Specification for Wellhead and Tree Equipment

API SPECIFICATION 6A
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Introduction

The International System of Units (SI) is used in this specification. However, nominal sizes are shown as fractions in the inch system.

The fractions and their decimal equivalents are equal and interchangeable. Metric conversions and inch dimensions in this specification are based on the original fractional inch designs. Functional dimensions have been converted into the metric system to ensure interchangeability of products manufactured in metric or inch systems; see also Annex C.

An "—" symbol when used in tables means that the applicable size, value, or dimension does not apply.

Be aware that further or differing requirements may be needed for individual applications. This specification is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This can be particularly applicable where there is innovative or developing technology. Where an alternative is offered, it is the responsibility of the vendor to identify any variations from this specification and provide details.

Specification for Wellhead and Tree Equipment

1 Scope

This specification identifies requirements and gives recommendations for the performance, dimensional and functional interchangeability, design, materials, testing, inspection, welding, marking, handling, storing, shipment, and purchasing of wellhead and tree equipment for use in the petroleum and natural gas industries.

This specification does not apply to field use or field testing. This specification also does not apply to repair of wellhead and tree equipment except for weld repair in conjunction with manufacturing. Tools used for installation and service (e.g. running tools, test tools, wash tools, wear bushings, and lubricators) are outside the scope of this standard.

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This specification is applicable to the equipment identified in Section 4.1 and Section 14.

This specification establishes requirements for four product specification levels (PSLs): PSL 1, PSL 2, PSL 3, and PSL 4. A supplemental level to PSL 3G applies to PSL 3 products that have satisfied the additional requirements of gas testing. The PSLs define different levels of technical quality requirements.

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 applies (including any addenda/errata).

API Recommended Practice 5A3, *Recommended Practice on Thread Compounds for Casing, Tubing, Line Pipe, and Drill Stem Elements,* Fourth Edition or a subsequent edition including addenda.

API Specification 5B, *Threading, Gauging, and Inspection of Casing, Tubing, and Line Pipe Threads,* Sixteenth Edition or a subsequent edition including addenda.

API Specification 5CT, *Casing and Tubing,* Eleventh Edition or a subsequent edition including addenda.

API Standard 6ACRA, *Age-hardened Nickel-based Alloys for Oil and Gas Drilling and Production Equipment*, Second Edition or a subsequent edition including addenda.

API Standard 6AV1, *Validation of Safety and Shutdown Valves for Sandy Service,* Fourth Edition or a subsequent edition including addenda.

API Standard 6X, *Design Calculations for Pressure-containing Equipment,* Second Edition or a subsequent edition including addenda.

API Recommended Practice 14F, *Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class 1, Division 1 and Division 2 Locations,* Sixth Edition or a subsequent edition including addenda.

API Specification 16A, *Specification for Drill-through Equipment,* Fourth Edition or a subsequent edition including addenda.

API Specification 17D, *Design and Operation of Subsea Production Systems—Subsea Wellhead and Tree Equipment,* Third Edition or a subsequent edition including addenda.

API Specification 20A, *Carbon Steel, Alloy Steel, Stainless Steel, and Nickel Base Alloy Castings for Use in the Petroleum and Natural Gas Industry,* Third Edition or a subsequent edition including addenda.

API Specification 20E, *Alloy and Carbon Steel Bolting for Use in the Petroleum and Natural Gas Industries,* Third Edition or a subsequent edition including addenda.

API Specification 20F, *Corrosion-resistant Bolting for Use in the Petroleum and Natural Gas Industries,* Second Edition or a subsequent edition including addenda.

API Standard 20S, *Qualification of Metal Additive Manufacturing Processes and Components Production Control for Use in the Petroleum and Natural Gas Industries,* Second Edition or a subsequent edition including addenda.

ASME B1.1-2024 [1], *Unified Inch Screw Threads (UN and UNR Thread Form),* or a subsequent edition

ASME B1.2-1983 (R2017), *Gages and Gaging for Unified Inch Screw Threads,* or a subsequent edition

ASME B1.3-2007 (R2022), *Screw Thread Gaging Systems for Acceptability: Inch and Metric Screw Threads (UN, UNR, UNJ, M, and MJ),* or a subsequent edition

ASME B1.5-1997 (R2024), *Acme Screw Threads,* or a subsequent edition

ASME B1.8-1998 (R2021), *Stub Acme Screw Threads,* or a subsequent edition

ASME B1.20.1-2013 (R2018), *Pipe Threads, General Purpose (Inch) ,* or a subsequent edition

ASME *Boiler and Pressure Vessel Code, Section V*-2025*, Nondestructive Examination,* or a subsequent edition

ASME *Boiler and Pressure Vessel Code, Section VIII, Division 1*-2025*, Rules for Construction of Pressure Vessels,* or a subsequent edition

ASME *Boiler and Pressure Vessel Code, Section IX*-2025*, Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators,* or a subsequent edition

ASNT SNT-TC-1A [2]-24, *Personnel Qualification and Certification in Nondestructive Testing,* or a subsequent edition including addenda.

ASTM A1080/A1080M[3] -24, *Standard Practice for Hot Isostatic Pressing of Steel, Stainless Steel, and Related Alloy Castings,* or a subsequent edition

ASTM A193/A193M-25, *Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications,* or a subsequent edition

ASTM A194/A194M-24, *Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both,* or a subsequent edition

ASTM A320/A320M-24a, *Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low-Temperature Service,* or a subsequent edition

[1] American Society of Mechanical Engineers, Two Park Avenue, New York, New York 10016, www.asme.org.

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

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

ASTM A370-24a, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products,* or a subsequent edition

ASTM A388/A388M-23, *Standard Practice for Ultrasonic Examination of Steel Forgings,* or a subsequent edition

ASTM A453/A453M-17(2024), *Standard Specification for High-Temperature Bolting Materials, with Expansion Coefficients Comparable to Austenitic Stainless Steels,* or a subsequent edition

ASTM A609/A609M-12(2023), *Standard Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof,* or a subsequent edition

ASTM D395-20, *Standard Test Methods for Rubber Property—Compression Set,* or a subsequent edition

ASTM D412-16(2021), *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension,* or a subsequent edition

ASTM D471-16a(2021), *Standard Test Method for Rubber Property—Effect of Liquids,* or a subsequent edition

ASTM D1414-22, *Standard Test Methods for Rubber O-Rings,* or a subsequent edition

ASTM D1415-18, *Standard Test Method for Rubber Property—International Hardness,* or a subsequent edition

ASTM D1418-22, *Standard Practice for Rubber and Rubber Latices—Nomenclature,* or a subsequent edition

ASTM D2240-15(R2021), *Standard Test Method for Rubber Property—Durometer Hardness,* or a subsequent edition

ASTM E8-25, *Standard Test Method for Tension Testing of Metallic Materials,* or a subsequent edition

