INTERNATIONAL STANDARD

ISO 19037

First edition
2019-06

Ships and marine technology — Gate valves for use in low temperature applications — Design and testing requirements

Navires et technologie maritime — Robinets vannes destinés aux applications à basse température — Exigences de conception et d'essai

Reference number
ISO 19037:2019(E)

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Published in Switzerland

Contents

Page

Foreword ..... **v**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **2**

4 Pressure-temperature rating **3**
4.1 Types of fluids 3
4.2 Working pressure and design temperature 3

5 Design **4**
5.1 General structure of a gate valve 4
5.2 Materials general 4
5.3 Types and materials of body 4
5.3.1 Types 4
5.3.2 Manufacturing 4
5.4 Design and materials of extended bonnet 5
5.4.1 Design 5
5.4.2 Materials 6
5.5 Design types and materials of wedge 6
5.5.1 Design 6
5.5.2 Materials 6
5.6 Types and materials of stem 7
5.6.1 Design 7
5.6.2 Materials 7
5.7 Stem sealing 7
5.8 Types and materials of a seat ring 7
5.8.1 Design 7
5.8.2 Materials 7
5.9 Types and materials of bolts and nuts 7
5.9.1 Design 7
5.9.2 Materials 8
5.10 Requirements of driving system and operating devices 8
5.11 Surface treatment 8

6 Welding heat treatment **8**
6.1 Welding 8
6.2 Heat treatment 9

7 Test and inspection **9**
7.1 Material test 9
7.2 Non-destructive inspection 9
7.2.1 Radiographic testing (RT) 9
7.2.2 Penetrant testing (PT) 10
7.2.3 Ultrasonic testing (UT) 10
7.2.4 Retest 10
7.3 Dimension check 10
7.4 Visual inspection 10
7.5 Heat treatment inspection 10
7.6 Operating tests 11
7.7 Pressure tests, back seat tests and leak tests 11
7.7.1 Pressure tests 11
7.7.2 Back seat tests 11
7.7.3 High-pressure pneumatic shell test 12
7.8 Fire safety test 12
7.9 Cryogenic tests 12
7.9.1 Scope of tests 12

7.9.2 Test procedure 12
7.9.3 Submission of test result 14
8 Marking 14
Annex A (informative) **Cryogenic gate valve — Example 15**
Bibliography 16

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).

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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 8, *Ships and marine technology*, Subcommittee SC 3, *Piping and machinery.*

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.

Ships and marine technology — Gate valves for use in low temperature applications — Design and testing requirements

1 Scope

This document specifies requirements of design, manufacture, and test methods for cryogenic gate valves to have excellent quality of leakage stability in very low temperature environments (–50 °C to –196 °C).

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 28921-1, *Industrial valves — Isolating valves for low-temperature applications — Part 1: Design, manufacturing and production testing*

API 598:2016, *Valve Inspection and Testing*

API 600:2015, *Steel Gate Valves, Flanged and Butt-Welding Ends*

ASME B1.5, *Acme Screw Threads*

ASME B1.8, *Stub Acme Screw Threads*

ASME B1.20.1, *Pipe Threads, General Purpose (Inch)*

ASME B16.5, *Pipe Flanges and Flanged Fittings*

ASME B16.10, *Face-to-Face and End-to-End Dimensions of Valves*

ASME B16.11, *Forged Fittings, Socket-Welding and Threaded*

ASME B16.25, *Butt-welding Ends*

ASME B16.34:2017, *Valves-Flanged, Threads, and Welding End*

ASME B46.1, *Surface Texture (Surface Roughness, Waviness, and Lay)*

ASME B16.47, *Large diameter steel flanges: NPS 26 through NPS 60 Metric/Inch Standard*

ASME Sec. V, *Nondestructive examination, RT, UT, PT mentioned in this document*

ASME Sec. VIII, Div.1:2018, *Pressure Vessels*

ASTM A53, *Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless*

ASTM A105/A105M, *Forgings, Carbon Steel, for Piping Components*

ASTM A106, *Seamless Carbon Steel Pipe for High-Temperature Service*

ASTM A182/A182M, *Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings and Valves and Parts for High-temperature Service*

