Specification for Subsea Pipeline Valves

1 Scope

This specification defines the requirements for the design, manufacturing, quality control, assembly, testing, and documentation of ball, check, gate, plug, and axial on–off valves for application in subsea pipeline systems for the petroleum and natural gas industries.

This specification applies to ASME Class 150, 300, 600, 900, 1500, and 2500 valves intended for use in subsea pipelines. Use of these valves for any other purpose is outside the scope of this document.

2 Normative References

The following referenced documents are indispensable for the application 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., except that new editions may be used on issue and shall become mandatory upon the effective date specified by the publisher or 6 months from the date of the revision (where no effective date is specified).

API Technical Report 17TR11, *Pressure Effects on Subsea Hardware During Flowline Pressure Testing in Deep Water*

API Specification 20E, *Alloy and Carbon Steel Bolting for Use in the Petroleum and Natural Gas Industries*

API Specification 20F, *Corrosion Resistant Bolting for Use in the Petroleum and Natural Gas Industries*

ASME B16.5 [1], *Pipe Flanges and Flanged Fittings: NPS 1/2 Through 24 Metric/Inch Standard*

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

ASME B16.25, *Buttwelding Ends*

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

ASME B16.47, *Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard*

ASME B31.4, *Pipeline Transportation Systems for Liquids and Slurries*

ASME B31.8, *Gas Transmission and Distribution Piping Systems*

ASME *Boiler and Pressure Vessel Code (BPVC)*, *Section II: Materials, Part D: Properties*

ASME *Boiler and Pressure Vessel Code (BPVC)*, *Section V: Nondestructive Examination*

ASME *Boiler and Pressure Vessel Code (BPVC)*, *Section VIII: Pressure Vessels; Division 1: Rules for Construction of Pressure Vessels*

ASME *Boiler and Pressure Vessel Code (BPVC)*, *Section VIII: Pressure Vessels; Division 2: Alternative Rules*

ASME *Boiler and Pressure Vessel Code (BPVC)*, *Section IX: Welding and Brazing Qualifications*

[1] ASME International, 2 Park Avenue, New York, New York 10016-5990, www.asme.org.

ASNT SNT-TC-1A [2], *Personnel Qualification and Certification in Nondestructive Testing*

ASTM A320/A320M [3], *Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service*

ASTM A370, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A578/A578M, *Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications*

ASTM A609/A609M, *Standard Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof*

ASTM E8/E8M, *Standard Test Methods for Tension Testing of Metallic Materials*

ASTM E10, *Standard Test Method for Brinell Hardness of Metallic Materials*

ASTM E18, *Standard Test Methods for Rockwell Hardness of Metallic Materials*

ASTM E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*

ASTM E110, *Standard Test Method for Rockwell and Brinell Hardness of Metallic Materials by Portable Hardness Testers*

ASTM E562, *Standard Test Method for Determining Volume Fraction by Systematic Manual Point Count*

ASTM E1245, *Standard Practice for Determining the Inclusion or Second-Phase Constituent Content of Metals by Automatic Image Analysis*

ASTM G48, *Standard Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution*

AWS QC1 [4], *Specification for AWS Certification of Welding Inspectors*

EN 287-1 [5], *Qualification test of welders—Fusion welding—Part 1: Steels*

EN 10204, *Metallic products—Type of inspection documents*

ISO 148-1 [6], *Metallic materials—Charpy pendulum impact test—Part 1: Test method*

ISO 5208:2015, *Industrial valves—Pressure testing of valves*

ISO 5817, *Welding—Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded)—Quality levels for imperfections*

ISO 6506-1, *Metallic materials—Brinell hardness test—Part 1: Test method*

[2] American Society for Nondestructive Testing, 1711 Arlingate Lane, P.O. Box 28518, Columbus, Ohio 43228, www.asnt.org.

[3] ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

[4] American Welding Society, 8669 NW 36 Street, #130, Miami, Florida 33166-6672, www.aws.org.

[5] European Committee for Standardization, Avenue Marnix 17, B-1000 Brussels, Belgium, www.cen.eu.

[6] International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland, www.iso.org.

ISO 6508-1, *Metallic materials—Rockwell hardness test—Part 1: Test method*

ISO 6892-1, *Metallic materials—Tensile testing—Part 1: Method of test at room temperature*

ISO 9606-1, *Qualification testing of welders—Fusion welding—Part 1: Steels*

ISO 9712, *Non-destructive testing—Qualification and certification of NDT personnel*

ISO 10474, *Steel and steel products—Inspection documents*

ISO 15156 (all parts), *Petroleum and natural gas industries—Materials for use in H_2S-containing environments in oil and gas production*

ISO 15607, *Specification and qualification of welding procedures for metallic materials—General rules*

ISO TR 15608:2013, *Welding—Guidelines for a metallic materials grouping system*

ISO 15609 (all parts), *Specification and qualification of welding procedures for metallic materials—Welding procedure specification*

ISO 15614-1, *Specification and qualification of welding procedures for metallic materials—Welding procedure test—Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys*

ISO 15614-7, *Specification and qualification of welding procedures for metallic materials—Welding procedure test—Part 7: Overlay welding*

ISO 17636-1, *Non-destructive testing of welds—Radiographic testing—Part 1: X- and gamma-ray techniques with film*

ISO 17637, *Non-destructive testing of welds —Visual testing of fusion-welded joints*

ISO 80000-1:2009, *Quantities and units: Part 1—General principles*

MSS SP-55 [7], *Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components—Visual Method for Evaluation of Surface Irregularities*

NACE MR0175 [8] (all parts), *Petroleum, petrochemical, and natural gas industries—Materials for use in H_2S-containing environments in oil and gas production*

NACE TM0284, *Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking*

SAE AMS 2750 [9], *Pyrometry*

3 Terms, Definitions, Acronyms, Abbreviations, Symbols, and Units

3.1 Terms and Definitions

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

3.1.1
actuator

[7] Manufacturers Standardization Society of the Valve and Fittings Industry, 127 Park Street, NE, Vienna, Virginia 22180-4602, www.mss-hq.com.

[8] NACE International, 15835 Park Ten Place, Houston, Texas 77084, www.nace.org.

[9] SAE International, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001, www.sae.org.

Electric or hydraulic device bolted or otherwise attached to the valve for powered opening and closing of the valve.

3.1.2
assembler
manufacturer
Organization that performs assembly (see 3.1.3) and conforms to the requirements of Section 15.

NOTE The terms "assembler" and "manufacturer" are used interchangeably throughout this document and are considered to be equivalent.

3.1.3
assembly
Association of multiple parts/components into a finished product, including, as a minimum, installation of all pressure-containing parts and pressure-controlling parts needed to ensure conformance to applicable pressure testing requirements.

3.1.4
bidirectional seat
Valve seat designed to seal against pressure source in either direction.

3.1.5
bidirectional valve
Valve designed for blocking the fluid in either direction.

3.1.6
bleed (verb)
To drain or vent.

3.1.7
block and bleed valve
BB
Single valve with at least one seating surface that, in the closed position, provides a seal against pressure from one end of the valve with the body vented.

3.1.8
block valve
Gate, plug, or ball valve that blocks flow into the downstream conduit when in the closed position.

NOTE Valves are both single seated or double seated and either bidirectional or unidirectional.

3.1.9
body connection
Connection provided for in-service purposes such as leak detection, fluid injection, flushing, and/or hydrate remediation and as specified by the purchaser.

3.1.10
body test port
Connection provided to permit monitoring of seat leakage during test.

NOTE Single seated valves and downstream seating valves have no requirement for a body test port.

3.1.11
breakaway thrust
breakaway torque
Maximum thrust or torque required to operate a valve at maximum pressure differential (MPD).

3.1.12
by agreement
Agreed between manufacturer and purchaser.

3.1.13
cycle
Operation from the fully closed to fully open and return to the closed position or fully open to fully closed and return to the open position.

3.1.14
critical parts
Minimally, those defined in 3.1.45 (pressure-containing), 3.1.46 (pressure-controlling), and 3.1.42 (pressure boundary bolting).

3.1.15
double block and bleed valve
DBB
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 the seating surfaces.

NOTE This valve does not provide positive double isolation when only one side is under pressure. See **double isolation and bleed valve** (see 3.1.16).

3.1.16
double isolation and bleed valve
DIB
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 This feature can be provided in one direction or in both directions.

3.1.17
downstream
Side of the valve where there would be no pressure or a lower pressure.

NOTE 1 Where the valve is bidirectional, this reference may change sides.

NOTE 2 The term does not refer to flow direction.

3.1.18
drive train
All parts of a valve drive between the operator and the obturator that transmit or react loads, including the obturator but excluding the operator.

3.1.19
drain
Connection in the valve body, supplied by manufacturer, for the purpose of draining test fluids from the valve on completion of test.

NOTE Single seated valves without cavities (such as check valves) and valves that can be drained by other means need not have drains.

3.1.20
factory acceptance test
FAT
Pressure testing required by this specification in Section 10.

3.1.21

flow coefficient
K_v
Volumetric flow rate of water at a temperature between 5 °C (40 °F) and 40 °C (104 °F) passing through a valve and resulting in a pressure loss of 0.1 MPa (1 bar; 14.5 psi).

NOTE 1 K_v is expressed in SI units of cubic meters per hour.

NOTE 2 K_v is related to the flow coefficient C_v, expressed in USC units of U.S. gallons per minute at 15.6 °C (60 °F) resulting in a 1 psi pressure drop as given by Equation (1):

$$K_v = \frac{C_v}{1.156} \quad (1)$$

3.1.22
full-opening valve
Valve with an unobstructed opening, not smaller than the internal bore of the end connections.

3.1.23
gearbox
Mechanical torque and/or thrust multiplying device used to operate a valve.

3.1.24
hand-wheel
Wheel consisting of a rim connected to a hub, e.g. by spokes, and used to manually operate a valve requiring multiple turns.

3.1.25
localized testing
Test performed to prove the proper function of a specific feature of the valve; this usually involves a limited and local area of the valve.

NOTE When referred to hyperbaric testing, this applies to the testing of a specific barrier (e.g. localized testing of the valve body environmental barrier, or localized testing of the stem environmental barrier).

3.1.26
locking device
Part or an arrangement of parts for securing a valve in the open and/or closed position.

3.1.27
major weld repairs
Any cavity prepared for repair welding that exceeds 20 % of the part wall thickness or 1 in. depth, whichever is smaller or on the surface areas greater than 10 $in.^2$ (65 cm^2).

3.1.28
maximum allowable stem torque/thrust
MAST
Maximum torque/thrust that it is permissible to apply to the valve drive train without risk of damage, as defined by the valve manufacturer.

3.1.29
maximum pressure differential
MPD
Maximum difference between the upstream and downstream pressure across the obturator at which the obturator may be operated.

3.1.30

nominal pipe size
NPS
Numerical designation of size in inches that is common to components in piping systems.

NOTE Nominal pipe size is designated by the abbreviation “NPS” followed by a number.

3.1.31
nominal size
DN
Numerical designation of size in millimeters that is common to components in piping systems.

NOTE Nominal size is designated by the abbreviation “DN” followed by a number.

3.1.32
obturator
closure member
Part of a valve, such as a ball, clapper, disc, gate, or plug, that is positioned in the flow stream to permit or prevent flow.

3.1.33
off-site
Related facility location other than the assembler’s/manufacturer’s facility where a required process activity is performed conforming to an API Q1 or ISO 9001 quality management system.

3.1.34
on-site
Assembler’s/manufacturer’s facility.

3.1.35
operator
Device (or assembly) for opening or closing a valve, includes gearbox, actuator, and direct drive devices.

EXAMPLE Direct mount hand-wheel or lever.

3.1.36
outsource
outsourced activity
Function or process that is performed by an external supplier conforming to a quality management system for the activities performed on behalf of the assembler/manufacturer.

3.1.37
packing gland
Components used to retain the stem packing.

3.1.38
piggability
Capability of a valve to permit the unrestricted passage of a pig.

3.1.39
pipe pup
transition piece
Piece(s) of pipe or forged material, welded to the valve to prevent valve-seal damage from girth welding and/or matching of valve material to pipeline strength properties, or to provide a valve end matching the pipeline dimensions.

3.1.40

position indicator
Device to show the position of the valve obturator.

3.1.41
preparation for shipment
Preparation of the valve in accordance with this specification.

3.1.42
pressure boundary bolting
Fasteners used to connect pressure-containing parts.

3.1.43
pressure cap
Cap designed to contain internal pressure in the event of seal leakage or to prevent ingress due to hyperbaric pressure.

3.1.44
pressure class
Numerical pressure design class pressure–temperature (P-T) ratings are designated by class numbers defined in ASME B16.34.

NOTE The ASME rating class is designated by the word “Class” followed by a number. Pressure rating designation is the word “Class,” followed by a dimensionless number (the designation for pressure–temperature ratings) as follows: Class 150, Class 300, Class 600, Class 900, Class 1500, or Class 2500.

3.1.45
pressure-containing parts
Part whose failure to function as intended results in a release of contained fluid into the environment and as a minimum includes bodies, end connections, bonnets/covers, and stems.

3.1.46
pressure-controlling parts
Part intended to prevent or permit the flow of fluids and as a minimum includes ball, disc, plug, gate, and seat.

3.1.47
process wetted parts
Parts exposed directly to the pipeline or piping fluid.

3.1.48
receiving verification
Process of verifying that the inward goods received by the assembler/manufacturer are in conformance with purchase-order requirements.

3.1.49
reduced opening valve
Valve with the opening through the obturator smaller than at the end connection(s).

3.1.50
remotely operated tool system
ROT system
Dedicated, unmanned, subsea tools used for installation and inspection, maintenance, and repair tasks that require lift and/or handling capacity beyond that of free-swimming remotely operated vehicle (ROV) systems.

NOTE 1 The ROT system comprises wire-suspended tools with control system and support-handling system for performing dedicated subsea intervention tasks.

NOTE 2 ROT systems are usually deployed on lift wires or a combined lift wire/umbilical. Lateral guidance may be via guidelines, dedicated thrusters, or ROV assistance.

3.1.51
remotely operated vehicle
ROV
Free-swimming or tethered submersible craft used to perform tasks such as inspection, valve operations, hydraulic functions, and other general tasks.

3.1.52
seal test port
Connection provided to test the function of individual seals, when multi-barrier seals are provided in series, such as stem seals and body seals, and not intended to demonstrate function of internal seals.

3.1.53
sealing surfaces
Contact surface of the dynamic or static seals within the valve shell.

EXAMPLES Stem, seat, cover/bonnet seals, and backseat.

3.1.54
seating surfaces
Contact surfaces of the obturator and seat that ensure valve sealing.

3.1.55
self-relieving seat
Valve seat assembly designed to relieve pressure in the valve cavity.

NOTE Depending upon valve type, the pressure may be relieved to the pressure source or the low-pressure side.

3.1.56
shaft
Part that supports the obturator on a check valve and may or may not pass through the pressure boundary.

3.1.57
shell test
Test of the assembled pressure-containing parts.

3.1.58
stem
Part that drives the obturator and passes through the pressure boundary.

3.1.59
stem/shaft protector
Cover to protect valve parts from mechanical damage.

NOTE A pressure cap may also be used for protection.

3.1.60
support ribs or legs
Metal structure that provides a stable footing when the valve is set on a fixed base.

3.1.61
test coupon
TC
Sample of material representing the properties after heat treatment, inclusive of simulated post-weld heat treatment when required, of the material comprising the production parts it qualifies.

3.1.62

test fixtures
Equipment/tool/device used to test a specific item or a specific feature of the valve.

NOTE When referred to hyperbaric testing, this might refer to blind flanges, pressure caps, spool pieces, or any other similar item meant to validate the hyperbaric functionality of the valve (if not performed in the hyperbaric chamber).

3.1.63
through-conduit valve
Valve with an unobstructed and continuous cylindrical opening.

3.1.64
unidirectional seat
Valve seat designed to seal the pressure source in one direction only.

3.1.65
unidirectional valve
Valve designed for blocking the flow in one direction only.

3.1.66
unless otherwise agreed
Modification of the requirements of this specification when the manufacturer and purchaser agree on a deviation.

3.1.67
upstream
Side of the valve where the pressure is retained.

NOTE 1 Where the valve is bidirectional, this reference may change sides.

NOTE 2 The term does not refer to flow direction.

3.1.68
vent
Connection in the valve body supplied by the manufacturer, for the purpose of venting air from the valve body during liquid filling required for test.

NOTE Alternative means of water filling may obviate the need for a vent connection (e.g. valve placed vertically on test fixture).

3.1.69
venturi plug valve
Valve with a substantially reduced opening through the plug and a smooth transition from each full-opening end to the reduced opening.

3.1.70
visually detectable leakage
Leakage during a valve pressure test, either through or past a pressure boundary or closure member that is observed with normal vision.

NOTE Use of a camera is allowed.

3.1.71
welding
Fusion of materials, with or without the addition of filler materials on parts or final assemblies.

3.2 Acronyms, Abbreviations, Symbols, and Units

For the purposes of this document, the following acronyms and abbreviations apply.

BB block and bleed

BM	base metal
BTC	break-to-close
BTO	break-to-open
CE	carbon equivalent
CP	cathodic protection
CRA	corrosion resistant allow
DBB	double block and bleed
DC	direct current
DIB	double isolation and bleed
DN	nominal size
ENP	electroless nickel plating
ETC	end-to-close
ETO	end-to-open
FAT	factory acceptance testing
FEA	finite element analysis
HAZ	heat-affected zone
HBW	Brinell hardness, tungsten ball indenter
HRC	Rockwell C hardness
MAST	maximum allowable stem torque
MPD	maximum pressure differential
MT	magnetic-particle testing
NDE	nondestructive examination
NPS	nominal pipe size
OD	outside diameter
PQR	(weld) procedure qualification record
PREN	pitting resistance equivalent number
PT	penetrant testing
PWHT	postweld heat treatment
QL	quality level
ROT	remotely operated tool
ROV	remotely operated vehicle
rpm	revolutions per minute

RT	radiographic testing
RWP	rated working pressure
SMYS	specified minimum yield strength
TC	test coupon
TCC	tungsten carbide coating
UT	ultrasonic testing
VT	visual testing
WM	weld metal
WPQ	welder performance qualification
WPS	weld procedure specification
C_v	flow coefficient in USC units
K_v	flow coefficient in metric units
S_m	design stress intensity value
t	thickness
Ω	ohms

4 Valve Types and Configurations

4.1 Valve Types

4.1.1 General

For the manufacture of valves under this specification, requirements from all reference documents in Section 2 in effect at the time of publication of this specification are mandatory by the effective date of this specification. Requirements that are specified from an undated reference document identified in Section 2 that has been published after the effective date of this specification may be implemented at any time after publication of the newly issued reference document but a delayed implementation of those requirements of up to 12 months after the effective date of the reference document shall be permitted. Thereafter, all requirements from newly issued reference documents identified in Section 2 shall become mandatory by 12 months after the effective date of the reference document.

NOTE Typical configurations of valves are shown in Annex B for illustration purposes only.

4.1.2 Gate Valves

Gate valves shall have an obturator that moves in a plane perpendicular to the direction of flow.

NOTE 1 The gate can be constructed of one piece for slab-gate valves or of two or more pieces for expanding-gate valves.

Gate valves shall be provided with a backseat or secondary stem sealing feature in addition to the primary stem seal.

NOTE 2 Typical configurations for gate valves with flanged and welding ends are shown, for illustration purposes only, in Figure B.1 and Figure B.2.

4.1.3 Lubricated and Nonlubricated Plug Valves

Plug valves shall have a cylindrical or conical obturator that rotates about an axis perpendicular to the direction of flow.

NOTE Typical configurations for plug valves with flanged and welding ends are shown, for illustration purposes only, in Figure B.3.

4.1.4 Ball Valves

Ball valves shall have a spherical obturator that rotates on an axis perpendicular to the direction of flow.

NOTE Typical configurations for ball valves with flanged or welding ends are shown, for illustration purposes only, in Figure B.4 to Figure B.6.

4.1.5 Check Valves

Check valves shall have an obturator that responds automatically to block fluid in one direction.

NOTE Typical configurations for swing and axial-flow check valves are shown, for illustration purposes only, in Figure B.7 to Figure B.9.

4.1.6 Axial On–off Valves

Axial on–off valves shall have a cylindrical obturator that moves on an axis parallel to the direction of flow.

NOTE Typical configuration for axial on–off valves with flanged or welding ends is shown, for illustration purposes only, in Figure B.10.

4.2 Valve Configurations

4.2.1 Full-opening Valves

Full-opening valves shall be unobstructed in the fully opened position and shall have an internal minimum cylindrical opening for categorizing bore size as specified in Table 1. When pipe is used in the construction of the valves, the pipe shall meet the tolerances of the applicable pipe specification. Obturator and seat dimensions shall meet Table 1.

NOTE 1 There is no restriction on the upper limit of valve bore sizes.

When there is no minimum bore dimensions listed for a valve pressure class and size stated in Table 1, the size and bore shall be by agreement and the manufacture shall stamp the size and bore on the nameplate.

NOTE 2 Welding-end valves can require a smaller bore at the welding end to mate with the pipe.

Valves with a noncircular opening through the obturator shall not be considered full opening.

Except for reduced-opening valves, valve sizes shall be specified by the NPS or nominal diameter (DN).

4.2.2 Reduced-opening Valves

Reduced-opening valves with a circular opening through the obturator shall be supplied with a minimum bore as follows. Valves sizes below NPS 4 (DN 100) and above NPS 24 (DN 600) shall be by agreement.

— Valves NPS 4 (DN 100) to NPS 12 (DN 300): one size below nominal size of valve with bore according to Table 1.

— Valves NPS 14 (DN 350) to NPS 24 (DN 600): two sizes below nominal size of valve with bore according to Table 1.

EXAMPLE A NPS 16 (DN 400) Class 1500 reduced-opening ball valve has a minimum bore of 11.31 in. (287 mm).

Reduced-opening valves with a noncircular opening through the obturator shall be supplied with a minimum opening by agreement.

Reduced-opening valves with a circular opening shall be specified by the nominal size of the end connections and the nominal size of the reduced opening in accordance with Table 1.

EXAMPLE 1 A NPS 16 (DN 400) Class 150 valve with a reduced 11.94 in. (303 mm) diameter circular opening is specified as NPS 16 (DN 400) × NPS 12 (DN 300).

Reduced-opening valves with a noncircular opening and reduced-opening check valves shall be designated as reduced-bore valves and specified by the nominal size corresponding to the end connections followed by the letter “R.”

EXAMPLE 2 Reduced-bore valve with NPS 16 (DN 400) end connections and a 15 in. × 12 in. (381 mm × 305 mm) rectangular opening is specified as 16R.

Table 1—Minimum Bore for Full-opening Valves

NPS	DN	Minimum Bore by Class in. (mm)			
		Class 150, 300, 600	**Class 900**	**Class 1500**	**Class 2500**
1	25	1.00 (25)	1.00 (25)	1.00 (25)	1.00 (25)
1 1/2	40	1.50 (38)	1.50 (38)	1.50 (38)	1.50 (38)
2	50	1.94 (49)	1.94 (49)	1.94 (49)	1.69 (42)
2 1/2	65	2.44 (62)	2.44 (62)	2.44 (62)	2.06 (52)
3	80	2.94 (74)	2.94 (74)	2.94 (74)	2.44 (62)
4	100	3.94 (100)	3.94 (100)	3.94 (100)	3.44 (87)
6	150	5.94 (150)	5.94 (150)	5.69 (144)	5.19 (131)
8	200	7.94 (201)	7.94 (201)	7.56 (192)	7.06 (179)
10	250	9.94 (252)	9.94 (252)	9.44 (239)	8.81 (223)
12	300	11.94 (303)	11.94 (303)	11.31 (287)	10.44 (265)
14	350	13.19 (334)	12.69 (322)	12.44 (315)	11.50 (292)
16	400	15.19 (385)	14.69 (373)	14.19 (360)	13.13 (333)
18	450	17.19 (436)	16.69 (423)	16.00 (406)	14.75 (374)
20	500	19.19 (487)	18.56 (471)	17.88 (454)	16.50 (419)
22	550	21.19 (538)	20.56 (522)	19.69 (500)	—
24	600	23.19 (589)	22.44 (570)	21.50 (546)	—
26	650	24.94 (633)	24.31 (617)	23.38 (594)	—
28	700	26.94 (684)	26.19 (665)	25.25 (641)	—
30	750	28.94 (735)	28.06 (712)	27.00 (686)	—
32	800	30.69 (779)	29.94 (760)	28.75 (730)	—
34	850	32.69 (830)	31.81 (808)	30.50 (775)	—
36	900	34.44 (874)	33.69 (855)	32.25 (819)	—
38	950	36.44 (925)	35.63 (904)	—	—
40	1000	38.44 (976)	37.63 (956)	—	—
42	1050	40.19 (1020)	39.63 (1006)	—	—
48	1200	45.94 (1166)	45.25 (1149)	—	—
54	1350	51.69 (1312)	—	—	—
56	1400	53.56 (1360)	—	—	—
60	1500	57.44 (1458)	—	—	—

5 Design

5.1 Design Standards and Calculations

Pressure-containing parts, including bolting, shall be designed with materials specified in Section 6.

Design and calculations for pressure-containing elements shall be in accordance with an internationally recognized design code or standard with consideration for external loading conditions, operating forces, etc.

NOTE Examples of internationally recognized design codes or standards are ASME *BPVC*, Section VIII, Division 1 or Division 2; ASME B16.34; EN 12516-1 or EN 12516-2; and EN 13445-3.

The allowable stress values shall be consistent with the selected design code or standard.

If the selected design code or standard specifies a test pressure less than 1.5 times the design pressure, then the design pressure for the body calculation shall be increased such that the hydrostatic test pressure in 10.3 can be applied.

NOTE Other design codes may be specified for the equipment; however, all requirements of this specification must be met.

5.2 Pressure and Temperature Rating

Valves covered by this specification shall be furnished in one of the following pressure classes:

— Class 150,

— Class 300,

— Class 600,

— Class 900,

— Class 1500,

— Class 2500.

Pressure–temperature ratings for valves shall be in accordance with the applicable rating table for the appropriate material group in ASME B16.34.

Pressure–temperature ratings for valves made from materials not covered by ASME B16.34 shall be determined from the material properties in accordance with the applicable design standard.

NOTE It is not required that the same material grade, chemistry, or strength be used for body and bonnet or cover parts.

The selection of the pressure class shall be specified by the purchaser and shall take in to account the internal pressure and the head of the process fluid. The seawater external pressure shall not be offset.

The design of pressure-containing subsea valve components shall not take into account the effects of external seawater pressure with respect to stress analysis.

Pressure differentials caused by trapped pressure between seals on assembly per API 17TR11 shall be included in the design. The effect of external seawater pressure/column height and zero absolute pressure in the valve cavity shall be included in the design.

The pressure–temperature rating applied shall be based on the material group of the valve end connection. Where the valve ends are made from material in two different groups, the material with the lower pressure–temperature rating shall govern.

All metallic and nonmetallic pressure-containing and pressure-controlling parts shall be designed to meet the applicable valve pressure–temperature rating.

If intermediate design pressures and temperatures are specified by the purchaser, they shall only be applicable to weld end configuration. The pressure–temperature rating shall be determined by linear interpolation in accordance with ASME B16.34.

Valves with flanged end(s) shall not be designed to an intermediate rating due to the risk of the valve being transferred to a different application, which may utilize the full flange rating.

The maximum operating pressure at the minimum and maximum operating temperatures shall be marked on the nameplate.

Minimum design temperature shall be 32 °F (0 °C), unless otherwise specified by the purchaser.

5.3 Sizes

Valves constructed to this specification shall be furnished in nominal sizes as listed in Table 1.

Valves with an intermediate pressure–temperature rating shall have a bore size by agreement.

NOTE 1 In this specification, NPS sizes are stated first followed by the equivalent DN size between brackets.

NOTE 2 All axial-flow check valves and axial on–off valves are considered reduced bore.

5.4 Face-to-face and End-to-end Dimensions

Unless otherwise agreed, face-to-face (A) and end-to-end (B and C) dimensions of valves shall be in accordance with Table C.1 to Table C.5; see Figure B.1 to Figure B.10 for diagrams of dimensions A, B, and C where shown.

Face-to-face and end-to-end dimensions for valve sizes not specified in Table C.1 to Table C.5 shall be in accordance with ASME B16.10. Face-to-face and end-to-end dimensions not shown in Table C.1 to Table C.5 or in ASME B16.10 shall be established by agreement.

The length of valves having one welding end and one flanged end shall be determined by adding half the length of a flanged-end valve to half the length of a welding-end valve.

Tolerances on the face-to-face and end-to-end dimensions shall be ±0.06 in. (±1.5 mm) for valve sizes NPS 10 (DN 250) and smaller and ±0.12 (±3.0 mm) for valve sizes NPS 12 (DN 300) and larger.

The nominal size and face-to-face or end-to-end dimensions shall be stated on the nameplate if not specified in, or not in accordance with, Table C.1 to Table C.5.

NOTE In some cases the support legs on some valve designs may have to be extended beyond the end-to-end dimensions to assure that the valve can be safely supported. If required, these extensions may be removed after installation.

5.5 Valve Operation

The purchaser should specify the method of operation and the MPD at which the valve is required to be opened by the lever, gearbox, or actuator. If not specified, the pressure as determined in accordance with 5.2 for material at 100 °F (38 °C) shall be the MPD.

The manufacturer shall provide the following data to the purchaser, when requested:

— flow coefficient C_v or K_v;

— breakaway thrust or torque for new valve and the breakaway travel or angle;

— valve run thrust or torque;

— reseat thrust or torque,

— maximum allowable stem thrust or torque on the valve and, if applicable, the maximum allowable input torque to the gearbox;

— number of turns for manually operated valves.

5.6 Operator Information

5.6.1 General

The integrator of the operator onto the valve shall ensure the maximum allowable stem torque (MAST) and maximum torque/thrust are compared to ensure the MAST is not exceeded.

The following data shall be provided by the purchaser:

— minimum and maximum operating temperatures;

— minimum and maximum ambient temperatures;

— minimum and maximum temperatures encountered from the time of shipment from the factory to time of installation;

— required safety factors;

— design water depth;

— valve type (see 4.1);

— minimum and maximum required time of operation in the open and closed directions;

— location and orientation of position indicator in relation to the valve stem and/or the ROT interface

— need for subsea retrieval (must specify diver or ROV retrievable);

If ROT drive or override is requested, the following shall be provided:

— ROT interface type and class;

— rpm of ROT;

— minimum and maximum ROT input torque;

— ROV reaction loads (refer to 5.18);

— axial configuration of ROT interface, i.e. orientation of input shaft in relation to valve stem.

5.6.2 Valve Thrust/torque Data

The following data shall be provided by the valve manufacturer, for both the opening and closing directions.

— Valve top works dimensions.

— Breakaway torque or thrust at zero and operating water depth [break-to-open (BTO) and break-to-close (BTC)].

— Valve breakaway angle or percent of stroke.

— Run torque or thrust.

— Reseat torque or thrust [end-to-open (ETO) and end-to-close (ETC)].

— Valve drive train MAST.

— Length and direction of stroke to open and close for linear valves.

— Angle and direction of rotation for part-turn or check valves.

— Direction of rotation and number of turns for multi-turn valves.

— Thrust necessary to enable valve to maintain position, if applicable.

— Any other specific torque or thrust conditions of the valve.

NOTE The breakaway angle or percent of stroke is the point at which the seat makes sealing contact with the obturator, which can be a significant factor in operator sizing when in excess of 5° or 5 %, respectively.

5.6.3 Hydraulic Actuator Data Input

The following data shall be provided by the purchaser:

— control fluid type;

— minimum and maximum supply pressures;

— minimum hold open/close pressures;

— actuator configuration (single or double acting);

— failsafe action (close, open, or fail-last);

— number of strokes from stored power source;

— hydraulic supply connection type and size;

— end of stroke damping feature, when required.

5.6.4 Direct Gas Actuator Data

For actuators directly powered from a gas pipeline, valve torque or thrust associated with the minimum and maximum pipeline operating pressures at operating temperature shall be provided by the valve manufacturer.

5.6.5 Electric Actuator Data

The following data shall be provided by the purchaser:

— voltage, phase, frequency;

— voltage variation and frequency variation;

— number of consecutive valve strokes;

— number of starts per hour;

— failsafe action (close, open, or fail-last);

— number of strokes from stored-power source;

— communication protocol between the operating system and actuator.

5.6.6 Gearbox Data Input

The following data shall be provided by the purchaser:

— axial configuration of gearbox (i.e. orientation of input shaft in relation to valve stem);

— limits on input shaft number of turns to complete one stroke;

— part-turn or multi-turn gearbox;

— self-locking capability provided by the operator or the valve.

5.7 Pigging

The purchaser shall specify the requirements for piggability of the valves.

NOTE Guidance can be found in Q.2.

5.8 Valve Ends

5.8.1 Flanged Ends

5.8.1.1 General

Flanges shall be furnished with a raised face or ring joint face (raised face or full face). Specified dimensions, tolerances, and finishes, including drilling templates, flange facing, nut-bearing surfaces (i.e. spot facing and back facing), outside diameters, and thickness (see Figure 1), shall be in accordance with:

— ASME B16.5 for sizes up to and including NPS 24 (DN 600);

— ASME B16.47, Series A for NPS 26 (DN 650) and larger sizes.

Flanges and flanged fittings shall have bearing surfaces for bolting that are parallel to the flange face within 1°. As-cast or as-forged (unmachined nut-bearing surfaces) back face of the flanges shall not be permitted.

If none of the above standards applies, the selection of another design code or standard shall be made by agreement.