ASTM E10-23, *Standard Test Method for Brinell Hardness of Metallic Materials,* or a subsequent edition

ASTM E18-25, *Standard Test Methods for Rockwell Hardness of Metallic Materials,* or a subsequent edition

ASTM E23-25, *Standard Test Methods for Notched Bar Impact Testing of Metallic Materials,* or a subsequent edition

ASTM E92-23, *Standard Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials,* or a subsequent edition

ASTM E110-14(2023), *Standard Test Method for Rockwell and Brinell Hardness of Metallic Materials by Portable Hardness Testers,* or a subsequent edition

ASTM E127-20, *Standard Practice for Fabrication and Control of Flat Bottomed Hole Ultrasonic Standard Reference Blocks,* or a subsequent edition

ASTM E140-12B(2019)ε1, *Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness,* or a subsequent edition

ASTM E165/E165M-11(2016), *Standard Practice for Liquid Penetrant Examination for General Industry,* or a subsequent edition

ASTM E186-20, *Standard Reference Radiographs for Heavy-Walled (2 to 4 1/2 in. (50.8 to 114 mm)) Steel Castings,* or a subsequent edition

ASTM E280-21, *Standard Reference Radiographs for Heavy-Walled (4$^{1}/_{2}$ to 12 in. (114 to 305 mm)) Steel Castings,* or a subsequent edition

ASTM E446-20, *Standard Reference Radiographs for Steel Castings up to 2 in. (50.8 mm) in Thickness,* or a subsequent edition

ASTM E709-21, *Standard Guide for Magnetic Particle Testing,* or a subsequent edition

ISO 148-1:2016 [4], *Metallic materials—Charpy pendulum impact test—Part 1: Test method,* or a subsequent edition

ISO 3834-1:2021, *Quality requirements for fusion welding of metallic materials Part 1: Criteria for the selection of the appropriate level of quality requirements,* or a subsequent edition

ISO 3834-2:2021, *Quality requirements for fusion welding of metallic materials Part 2: Comprehensive quality requirements,* or a subsequent edition

ISO 3834-3:2021, *Quality requirements for fusion welding of metallic materials Part 3: Standard quality requirements,* or a subsequent edition

ISO 3834-4:2021, *Quality requirements for fusion welding of metallic materials Part 4: Elementary quality requirements,* or a subsequent edition

ISO 3834-5:2021, *Quality requirements for fusion welding of metallic materials Part 5: Documents with which it is necessary to conform to claim conformity to the quality requirements of ISO 3834-2, ISO 3834-3 or ISO 3834-4,* or a subsequent edition

ISO 3834-6:2024, *Quality requirements for fusion welding of metallic materials Part 6: Guidelines on implementing the ISO 3834 series,* or a subsequent edition

ISO 5208:2015, *Industrial valves—Pressure testing of metallic valves,* or a subsequent edition

ISO 6506-1:2014, *Metallic materials — Brinell hardness test Part 1: Test method,* or a subsequent edition

ISO 6506-2:2017, *Metallic materials — Brinell hardness test Part 2: Verification and calibration of testing machines,* or a subsequent edition

ISO 6506-3:2014, *Metallic materials — Brinell hardness test Part 3: Calibration of reference blocks,* or a subsequent edition

ISO 6506-4:2014, *Metallic materials — Brinell hardness test Part 4: Table of hardness values,* or a subsequent edition

ISO 6507-1:2023, *Metallic materials — Vickers hardness test Part 1: Test method,* or a subsequent edition

ISO 6507-2:2018, *Metallic materials — Vickers hardness test Part 2: Verification and calibration of testing machines,* or a subsequent edition

ISO 6507-3:2018, *Metallic materials — Vickers hardness test Part 3: Calibration of reference blocks,* or a subsequent edition

[4] International Organization for Standardization, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, www.iso.org.

ISO 6507-4:2018, *Metallic materials — Vickers hardness test Part 4: Tables of hardness values,* or a subsequent edition

ISO 6508-1:2023, *Metallic materials — Rockwell hardness test Part 1: Test method,* or a subsequent edition

ISO 6508-2:2023, *Metallic materials — Rockwell hardness test Part 2: Verification and calibration of testing machines and indenters,* or a subsequent edition

ISO 6508-3:2023, *Metallic materials — Rockwell hardness test Part 3: Calibration of reference blocks,* or a subsequent edition

ISO 6892-1:2019, *Metallic materials—Tensile testing—Part 1: Method of test at room temperature,* or a subsequent edition

ISO 9606-1:2012, *Qualification testing of welders — Fusion welding Part 1: Steels,* or a subsequent edition

ISO 9606-2:2004, *Qualification test of welders — Fusion welding Part 2: Aluminium and aluminium alloys,* or a subsequent edition

ISO 9606-3:1999, *Approval testing of welders — Fusion welding Part 3: Copper and copper alloys,* or a subsequent edition

ISO 9606-4:1999, *Approval testing of welders — Fusion welding Part 4: Nickel and nickel alloys,* or a subsequent edition

ISO 9606-5:2000, *Approval testing of welders — Fusion welding Part 5: Titanium and titanium alloys, zirconium and zirconium alloys,* or a subsequent edition

ISO 9712:2021, *Non-destructive testing—Qualification and certification of NDT personnel,* or a subsequent edition

ISO 14732:2025, *Welding personnel—Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials,* or a subsequent edition

ISO 15609-1:2019, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification Part 1: Arc welding,* or a subsequent edition

ISO 15609-2:2019, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification Part 2: Gas welding,* or a subsequent edition

ISO 15609-3:2004, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification Part 3: Electron beam welding,* or a subsequent edition

ISO 15609-4:2009, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification Part 4: Laser beam welding,* or a subsequent edition

ISO 15609-5:2011, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification Part 5: Resistance welding,* or a subsequent edition

ISO 15609-6:2013, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification Part 6: Laser-arc hybrid welding,* or a subsequent edition

ISO 15614-1:2017, *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,* or a subsequent edition

ISO 15614-7:2016, *Specification and qualification of welding procedures for metallic materials—Welding procedure test—Part 7: Overlay welding,* or a subsequent edition

ISO 18265:2013, *Metallic materials—Conversion of hardness values,* or a subsequent edition

ISO 2859-1:1999, *Sampling procedures for inspection by attributes—Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

NACE AMPP TM0177-2024, *Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H_2S Environments,* or a subsequent edition

NACE MR0175-2021-ISO 15156-2020, Petroleum and Natural Gas Industries - Materials for Use in H_2S-Containing Environments in Oil and Gas Production, or a subsequent edition

SAE AMSH6875C [5], *Heat Treatment of Steel Raw Materials,* or a subsequent edition

SAE AS568A, *Aerospace Size Standard for O-Rings*

SAE AMS2750H, *Pyrometry,* or a subsequent edition

3 Terms, Definitions, Abbreviated Terms, and Symbols

3.1 Terms and Definitions

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

3.1.1
accessible wetted surface
Wetted surface for purposes of nondestructive examination (NDE) that can be viewed by direct line of sight.