ASTM A194/A194M, *Carbon and Alloy Steel Nuts and Bolts for High-Pressure and High Temperature Service*

ASTM A216/216M, *Steel Castings, Carbon Suitable for Fusion Welding for High-Temperature Service*

ASTM A312, *Grade TP304L, TP316*

ASTM A320/A320M, *Alloys-Steel Bolting Material for Low-Temperature Service*

ASTM A350/A350M, *Forgings, Carbon and Low-Alloy Steel, Requiring Notch Toughness Testing for Piping Components*

ASTM A351/A351M, *Casting, Austenitic, Austenitic-Ferritic (Duplex), for Pressure-Containing Parts*

ASTM A358, *Grade 304L, 316L*

ASTM A694/694M, *Forgings, Carbon and Alloy Steel, for Pipe Flanges, Fittings, Valves, and Parts for High-Pressure Transmission service*

ASTM E186, *Reference Radiographs for Heavy-Walled (2 to 41/2-in) Steel Castings*

ASTM E446, *Reference Radiographs for Steel Castings up to 2in. in Thickness*

MSS SP-55, *Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components (Visual Method)*

3 Terms and definitions

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

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

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

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

3.1
nominal diameter
DN
alphanumeric designation of size for components of a pipework system, used for reference purposes which comprises the letters DN followed by a dimensionless whole number that is related to the physical size, in millimetres, of the bore or outside diameter of the end connections

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

Note 2 to entry: In those standards that use the DN designation system, any relationship between DN and component dimensions shall be given, e.g. DN/OD or DN/ID.

[SOURCE: ISO 18139:2017, 3.1]

3.2
nominal pressure
PN
numerical designation relating to pressure that is a convenient round number for reference purposes

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

Note 2 to entry: The permissible working pressure depends upon materials, design and working temperature and has to be selected from the pressure/temperature rating tables in corresponding standards.

[SOURCE: ISO 18139:2017, 3.2]

3.3
nominal pipe size
NPS
dimensionless number for the purpose of pipe, flange, or flanged fitting end connection size identification

Note 1 to entry: The number is not necessarily the same as the flange or flanged fitting inside diameter.

[SOURCE: ISO 18139:2017, 3.3]

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

[SOURCE: ISO 18139:2017, 3.4]

4 Pressure-temperature rating

4.1 Types of fluids

The types of fluids and associated temperatures are shown in Table 1.

Table 1 — Types of fluids

Type	Temperature (in atmospheric pressure)	Liquid density (density)
LNG (Liquefied natural gas)	−163 °C to −88 °C	434 kg to 478 kg/m^3
NG (Natural gas)	−160 °C to −65 °C	(0,7 kg to 0,89 kg/m^3)
LN2 (Liquefied nitrogen)	−196 °C	804 kg/m^3
N2 (Nitrogen)	−196 °C to −65 °C	(1 184 kg/m^3)

4.2 Working pressure and design temperature

The valve shall be designed to operate without failure or leakage at the extreme temperatures and pressure ranges expected in service.

Class and maximum working pressure shall satisfy the standard class specified in ASME B16.34.

The manufacturers and the purchasers may reach an agreement when Class exceeds 900.

The working pressure and design temperature for this valve are shown in Table 2.

Table 2 — Working pressure and design temperature

Class	Maximum pressure MPa	Note
150	2,0	in ambient temperature
300	5,2	
600	10,3	
800	13,8	
900	15,5	

NOTE Working pressure is set following a piping design condition that is provided by the purchasers.

5 Design

5.1 General structure of a gate valve

This valve shall be structured as outside screw and yoke (OS&Y), bolted bonnet (BB), flexible wedge and extended bonnet. When the valve is opening, the stem of the valve shall be rising. The hand wheel shall be rising or non-rising. Composition, function and standardization of the valve shall be satisfied with the requirements of the following sections.

