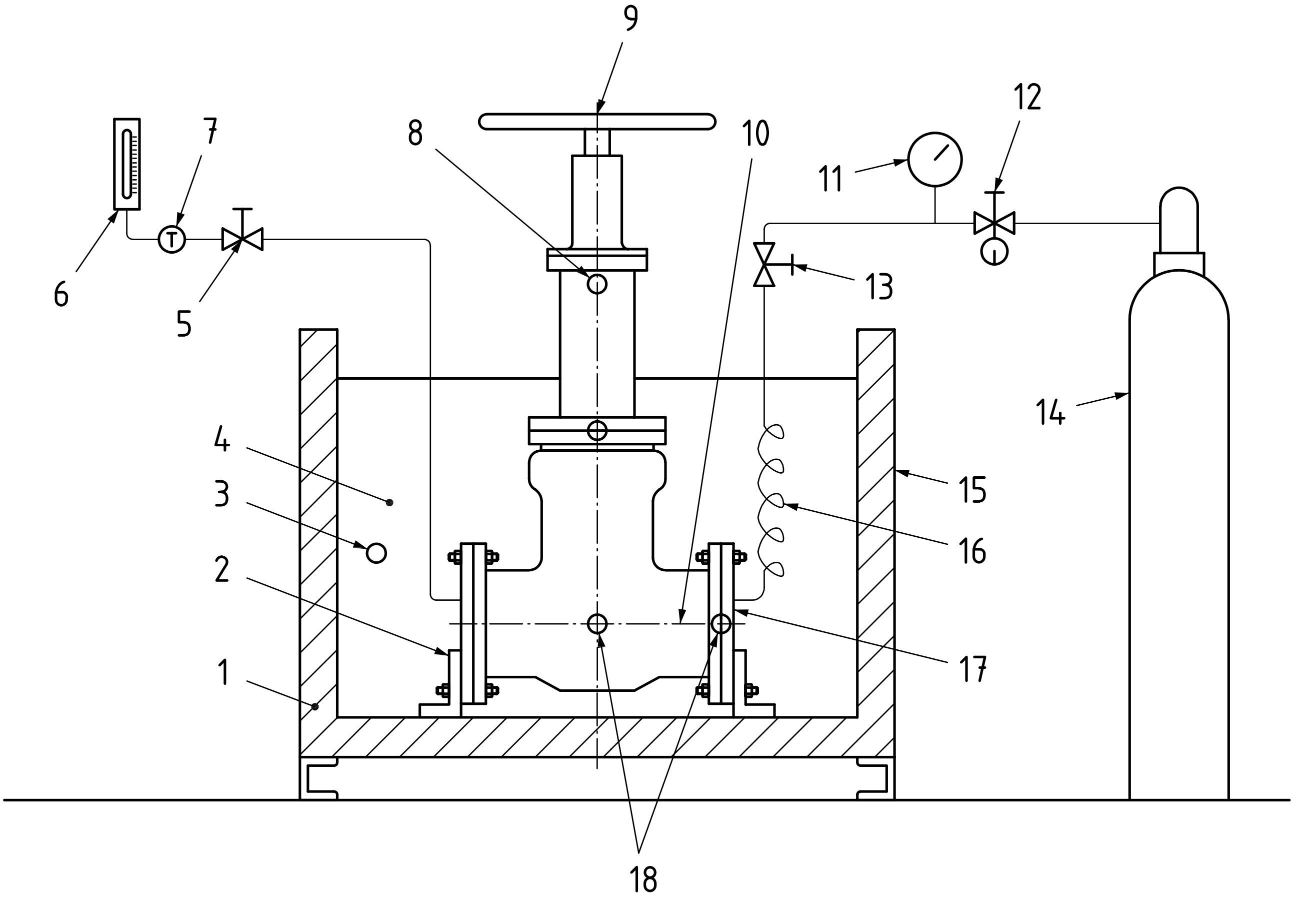
A.8.1 Test equipment

The cooling medium shall be contained in an insulated stainless-steel tank that is open on the top. When possible, 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. If not possible, stainless steel caps may be welded to the valve end exterior and small bore tubing connected to the pressurizing media. The caps shall be removed from the valve after the low temperature or cryogenic test has been finished.

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 (key 18), obturator area from valve interior (key 10) and the stuffing box area (key 8), 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 stuffing box area (key 8) and one inside the valve as close as possible to the obturator area (key 10) 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 stuffing box area	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.3.

Table A.3 — 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 can 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.4, from a charged bottle is used to provide test pressure on the inlet side of the valve.

Table A.4 — Test gas

Test gas	Test valve temperature
Nitrogen and minimum 97 % pure 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.

A.9 Flowmeter, 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 (for example, 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 are 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, Formulae (A.1) and (A.2), assuming constant pressure to determine the temperature correction for the flow rate.

$$V_1 \times T_2 = V_2 \times T_1 \quad \text{(A.1)}$$

$$Q_1 \times T_2 = Q_2 \times T_1 \quad \text{(A.2)}$$

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:	≤ mm^3/s
Flowmeter type:				Allowed external leak:	50 ppmv or — 1,78 × 10^{-6} mbar.l/(s.mm dia) for stem — 1,78 × 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)	

a) part 1/2

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

b) part 2/2

Figure B.1 — Low-temperature test record example

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