NOTE This excludes test ports, control line ports, lockdown screw holes, and other penetrations of these types.

3.1.2
actuator
Mechanism for the remote or automatic operation of a valve or choke.

3.1.3
adapter
Type of connector (see 3.1.21) with ends of different dimensions or different pressure ratings or different designs or any combination thereof.

3.1.3.1
adapter flange
Fitting used to join equipment with different flange types, sizes, standards, or to connect a flanged end to a non-flanged system.

[5] SAE International, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096, www.sae.org.

3.1.3.2
adapter spool

Connector section having no provision for suspension of tubular members or sealing of tubular members.

3.1.3.3
crossover adapter
Connector with a restricted area sealing means (see 3.1.21.1) used between two casing spools, or between casing and tubing spools, to allow an increase in pressure rating between the spools.

3.1.3.4
crossover tubing head adapter
Connector with a restricted area sealing means (see 3.1.21.1) used between a tree and the tubing head to allow an increase in pressure rating between the two.

3.1.3.5
tubing head adapter
Product that adapts the uppermost connector of a tubing head to the lowermost valve of the tree.

NOTE Tubing head adapters may be integral to the master valve (as the valve lower end connector) or an independent piece of equipment.

3.1.4
annular packoff
Mechanism that seals off annular pressure between the outside diameter of a suspended tubular member or hanger and the inside diameter of the head or spool through which the tubular member passes or hanger is suspended.

3.1.5
back-pressure valve
Unidirectional or bidirectional check valve that is installed through the tree, into the tubing hanger, and prevents well fluids from flowing out of the well.

3.1.6
ball valve
Valve with a nominally spherical closure member that rotates on an axis perpendicular to the direction of flow.

3.1.7
boarding shutdown valve
BSDV
Automatic valve assembly installed between an underwater production system and a surface facility that closes on loss of power supply.

NOTE Where used in this specification, the term is understood to include a BSDV valve and BSDV actuator.

3.1.8
body
Any portion of wellhead and tree equipment that includes one or more end connectors and is designed to be exposed to and contain well bore pressure and fluid.

3.1.9
bonnet
Pressure-containing closure of a body, other than an end or outlet connector.

3.1.10
bottom casing packoff
Mechanism that seals off annular pressure between the outside diameter of a suspended tubular member or hanger and the inside diameter of the spool or tubing-head adapter placed over the suspended tubular or hanger.

3.1.11
bullplug
Pressure-containing closure for a female-threaded end or outlet connector that may have an internal counterbore or test and gauge connector port or both.

3.1.12
casing-head housing
Equipment that suspends and seals a casing string.

NOTE Casing-head housings are designed to accept hanging and packing mechanisms that suspend and seal casing strings.

3.1.13
casting (noun)
Object at or near finished shape obtained by solidification of a fluid substance in a mold.

NOTE Parts made by hot isostatic pressing do not conform to the definition of a casting.

3.1.14
certificate of conformance
Document declaration by the manufacturer certifying that the equipment meets the requirements of this specification.

3.1.15
check valve
Valve that permits fluid to flow in one direction and includes a mechanism to automatically prevent flow in the opposite direction.

3.1.16
choke
Equipment used to restrict and control the flow rate and pressure of fluids.

NOTE 1 Positive chokes include fixed restrictions or orifices to control the flow rate of fluids.

NOTE 2 Adjustable chokes have an externally controlled variable-area orifice.

3.1.17
choke bean
flow bean
Replaceable orifice part used in positive chokes to control flow rate.

3.1.18
choke trim
Pressure-controlling choke part, including choke beans, used to control or regulate the flow of fluids.

3.1.19
clamp hub
Protruding rim with an external angled shoulder and a sealing mechanism used to join pressure-containing equipment.

3.1.20
closure bolting
Threaded fastener used to assemble well bore pressure-containing parts or join end or outlet connectors.

EXAMPLE Studs, nuts, bolts, and capscrews.

3.1.21
connector
Product or component which joins two or more pieces of equipment together.

NOTE Connector is a general category term. Other specific categories of connector include adapter (see 3.1.3) and spool (see 3.1.83) which have specific performance requirements or function requirements or both within that category type.

3.1.21.1
crossover connector
Product with a restricted-area sealing means and with an one connector pressure rating higher than that of the other connector.

NOTE Types of crossover connectors include crossover spools, multistage crossover spools, crossover adapters, and crossover tubing-head adapters.

3.1.21.2
end connector
outlet connector
Integral feature of a body used to join equipment together that contains pressure, permits flow of retained fluid between the joined equipment, and provides a seal at the joint.

NOTE 1 End and outlet connectors include, but are not limited to, internal or external thread, clamp hub, studded outlet, and studded or through-bolted flange.

NOTE 2 A bonnet connector is not an end connector.

3.1.21.3
loose connector
Product that is not made integral with equipment conforming to this specification.

EXAMPLE Loose connectors can be blind, threaded, weld-neck, flanged, studded, or OEC.

3.1.21.4
other end connector
OEC
End or outlet connector in which material designations (standard or nonstandard), or dimensions or both are not fully specified in this document.

NOTE 1 OEC includes API flanges and hubs with non-API gasket preparations and manufacturer's proprietary connections.

NOTE 2 API 16A hubs and API 17D swivel flanges are not OECs.

3.1.21.5
studded (end) connector
End or outlet connector in which thread-anchored studs screwed into tapped holes replace the holes for bolt studs.

3.1.21.6
top connector
Uppermost component of a tree that allows access to the vertical bores of the tree.

NOTE This can be referred to as a tree cap.

3.1.22
corrosion-resistant alloy
CRA

Alloy resistant to general and localized corrosion in environments that are corrosive to carbon and low-alloy steels.

NOTE See 6.1.4.

3.1.23

corrosion-resistant ring groove
Ring groove lined or overlaid with a CRA to resist metal-loss corrosion.

3.1.24
critical dimensions
Toleranced dimensions of features determined by the manufacturer to be essential to the function of the equipment.

3.1.25
critical section
Cross-sectional thickness within a part where specified material properties are necessary to satisfy the design.

3.1.26
cross
Pressure-containing part with a minimum of four end connectors.

3.1.27
date of manufacture
The two digit month and two or four digit year of completion of final inspection or testing.

3.1.28
equipment
Any product included in the scope of this specification.

3.1.28.1
Measuring and Testing Equipment
Device used to inspect, test, or examine material, equipment or measuring and test devices used to verify conformance to the requirements of this specification.

3.1.29
equivalent round
ER
Standard for comparing various shaped sections to round bars, in determining the response to hardening characteristics when heat-treating low-alloy and martensitic corrosion-resistant steel.