5.2 Materials general

Throughout this document, materials are specified for each of the various parts of the valve. In lieu of the materials specified, other materials may be used provided they are manufactured by the same process as the material specified, such as forging, casting, bar, or seamless pipe. In addition, the material shall be suitable for the operating temperatures of the valve and the materials shall have mechanical properties, including low temperature impact resistance, and resistance to corrosion equal to or better than the material specified for the specific valve part.

5.3 Types and materials of body

5.3.1 Types

a) The gate valve shall be a top entry bolted bonnet type.

b) Materials shall be equal quality or better than the materials shown in Table 3. Welded ends type valve materials may be used for flanged ends types.

Table 3 — Materials by manufacturing method

Manufacturing method	Materials	
	Flanged ends type	Welded ends type
Forging	ASTM A182 F304, F316	ASTM A182 F304L, F316L
Casting	ASTM A351 CF8, CF8M	ASTM A351 CF3, CF3M

5.3.2 Manufacturing

The valve shall be manufactured per the following procedure except for special orders by the purchaser.

5.3.2.1 A port shall be a 'full port (full bore) type', and the inside diameter shall comply with ASME B16.34:2017, Annex A.

5.3.2.2 Face-to-face and end-to-end dimensions shall satisfy ASME B16.10.

5.3.2.3 Minimum wall thickness of the body shall be as shown in ASME B16.34.

5.3.2.4 End connection of the body is classified with 'welding ends' type or 'flanged ends' type, and shall be manufactured as below.

5.3.2.4.1 Welding type

a) NPS 2 (DN 50) and under: 'socket welding ends'

- Class 150, 300: to the requirements of Class 3000 in ASME B16.11
- Class 600: to the requirements of Class 6000 in ASME B16.11
- Class 800 to Class 1500: to the requirements of Class 9000 in ASME B16.11

b) NPS 2 1/2 (DN 65) and over: butt welding ends

- Thickness of connected pipes under schedule 40s shall satisfy schedule 40s and be manufactured in accordance with ASME B16.25.
- Thickness of connected pipes over schedule 40s: shall satisfy thickness of connected pipes and be manufactured in accordance with ASME B16.25.
- Thickness of connected pipes shall satisfy 'line schedules', which is given by the purchasers.

5.3.2.4.2 Flanged ends type

a) NPS 24 (DN 600) and under: to satisfy ASME B16.5

- Class 150 (PN 20), Class 300 (PN 50): raised face (RF) type flange
- Class 600 (PN 110) and over: large groove face (LGF) type flange or raised face (RF) type flange

b) Over NPS 26: to satisfy ASME B16.47

- Class 150(PN 20), Class 300 (PN 50): raised face (RF) type flange
- Class 600 (PN 110) and over: large groove face (LGF) type flange or raised face (RF) type flange

c) Processing accuracy of face shall satisfy ASME B16.5 and ASME B16.47, and also be measured in accordance with ASME B46.1.

5.4 Design and materials of extended bonnet

5.4.1 Design

Design of the extended bonnet is as follows:

a) Minimum wall thickness shall be thicker than the values shown in ASME B16.34 for corrosion, thermal stress, etc.

b) Flange connection of the bonnet connected to the body shall satisfy API 600:2015, 2.2.2 to 2.2.4.

c) Length of the extended bonnet shall satisfy ISO 28921-1.

d) An insulation collar and drip plate may be installed on the stem of the extended bonnet where not insulated.

e) Insulation line shall be specified on a design drawing so that the valve operating area does not freeze.

f) The back seat shall be installed inside of the extended bonnet.

5.4.2 Materials

Manufacturing methods shall be casting or welded casting (forging) parts and connected pipe.

a) In case of casting: materials shall be equal to or better than materials specified for the body

b) Welded casting (forging) part and connected pipe

- Casting area: ASTM A351 CF3, CF3M
- Forging area: ASTM A182 F304L, F316L
- Connected pipe area: ASTM A312 or equal to ASTM A358 304L, 316L or better
- Connected pipe shall be seamless pipe or one longitudinal seam; orbital welding methods are not allowed.

