

Specification for Subsea Pipeline Valves

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Contents

	Page
1 Scope	1
2 Normative References	1
3 Terms, Definitions, Acronyms, Abbreviations, Symbols, and Units	3
3.1 Terms and Definitions	3
3.2 Acronyms, Abbreviations, Symbols, and Units	10
4 Valve Types and Configurations	12
4.1 Valve Types	12
4.2 Valve Configurations	13
5 Design	15
5.1 Design Standards and Calculations	15
5.2 Pressure and Temperature Rating	15
5.3 Sizes	16
5.4 Face-to-face and End-to-end Dimensions	16
5.5 Valve Operation	16
5.6 Operator Information	17
5.7 Pigging	19
5.8 Valve Ends	19
5.9 Valve Cavity Pressure Relief	21
5.10 Drains, Vents, Body Test Ports, Seal Test Port, and Body Connections	21
5.11 Stem/Seat and Cavity Injection Points	22
5.12 Drain, Sealant, and Vent Valves	22
5.13 Hand-wheels and Wrenches—Levers	22
5.14 Position of the Obturator	22
5.15 Position Indicators	23
5.16 Travel Stops	23
5.17 Valve Operator Interface Requirements	23
5.18 ROT System	24
5.19 Lifting Points and Supports	24
5.20 Drive Trains	24
5.21 Stem Retention	26
5.22 Body and Stem Seals	26
5.23 Valve Stem Seal Integrity Verification	26
5.24 Overpressure Protection	26
5.25 Pressure Cap	26
5.26 Stem/Shaft Protector	26
5.27 Hydraulic Lock	26
5.28 Corrosion/Erosion	26
5.29 Design Validation	27
5.30 Hyperbaric Performance	27
6 Materials	27
6.1 Material Specification	27
6.2 Tensile Test Requirements	28
6.3 Service Compatibility	28
6.4 Cast Material	28
6.5 Forged Material	29
6.6 Composition Limits	29

Contents

	Page
6.7 Impact Test Requirements.....	30
6.8 Bolting.....	31
6.9 Cathodic Protection	32
6.10 Sour Service	32
6.11 Hydrogen-induced Cracking	32
6.12 Drain Connections.....	32
6.13 Heat Treating Equipment Qualification.....	32
7 Welding	34
7.1 Welding Consumables	34
7.2 Welding Procedure and Welder/Welding Operator Qualifications	34
7.3 Impact Testing	35
7.4 Hardness Testing	36
7.5 Repairs	36
8 Quality Control.....	37
8.1 Quality Control Procedures	37
8.2 NDE Requirements	37
8.3 Measuring and Test Equipment	37
8.4 Qualification of Personnel	38
8.5 Welding Inspectors.....	39
8.6 NDE of Repairs	39
8.7 Production Material Hardness Testing on Critical Parts	39
8.8 Marking, Age Control, and Storage for Nonmetallic Seals.....	40
9 Valve Assembly	41
10 Factory Acceptance Testing (FAT)	41
10.1 General.....	41
10.2 Stem Backseat Test.....	42
10.3 Hydrostatic Shell Test.....	43
10.4 Operational/Functional Test	43
10.5 Hydrostatic Seat Test.....	44
10.6 Cavity Relief Test.....	46
10.7 Draining.....	48
10.8 Low-pressure Gas Seat Test.....	48
10.9 High-pressure Gas Shell Test	48
10.10 High-pressure Stem Seal Integrity Testing	49
10.11 High-pressure Gas Seat Test	49
10.12 Check Valves	49
10.13 Installation of Body Connections After Testing	50
10.14 Testing of Body Connections	50
10.15 CP Continuity Test.....	50
10.16 Post-testing Corrosion Protection	50
11 Coating/Painting	50
12 Marking	51
13 Preparation for Shipment.....	53
14 Documentation	54
14.1 Minimum Documentation and Retention	54