3.1.30
exposed bolting
Bolting that can be exposed directly to a sour environment or that is buried, insulated, equipped with flange protectors, or otherwise denied direct atmospheric exposure.

3.1.31
fitting
Type of pressure boundary penetration that is used for the purpose of lubrication, maintenance, venting, monitoring, or testing another part.

NOTE A fitting is not an end connector.

3.1.32
flange
Protruding flat rim with holes to accept bolts and having a sealing mechanism used to join pressure-containing equipment, with dimensions specified in this specification.

3.1.32.1
adapter flange
See 3.1.3.1

3.1.32.2
blind flange
Loose solid component with no through-bore used to close off an end or outlet connector (see 3.1.21.2).

3.1.32.2.1
test flange
Type of blind flange with a test and gauge connector port.

3.1.32.3
companion flange
threaded flange
Loose connector having a sealing face on one side and a female thread on the other for joining flanged connectors to threaded connectors.

3.1.32.4
loose flange
Type of flange, as-manufactured, that is not intended to be made integral with equipment conforming to this specification.

3.1.32.5
spacer flange
Loose connector with a through-bore and the same body diameter from one end face to the other end face used to create separation for alignment, access, or adjustment between other components.

3.1.32.5.1
instrument flange
Type of spacer flange with a through-bore and one or more test and gauge connector ports from the outside diameter to the through-bore.

3.1.32.6
weld-neck flange
Type of connector with a neck terminating in a weld preparation on the side opposite the sealing face.

3.1.33
forging (noun)
Shaped metal part resulting from a metalworking process that uses localized compressive forces to create a wrought microstructure, typically by hammering, pressing, or rolling, at elevated temperatures.

3.1.34
full overlay
Referring to a welding procedure, welding operations, or equipment where all retained fluid-wetted surfaces are clad with a corrosion-resistant alloy.

3.1.35
full-bore valve
Valve whose closure mechanism has a bore dimension the same as or larger than the bore of the valve body.

3.1.36
fusion face
Surface of the base metal that will be melted during welding.

3.1.37
gate valve
Valve assembly with a closure mechanism operating linearly within the body, 90° to the conduit.

3.1.38
hanger mandrel
Portion of a casing or tubing hanger that is attached by a threaded connector to the tubular string and forms the upper end of that tubular string.

3.1.39
hanger (mandrel-type)
Mechanism used to support a casing or tubing string in a casing or tubing head by means of a male or female thread attached to the casing.

3.1.40
hanger (slip-type)
Mechanism used to support a casing string in a casing head by gripping the pipe with wedge-type members.

3.1.41
heat
heat lot
Material originating from a final melt, or for remelted alloys, the raw material originating from a single remelted ingot.

3.1.42
heat-treat lot, batch furnace
Material in a single batch furnace load which is subjected to a heat-treat cycle including, when applicable, the same quenching practice.

3.1.43
heat-treat lot, continuous furnace
Group of pieces of material with the same nominal size that is moved sequentially through the heat-treatment process using the same process parameters.

3.1.44
heat-treatment
heat-treat

Specified, timed sequence of controlled heating and cooling of materials for the purpose of changing physical or mechanical properties.

3.1.44.1
heat-treating equipment
heat-treatment equipment
Implements, apparatus, or devices used for the explicit purpose of performing, facilitating, measuring, or monitoring one or more heat treatment operations or processes.

NOTE: Production heat-treating equipment is used to process production parts.

3.1.45
heat-affected zone
HAZ
Portion of the base metal that has not been melted, but whose mechanical properties or microstructure has been altered by the heat of welding or cutting.

3.1.46
heat-sensitive lock-open device
Device installed on a surface safety valve (SSV) actuator to maintain the SSV valve in a full-open position until exposed to sufficient heat to cause the device to release and allow the SSV valve to close.

3.1.47
hot isostatic pressing
Special forming process used to compact and metallurgically bond metal powder.

NOTE This process takes place within a flexible, metal container whose contents are formed into the desired shape by subjecting the container to high temperature and pressure in an autoclave. It produces a fully wrought structure.

3.1.48
hydrostatic test
Any pressure test performed with a liquid-state test fluid.

3.1.49
job-lot traceability
Ability to trace parts as originating from a job lot that identifies the included heat(s).

3.1.50
linear indication
Surface NDE indication whose length is equal to or greater than three times its width.

3.1.51
lock screw
tie-down screw
Threaded pin extending through the wall of a casing-head or tubing-head connector used to lock down hangers or energize seals.

3.1.52
manufacturer
Organization that produces equipment that meets the requirements of this specification.

3.1.53
multiple cavity valves
Full-bore gate, ball or plug valves containing more than one closure mechanism integrated into a single body.

NOTE 1 Cavities in a multiple cavity valve may share a bore or be on separate bores within the same body.

NOTE 2 Two or more single valves with valve bodies attached to each other does not constitute a multiple cavity valve

3.1.54
objective evidence
Documented field experience, test data, publications, finite element analysis, or calculations that confirm performance characteristics, as applicable.

3.1.55
part
Individual piece used in the assembly of single equipment units.

EXAMPLE Body, bonnet, gate, stud, handwheel, etc., are parts of a valve.

NOTE A part may also be a piece not in finished form.

3.1.56
partial overlay
Referring to a welding procedure, welding operations or equipment where some, but not all, retained fluid-wetted surfaces are clad with a corrosion-resistant alloy.

3.1.57
plug valve
Valve assembly with a cylindrical or tapered closure member mounted across the conduit so that, when rotated 90°, it results in closure.

3.1.58
post-weld heat-treatment
Any heat-treatment subsequent to welding for the purpose of stress relief.

3.1.59
pressure boundary penetration
Device that penetrates directly into or communicates with the well bore.

3.1.60
pressure-containing part
Part whose failure to function as intended results in a release of retained fluid to the atmosphere.

EXAMPLE Bodies, bonnets, one-piece stems, and that segment of multipiece stems that passes through the pressure boundary, are pressure-containing parts.

3.1.61
pressure-containing weld
Closure weld that is part of the pressure envelope of the part and contributes to the retention of pressure.

3.1.62
pressure-controlling part
Part intended to control or regulate the movement of pressurized fluids.

EXAMPLE Valve bore sealing mechanisms, choke trim, and hangers.

3.1.63
pressure integrity
Structural and leak-resistant capability of a product to contain applied pressure.

3.1.64
primary equipment
Pieces of equipment that cannot normally be isolated from well fluid or well pressure.

3.1.65
prolongation
Extension of a piece of raw material or an extension of a production part made integrally during forging, hot working, cold working, or casting.

3.1.66
proration bean
Type of positive choke bean of fixed length used to regulate the flow of fluid from a well.