5.5 Design types and materials of wedge

5.5.1 Design

5.5.1.1 The wedge shall be one piece and of the flexible type.

5.5.1.2 Wear of the seat ring shall be minimized when the wedge and shell are working, and a wedge guide shall be installed to align the wedge and stem in a line.

5.5.1.3 Flow direction shall be specified by the customer. The valve shall be manufactured based on the requirements below in order to prevent abnormal pressures that may result from evaporating liquid remaining in the sealed structure of the valve body when the valve is closed.

5.5.1.4 Unidirectional valve

- A vent hole shall be manufactured in the upstream side of the wedge to balance pressure in the centre cavity.

5.5.1.5 Bidirectional valve

- A system to remove abnormally high pressure in the valve cavity shall be installed as follows:

  a) Materials: austenitic steel and stainless steel

  b) Standardization and size: the thread manufacture shall satisfy ASME B1.20.1

  - NPS 1/2 thick-walled stub (thread)
  - NPS 1/2 body root ball valve (thread, class and material is the same as gate valve body or better material)
  - NPS 1/2 pipe (thread, relief valve, using front side)
  - NPS 1/2X3/4 cavity relief valve (thread, valve pressure levels are the same as the gate valve pressure)
  - NPS 3/4 pipe (thread, relief valve, using back side)

5.5.2 Materials

Materials shall satisfy ASTM A182 F316, ASTM A351 CF8M or equal and better than body's materials. A part which is adhered to a seat ring needs a hard surface treatment to improve wear resistance. The thickness of hard surface treatment shall be at least 1,6 mm.

5.6 Types and materials of stem

5.6.1 Design

a) A stem shall be an 'extended stem type' unless there are special orders.

b) Minimum diameter of the stem shall satisfy API 600:2015.

c) A stem part connected to the wedge shall not be detached when the valve is working and it shall have sufficient strength.

d) The outer surface of the stem shall precisely adhere to packing in order to retain sealing, and be accurately fabricated (surface roughness: less than 0,8 µm) to not be damaged when the valve is working.

e) When the valve is fully open, the stem parts contacting the back seat shall be made in 'coning type' or 'spherical type' to adhere to the back seat correctly.

f) Threads of the stem shall satisfy ASME B1.5 or ASME B1.8.

5.6.2 Materials

Materials of a stem shall be ASTM A182 F316, or equal to or better than body's materials.

5.7 Stem sealing

a) The stem shall be sealed with an appropriate structure (e.g. stem packing, lantern ring) to prevent leakage.

b) Packing for stem sealing shall have enough sealing characteristics and strength to prevent damages when the valve is open/closed repeatedly.

c) The packing materials for stem sealing may be PTFE, or other materials agreed to between manufacturer and purchaser. However, packing materials shall not chemically react to the working fluid or otherwise create physical deposits.

d) Packing arrangements for stem sealing shall be easily replaceable.

5.8 Types and materials of a seat ring

5.8.1 Design

The seat ring and wedge width of the valve body shall satisfy API 600 2.3.9, considering wear between the seat ring and wedge as a result of the stem's reciprocating motion when the valve is opened.

5.8.2 Materials

Materials for the seat ring shall be ASTM A182 F316, or equal to or better than body's materials. A part that adheres to a face of a wedge needs a hard facing treatment to improve wear resistance. In case of the soft seat type wedge (disc), hard facing of seat face is not required. The thickness of any hard surface treatment shall be thicker than 1,6 mm.

5.9 Types and materials of bolts and nuts

5.9.1 Design

Bolts and nuts for bonnet flanges, yokes and gland flanges shall satisfy API 600.

5.9.2 Materials

Materials of bolts and nuts are shown as below.

a) Materials of the bolts shall be equal to or better than ASTM A320 Gr. B8 Class 2.

b) Materials of the nuts shall be equal to or better than ASTM A194 Gr. 8.

5.10 Requirements of driving system and operating devices

5.10.1 Manual operation shall be hand wheel type and the operating effort in the end of the manual operating device shall not exceed maximum 360 N (36 kgf) under differential pressure condition of working pressure.

