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

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

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Contents

Page

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 — Butterfly valves for use in low temperature applications — Design and testing requirements

1 Scope

This document specifies requirements for design, manufacture, and test methods of cryogenic butterfly valves in order to have an excellent quality leakage stability in a very low temperature service (–196 °C to 80 °C).

It is applicable to valves of nominal sizes: DN: 80, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600 corresponding to nominal pipe size (NPS): 3, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24.

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 5211, *Industrial valves — Part-turn actuator attachments*

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

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

API 609, *Butterfly Valves: Double flanged, lug and wafer-type*

ASME B 16.5, *Pipe Flanges and Flanged Fittings*

ASME B 16.10, *Face-to-Face and End-to-End Dimensions of Valves*

ASME B 16.25, *Buttwelding Ends*

ASME B16.34:2007, *Valves — Flanged, Threaded, and Welding End*

Sec ASME V, *Non-destructive Examination*

Sec ASME VIII, *Pressure vessels*

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

ASTM A193/A193M, *Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications*

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

ASTM A276, *Standard Specification for Stainless Steel Bars and Shapes*

ASTM A312/A312M, *Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes*

ASTM A320/A320M, *Alloys-Steel Bolting material for Low-Temperature service*

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

ASTM E186, *Reference Radiographs for Heavy-Walled (2 to 4 1/2-in) Steel Castings*

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

MSS SP-44. *Steel pipeline flanges*

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 purpose 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 pipe-work system, 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

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

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

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. 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.

3.3
nominal pipe size
NPS
alphanumeric designation of size that is common for components used in a piping system, used for reference purposes, comprising the letters NPS followed by a dimensionless number having an indirect correspondence to the physical size of the bore or outside diameter of the component end connections.

Note 1 to entry: The dimensionless number may be used as a size identifier without the prefix NPS. The dimensionless number does not represent a measurable value and is not used for calculation purposes.

Note 2 to entry: Prefix NPS usage is applicable to components bearing Class designations according to ISO 7268.

3.4
class
alphanumeric designation, used for reference purposes, related to a combination of mechanical and dimensional characteristics of a component of a pipe-work system, comprising the word "class" followed by a dimensionless whole number

4 Pressure-temperature rating

4.1 The types of typical fluid are shown in Table 1.

Table 1 — Types of typical fluid

Fluid	Temperature (in atmospheric pressure)	Liquid density (density)
LNG (Liquefied natural gas)	−163 °C to −88 °C	(434 to 478) kg/m^3
NG (Natural gas)	−160 °C to −65 °C	(0,7 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 The valve shall be designed to operate without failure or leakage at the extreme temperature and pressure ranges expected in service. The maximum working pressure and design temperature are shown in Table 2.

Table 2 — Maximum working pressure

PN	Class	Maximum working pressure MPa(psi)	Note
20	150	2,0(290)	in ambient temperature
50	300	5,2(750)	

NOTE The piping design condition including, but not limited to, working pressure, service temperature and fluid is provided by the purchasers.

4.3 The manufacturers and purchasers may reach an agreement when Class exceeds 300.

4.4 Design temperature should be between −196 °C and 80 °C.

5 Structure

5.1 General

5.1.1 Structure

Butterfly valves can be divided into two types, with maintenance holes and without maintenance holes. For butterfly valves with maintenance holes, the disc or seat sealing shall be removable from the maintenance hole without removing the valve from the pipe. The butterfly valve is extended bonnet type. The end connection of the body is welding ends type or flanged ends type. A wheel or levers is used to apply the turning torque or thrust to open or close the valve. The butterfly valve may be either soft-seated or metal-seated. Configuration and functions of the butterfly valve are shown in this document. If there are some differences from this document, the manufacturers can make a decision after reaching an agreement with the purchasers. General examples of the structure of the valve are shown in Annex A.

5.1.2 Materials

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 materials specified, such as forging, casting, bar, or seamless pipe. In addition, the material shall be suitable for the operating temperatures and pressure of the valve and the metal 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.

5.2 Design and materials of the body

5.2.1 Design

The body should be casting integrally, in case the valve contains suitably located lugs which have sufficient strength to support the valve lift and valve support legs, they cannot affect the connection bolts.

5.2.2 Materials

Materials are shown in Table 3. Materials for 'welding ends' type valves may be used for 'flange ends' type material.