NOTE For valves with heavy wall sections, flanges with nut stops in accordance with ASME *BPVC*, Section VIII, Division 1, Mandatory Appendix 2, Figure 2-4 (Sketch 12 or 12a) may be required.

The manufacturing method shall ensure flange alignment in accordance with 5.8.1.2, 5.8.1.3, and 5.8.1.4.

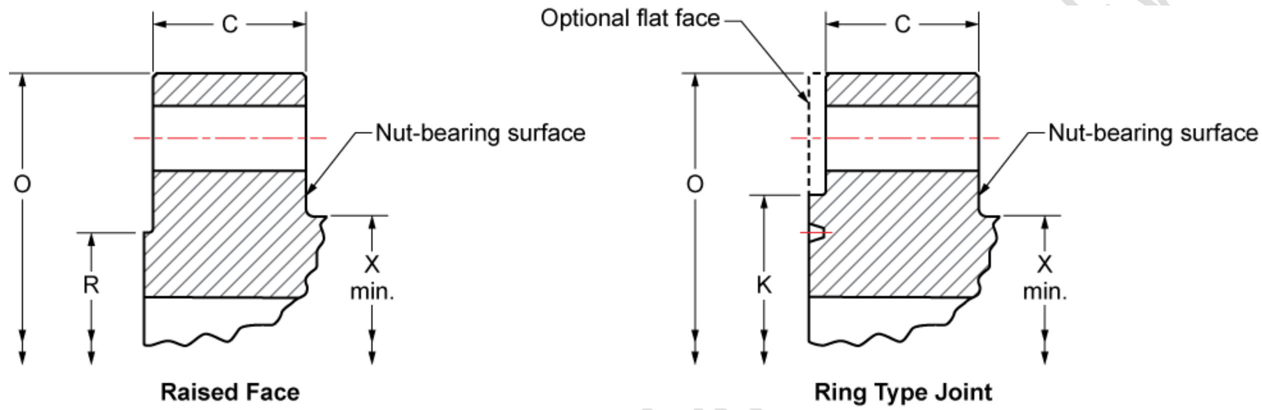
5.8.1.2 Offset of Aligned Flange Centerlines—Lateral Alignment

For valves up to and including NPS 4 (DN 100), the maximum flange misalignment shall be 0.079 in. (2 mm).

For valves larger than NPS 4 (DN 100), the maximum flange misalignment shall be 0.118 in. (3 mm).

5.8.1.3 Parallelism of Aligned Flange Faces—Angular Alignment

The maximum measured difference between flanges shall be 0.03 in./ft (2.5 mm/m).



Key

C flange thickness
O outside diameter of flange
R raised-face diameter
K minimum diameter of raised portion of ring type joint flange
X_{min} hub diameter

Figure 1—Typical Flange Dimensions

5.8.1.4 Total Allowable Misalignment of Bolt Holes

For valves up to and including NPS 4 (DN 100), the maximum total allowable misalignment shall be no greater than 0.079 in. (2 mm) at the bolt holes (see Figure 2).

For valves larger than NPS 4 (DN 100), the maximum total allowable misalignment shall be equivalent to 0.118 in. (3 mm) at the bolt holes.

The surface of the nut-bearing area at the back face of flanged valves shall be parallel to within 1° of the flange face.

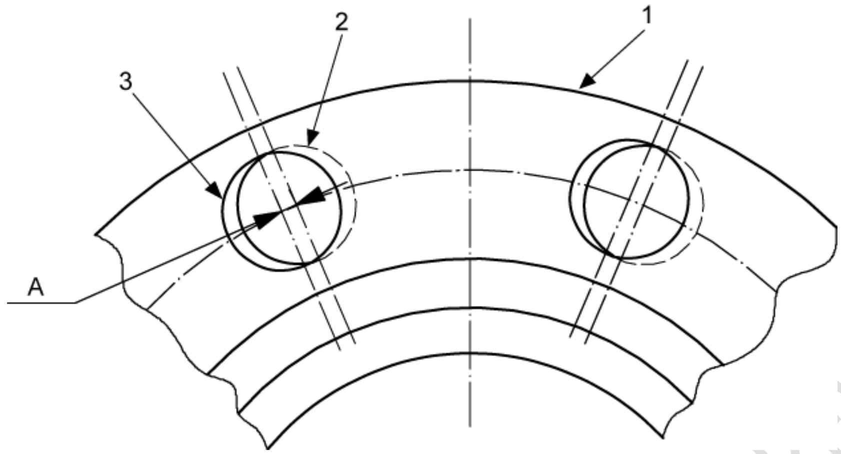
5.8.2 Welding Ends

5.8.2.1 General

Welding ends shall conform to ASME B31.4 or ASME B31.8, unless otherwise agreed.

NOTE In the case of a heavy-wall valve body, the outside profile may be tapered at 30° and then to 45° as illustrated in ASME B16.25.

The purchaser shall specify the outside diameter, wall thickness, material grade, specified minimum yield strength (SMYS) and any special chemistry of the mating pipe, and whether cladding has been applied.



Key

1 flange

2 hole in first flange

3 hole in opposite flange for alignment

A bolt hole misalignment (see 5.8.1.4)

Figure 2—Bolt Hole Misalignment

5.8.2.2 Parallelism of Aligned Weld Ends—Angular Alignment

The maximum measured difference between weld ends shall be 0.03 in./ft (2.5 mm/m) not to exceed 0.125 in. (3 mm).

5.8.3 Alternate Valve End Connections

Other end connections may be specified by the purchaser.

EXAMPLE Clamp, compact, hub, swivel, etc.

5.9 Valve Cavity Pressure Relief

Cavity relief to the environment shall not be used. Testing for internal cavity relief shall be performed in accordance with 10.6.

5.10 Drains, Vents, Body Test Ports, Seal Test Port, and Body Connections

Valves shall be provided with the following connections.

— A drain connection in the valve body, supplied by manufacturer, for the purpose of draining test fluids from the valve on completion of test. Single seated valves without cavities (e.g. check valves) and downstream sealing valves than can be drained by other means need not have drains.

— A vent connection in the valve body supplied by the manufacturer, for the purpose of venting air from the valve body during liquid filling required for test. Alternative means of water filling may obviate the need for a vent connection (e.g. valve placed vertically on test fixture).

— A body test port connection provided to permit monitoring of seat leakage during test. Single seated valves and downstream seating valves have no requirement for a body test port.

— Seal test port connection(s) provided to test the function of individual seals, when multi-barrier seals are provided in series, e.g. stem seals and body seals. Seal test ports shall be provided on all valves used for performance testing in accordance with Annex F. Seal test ports shall only be provided on production valves when specified by the purchaser.

— When specified by the purchaser, permanently installed body connection(s) provided for in-service purposes such as leak detection, fluid injection, flushing, and/or hydrate remediation.

NOTE 1 If the vents and drains can be successfully used for testing, a separate body test connection need not be provided.

NOTE 2 Vents, drains, and body test ports may be used as permanently installed body connections when agreed by the purchaser.

On completion of testing, vents, drains, body test ports, and seal test ports shall be sealed after test, by an agreed method.

NOTE 3 Sealing of test ports may include:

— screwed and sealed NPT fittings,

— seal welded screwed fittings,

— blind flanges with purchaser-specified gaskets and bolting,

— other welded connections.

Permanently installed body connections shall be installed per purchaser instruction.

5.11 Stem/Seat and Cavity Injection Points

Seat and/or stem injection points shall not be required, except by agreement.

5.12 Drain, Sealant, and Vent Valves

Drain, sealant, and vent valves shall not be required, except by agreement**.**

5.13 Hand-wheels and Wrenches—Levers

Wrenches for valves shall either be of an integral design or consist of a head that fits on the stem and is designed to take an extended handle. The head design shall allow permanent attachment of the extended section if specified by the purchaser.

The force required for manual operation of the valve shall not exceed 40 lbf (180 N).

Wrenches that are of integral design (not loose) shall not be longer than twice the face-to-face or end-to-end dimension.

Hand-wheel diameter(s) shall not exceed the face-to-face or end-to-end length of the valve, whichever is smaller. Spokes on the hand-wheel shall not extend beyond the perimeter of the hand-wheel.

Direction of closing shall be clockwise.

5.14 Position of the Obturator

Except for check valves, the position of the obturator shall not be altered by dynamic forces of the passing flow or in the case of screw-operated gate valves by forces generated from internal or external pressure.

5.15 Position Indicators

Valves fitted with operators shall be furnished with a visible indicator to show the open and the closed position of the obturator.

For plug and ball valves, the wrench and/or the position indicator shall be in line with the pipe when the valve is open and transverse when the valve is closed. The design shall be such that the component(s) of the indicator and/or wrench cannot be assembled to falsely indicate the valve position.

Valves with the operator removed and without a position indicator shall have provision for the verification of open and closed position.

When the valve stem is provided with a key slot or master spline in plug or ball valves, the key/master spline shall be in line with the plug/ball bore.

The position indicators shall not be impacted by any marine growth. Method for this protection shall be by agreement.

5.16 Travel Stops

Valves that do not require mechanical force to affect a seal shall be provided with travel stops on the valve and/or operator and they shall locate the position of the obturator in the open and closed position. The travel stops shall not affect the sealing capability of the valve.

NOTE See Annex E for guidance for travel stops by valve type.

5.17 Valve Operator Interface Requirements

Operators shall be mounted on the valves by the valve manufacturer at the factory, unless otherwise agreed.

The interface between operator and valve bonnet shall be designed to prevent misalignment or improper assembly of the components and preserve orientation of the obturator.

Misalignment or improper assembly of valve/operator components shall be prevented by use of a guiding part, such as dowel pin or fitting bolt, which ensures the correct location of operator.

The interface between operator and valve bonnet shall be sealed, e.g. with gaskets or O-rings, to prevent seawater ingress from entering the assembly.

NOTE See Annex D for additional recommendations for operators.

The purchaser shall specify whether it is required that an operator be capable of being removed from the valve subsea.

Where mounting kit, gearbox, or actuator is required to be replaced on the valve while subsea, the valve interface shall as a minimum be provided with the following:

— end stops for open and close position designed to withstand the maximum output load from the operator and located, to allow the obturator to be aligned to the bore in the fully open position and assure full sealing contact in closed position;

— valve interface designed for installation of the gearbox or actuator in only one position;

— suitable visual indicator to give valve position when gearbox or actuator has been removed;

— subsea connection to flush any cavity exposed to seawater after subsea installation—the flushing connection may be located on the mounting kit, gearbox, or actuator;

— dowel pins designed and located to allow gearbox or actuator alignment during subsea installation.

5.18 ROT System

The purchaser shall specify if the valves are required to be ROT operated. The selection of ROT size/class shall be by agreement.

The manufacturer shall stipulate the following:

— normal operating force/torque throughout the operating strokes, for open and closing conditions;

— maximum allowable force/torque such that the stress limits in the valve drive train are not exceeded, as defined by 5.20.2 and 5.20.3;

— number of turns required to operate the valve for one complete stroke.

NOTE 1 Purchasers may choose to standardize on a particular ROT system, but it may not be practical in all cases to size the entire valve for the maximum ROT system loads, requiring the ROT torque/force to be regulated/restricted when operating the valve.

NOTE 2 Typical ROT system interfaces are addressed in API 17H.

Purchaser shall specify one of the following options;

— For the ROT system connected directly to the valve/actuator/gearbox such that the torque/force reaction is transmitted to the valve assembly, the effect of ROV impact loads shall be considered.

— For the ROT system mounted on an adjacent structure such that torque/force reaction is transmitted to the structure and not the valve assembly, the effect of differential movement between valve and structure shall be considered (e.g. thermal, environmental, and seismic as appropriate).

5.19 Lifting Points and Supports

The manufacturer shall determine the need for and verify the design of the lifting points of the valve and/or valve and operator assembly.

In addition, the manufacturer shall provide a lifting procedure for valve and/or valve and operator assembly.

The lifting of the valve and operator assembly by the operator shall not be permitted unless the operator lifting points and the connection between the valve and operator are specifically designed for this purpose.

NOTE 1 See API 17D, Annex K for guidance on pad-eyes.

Subsea valves and operator assemblies shall be designed to ensure freestanding stability.

NOTE 2 Regulatory requirements can specify special design, manufacturing and certification of lifting points.

5.20 Drive Trains

5.20.1 Design Thrust or Torque

The design thrust or torque for all drive train calculations shall be at least two times the calculated breakaway thrust or torque.

NOTE This design factor is to allow for thrust or torque increase in service due to infrequent cycling, low-temperature operation, and the adverse effect of debris.

The design thrust or torque shall be based on the operating mode that requires the greatest value of the thrust or torque. The manufacturer shall identify which of the following operating modes requires the greatest thrust or torque:

— close to open, with a pressure differential equal to MPD;

— close to open, with MPD on both sides of the obturator and with the valve cavity at atmospheric pressure;

— open to close, with the MPD in the valve bore and the valve cavity at atmospheric pressure;

— maximum thrust or torque at zero or the maximum water depth.

5.20.2 Allowable Stresses

Design stresses for tensile stress, shear stress (including torsional shear stress) and bearing stress shall comply with ASME *BPVC*, Section VIII except that the design stress intensity value, S_m, shall be taken as 67 % of yield strength S_y at temperature. In addition the average primary shear stress across a section loaded under design conditions in pure shear (e.g. keys, shear rings, screw threads, etc.) shall be limited to $0.6S_m$.

The maximum primary shear under design conditions, exclusive of stress concentration at the periphery of a solid circular section in torsion, shall be limited to $0.8S_m$.

The average bearing stress for resistance to crushing under the maximum design load shall be limited to the yield strength S_y at temperature.

When bearing loads are applied on parts having free edges, such as at a protruding edge or a keyway, the possibility of a shear failure shall be considered. In the case of load stress only the average shear stress shall be limited to $0.6S_m$.

NOTE These stress limits do not apply to the components of rolling-element or other proprietary bearings or high bearing strength capable materials that are included in the drive train where manufacturer's recommendations or limits derived from tests and service experience apply.

Allowable stress limits of this section shall be justified in design documents.

The drive train shall be designed such that the weakest component is outside the pressure boundary.

A joint efficiency factor of 0.75 shall be used for fillet welds.

5.20.3 Allowable Deflections

Deflections of the drive train shall not prevent the obturator from reaching the fully closed or fully open position.

For all valves, attention shall be paid to deflection and strain.

NOTE Adherence to the allowable stress limits of design codes alone might not result in a functionally acceptable design.

The manufacturer shall demonstrate, by calculation or test, that under loads resulting from design pressure and any purchaser-defined pipe or external loads, distortion of the obturator or seat does not impair functionality or sealing.

5.20.4 Drive Train Bolting

Bolting in the drive train shall be designed to accommodate the direct loading applied by the full actuator/gearbox output and, if applicable, loads from pressure and purchaser-defined external loads. Bolting shall not be subjected to direct shear.

5.21 Stem Retention

Valves shall be designed to ensure that the stem shall not eject under any internal pressure condition or if the packing gland components (see 3.1.37) and/or valve operator mounting components are removed.

5.22 Body and Stem Seals

Seals shall be designed and tested for the specified external pressure (water depth) and operating conditions. Valves with packing that requires adjustment in service shall not be used.

5.23 Valve Stem Seal Integrity Verification

When the stem seal arrangement consists of individual sealing components and the requirement for individual stem seal ports have been agreed upon with the purchaser provision shall be made to allow the primary seal to be independently tested (see 5.10).

5.24 Overpressure Protection

Operators and any intermediate support assemblies shall be provided with a means of preventing pressure buildup resulting from stem or bonnet seal leakage.

5.25 Pressure Cap

If specified by the purchaser, the design shall have provisions for fitting a pressure cap.

The cap and the method of attachment shall be capable of withstanding the valve design pressure and external hydrostatic pressure and shall be hydrostatically tested in accordance with this specification per 10.3. The cap shall have provisions for venting prior to removal and during fitting.

5.26 Stem/Shaft Protector

If specified by the purchaser, the design shall have provisions for fitting a stem/shaft protector. The stem/shaft protector shall not be capable of retaining pressure.

5.27 Hydraulic Lock

If valves or valve components are designed for subsea maintenance, provisions shall be made for venting of all enclosed cavities to ensure that entrapped fluid does not prevent the disassembly or subsequent reassembly of the components.

5.28 Corrosion/Erosion

If specified by the purchaser, the manufacturer shall include corrosion-resistant material or overlay.

NOTE 1 If overlay is specified, any of the following may be applied.

— over the entire internal wetted surface of the valves, or

— only in sealing areas and gasket/body joints, or

— sealing areas only.

If a corrosion allowance is specified by the purchaser, the valve supplier shall conduct all calculations based on the corroded thickness.

NOTE 2 The corrosion allowance does not apply to any areas CRA overlay and CRA material.

NOTE 3 Corrosion allowance may be required for commissioning and hydrostatic test conditions.

NOTE 4 The purchaser may specify an erosion allowance, which is applied to the flow bore of the valve.

The valve supplier shall conduct all calculations based on the eroded thickness.

5.29 Design Validation

All valves designed shall be validated in accordance with the manufacturer's written procedures.

NOTE The manufacturer or purchaser may specify that design validation testing conforms to the minimum requirements in Annex F.

5.30 Hyperbaric Performance

The manufacturer shall demonstrate by calculation (see 5.1) or other means that the valve design is suitable for the required water depth with zero internal pressure in the valve.

NOTE 1 If hyperbaric testing is specified by the purchaser to demonstrate suitability, hyperbaric validation testing may be performed in conformance to the requirements of Annex G.

NOTE 2 Valve and actuator assemblies are preferably tested in a hyperbaric chamber as a single unit. In cases where due to size limitations the complete unit does not fit into the hyperbaric chamber, the valve and operator may be tested separately.

NOTE 3 Valves and/or actuators that cannot be tested in hyperbaric chambers separately due to size limitations may be tested using test fixtures or localized testing.

NOTE 4 A test fixture that simulates the valve operating characteristics is attached to the actuator assembly during hyperbaric testing.

6 Materials

6.1 Material Specification

Specifications for metallic pressure-containing and pressure-controlling parts shall be issued by the manufacturer and shall address the following:

— material grade;

— chemical analysis;

— heat treatment;

— mechanical properties (tensile);

— certification to report all items listed in 6.1.

Other requirements of the material specifications shall be as follows, if applicable:

— carbon equivalent (CE);

— Charpy impacts;

— hardness;

— other testing.

Metallic pressure-containing parts shall be made of materials consistent with the pressure–temperature rating as determined in accordance with 5.2. Use of other materials shall be by agreement.

6.2 Tensile Test Requirements

Tensile test specimens shall be removed from a test coupon (TC) after the final heat treatment cycle. Test specimens shall be cut from a separate or attached block taken from the same heat, reduced by forging where applicable, and heat treated together including stress relieving, as the product materials, except that it is not necessary to retest pressure-containing parts stress relieved at or below a previous stress-relieving or tempering temperature.

Pressure-containing and pressure-controlling parts made from metallic materials shall have a minimum of one tensile test performed at room temperature in accordance with the procedures specified in ASTM A370, ASTM E8/E8M, or ISO 6892-1. For metallic materials, the yield strength shall be in accordance with the industry material standards in the final heat-treated condition.

Pressure-controlling parts made from nonductile metallic materials shall have a minimum of one tensile test performed using the established ASTM method for that material. Where no test method is established, the testing shall be in accordance with ASTM A370, ASTM E8/E8M, or ISO 6892-1.

NOTE 1 For wear-resistant alloys as defined per NACE MR0175/ISO 15156, a tensile test is not required.

Nonductile materials shall not be used for pressure-containing parts.

If the results of the tensile test(s) do not satisfy the applicable requirements, two additional tests from the same TC with no additional heat treatment shall be performed in an effort to qualify the material. The results of both additional tensile tests shall exhibit the minimum applicable requirements.

NOTE 2 Depending on the hardenability of a given material, the TC results might not always correspond to the properties of the actual parts at all locations throughout their cross-section.

NOTE 3 API 6HT provides guidance and good practices for heat treatment of parts with large cross-section, with the goal of achieving the required mechanical properties at the depth below the surface established by the manufacturer.

6.3 Service Compatibility

All process-wetted parts, metallic and nonmetallic, and lubricants shall be suitable for the commissioning fluids and service when specified by the purchaser.

Metallic materials shall be selected so as to avoid corrosion and galling, which would impair function and/or pressure-containing capability.

Selection of elastomeric materials for valves intended for rapid gas decompression service at pressures of Class 600 and above shall address the effect of explosive decompression.

If specified by the purchaser, the manufacturer shall include corrosion-resistant material or overlay on the sealing areas of the pressure-containing and pressure-controlling parts of the valves.

Materials for external components shall be suitable for the subsea environment or shall be suitably protected. Functionality of exposed stems and shafts shall take into account the possibility of calcareous marine growth as a result of cathodic protection (CP). Care shall be taken to avoid galvanic coupling.

Graphite should not be used for stem packing, seals, or gaskets that can come into contact with seawater.

6.4 Cast Material

Cast material shall be an object at or near finished shape obtained by solidification of a fluid substance in a mold. All cast pressure-containing material(s) shall be manufactured using an industry-recognized process.

NOTE See Annex I for guidance for using cast material.

6.5 Forged Material

All forged pressure-containing material(s) shall be formed using a hot-working practice and heat treatment throughout that produces a forged structure with a minimum forge ratio of 3:1. The forging ratio shall be included as part of the material certifications.

NOTE 1 For the purpose of this document, the terms “forged” and “wrought” are used interchangeably.

NOTE 2 See Annex I for guidance for using forge material.

6.6 Composition Limits

The chemical composition of carbon and alloy steel pressure-containing and pressure-controlling parts shall be in accordance with the applicable material standards.

The chemical composition of carbon steel pressure-containing welding ends shall meet the following requirements.

— The carbon (C) content shall not exceed 0.23 % by mass.

— The sulfur (S) content shall not exceed 0.020 % by mass.

— The phosphorus (P) content shall not exceed 0.025 % by mass.

— The carbon equivalent (CE) shall not exceed 0.43 %.

The CE shall be calculated in accordance with the Equation (2):

$$CE = \%C + \%Mn/6 + (\%Cr + \%Mo + \%V)/5 + (\%Ni + \%Cu)/15 \quad (2)$$

The chemical composition of other carbon steel parts shall be in accordance with the applicable material standards.

The carbon content of austenitic stainless steel welding ends shall not exceed 0.03 % by mass, except for stabilized material in which case a carbon content of up to 0.08 % by mass is permissible.

The chemical composition of other materials shall be established by agreement.

Duplex stainless steel used for pressure-containing and pressure-controlling parts shall include a microstructure examination as follows.

— Test specimens shall be cut from a separate or attached block taken from the same heat in the final heat-treated condition.

— Duplex or super duplex intermetallic phases and nitride precipitates shall be examined as follows.

  — The microstructure shall be examined and shall be free from detrimental intermetallic phases and precipitations at minimally 200X magnification. Any presence of intermetallic phases and/or precipitates shall be reported.

NOTE Higher magnification (e.g. 400X to 500X) may be needed to ensure this requirement is met. See ASTM A923 for guidance on acceptance.

— In case intermetallic phases and/or precipitations are detected, the acceptance of product shall be based upon the corrosion and Charpy V-notch test results.

— The ferrite content shall be determined by point counting according to ASTM E562 or by image analysis according to ASTM E1245. The relative accuracy shall be less than 20 %. The ferrite content shall be within 35 % to 65 %.

Duplex stainless steel used for pressure-containing and pressure-controlling parts shall have a corrosion test performed as follows.

— Material taken from the TC after the final heat treatment cycle shall be corrosion tested in accordance with ASTM G48 (latest revision).

— Method A. If the TC is a solid block, one ASTM G48 test specimen shall be taken from the center of the block. If the TC has a hole, two ASTM G48 test specimens shall be taken. One shall be taken adjacent to the inside surface and one from the center of the thickest cross-section. The specimen surface shall be parallel to the internal surface (for the TCs with a hole). Sides of the test specimen shall be ground to a 120-grit finish (or better) with the edges rounded.

— Test temperature shall be 25 ± 2 °C for 22Cr and 50 ± 2 °C for 25Cr duplex stainless and the exposure time 24 hours.

— The acceptance criteria are as follows: Test material shall show no evidence of pitting after 24 hours immersion in the test solution when examined with a low power magnification (minimum 20X), and the maximum weight loss shall be less than 4 g/m^2.

Duplex stainless steel used for pressure-containing and pressure-controlling parts shall have the PREN be calculated in accordance with the Equation (3):

$$PREN = \%Cr + 3.3\ \% (Mo + 0.5W) + 16\ \%N\text{: all \% by weight} \tag{3}$$

Acceptance criteria shall be as follows.

— For 22Cr, the PREN shall be ≥ 35.0.

— For 25Cr, the PREN shall be ≥ 40.0.

6.7 Impact Test Requirements

Carbon, alloy, and stainless steel (except austenitic grades) for pressure-containing and pressure-controlling parts in valves with a specified design temperature below 32 °F (0 °C) shall be impact tested. The test method shall be the V-notch technique in accordance with ASTM A370 or ISO 148-1.

When using ISO 148-1, a striker with a radius of 8 mm shall be used (refer to ISO 148-1 for further details).

NOTE 1 Design standards or local requirements can require impact testing for minimum design temperatures higher than 32 °F (0 °C).

A minimum of one impact test, comprised of a set of three specimens, shall be performed on a representative test bar of each heat of the material in the final heat-treated condition.

Test specimens shall be removed from a TC after the final heat treatment cycle. Test specimens shall be cut from a separate or attached block taken from the same heat, reduced by forging where applicable, and heat treated together, including stress relieving, as the product materials, except that it is not necessary to retest pressure-containing parts stress relieved at or below a previous stress-relieving or tempering temperature.

The impact test shall be performed at the lowest temperature as defined in the applicable material specifications. Except for material for bolting, impact test results for full-size specimens shall meet the requirements of Table 3.

Where the material specification for the subsea pipeline design standard requires impact values to be higher than those shown in Table 2 or Table 3, the higher values shall apply.

Impact test results for bolting material shall meet the requirements of ASTM A320/A320M.

Table 2—Minimum V-notch Impact Requirements for Carbon and Low-alloy Steels (Full-size Specimen)

Specified Minimum Yield Strength		Average of Three Specimens		Minimum of Single Specimen	
psi	MPa	ft lb	Joules	ft lb	Joules
≤40,000	≤275	21	28	16	21
40,000 to 43,500	276 to 300	22	30	17	23
43,500 to 47,125	300 to 325	24	32	18	25
>47,125	>325	27	37	21	28

Table 3—Minimum V-notch Impact Requirements for Duplex and Super Duplex Stainless Steel (Full-size Specimen)

Minimum Test Temperature		Average of Three Specimens		Minimum of Single Specimen	
°F	°C	ft lb	Joules	ft lb	Joules
–50	–46	33	45	26	35

If any impact test fails, then a retest of 1 set of 3 Charpy specimens shall be removed from the same TC with no additional heat treatment, to be performed in an effort to qualify the material. Each impact specimen shall exhibit an impact value equal to or exceeding the required average value.

NOTE 2 As an alternate, sub-sized impact test specimens may be permitted only by agreement; however, the minimum V-notch impact requirements in Table 3 still apply.

Charpy impact values for other materials shall be by agreement.

6.8 Bolting

Pressure boundary bolting shall conform to the requirements of API 20E or API 20F in accordance with Annex H.

Carbon and low-alloy steel bolting material, with a hardness exceeding HRC 34 (HBW 319), shall not be used for valve applications where hydrogen embrittlement can occur.

NOTE 1 Carbon and low-alloy steel bolting material with HRC 32 (HBW 301) or less may provide additional resistance for hydrogen embrittlement.

Hardness limits for bolting other than carbon and low-alloy bolting material materials shall be by agreement.

NOTE 2 See Annex H for CRA material requirements per API 20F.

When low-temperature bolting is required, it shall be provided in accordance with ASTM A320/A320M for the specific grade of material. Subsea and splash-zone bolting $2^{1}/_{2}$ in. (62.5 mm) and larger on pressure boundary bolting shall conform the ASTM A320/A320M, Grade L43.

Pressure boundary carbon steel bolting in CP system shall not be zinc plated. Other coating or plating shall be by agreement.

6.9 Cathodic Protection

The purchaser shall advise the manufacturer if the valve will be exposed to a CP system. The purchaser shall select materials and stress levels to avoid the risk of hydrogen embrittlement due to the presence of the CP system, which could result in hydrogen induced stress corrosion cracking (HISCC).

The manufacturer shall ensure electrical continuity between all parts, including bolting.

If specified, the equipment manufacturer shall document the following as a minimum.

— External total wetted surface area, individual areas for each specific material and for each coated and uncoated surface.

— Metallurgy of construction materials exposed to the external wetted surfaces.

— Manufacturer and specification of coating systems applied to external wetted surfaces.

— Electrical continuity in accordance with 10.15.

Components with external wetted surfaces and exposed to CP system shall not exceed the following hardness limitations.

— Carbon and low-alloy steels, including bolting shall have a hardness not exceeding 34 HRC (319 HBW), unless they are exposed to wellbore fluids where the NACE minimum requirements shall apply.

— Precipitation hardening nickel-based alloys materials, including that used in bolting, shall have a hardness not exceeding that specified by NACE.

NOTE Design stress levels per DNVGL ST F101 and DNV RP F112 are available for guidance.

6.10 Sour Service

Materials for pressure-containing and pressure-controlling parts and bolting for sour service shall meet the requirements of NACE MR0175 or ISO 15156 (all parts).

6.11 Hydrogen-induced Cracking

Process-wetted and pressure-controlling parts for valves in sour service applications that are manufactured from plate shall be resistant to HIC.

Resistance shall be demonstrated by HIC testing in accordance with NACE TM0284, per heat, per heat treatment batch combination.

Acceptance criteria shall be in accordance with NACE MR0175 (ISO 15156-2).

6.12 Drain Connections

Drain connection material shall be compatible with the valve body material or made from a corrosion-resistant material compatible for subsea service condition.

6.13 Heat Treating Equipment Qualification

6.13.1 General

Heat treating of pressure-containing and pressure-controlling parts and associated TCs shall be performed with “production-type” equipment meeting the requirements specified by the manufacturer.

“Production-type” heat treating equipment shall be recognized as equipment that is routinely used to process production parts.

All heat treatment for mechanical properties shall be performed using furnaces that are calibrated in conformance with Annex J. Postweld heat treatment (PWHT) shall be performed with heat treating conforming to requirements specified by the manufacturer.

6.13.2 Temperature Tolerance

6.13.2.1 Austenizing, Normalizing, Annealing, or Solution Annealing Furnaces

The temperature at any point in the working zone of a furnace used for austenitizing, normalizing, annealing, or solution annealing shall not vary by more than ±25 °F (±14 °C) from the furnace set-point temperature after the furnace working zone has been brought up to temperature. Before the furnace set-point temperature is reached, none of the temperature readings shall exceed the set-point temperature by more than the temperature tolerance.

6.13.2.2 Tempering, Aging, or Stress-relieving Furnaces

Furnaces that are used for tempering, ageing and/or stress-relieving shall not vary by more than ±15 °F (±8 °C) from the furnace set-point temperature after the furnace working zone has been brought up to temperature. Before the furnace set-point temperature is reached, none of the temperature readings shall exceed the set-point temperature by more than the temperature tolerance.

6.13.2.3 Multiple Use Furnaces

For furnaces used for both of the above heat treatment operations, the heat treatment supplier shall define the temperature range for each operation. The furnace temperature uniformity survey shall conform to the requirements specified in 6.13.2.1 and 6.13.2.2, as appropriate for the process used.

6.13.3 Temperature Uniformity Survey Frequency

The temperatures within each furnace shall be surveyed within 1 year prior to use of the furnace for heat treatment and shall be recalibrated at a frequency not longer than 12 months from the last survey.

6.13.4 Instrument Accuracy

The controlling and recording instruments used for the heat treatment processes shall be accurate to ±1 % of full-scale range.

6.13.5 Calibration

Temperature-controlling and recording instruments shall be calibrated at least once every 3 months.

Equipment used to calibrate the production equipment shall be accurate to ±0.25 % of full-scale range.

6.13.6 Major and Minor Furnace Repairs

The requirements of Annex J shall apply to major and minor furnace repairs.

NOTE Both major and minor furnace repairs can affect the frequency of furnace temperature surveys.

6.13.7 Method for Performing Furnace Temperature Surveys

Annex J shall apply for performing furnace temperature surveys.

6.13.8 Records Retention

Records of furnace calibration and surveys shall be for a period not less than 5 years. The minimum records of furnace calibration/survey shall be a certificate of conformance in accordance with Annex J.

7 Welding

7.1 Welding Consumables

Welding consumables shall conform to the American Welding Society's or manufacturer's specifications. The manufacturer shall have a documented procedure for storage and control of welding consumables. Materials of low-hydrogen type (including electrodes, wires, and fluxes) shall be stored and used as recommended by the manufacturer of the welding consumable to retain their original low-hydrogen properties.

7.2 Welding Procedure and Welder/Welding Operator Qualifications

Welding, including repair welding, of pressure-containing and pressure-controlling parts shall be performed in accordance with procedures conforming to this specification, and qualified to:

— ASME BPVC, Section IX; or

— ISO 15609 and ISO 15614-1.

Welders and welding operators shall be qualified in accordance with ASME *BPVC*, Section IX or ISO 9606-1, or EN 287-1.

NOTE 1 The purchaser, pipeline or piping design standards, material specifications, and/or local requirements may specify additional requirements.

The results of all qualification tests shall be documented in a procedure qualification record (PQR).