NOTE Proration is a system of allocating the amount of oil or gas a well or field is allowed to produce within a given period by a regulatory agency.

3.1.67
purchaser
Entity that buys equipment from the manufacturer.

3.1.68
qualification test coupon
QTC
Material used to represent the production part(s) for the purposes of mechanical property testing or microstructural assessment or both.

3.1.69
rated working pressure
RWP
Maximum internal pressure that the equipment is specified to contain and/or control when in operation.

3.1.70
reduced-opening valve
Valve with an opening through the valve bore sealing mechanism, where that opening is smaller in area than the minimum bore as specified in 14.11.

3.1.71
relevant indication
Surface NDE indication with major dimensions greater than 1.6 mm ($^{1}/_{16}$ in.).

NOTE An indication not associated with a surface rupture is not considered to be a relevant indication.

3.1.72
repair weld
Welding used to restore a part to design requirements or to improve appearance.

3.1.73
restricted-area sealing means
Packoff or other device used to isolate an area at higher pressure from one at lower pressure.

NOTE This device serves to limit pressure-induced loads on connectors or areas of a lower-pressure rating. It may also be a seal that encloses a pressure-containment area smaller than the adjacent ring gasket or connector seal.

3.1.74
retained fluid
Actual fluid produced by a well or injected into a well.

3.1.75
rounded indication
Surface NDE indication that is circular or elliptical, having a length less than 3 times its width.

3.1.76
safety valve
Surface safety valve (SSV) or underwater safety valve (USV) or boarding shutdown valve (BSDV), as defined in this specification.

NOTE A safety valve is any one of the valves per 3.1.85 assembled with the corresponding actuator per 3.1.84.

3.1.77
safety valve actuator
Any one of the actuators of 3.1.84.

3.1.78
sandy service
Application where the retained fluid could contain particulates such as sand.

3.1.79
secondary equipment
Piece of equipment that can normally be isolated from the well fluid or well pressure.

3.1.80
serialization
Assignment of a unique code to an individual part and/or piece of equipment to maintain records.

3.1.81
shell test
Hydrostatic test required by this specification that exceeds the rated working pressure.

3.1.82
slip bowl
Piece of equipment between the wedge type members and casing-head bowl.

3.1.83
spool
Pressure-containing wellhead component that, unless otherwise noted, can provide a means to suspend and seal off casing or tubing strings.

3.1.83.1
adapter spool
(see 3.1.3.2)

3.1.83.2
casing-head spool
Product that suspends and seals a secondary casing string.

NOTE Casing-head spools are designed to accept hanging and packing mechanisms that suspend and seal casing strings.

3.1.83.3
crossover spool
Product that suspends and seals around a string of casing or tubing containing a restricted-area sealing means at or near the face of the lower connector, permitting a pressure rating greater than the pressure rating of the lower connector in the section above the restricted-area sealing means.

3.1.83.4
multistage crossover spool
Product with the capability to suspend and seal around multiple inner strings of casing or tubing at several stages containing more than one restricted-area sealing means at each stage permitting an increase of one or more pressure ratings greater than the stage or connector immediately below.

3.1.83.5
spacer spool
Type of connector (see 3.1.21) with ends of same dimensions, pressure ratings and designs and having no provision for suspension of tubular members or sealing of tubular members.

3.1.83.6
tubing head spool
Product designed to accept packing mechanisms that suspend tubing strings and accept packing mechanisms to seal the annular space between the tubing and casing strings.

3.1.84
SSV actuator
USV actuator
BSDV actuator
Device that causes the SSV/USV/BSDV to open when power is supplied and to close automatically when power is lost or released.

3.1.85
SSV valve
USV valve
BSDV valve
Portion of the SSV/USV/BSDV that contains the well stream and shuts off flow when closed.

3.1.86
stainless steel
Steel containing more than 11 % mass fraction chromium to render the steel corrosion-resistant.

NOTE Other elements may be added to secure special properties.

3.1.87
substantive change
One or more modifications to the characteristics of a product identified by the manufacturer that affects the performance of the product in the intended service condition.

3.1.88
surface safety valve
SSV
Automatic wellhead valve assembly operating above the water line or on land that closes upon loss of power supply.

NOTE Where used in this specification, the term is understood to include an SSV valve and SSV actuator.

3.1.89
supply pressure rating
Maximum hydraulic or pneumatic pressure specified to operate an actuator.

3.1.90
swab valve
crown valve
Uppermost valve on the vertical bore of the tree above the flowline outlet.

3.1.91
tee
Pressure-containing part with three end connectors; two openings opposite one another form the run portion of the tee, and one opening is at 90° to the line of the run.

NOTE Tees may be equipped with threads, flanges, studs, or other end connectors.

3.1.92
test agency
Independent party that provides a facility and administers a testing program that conforms to the SSV/USV/BSDV valve bore sealing mechanism validation requirements of API 6AV1.

3.1.93
test and gauge connector port
Port in wellhead and tree equipment for attachment of a fitting (see 3.1.31).

3.1.94
tree
Assembly of equipment, including tubing-head adapters, valves, tees, crosses, top connectors, and chokes attached to the uppermost connector of the tubing head, used to control well production.

NOTE This is sometimes referred to as a “christmas tree.”

3.1.95
trepanned core
Type of qualification test coupon (see 3.1.68) extracted from a part using a hollow drilling process.

3.1.96
tubing hanger mandrel
Mechanism used to support a tubing string in a tubing head by means of a male or female thread attached to the tubing.

3.1.97
underwater safety valve
USV
Automatic valve assembly installed at an underwater wellhead location that closes on loss of power supply.

NOTE Where used in this specification, the term is understood to include a USV valve and USV actuator.

3.1.98
valve bore sealing mechanism
Internal valve parts that close off the flow through the valve bore.

EXAMPLE Gates, balls, plugs, poppets, flappers, and their respective seats.

3.1.99
valve-removal plug
VR plug
Threaded plug that can be installed in the wellhead to enable gate valve removal under pressure.

3.1.100
visible leakage
Leakage of test fluid seen during a pressure test, either through direct observation or with the use of video monitoring devices.

NOTE Leakage may be observed through or past a pressure boundary or at an interface.

3.1.101
well bore
Cavity that contains retained fluid.

3.1.102
wellhead
All permanent equipment between the uppermost portion of the surface casing and the tubing-head adapter connector.

3.1.103
wetted surface
Any surface that has contact with pressurized well fluid, either by design or because of internal seal leakage.

3.1.104
wrought
Product, structure, or material that contains no cast dendritic elements.

3.1.105
yield strength
Stress level at which material plastically deforms and does not return to its original dimensions when the load is released based on the 0.2 % offset method in conformance with ISO 6892-1 or ASTM A370.