Contents

Page

14.2 Documentation Provided with the Valve	54
14.3 Supplementary Documentation.....	55
15 Facility Requirements	55
15.1 Minimum Facility Requirements for the Assembler/manufacturer Category of Manufacturing.....	55
15.2 Conformance with Specification	56
15.3 Processes Requiring Validation.....	56
16 Purchasing Guidelines.....	56
Annex A (informative) Use of API Monogram by Licensees	57
Annex B (informative) Valve Configurations	58
Annex C (normative) Valve End-to-End and Face-to-Face Dimensions	69
Annex D (informative) Actuator—Gearbox Requirements	86
Annex E (informative) Guidance for Travel Stops by Valve Type.....	87
Annex F (informative) Design Validation	88
Annex G (informative) Hyperbaric Validation Testing.....	100
Annex H (normative) Pressure Boundary Bolting.....	104
Annex I (informative) Pressure-containing Castings and Forgings.....	105
Annex J (normative) Qualification of Heat Treating Equipment.....	106
Annex K (normative) Requirements for Nondestructive Examination.....	108
Annex L (informative) Supplementary Test Requirements	113
Annex M (informative) Isolation Valve Features.....	115
Annex N (normative) External Coating for End Connections.....	118
Annex O (informative) Marking Example	120
Annex P (informative) Supplementary Documentation Requirements	122
Annex Q (informative) Purchasing Guidelines	123
Bibliography	126

Figures

1 Typical Flange Dimensions	20
2 Bolt Hole Misalignment	21
3 Charpy V-notch WM Specimen Location.....	35
4 Charpy V-notch HAZ Specimen Location.....	35
5 Typical Identification Plate for a Valve with One Seat Unidirectional and One Seat Bidirectional	53
B.1 Expanding Gate/Rising Stem Gate Valve	59
B.2 Slab Gate/Through-conduit Rising Stem Gate Valve.....	60
B.3 Plug Valve.....	61
B.4 Top Entry Trunnion-mounted Ball Valve	62
B.5 Two-piece Bolted Ball Valve.....	63
B.6 Two-piece Welded Ball Valve	64
B.7 Full-opening Cast Swing Check Valve	65

Contents

	Page
B.8 Full-opening Forged Swing Check Valve	66
B.9 Axial-flow Check Valve	67
B.10 Axial On-off Valve	68
F.1 Test Procedure for Pressure Temperature Cycle	98
J.1 Thermocouple Location—Rectangular Furnace (Working Zone)	107
J.2 Thermocouple Location—Cylindrical Furnace (Working Zone)	107
M.1 Block and Bleed—Type A	116
M.2 Block and Bleed—Type B	116
M.3 Double Block and Bleed—Type A	116
M.4 Double Block and Bleed—Type B	117
M.5 Double Isolation and Bleed—Type A	117
M.6 Double Isolation and Bleed—Type B	117
N.1 Raised Face	118
N.2 Ring Type Joint or Raised Face Ring Type Joint	118
N.3 Weld Face	119
N.4 Pipe Pup Weld Ends	119
 Tables	
1 Minimum Bore for Full-opening Valves	14
2 Minimum V-notch Impact Requirements for Carbon and Low-alloy Steels (Full-size Specimen)	31
3 Minimum V-notch Impact Requirements for Duplex and Super Duplex Stainless Steel (Full-size Specimen)	31
4 Chemical Composition of Nickel-based Alloy UNS N06625	34
5 Minimum Duration of Stem Backseat Tests	42
6 Valve Marking	52
7 Minimum Facility Requirements	55
C.1 Gate Valves—Face-to-face (A) and End-to-end (B and C) Dimensions	70
C.2 Plug Valves—Face-to-face (A) and End-to-end (B and C) Dimensions	73
C.3 Ball Valves—Face-to-face (A) and End-to-end (B and C) Dimensions	78
C.4 Check Valves—Face-to-face (A) and End-to-end (B and C) Dimensions	82
C.5 Axial On-off Valves—Face-to-face (A) and End-to-end (B and C) Dimensions	85
E.1 Valve Travel Stops	87
F.1 Design Validation for Valves	94
F.2 Room Temperature Gas Leakage Acceptance Criteria	95
G.1 Hyperbaric Qualification Test	100
K.1 NDE Requirements	109
K.2 Extent, Method, and Acceptance Criteria of NDE/item Examination Code	110
M.1 Isolation Valve Types	115
Q.1 Valve Datasheet	124

Introduction

This specification is the result of updating the requirements from API Specification 6DSS, Second Edition, including Errata 1.

The revision of API 6DSS, Third Edition, is developed based on input from the API 6DSS Task Group technical experts. The technical revisions have been made in order to accommodate the needs of industry and to move this specification to a higher level of service to the petroleum and natural gas industry.