PWHT shall be performed in accordance with the applicable material specification or design code.

For weld overlay, qualification shall be in accordance with ASME *BPVC*, Section IX, Articles II and III or ISO 15614-7.

Chemical analysis of the weld metal (WM) shall be performed in accordance with the requirements of ASME *BPVC*, Section IX at the minimum overlay thickness as specified by the manufacturer for the finished component.

The minimum thickness of the finished corrosion-resistant weld overlay on all surfaces shall be at least 0.12 in. (3.0 mm). Other thickness shall be by agreement.

Rough machining tolerances and finished machined tolerances shall be controlled to ensure that the exposed layer meets the dilution established through qualification.

For the nickel-based alloy UNS N06625 clad/weld overlay, the chemical composition shall meet one of the classes given in Table 4. For all other composition, the chemical analysis of the weld overlay or clad welding shall conform to the manufacturer’s documented specification.

Fe10 shall be used unless Fe5 is specified by the purchaser.

NOTE 2 Some pipeline welding standards have more stringent requirements for the essential variables of welding. It may be necessary to provide full weld test rings, in the same heat treatment condition as the finished valve, for weld procedure qualification.

Table 4—Chemical Composition of Nickel-based Alloy UNS N06625

Class	Element	Composition (% mass fraction)
Fe10	Iron	10.0 maximum
Fe5	Iron	5.0 maximum

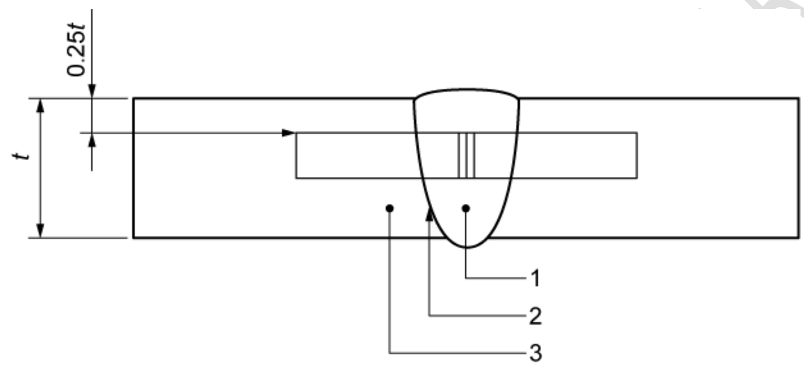
7.3 Impact Testing

Carbon, alloy, and stainless steel (except austenitic grades) for qualifications of procedures for welding, including repair welding, of pressure-containing and pressure-controlling parts shall meet the following toughness test requirements.

Impact testing shall be carried out for the qualification of procedures for welding on valves with a design temperature of 32 °F (0 °C) or below.

NOTE Design standards and/or local requirements may require impact testing at minimum design temperatures above 32 °F (0 °C).

As a minimum, one set of three WM impact specimens shall be taken from the WM at the location shown in Figure 3. The specimens shall be oriented with the notch perpendicular to the surface of the material. Multiple sets of WM impact specimens shall be required when more than one welding process is used. WM impact testing shall be performed to represent each welding process being qualified.



Key

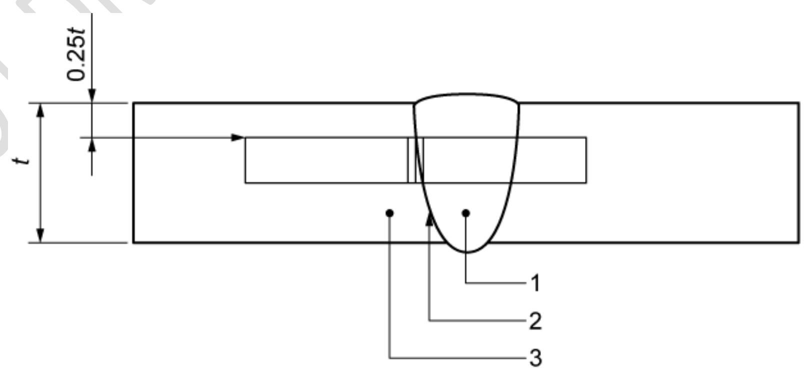
1 weld metal (WM)

2 heat-affected zone (HAZ)

3 base metal (BM)

Figure 3—Charpy V-notch WM Specimen Location

A set of three impact specimens shall be taken from the heat-affected zone (HAZ) at the location shown in Figure 4. The notch shall be placed perpendicularly to the material surface at a location resulting in a maximum amount of HAZ material located in the resulting fracture.



Key

1 weld metal (WM)

2 heat-affected zone (HAZ)

3 base metal (BM)

Figure 4—Charpy V-notch HAZ Specimen Location

HAZ tests shall be conducted for each of the materials being joined when the base materials being joined are of a different P-number and/or group number in accordance with ASME *BPVC*, Section IX or ISO 9606-1, ISO 15607, ISO 15609, ISO 15614-1, and ISO TR 15608:2013 or when one or both of the base materials being joined are not listed in the P-number and/or group number.

Impact testing shall be performed in accordance with ASTM A370 or ISO 148-1 using the Charpy V-notch technique.

When using ISO 148-1, a striker with a radius of 8 mm shall be used (refer to ISO 148-1 for further details). The impact test temperature for welds and HAZs shall be at or below the minimum design temperature specified for the valve. Impact test results for full-size specimens shall meet the requirements of 6.7. If the material specification requires higher impact values than those shown in 6.7, the higher values shall apply.

7.4 Hardness Testing

Hardness testing shall be carried out as part of the welding procedure qualification on pressure-containing and pressure-controlling parts in valves required to meet NACE MR0175 or ISO 15156 (all parts), as applicable.

Hardness surveys shall be performed on base metal (BM), WM, and HAZ in accordance with the requirements of NACE MR0175 or ISO 15156 as applicable.

7.5 Repairs

Repair of defects shall be performed in accordance with a documented procedure specifying requirements for defect removal, welding, heat treatment, nondestructive examination (NDE), and reporting as applicable.

NOTE 1 Minor defects may be removed by grinding provided there is a smooth transition between the ground area and the original contour and the minimum wall thickness requirements are not affected.

Weld repair of forgings and plates shall not be performed to correct material defects, unless otherwise agreed.

NOTE 2 Weld repair on forgings and plates may be used to correct machining errors.

The weld repair shall be in accordance with the applicable material standard, including any PWHT.

— A weld map shall be required for each casting, which details the surface area and configuration (length, width, and depth) of each major weld repair.

— A unique number or symbol shall be required and assigned to each casting with an associated weld map, which has been weld repaired.

— A hardness measurement on the weld deposit of one of the major weld repairs shall be required and made after the final PWHT operation.

— The information and test results from the above requirements shall be documented and reported on the materials test report or other documents.

— All major weld repairs of castings shall require PWHT.

— Weld repair of all castings shall be limited to 25 % of total surface area.

— No casting weld repair shall exceed 50 % of the wall thickness of the affected area, unless by agreement.

Repair of welds shall be performed in accordance with the applicable design code or standard listed in 5.1, including any PWHT where applicable.

8 Quality Control

8.1 Quality Control Procedures

All quality control work shall be controlled by the manufacturer's documented procedures, which include appropriate methodology and quantitative or qualitative acceptance criteria.

8.2 NDE Requirements

The extent, method, and acceptance criteria for NDE of parts shall be in accordance with Annex K, which specifies two levels of NDE requirements (QL-1 and QL-2) to assist the purchaser with the selection of a set of requirements appropriate for the intended valve duty.

If no NDE QL is specified by the purchaser, then QL-1 shall be provided as a minimum.

All base material and welding material surface [magnetic-particle testing (MT) and penetrant testing (PT)] and volumetric [ultrasonic testing (UT) and radiographic testing (RT)] NDE examination shall be conducted after the final heat treatment or PWHT, unless otherwise agreed.

The purchaser shall specify the NDE QL level at the time of the order placement, considering the following factors:

— service fluid;

— size/pressure/temperature;

— location:

— water depth;

— material of construction;

— application and function.

8.3 Measuring and Test Equipment

8.3.1 General

Equipment used to inspect, test, or examine material or other equipment used for acceptance shall be identified, controlled, calibrated, and adjusted at specified intervals in accordance with documented manufacturer instructions, and consistent with nationally or internationally recognized standards specified by the manufacturer, to maintain the accuracy required by this specification.

8.3.2 Dimension-measuring Equipment

Dimension-measuring equipment shall be controlled and calibrated in accordance with methods specified in documented procedures.

8.3.3 Pressure-measuring Devices

8.3.3.1 Type and Accuracy

Test pressure-measuring devices shall be accurate to at least ±2.0 % of the calibration pressure. If pressure gauges are used in lieu of pressure transducers, they shall be selected such that the test pressure is indicated within 20 % and 80 % of the full-scale value.

8.3.3.2 Calibration Procedure

Pressure-measuring devices shall be calibrated with a master pressure-measuring device or deadweight tester. Calibration shall be performed at a minimum of three points not including zero and full scale.

NOTE If the number of calibration points is x and the full scale pressure is Pfs, the intervals between calibration points would be $Pfs/(x+1)$. In terms of % of full scale, the intervals between calibration points would be (100 %)/(x + 1).

EXAMPLE 1 For the minimum requirement of three calibration points, x = 3, and the calibration intervals would be (100 %)/(3 + 1) = (100 %)/4 = 25 %. So calibration would be performed at 25 %, 50 %, and 75 % of full scale as a minimum.

EXAMPLE 2 For a requirement of five calibration points including full scale, x = 4, because the full scale calibration is not included in x. The calibration intervals then would be (100 %)/(4 + 1) = (100 %)/5 = 20 %. So calibration would be performed at 20 %, 40 %, 60 %, 80 %, and 100 % of full scale.

8.3.3.3 Calibration Intervals

Calibration intervals shall be established for calibrations based on repeatability and degree of usage.

Calibration intervals shall be a maximum of 3 months until recorded calibration history can be established by the manufacturer.

Intervals shall be shortened and may be lengthened based on review of the calibration history and determination of interval adjustments as defined in the manufacturer's documented procedure. Increments to establish longer intervals shall be limited to 3 months maximum.

The maximum calibration period shall not exceed 1 calendar year.

8.3.4 Temperature-measuring Devices

Temperature-measuring devices shall be capable of indicating and recording temperature fluctuations of 9 °F (5 °C).

8.3.5 Pressure Recording Devices

Pressure recording devices shall be accurate to at least ±2.0 % of the calibration pressure of the recording device (see 8.3.3.1).

8.3.6 Heat Treatment Equipment Calibration

Heat treatment equipment calibration shall be performed prior to putting the equipment in service and shall be recalibrated at a frequency not longer than 12 months from the last calibration.

8.4 Qualification of Personnel

8.4.1 NDE Personnel

NDE personnel shall be qualified in accordance with the manufacturer's documented training program that is based on and meets the minimum requirements specified in ASNT SNT-TC-1A or ASNT Central Certification Program (ACCP) or ISO 9712.

NOTE Alternative standards are acceptable provided they meet the minimum requirements of ASNT SNT-TC-1A.

8.4.2 Visual Examination Personnel

Personnel performing visual inspection for acceptance shall take and pass an annual vision examination in accordance with the manufacturer's documented procedures that meet the applicable requirements of ASNT SNT-TC-1A or ASNT Central Certification Program (ACCP) or ISO 9712.

NOTE Alternative standards are acceptable provided they meet the minimum requirements of ASNT SNT-TC-1A.

8.4.3 NDE Procedures

NDE procedures shall be detailed regarding the requirements of this specification and those of all applicable nationally or internationally recognized standards specified herein. All NDE procedures shall be approved by a qualified Level III examiner in accordance with ASNT SNT-TC-1A or ASNT Central Certification Program (ACCP) or ISO 9712.

8.4.4 NDE Inspections

All NDE inspection activities for interpretation of acceptance criteria shall be performed by minimum NDE Level 2 personnel.

8.4.5 Other Personnel

All personnel performing other quality control activities directly affecting material and product quality shall be qualified in accordance with manufacturer's documented requirements.

8.5 Welding Inspectors

Personnel performing visual inspections of welding operations and completed welds shall be qualified and certified in accordance with one of the following:

— AWS QC1 or equivalent certified welding inspector, or

— AWS QC1 or equivalent senior certified welding inspector, or

— AWS QC1 or equivalent certified associated welding inspector, or

— welding inspector certification in accordance with the manufacturer's documented training program.

8.6 NDE of Repairs

After defect removal, the excavated area shall be examined by MT or PT methods in accordance with Annex K.

Repair welds on pressure-containing parts shall be examined using the same NDE method that was used to identify the defect with a minimum of MT or PT.

Acceptance criteria shall be as specified in Annex K for the appropriate product form (e.g. cast, forged, plates, etc.). The final NDE activities shall be conducted after PWHT, unless otherwise agreed.

The NDE requirements specified by the purchaser in 8.2 shall also apply to repair welding.

8.7 Production Material Hardness Testing on Critical Parts

A production material hardness test shall be performed on all metallic pressure-containing, pressure-controlling, and pressure boundary bolting (magnetic, nonmagnetic, duplex, or CRA materials). Hardness testing shall not be performed on finished machined sealing surfaces.

The method of hardness testing shall be performed in accordance with the following.

— For Brinell hardness measurements, testing shall be performed in accordance with ASTM E10 or ISO 6506-1.

— For Rockwell hardness measurements, testing shall be performed in accordance with ASTM E18 or ISO 6508-1.

— Portable hardness measurements shall be performed in accordance with ASTM E110.

In case of sour service, the maximum hardness shall be as per NACE MR0175/ISO 15156 requirements.

In case of non-sour service, the maximum hardness reading shall be in accordance with the material specifications issued by the manufacturer (see 6.1).

Results of the production hardness testing shall be reported and records maintained (see Section 14).

NOTE This hardness test may be performed by the suppler of the material and reported on the material test report.

8.8 Marking, Age Control, and Storage for Nonmetallic Seals

8.8.1 Marking and Age Control

The manufacturer’s written requirements for nonmetallic seals shall include the following minimum provisions:

a) batch number;

b) cure/mold date;

c) shelf-life expiration date.

8.8.2 Storage

The manufacturer's written requirements for nonmetallic seals shall include the following minimum provisions:

— indoor storage;

— maximum temperature not to exceed 120 °F (49 °C);

— protected from direct natural light;

— stored unstressed (see text below);

— stored away from contact with liquids;

— protected from ozone and radiographic damage.

Packaging and storage of elastomeric seals shall not impose tensile or compressive stresses sufficient to cause permanent deformation or other damage.

NOTE 1 Recommendations are typically available from seal manufacturers.

NOTE 2 Where applicable, for a given seal design, rings of large inside diameter and relatively small cross-section may be formed into three equal super imposed loops to avoid creasing or twisting, but it is not possible to achieve this condition by forming just two loops.

9 Valve Assembly

Valve assembly instructions shall be provided to outline conformance to the following as a minimum.

— Assembly thread compound application above 500 °F (260 °C) that includes any of the following elements—antimony, bismuth, lead, or tin—shall not be permitted.

— Bolt loading and tightening sequence requirements for pressure boundary bolting shall be controlled in accordance with the manufacturer's written procedure.

10 Factory Acceptance Testing (FAT)

10.1 General

Each valve shall have a FAT in the final assembled condition in order to perform the required tests as specified herein prior to shipment.

Valves for gas service shall be subject to a gas shell and seat test in accordance with 10.9 and 10.11.

The hydrostatic shell test shall be performed first before any other pressure test.

Testing shall be performed in the sequence detailed in 10.3 to 10.15.

NOTE 1 Backseat test that is only applicable to valves per 10.2 may be performed before or after the hydrostatic shell test in 10.3.

The equipment used by the valve manufacturer to perform the required pressure tests shall not apply external forces that affect seat leakage or reduce the axial load acting on the bolted connections. When a test fixture is used that does not allow the full pressure force to be transmitted to the bolted connection, at least one production valve for the size/class shall be tested with valve inlet and outlet end caps to ensure that the full axial test pressure force is transmitted to the bolted connection and sealing elements. The valve manufacturer shall demonstrate that the test fixture does not affect the seat sealing capability of the valve being tested.

Pressure testing shall be carried out before external coating of the valve.

NOTE 2 If the valve has been previously tested and passed in accordance with this specification, subsequent repeat of hydrostatic and pneumatic testing may be performed without removal of the valve external coating.

Test fluid shall be fresh water and shall contain a corrosion inhibitor. In addition, all seals shall be compatible with the test fluid when using glycol is added. The water temperature shall be maintained between 35 °F (2 °C) minimum and 100 °F (38 °C) maximum during the testing period.

Room temperature during testing shall be held between 40 °F and 100 °F (4 °C and 38 °C) during the test period.

The chloride content of test water in contact with austenitic and duplex stainless steel wetted components of valves shall not exceed 30 µg/g (30 ppm by mass). The chloride content in the test water shall be tested at least every 12 months and records shall be maintained in accordance with Section 14.

Valves shall be tested with the seating and sealing surfaces free from sealant except if by agreement the sealant is the primary means of sealing. The use of sealant shall only be permitted if it can be replenished when the equipment is in a subsea environment. A secondary seat and/or stem packing sealant system, if provided, shall not be used before or during tests.

All hydrostatic and gas shell tests specified shall be performed with the valve unseated and partially open and may also be performed with the valve fully open, provided the body cavity is simultaneously filled and pressurized through a cavity connection.

If the valve body connections are not available for direct monitoring, methods for monitoring pressures and/or leakage shall be determined by other methods.

Supply pressure shall be isolated from the valve being tested and shall be stabilized prior to the start of shell pressure testing duration.

The pressure/temperature measuring device shall be installed in the test apparatus in such a manner that the device continuously monitors/records the internal test pressure/temperature of the valve assembly. The pressure tests shall be held for the minimum test durations listed in 10.2, 10.3, and 10.5 once the pressure stabilized.

Pressure shall be considered stabilized when the rate of change is no more than 3 % of the initial test pressure per hour. The test pressure shall not drop below the minimum test pressure during the specified hold period.

The initial test pressure shall not be greater than 5 % above the specified minimum test pressure. All pressure testing shall be performed in accordance with manufacturer's documented procedures.

A calibrated chart recorder or other suitable recording devices shall be used to provide a record for all hydrostatic tests.

NOTE 3 Supplementary pressure tests are found in Annex L and are required if specified by the purchaser at time of order placement.

10.2 Stem Backseat Test

10.2.1 General

Testing of the backseat on valves that have this feature shall be performed. Self-energized packing or seals shall be removed unless a test port is provided for this test.

The valves shall be filled with the ends closed off and the obturator in the partially open position until leakage of the test fluid around the stem is observed. The backseat shall then be closed and a minimum pressure of 1.1 times the pressure rating determined in accordance with 5.2 for material at 100 °F (38 °C) applied for the duration specified in Table 5.

Monitoring for leakage shall be through a test access port or by monitoring leakage around the loosened packing.

10.2.2 Acceptance Criteria

Any visually detectable leakage during the test duration at test pressure on any external surface of the shell shall be cause for rejection.

Warning—Appropriate safety precautions must be taken.

Table 5—Minimum Duration of Stem Backseat Tests

Valve Size		**Test Duration** min
NPS	**DN**	
≤4	≤100	5
≥6	≥150	10

10.3 Hydrostatic Shell Test

10.3.1 General

Valve ends shall be closed off during the test. If specified by the purchaser, the method of closing the ends shall permit the transmission of the full-pressure force acting on the end blanks to the valve body.

Final pressure-containing fittings that are not used for leakage monitoring or detection shall be fitted for hydrostatic shell testing.

The test pressure shall be at least 1.5 times the pressure rating determined in accordance with 5.2 for material at 100 °F (38 °C) based on the valve end connection material.

When performing a higher hydrostatic shell test and the valve is flanged, the hydrostatic shell test shall be performed with bore sealing plugs to ensure the flanges are not subjected to test pressures greater than 1.5 times the valve flange rating.

The test duration shall not be less than 4 hours for all valve sizes.

10.3.2 Acceptance Criteria

No visually detectable leakage shall be permitted during the hydrostatic shell test.

10.3.3 Hydrostatic Shell Test with Pipe Pups

Hydrostatic shell test shall be required if pipe pups are to be welded to the valve as part of the final valve assembly by the manufacturer. Test pressure, duration, and acceptance criteria shall be in accordance with 10.3.

When the allowable test pressure rating of the pipe pup is less than the required hydrostatic test pressure, the valve shall first be hydrostatic tested without the pipe pups welded to the valve. Subsequently, the pipe pups shall be welded to the valve followed by a hydrostatic shell test of the assembly at a lower pressure specified by the purchaser.

Test duration shall not be less than 30 minutes minimum after stabilization with no visually detectable leakage allowed.

Following the hydrostatic test of assembly the external weld surface shall be subject to NDE (MT or PT) as specified in K.13 or K.16, as applicable.

10.4 Operational/Functional Test

10.4.1 General

The measured torque or thrust results shall be recorded and shall not exceed the manufacturer's documented calculated breakaway torque/thrust. The valve shall be operated for each appropriate condition defined in 10.5.4.

10.4.2 Manual Valves

Each manual or ROT-operated valve, excluding check valves, shall be operated a minimum of four times while subject to the differential pressure specified in 5.2.

Valves requiring input forces exceeding that specified in 5.20.1, or that fail to seal after operation, shall be rejected.

The measured torque or thrust results shall be recorded and shall not exceed the manufacturer's documented calculated breakaway torque/thrust.

10.4.3 Actuated Valves

Each actuated valve, excluding check valves, shall be operated a minimum of four times while subjected to the differential pressure specified in 5.2. For bidirectional valves, the valves shall be tested a minimum of four times in each direction.

The thrust or torque shall be measured. Valves requiring thrust or torque exceeding the design torque specified in 5.20.1, or that fail to seal after operation, shall be rejected.

The measured torque or thrust results shall be recorded and shall not exceed the manufacturer's documented calculated breakaway torque/thrust.

10.4.4 Check Valves

Each check valve fitted with an operating mechanism shall be operated (close–open–close) four times while the entire body cavity is subjected to the rated pressure listed in 5.2. Valves that fail to operate, fail to seal after cycling or require torque exceeding the design torque values specified in 5.20.1 shall be rejected.

The measured torque or thrust results shall be recorded and shall not exceed the manufacturer's documented calculated breakaway torque/thrust.

10.5 Hydrostatic Seat Test

10.5.1 Preparation

NOTE Assembly lubricants for metal-to-metal contact surfaces may be used by agreement.

10.5.2 Test Pressure and Duration

The test pressure for all seat tests shall not be less than 1.1 times the pressure rating determined in accordance with 5.2 for material at 100 °F (38 °C) based on the valve end connection material.

The hydrostatic seat test shall consist of three tests.

— Reduce pressure to zero after each test.

— Cycle the valve fully open and fully closed after each test.

— Check valves shall be unseated and reseated. Method for unseating and reseating shall be per manufacturer's written procedure.

— Tests 1 and 3 shall have test duration not less than 15 minutes.

— Test 2 shall have an extended duration not less than 30 minutes.

For bidirectional valves, the valves shall be tested in each direction.

The duration listed shall apply to all valves sizes.

10.5.3 Acceptance Criteria

Leakage for soft-seated valves and lubricated plug valves shall not exceed ISO 5208, Rate A (no visually detectable leakage for the duration of the test at test pressure).

For metal-seated valves, other than check valves the liquid leakage rate shall not exceed ISO 5208, Rate C. The test procedures for various types of block valve are given in 10.5.4.

For metal-seated check valves, the liquid leakage rate shall not exceed ISO 5208, Rate D.

Seat leakage shall be monitored from each seat via the valve body cavity vent or drain connection. Leakage detected as originating from behind seat rings or around resilient closure materials shall be cause for rejection.

NOTE Special application may require that the metal-to-metal valves leakage rate be less than ISO 5208, Rate C or D.

10.5.4 Seat Test Procedures for Block Valves

10.5.4.1 Unidirectional

With the valve half-open, the valve and its cavity shall be completely filled with test fluid. The valve shall then be closed and the test pressure applied to the appropriate end of the valve.

Leakage from the upstream seat shall be monitored via the valve body cavity vent or drain connection, where provided. For valves without body cavity or drain connection, or downstream seated valves, seat leakage shall be monitored at the respective downstream end of the valve (the valve end downstream of the pressurized test fluid).

10.5.4.2 Bidirectional

With the valve half-open, the valve and its cavity shall be completely filled with test fluid. When filled, the valve shall be closed, the test pressure applied to one end of the valve, held for the required test duration, and then depressurized. Subsequently, the pressure shall be applied to the other end of the valve, held for the required test duration, and then depressurized.

Seat leakage shall be monitored from each seat via the valve body cavity vent or drain connection, where provided. For valves without a body-cavity vent or drain connection, seat leakage shall be monitored from the respective downstream end of the valve.

10.5.4.3 Double Block and Bleed (DBB)

If the functionality for the valve is to be DBB, the test shall be performed as follows.

With the valve unseated and partially open, the valve and its cavity shall be completely filled with test fluid. The valve shall then be closed and the valve body vent valve opened to allow excess test fluid to overflow from the valve cavity test connection. The test pressure shall be applied simultaneously from both valve ends.

Seat tightness shall be monitored via overflow through the valve cavity connection.

Acceptance criteria shall be per the requirements of 10.5.3, except the metal-to-metal seat test leakage rate shall not be more than two times ISO 5208, Rate C.

10.5.4.4 Double Isolation and Bleed DIB-1 (Both Seats Bidirectional)

If the functionality for the valve is to be double isolation and bleed (DIB-1), both seats bidirectional, the test shall be performed as follows.

— Each seat shall be tested in both directions.

— The valve and cavity shall be filled with test fluid, with the valve unseated and partially open, until the test fluid overflows through the valve body cavity connection.

— To test for seat leakage in the direction of the cavity, the valve shall be closed. The test pressure shall be applied successively to each valve end to test each seat separately from the upstream side. Leakage shall be monitored via the valve body cavity connection.

— Thereafter, each seat shall be tested as a downstream seat. Both ends of the valve shall have the ends open to atmosphere and the valve cavity filled with test fluid or valve types can require the balancing of the upstream and valve cavity pressure during the downstream seat test in which case only one end of the valve shall be open to atmosphere. Pressure shall then be applied while monitoring leakage through each seat at both ends of the valve.

Acceptance criteria shall be per the requirements of 10.5.3, except the metal-to-metal seat test leakage rate shall not be more than two times ISO 5208, 2015 Rate C.

10.5.4.5 Double Isolation and Bleed DIB-2 (One Seat Unidirectional and One Seat Bidirectional)

If the functionality for the valve is to be double isolation and bleed (DIB-2), one seat unidirectional and one seat bidirectional, the test shall be performed as follows.

— The bidirectional seat shall be tested in both directions.

— The valve and cavity shall be filled with test fluid, with the valve unseated and partially half-open, until the test fluid overflows through the body cavity connection.

— To test for seat leakage in the direction of the cavity, the valve shall be closed. The test pressure shall be applied successively to each valve end to test each seat separately from the upstream side. Leakage shall be monitored via the body cavity connection.

— To test the bidirectional seat from the cavity test, pressure shall be applied simultaneously to the valve cavity and upstream end. Monitor leakage at the downstream end of the valve.

Acceptance criteria shall be per the requirements of 10.5.3, except the metal-to-metal seat test leakage rate shall not be more than two times ISO 5208, 2015, Rate C.

NOTE See Annex M for additional information on isolation features.

10.6 Cavity Relief Test

10.6.1 General

If the valve has a cavity relief system other than self-relieving seats, testing shall be performed in accordance with a documented procedure by agreement.

Each valve shall be tested, except valves that cannot trap pressure in the cavity.

For valves where cavity overpressure relief is provided via one or more self-relieving seats, this shall be demonstrated by one of the cavity relief tests in 10.6.2.

For trunnion-mounted ball valves with self-relieving seats, selection of one of the two procedures in 10.6.2 shall be by agreement.

10.6.2 Trunnion-mounted Ball Valves with Internal-relieving Seats

10.6.2.1 Procedure 1

The procedure for cavity-relief testing of trunnion-mounted ball valves with internal-relieving seats shall be as follows.

a) Fill the valve in the half-open position with water and purge trapped air.

b) Close the valve.

c) Close both branch vents.

d) Apply pressure to the valve cavity until one branch pressure starts to rise and the seat relieves the cavity pressure into the valve end; record this relief pressure and port location.

For valve types with two self-relieving seats, continue to increase the pressure to the cavity until the second branch pressure starts to rise and the second seat relieves; record the relief pressure of the second seat.

e) Failure to relieve at a differential pressure less than 33 % the valve pressure rating shall be cause for rejection.

EXAMPLE 1 Class 150, 275 psi (19.0 bar), the maximum rated pressure-relief pressure is 90 psi (6.2 bar).

EXAMPLE 2 Class 2500, 6250 psi (430.9 bar), the maximum rated pressure-relief pressure is 2060 psi (142.1 bar).

f) Failure to relieve pressure shall be cause for rejection.

Pressure–temperature ratings for class-rated valves shall be in accordance with the applicable rating table for the appropriate material group in ASME B16.34.

10.6.2.2 Optional Procedure 2

The procedure for cavity-relief testing of trunnion-mounted ball valves with one or more self-relieving seats shall be conducted using the following.

a) Fill the valve in the half-open position with water.

b) Close the valve.

c) Pressurize both sides of the valve and the valve cavity simultaneously, up to 1.0 times rated working pressure (RWP).

d) Isolate both sides of the valve and the valve cavity from pressure source.

e) Slowly decrease pressure on one side while monitoring the valve cavity pressure. Record pressure on that side required to activate SPE seat seal relief (point at which valve cavity pressure decreases).

f) Repeat Steps a) to d) for the other side, if it has a self-relieving seat.

g) Failure to relieve at a differential pressure less than 33 % the valve pressure rating shall be cause for rejection.

Pressure–temperature ratings for class-rated valves shall be in accordance with the applicable rating table for the appropriate material group in ASME B16.34.

10.6.3 Through-conduit Slab Gate Valves with Self-relieving Seats

Slab gate valves one or more self-relieving seats that are either upstream and/or downstream shall internally relieve the excess cavity pressure.

The procedure for cavity-relief testing of through-conduit slab gate valves with internal-relieving seats shall be as follows.

a) Fill the valve in the half-open position with water and purge any trapped air.

b) Close the valve (see Note 1).

c) Close both branch vents.

d) Apply design pressure (or other pressure agreed with the purchaser) via one of the valve branches with the opposite branch vented to atmosphere.

e) Apply pressure to the valve cavity until the pressure in the pressurized branch starts to rise and the seat relieves the cavity pressure into the valve end; record this relief pressure.

f) Failure to relieve at a differential pressure less than 33 % the valve pressure rating over the valve pressure rating shall be cause for rejection.

NOTE 1 For through-conduit gate valves with rising stem, water volume may need to be adjusted during the closing stroke.

NOTE 2 For downstream sealing through-conduit gate valves, a center cavity pressure port will be required.

10.7 Draining

Upon completion of all liquid tests, valves shall be drained of test fluids and dried with shop air or nitrogen.

10.8 Low-pressure Gas Seat Test

10.8.1 Preparation

The valve shall be drained of hydrostatic test fluid prior to the start of the low-pressure gas seat test.

10.8.2 Test Pressure and Duration

The seat test specified in 10.5 shall be repeated at a test pressure between 80 psi and 100 psi (5.5 barg and 6.9 barg) using air or nitrogen as the test medium.

10.8.3 Acceptance Criteria

The acceptable leakage rate for low-pressure gas seat testing shall be as follows.

— Leakage for soft-seated valves and lubricated plug valves shall not exceed ISO 5208, Rate A (no visible leakage).

— For metal-seated valves, the leakage rate shall not exceed ISO 5208, Rate C, unless otherwise agreed.

— For metal-seated check valves the liquid leakage rate shall not exceed ISO 5208, Rate D.

10.9 High-pressure Gas Shell Test

10.9.1 General

Valves for gas service shall be subject to a gas shell test as follows.

Warning—High-pressure gas testing involves potential hazards. Appropriate safety precautions must be taken.

All gas shell tests specified shall be performed with the valve unseated and partially open and may also be performed with the valve fully open, provided the body cavity is simultaneously filled and pressurized through a cavity connection.

Valves shall have a high-pressure gas shell test performed. Test shall be performed using 100 % nitrogen with valve submerged in a water bath during testing.

NOTE By agreement, when the appropriate safety precautions are taken, the high-pressure gas shell test may be performed in a test cell and not submerged in a water bath.

The minimum test pressure shall be 1.1 times the pressure rating determined in accordance with 5.2 for the material at 100 °F (38 °C).

The test duration shall not be less than 1 hour for all valve sizes.

10.9.2 Acceptance Criteria

Acceptance criteria shall be no visually detectable leakage during the high-pressure gas shell test.

10.10 High-pressure Stem Seal Integrity Testing

10.10.1 General

Valves shall have a high-pressure gas stem seal integrity test performed by using one of the following methods:

— Method 1: Test shall be performed using 100 % nitrogen measured using a bubble counter/soap solution, or

— Method 2: Test shall be performed using 100 % nitrogen submerged in a water bath.

The minimum test pressure for all methods shall be 1.1 times the pressure rating determined in accordance with 5.2 for the material at 100 °F (38 °C).

The test duration for all methods shall be a minimum of 15 minutes.

10.10.2 Acceptance Criteria

Acceptance criteria shall be no visible leakage allowed.

10.11 High-pressure Gas Seat Test

10.11.1 General

Valves for gas service shall be subject to a gas seat test as follows.

