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

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Foreword

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

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For an explanation on 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 the following URL: 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 — Check 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 check 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 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 594, *Check Valves: Flanged, Lug, Wafer, and Butt-welding*

API 598:2016, *Valve Inspection and Testing*

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

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

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

ASME B16.25, *Buttwelding Ends*

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

ASME BPVC Sec. V, *Nondestructive Examination*

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

ASTM A182, *Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service*

ASTM A194, *Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both*

ASTM A320, *Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service*

ASTM A351/A351M, *Standard Specification for Castings, Austenitic, for Pressure-Containing Parts*

ASTM E186/280/446, *Standard Reference Radiographs for Heavy-Walled Steel Castings*

BS 1868, *Specification for steel check valves (flanged and butt-welding ends) for the petroleum, petrochemical and allied industries*

BS 6364, *Specification for valves for cryogenic service*

MSS SP-55, *Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components - Visual Method for Evaluation of Surface Irregularities*

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:

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

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

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 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 designed 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 meet the requirements of 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 these valves are shown in Table 2.

Table 2 — Working pressure and design temperature

PN	Class	Maximum pressure MPa	Note
20	150	2,0	in ambient temperature
50	300	5,2	
100	600	10,3	
128	800	13,8	
150	900	15,5	

NOTE Working pressure is based on the piping design condition provided by the purchasers.

5 Design

5.1 General structure of a check valve

The valve shall be designed as a 'swing', 'dual plate' or 'lift' configuration. Function and standardization of the valve shall be satisfied with the following requirements. The manufacturers shall follow agreements with each other if there are minor differences from this document.

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 Body

5.3.1 Materials

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' type.

Table 3 — Materials by manufacturing method

Manufacturing method	Materials	
	Flanged ends type	Welding 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 according to the following procedures.

5.3.2.1 Face-to-face and end-to-end dimensions shall meet the requirements of the following standards:

a) swing type: ASME B16.10;

b) dual plate type: API 594;

c) lift type: ASME B16.10.

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

5.3.2.3 The end connection of the body is classified as 'welding ends' type or 'flanged ends' type and shall be manufactured as below.

5.3.2.3.1 Welding ends type

a) Socket welding ends

- Class 150, 300: to the requirements of Class 3 000 in ASME B16.11
- Class 600: to the requirements of Class 6 000 in ASME B16.11
- Class 800 to 1 500: to the requirements of Class 9 000 in ASME B16.11

b) Butt welding ends

- Thickness of connected pipes under Sch. 40s shall meet the requirements of Sch. 40s and be manufactured according to ASME B16.25.
- Thickness of connected pipes over Sch. 40s: shall be at least the thickness of connected pipes and be manufactured according to ASME B16.25.
- Thickness of connected pipes shall meet the requirements of 'pipe schedules' given by the purchasers.

5.3.2.3.2 Flanged ends type

a) NPS 24 and under: to meet the requirements of ASME B16.5

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

b) Over NPS 26: to meet the requirements of ASME B16.47

- Class 150, Class 300: raised face (RF) type flange
- Over Class 600: large groove face (LGF) type flange or raised face (RF) type flange

c) Processing accuracy of face shall meet the requirements of ASME B16.5 and ASME B16.47, and also be measured according to ASME B46.1.

- Raised face (RF) type flange: 3,2 µm Ra to 6,3 µm Ra (125 µm to 250 µm)
- Large groove face (LGF) type flange: Less than 3,2 µm Ra (125 µm)

5.3.2.4 A valve lifting lug and supporting leg may be installed on the valve to facilitate delivery and use. The size should be determined by agreement between manufacturers and the purchasers.

5.4 Cover (bonnet)

5.4.1 Types

The welding connection between bonnet and body shall be welded by screw type after first combination.

5.4.2 Materials

Materials shall be ASTM A182 F316, ASTM A351 CF8M or equal to or better than body's materials.

5.5 Disc

5.5.1 Types

Discs may be manufactured as solid type (one-piece type) and dual type.