3.2 Abbreviated Terms

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

AQL acceptance quality limit

BSDV boarding shutdown valve

BSL bolting specification level

CRA corrosion-resistant alloy

CSL casting specification level

CMM coordinate measuring machine

CVN Charpy V-notch impact test

DAC distance amplitude curve

DED directed energy deposition (see API 20S)

ER	equivalent round
H_2S	hydrogen sulfide
HASS	highly alloyed stainless steel
HAZ	heat-affected zone
HBW	Brinell hardness
HIP	hot isostatic pressing
HRB	Rockwell hardness scale B
HRC	Rockwell hardness scale C
HPVR	high-pressure valve removal (plug)
HVOF	high-velocity oxygen fuel
MT	magnetic particle test
NA	not applicable
NDE	nondestructive examination
NPT	American national standard taper pipe thread
NS	nonstandard
OD	outside diameter
OEC	other end connector
PBF	powder bed fusion (see API 20S)
PMR	per manufacturer's requirement
PREN	pitting resistance equivalent number
PQR	procedure qualification record
PR	performance requirement
psi	pounds per square inch (gauge)
psia	pounds per square inch absolute
PSL	product specification level
PT	penetrant test
QTC	qualification test coupon
RMS	root mean square

ROE radius of exposure

RT radiographic test

RWP rated working pressure

SCC stress corrosion cracking

SI International System of Units

SSC sulfide stress cracking

SSV surface safety valve

TPI threads per inch

UNS unified numbering system

USC US Customary

USV underwater safety valve

UT ultrasonic test

VR valve removal (plug)

WPQ welder performance qualification

WPQR welder performance qualification record

WPS welding procedure specification

3.3 Symbols

For the purposes of this document, the following symbols and units apply.

A_{s} stress area

E_{ty} elevated-temperature yield strength

R_{m} ultimate tensile strength

R_{ty} room-temperature yield strength

S_{A} allowable tensile stress

S_{e} de-rated material yield strength

S_{E} maximum allowable equivalent stress at the most highly stressed distance into the pressure vessel wall

S_{my} minimum specified room-temperature yield strength

S_Y material-specified minimum yield strength

T thickness

Y_r yield reduction ratio at temperature

τ torque

4 Application and Performance

4.1 Applicability

NOTE The nomenclature used in this specification for typical equipment is shown in Figure 1, Figure 2, and Figure 3. These are shown as examples only. Other configurations are possible.

This specification shall be applicable to the following specific equipment:

a) plugs, connectors, and gaskets — API defined (applicable product-specific sections referenced as follows):

— flange (adapter, blind, companion, integral, instrument, spacer, test, threaded and weld-neck) (see 14.1);

— ring gaskets (see 14.2);

— threaded connectors (see 14.3);

— tees and crosses (see 14.4);

— bullplugs (see 14.5);

— valve-removal plugs (see 14.6);

— top connectors (standard) (see 14.7);

b) connectors — manufacturer-defined (applicable product-specific sections referenced as follows):

— top connectors (nonstandard) (see 14.7);

— crossover connectors (single- or double-studded, single- or multistage) (see 14.8);

— other end connectors (OECs) (see 14.9);

— spools (adapter and spacer) (see 14.10);

— tubing-head adapters (see 14.15)

c) valves (all types except back-pressure valves) (see 14.11):

— gate valves (single and multiple cavity);

— plug valves (single and multiple cavity);

— ball valves (single and multiple cavity);

- actuated valves (manual and remote, single and multiple cavity);
- valves prepared for actuators;
- check valves (swing- and lift-type);
- back-pressure valves (see 14.12);

d) casing and tubing hangers (see 14.13):

- slip-type;
- mandrel-type;

e) casing and tubing heads (see 14.14);

f) chokes (fixed, manually actuated, remotely actuated) (see 14.16);

g) actuators (for valves and chokes) (see 14.17);

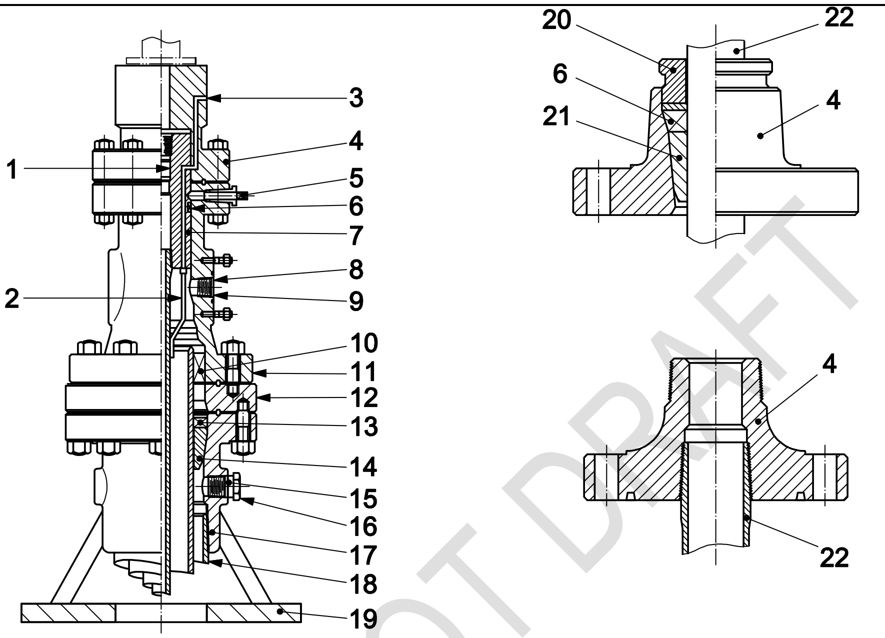
h) safety valves, shutdown valves, and actuators (see 14.18):

- surface safety valve (SSV) assemblies, valves prepared for actuators, and actuators;
- underwater safety valve (USV) assemblies, valves prepared for actuators, and actuators;
- boarding shutdown valve (BSDV) assemblies, valves prepared for actuators, and actuators;

i) tree assemblies (see 14.19);

j) other:

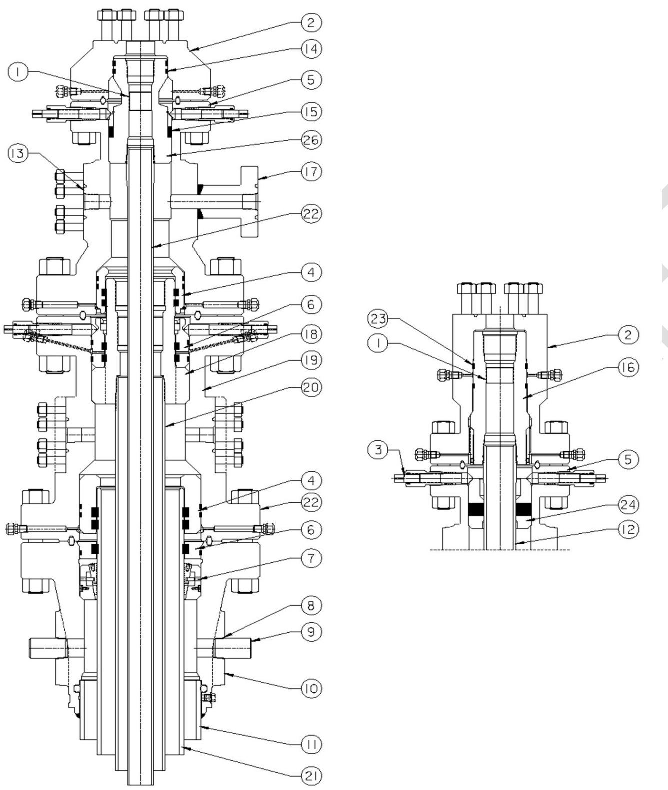
- packing mechanisms for lock screws, alignment pins, and retainer screws (see Section 9);
- fittings and pressure boundary penetrations (see Section 9);
- test, gauge, vent, and injection connector ports (see Section 9);



Key

1 back-pressure valve preparation
2 subsurface safety valve control line
3 subsurface safety valve control line outlet
4 tubing-head adapter
5 lock screw
6 tubing hanger packoff
7 extended neck tubing hanger with subsurface safety valve control line
8 studded side outlet
9 valve-removal preparation
10 bottom casing packoff
11 tubing-head spool
12 adapter spool (double-studded)
13 annular casing packoff
14 casing hanger (slip style)
15 threaded outlet connection
16 bullplug
17 casing-head housing
18 surface casing
19 wellhead support plate or landing base
20 tubing packoff retainer
21 tubing hanger (slip style)
22 tubing

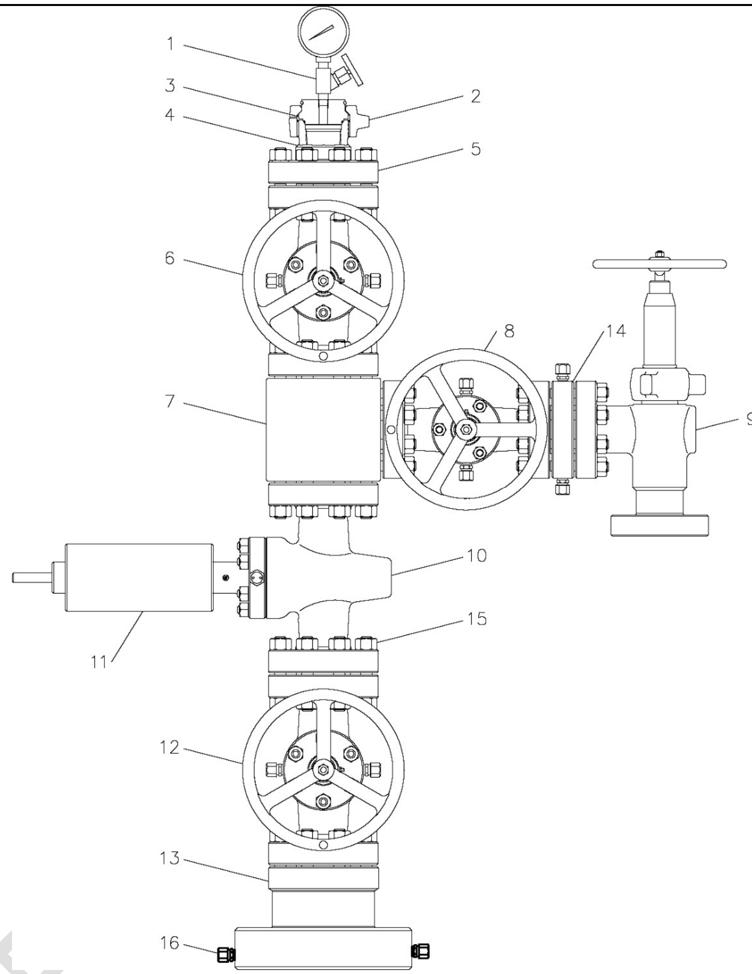
Figure 1—Typical Wellhead Assembly Nomenclature



Key

1 back-pressure valve preparation
2 tubing-head adapter
3 lock screw
4 bottom casing packoff
5 tubing-head spool
6 annular casing packoff
7 casing hanger (slip style)
8 threaded outlet connection
9 bullplug
10 casing-head
11 surface casing
12 tubing
13 studded side outlet connector
14 extended neck tubing hanger seal
15 annular tubing hanger seal
16 tubing hanger mandrel
17 flanged outlet connector
18 casing hanger mandrel
19 casing-head spool
20 inner casing
21 intermediate casing
22 flanged end connector
23 tubing hanger mandrel seals
24 hanger packoff

Figure 2—Typical Wellhead Assembly Nomenclature



Key

1 gauge valve
2 bonnet nut
3 blanking plug
4 body
5 top connector
6 swab or crown valve
7 tee
8 wing valve (manual or actuated)
9 choke
10 surface safety valve
11 SSV actuator
12 master valve
13 tubing-head adapter
14 instrument flange
15 closure bolting
16 test port-pressure boundary penetration

Figure 3—Typical Tree Nomenclature

4.2 Performance Requirements (PR)—General

All equipment shall conform with Section 4. All equipment shall be designed to conform to the requirements of Section 5 and the specified performance requirements of Section 14.

NOTE 1 See Annex B for other requirements that may be specified by the purchaser.

When specified in Section 14 of this document, equipment shall be identified with one of two performance requirements (PR1 or PR2) that is specific to each product in the as-shipped condition. Equipment further identified as PR2F shall conform to the design validation requirements specified in Annex F of this document.

NOTE 2 PR2F is a designation identifying one specific validation to PR2. Other methods of validating products to PR2 are possible.

4.3 Service Conditions

4.3.1 Pressure Ratings

4.3.1.1 General

Equipment, except actuators, shall be designed to operate at only the following rated working pressures:

— 13.8 MPa (2000 psi);

— 20.7 MPa (3000 psi);

— 34.5 MPa (5000 psi);

— 69.0 MPa (10,000 psi);

— 103.5 MPa (15,000 psi);

— 138.0 MPa (20,000 psi).

NOTE Rated working pressure values other than those listed in this section are outside the scope of this document.

4.3.1.2 Threaded Equipment Limitations

Equipment designed with internally threaded end and outlet connectors shall be limited to the thread sizes and rated working pressures in Table 1.

Table 1 shall not apply to tubing and casing hangers.

4.3.1.3 Design Inputs

Designs shall account for the effects of pressure containment and other pressure-induced loads, including (but not limited to) pressure rating changes in crossover connectors, pressurizing with temporary test plugs, or other applicable special conditions.

NOTE The capacity for external loading (e.g. bending moments, tensions, etc.) on the rating of equipment is not explicitly addressed by this specification (see B.2).