Valves shall have a high-pressure gas seat test performed using inert gas as the test medium. The minimum test pressure shall be 1.1 times the pressure rating determined in accordance with 5.2 for the material at 100 °F (38 °C). The test duration shall not be less than 1 hour for all valve sizes.

10.11.2 Acceptance Criteria

Leakage for soft-seated valves and lubricated plug valves shall not exceed ISO 5208, Rate A (no visible leakage).

For metal-seated valves, the leakage rate shall not be more than two times ISO 5208, Rate C, unless otherwise agreed.

For metal-seated check valves, the leakage rate shall not exceed ISO 5208, Rate D.

10.12 Check Valves

The seat test pressure for check valves shall be applied in the direction of the required flow blockage.

10.13 Installation of Body Connections After Testing

Final body fittings and stem seal test ports, such as plugs shall be fitted on completion of testing in accordance with documented procedures.

Following installation, body connections shall be seal welded, when specified by the purchaser. A qualified WPS/PQR shall be used. When welding is used, a surface NDE (PT) shall be performed in accordance with K.16 as a minimum after each welding pass.

10.14 Testing of Body Connections

Testing of body connections per 10.9 shall be subject to a gas shell test pressure rating determined in accordance with 5.2 for material at 100 °F (38 °C) based on the valve end connection material.

Test duration shall be 20 minutes minimum after stabilization with no visible leakage allowed.

Following the test of body welded connections with gas, a surface NDE (PT) of the weldment shall be performed in accordance with K.16 as a minimum.

10.15 CP Continuity Test

All external items of the valve, operator and other connected equipment shall be checked for electrical continuity before coating as follows.

The electrical resistance shall be measured and recorded as follows.

— Ball valve: between the body and cover/bonnet, body and bolting, body and stem.

— Check valve: between the body and cover/bonnet, body and bolting, body and gland body external components.

— Gate valve: between the body and bonnet, body and bolting, body and stem.

— Plug valve: between the body and cover/bonnet, body and bolting, body and stem.

The measured resistance shall not exceed 0.1 Ω. A calibrated meter in accordance with 8.3.1 shall be used to measure the resistance.

10.16 Post-testing Corrosion Protection

Upon completion of all tests a rust preventative shall be applied to all accessible internal surfaces of non-corrosion-resistant valves in accordance with Section 11.

11 Coating/Painting

All non-corrosion-resistant valves shall be coated or painted externally in accordance with the purchaser's requirements.

Caution—If external coating or painting operations are performed by the manufacturer or their coating or painting contractor, preventative measures should be taken to ensure that no foreign material enters the internal cavity of the valve and external parts that may impact the valve function.

Corrosion-resistant valves shall not be coated or painted, unless by agreement.

Flanges, operator mounting flange sealing surfaces, weld bevel ends, and exposed stems shall not be coated, unless by agreement.

The coating requirements of Annex N for both flange and weld end connections that shall be applied after all testing is completed.

Bare metallic machined surfaces such as flange faces, weld bevel ends, exposed stems, and internal surfaces of the equipment shall be provided with corrosion protection using the manufacturer's documented requirements. Corrosion protection shall be applied to exposed metallic surfaces of steels with less than 15 % chromium on flange faces, weld bevel ends, exposed stems, and internal surfaces of the equipment. Corrosion protection provided by a corrosion inhibitor shall resist runoff at temperatures less than 200 °F (93 °C). Corrosion protection measures for long-term storage or unusual/harsh conditions shall be provided if specified by the purchaser.

NOTE Applying inhibitor on a stem and not removing it prior to operating the valve can damage stem seals.

No corrosion protection (rust inhibitor) shall be applied to corrosion-resistant surfaces, unless by agreement.

12 Marking

Valves shall be marked in accordance with the requirements of Table 6 to be in compliance with this product specification.

Body, closure/end connector, and cover/bonnet marking shall be performed using a low-stress die-stamp (rounded "V" or dot face type) or cast. The size of marking when stamped shall be not less than 0.25 in. (6 mm) in height. If the marking is cast on the part, the marking shall be of a size in proportion to the valve nominal size.

Each valve shall be provided with an austenitic stainless steel nameplate and rivets/bolting securely affixed and so located that it is easily accessible. The nameplate shall be attached to the valve body; however, based on valve design, the nameplate may be attached to the bonnet/cover or end connector at the option of the manufacturer.

For valves smaller than NPS 2 (DN 50), the nameplate may be attached to the valve with stainless steel braided wire.

The marking on nameplate shall be visually legible.

For valves with one unidirectional seat and one bidirectional seat, the directions of both seats shall be specified on a separate identification plate as illustrated in Figure 5.

Table 6—Valve Marking

No.	Marking	Location
1a	Manufacturer's name	On body and/or nameplate
1b	Trademark or mark (optional)	On body and/or nameplate
2a	Pressure class (except when 2b applies)	On both body and nameplate
2b	Intermediate pressure rating (upon agreement)	Agreed upon pressure rating on body and nameplate
3	Maximum water depth	On nameplate
4	Pressure–temperature rating: a) maximum operating pressure at maximum operating temperature b) maximum operating pressure at minimum operating temperature c) intermediate maximum operating pressure at maximum operating temperature d) intermediate maximum operating pressure at minimum operating temperature	On nameplate
5	Face-to-face/end-to-end dimensions, if not shown in Table C.1 to Table C.5 (5.4)	On nameplate
6a	Body/closure/end connection material designation [a c]: material grade	On both body/closure/end connection and nameplate
6b	Body/closure/end connection melt identification (e.g. cast or heat number)	On both body/closure/end connection only
7a	Bonnet/cover material designation [c]: material grade	On bonnet/cover
7b	Bonnet/cover melt identification (e.g. heat number)	On bonnet/cover
8	Trim identification [b]: material grade symbols indicating material of stem and sealing faces of closure members if different from that of body	On nameplate
9	Nominal valve size a) full-opening valves: nominal valve size b) reduced-opening valves: shall be marked as specified in 5.3	On both body and nameplate
10	Ring joint groove number	On valve flange OD
11	SMYS (units) of valve ends (where applicable)	On body weld ends
12	Flow direction (for check valves only)	On body
13	Seat sealing direction (valves with preferred direction only)	On separate identification plate affixed to valve body
14	QL level: QL-1 or QL-2 (as applicable)	On nameplate
15	DBB or DIB-1 or DIB-2 (as applicable)	On nameplate
16	Unique serial number	On both body and nameplate
17	Date of manufacture (month and year)	On nameplate
18	6DSS or API 6DSS (product specification number)	On nameplate

[a] When the body is manufactured from more than one type of material, both the body and end-connection material shall be identified.

[b] MSS SP-25 gives guidance on marking.

[c] Where the grade and class does not uniquely identify the material specification, the material specification, grade, and class shall be marked. Example: A350–LF2 Class 2.

NOTE 1 In Figure 5, one symbol indicates the bidirectional seat and the other symbol indicates the unidirectional seat.

NOTE 2 An example of valve marking is given in Annex O.

When an intermediate pressure–temperature rating is specified by the purchaser the valve shall be marked with the agreed intermediate pressure rating (see 5.2), including unit of measure on the body and nameplate (see Annex O).

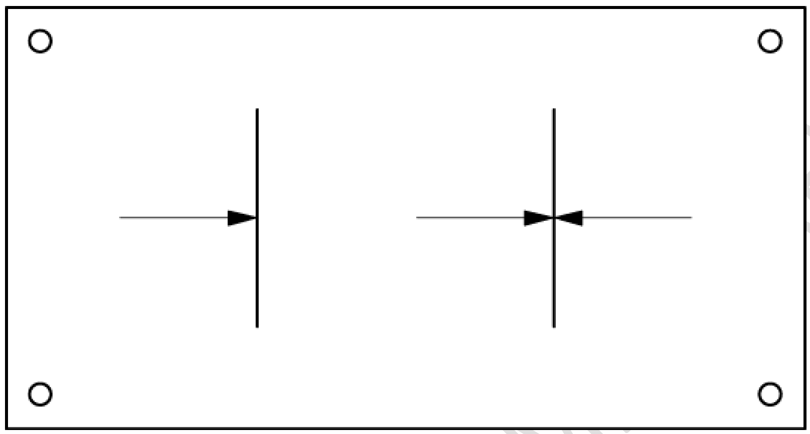


Figure 5—Typical Identification Plate for a Valve with One Seat Unidirectional and One Seat Bidirectional

13 Preparation for Shipment

Flanged and welding ends shall be blanked off to protect the gasket surfaces, welding ends, and valve internals during shipment.

Protective covers shall be made of wood, wood fiber, plastic, or metal and shall be securely attached to the valve ends by using bolting/nuts, plastic straps, steel clips, or friction-locking devices. Protective covers shall be weather resistant and shall be used to seal the valve ends in order to avoid foreign material or moisture from entering the valve bore.

Protective covers made of wood or wood fiber shall be fitted with a nonporous moisture barrier between the cover and the metal flange or welding end.

The design of the covers shall prevent the valves from being installed unless the covers have been removed.

Plug, ball, and through-conduit gate valves shall be shipped in the fully open position, unless fitted with a fail-to-close actuator.

Other gate valve types shall be shipped with the gate in the fully closed position.

Check valves shall be shipped with the disc secured or supported during transport. A warning label shall be attached to the protective cover with instructions to remove prior to installation, material from inside the valve that secures or supports the disc.

Exposed seals shall be protected from mechanical damage during storage and shipping.

14 Documentation

14.1 Minimum Documentation and Retention

The documentation listed below shall be retained by the manufacturer for a minimum of 10 years following the date of manufacture:

a) design documentation;

b) weld procedure specification (WPS);

c) PQR;

d) welder performance qualification (WPQ);

e) qualification records of NDE personnel;

f) records of test equipment calibration;

g) NDE records (for RT, minimum NDE records are reader sheets and technique sheet)—MT, PT, and UT;

h) production hardness test;

i) FAT reports(including hydrostatic and or gas) and charts/digital recording as applicable;

j) chloride content in the test water;

k) material test report for body, bonnet/cover(s), and end connector(s)/closure(s) traceable to the unique valve serial number as well material test reports for stems;

l) weld repair maps for major weld repair of castings;

m) valve assembly serial number;

n) certificate of conformance to NACE MR0175 or ISO 15156 (all parts) for sour service valves.

NOTE 1 Purchaser or regulatory requirements can specify a longer record retention period.

The documentation provided by the manufacturer shall be in legible, retrievable, and reproducible form and free of damage.

NOTE 2 The purchaser may specify any supplementary documentation in accordance with Annex P.

14.2 Documentation Provided with the Valve

The documentation listed below shall be supplied by the manufacturer with each valve.

a) Certificate of conformance to this specification shall be supplied by the manufacturer. The certificate(s) shall identify the valve type, size, class, end connection, serial number(s), any additional requirement specified by the manufacturer or purchaser, and a statement that valve(s) is/are in full conformance with this product specification edition and all addenda.

b) Test report (including pressure, test duration, leakage rate, ROT input torque/thrust, and test medium) together with pressure test charts/digital recording.

c) Coating/plating certification.

d) Material test reports for pressure-containing and pressure-controlling parts.

e) Statement of quality level (QL) to NDE and applicable records (see Annex K).

f) Certificate stating the maximum allowable torque/thrust value for the drive train (ball, gate, and plug valves only), if applicable.

g) Lifting procedure.

h) Installation, operation, and maintenance instructions/manuals for valve and operator.

i) General arrangement and detail parts drawings.

14.3 Supplementary Documentation

NOTE Annex P provides a list of supplementary documentation from which a purchaser may select at the time of order placement.

15 Facility Requirements

15.1 Minimum Facility Requirements for the Assembler/manufacturer Category of Manufacturing

The assembler/manufacturer (see 3.1.2) shall have on-site equipment and personnel to perform all the required activities applicable to an assembler/manufacturer facility.

The activities for an assembler/manufacturer listed in Table 7 and shall be performed at the applicable facility.

Table 7—Minimum Facility Requirements

Item	Process Activity	Location
1	Product design	Performed on-site, off-site, and/or outsourced
1b [a]	Product design validation documentation	Performed on-site, off-site
2	Material procurement	Performed on-site, off-site, and/or outsourced
3	Receiving verification	Performed on-site
4	Machining	Performed on-site, off-site, and/or outsourced
5	In-process inspection	Performed on-site, off-site, and/or outsourced
6	Welding and other processes (e.g. ENP-TCC, etc.)	Performed on-site, off-site, and/or outsourced
7 [b]	Assembly (see 3.1.3)	Performed on-site
8	FAT (Section 10)	Performed on-site
9	Supplementary test—Annex G and Annex L	Performed on-site, off-site, and/or outsourced
10	Painting/coating (Section 11)	Performed on-site, off-site, and/or outsourced
11	Marking/tagging/nameplate (Section 12)	Performed on-site
12	Preparation for shipment (Section 13)	Performed on-site
13	Final inspection/release	Performed on-site

[a] Collection and maintenance of documented evidence of validated designs: testing associated with design validation is performed as part of "1 product design" and may be performed on-site, off-site, or outsourced.

[b] Except for closure welding of welded body valves.

15.2 Conformance with Specification

A quality management system such as API Q1, ISO 9001, or equivalent shall be applied to assist conformance with the requirements of this specification. The assembler/manufacturer shall be responsible for conforming to all of the applicable requirements of this specification.

It shall be permissible for the purchaser to make any investigation necessary in order to be assured of conformance by the assembler/manufacturer and to reject any material that does not conform.

15.3 Processes Requiring Validation

The following operations performed during manufacturing shall be validated, by the manufacturer, in accordance with their quality system as applicable:

— heat treating—refer to 6.13 and Annex J;

— welding—refer to Section 7;

— NDE—refer to 8.2;

— external coating/component plating that may impact product performance, by agreement.

16 Purchasing Guidelines

NOTE Annex Q contains additional purchasing guidelines to assist the purchaser with valve type selection and specification of specific requirements when ordering valves.

Annex A
(informative)

Use of API Monogram by Licensees

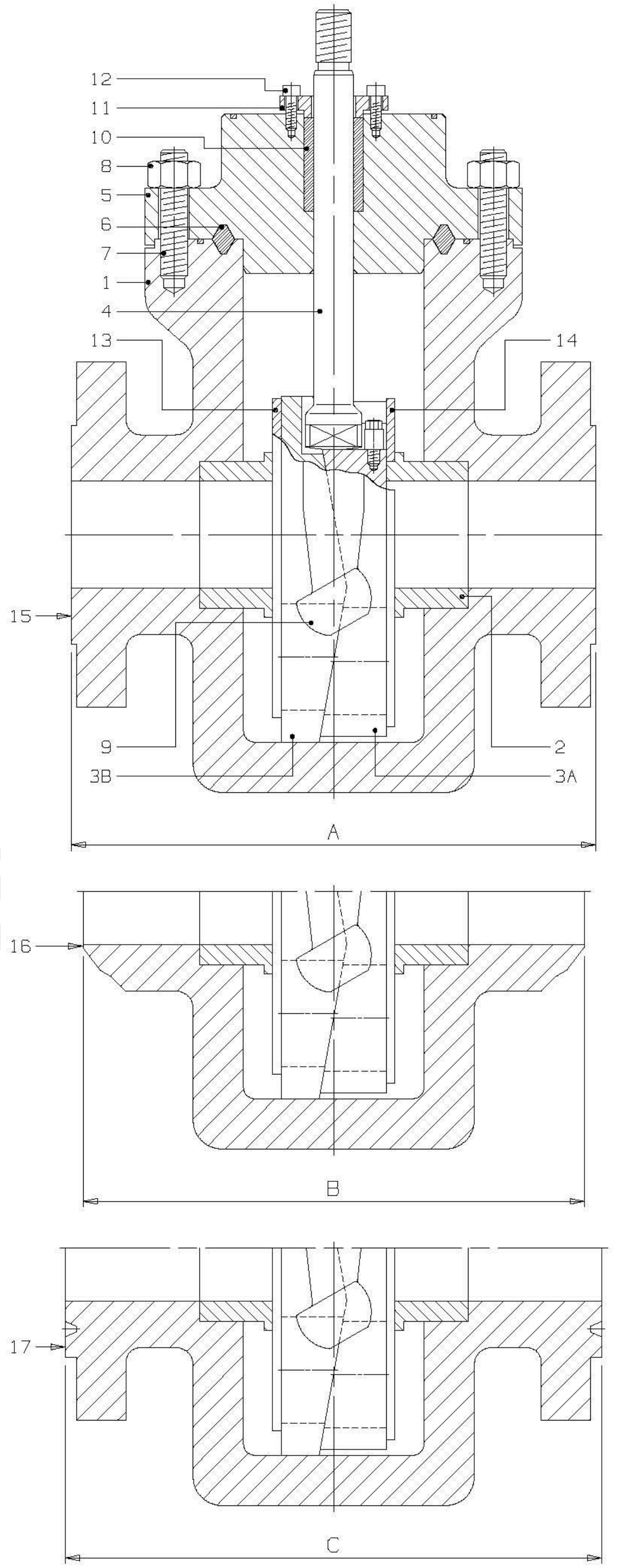
The information in this annex has been intentionally removed.

See API Specification Q1 (Annex A), or the API website for information pertaining to the API Monogram Program and use of the API Monogram on applicable products.

Annex B
(informative)

Valve Configurations

This annex shows typical configurations for gate, plug, ball, and check valves with flanged and welding ends.

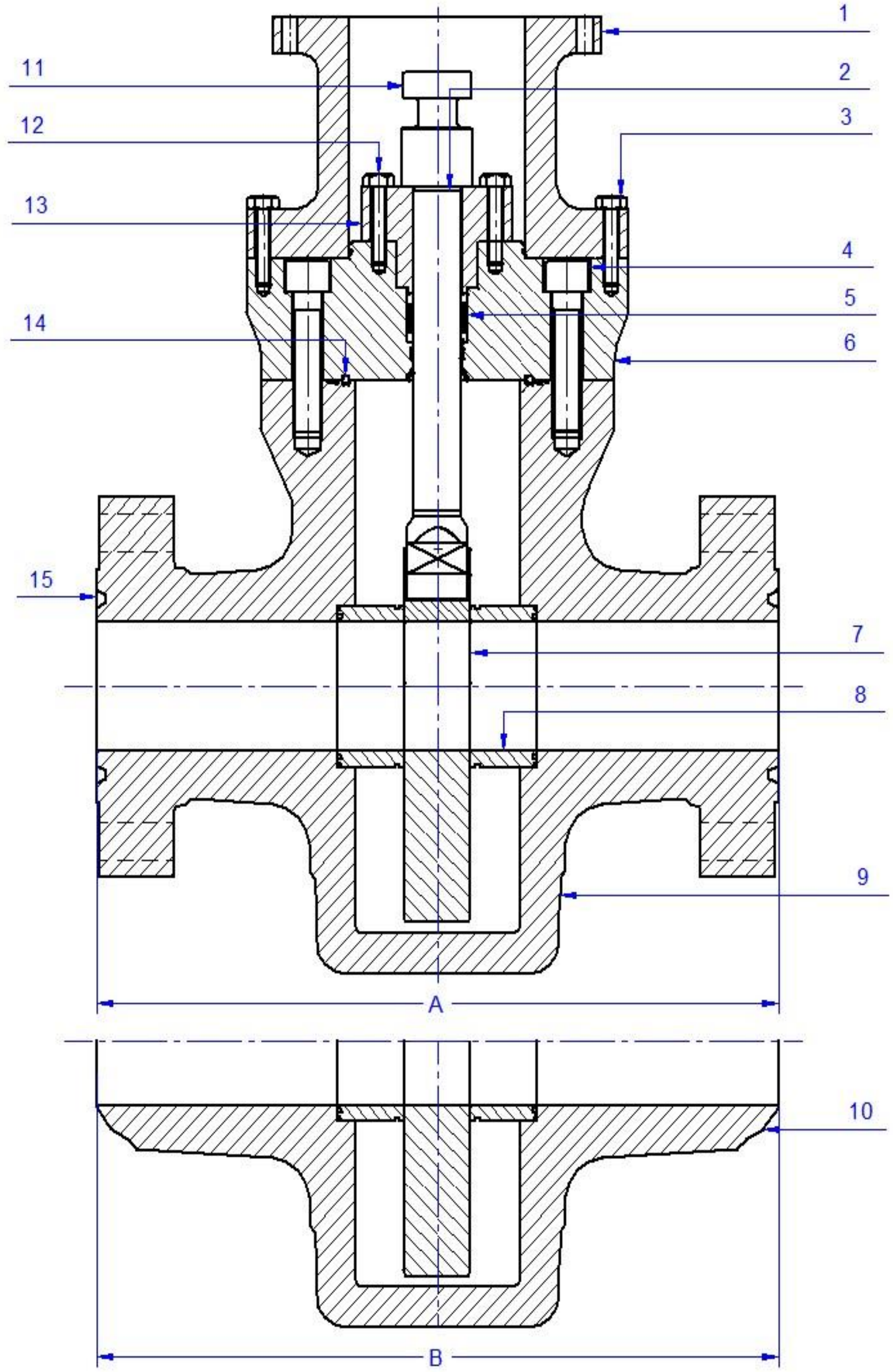


Key

1	body
2	seat ring
3A	gate
3B	gate
4	stem
5	bonnet
6	body/bonnet gasket
7	stud bolt
8	stud bolt nut
9	lever
10	stem gasket
11	cover
12	cap screw
13	guide
14	guide
15	raised face
16	welding end
17	ring joint
A	raised-face face-to-face dimension
B	welding-end end-to-end dimension
C	ring joint end-to-end dimension

NOTE See Table C.1 for dimensions *A*, *B,* and *C.*

Figure B.1—Expanding Gate/Rising Stem Gate Valve

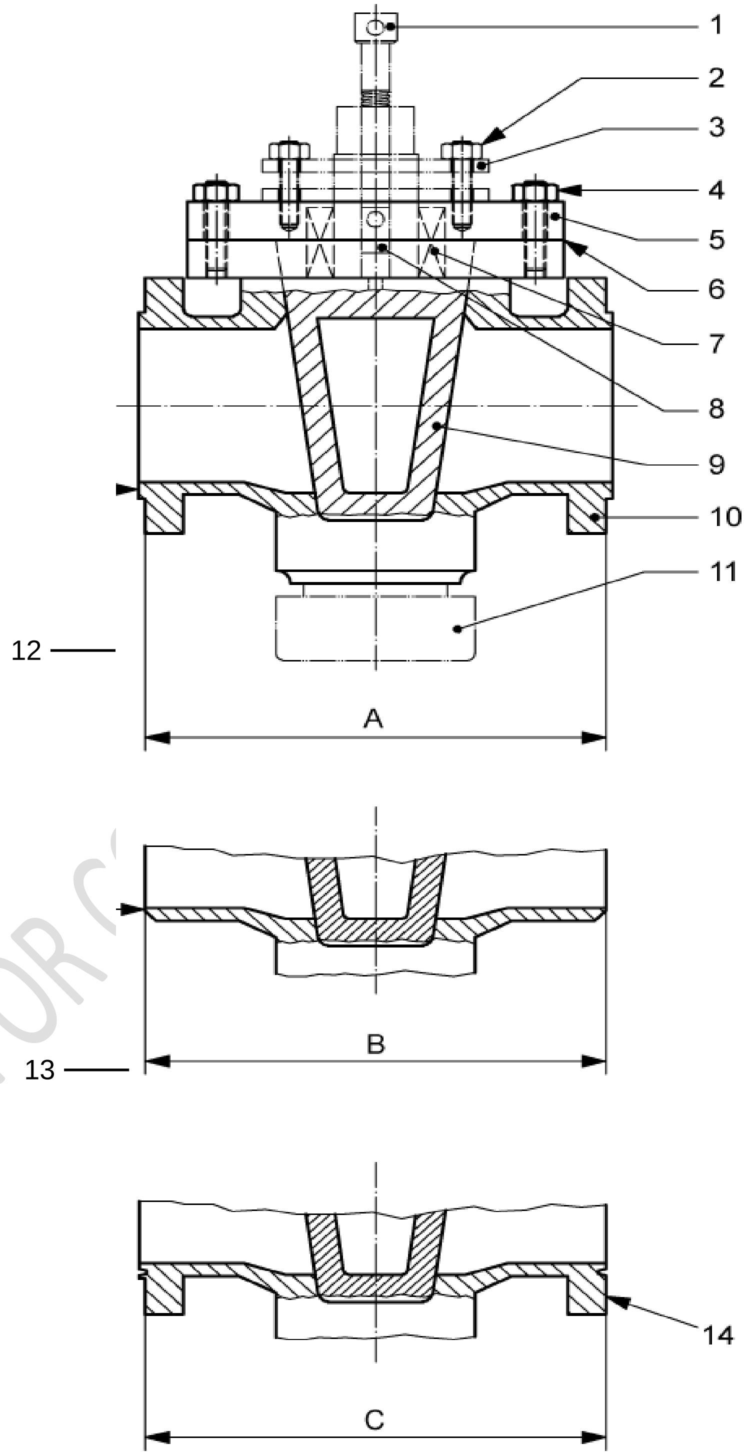


Key

1 yoke
2 stem
3 yoke bolting
4 bonnet bolting
5 multi-barrier stem seal
6 bonnet
7 gate
8 seat ring
9 body
10 welding end
11 stem joint
12 gland bolting
13 gland flange
14 body bonnet metal gasket
15 ring joint
A ring joint end-to-end dimension
B welding-end end-to-end dimension

NOTE See Table C.1 for dimensions *A* and *B*.

Figure B.2—Slab Gate/Through-conduit Rising Stem Gate Valve

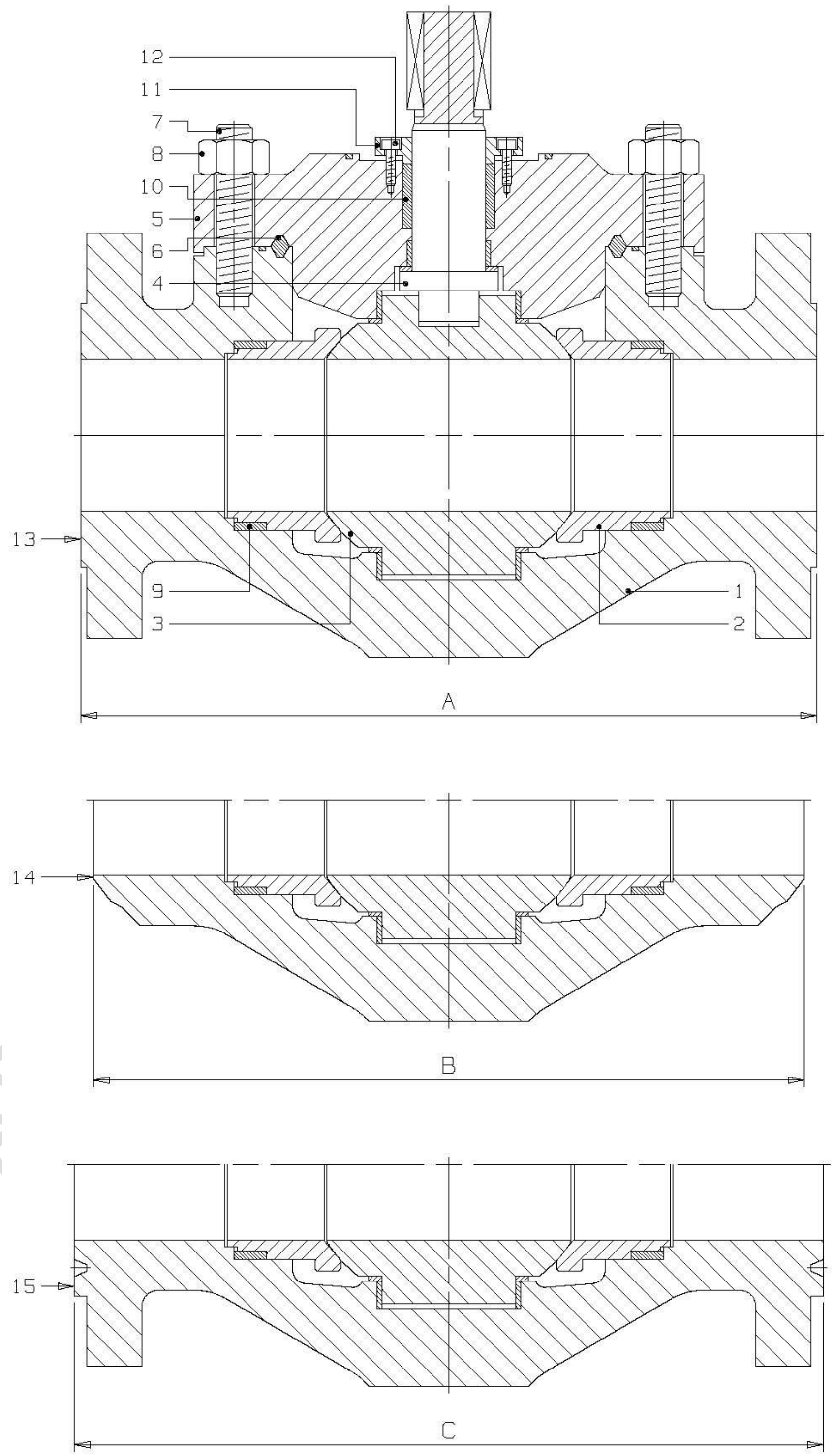


Key

1 lubricator screw
2 gland studs and nuts
3 gland
4 cover studs and nuts
5 cover
6 cover gasket
7 stem packing
8 lubricant check valve
9 plug
10 body
11 stop collar
12 raised face
13 welding end
14 ring joint
A raised-face face-to-face dimension
B welding-end end-to-end dimension
C ring joint end-to-end dimension

NOTE See Table C.2 for dimensions *A*, *B*, and *C*.

Figure B.3—Plug Valve

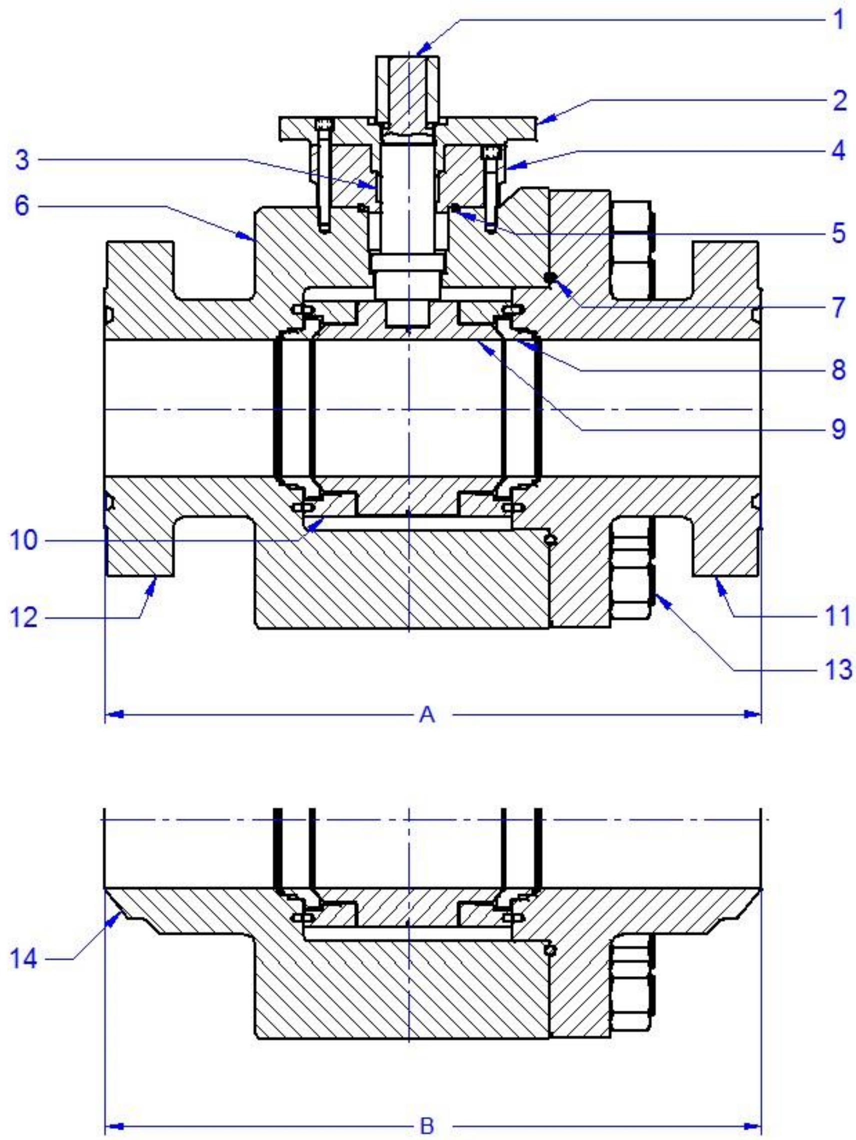


Key

1 body
2 seat ring
3 ball
4 stem
5 bonnet
6 body/bonnet gasket
7 stud bolt
8 stud bolt nut
9 seat gasket
10 stem gasket
11 cover
12 cap screw
13 raised face
14 welding end
15 ring joint
A raised-face face-to-face dimension
B welding-end end-to-end dimension
C ring joint end-to-end dimension

NOTE See Table C.3 for dimensions *A*, *B*, and *C.*

Figure B.4—Top Entry Trunnion-mounted Ball Valve

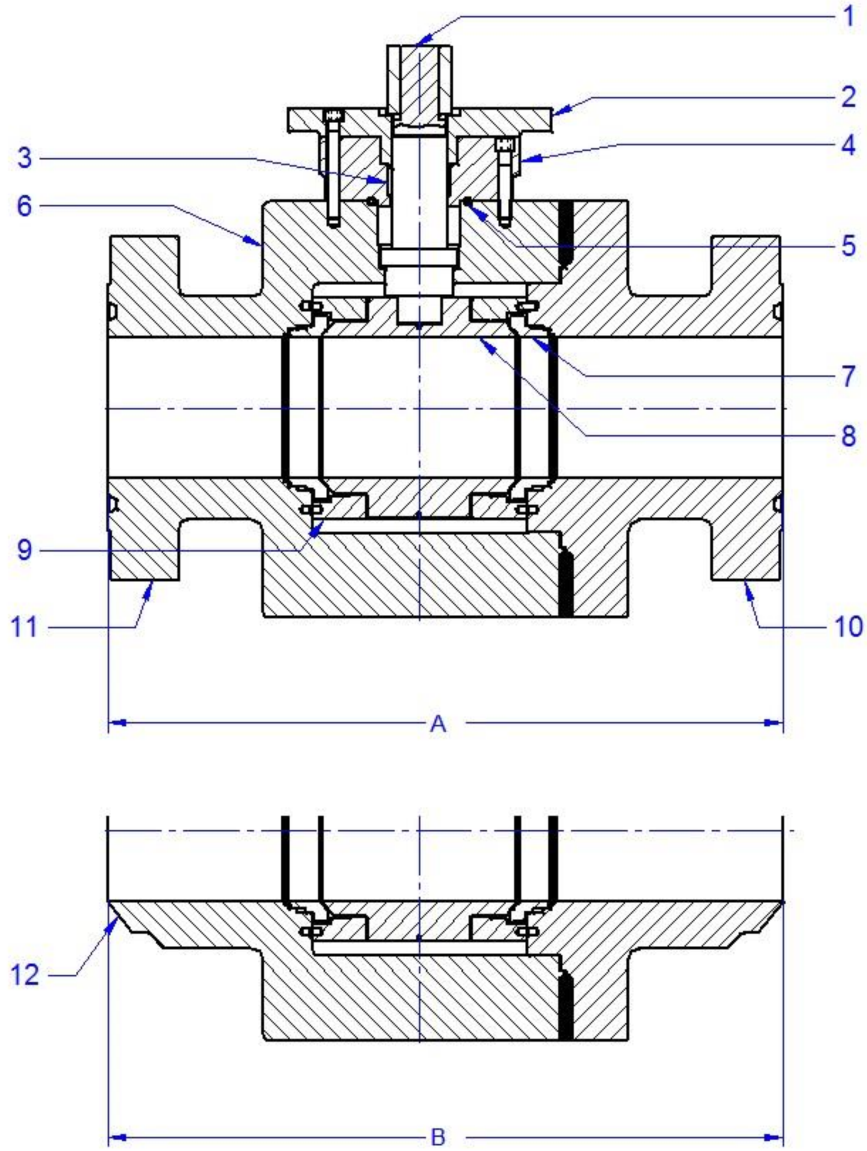


Key

1 stem
2 adapter plate
3 multi-barrier stem seal
4 body cover
5 body top cover metal gasket
6 body
7 body closure metal gasket
8 seat
9 ball
10 support plate
11 closure
12 ring joint
13 body bolting
14 welding end
A ring-joint end-to-end dimension
B welding-end end-to-end dimension

NOTE See Table C.3 for dimensions *A* and *B*.