5.5.2 Materials

Materials shall meet the requirements of ASTM A182 F316, ASTM A351 CF8M or be equal to or better than body's materials. A part adhered to a body ring needs a hard surface treatment to improve wear resistance. The thickness of a hard surface treatment shall be thicker than 1,6 mm.

5.6 Gasket

A material that can be used in temperatures from –196 °C to +100 °C shall be used.

5.7 Valve Seat

5.7.1 Types

The valve seat in the body shall block the flow by mating with the disc.

5.7.2 Materials

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

5.8 Hinges and hinge pin (as applicable)

5.8.1 Types

It shall be installed in the body and be solid.

5.8.2 Materials

ASTM A182 F316 or equal to ASTM A351 CF8M or better.

5.9 Bolts and nuts

5.9.1 Types

Bolts and nuts for bonnet flanges shall meet the requirements of BS 1868.

5.9.2 Materials

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

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

6 Surface treatment

All valves shall be treated using pickling and passivation.

7 Welding and heat treatment

7.1 Welding

a) Welding shall be conducted in accordance with an approved WPS (welding procedure specification) and PQR (procedure qualification record).

b) Repair welding and non-destructive inspection for repair welding parts shall be conducted by agreement between the manufacturers and purchasers. However, it is not allowed to repair crack defects by welding.

7.2 Heat treatment

Heat treatment shall be conducted by agreement between the manufacturers and purchasers.

8 Test and inspection

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

8.1 Material test

8.1.1 Chemical analysis, mechanical tests and cryogenic impact test shall meet the requirements of standards for body, plug, pin, seat ring, bolts, cover and nuts as applicable.

8.1.2 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 impact test.

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

8.2 Non-destructive inspection

The purchasers and manufactures 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. Related radiographs and reports shall be submitted upon the purchaser's request.

8.2.1 Radiographic testing (RT)

The test scope is as below.

a) It shall meet the requirements of ASME B16.34:2017 Chapter 8. Radiographic testing shall be conducted at welding part of every casting valve and critical area. The end part 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. If further defects are revealed at this time, all casting parts are considered to fail.

The test procedure and acceptance criteria are as below.

1) It shall meet the requirements of ASME Sec. V and ASME B16.34:2017, Annex B.

2) In case of casting parts, it shall be compared with reference radiographs that meet the requirements of 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.

3) Acceptance criteria of casting parts shall meet the requirements of ASME 16.34.

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

8.2.2 Penetrant testing (PT)

The test scope is as follows.

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

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

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

d) Penetrant testing shall be conducted 100 % on disc and body seat. Also it shall be conducted after surface machining on disc and body seat where hard surface treatment is conducted.

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

The test procedure shall meet the requirements of ASME Sec. V and ASME B16.34:2017, Appendix 3.

Acceptance criteria are as below.

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

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

8.2.3 Ultrasonic testing (UT)

The test scope is as below.

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

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

The test procedure shall meet the requirements of ASME Sec. V and ASME B16.34:2017, Appendix IV.

Acceptance criteria shall meet the requirements of ASME B16.34:2017, Annex E.

8.2.4 Retest

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

8.2.5 Reporting test result

The manufacturers shall submit the test results in a report to the purchasers. A drawing sketch shall be included indicating inspection points.

8.3 Dimension check

Main dimensions shall be verified for compliance with relevant standards and drawings which the manufacturers submit.

8.4 Visual inspection

The valves shall be visually checked for scratches cracks, creases, contractions, spurs, moulding sand and corrosion, etc., on the surface according to MSS-SP-55. Additionally, the machined/seat ring surface shall be inspected for damage. There should be no flaws, under-cut, arc strikes, etc., on welding parts, and the bead height on welding parts shall not be lower than the basic material surface.

8.5 Heat treatment inspection

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

8.6 Pressure tests

These tests shall be conducted in accordance with API 598 to check the strength and leakage of every finished valve. The test results shall be submitted as record. When blocking the entry and exit ports for pressure and leak tests, appropriate test devices shall be installed so as to not apply stress to the valve body.