Table 3 — Materials by manufacturing method

Manufacturing method	Materials	
	Flange ends type	Welding ends type
Casting	ASTM A351 CF8M	ASTM A351 CF3M

5.2.3 Manufacturing

The valve shall be manufactured according to the following requirements except when there are purchaser's special orders.

a) Face-to-face and end-to-end dimensions of flange ends type shall satisfy ASME B16.10. Face-to-face and end-to-end dimensions of welding ends type shall reach an agreement between purchasers and manufacturers.

b) The minimum wall thickness shall be equal to or thicker than the values shown in ASME B16.34:2007 6.1.

c) The end connection of the body shall be manufactured as specified below:

   1) butt welding ends:

      — according to the wall thickness of connected pipes which is given by the purchasers, manufactured according to ASME B16.25; and

      — the butt welding ends may add a short stub if specified in the order. The wall thickness shall conform to the requirements of purchasers;

   2) flange ends type:

      — NPS 24(DN 600) and under, except NPS22(DN550): to be manufactured in accordance with ASME B16.5; and

      — NPS 22(DN 550): to be manufactured in accordance with MSS SP-44.

5.3 Design and materials of the extended bonnet

5.3.1 Design

The extended bonnet shall meet the following:

a) the minimum wall thickness shall conform to ASME B 16.34:2007 6.1 and the operation torque produced by actuators shall be considered when determining the neck thickness;

b) the minimum bonnet extension length shall satisfy ISO 28921-1 or shall be sufficient to maintain the stem packing at a temperature high enough to permit operation within the normal temperature range of the packing material;

c) drip plate may be installed by welding or clamping; the welding procedure for the drip plate is beyond the requirements of 5.11;

d) lifting points are optional; the manufacturer shall ensure the necessity of lifting points and verify the suitability.

5.3.2 Materials

Materials are shown in Table 3 for the valve body.

If short pipe is used for the extended bonnet, it shall be seamless and made of ASTM A312 or 316L.

5.4 Design and materials of the disc

5.4.1 Design

The disc shall meet the following:

a) it shall be eccentric;

b) it shall be able to ensure the maximum working pressure without deleterious deformation and damage;

c) the connection with the stem should be without leakage and have e.g. spline, taper pins, etc. that can effectively deliver stem torque, and can prevent loosening caused by the vibration;

d) the gap between the disc and the pipe shall meet at least the provisions of API 609, but the purchaser should review the structure of the pipeline to ensure that the disc in the open with the adjacent piping components, such as check valves, filters, gaskets, etc., does not interfere with the other parts;

e) the sealing face of the valve should be designed with metal-to-metal or metal-to-soft seal.

5.4.2 Materials

The disc materials shall be ASTM A351 CF8M. The surface of the sealing part shall be adhered with hard alloy. If overlay hard surface is selected, its thickness should be at least 1,6 mm.

5.5 Design and materials of the stem

5.5.1 Design

The stem shall meet the following.

a) It shall be of an extended type.

b) The critical section of the stem should be in addition to the valve pressure interface, the torsional strength of the stem shall be at least 10 % greater than the pressure outside interface, and able to withstand 1,5 times the maximum working pressure under load.

c) The butterfly valve shall have an anti-static device if specified by the order.

d) The butterfly valve shall be designed to ensure that the stem does not eject under any internal pressure condition or if the packing gland components and/or valve operator mounting components are removed.

5.5.2 Materials

Materials shall be ASTM A182 F316 and ASTM A276 316, and allow the sealing surface or high stress surface hardening process.

5.6 Stem sealing

The requirements for stem sealing shall be as follows.

a) The stem packing should be designed to help maintain the shape of the sealing.

b) The stem shall be sealed in the appropriate form and structure (e.g. stem packing, lantern ring) to prevent leakage and shall be easily adjustable.

c) The packing materials for stem sealing may be graphite or PTFE. Use of other materials shall be by agreement. However, they shall not chemically react to the working fluid or make physical deposits.

5.7 Design and materials of the seat

5.7.1 Design

The seat shall meet the following.

a) The whole seating surface shall contact with the disc when the butterfly valve is in the closed position.

b) A soft seated valve shall be designed to ensure that the packing does not eject or shift by internal pressure during opening or closing.

5.7.2 Bore materials

The seat ring materials shall meet the following.

a) The selection and use of soft seat materials shall ensure reliable performance under working temperature, for example PCTFE, etc.

b) Where a soft seating ring is placed in a metal circle, the metal material shall be ASTM A182 F316.

c) The base material of the metal seating ring shall be ASTM A182 F316. The seating surface needs a hard facing treatment. If overlay hard surface is selected, its thickness should be at least 1,6 mm.

d) Where a seat contains elastic metal materials, it shall have reliable performance in low temperature conditions, such as nickel-based alloy.