In this specification, data are expressed in both U.S. customary (USC) and metric (SI) units.

Except as otherwise required by this specification, to determine conformance with the specified requirements, observed or calculated values are to be rounded to the nearest unit in the last right-hand place of figures used in expressing the limiting value, in accordance with the rounding method of ASTM E29 or ISO 80000-1, Annex B, Rule A.

This specification is not intended to inhibit a manufacturer from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly applicable where there is innovative or developing technology.

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 B16.5¹, *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, *Butt welding 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*

ISO 6508-1, *Metallic materials—Rockwell 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 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 H₂S-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 H₂S-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

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

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.

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 cm²).

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/manufacture'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/manufacture'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/manufacture.

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/manufacture 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 alloy
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

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 and marked 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)
1½	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)
2½	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;
- reseal 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.

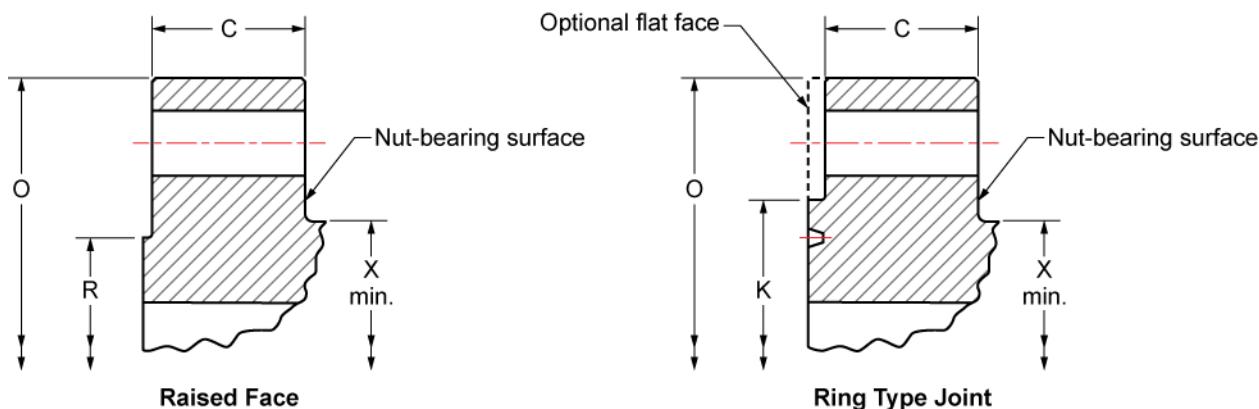
5.8.1.2 Offset of Aligned Flange Centerlines—Lateral Alignment

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.

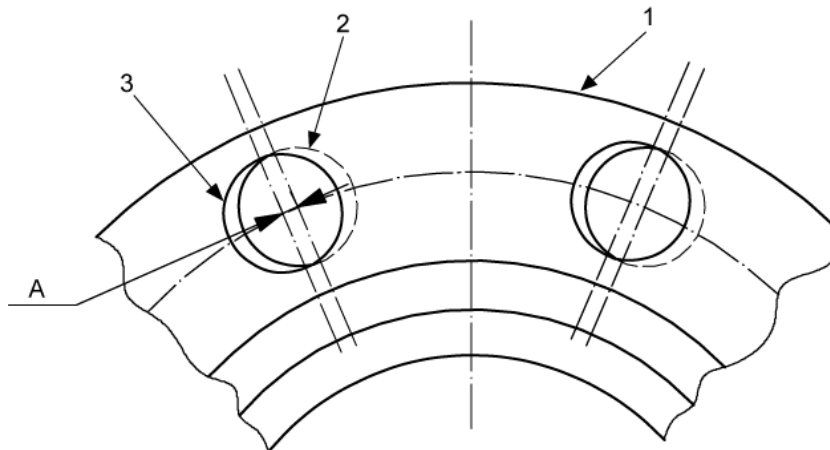
5.8.2 Welding Ends

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/m².

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

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

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 $\pm 25^{\circ}\text{F}$ ($\pm 14^{\circ}\text{C}$) 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 $\pm 15^{\circ}\text{F}$ ($\pm 8^{\circ}\text{C}$) 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 $\pm 1\%$ 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 $\pm 0.25\%$ 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.