Table 5 — Pressure tests

Clause	Shell pressure test	High pressure closure test
Test medium	Volatile liquids as kerosene, methanol, alcohol, etc.	Volatile fluids as kerosene, methanol, alcohol, etc.
Test pressure	1,5 times pressure rating at 38 °C which is specified in ASME B16.34:2017, Table 2-2.1B and 2.2B (special class) (slightly open)	1,1 times maximum working pressure at 38 °C which is specified in ASME B16.34:2017, Table 2-2.1B and 2.2B (special class) (closed)
Test time	Minimum 5 min	Minimum 5 min
Acceptable criteria	No leakage	No leakage, but dual plate type shall be less than (1 016 ml/(min·mm) of DN

NOTE Seat leakage test (seat closure test) is conducted by putting pressure on the discharge side of the check valve (i.e. reverse of normal flow direction) and checking for any leakage through to the inlet side.

The end flange type and dual plate check valves shall meet the requirements of ASME B16.34 in standard class ratings.

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

8.7 Fire safety test

An API 6FA certificate is considered acceptable.

8.8 Cryogenic tests

Cryogenic tests shall be conducted as specified below. Requirements not mentioned below shall be in accordance with ISO 28921-1.

8.8.1 Test scope

a) 5 % (at least one) of all the production numbers classified by size and pressure classes are sampled and tested.

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

8.8.2 Test procedure

Cryogenic tests shall be conducted in the following order: initial proving test, cryogenic performance test, returning ambient temperature test, disassembly test. Test procedures are as below.

8.8.2.1 Initial proving test

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

a) Test temperature: ambient temperature

b) Test medium: helium, N_2 gas or dry air

c) Test pressure: 1,1 times working pressure put on downstream area

d) Test time: 5 min

e) Acceptable leakage amount:

Lift: 0 cm^3/(min × mm); swing: 0 cm^3/ (min × mm); dual plate: 1 016 cm^3/(min × mm).

8.8.2.2 Cryogenic performance tests

8.8.2.2.1 Preparing tests

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

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

8.8.2.2.2 Test types and methods

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

a) Cryogenic shell pressure test: Test medium shall be helium. Test procedure is that it shall be tested to 1,1 times working pressure for 15 min when the valve is slightly open. There shall also be no leakage through the connection between the body and valve cover.

b) Initial proving test: It shall be conducted according to 8.8.2.1. At this time, the temperature shall be –196 °C. The lift, swing, and dual plate type acceptable leakages shall be 0, 508, and 7 620 cm^3/(min × mm) respectively.

8.8.2.3 Returning ambient temperature test

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

8.8.2.4 Leakage test in ambient temperature

Leakage of valve shall be checked according to 8.8.2.1. Maximum acceptable leakage rate classified by NPS shall meet the requirements of API 598:2016, Table 5.

8.8.2.5 Disassembly test

It shall be conducted in a clean space after the returning ambient temperature test. The valve shall be disassembled and the components checked for damage or wear.

8.8.2.6 Final leakage test

After disassembly test, the valve shall be reassembled, and then the low pressure closure test and high pressure closure test and back seat test shall be conducted according to 8.6.

8.8.3 Submission of test result

After cryogenic tests, a test report including the following contents shall be submitted.

a) Initial proving test result in ambient temperature (8.8.2.1).

b) Bolting torque of valve body and bonnet (cover) (8.8.2.2.1).

c) Temperature check result in cryogenic temperature [8.8.2.2.1 b)].

d) Leakage test result classified by pressure stages in cryogenic temperature [8.8.2.2.2 b)].

e) Shell pressure test result in cryogenic temperature [8.8.2.2.2 a)].

f) Leakage test result after returning to ambient temperature (8.8.2.3).

g) Status of valve components after cryogenic tests and disassembly (8.8.2.4).

h) Final leakage test result after returning to ambient temperature (8.8.2.5).

9 Marking

Contents marked on valve body shall meet the requirements of ISO 5209, and fluid flow direction shall be marked.

Contents marked on a name tag shall meet the requirements of ISO 5209. The manufacturers and the purchasers may reach an agreement about tag standards, materials, designation method, and attachment location.