5.10.2 Materials for manual operating devices shall be equal to or better than as listed below, and require treatment (for instance galvanizing) to prevent corrosion. Operating devices shall be designed and manufactured to resist the stress created by the working nominal pressure.

a) Materials of gear operation types

— ASTM A105, A350 LF2, A694 F52, ASTM A216 WCC or better.

b) Materials of hand wheel types

— Ductile Cast Iron, ASTM A53, ASTM A106 or better.

5.10.3 Explosion class of power-operating devices (especially electric explosion proof devices) shall satisfy the explosion safety criteria of any hazardous area where a valve is to be installed.

5.10.4 A position indicator shall be installed to indicate the open or closed position of the valve. Additionally, a position indicator and a limit switch shall be installed on auto-operating devices to check the position of wedge of the valve. The sensor shall not apply any excessive force to the stem and the seat ring when the valve is open/closed.

5.10.5 Sealing class for gear operators shall be water/rain proof.

5.10.6 Opening of valve shall be in a counter-clockwise direction of the handwheel.

5.10.7 Installation of a water-proof protector should be considered in order to protect the stem.

5.11 Surface treatment

All valves shall be subjected to pickling and passivation treatment.

6 Welding heat treatment

6.1 Welding

a) Welding shall be conducted as per a welding procedure specification (WPS) and procedure qualification record (PQR) in accordance with approved standards. However, repair of crack defects by welding is not allowed.

b) Non-destructive inspection for any repair welding shall be conducted by an appropriate inspection procedure.

6.2 Heat treatment

Heat treatment shall be conducted by heat treatment standards appropriate to the materials.

7 Test and inspection

All tests and inspections shall be conducted by related standards, test procedures, inspection procedures and working drawings based upon agreement between the purchasers and the manufacturers. Also these may be conducted by the purchasers or third parties whom the purchasers select.

7.1 Material test

7.1.1 Chemical analysis, mechanical tests and cryogenic impact testing shall be conducted on materials used for valve components (body, wedge, stem, connected pipes, seat ring, extended bonnet, bolts and nuts).

7.1.2 Cryogenic impact tests shall be conducted at −196 °C in accordance with ASME Sec. VIII, Div. 1:2018, Paragraphs UHA 51 and UG 84. Additionally the three specimens lateral expansions shall be more than 0,381 mm in an impact test.

7.1.3 The amount of δ-ferrite in materials of valve body shall be between 5 % and 10 %.

7.2 Non-destructive inspection

The purchasers and manufacturers may reach an agreement before inspections. Radiographic testing radiographs and non-destructive inspection interpretation result reports shall be stored and maintained at least for five years. Also, related radiographs and reports shall be submitted to the purchaser upon request.

7.2.1 Radiographic testing (RT)

The test scope is as below.

a) It shall satisfy ASME B16.34:2017, Chapter 8. Radiographic testing shall be conducted at the welded part of every casting valve and critical area. The end parts of bodies shall be inspected before machining bevels.

b) In case of casting valves, 5 % (at least one) of all the numbers (casting parts) are sampled and then tested about the critical areas shown in ASME 16.34. If there are defects, an additional 10 % of all the numbers (casting parts) are sampled and tested. Defects shown at this time result in failure of all casting parts.

The test procedure and acceptance criteria are as below.

a) It shall satisfy ASME Sec. V and ASME B16.34 mandatory appendix.

b) In case of casting parts, it shall be compared with reference radiographs which satisfy ASTM E446 (wall thickness less than 50,8 mm) and ASTM E186 (wall thickness between 50,8 mm and 114,3 mm) and then radiograph interpretation shall be conducted.

c) Acceptance criteria of casting parts shall satisfy ASME 16.34.

d) Acceptance criteria of welded parts shall satisfy ASME Sec. VIII, Div. 1:2018, UW-51 and Appendix 4.