Figure B.5—Two-piece Bolted Ball Valve

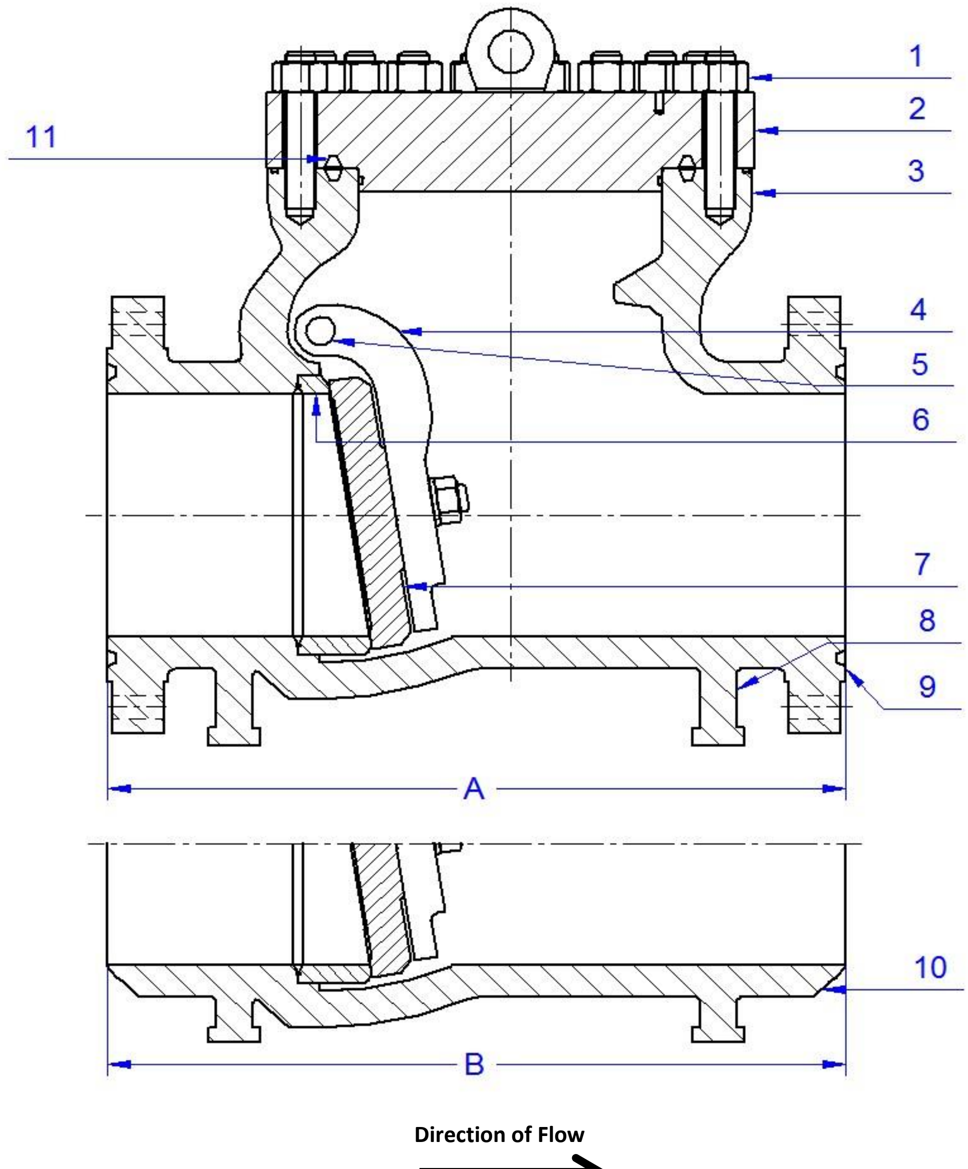


Key

1 stem
2 adapter plate
3 multi-barrier stem seal
4 body cover
5 body top cover metal gasket
6 body
7 seat
8 ball
9 support plate
10 closure
11 ring joint
12 welding end
A ring-joint end-to-end dimension
B welding-end end-to-end dimension

NOTE See Table C.3 for dimensions *A* and *B.*

Figure B.6—Two-piece Welded Ball Valve

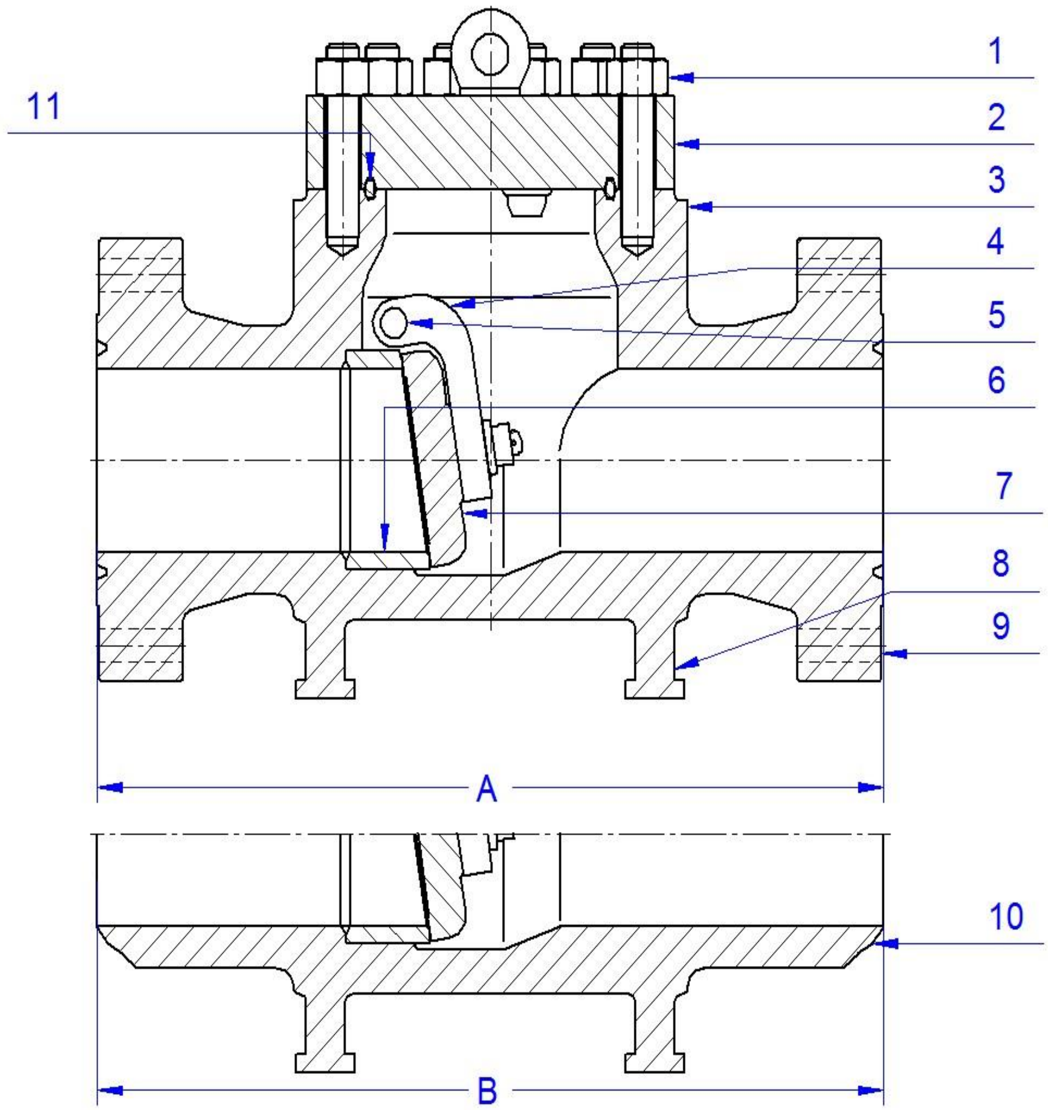


Key

1 cover bolting
2 cover
3 body
4 clapper disc arm
5 shaft
6 seat ring
7 clapper disc
8 support ribs or legs
9 ring joint
10 welding end
11 body cover metal gasket
A ring-joint end-to-end dimension
B welding-end end-to-end dimension

NOTE See Table C.4 for dimensions *A* and *B.*

Figure B.7—Full-opening Cast Swing Check Valve

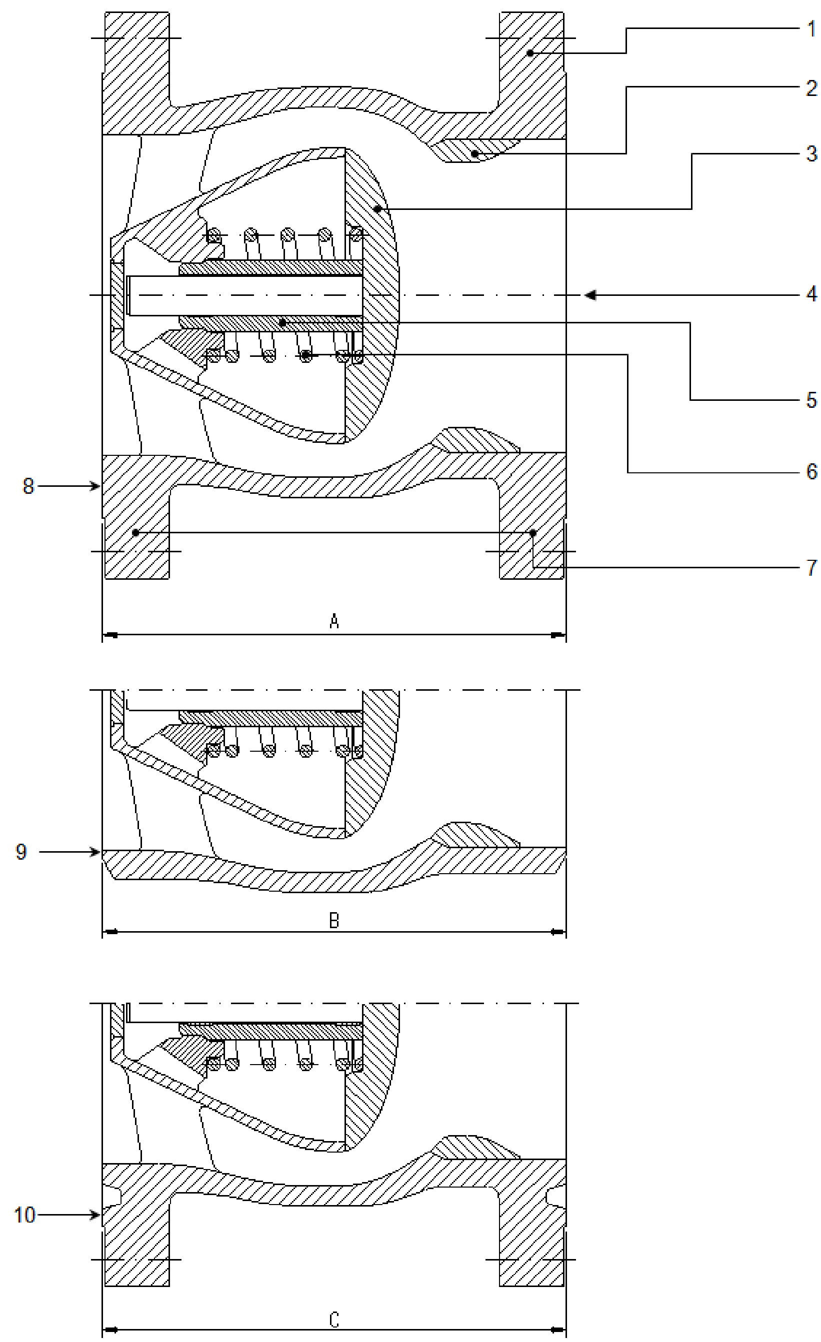


Key

1 cover bolting
2 cover
3 body
4 clapper disc arm
5 shaft
6 seat ring
7 clapper disc
8 support ribs or legs
9 ring joint
10 welding end
11 body cover metal gasket
A ring-joint end-to-end dimension
B welding-end end-to-end dimension

NOTE See Table C.4 for dimensions *A* and *B.*

Figure B.8—Full-opening Forged Swing Check Valve

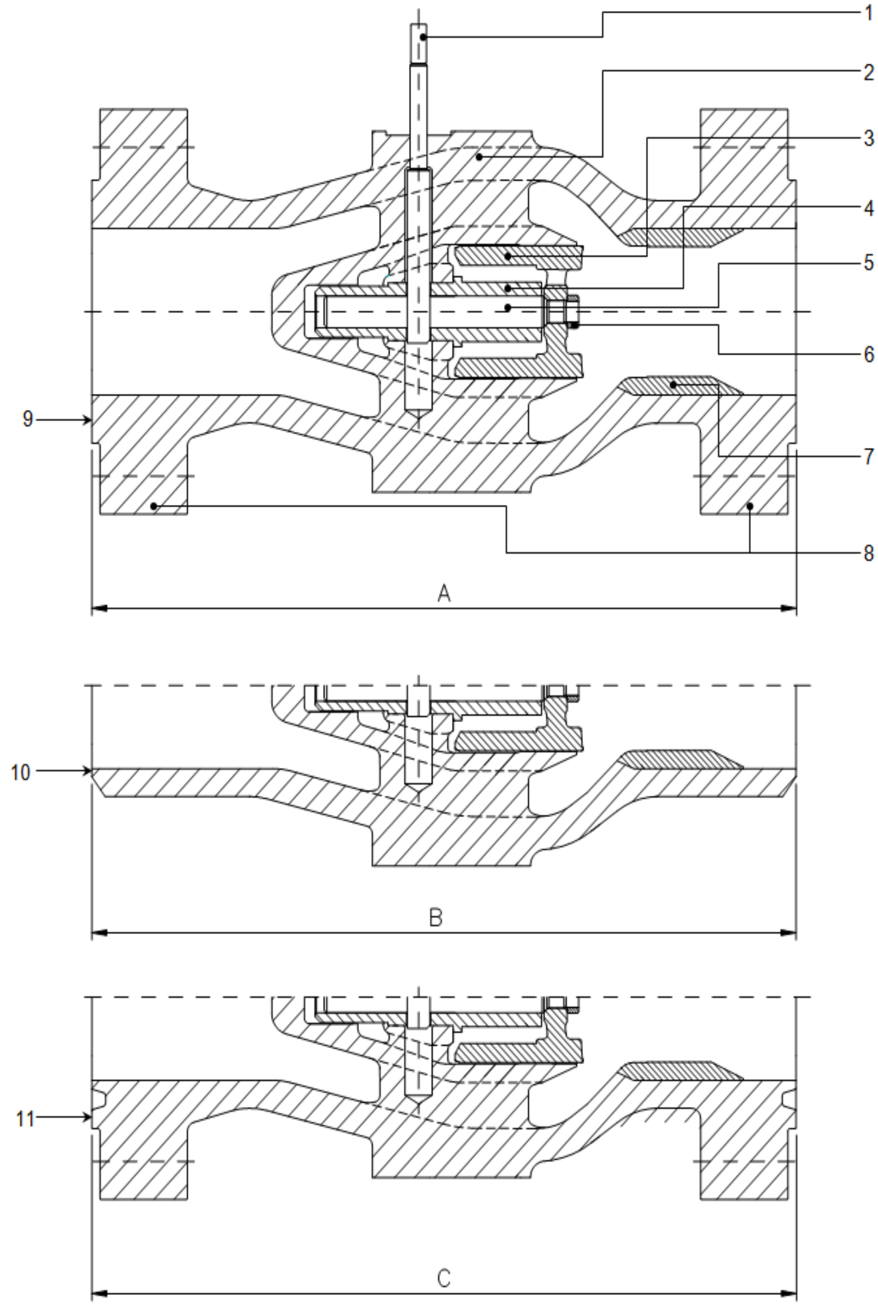


Key

1 body
2 seat ring
3 disc
4 flow direction
5 rod guidance
6 spring
7 end connector
8 raised face
9 welding end
10 ring joint
A raised-face face-to-face dimension
B welding-end end-to-end dimension
C ring joint end-to-end dimension

NOTE See Table C.4 for dimensions *A*, *B*, and *C*.

Figure B.9—Axial-flow Check Valve



Key

1 stem
2 body
3 piston
4 piston rod guide
5 piston rod
6 piston nut
7 seat ring
8 end connector
9 raised face
10 welding end
11 ring joint
A raised-face face-to-face dimension
B welding-end end-to-end dimension
C ring joint end-to-end dimension

NOTE See Table C.5 for dimensions *A*, *B*, and *C*.

Figure B.10—Axial On–off Valve

Annex C
(normative)

Valve End-to-End and Face-to-Face Dimensions

NOTE This annex shows valve end-to-end and face-to-face dimensions for gate, plug, ball, and check valves with raised face, welding end, and ring joint.

Table C.1—Gate Valves—Face-to-face (*A*) and End-to-end (*B* and *C*) Dimensions

Dimensions in inches (millimeters)

NPS	DN	Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*
		Class 150			Class 300		
2	50	7.00 (178)	8.50 (216)	7.50 (191)	8.50 (216)	8.50 (216)	9.13 (232)
2 1/2	65	7.50 (191)	9.50 (241)	8.00 (203)	9.50 (241)	9.50 (241)	10.13 (257
3	80	8.00 (203)	11.13 (283)	8.50 (216)	11.13 (283)	11.13 (283)	11.75 (298)
4	100	9.00 (229)	12.00 (305)	9.50 (241)	12.00 (305)	12.00 (305)	12.63 (321)
6	150	10.50 (267)	15.88 (403)	11.00 (279)	15.88 (403)	15.88 (403)	16.50 (419)
8	200	11.50 (292)	16.50 (419)	12.00 (305)	16.50 (419)	16.50 (419)	17.13 (435)
10	250	13.00 (330)	18.00 (457)	13.50 (343)	18.00 (457)	18.00 (457)	18.63 (473)
12	300	14.00 (356)	19.75 (502)	14.50 (368)	19.75 (502)	19.75 (502)	20.38 (518)
14	350	15.00 (381)	22.50 (572)	15.50 (394)	30.00 (762)	30.00 (762)	30.63 (778)
16	400	16.00 (406)	24.00 (610)	16.50 (419)	33.00 (838)	33.00 (838)	33.63 (854)
18	450	17.00 (432)	26.00 (660)	17.50 (445)	36.00 (914)	36.00 (914)	36.63 (930)
20	500	18.00 (457)	28.00 (711)	18.50 (470)	39.00 (991)	39.00 (991)	39.75 (1010)
22	550	—	—	—	43.00 (1092)	43.00 (1092)	43.88 (1114)
24	600	20.00 (508)	32.00 (813)	20.50 (521)	45.00 (1143)	45.00 (1143)	45.88 (1165)
26	650	22.00 (559)	34.00 (864)	—	49.00 (1245)	49.00 (1245)	50.00 (1270)
28	700	24.00 (610)	36.00 (914)	—	53.00 (1346)	53.00 (1346)	54.00 (1372)
30	750	24.00 (610) [a]	36.00 (914)	—	55.00 (1397)	55.00 (1397)	56.00 (1422)
32	800	28.00 (711)	38.00 (965)	—	60.00 (1524)	60.00 (1524)	61.13 (1553)
34	850	30.00 (762)	40.00 (1016)	—	64.00 (1626)	64.00 (1626)	65.13 (1654)
36	900	28.00 (711) [b]	40.00 (1016)	—	68.00 (1727)	68.00 (1727)	69.13 (1756)

Table C.1—Gate Valves—Face-to-face (*A*) and End-to-end (*B* and *C*) Dimensions (Continued)

Dimensions in inches (millimeters)

NPS	DN	Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*
		Class 600			Class 900		
2	50	11.50 (292)	11.50 (292)	11.63 (295)	14.50 (368)	14.50 (368)	14.63 (371)
2 1/2	65	13.00 (330)	13.00 (330)	13.13 (333)	16.50 (419)	16.50 (419)	16.63 (422)
3	80	14.00 (356)	14.00 (356)	14.13 (359)	15.00 (381)	15.00 (381)	15.13 (384)
4	100	17.00 (432)	17.00 (432)	17.13 (435)	18.00 (457)	18.00 (457)	18.13 (460)
6	150	22.00 (559)	22.00 (559)	22.13 (562)	24.00 (610)	24.00 (610)	24.13 (613)
8	200	26.00 (660)	26.00 (660)	26.13 (664)	29.00 (737)	29.00 (737)	29.13 (740)
10	250	31.00 (787)	31.00 (787)	31.13 (791)	33.00 (838)	33.00 (838)	33.13 (841)
12	300	33.00 (838)	33.00 (838)	33.13 (841)	38.00 (965)	38.00 (965)	38.13 (968)
14	350	35.00 (889)	35.00 (889)	35.13 (892)	40.50 (1029)	40.50 (1029)	40.88 (1038)
16	400	39.00 (991)	39.00 (991)	39.13 (994)	44.50 (1130)	44.50 (1130)	44.88 (1140)
18	450	43.00 (1092)	43.00 (1092)	43.13 (1095)	48.00 (1219)	48.00 (1219)	48.50 (1232)
20	500	47.00 (1194)	47.00 (1194)	47.25 (1200)	52.00 (1321)	52.00 (1321)	52.50 (1334)
22	550	51.00 (1295)	51.00 (1295)	51.38 (1305)	—	—	—
24	600	55.00 (1397)	55.00 (1397)	55.38 (1407)	61.00 (1549)	61.00 (1549)	61.75 (1568)
26	650	57.00 (1448)	57.00 (1448)	57.50 (1461)	—	—	—
28	700	61.00 (1549)	61.00 (1549)	61.50 (1562)	—	—	—
30	750	65.00 (1651)	65.00 (1651)	65.50 (1664)	—	—	—
32	800	70.00 (1778)	70.00 (1778)	70.63 (1794)	—	—	—
34	850	76.00 (1930)	76.00 (1930)	76.63 (1946)	—	—	—
36	900	82.00 (2083)	82.00 (2083)	82.63 (2099)	—	—	—

Table C.1—Gate Valves—Face-to-face (*A*) and End-to-end (*B* and *C*) Dimensions (Continued)

Dimensions in inches (millimeters)

NPS	DN	Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*
		Class 1500			Class 2500		
2	50	14.50 (368)	14.50 (368)	14.63 (371)	17.75 (451)	17.75 (451)	17.88 (454)
$2^1/_2$	65	16.50 (419)	16.50 (419)	16.63 (422)	20.00 (508)	20.00 (508)	20.25 (514)
3	80	18.50 (470)	18.50 (470)	18.63 (473)	22.75 (578)	22.75 (578)	23.00 (584)
4	100	21.50 (546)	21.50 (546)	21.63 (549)	26.50 (673)	26.50 (673)	26.88 (683)
6	150	27.75 (705)	27.75 (705)	28.00 (711)	36.00 (914)	36.00 (914)	36.50 (927)
8	200	32.75 (832)	32.75 (832)	33.13 (841)	40.25 (1022)	40.25 (1022)	40.88 (1038)
10	250	39.00 (991)	39.00 (991)	39.38 (1000)	50.00 (1270)	50.00 (1270)	50.88 (1292)
12	300	44.50 (1130)	44.50 (1130)	45.13 (1146)	56.00 (1422)	56.00 (1422)	56.88 (1445)
14	350	49.50 (1257)	49.50 (1257)	50.25 (1276)	—	—	—
16	400	54.50 (1384)	54.50 (1384)	55.38 (1407)	—	—	—
18	450	60.50 (1537)	60.50 (1537)	61.38 (1559)	—	—	—
20	500	65.50 (1664)	65.50 (1664)	66.38 (1686)	—	—	—
22	550	—	—	—	—	—	—
24	60	76.50 (1943)	76.50 (1943)	77.63 (1972)	—	—	—

For Class 2500:

[a] Through-conduit valves shall be 26.00 in. (660 mm).

[b] Through-conduit valves shall be 32.00 in. (813 mm).

Tolerance: ±$^1/_{16}$ in. (1.59 mm) on valve sizes 10 in. and smaller ±$^1/_8$ in. (3.18 mm) on valve sizes 12 in. and larger.

Table C.2—Plug Valves—Face-to-face (*A*) and End-to-end (*B* and *C*) Dimensions

Dimensions in inches (millimeters)

NPS	DN	Short Pattern			Regular Pattern			Venturi Pattern			Round Port, Full Bore		
		Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*
		Class 150											
2	50	7.00 (178)	10.50 (267)	7.50 (191)	—	—	—	—	—	—	10.50 (267)	—	11.00 (279)
2 1/2	65	7.50 (191)	12.00 (305)	8.00 (203)	—	—	—	—	—	—	11.75 (298)	—	12.25 (311)
3	80	8.00 (203)	13.00 (330)	8.50 (216)	—	—	—	—	—	—	13.50 (343)	—	14.00 (356)
4	100	9.00 (229)	14.00 (356)	9.50 (241)	—	—	—	—	—	—	17.00 (432)	—	17.50 (445)
6	150	10.50 (267)	18.00 (457)	11.00 (279)	15.50 (394)	—	16.00 (406)	—	—	—	21.50 (546)	—	22.00 (559)
8	200	11.50 (292)	20.50 (521)	12.00 (305)	18.00 (457)	—	18.50 (470)	—	—	—	24.50 (622)	—	25.00 (635)
10	250	13.00 (330)	22.00 (559)	13.50 (343)	21.00 (533)	—	21.50 (546)	21.00 (533)	22.00 (559)	21.50 (546)	26.00 (660)	—	26.50 (673)
12	300	14.00 (356)	25.00 (635)	14.50 (368)	24.00 (610)	—	24.50 (622)	24.00 (610)	25.00 (635)	24.50 (622)	30.00 (762)	—	30.50 (775)
14	8050	—	—	—	—	—	—	27.00 (686)	27.00 (686)	27.50 (699)	—	—	—
16	400	—	—	—	—	—	—	30.00 (762)	30.00 (762)	30.50 (775)	—	—	—
18	450	—	—	—	—	—	—	34.00 (864)	34.00 (864)	34.50 (876)	—	—	—
20	500	—	—	—	—	—	—	36.00 (914)	36.00 (914)	36.50 (927)	—	—	—
24	600	—	—	—	—	—	—	42.00 (1067)	42.00 (1067)	42.50 (1080)	—	—	—

Table C.2—Plug Valves—Face-to-face (*A*) and End-to-end (*B* and *C*) Dimensions (Continued)

Dimensions in inches (millimeters)

NPS	DN	Short Pattern			Regular Pattern			Venturi Pattern			Round Port, Full Bore		
		Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*
		Class 300											
2	50	8.50 (216)	10.50 (267)	9.13 (232)	—	—	—	—	—	—	11.13 (283)	11.13 (283)	11.75 (298)
2 1/2	65	9.50 (241)	12.00 (305)	10.13 (257)	—	—	—	—	—	—	13.00 (330)	13.00 (330)	13.63 (346)
3	80	11.13 (283)	13.00 (330)	11.75 (298)	—	—	—	—	—	—	15.25 (387)	15.25 (387)	15.88 (403)
4	100	12.00 (305)	14.00 (356)	12.63 (321)	—	—	—	—	—	—	18.00 (457)	18.00 (457)	18.63 (473)
6	150	15.88 (403)	18.00 (457)	16.50 (419)	15.88 (403)	—	16.50 (419)	15.88 (403)	18.00 (457)	16.50 (419)	22.00 (559)	22.00 (559)	22.63 (575)
8	200	16.50 (419)	20.50 (521)	17.13 (435)	19.75 (502)	—	20.38 (518)	16.50 (419)	20.50 (521)	17.13 (435)	27.00 (686)	27.00 (686)	27.63 (702)
10	250	18.00 (457)	22.00 (559)	18.63 (473)	22.38 (568)	—	23.00 (584)	18.00 (457)	22.00 (559)	18.63 (473)	32.50 (826)	32.50 (826)	33.13 (841)
12	300	19.75 (502)	25.00 (635)	20.38 (518)	—	—	—	19.75 (502)	25.00 (635)	20.38 (518)	38.00 (965)	38.00 (965)	38.63 (981)
14	350	—	—	—	—	—	—	30.00 (762)	30.00 (762)	30.63 (778)	—	—	—
16	400	—	—	—	—	—	—	33.00 (838)	33.00 (838)	33.63 (854)	—	—	—
18	450	—	—	—	36.00 (914)	—	36.63 (930)	36.00 (914)	36.00 (914)	36.63 (930)	—	—	—
20	500	—	—	—	39.00 (991)	—	39.75 (1010)	39.00 (991)	39.00 (991)	39.75 (1010)	—	—	—
22	550	—	—	—	43.00 (1092)	—	43.88 (1114)	43.00 (1092)	43.00 (1092)	43.88 (1114)	—	—	—
24	600	—	—	—	45.00 (1143)	—	45.88 (1165)	45.00 (1143)	45.00 (1143)	45.88 (1165)	—	—	—
26	650	—	—	—	49.00 (1245)	—	50.00 (1270)	49.00 (1245)	49.00 (1245)	50.00 (1270)	—	—	—
28	700	—	—	—	53.00 (1346)	—	54.00 (1372)	53.00 (1346)	53.00 (1346)	54.00 (1372)	—	—	—
30	750	—	—	—	55.00 (1397)	—	56.00 (1422)	55.00 (1397)	55.00 (1397)	56.00 (1422)	—	—	—
32	800	—	—	—	60.00 (1524)	—	61.13 (1553)	60.00 (1524)	60.00 (1524)	61.13 (1553)	—	—	—
34	850	—	—	—	64.00 (1626)	—	65.13 (1654)	64.00 (1626)	64.00 (1626)	65.13 (1654)	—	—	—
36	900	—	—	—	68.00 (1727)	—	69.13 (1756)	68.00 (1727)	68.00 (1727)	69.13 (1756)	—	—	—

Table C.2—Plug Valves—Face-to-face (*A*) and End-to-end (*B* and *C*) Dimensions (Continued)

Dimensions in inches (millimeters)