5.8 Design and materials of the connection

5.8.1 Design

The connections shall meet the following.

a) The design of the body joint bolting shall satisfy the relevant requirements of ASME B16.34. The minimum size should be M10.

b) The design of actuators connection should satisfy the relevant requirements of ISO 5211.

c) The tensile stress of packing gland bolting shall not exceed 1/3 of the maximum tensile stress of the materials.

5.8.2 Materials

The bolting materials shall meet the following:

a) The body joint bolt materials shall be materials of ASTM A320 Gr.B8 Class 2 and the mating nut materials shall be materials of ASTM A194 Gr.8.

b) The materials of other bolts shall be materials of ASTM A193 Gr.B8 and the mating nut materials shall be materials of ASTM A194 Gr.8.

5.9 Requirements of operating device and actuators

5.9.1 Actuators can be powered by electric, hydraulic or pneumatic means. They can also be manual.

5.9.2 Manual operators shall be hand wheel or level type and the operating effort at the end of the manual operating device shall not exceed maximum 360 N, except for valve seating and unseating only, when it shall be permissible for this value to be increased to 500 N. Also the diameter of the hand wheel should be less than 760 mm.

5.9.3 The direction of closing shall be clockwise and marked permanently.

5.9.4 Actuators shall be furnished with a visible indicator to show the open and the closed position of the closure. For a manual valve, the position indicator shall be in line with the pipeline.

5.9.5 Valves shall be supplied with locking devices if specified by the purchaser.

5.9.6 Actuators and drive trains shall have enough strength under the differential pressure condition of nominal pressure.

5.9.7 The explosion class of auto-operating devices (especially electric explosion proof devices) shall satisfy the criteria of the hazardous area where the valve is installed.

5.9.8 If an actuator is too heavy, it shall be designed to be a self-supported structure to prevent damage to the valve stem and extended bonnet.

5.10 Surface treatment

Stainless steel surface treatment, except seating surfaces, shall be passivation.

5.11 Welding and heat treatment

5.11.1 Welding

The requirements for welding shall meet the following.

a) The welding shall be conducted as per a Welding Procedure Specification (WPS) and Procedure Qualification Record (PQR).

b) Any repair welding shall be conducted as per a Repair Welding Procedure Specification (RWPS) agreed to between the purchasers and manufacturers.

c) The manufacturers shall write a defect record regarding the main part of the valve before any repair work, and provide it to inspectors prior to inspection.

5.11.2 Heat treatment

Heat treatment shall be conducted as per a recognized heat treatment standard which is classified by the materials and/or approved by the purchasers.

5.12 Repair welding

Repair of defects is allowed only once on the same position provided that the welding repair procedure is approved. Parts shall be examined using an NDE method after welding repair and the repair position shall be recorded.

The record of repairs shall be retained by the manufacturer for a minimum of five years.

6 Test and inspection

6.1 General

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

6.2 Material test

Mill certificates and cryogenic impact test reports, which specify chemical analysis and physical test results about main components (body, disc, pup piece, seat metal ring, extended bonnet, and stem), shall be submitted and approved, and the test results shall meet the requirements of related standards.

6.3 Non-destructive inspection

6.3.1 General

The purchasers and manufactures may reach an agreement before inspection. 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.

6.3.2 Radiographic testing (RT)

6.3.2.1 The test scope is as follow.

a) It shall satisfy ASME B16.34 Chapter 8. Radiographic testing shall be conducted at the welding part of all casting valves. Critical areas, as well as joint welds of the body and short pipe, and butt-welded end part of bodies, shall be inspected before machining bevels.

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

6.3.2.2 Test procedure and acceptance criteria are as follows:

a) the test procedure shall satisfy ASME Sec. V and ASME B16.34 Appendix I;

b) in case of casting parts, they 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 are shown in ASME B16.34 Appendix I; and

d) acceptance criteria of welding parts shall satisfy ASME Sec. VIII Div.1 UW-51 and Appendix 4.

6.3.3 Dye penetrant testing (PT)

6.3.3.1 The test scope is as follows:

a) penetrating testing shall be conducted 100 % on each body, the outside surface of the bonnet and the inside surface of the bonnet which 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) when a casting crack exists, penetrating testing shall be conducted 100 % on repair position of the crack;

c) penetrating testing shall be conducted 100 % on bolts which are over 25,4 mm in diameter;

d) penetrating testing shall be conducted 100 % on the plug and body seat ring. Also it shall be conducted after surface machining on the plug and body seat ring where hard surface treating is conducted for high hardness materials; and

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

6.3.3.2 The test procedure shall satisfy ASME Sec. V and ASME B16.34 Appendix III.

6.3.3.3 Acceptance criteria are as follows:

a) casting, forging : ASME B16.34 Appendix III;

b) welded areas: ASME Sec. VIII Div.1 Appendix 8.