7.2.2 Penetrant testing (PT)

The test scope is as below.

a) Penetrant testing shall be conducted 100 % on the body, outside surface of the bonnet and the inside surface of bonnet that can be inspected. Also, PT shall be performed on machined surfaces of bevels, sockets and welded fillets (lifting lug, supporting leg, etc.) for which radiographic testing is impossible.

b) When casting cracks exist, penetrant testing shall be conducted 100 % on elimination areas of crack.

c) Penetrating testing shall be conducted 100 % on bolts over 25,4 mm length.

d) Penetrating testing shall be conducted 100 % on plug and body seating surfaces. Also it shall be conducted after surface machining on plug and body seat ring for which hard surface treating is conducted.

e) Penetrating testing shall be conducted 100 % on every welded sealing area.

The test procedure shall satisfy ASME Sec. V and ASME B16.34:2017, Appendix 3. Acceptance criteria is as below.

a) Casting, forging: ASME B16.34:2017, Annex D.

b) Welded areas: ASME Sec. VIII, Div.1:2018, Appendix 8.

7.2.3 Ultrasonic testing (UT)

The test scope is as below.

a) Ultrasonic testing shall be conducted 100 % on body and bonnet of forging valves in accordance with ASME B16.34:2017, Chapter 8.

b) Ultrasonic testing shall be conducted 100 % on stems of every valve.

c) Test procedure shall satisfy ASME Sec. V and ASME B16.34:2017, Appendix IV.

d) Acceptance criteria shall satisfy ASME B16.34:2017, Annex E.

7.2.4 Retest

If the inspection result fails, relevant areas shall be retested after repair work.

7.3 Dimension check

Main dimensions shall be verified to the relevant standards and drawings of the manufacturers.

7.4 Visual inspection

The valve shall be checked for scratches, cracks, creases, contractions, spurs, moulding sand and corrosion etc., on the surface of the valve casting in accordance with MSS SP-55. Also the machined/seat ring surface shall be checked for defects. There shall not be flaws, under-cut, arc strikes etc., on the welded parts, and height of the bead on welded parts shall not be lower than the basic material surface.

7.5 Heat treatment inspection

It shall be conducted by standards for which the purchasers and manufacturers reach an agreement. There are heating temperatures, heating methods, heating time, holding time, cooling speed, and cooling methods written in the standards.

7.6 Operating tests

Operating tests of finished valves shall be conducted at least five times. It shall be conducted without any pressure the first two times. The remaining tests shall be made with nominal pressure, checking for proper operation and no defects. Required operating effort shall not exceed maximum 360 N.

7.7 Pressure tests, back seat tests and leak tests

These tests shall be conducted according to API 598 in order to check the strength and leakage of valves on every finished valve. The test results shall be submitted as recorded charts by a pressure recorder. Additionally, when blocking the valve entry and exit ports for pressure and leak tests, test devices shall not apply undue stress to the valve body.

7.7.1 Pressure tests

Put pressure on the upper area of fluid flow direction to inspect for leakage on the lower area for leakage test.

Manufacturers and purchasers may reach an agreement regarding additional test mediums other than those shown in Table 4.

Table 4 — Pressure tests

Clause	Shell pressure test	Low pressure closure test	High pressure closure test
Test medium	Volatile liquids as kerosene, methanol, alcohol, etc.	Dried air or nitrogen	Volatile liquids as kerosene, methanol, alcohol, etc.
Test pressure	1,5 times maximum working pressure at 38 °C specified in ASME B16.34:2017, Table 2-2.1B and 2.2B (special class) (slightly open)	0,7 MPa (closed)	1,1 times maximum working pressure at 38 °C specified in ASME B16.34:2017, Table 2-2.1B and 2.2B (special class) (closed)
Test time	Minimum 5 min	Minimum 5 min (bubble test time)	Minimum 5 min
Test method	Tightening packing gland completely	Tightening packing gland completely	Tightening packing gland completely
Acceptable criteria	No leakage	API 598	API 598

7.7.2 Back seat tests

The back seat tests are conducted upon request of purchaser.

Manufacturers and purchasers may reach an agreement regarding additional test mediums other than those shown in Table 5.