NPS	DN	Regular Pattern			Venturi Pattern			Round Port, Full Bore		
		Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*
		Class 600								
2	50	11.50 (292)	11.50 (292)	11.63 (295)	—	—	—	13.00 (330)	—	13.13 (333)
$2^1/_2$	65	13.00 (330)	13.00 (330)	13.13 (333)	—	—	—	15.00 (381)	—	15.13 (384)
3	80	14.00 (356)	14.00 (356)	14.13 (359)	—	—	—	17.50 (445)	—	17.63 (448)
4	100	17.00 (432)	17.00 (432)	17.13 (435)	—	—	—	20.00 (508)	22.00 (559)	20.13 (511)
6	150	22.00 (559)	22.00 (559)	22.13 (562)	22.00 (559)	22.00 (559)	22.13 (562)	26.00 (660)	28.00 (711)	26.13 (664)
8	200	26.00 (660)	26.00 (660)	26.13 (664)	26.00 (660)	26.00 (660)	26.13 (664)	31.25 (794)	33.25 (845)	31.38 (797)
10	250	31.00 (787)	31.00 (787)	31.13 (791)	31.00 (787)	31.00 (787)	31.13 (791)	37.00 (940)	40.00 (1016)	37.13 (943)
12	300	—	—	—	33.00 (838)	33.00 (838)	33.13 (841)	42.00 (1067)	42.00 (1067)	42.13 (1070)
14	350	—	—	—	35.00 (889)	35.00 (889)	35.13 (892)	—	—	—
16	400	—	—	—	39.00 (991)	39.00 (991)	39.13 (994)	—	—	—
18	450	—	—	—	43.00 (1092)	43.00 (1092)	43.13 (1095)	—	—	—
20	500	—	—	—	47.00 (1194)	47.00 (1194)	47.25 (1200)	—	—	—
22	550	—	—	—	51.00 (1295)	51.00 (1295)	51.38 (1305)	—	—	—
24	600	—	—	—	55.00 (1397)	55.00 (1397)	55.38 (1407)	—	—	—
26	650	—	—	—	57.00 (1448)	57.00 (1448)	57.50 (1461)	—	—	—
30	750	—	—	—	65.00 (1651)	65.00 (1651)	65.50 (1664)	—	—	—
32	800	—	—	—	70.00 (1778)	70.00 (1778)	70.63 (1794)	—	—	—
34	850	—	—	—	76.00 (1930)	76.00 (1930)	76.63 (1946)	—	—	—
36	900	—	—	—	82.00 (2083)	82.00 (2083)	82.63 (2099)	—	—	—

Table C.2—Plug Valves—Face-to-face (*A*) and End-to-end (*B* and *C*) Dimensions (Continued)

Dimensions in inches (millimeters)

NPS	DN	Regular Pattern			Venturi Pattern			Round Port, Full Bore		
		Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*
		Class 900								
2	50	14.50 (368)	—	14.63 (371)	—	—	—	15.00 (381)	—	15.13 (384)
2 1/2	65	16.50 (419)	—	16.63 (422)	—	—	—	17.00 (432)	—	17.13 (435)
3	80	15.00 (381)	15.00 (381)	15.13 (384)	—	—	—	18.50 (470)	—	18.63 (473)
4	100	18.00 (457)	18.00 (457)	18.13 (460)	—	—	—	22.00 (559)	—	22.13 (562)
6	150	24.00 (610)	24.00 (610)	24.13 (613)	24.00 (610)	24.00 (610)	24.13 (613)	29.00 (737)	—	29.13 (740)
8	200	29.00 (737)	29.00 (737)	29.13 (740)	29.00 (737)	29.00 (737)	29.13 (740)	32.00 (813)	—	32.13 (816)
10	250	33.00 (838)	33.00 (838)	33.13 (841)	33.00 (838)	33.00 (838)	33.13 (841)	38.00 (965)	—	38.13 (968)
12	300	—	—	—	38.00 (965)	38.00 (965)	38.13 (968)	44.00 (1118)	—	44.13 (1121)
16	400	—	—	—	44.50 (1130)	44.50 (1130)	44.88 (1140)	—	—	—

Table C.2—Plug Valves—Face-to-face (*A*) and End-to-end (*B* and *C*) Dimensions (Continued)

Dimensions in inches (millimeters)

NPS	DN	Regular Pattern			Venturi Pattern			Round Port, Full Bore		
		Raised Face	Welding End	Ring Joint	Raised Face	Welding End	Ring Joint	Raised Face	Welding End	Ring Joint
		A	*B*	*C*	*A*	*B*	*C*	*A*	*B*	*C*
		Class 1500								
2	50	14.50 (368)	—	14.63 (371)	—	—	—	15.38 (391)	—	15.50 (394)
2 1/2	65	16.50 (419)	—	16.63 (422)	—	—	—	17.88 (454)	—	18.00 (457)
3	80	18.50 (470)	18.50 (470)	18.63 (473)	—	—	—	20.63 (524)	—	20.75 (527)
4	100	21.50 (546)	21.50 (546)	21.63 (549)	—	—	—	24.63 (625)	—	24.75 (629)
6	150	27.75 (705)	27.75 (705)	28.00 (711)	27.75 (705)	27.75 (705)	28.00 (711)	31.00 (787)	—	31.25 (794)
8	200	32.75 (832)	32.75 (832)	33.13 (841)	32.75 (832)	32.75 (832)	33.13 (841)	35.00 (889)	—	35.38 (899)
10	250	39.00 (991)	39.00 (991)	39.38 (1000)	39.00 (991)	39.00 (991)	39.38 (1000)	42.00 (1067)	—	42.38 (1076)
12	300	44.50 (1130)	44.50 (1130)	45.13 (1146)	44.50 (1130)	44.50 (1130)	45.13 (1146)	48.00 (1219)	—	48.63 (1235)
Class 2500										
2	50	17.75 (451)	—	17.88 (454)	—	—	—	—	—	—
2 1/2	65	20.00 (508)	—	20.25 (514)	—	—	—	—	—	—
3	80	22.75 (578)	—	23.00 (584)	—	—	—	—	—	—
4	100	26.50 (673)	—	26.88 (683)	—	—	—	—	—	—
6	150	36.00 (914)	—	36.50 (927)	—	—	—	—	—	—
8	200	40.25 (1022)	—	40.88 (1038)	—	—	—	—	—	—
10	250	50.00 (1270)	—	50.88 (1292)	—	—	—	—	—	—
12	300	56.00 (1422)	—	56.88 (1445)	—	—	—	—	—	—

Table C.3—Ball Valves—Face-to-face (*A*) and End-to-end (*B* and *C*) Dimensions

Dimensions in inches (millimeters)

NPS	DN	Full Bore and Reduced Bore			Short Pattern, Full Bore, and Reduced Bore		
		Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*
		Class 150					
2	50	7.00 (178)	8.50 (216)	7.50 (191)	—	—	—
2 1/2	65	7.50 (191)	9.50 (241)	8.00 (203)	—	—	—
3	80	8.00 (203)	11.13 (283)	8.50 (216)	—	—	—
4	100	9.00 (229)	12.00 (305)	9.50 (241)	—	—	—
6	150	15.50 (394)	18.00 (457)	16.00 (406)	10.50 (267)	15.88 (403)	11.00 (279)
8	200	18.00 (457)	20.50 (521)	18.50 (470)	11.50 (292)	16.50 (419)	12.00 (305)
10	250	21.00 (533)	22.00 (559)	21.50 (546)	13.00 (330)	18.00 (457)	13.50 (343)
12	300	24.00 (610)	25.00 (635)	24.50 (622)	14.00 (356)	19.75 (502)	14.50 (368)
14	350	27.00 (686)	30.00 (762)	27.50 (699)	—	—	—
16	400	30.00 (762)	33.00 (838)	30.50 (775)	—	—	—
18	450	34.00 (864)	36.00 (914)	34.50 (876)	—	—	—
20	500	36 (914)	39 (991)	36.5 (927)	—	—	—
22	550	—	—	—	—	—	—
24	600	42.00 (1067)	45.00 (1143)	42.50 (1080)	—	—	—
26	650	45.00 (1143)	49.00 (1245)	—	—	—	—
28	700	49.00 (1245)	53.00 (1346)	—	—	—	—
30	750	51.00 (1295)	55.00 (1397)	—	—	—	—
32	800	54.00 (1372)	60.00 (1524)	—	—	—	—
34	850	58.00 (1473)	64.00 (1626)	—	—	—	—
36	900	60.00 (1524)	68.00 (1727)	—	—	—	—
38	950	—	—	—	—	—	—
40	1000	—	—	—	—	—	—
42	1100	—	—	—	—	—	—
48	1200	—	—	—	—	—	—
54	1400	—	—	—	—	—	—
60	1500	—	—	—	—	—	—

Table C.3—Ball Valves—Face-to-face (*A*) and End-to-end (*B* and *C*) Dimensions (Continued)

Dimensions in inches (millimeters)

NPS	DN	Full Bore and Reduced Bore			Short Pattern, Full Bore, and Reduced Bore		
		Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*
		Class 300					
2	50	8.50 (216)	8.50 (216)	9.13 (232)	—	—	—
$2^1/_2$	65	9.50 (241)	9.50 (241)	10.13 (257)	—	—	—
3	80	11.13 (283)	11.13 (283)	11.75 (298)	—	—	—
4	100	12.00 (305)	12.00 (305)	12.63 (321)	—	—	—
6	150	15.88 (403)	18.00 (457)	16.50 (419)	—	—	—
8	200	19.75 (502)	20.50 (521)	20.38 (518)	16.50 (419)	16.50 (419)	17.13 (435)
10	250	22.38 (568)	22.00 (559)	23.00 (584)	18.00 (457)	18.00 (457)	18.63 (473)
12	300	25.50 (648)	25.00 (635)	26.13 (664)	19.75 (502)	19.75 (502)	20.38 (518)
14	350	30.00 (762)	30.00 (762)	30.63 (778)	—	—	—
16	400	33.00 (838)	33.00 (838)	33.63 (854)	—	—	—
18	450	36.00 (914)	36.00 (914)	36.63 (930)	—	—	—
20	500	39.00 (991)	39.00 (991)	39.75 (1010)	—	—	—
22	550	43.00 (1092)	43.00 (1092)	43.88 (1114)	—	—	—
24	600	45.00 (1143)	45.00 (1143)	45.88 (1165)	—	—	—
26	650	49.00 (1245)	49.00 (1245)	50.00 (1270)	—	—	—
28	700	53.00 (1346)	53.00 (1346)	54.00 (1372)	—	—	—
30	750	55.00 (1397)	55.00 (1397)	56.00 (1422)	—	—	—
32	800	60.00 (1524)	60.00 (1524)	61.13 (1553)	—	—	—
34	850	64.00 (1626)	64.00 (1626)	65.13 (1654)	—	—	—
36	900	68.00 (1727)	68.00 (1727)	69.13 (1756)	—	—	—
38	950	—	—	—	—	—	—
40	1000	—	—	—	—	—	—
42	1100	—	—	—	—	—	—
48	1200	—	—	—	—	—	—
54	1400	—	—	—	—	—	—
60	1500	—	—	—	—	—	—

Table C.3—Ball Valves—Face-to-face (*A*) and End-to-end (*B* and *C*) Dimensions (Continued)

Dimensions in inches (millimeters)

NPS	DN	Full Bore and Reduced Bore			Full Bore and Reduced Bore		
		Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*
		Class 600			Class 900		
2	50	11.50 (292)	11.50 (292)	11.63 (295)	14.50 (368)	14.50 (368)	14.63 (371)
$2^1/_2$	65	13.00 (330)	13.00 (330)	13.13 (333)	16.50 (419)	16.50 (419)	16.63 (422)
3	80	14.00 (356)	14.00 (356)	14.13 (359)	15.00 (381)	15.00 (381)	15.13 (384)
4	100	17.00 (432)	17.00 (432)	17.13 (435)	18.00 (457)	18.00 (457)	18.13 (460)
6	150	22.00 (559)	22.00 (559)	22.13 (562)	24.00 (610)	24.00 (610)	24.13 (613)
8	200	26.00 (660)	26.00 (660)	26.13 (664)	29.00 (737)	29.00 (737)	29.13 (740)
10	250	31.00 (787)	31.00 (787)	31.13 (791)	33.00 (838)	33.00 (838)	33.13 (841)
12	300	33.00 (838)	33.00 (838)	33.13 (841)	38.00 (965)	38.00 (965)	38.13 (968)
14	350	35.00 (889)	35.00 (889)	35.13 (892)	40.50 (1029)	40.50 (1029)	40.88 (1038)
16	400	39.00 (991)	39.00 (991)	39.13 (994)	44.50 (1130)	44.50 (1130)	44.88 (1140)
18	450	43.00 (1092)	43.00 (1092)	43.13 (1095)	48.00 (1219)	48.00 (1219)	48.50 (1232)
20	500	47.00 (1194)	47.00 (1194)	47.25 (1200)	52.00 (1321)	52.00 (1321)	52.50 (1334)
22	550	51.00 (1295)	51.00 (1295)	51.38 (1305)	—	—	—
24	600	55.00 (1397)	55.00 (1397)	55.38 (1407)	61.00 (1549)	61.00 (1549)	61.75 (1568)
26	650	57.00 (1448)	57.00 (1448)	57.50 (1461)	65.00 (1651)	—	65.88 (1673)
28	700	61.00 (1549)	61.00 (1549)	61.50 (1562)	—	—	—
30	750	65.00 (1651)	65.00 (1651)	65.50 (1664)	74.00 (1880)	—	74.88 (1902)
32	800	70.00 (1778)	70.00 (1778)	70.63 (1794)	—	—	—
34	850	76.00 (1930)	76.00 (1930)	76.63 (1946)	—	—	—
36	900	82.00 (2083)	82.00 (2083)	82.63 (2099)	90.00 (2286)	—	91.13 (2315)
38	950	—	—	—	—	—	—
40	1000	—	—	—	—	—	—
42	1100	—	—	—	—	—	—
48	1200	—	—	—	—	—	—

Table C.3—Ball Valves—Face-to-face (*A*) and End-to-end (*B* and *C*) Dimensions (Continued)

Dimensions in inches (millimeters)

NPS	DN	Full Bore and Reduced Bore			Full Bore and Reduced Bore		
		Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*
		Class 1500			Class 2500		
2	50	14.50 (368)	14.50 (368)	14.63 (371)	17.75 (451)	17.75 (451)	17.88 (454)
2 1/2	65	16.50 (419)	16.50 (419)	16.63 (422)	20.00 (508)	20.00 (508)	20.25 (514)
3	80	18.50 (470)	18.50 (470)	18.63 (473)	22.75 (578)	22.75 (578)	23.00 (584)
4	100	21.50 (546)	21.50 (546)	21.63 (549)	26.50 (673)	26.50 (673)	26.88 (683)
6	150	27.75 (705)	27.75 (705)	28.00 (711)	36.00 (914)	36.00 (914)	36.50 (927)
8	200	32.75 (832)	32.75 (832)	33.13 (841)	40.25 (1022)	40.25 (1022)	40.88 (1038)
10	250	39.00 (991)	39.00 (991)	39.38 (1000)	50.00 (1270)	50.00 (1270)	50.88 (1292)
12	300	44.50 (1130)	44.50 (1130)	45.13 (1146)	56.00 (1422)	56.00 (1422)	56.88 (1445)
14	350	49.50 (1257)	49.50 (1257)	50.25 (1276)	—	—	—
16	400	54.50 (1384)	54.50 (1384)	55.38 (1407)	—	—	—
18	450	60.50 (1537)	—	61.38 (1559)	—	—	—
20	500	65.50 (1664)	—	66.38 (1686)	—	—	—
22	550	—	—	—	—	—	—
24	600	—	—	77.63 (1972)	—	—	—
26	650	76.50 (1943)	—	—	—	—	—
28	700	—	—	—	—	—	—
30	750	—	—	—	—	—	—
32	800	—	—	—	—	—	—
34	850	—	—	—	—	—	—
36	900	—	—	—	—	—	—

Table C.4—Check Valves, Face-to-face (*A*) and End-to-end (*B* and *C*) Dimensions

Dimensions in inches (millimeters)

NPS	DN	Class 150			Class 300		
		Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*
2	50	8.00 (203)	8.00 (203)	8.50 (216)	10.50 (267)	10.50 (267)	11.13 (283)
2 1/2	65	8.50 (216)	8.50 (216)	9.00 (229)	11.50 (292)	11.50 (292)	12.13 (308)
3	80	9.50 (241)	9.50 (241)	10.00 (254)	12.50 (318)	12.50 (318)	13.13 (333)
4	100	11.50 (292)	11.50 (292)	12.00 (305)	14.00 (356)	14.00 (356)	14.63 (371)
6	150	14.00 (356)	14.00 (356)	14.50 (368)	17.50 (445)	17.50 (445)	18.13 (460)
8	200	19.50 (495)	19.50 (495)	20.00 (508)	21.00 (533)	21.00 (533)	21.63 (549)
10	250	24.50 (622)	24.50 (622)	25.00 (635)	24.50 (622)	24.50 (622)	25.13 (638)
12	300	27.50 (699)	27.50 (699)	28.00 (711)	28.00 (711)	28.00 (711)	28.63 (727)
14	350	31.00 (787)	31.00 (787)	31.50 (800)	33.00 (838)	33.00 (838)	33.63 (854)
16	400	34.00 (864)	34.00 (864)	34.50 (876)	34.00 (864)	34.00 (864)	34.63 (879)
18	450	38.50 (978)	38.50 (978)	39.00 (991)	38.50 (978)	38.50 (978)	39.13 (994)
20	500	38.50 (978)	38.50 (978)	39.00 (991)	40.00 (1016)	40.00 (1016)	40.75 (1035)
22	550	42.00 (1067)	42.00 (1067)	42.50 (1080)	44.00 (1118)	44.00 (1118)	44.88 (1140)
24	600	51.00 (1295)	51.00 (1295)	51.50 (1308)	53.00 (1346)	53.00 (1346)	53.88 (1368)
26	650	51.00 (1295)	51.00 (1295)	—	53.00 (1346)	53.00 (1346)	54.00 (1372)
28	700	57.00 (1448)	57.00 (1448)	—	59.00 (1499)	59.00 (1499)	60.00 (1524)
30	750	60.00 (1524)	60.00 (1524)	—	62.75 (1594)	62.75 (1594)	63.75 (1619)
36	900	77.00 (1956)	77.00 (1956)	—	82.00 (2083)	82.00 (2083)	—
38	950	—	—	—	—	—	—
40	1000	—	—	—	—	—	—
42	1100	—	—	—	—	—	—
48	1200	—	—	—	—	—	—
54	1400	—	—	—	—	—	—
60	1500	—	—	—	—	—	—

Table C.4—Check Valves, Face-to-face (*A*) and End-to-end (*B* and *C*) Dimensions (Continued)

Dimensions in inches (millimeters)

NPS	DN	Class 600			Class 900		
		Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*
2	50	11.50 (292)	11.50 (292)	11.63 (295)	14.50 (368)	14.50 (368)	14.63 (371)
2 1/2	65	13.00 (330)	13.00 (330)	13.13 (333)	16.50 (419)	16.50 (419)	16.63 (422)
3	80	14.00 (356)	14.00 (356)	14.13 (359)	15.00 (381)	15.00 (381)	15.13 (384)
4	100	17.00 (432)	17.00 (432)	17.13 (435)	18.00 (457)	18.00 (457)	18.13 (460)
6	150	22.00 (559)	22.00 (559)	22.13 (562)	24.00 (610)	24.00 (610)	24.13 (613)
8	200	26.00 (660)	26.00 (660)	26.13 (664)	29.00 (737)	29.00 (737)	29.13 (740)
10	250	31.00 (787)	31.00 (787)	31.13 (791)	33.00 (838)	33.00 (838)	33.13 (841)
12	300	33.00 (838)	33.00 (838)	33.13 (841)	38.00 (965)	38.00 (965)	38.13 (968)
14	350	35.00 (889)	35.00 (889)	35.13 (892)	40.50 (1029)	40.50 (1029)	40.88 (1038)
16	400	39.00 (991)	39.00 (991)	39.13 (994)	44.50 (1130)	44.50 (1130)	44.88 (1140)
18	450	43.00 (1092)	43.00 (1092)	43.13 (1095)	48.00 (1219)	48.00 (1219)	48.50 (1232)
20	500	47.00 (1194)	47.00 (1194)	47.25 (1200)	52.00 (1321)	52.00 (1321)	52.50 (1334)
22	550	51.00 (1295)	51.00 (1295)	51.38 (1305)	—	—	—
24	600	55.00 (1397)	55.00 (1397)	55.38 (1407)	61.00 (1549)	61.00 (1549)	61.75 (1568)
26	650	57.00 (1448)	57.00 (1448)	57.50 (1461)	—	—	—
28	700	63.00 (1600)	63.00 (1600)	63.50 (1613)	—	—	—
30	750	65.00 (1651)	65.00 (1651)	65.50 (1664)	—	—	—
36	900	82.00 (2083)	82.00 (2083)	—	—	—	—
38	950	—	—	—	—	—	—
40	1000	—	—	—	—	—	—
42	1100	—	—	—	—	—	—
48	1200	—	—	—	—	—	—
54	1400	—	—	—	—	—	—
60	1500	—	—	—	—	—	—

Table C.4—Check Valves, Face-to-face (*A*) and End-to-end (*B* and *C*) Dimensions (Continued)

Dimensions in inches (millimeters)

NPS	DN	Class 1500			Class 2500		
		Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*
2	50	14.50 (368)	14.50 (368)	14.63 (371)	17.75 (451)	17.75 (451)	17.88 (454)
2 1/2	65	16.50 (419)	16.50 (419)	16.63 (422)	20.00 (508)	20.00 (508)	20.25 (514)
3	80	18.50 (470)	18.50 (470)	18.63 (473)	22.75 (578)	22.75 (578)	23.00 (584)
4	100	21.50 (546)	21.50 (546)	21.63 (549)	26.50 (673)	26.50 (673)	26.88 (683)
6	150	27.75 (705)	27.75 (705)	28.00 (711)	36.00 (914)	36.00 (914)	36.50 (927)
8	200	32.75 (832)	32.75 (832)	33.13 (841)	40.25 (1022)	40.25 (1022)	40.88 (1038)
10	250	39.00 (991)	39.00 (991)	39.38 (1000)	50.00 (1270)	50.00 (1270)	50.88 (1292)
12	300	44.50 (1130)	44.50 (1130)	45.13 (1146)	56.00 (1422)	56.00 (1422)	56.88 (1445)
14	350	49.50 (1257)	49.50 (1257)	50.25 (1276)	—	—	—
16	400	54.50 (1384)	54.50 (1384)	55.38 (1407)	—	—	—
18	450	60.50 (1537)	60.50 (1537)	61.38 (1559)	—	—	—
20	500	65.50 (1664)	65.50 (1664)	66.38 (1686)	—	—	—
24	600	76.50 (1943)	76.50 (1943)	77.63 (1972)	—	—	—

Table C.5—Axial On–off Valves—Face-to-face (*A*) and End-to-end (*B* and *C*) Dimensions

Dimensions in inches (millimeters)

NPS	DN	Raised Face *A*	Welding End *B*	Ring Joint *C*	Raised Face *A*	Welding End *B*	Ring Joint *C*
		Class 1500			Class 2500		
2	50	14.50 (368)	—	14.63 (371)	17.75 (451)	—	17.88 (454)
2 1/2	65	—	—	—	—	—	—
3	80	18.50 (470)	15.00 (381)	18.63 (473)	22.75 (578)	16.55 (420)	23.00 (584)
4	100	21.50 (546)	18.00 (457)	21.63 (549)	26.50 (673)	18.00 (457)	26.88 (683)
6	150	27.75 (705)	24.00 (610)	28.00 (711)	36.00 (914)	24.00 (610)	36.50 (927)
8	200	32.75 (832)	29.00 (737)	33.13 (841)	40.25 (1022)	29.00 (737)	40.88 (1038)
10	250	39.00 (991)	33.00 (838)	39.38 (1000)	50.00 (1270)	33.00 (838)	50.88 (1292)
12	300	44.50 (1130)	38.00 (965)	45.13 (1146)	56.00 (1422)	38.00 (965)	56.88 (1445)
14	350	49.50 (1257)	40.50 (1029)	50.25 (1276)	62.75 (1594)	40.50 (1029)	—
16	400	54.50 (1384)	44.50 (1130)	55.38 (1407)	70.00 (1778)	44.50 (1130)	—
18	450	60.12 (1527)	48.00 (1219)	61.00 (1549)	—	—	—
20	500	65.50 (1664)	52.00 (1321)	66.38 (1686)	—	—	—
22	550	—	—	—	—	—	—
24	600	76.26 (1937)	61.00 (1549)	77.36 (1965)	—	—	—
26	650	—	—	—	—	—	—
28	700	—	—	—	—	—	—
30	750	—	—	—	—	—	—
32	800	—	—	—	—	—	—
34	850	—	—	—	—	—	—
36	900	—	—	—	—	—	—
38	950	—	—	—	—	—	—
40	1000	—	—	—	—	—	—
42	1050	—	—	—	—	—	—
48	1200	—	—	—	—	—	—

Annex D
(informative)

Actuator—Gearbox Requirements

D.1 General

This annex specifies requirements for supplementary operator, which shall be performed by the manufacturer if specified by the purchaser.

D.2 Valve Operator Interface

The interface between the operator and valve bonnet shall be pressure-balanced to the environment, filled with an appropriate pressure compensating fluid and provided with inlet and outlet pressure-relief valves.

The compensating system design shall take into account the entire life cycle the following;

— volume changes,

— temperature changes,

— removable or installation of operator subsea.

The hydrostatic head pressure shall be taken into account when designing the actuator/gearbox.

The output of the actuator shall not exceed the valve MAST.

Caution—Permanent deformation or failure of drive-train components can occur if they are exposed to thrust or torque exceeding these stress limits.

Actuator, gear box, sizing, and mounting kits shall conform to the requirements specified by the purchaser.

Operators and their interfaces shall be sealed to prevent ingress of external contaminants and moisture.

Operators shall be provided with a means of preventing pressure buildup in the mechanism resulting from stem or bonnet seal leakage.

EXAMPLE Use of inlet/outlet pressure-relief valves.

The manufacturer shall state the maximum permissible input torque or thrust for the valve operator.

Annex E
(informative)

Guidance for Travel Stops by Valve Type

This annex provides guidance on travel stops by common valve type (see Table E.1).

Table E.1—Valve Travel Stops

Valve Type	Option/Detail	Travel Stop Requirements in Valve	Manual Gearbox	Actuator
Ball	All	Stops for open and close	Stops in gearbox for open and close	Actuator should control position, not valve stops.
Axial-on-off	All	Stops for open and close	Stops for open and close in gearbox	Actuator should control position, not valve stops.
Plug—nonexpanding type	All	Stops for open and close	Stops in valve for open or close	Actuator should control position, not valve stops.
Gate—slab/parallel through conduit	Conventional (down to close), no backseat	Stops for open and close	Stops in valve for open or close (1)	Actuator should control position, not valve stops.
Gate—slab/parallel through conduit	Conventional (down to close), no backseat	Stops for open and close (2)	Stops for open and close in valve. Backseat provides open stop (1).	Actuator torque/thrust adjusted or selected to suit backseat in open.
Gate—slab/parallel through conduit	Reverse acting (up to close), no backseat	Stops for open and close	Close stops may be in yoke or on stem (1).	Actuator should control position, not valve stops.
Gate—slab/parallel through conduit	Reverse acting (up to close), with backseat	Stops for open and close (2)	Stops for open and close in valve (1) .	Actuator should control position for open. Actuator torque/thrust adjusted or selected to suit backseat in closed position.
Gate—expanding	Conventional, single expanding with backseat	No stops required. Wedging action provides close stop. Backseat provides open stop.	Stops for open in valve. Backseat provides open stop. Gearbox stop not required.	Actuator torque/thrust adjusted or selected to suit closing load in closed and backseat in open.
Gate—expanding	Conventional, single expanding without backseat	No stops required in closed. Wedging action provides close stop. Stop in valve required in open.	Stops for open in valve. Gearbox stop not required.	Actuator torque/thrust adjusted or selected to suit closing load in close.
Gate—expanding	Conventional, double or expanding without backseat	No stops required. Wedging action provides close and open stop.	Gearbox stop not required.	Actuator torque/thrust adjusted or selected to suit closing load in closed and wedging load in open.
Gate—non-rising stem, multi-turn	Conventional (down to close)	Stops for open and close.	Stops for open and closed in valve.	Actuator may have supplemental stops.
Check	With external clapper lift	Stop in body required for open. No stop required for close.	Gearbox stops in open and closed position to avoid overloading valve shaft in the open position and over-rotating the shaft passed the closed position.	Actuator stops should control open position, not valve stop, to avoid overloading valve shaft.

NOTES
(1) Close stops may be in yoke or on stem.

(2) Backseat provides open stop.

Annex F
(informative)

Design Validation

F.1 General

This annex provides design validation test procedures for equipment identified in this specification, which shall be applied if specified by the manufacturer or purchaser.

When this annex is applied, the design validation procedures in this annex shall be applied to the designs of products, including design changes. It is intended that this annex shall not apply to validation of components and or parts.

NOTE Additional procedures may be used by agreement, provided the test requirements of this annex are met or exceeded.

F.2 Effect of Changes in Product

F.2.1 Design Changes

A change in one of the following parameters shall require a new design validation:

— valve type;

— valve configuration;

— body style (e.g. two piece versus three piece, top entry versus side entry);

— type of sealing element (e.g. O-ring, lipseals, chevrons, BX ring, RTJ);

— sizing criteria on pressure-containing parts;

— sizing criteria of obturator and seats;

— design of seal mating parts;

— sizing criteria of seat/obturator interfaces;

— sizing criteria of the drive train;

— maximum speed of operation (e.g. a valve qualified for a 10 second operation would qualify all slower operating times).

Valve operations during the design validation shall be performed at the qualified speed of operation or faster (e.g. a qualified speed of 10 seconds requires all valve operations to be 10 seconds or less).

Other changes shall not require new design validation if the manufacturer demonstrates that the performance of the product in the intended pressure, temperature, and service condition shall be maintained.

F.2.2 Metallic Materials

Substitution of metallic materials for critical parts with materials that have lower SMYS shall require a new design validation.

The substitution of wrought material with cast material shall require a new design validation.

For the critical parts any change of materials as defined in ASME *BPVC*, Section II, Part D, Table TM-1 shall require a new design validation.

The substitution of product form (e.g. forged, plates, etc.) shall be acceptable if the manufacturer demonstrates that the performance of the product in the intended pressure, temperature, and service conditions shall be maintained.

F.2.3 Nonmetallic Seals and Bearings

A change in one of the following parameters shall require a new design validation:

— type of sealing element (e.g. O-ring, lipseals, chevrons, etc.);

— sizing criteria of seals;

— material of seals or bearing;

— roughness of sealing surfaces;

— contact pressure of bearing.

Other changes shall not require new design validation if the manufacturer demonstrates that the performance of the product in the intended pressure, temperature and service condition shall be maintained.

F.2.4 Hardfacing

A change in one of the following parameters shall require a new design validation:

— hardfacing material;

— hardfacing process that may impact product performance;

— sizing criteria for contact pressure;

— reduction of minimum specified coating thickness.

Other changes shall not require new design validation if the manufacturer demonstrates that the performance of the product in the intended pressure, temperature and service condition shall be maintained.

F.3 Products for Design Validation

F.3.1 General

Design validation shall be performed on full-size prototypes or production unit.

NOTE Valves or components that have undergone validation testing may be used for further testing or in a production unit.

If the valve is to be reassembled after design validation testing is performed, the following minimum activities shall apply:

— all seals replaced, and

— dimensional inspection on pressure-containing and pressure-controlling parts performed to ensure continued conformance with the manufacturer's drawing dimensions and design acceptance criteria, and

— sealing surface finishes on pressure-containing and pressure-controlling parts checked to ensure continued conformance with the design acceptance criteria, and

— nonconforming parts reworked or replaced, and

— for reworked components, manufacturer shall demonstrate that the rework does not affect any of the elements or parameters listed in F.2, and

— reapply the same surface NDE already applied on the finished machined components during production for critical parts, and

— production testing is performed.

F.3.2 Testing Product

Design validation shall be performed on full-size products.

For product that are provided with multiple stem seals, each seal mechanism shall be independently verified at the beginning, at the minimum and maximum temperatures, and at the end of the design validation procedure.

F.4 External Paint or Coatings

The product used in any pressure test shall be free of paint or other coatings that can impede leak detection and/or leak observation.

F.5 Safety

The manufacturer shall identify and implement the actions needed to ensure the safety of personnel and equipment.

F.6 Test Orientation

Validation test shall be performed with stem in vertical orientation with horizontal bore, unless otherwise agreed.

Different installation between prototype and production valve shall not require a new validation test, if the suitability of the orientation can be substantiated by other means.

F.7 Hydrostatic Testing

The following shall apply.

The testing medium shall be a fluid that remains in the liquid or gaseous state throughout the testing temperature.

NOTE 1 Water with or without additives, gas, hydraulic fluid, or other mixtures of fluids may be used as the testing medium.

NOTE 2 The manufacturer may use gas as the test medium provided the testing method and acceptance criteria for gas testing (see F.8) are used.

F.8 Gas Testing

F.8.1 General

Gas shell testing at room temperature shall be conducted as per 10.9 or using the method described below.

Valves shall have a high-pressure gas shell test performed using inert gas as the test medium. Test shall be performed using 90 % nitrogen with a 10 % helium tracer measured using a mass spectrometer. The minimum test pressure shall be 1.1 times the pressure rating determined in accordance with 5.2 for the material at 100 °F (38 °C).

The acceptance criteria shall be a leakage rate not to exceed 1×10^{-4} std cm^3/s (1×10^{-5} $Pa\text{-}m^3/s$).

F.8.2 Leak Detection

Gas testing at room temperature shall be conducted with a method for leak detection.

NOTE 1 The product may be completely submerged in a liquid, or the product may be flooded in the seal areas being validated, such that all possible leak paths are covered.

NOTE 2 The product may be assembled with one end of a tube connected to a blind connector enclosing all possible leak paths being validated.

When one end of the tube is connected to a blind connector, the other end of the tube shall be immersed in a liquid or attached to a leakage measurement device.