6.3.4 Ultrasonic Testing (UT)

6.3.4.1 The test scope is as follows:

a) ultrasonic testing shall be conducted 100 % on the forging parts of valves in accordance with ASME B16.34 Chapter 8;

b) ultrasonic testing shall be conducted 100 % on forging stems of every valve; and

c) ultrasonic testing may not be carried out if radiographic testing and dye penetrant testing are thoroughly carried out.

6.3.4.2 The test procedure shall satisfy ASME Sec. V and ASME B16.34 Appendix IV.

6.3.4.3 The acceptance criteria shall satisfy ASME B16.34 Appendix IV.

6.3.5 Retest

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

6.3.6 Submission of inspection results

The manufacturers shall submit an inspection result of tests and inspection reports to the purchasers. Inspection reports shall include drawings that show inspection areas.

6.4 Dimension check

It shall be checked that the main dimensions are matched with the relevant standards and the drawings which the manufacturers submit.

6.5 Visual inspection

All valves shall be checked for scratches, cracks, creases, contractions, spurs, moulding sand and corrosion, etc., on the surface of the valve in accordance with MSS SP-55. Also, damage to machining/seat ring surface shall be checked. There shall not be flaws, under-cut, arc strikes, etc., on the welding parts, and the height of beads on welding parts shall not be lower than the basic material surface.

6.6 Heat treatment inspection

Heat treatment inspection shall be conducted as per standards on which the purchasers and manufacturers reach an agreement. Heating temperature, heating methods, heating time, holding time, cooling speed and cooling methods are indicated in the standards. When conducting heating treatment, the temperature shall be recorded by an auto-temperature recorder.

The heat treatment records may be provided at the purchaser's request. The records should be retained at the factory for at least five years.

6.7 Operating tests

Operating tests of finished valves shall be conducted at least five times. Tests shall be conducted without any pressure the first two times, then with nominal pressure the next three times. Tests shall verify that there are no errors in the operation. Also an operating test shall be conducted more than once under differential pressure conditions (test medium given in Table 4), and the proper operation shall be verified. The operating effort shall satisfy the requirements of 5.9.2.

6.8 Pressure test

Each valve shall be tested prior to shipment in ambient temperature. Test results shall be recorded. Any fixtures and tools needed shall not impair functionality or sealing.

6.8.1 Pressure test in ambient temperature

Requirements for pressure test in ambient temperature are specified in Table 4.

Table 4 — Pressure test in ambient temperature

Clause	Shell pressure test	Low pressure closure test	High pressure closure test
Test medium	Pure water, dried air or nitrogen.	Dried air or nitrogen.	Dried air or nitrogen.
Test pressure	1,5 times maximum working pressure in ambient environment.	0,7 MPa	1,1 times o maximum working pressure in ambient environment.
Test time	≥ 5 min	≥ 5 min	≥ 5 min
Acceptable criteria	no visual leakage	soft seated valve: no visual leakage metal seated valve: ISO 5208	soft seated valve: no visual leakage metal seated valve: ISO 5208
NOTE 1 Dry the samples completely before cryogenic testing if pure water is used. NOTE 2 In consideration that pressure for seat leakage valves varies by manufacturers, specification for seat to stop at both ends seat can been agreed between purchasers and manufacturers.			

6.8.2 Test procedure and method

The test procedure and method are specified as follows.

a) Shell pressure test: Valve ends shall be closed off with the valve body assembling with bonnet during the test. Fill the valve with test fluid and then apply the test pressure.

b) Seat test procedures:

   1) Unidirectional: With the valve closed, fill the valve completely with test fluid. The test pressure is applied to the appropriate end of the valve. Leakage from the downstream seat shall be monitored.

   2) Bidirectional: With the valve closed, the test pressure is applied successively to both ends of the valve. The valve and its cavity shall be completely filled with test fluid. Seat leakage shall be monitored from each seat.

6.9 Fire-resistance test (if necessary)

The fire-resistance design of valves shall be qualified by fire type-testing in accordance with ISO 10497. Purchaser and manufacturer can reach an agreement to approve a certificate as per other acceptable standards.

6.10 Anti-static testing

The electrical resistance for a soft seat valve between the disc and the valve body and between the stem/shaft and the valve body shall be measured using a direct-current power source not exceeding 12 V when anti-static properties are required by order. The resistance shall be measured on dry valves before pressure testing and shall not exceed 10 Ω.

6.11 Cryogenic tests

6.11.1 General

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