Table 5 — Back seat tests

Clause	High pressure back seat test	Low pressure back seat test
Test medium	Volatile liquids as kerosene, methanol, alcohol, etc.	Dried air or nitrogen
Test pressure	1,5 times maximum use pressure at 38 °C specified in ASME B16.34:2017, table 2-2.1B and 2.2B (special class) (fully open)	0,7 MPa (closed)
Test time	Minimum 5 min	Minimum 5 min

Table 5 *(continued)*

Clause	High pressure back seat test	Low pressure back seat test
Test method	Loosening packing gland completely	Loosening packing gland completely
Acceptable criteria	No leakage from packing gland	No leakage from packing gland

7.7.3 High-pressure pneumatic shell test

The high-pressure pneumatic shell test shall be conducted after shell pressure tests.

Table 6 — High-pressure pneumatic shell test

Clause	High-pressure pneumatic shell test
Test medium	Dried air or nitrogen
Test pressure	1,1 times maximum working pressure (slightly open)
Test time	Minimum 5 min
Acceptable criteria	No leakage from shell or packing gland
Bi-Directional	Attach relief valve during the test

7.8 Fire safety test

The fire safety test can be replaced by an API 6FA certificate.

7.9 Cryogenic tests

Tests shall be conducted as specified below. If necessary, other test requirements not mentioned in this paragraph shall satisfy ISO 28921-1.

7.9.1 Scope of tests

a) 5 % (at least one) of all valves classified by size and pressure class are sampled and tested.

b) If there are failures, an additional 10 % of all the numbers are sampled and tested. Defects shown at this time result in failure of all valves. Acceptable criteria for cryogenic tests means that each test result satisfies the criteria for the initial proving test, cryogenic performance test, returning ambient temperature test, and disassembly.

7.9.2 Test procedure

Cryogenic tests shall be conducted in the following order for type test:

1) initial proving test,

2) cryogenic performance test,

3) returning ambient temperature test.

In the case of product testing, only test 2) is required. Test methods and procedures are as below.

7.9.2.1 Initial proving test

This test is conducted before cryogenic tests to check leakage from valves. It shall be conducted as described below with the valve closed.

a) Test temperature: ambient temperature

b) Test medium: helium or N_2 gas

c) Test pressure: 1,1 times working pressure, putting pressure on upstream area

d) Test time: 5 min

e) Acceptable leakage amount: no visible leaks

7.9.2.2 Cryogenic performance tests

a) Preparing tests

1) Appropriate test devices for cryogenic tests shall be manufactured to ISO 28921-1. Thermocouples shall be installed on appropriate positions for the valve body, bonnet, gland housing, etc.

2) The body and the bonnet connection shall be cooled down in a liquid nitrogen container. The inside of the valve shall be purged by helium during cool down, and the temperature on inside and outside of valve body, bonnet, gland housing checked by thermocouple.

b) Test types and methods

When −196 °C is set steadily, the valve shall be tested as below.

1) Cryogenic closure test: It shall be conducted according to 7.9.2. The temperature shall be −196 °C and the acceptable leakage rate under ISO 5208, Class D. Stage of pressure rising methods to test pressure is in Table 7.

2) Cryogenic operating test (for type test only): Open-close test shall be conducted at least 1 time under differential pressure condition of working pressure in −196 °C. Operating effort shall be checked at the end of operating device when the valve is open or closed and then recorded the result (an acceptable criterion is under 400 N (40 kgf)). Also it shall be conducted more than 5 times under working pressure with no differential pressure.

Table 7 — Stage of pressure rising methods classified by valve pressure (reference)

Valve pressure class	Pressure rising value classified stage [MPa]	Holding time classified pressure rising stage	Note
Class 150	0,35	10 min	Checking and recording leakage classified pressure rising stage
Class 300	0,75	10 min	
Class 600	1,0	10 min	
Over Class 800	2,0	10 min	

7.9.2.3 Returning ambient temperature test

When cryogenic tests are finished, tests shall be conducted as below after the temperature of the valve reaches ambient temperatures.

a) Leakage test in ambient temperature

Valve leakage shall be checked to 7.9.2.1. Maximum acceptable leakage rate classified by NPS shall satisfy API 598:2016, Table 5.