NOTE 3 Other methods that can detect leakage accurately are acceptable.

F.9 Temperature Testing

F.9.1 Location of Temperature Measurement

The temperature shall be measured at the defined location by one of the methods below:

Method 1:

— On the outside surface of the valve in the seat area, and

— On the bonnet adjacent to the stem seal.

— Thermal analysis shall be performed to establish the outside surface temperature that corresponds to the required temperature for the internal parts. Hold periods shall start after the external temperature as defined by the analysis has been achieved.

Method 2:

— If the body wall thickness is greater than 0.5 in. (13 mm), drill a hole from the outside surface of the body in the seat area to within 0.5 in. (13 mm) of the surface wetted by the retained fluid.

— If the bonnet wall thickness is greater than 0.5 in. (13 mm), drill a hole from the outside surface of the bonnet to within 0.5 in. (13 mm) adjacent to the stem seal.

Temperature shall be considered stabilized when the rate of change is less than 0.5 °C/min (1 °F/min). The temperature shall remain at or beyond the extreme during the hold period, but should not go beyond the upper and lower temperatures by more than 11 °C (20 °F).

F.9.2 Application of Cooling for Minimum Temperature Testing

The cooling for minimum temperature testing shall be applied on the external surface of the equipment and/or through the valve bore, per manufacturer's design criteria.

F.10 Hold Periods

F.10.1 Start of Hold Periods

Hold periods shall start after pressure and temperature stabilization has occurred and the equipment with a pressure-monitoring device has been isolated from the pressure source. The specified hold times shall be a minimum.

F.10.2 Pressure Stabilization

Pressure shall be considered stabilized when the rate of change is no more than 5 % of the test pressure per hour or 500 psi/h (3.45 MPa/h), whichever is less.

F.10.3 Pressure Maintenance

Pressure shall remain within 5 % of the test pressure or within 500 psi (3.45 MPa), whichever is less, during the test hold period. Pressure shall not fall below the test pressure before the end of the test hold period.

F.10.4 Temperature Stabilization

Temperature shall be considered stabilized when the rate of change is less than 0.5 °C/min (1 °F/min).

F.11 Scaling

F.11.1 General

Design validation of a valve shall be independent of the type of actuation used during the validation test.

NOTE Scaling may be used to validate members of a product family in accordance with the requirement of this paragraph.

F.11.2 Product Family

A product family shall meet the following design criteria:

— configuration (see Annex B) is the same;

— operation, principles of functional operation are the same (e.g. nonreturn, linear quarter-turn, etc.);

— code or standard, design requirements are the same resulting in a comparable safety factor in relation to material properties.

NOTE If finite element analysis (FEA) is available, the design stress levels in relation to material mechanical properties may be based on these same criteria.

F.12 Limitations of Scaling

F.12.1 Design Validation by Pressure Rating

The test product shall be used to validate products of the same family having equal or lower pressure ratings.

F.12.2 Design Validation by Size

Testing of one size of a product family shall validate products as follows:

— one nominal size larger and one nominal size smaller than the tested size for valve sizes up to and including NPS 12 (DN 300) at the obturator,

— two nominal sizes larger and two nominal sizes smaller than the tested size for valve sizes NPS 14 (DN 350) and above at the obturator.

NOTE When using scaling additional verification by FEA may be required to validate NS12 (DN 300) and above.

F.12.3 Design Validation by Temperature

The temperature range validated by the test product shall validate all temperatures that fall entirely within that range.

F.13 Documentation

F.13.1 Design Validation Files

The manufacturer shall maintain a file on each design validation.

F.13.2 Contents of Design Validation Files

Design validation files shall contain or reference the following information, if applicable:

a) test number and revision level, or test procedure;

b) complete identification of the product being tested;

c) date of test completion;

d) test results and post-test examination conclusions (see F.17);

e) model numbers and other pertinent identifying data on all other sizes, rated pressures temperature ranges, and standard test fluid ratings of products of the same product family that are validated by the validation of this particular product;

f) all detailed dimensional drawings and material specifications applicable to the tested product, including seals and nonextrusion devices;

g) sketch of test rig, product ,and seal or sample; temperature and pressure measurement locations should be shown;

h) actual sealing-surface dimensions;

i) all test data specified in this annex, including actual test conditions (pressure, temperature, etc.) and observed leakages or other acceptance parameters; identification of testing media used;

j) test equipment identification and calibration status;

k) certification of manufacturer report, including the supplier of test seals, molding dates, compound identifications, and batch numbers for nonmetallic materials;

F.14 Test Equipment Calibration Requirements

Measuring and test equipment shall be identified, controlled, calibrated, and adjusted as per 8.3.

F.15 Design Validation Procedure

Procedure to validate a valve design shall be as identified in Table F.1.

For a valve with a bidirectional sealing seat, the valve shall be tested on one side only but in both directions.

NOTE Testing of bidirectional valves with same seat configuration on both sides of the valve may be conducted in one direction only, provided that the same direction is used for all tests.

Table F.1—Design Validation for Valves

Design Validation Tests	Reference Section
Hydrostatic body test	As specified in F.18.1

Seat test	As specified in F.18.2
Force or torque measurement	As specified in F.19
Open/close cycling dynamic pressure test at room temperature	160 cycles as specified in F.20
Gas seat test	As specified in F.18.2
Open/close cycling dynamic pressure gas test at maximum temperature	20 cycles as specified F.21
Gas body test at maximum temperature	As specified in F.22
Gas seat test at maximum temperature	As specified in F.23
Low-pressure seat test at maximum temperature	As specified in F.24
Open/close cycling dynamic pressure gas test at minimum temperature	20 cycles as specified F.21
Gas body test at minimum temperature	As specified in F.22
Gas seat test at minimum temperature	As specified in F.23
Low-pressure seat test at minimum temperature	As specified in F.24
Raise the temperature to room temperature	
Pressure/temperature cycling	As specified in F.25
Gas body test at room temperature	As specified in F.8.1
Gas seat test at room temperature	As specified in F.26
Low-pressure seat test at room temperature	As specified in F.27
Final force or torque measurement	As specified in F.28

F.16 Acceptance Criteria

F.16.1 Structural Integrity

Product that deforms to an extent that any other performance requirement cannot be achieved shall be considered not acceptable and the product shall be rejected. See F.17.

F.16.2 Pressure Integrity

The following shall apply.

a) Hydrostatic test at room temperature: the hydrostatic shell test at room temperature shall be performed as per 10.3.

b) Gas test at room temperature: the gas test at room temperature shall be acceptable. Leakage rate shall be less than the rates shown in Table F.2, measured at atmospheric pressure, during specified pressure-hold periods.

c) Minimum/maximum temperature tests: the hydrostatic or gas test at high or low temperature shall be acceptable if the pressure change observed on the pressure-measuring device is less than 5 % of the test pressure or 500 psi (3.45 MPa), whichever is less.

Table F.2—Room Temperature Gas Leakage Acceptance Criteria

Equipment	Seal Type	Allowable Leakage
Valves, ball, check, gate, and plug.	Through-bore	See 10.11.2
	Stem seal	No visible leakage [a]
	Static (bonnet seal, end connections)	No visible leakage [a]

[a] No visible leakage is selected for stem and static seals, which means:

— no visually detectable leakage shall be permitted for submerged test (see Section 10);

— see F.8.2.

F.17 Post-test Examination

The tested prototype shall be disassembled and inspected and all critical parts shall be photographed.

The examination shall be performed to ensure that neither the product nor component design contains defects to the extent that any performance requirement cannot be met. The results of the examination shall be documented.

F.18 Static Pressure Testing at Room Temperature

F.18.1 Hydrostatic Body Pressure Test

Hydrostatic body testing shall be performed at the RWP of the valve. The body test shall be in accordance with 10.3.

Test duration shall be a minimum of 1 hour.

F.18.2 Seat Static Pressure Test

Hydrostatic seat test shall be performed in accordance with 10.5.

Gas seat test shall be performed in accordance with 10.11.

Test duration shall be a minimum of 1 hour.

F.19 Force or Torque Measurement

The breakaway and running torques or forces shall be measured at the maximum design pressure difference.

This shall be applicable to all valves, including check valves provided with an external operator as long as no differential pressure is applied across the obturator.

NOTE The force/torque may be determined by direct or indirect measurement (i.e. pressure applied to an area).

A procedure to measure breakaway and running torques or forces shall be prepared by the manufacturer.

The operating forces or torques shall be within the manufacturer's specifications.

F.20 Dynamic Test at Room Temperature

F.20.1 Speed of Operation

The valve operation during the design validation shall be performed at the same speed that is the qualified speed of operation. The speed of operation shall be recorded.

F.20.2 Procedure for On–Off Valves (Plug, Gate, Ball, and Axial-flow) Valves

The valves shall be tested as follows.

a) Fill the downstream end of the valve with the test medium at 1 % or less of test pressure.

b) Apply pressure equal to the RWP against the upstream side of the valve. All subsequent seat tests shall be in the same direction.

c) Open the valve fully, starting against the full differential pressure. Pressure shall be maintained at a minimum of 50 % of the initial test pressure after the BTO. The opening stroke may be interrupted to adjust the pressure within the above limits.

d) Close the valve fully while pressure is maintained within the limits of the preceding step.

e) Bleed the downstream pressure to 1 % or less of test pressure after the valve is fully closed.

F.20.3 Procedure for Check Valves

Check valves shall be tested as follows.

a) Apply pressure equal to the RWP to the downstream side of the valve.

b) Relieve the pressure on the downstream side and apply 1 % or less of test pressure on the upstream side and unseat the valve.

c) Repeat until a minimum of 160 pressure cycles has been carried out.

For check valves provided with external operator, 160 opening closing cycle shall be performed on the external operator without differential pressure across the obturator.

A procedure for check valve testing shall be prepared by the manufacturer.

F.21 Dynamic Test at Maximum/Minimum Rated Temperature

At the maximum/minimum design temperature, the procedure of F.20 shall be followed with the exception that the number of cycles shall be 20 and the test medium shall be gas.

F.22 Gas Body Test at Maximum/Minimum Rated Temperature

The gas body test shall be performed as follows.

a) The valves shall be in the partially open position during testing. Check valves shall be tested from the upstream side.

b) The test pressure shall be the RWP.

a) The hold period shall be 1 hour.

Acceptance criteria shall be as per F.16.2 c).

F.23 Gas Seat Test at Maximum/Minimum Rated Temperature

The RWP shall be applied on the upstream side of the gate or ball and released on the downstream side. Check valves shall be tested from the downstream side.

The hold period shall be a minimum of 1 hour.

The pressure shall be released after the hold period.

F.24 Low-pressure Seat Test at Maximum/Minimum Rated Temperature

The valves shall be subjected to a differential pressure between 5 % and no more than 10 % of the rated working pressure, with a minimum of 80 psi (5.5 barg). The pressure shall be applied on the upstream side of the gate or ball and released on the downstream side. For check valves, the low-pressure seat test pressure shall be applied on the downstream end of the valve with the opposite end vented to the atmosphere.

The hold period shall be a minimum of 1 hour.

Pressure change observed on the pressure-measuring device shall be less than 10 % of the testing pressure for Class 150 to 600 and less than 5 % for all other classes.

F.25 Pressure and Temperature Cycles

F.25.1 General

Pressure/temperature cycles shall be performed as specified in Figure F.1.

F.25.2 Test Pressure and Temperature

The test pressure and temperature extremes shall be as specified in a validation procedure.

F.25.3 Test Procedure

Pressure shall be monitored and controlled during temperature change. The following procedure shall be performed.

NOTE The item letters of the steps of the procedure correspond to the letters shown in Figure F.1.

a) Apply the test pressure at room temperature and maintain at 50 % to 100 % of test pressure while raising temperature to the maximum.

b) Hold for a period of 1 hour minimum at test pressure.

c) Reduce the temperature to the minimum while maintaining 50 % to 100 % of test pressure.

d) Hold for a minimum period of 1 hour at test pressure.

e) Raise the temperature to room temperature while maintaining 50 % to 100 % of test pressure.

f) Release the pressure, and then raise the temperature to the maximum.

g) Apply the test pressure, hold for a minimum period of 1 hour, and then release the pressure.

h) Reduce the temperature to the minimum.

i) Apply the test pressure, hold for a minimum period of 1 hour, and then release the pressure.

j) Raise the temperature to room temperature.

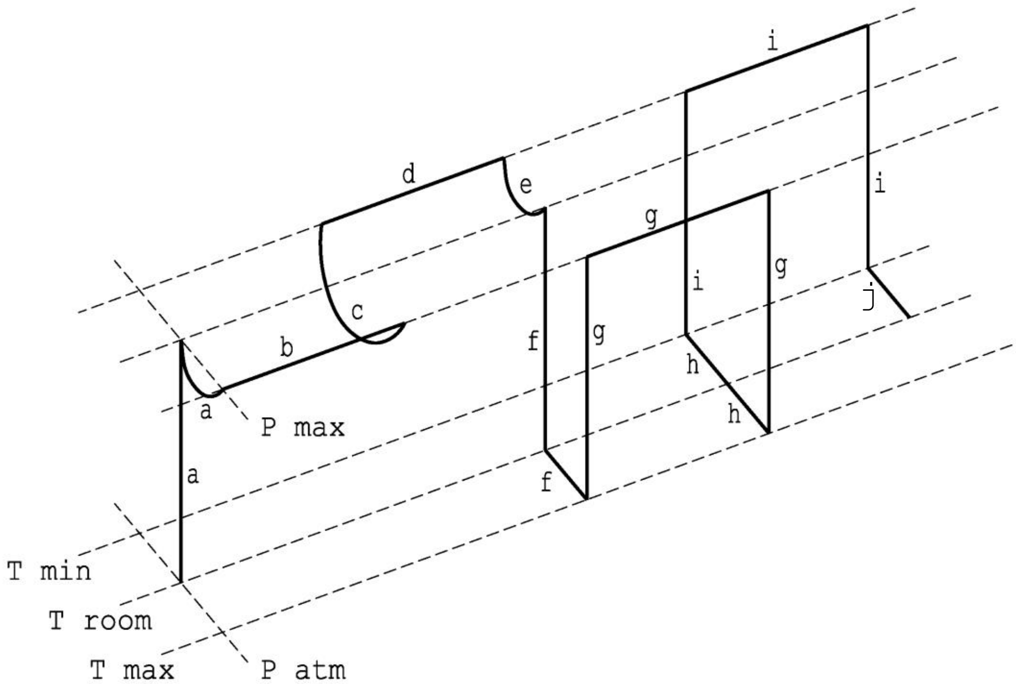


Figure F.1—Test Procedure for Pressure Temperature Cycle

F.26 High-pressure Gas Seat Test at Room Temperature

F.26.1 General

Valves shall be subjected to a seat test in accordance with 10.11.

F.26.2 Acceptance Criteria

Leakage for soft-seated valves and lubricated plug valves shall not exceed ISO 5208, Rate B.

For metal-seated valves, the leakage rate shall not exceed ISO 5208, Rate D.

For metal-seated check valves, the leakage rate shall not exceed ISO 5208, Rate F.

F.27 Low-pressure Gas Seat Test at Room Temperature

F.27.1 General

Valves shall be subjected to a seat test in accordance with 10.8.

F.27.2 Acceptance Criteria

Leakage for soft-seated valves and lubricated plug valves shall not exceed ISO 5208, Rate B.

For metal-seated valves, the leakage rate shall not exceed ISO 5208, Rate D.

For metal-seated check valves, the leakage rate shall not exceed ISO 5208, Rate F.

F.28 Final Force or Torque Measurement

The breakaway and running torques or forces shall be measured. For check valves provided with an external operator, torques or forces shall be measured without differential pressure on the obturator.

The procedure for final force or torque measurement shall be determined and documented by the manufacturer.

The operating forces or torques shall be within the manufacturer's specifications.

Annex G
(informative)

Hyperbaric Validation Testing

G.1 General

This annex provides hyperbaric (external pressure) test procedures and requirements to validate designs in subsea conditions for valves and actuators/operators identified in this specification, which shall be applied if specified by the manufacturer or purchaser.

The type of assembly to be tested (valve only, or valve and operator complete assembly) shall be specified by the purchaser.

NOTE Scaling, as defined in G.3, may be used to validate the members of a product family, by agreement.

Valve or assemblies shall be tested in hyperbaric conditions at a minimum external pressure equivalent to 1.1 times the design water depth.

A specific procedure on the method of localized testing shall be by agreement.

G.2 Minimum Design Validation Test Requirements

G.2.1 General

FEA shall be performed prior to qualification testing in order to demonstrate that the valve and any pressure-containing mounting spools have the capability to withstand the proposed external test pressure without failure. The manufacturer shall document the results of the FEA.

NOTE Components that are pressure compensated do not require FEA or pressure testing.

If applicable, the proper functionality of the compensation system shall be evaluated during the qualification.

The hyperbaric validation procedure shall include, as a minimum, the tests specified in Table G.1.

Table G.1—Hyperbaric Qualification Test

Valve Type	Hyperbaric Ingress Test [a]	Shell Test per 10.3 [a]	Seat Test per 10.5 [a]	Hyperbaric Endurance Test [b]
Ball	G.2.2.2 Step 1	G.2.2.2 Step 2	G.2.2.2 Step 3	G.2.2 Step 4 200 dynamic cycles with an external operator
Check	G.2.2.2 Step 1	G.2.2.2 Step 2	G.2.2.2 Step 3	G.2.2 Step 4 20 dynamic cycles with an external operator. N/A for check valve without an external operator
Gate Axial on–off	G.2.2.2 Step 1	G.2.2.2 Step 2	G.2.2.2 Step 3	200 dynamic cycles with an external operator
Plug	G.2.2.2 Step 1	G.2.2.2 Step 2	G.2.2.2 Step 3	200 dynamic cycles with an external operator

[a] Applicable to valve only.

[b] Applicable to valves and actuators.

G.2.2 Hyperbaric Validation Tests

G.2.2.1 Prior to Test

Before starting with the qualification tests, the following preliminary activities shall be performed.

— Hyperbaric chamber shall be at atmospheric pressure and the valve shall be placed into the hyperbaric chamber.

— The valve ends shall be closed and all test connections shall be in place. All the test ports shall be connected with the relative pipes and they shall be filled with test fluid.

— With the valve in half open position, all air shall be removed from the valve internal cavity and then filled with test fluid. During this operation the hyperbaric chamber shall not be pressurized and be empty of test fluid.

— Perform a hydrostatic shell test at 1.5 times the rated pressure to check all the connection sealing behaviors. The test shall be performed with the valve unseated and partially open and may also be performed with the valve fully open, provided the body cavity is simultaneously filled and pressurized through a cavity connection. The minimum holding time shall be 15 minutes, during which the pressure shall be monitored. Acceptance criteria shall be no pressure drop during this test. Release pressure in the valve cavity to atmosphere.

— Fill the hyperbaric chamber with test fluid.

— Apply 5 % to 10 % of the design water depth pressure for 15 minutes. This pressure shall be applied to the valve cavity prior to start of any hyperbaric test. Relieve the pressure to atmosphere.

G.2.2.2 Hyperbaric Testing

G.2.2.2.1 General

Hyperbaric testing shall consist of the following steps.

G.2.2.2.2 Step 1—Hyperbaric Ingress Test

a) Requirements.

The hyperbaric ingress test shall be conducted on valves only.

With the valve in half open position and completely filled with test fluid, pressurize the hyperbaric chamber with a pressure equal to 1.1 times the design water depth for a minimum hold time of 2 hours, while the valve cavity pressure shall be at atmospheric pressure. Valve internal pressure shall be monitored.

If practical, the use of test port is permitted as alternative. In this case, a test port needs to be provided outside the primary external pressure gasket/seal. The test port needs to be filled with test fluid. During the holding time, the test port shall be monitored for any leakage.

b) Acceptance criteria.

Any increase in the valve internal pressure that cannot be justified by temperature fluctuations shall be cause for rejection.

If test ports are used, the acceptance criterion for the hyperbaric ingress test shall be no visible detectable leakage from any of the test ports.

G.2.2.2.3 Step 2—Hydrostatic Shell Test in Hyperbaric Conditions

a) Requirements.

Perform a hydrostatic shell test pressures as per 10.3 (see Table G.1), with external hyperbaric pressure equal to 1.1 times the design water depth applied, however the minimum hold time shall be reduced to 15 minutes and the test pressure in the valve cavity shall be at least 1.1 times the valve pressure rating. Valve internal pressure shall be monitored.

If practical, the use of test port is permitted as alternative. In this case, a test port shall be provided, located outside any primary gasket/seal sealing against the valve cavity internal pressure. The test port shall be filled with test fluid. During the holding time, the test port needs to be monitored for any leakage.

b) Acceptance criteria.

The acceptance criterion shall be that the valve internal pressure change is less than 3 % per hour of the test pressure.

If test ports are used, the acceptance criterion shall be no visible detectable leakage from any of the test ports.

G.2.2.2.4 Step 3—Hydrostatic Seat Test

a) Requirements.

Perform a 3-cycle hydrostatic seat test pressures as per 10.5 (see Table G.1), with external hyperbaric pressure equal to 1.1 times the design water depth applied; however, the minimum hold time shall be 15 minutes for each cycle. If the valve contains a bidirectional sealing seat, then the valve shall be tested in all the sealing direction. 3-cycle seat tests are required for each seal direction.

b) Acceptance criteria.

The hydrostatic seat test acceptance criteria shall be per the requirements of 10.5.3.

G.2.2.2.5 Step 4—Hyperbaric Endurance Test

a) Requirements.

The endurance test consists of operating the valve for a number of cycles as specified in Table G.1, while subjected to the differential pressure specified in 5.5 and with external hyperbaric pressure equal to 1.1 times the design water depth applied.

The opening torque or force to operate the valve shall be monitored and recorded (starting from the first cycle) and at every 10 cycles, thereafter.

If the valve is operated by an actuator with an ROT interface, then 10 % of the cycles shall be performed using the ROT interface.

A hyperbaric endurance test shall be conducted on all the valve types, except for the check valve without an external operator. For the check valve provided with an external operator, the above procedure is applicable, but the valve is operated without differential pressure across its obturator.

b) Acceptance criteria.

The forces or torques shall be within the manufacturer's specifications.

If the valve is operated by a spring-return hydraulic actuator, the minimum hydraulic pressure in the cylinder during the failsafe function shall be a minimum of 100 psi (0.69 MPa) above the hyperbaric pressure, and with atmospheric pressure in the valve body cavity.

G.2.2.2.6 Step 5—Hydrostatic Shell at Ambient Condition

a) Requirements.

For valves only, perform a single internal hydrostatic shell as per 10.3; however, the minimum hold time shall be reduced to 15 minutes. The test shall be performed after all hyperbaric functional cycles have been completed and hyperbaric conditions depressurized to atmospheric pressure.

b) Acceptance criteria.

The hydrostatic shell test acceptance criteria for shall be per the requirements of 10.3.

G2.2.2.7 Step 6—Hydrostatic Seat Test at Ambient Condition

a) Requirements.

For valves only, perform a single internal hydrostatic seat test (as per 10.5); however, the minimum hold time shall be reduced to 15 minutes.

b) Acceptance criteria.

The hydrostatic seat test acceptance criteria shall be per the requirements of 10.5.3.

G.2.2.2.8 Step 7—Valve Disassembly and Visual Inspection

After all the qualification tests have been completed, the valve shall be disassembled and inspected. Where the valve disassembly is not practical, then the disassembly and inspection shall be done by agreement. There shall be no evidence of galling or permanent deformation of metallic components, excluding gaskets and seals.

G.3 Scaling

For a given test product used, scaling shall be permitted to validate products of the same family within the same pressure class for shallower water depth.

Testing of one size of a product family shall validate products as follows:

— one nominal size larger and one nominal size smaller than the tested size for valve sizes up to and including NPS 12 (DN 300) at the obturator,

— two nominal sizes larger and two nominal sizes smaller than the tested size for valve sizes NPS 14 (DN 350) and above at the obturator.

Annex H
(normative)

Pressure Boundary Bolting

H.1 General

This annex shall apply to performance requirements for pressure boundary bolting.

H.2 Carbon and Alloy Steel Bolting

Alloy steel bolting shall meet the requirements specified per API 20E in accordance with bolting specification level-2 (BSL-2) minimum for each bolting type as applicable.

H.3 CRA Bolting

CRA bolting shall meet the requirements specified per API 20F in accordance with bolting specification level-2 (BSL-2) minimum for each bolting type as applicable.

Annex I
(informative)

Pressure-containing Castings and Forgings

I.1 General

NOTE 1 This annex provides performance requirements for pressure-containing castings and forgings.

NOTE 2 The standards referenced in this annex may become mandatory (normative) in future edition(s) or addendum(s) of this standard.

I.2 Castings

NOTE Castings may be specified by the purchaser to conform to API 20A for pressure-containing castings in accordance with casting specification level-2 (CSL-2) or greater for each material group as applicable.

I.3 Open Die Forgings

NOTE Open die forgings may be specified by the purchaser to conform to API 20B for pressure-containing forgings in accordance with forging specification level-2 (FSL-2) or greater for each material group as applicable.

I.4 Closed Die Forgings

NOTE Closed die forgings may be specified by the purchaser to conform to API 20C for pressure-containing forgings in accordance with forging specification level-2 (FSL-2) or greater for each material group as applicable.

Pressure-containing forgings shall be capable of meeting the NDE requirements of this product specification.

Annex J
(normative)

Qualification of Heat Treating Equipment

J.1 General

Heat treating equipment shall meet the requirements of 6.13.

NOTE This annex provides a method for meeting the requirements of 6.13.

Qualification of heat treating equipment shall meet or exceed the requirements of this annex.

J.2 Furnace Calibration

J.2.1 General

Heat treatment of production parts shall be performed with heat treating equipment that has been calibrated and surveyed.

J.2.2 Temperature Survey Method for Calibration of Batch-type Furnaces

The furnace working zone shall be defined by the manufacturer. A temperature survey within the furnace working zone(s) shall be performed on each furnace at the maximum and minimum temperatures for which each furnace is being used.

For furnaces having a working zone less than or equal to 10 ft^3 (0.3 m^3), a minimum of three thermocouples located either at the front, center, and rear or at the top, center, and bottom of the furnace working zone shall be used.

For furnaces having a working zone greater than 10 ft^3 (0.3 m^3) and not greater than 1125 ft^3 (31.5 m^3), a minimum of nine thermocouples shall be used. For each additional 125 ft^3 (3.5 m^3) beyond 1125 ft^3 (31.5 m^3) of furnace working zone surveyed, at least one additional thermocouple shall be used, up to a total of 40 thermocouples. The first nine thermocouples shall be located as per Figures J.1 and J.2. Each additional thermocouple location shall be equally spaced in the central additional working zone volume.

After insertion of the temperature-sensing devices, readings shall be taken at least once every 3 minutes to determine when the temperature of the furnace working zone approaches the bottom of the temperature range being surveyed.

Once the furnace temperature has reached the set-point temperature, the temperature of all test locations shall be recorded at 2 minute intervals, maximum, for at least 10 minutes. Then, readings shall be taken at 5 minute intervals, maximum, for sufficient time (at least 30 minutes) to determine the recurrent temperature pattern of the furnace working zone.

When a furnace is repaired or rebuilt, a new temperature survey shall be carried out before the furnace is used for heat treatment, subject to the following.

Repairs that return the furnace to the condition it was in at the time of the last furnace survey and calibration or repairs that do not affect the temperature tolerance of the furnace shall not require a new temperature survey and calibration.

The SAE AMS 2750 sections on furnace modifications and furnace repairs shall be used to determine whether a new furnace survey is required.

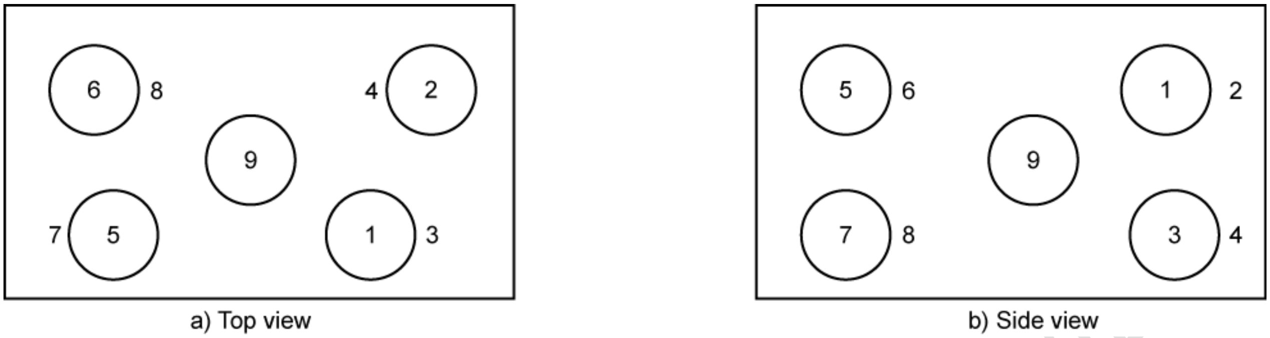


Figure J.1—Thermocouple Location—Rectangular Furnace (Working Zone)

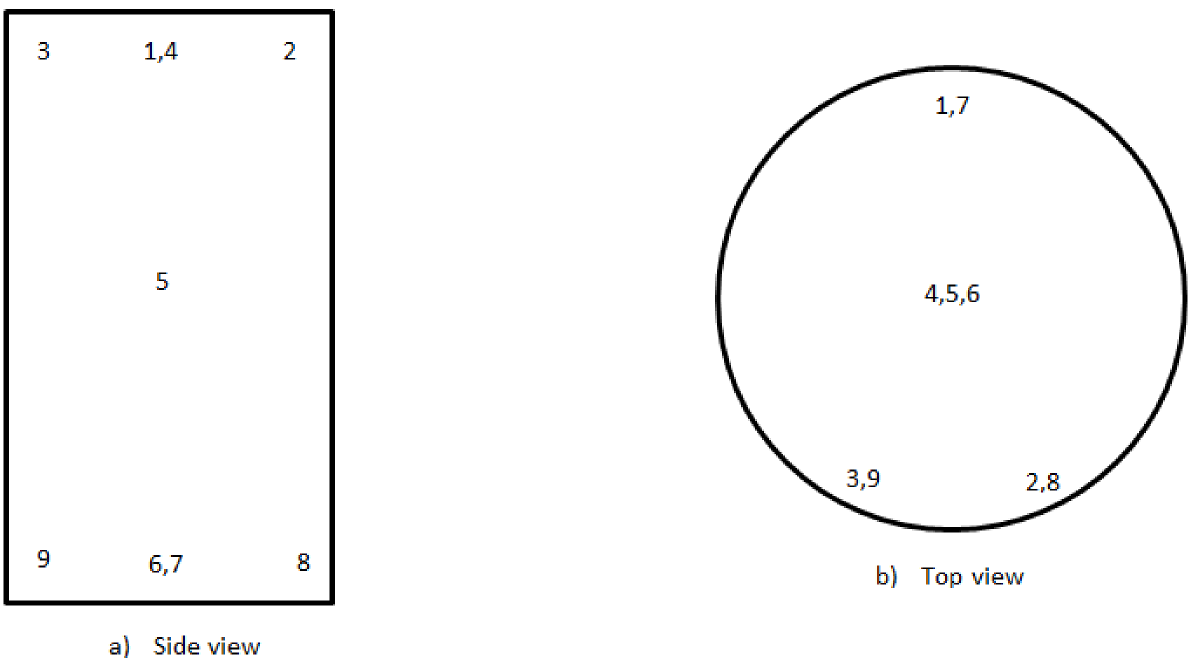


Figure J.2—Thermocouple Locations—Cylindrical Furnace (Working Zone)

All furnace repairs and modifications shall be documented and the responsible quality assurance organization shall make determination whether an additional furnace survey and calibration is required based on the repairs or modifications in accordance with SAE AMS 2750.

J.2.3 Continuous-type Furnaces Method

Furnaces used for continuous heat treatment shall be calibrated in accordance with procedures specified in SAE AMS 2750 or equivalent.

J.3 Instruments

Automatic controlling and recording instruments shall be used. Thermocouples shall be located in the furnace working zone(s) and protected from furnace atmospheres by means of suitable protective devices.

Annex K
(normative)

Requirements for Nondestructive Examination

K.1 General

This annex specifies two quality levels (QL-1 and QL-2) of NDE requirements for subsea pipeline valves. The specific QL to be used shall be specific by the purchaser at time of order entry.

K.2 Specification of QLs

Table K.1 specifies the mandatory NDE requirements for QL-1 and QL-2. Table K.2 specifies the method and acceptance criteria of NDE/item examination code.

K.3 RT of Castings

Examination shall be carried out in accordance with ASME *BPVC*, Section V, Article 2.

Acceptance criteria shall be in accordance with ASME *BPVC* Section VIII, Division 1, Appendix 7.

K.4 RT on Weldments

Examination shall be carried out in accordance with ASME *BPVC*, Section V, Article 2 or ISO 17636-1, Class B.

Acceptance criteria shall be in accordance with ASME *BPVC*, Section VIII, Division 1, UW-51 for linear indications and ASME *BPVC*, Section VIII, Division 1, Appendix 4 for rounded indications.

K.5 RT of Welding Ends After Machining of Castings

Examination shall be carried out in accordance with ASME *BPVC*, Section V, Article 2.

Acceptance criteria shall be maximum allowable severity level 1 for shrinkage and level 2 for sand or gas.

K.6 Ultrasonic Testing (UT) of Castings

This section is applicable for carbon, low-alloy steels, and martensitic stainless steels.

Examination shall be carried out in accordance with ASME *BPVC*, Section V, Article 5.

Acceptance criteria shall be in accordance with ASTM A609/A609M, QL-2.

K.7 UT of Forgings and Plate

Examination shall be carried out in accordance with ASME *BPVC*, Section V, Article 5.

Forgings: Acceptance criteria shall be in accordance with ASME *BPVC*, Section VIII, Division 1, and UF-55 for angle beam and ASME B16.34, Appendix IV for straight beam.

Plate: Acceptance criteria shall be in accordance with ASTM A578/A578M Acceptance Standard Level B.

Table K.1—NDE Requirements

Part	QL-1			QL-2		
	Cast	Forged	Plate	Cast	Forged	Plate
Body or closures and end connections or bonnet or cover or gland housing	VT1 and RT1 or UT1 and MT1 or PT1	VT2 and UT2 and MT1 or PT1	VT2 and UT2 and MT1 or PT1	VT1 and RT3 and UT4 and MT1 or PT1	VT2 and UT2 and MT1 or PT1	VT2 and UT2 and MT1 or PT1
Welding ends	VT1 and RT4 or UT5 and MT1 or PT1	VT2 and UT5 and MT1 or PT1	VT2 and UT2 and MT1 or PT1	VT1 and RT4 or UT5 and MT1 or PT1	VT2 and UT5 and MT1 or PT1	VT2 and UT2 and MT1 or PT1
Stem or shaft [a d]	N/A	VT2 and MT1 or PT1	N/A	N/A	VT2 and UT2 and MT1 or PT1	N/A
Trunnion [b d] or trunnion/bearing plates	VT1	VT2	VT2	VT1 and MT1 or PT1	VT2 and MT1 or PT1	VT2 and UT2 and MT1 or PT1
Bolting (pressure-containing)	N/A	VT2	N/A	N/A	VT2 and MT1 or PT1	N/A
Ball or gate [a]	VT1	VT2	VT2	VT1 and MT1 or PT1	VT2 and MT1 or PT1	VT2 and MT1 or PT1
Plug or clapper disc [a d]	VT1	VT2	VT2	VT1 and MT1 or PT1	VT2 and MT1 or PT1	VT2 and MT1 or PT1
Clapper disc arm	VT1	VT2	VT2	VT1 and RT3 or UT4 and MT1 or PT1	VT2 and UT2 and MT1 or PT1	VT2 and UT2 and MT1 or PT1
Seat rings [b d]	VT1	VT2	VT2	VT1 and MT1 or PT1	VT2 and MT1 or PT1	VT2 and MT1 or PT1
Corrosion-resistant overlay	VT3 and PT1			VT3 and UT3 and PT1		
Seals gaskets	VT4					
Seat springs	VT4					
Pressure-containing welds	VT3 and RT2 or UT3 and MT1 or PT1					
Reinforcement and stiffening welds	VT3					
Fillet and attachment welds to pressure-containing parts	VT3 and MT1 or PT1					
Pipe pup to valve welds or pipe pups [c]	VT3 and RT2 or UT3 and MT1 or PT1					
Plating	VT4					
Hardfacing	VT4 and PT1 and VT5					
Sealing surfaces	VT5 and MT2 or PT2					

NOTE 1 See Table K.2 for specification of the examinations referred to in this table.

NOTE 2 N/A means that the manufacturer is not allowed to use this material form for that specific part.

NOTE 3 All the NDE activities listed above for a specific product form or forms shall be conducted.

[a] MT or PT to be performed prior to coating, plating, or overlay.

[b] Trunnion may be pressure-containing or pressure-controlling, depending on design type. If trunnion is pressure-containing, then the requirements for body apply.

[c] NDE requirements of pipe pups shall be established by agreement.

[d] Requirements for examination of bar material shall be as for forgings.

Table K.2—Extent, Method, and Acceptance Criteria of NDE/Item Examination Code

Examination	NDE	Extent	Method	Acceptance
RT1	RT casting	Critical sections per ASME *BPVC*, Section VIII, Division 1	K.3	K.3
RT2	RT weldments	100 % where practicable	K.4	K.4
RT3	RT casting	100 % of accessible areas	K.3	K.3
RT4	RT welding ends after machining	100 % of circumference. Minimum length equal to 1.5 times the mating pipe wall thickness or 50 mm, whichever is greater	K.5	K.5
UT1	UT casting	Remaining areas of critical section ASME *BPVC* Section VIII, Division 1 not covered by RT1	K.6	K.6
UT2	UT forging and plate	100 % of surface area	K.7	K.7
UT3	UT weldments	100 %	K.8	K.8
	UT weld overlay	100 % accessible areas	K.9	K.9
UT4	UT casting	Remaining areas not covered by RT3	K.6	K.6
UT5	UT welding ends	100 % of circumference. Minimum length equal to 1.5 times the mating pipe wall thickness or 50 mm, whichever is greater.	K.10, K.11	K.10, K.11
MT1	MT all products	100 % accessible external and internal surfaces	K.12, K.13	K.12, K.13
MT2	MT seating areas	100 % sealing and seating surfaces	K.14	K.14
PT1	PT casting	100 % accessible external and internal surfaces	K.15, K.16	K.15, K.16
PT2	PT seating areas	100 % sealing & seating surfaces	K.17	K.17
VT1	VT castings	All surfaces	K.18	K.18
VT2	VT forging and plate	All surfaces	K.19	K.19
VT3	VT weldments	All surfaces	K.20	K.20
VT4	VT others	All surfaces	K.21	K.21
VT5	VT seating areas	100 % sealing & seating surfaces	K.22	K.22

K.8 UT of Full Penetration Welds

Examination shall be carried out in accordance with ASME *BPVC*, Section V, Article 4.

Acceptance criteria shall be in accordance with ASME *BPVC*, Section VIII, Division 1, Appendix 12.

K.9 UT of Weld Overlay

Examination shall be carried out in accordance with ASME *BPVC*, Section V, Article 4 straight beam method.

Acceptance criteria shall be:

No single indication exceeding reference distance amplitude curve.

No multiple indications exceeding 50 % of reference distance amplitude curve.

Multiple indications are defined as two or more indications (each exceeding 50 % of the reference distance amplitude curve) within 1/2 in. (13 mm) of each other in any direction.

K.10 UT of Welding Ends of Castings

This section is applicable for carbon, low-alloy steels, and martensitic stainless steels.

Examination shall be carried out in accordance with ASME *BPVC*, Section V, Article 5.

Acceptance criteria shall be in accordance with ASTM A609/A609M, QL-1.

K.11 UT of Welding Ends of Forgings

Examination shall be carried out in accordance with ASME *BPVC*, Section V, Article 5.

Forgings: Acceptance criteria shall be in accordance with ASME *BPVC*, Section VIII, Division 1, UF-55 for angle beam and ASME B16.34, Appendix IV for straight beam.

Plate: Acceptance criteria shall be in accordance with ASTM A578/A578M, Acceptance Standard Level A.

K.12 MT of Castings on 100 % of Surface Area

Examination shall be carried out in accordance with ASME *BPVC*, Section V, Article 7.

Acceptance criteria shall be in accordance with ASME *BPVC*, Section VIII, Division 1, Appendix 7.

K.13 MT of Forgings, Weldments, and Bolting

Examination shall be carried out in accordance with ASME *BPVC*, Section V, Article 7.

Acceptance criteria shall be in accordance with ASME *BPVC*, Section VIII, Division 1, Appendix 6.

K.14 MT on Sealing (Including Seating) Surfaces

Examination shall be carried out in accordance with ASME *BPVC*, Section V, Article 7.

Acceptance criteria for machined sealing surfaces shall be in accordance with ASME *BPVC*, Section VIII, Division 1, Appendix 6.

In addition to the stated acceptance criteria, no rounded or linear indications permitted on the sealing/seating surfaces.

K.15 PT of Castings

Examination shall be carried out in accordance with ASME *BPVC*, Section V, Article 6.

Acceptance criteria shall be in accordance with ASME *BPVC*, Section VIII, Division 1, Appendix 7.

K.16 PT of Forgings, Weldments, Weld Overlay, Bolting, and Seal Welds

Examination shall be carried out in accordance with ASME *BPVC, Section* V, Article 6.

Acceptance criteria shall be in accordance with ASME *BPVC*, Section VIII, Division 1, Appendix 8.

K.17 PT of Sealing (Including Seating) Surfaces

Examination shall be carried out in accordance with ASME *BPVC*, Section V, Article 6.

Acceptance criteria for machined sealing surfaces shall be in accordance with ASME *BPVC*, Section VIII, Division 1, Appendix 8.

In addition to the stated acceptance criteria, no rounded or linear indications permitted on the sealing/seating surfaces.

K.18 Visual Examination (VT) of Castings

Examination shall be carried out in accordance with MSS SP-55.

Acceptance criteria shall be:

— Type 1: none acceptable,

— Types 2 through 12: A and B.

K.19 VT of Forgings and Plate

Examination shall be carried out in accordance with ASME *BPVC*, Section VIII, Division 1, UF-45 and UF-46.

Acceptance criteria shall be in accordance with ASME *BPVC*, Section VIII, Division 1, UF-45 and UF-46.

K.20 VT of Weldments

Examination shall be carried out in accordance with ASME *BPVC*, Section V, Article 9 or ISO 17637.

Acceptance criteria: Undercut shall not reduce the thickness in the area (considering both sides) to below the minimum thickness or ISO 5817, QL B. In addition weld spatter is not allowed.

Surface porosity and exposed slag are not permitted on or within 0.125 in. (3 mm) of seating surfaces.

K.21 VT Related to Final Machined Parts or Purchased Goods

Examination shall be as per applicable industry material specification.

Acceptance criteria shall be as per applicable industry material specification.

K.22 Visual Examination (VT) of Sealing Surfaces

Method: Surface porosity and exposed slag.

Acceptance criteria: Not permitted on or within 0.125 in. (3 mm) of seating surfaces.

Annex L
(informative)

Supplementary Test Requirements

L.1 General

This annex specifies requirements for supplementary testing, which shall be performed by the manufacturer if specified by the purchaser. The frequency of testing shall also be specified by the purchaser, if not defined in this annex.

L.2 Bending Test

Bending moment value shall be defined by the purchaser. This test shall confirm the valve capability to seal under bending moment.

Seat test with bending moment applied shall be performed as per 10.5.

Gas seat test with bending moment applied shall be performed per 10.9.

A documented procedure shall be prepared by the manufacturer.

L.3 Test Sequence for Valves Required for DIB Operations

L.3.1 General

The following steps shall be performed on each end or each side of the valve.

— Step 1: With valve partly open, fill valve with test medium and pressurize to valve design pressure.

— Step 2: Close valve.

— Step 3: Reduce pressure on downstream side of valve to zero and monitor cavity pressure.

— Step 4: Monitor leakage between cavity and downstream side.

— Step 5: Reduce pressure in cavity slowly, and monitor upstream pressure and leakage to the downstream side.

— Step 6: Reintroduce pressure into the cavity slowly up to 145 psi (10 bar) and monitor leakage to the downstream side.

— Step 7: Reduce pressure in cavity slowly and monitor leakage to the downstream side.

— Step 8: With cavity and downstream vented to zero, measure upstream seat performance by monitoring leakage at the cavity port.

— Step 9: If applicable to the valve type, repeat Steps 1 through 8 on the opposite side of the valve.

L.3.2 Test Medium

Test fluid shall be fresh water in accordance with 10.1 or nitrogen gas, as specified.

L.3.3 Acceptance

Leakage for soft-seated valves shall not exceed ISO 5208, Rate A (no visible detectable leakage for the duration of the test at test pressure).

For metal-seated valves the leakage rate shall not exceed ISO 5208, Rate C; however, for valves in gas service the leakage rate shall not exceed ISO 5208, Rate D.

Annex M
(informative)

Isolation Valve Features

M.1 General

Table M.1 is intended to give informative guidance on typical valve functions/features and is not intended to either be all-inclusive or restrictive. Individual valve designs exist that have unique sealing characteristics for which the table may not be appropriate or applicable. The user should take guidance from the manufacturer on establishing particular valve features.

Table M.1—Isolation Valve Types

Valve Type	Sealing Arrangement	Block and Bleed	Double Block and Bleed	Double Isolation and Bleed
Two block valves with bleed between	Any valves with bidirectional sealing	Yes	Yes	Yes
Slab and/or through-conduit gate	Pressure energized—downstream sealing only/fixed seats (Note 1)	No (Note 2)	No	No
Slab and/or through-conduit gate DIB-1	Pressure energized—upstream and downstream sealing (Note 1)	Yes	Yes (Note 3)	Yes (Note 3)
Trunnion-mounted ball valve	Upstream sealing, pressure energized, self-relieving (Note 1)	Yes	(Note 4)	No (Note 5)
Trunnion-mounted ball valve DIB-1	Upstream and downstream sealing, pressure energized, e.g. two bidirectional sealing seats (Note 1)	Yes	(Note 4)	(Note 6)
Trunnion-mounted ball valve DIB-2	Upstream and downstream sealing, pressure energized, e.g. one bidirectional and one unidirectional sealing seat (Note 1)	Yes	(Note 4)	Only if the bidirectional seat is on the downstream side (Note 6)
Floating ball valve	Pressure energized	No (Note 2)	No	No
Plug	Pressure energized, downstream sealing	No (Note 2)	No	No
Expanding plug DIB-1	Mechanically energized	Yes	Yes	Yes
Expanding gate DIB-2	Mechanically energized	Yes	Yes (Note 3)	Yes (Note 3)

NOTE 1 The term upstream and downstream refer to the pressure source and open end/equipment respectively and do not refer to flow direction.

NOTE 2 Not possible to bleed from valve body, but bleed may be in downstream pipework/pipeline.

NOTE 3 Depending on detail design of the valve, some valves may have preferred sealing direction and/or a specified sequence of operation.

NOTE 4 Depending on detailed design.

NOTE 5 Downstream seat may provide a second barrier at pressures below the cavity relieving pressure, but will not provide a high-pressure barrier.

NOTE 6 Depending on detailed design and ability to achieve testing per L.4.

The user is responsible for ensuring the operational requirements are consistent with particular valve features including sealing capability and function.

The table and sketches are intended to give definition of the terms “block and bleed” (Figure M.1 and Figure M.2), “double block and bleed” (Figure M.3 and Figure M.4), and “double isolation and bleed” (Figure M.5 and Figure M.6) in a single valve or double valve arrangement as defined by this specification. Other documents, including applicable federal regulations, may have a different definition of these terms.

M.2 Block and Bleed (BB)

BB may be achieved by a connection in the pipework/pipeline downstream of the block valve or from a connection on the valve body when the valve is an upstream seating type.

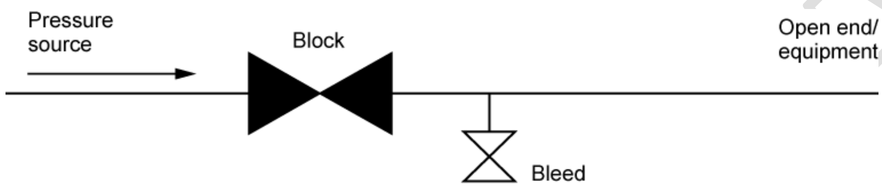


Figure M.1—Block and Bleed—Type A

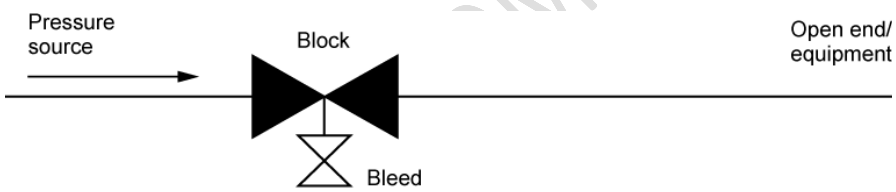


Figure M.2—Block and Bleed—Type B

M.3 Double Block and Bleed (DBB)

The DBB feature of the valve or valves is the ability to segregate two pressure sources and to bleed/vent pressure in the void between the two sealing elements (blocks). The bleed may be in the pipework/pipeline when two valves are used, or in the valve body between the two seats when the valve has the DBB feature.

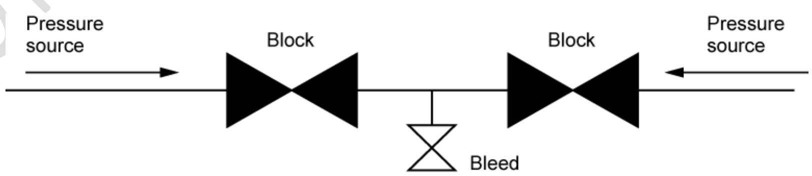


Figure M.3—Double Block and Bleed—Type A

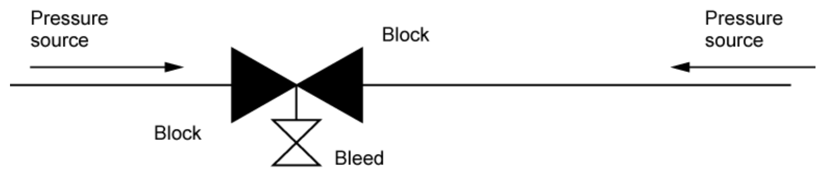


Figure M.4—Double Block and Bleed—Type B

M.4 Double Isolation and Bleed (DIB)

The DIB feature of the valve or valves is the ability to provide two sealing elements to a single pressure source and to bleed/vent between the two sealing elements. Note that some documents dealing with isolation of equipment may refer to this feature as double block and bleed.

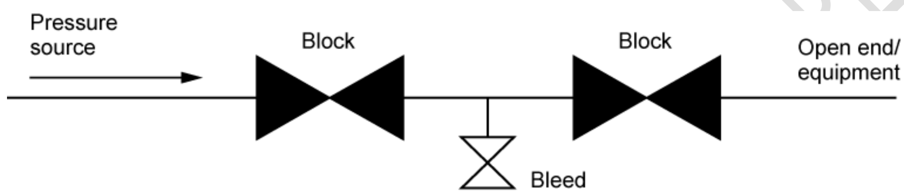


Figure M.5—Double Isolation and Bleed—Type A

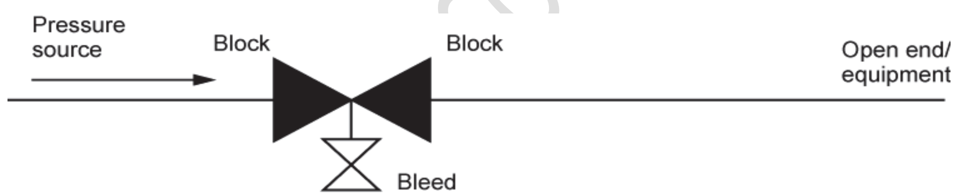


Figure M.6—Double Isolation and Bleed—Type B

Annex N
(normative)

External Coating for End Connections

N.1 General

This annex provides coating requirements for both flange and weld end connections that shall be performed after all testing is completed.

N.2 Raised Face

Valves with raised-face end connections shall have the entire flange coated except for the raised portion (see Figure N.1).

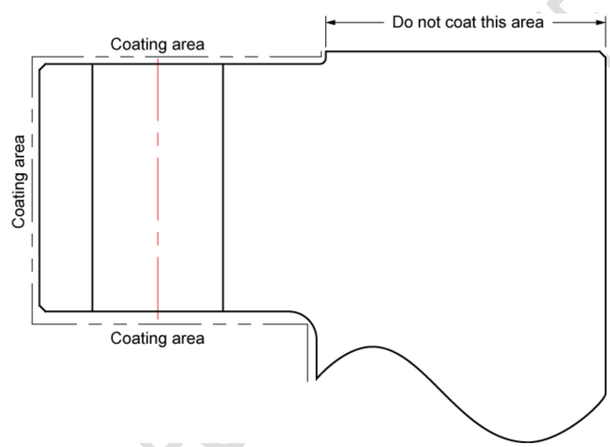


Figure N.1—Raised Face

N.3 Ring Type Joint or Raised Face Ring Type Joint

Valves with ring type joint or raised-face ring type joint end connections shall have the entire flange coated except for the portion from the ring joint OD to valve bore (see Figure N.2).

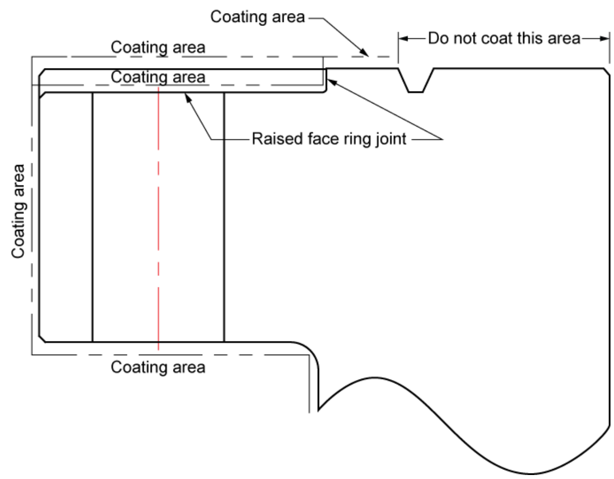


Figure N.2—Ring Type Joint or Raised Face Ring Type Joint

N.4 Weld End

Valves with weld end connections shall have the entire surface coated except for the portion from the OD that intersects the weld bevel to valve bore (see Figure N.3).

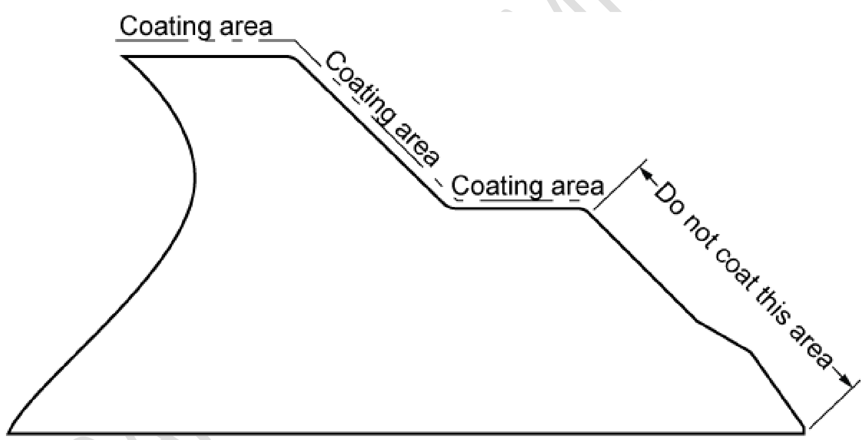


Figure N.3—Weld Face

N.5 Pipe Pup Weld Ends

Valves with pup pipe welded to end connections shall have the entire surface coated except for the portion 4 in. minimum from the weld bevel (see Figure N.4).

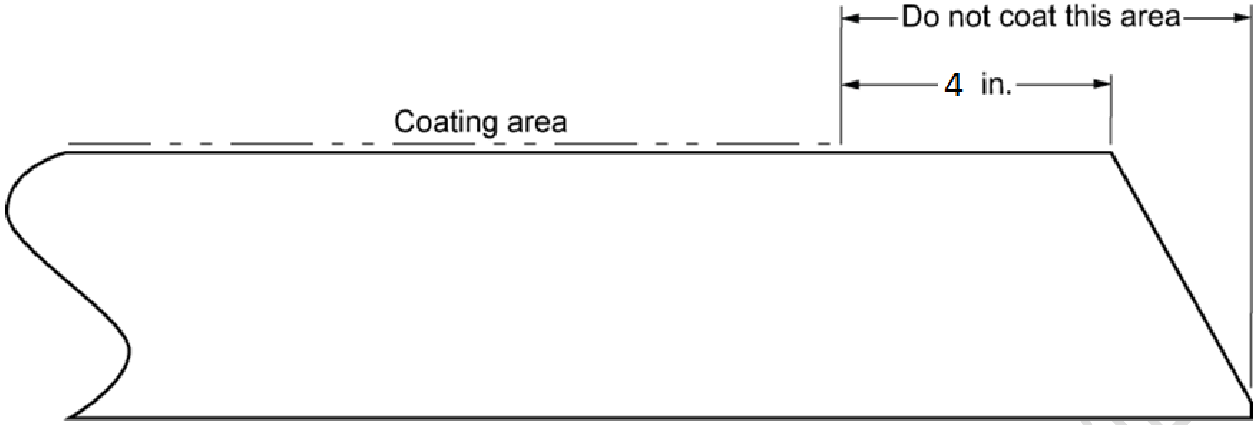


Figure N.4—Pipe Pup Weld Ends

Annex O
(informative)

Marking Example

O.1 Sample Marking for NPS16 (DN 400) Carbon Steel Check Valve

To illustrate the requirements for marking specified in this specification, an NPS16 (DN 400) carbon steel check valve, pressure Class 600 with ring joint end flanges, a 35.63 in. (905 mm) face-to-face dimension, a maximum operating pressure rating of 10 MPa (100 bar), duplex stainless steel, 25 chromium steel trim, HNBR seals, and manufactured in December 2016 should be marked on the nameplate as follows.

ABCO	(Item 1a or 1b: manufacturer)
600	(Item 2: pressure class)
1200m	Item 3: water depth
6DSS	(Item 18: product specification number)
1500 psi at –20 °F (10.4 MPa or 104 bar at –29 °C);	(Item 4: maximum operating pressure at minimum operating temperature)
1478 psi at 250 °F (10.2 MPa or 102 bar at 121 °C); 1478 psi at 250 °F	(maximum operating pressure at maximum operating temperature)
LCC or LCC/A350-LF2	(Item 6: body material) or (body/end connection) for multiple materials
Shaft 25Cr Disc 25Cr Seat 25Cr/HNBR Seals HNBR	(Item 8: trim identification)
26.13 9 or (664 mm)	(Item 5: face-to-face/end-to-end dimensions; see 5.4)
16 or DN 400 or 16 × 12 DN 400 ×300 or 16R or DN 400R	(Item 9: nominal valve size for full-opening valve) (Item 9: nominal valve size for reduced-bore valve) (Item 9: nominal valve size for reduced-bore valve)
DBB, DIB-1, or DIB-2, as applicable	(Item 15: when seat tests per 10.5.4.3, 10.5.4.4, and 10.5.5.5, respectively)
QL-1or QL-2 as applicable	(Item 14: to be specified by the purchaser)
12345	(Item 16: serial number)
12-16 or 12/16 or 12/2016	(Item 17: date of manufacture)

O.2 Sample Marking for NPS 16 (DN 400) Carbon Steel Check Valve

O.2.1 General

To illustrate the requirements for marking specified in this specification, an NPS 16 (DN 400) carbon steel check valve, intermediate pressure rating 3000 psi (207 bar) weld end with a maximum operating pressure rating of 20.7 MPa (207 bar) at 250 °F (121 °C) duplex stainless steel, 25 chromium steel trim, HNBR seals, and manufactured in December 2016 should be marked as follows.

O.2.2 Nameplate

Marking on the nameplate is as follows.

ABCO	(Item 1a or 1b: manufacturer)
3000 psi	(Item 2a: Intermediate pressure–temperature rating)
1200m	(Item 3: water depth)
6DSS	(Item 18: product specification number)
3000 psi at 250 °F (20.7MPa or 207bar at 121 °C); given value	(Item 4 point c: maximum operating pressure at maximum operating temperature)
3044 psi at –20 °F (21.0 MPa or 210 bar at –29 °C); interpolated value	(Item 4 point d: interpolated maximum operating pressure at minimum operating temperature)
LCC	(Item 6: body material)
Shaft 25Cr Disc 25Cr Seat 25Cr/HNBR Seals HNBR	(Item 8: trim identification)
Manufacturer Standard (35.63 in. or 905 mm)	(Item 5: face-to-face/end-to-end dimensions; see 5.4)
16 or DN 400 or 16 × 12 DN 400 ×300 or 16R or DN 400R	(Item 9: nominal valve size for full-opening valve) (Item 9: nominal valve size for reduced-bore valve) (Item 9: nominal valve size for reduced-bore valve)
DBB, DIB-1, or DIB-2, as applicable	(Item 15: when seat tests per 10.5.4.3, 10.5.4.4, and 10.5.5.5, respectively)
QL-1or QL-2 as applicable	(Item 14: to be specified by the purchaser)
12345	(Item 16: serial number)
12-16 or 12/16 or 12/2016	(Item 17: date of manufacture)

O.2.3 Body

Marking on the valve body is as follows.

ABCO	(Item 1a or 1b: manufacturer)
600	(Item 2: pressure class) for case O.1
3000 psi	(Item 2a: intermediate pressure–temperature rating) for case O.2
LCC/W46378	(Item 6: body material grade/melt identification)
16 or DN 400	(Item 7: nominal valve size) NOTE Item 6 can also be marked on nameplate or on both body and nameplate.
36 KSI or SMYS 250 MPa	(Item 11: SMYS)
12345	(Item 16: serial number)

O.2.4 Bonnet/Cover

Marking on the valve bonnet/cover is as follows.

A350-Gr LF2/H21655	(Item 7: bonnet/cover grade/melt identification)

Annex P
(informative)

Supplementary Documentation Requirements

The purchaser may select supplementary documentation from the list below at time of order placement.

a) calibration records (purchaser to identify requirements for equipment when ordering);

b) certificate of conformance to ANSI NACE MR0175/ISO 15156 (all parts) for sour service valves;

c) cross-sectional drawings with parts and materials list;

d) current quality management system certificate;

e) design calculations for pressure-containing parts and the drive train;

f) design calculations for pressure-controlling parts;

g) design verification by certification body/agency;

h) flow coefficient, C_v or K_v;

i) hardness test report on pressure-containing parts;

j) hardness test report on pressure-controlling parts;

k) heat treatment certification records (e.g. charts);

l) material inspection certificates in accordance with EN 10204 or ISO 10474, as applicable (the purchaser to specify the type of certification, and for which parts, when ordering);

m) NDE personnel qualification records;

n) NDE procedures;

o) PQR;

p) type approval by certification body/agency;

q) WPS;

r) WPQ.

Annex Q
(informative)

Purchasing Guidelines

Q.1 General

This annex provides guidelines to assist the purchaser with valve type selection and specification of specific requirements when ordering valves.

Q.2 Pigging

The purchaser shall specify the requirement if the valve design must be suitable for piggability when ordering valves for use in pipelines requiring pigging.

NOTE 1 Venturi or reduced-bore valves are not suitable for most pigging operations, including intelligent pigging, but can allow the passage of pipeline pigs.

NOTE 2 A valve in which the drive member or the obturator obstructs the bore in the otherwise fully open position (e.g. axial on–off) is not piggable.

NOTE 3 Certain full-opening valves with pockets can allow bypass of fluid around a short pig or sphere.

Q.3 Additional Testing

The purchaser shall specify any additional test requirements not covered by this specification.

Q.4 Valve Datasheet

The valve datasheet in Table Q.1 can be used to assist with the specification of valves for ordering.

Table Q.1—Valve Datasheet

Materials of construction: ____

Valve location and function: ____

Nominal valve size ____

Maximum water depth:
____

Maximum operating pressure ____

Maximum field test pressure ____

Valve pressure class ___________________________ Valve intermediate pressure class rating______________________

Maximum service temperature ____

Minimum service temperature ____

Liquid/gas service ____

Flow medium composition ____

Special flow requirements: Blow-down, solids, pigs, etc.

Valve

Type of valve: Gate _____________ Plug _____________ Ball ______________ Check _________

Design type ____

Full round opening required? ______________________________ Minimum bore _______________________

Valve Operation

Is valve actuated? If so, state manual or ROV-operated____
If actuated, provide required valve closing times____
ROT system required? Type_____________ Class _______________Horizontal_______ or Vertical __________

Is gearbox with hand-wheel required? If so, give details: ____

For a hand-wheel on a horizontal shaft, give distance from centerline of valve opening to hand-wheel: ______ mm

Or, for a hand-wheel on a vertical shaft, give distance from centerline of valve opening to center of rim of hand-wheel: __ mm

NOTE For plug valves having loose wrenches, it is necessary to order wrenches separately.

Wrench required? ____

Locking device required? ______________________________ Type____________________________________

Valve Support

Support ribs or legs required?

Table Q.1—Valve Datasheet (Continued)

End Connections

Upstream pipe: OD ________________ ID ______________ Material _________________________

Flanged end? Yes _____ No ______

Plain raised face or ring joint? ____

If ring joint, flat or raised face? ____

Size and pressure class, as per ASME B16.5_______; or MSS SP-44_______ or ASME B16.47, Series A __

Ring gasket or other gasket type and size ____

NOTE Gaskets are not furnished as a part of the valve.

Welding end? Yes _____ No ______

Attach specifications for welding-end configuration.

Special flanges or mechanical joints? ____

Downstream pipe: OD ______________ ID ______________ Material _________________________
Pipe pup length: ____

Flanged end? Yes _____ No ______

Plain raised face or ring joint? ____

If ring joint, flat or raised face? ____

Size and pressure class, as per ASME B16.5_______; or MSS SP-44_______ or ASME B16.47, Series A __

Ring gasket or other gasket type and size ____

NOTE Gaskets are not furnished as a part of the valve.

Welding end? Yes _____ No ______

Attach specifications for welding-end configuration.

Special flanges or mechanical joints? ____

Length: Any special requirements for end-to-end or face-to-face dimensions? ______________________________

Other Requirements

Supplementary requirements (see Annex L and Annex P; advise which items within each annex)

NACE MR0175 or ISO 15156 No__ Yes ___ ,If yes ,advise which spec.__________________________________

If yes, specify % mass fraction of H_2S _____; pH _____; % mass fraction of chlorides _____; temperature _______

External loads:____

Drain connections: Any requirements? ____

Bypass connections: Any requirements? ____

Supplementary documentation required? (see Annex P; advise which items) ______________________________

Third-party witness of processes/testing ____

Painting or coating required? ____

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