Table 1—Pressure Ratings for Internal Threaded End or Outlet Connectors

Type of Thread	Nominal Sizes of Pipe, Tubing, or Casing	Rated Working Pressure	
	in.	MPa	psi
NPT	1/2	69.0	10,000
	3/4 to 1 1/2	34.5	5000
Line pipe	1/2	69.0	10,000
	3/4 to 2	34.5	5000
	2 1/2 to 6	20.7	3000
Tubing, non-upset, and external upset round thread	1.050 to 4 1/2	34.5	5000
Casing (8 round, buttress, and extreme line)	4 1/2 to 10 3/4	34.5	5000
	11 3/4 to 13 3/8	20.7	3000
	16 to 20	13.8	2000

4.3.2 Temperature Ratings

Equipment shall be designed to operate in one or more of the specified temperature classes with minimum and maximum temperatures as shown in Table 2, or to minimum and maximum temperature ratings as agreed between the purchaser and manufacturer.

Table 2—Temperature Ratings

Temperature Class	Temperature Range			
	°C		°F	
	min.	max.	min.	max.
K	–60	82	–75	180
L	–46	82	–50	180
N	–46	60	–50	140
P	–29	82	–20	180
S	–18	60	0	140
T	–18	82	0	180
U	–18	121	0	250
V	2	121	35	250

NOTE Minimum temperature is the lowest ambient temperature to which the equipment can be subjected. Maximum temperature is the highest temperature of the fluid that can directly contact the equipment.

Design for temperature ratings above 121 °C (250 °F), e.g. classifications X and Y (see Table G.1), shall account for the effects of temperature on material strength (see Annex G for guidelines).

4.3.3 Material Classes

4.3.3.1 General

Equipment shall be designed with materials that meet the requirements specified in Table 3.

Table 3—Material Requirements

Material Class[e]		Body, Bonnet, End and Outlet Connectors	Mandrel Hangers, Valve Bore Sealing Mechanisms, Choke Trim, and Stems
AA	General service	Carbon steel, low-alloy steel, stainless steel or CRA [c,d]	Carbon steel, low-alloy steel, stainless steel or CRA [c,d]
BB	General service	Carbon steel, low-alloy steel, stainless steel or CRA [c,d]	Stainless steel or CRA [c,d]
CC	General service	Stainless steel or CRA [c,d]	Stainless steel or CRA [c,d]
DD	Sour service [a]	Carbon steel, low-alloy steel, stainless steel or CRA [b,c,d]	Carbon steel, low-alloy steel, stainless steel or CRA [b,c,d]
EE	Sour service [a]	Carbon steel, low-alloy steel, stainless steel or CRA [b,c,d]	Stainless steel or CRA [b,c,d]
FF	Sour service [a]	Stainless steel or CRA [b,c,d]	Stainless steel or CRA [b,c,d]
HH	Sour service [a]	CRA [b,c,d]	CRA [b,c,d]

FOOTNOTES

[a] As defined by NACE MR0175/ISO 15156.

[b] In conformance with NACE MR0175/ISO 15156 and 4.3.3.2.

[c] Either CRA material or CRA cladding of certain alloys on retained fluid-wetted surfaces of carbon or low-alloy steel, or stainless steel, or HASS, is permitted (see 7.5.1).

[d] CRA as defined in 3.1.22 and specified in 6.1.4

4.3.3.2 Material Classes for Sour Service

Unless otherwise specified, Material classes DD, EE, FF and HH shall use pre-qualified materials identified in NACE MR0175/ ISO 15156. Materials qualified for sour service by laboratory testing or documented field history shall be material class ZZ. Hanger retention mechanisms and load rings, which are loaded primarily in compression, do not require the use of materials identified in NACE MR0175 / ISO 15156.

NOTE 1 Choosing material class and specific materials for specific conditions is ultimately the responsibility of the purchaser.

Material classes DD, EE, FF, and HH shall include as part of the designation and marking the maximum allowable partial pressure of hydrogen sulfide (H_2S), when a value is specified by NACE MR0175/ISO 15156, in units consistent with the rated working pressure markings and prefixes. Where no H_2S limit is defined by NACE MR0175/ISO 15156 for the partial pressure, no partial pressure shall be marked. The maximum allowable partial pressure shall be in conformance with NACE MR0175/ISO 15156 at the designated temperature rating (see Table 2) for the limiting part(s) in the equipment assembly. When the rated working pressure is marked in pounds per square inch, the H_2S partial pressure limit shall be marked in pounds per square inch.

EXAMPLE 1 "FF-10" on equipment with the rated working pressure marked in megapascals indicates material class FF rated at 10 kPa H_2S maximum allowable partial pressure when used within the environmental limits specified in NACE MR0175/ISO 15156.

EXAMPLE 2 "FF" would be marked on a tee with a body constructed from a material that does not have an H_2S limit specified in NACE MR0175/ISO 15156 with a pH ≥ 3.5.

NOTE 2 API 6A requires the manufacturer to mark only the H_2S partial pressure and not the other parameters specified in NACE MR0175/ISO 15156 to define the environmental limits for H_2S service. Resistance to cracking caused by H_2S is influenced by several other factors, some of the limits for which are given in NACE MR0175/ISO 15156. These include, but are not limited to, the following:

— pH;

— temperature;

— chloride concentration;

— elemental sulfur.

NOTE 3 In making the material selections, it is the responsibility of the purchaser to consider the various environmental factors and production variables listed in Annex B.

NOTE 4 Other forms of cracking may result from the presence of chlorides (such as seawater) and or hydrogen (such as cathodic protection).

4.3.3.3 Material Class ZZ

For material class ZZ, the manufacturer shall conform to material specifications supplied or approved by the purchaser and shall maintain traceable records to document the materials of construction.

Additively manufactured materials shall be validated for the intended environment using the same Manufacturing Process Specification (see API 20S) as the target product. Additionally, additively manufactured material shall conform to the requirements of 6.1.3.

NOTE 1 NACE MR0175/ISO 15156 includes provisions by means of testing or documented field history for the qualification of materials for a specific sour-service application that is outside the parameters defined in NACE MR0175/ISO 15156. This can include the use of materials in fluid conditions exceeding the limits defined in NACE MR0175/ISO 15156, or the use of materials not addressed in NACE MR0175/ISO 15156.

NOTE 2 It is the responsibility of the purchaser to evaluate and determine the applicability of the documented data for the intended application.

4.3.4 Product Specification Level

4.3.4.1 Application

PSL designations shall define different levels of technical quality requirements as identified in this specification. Products manufactured to the requirements of this specification shall satisfy the material, welding, quality, and testing requirements for a PSL (PSL 1, PSL 2, PSL 3, and PSL 4), when applicable. PSLs shall be applied to products as designated in Table 4.

NOTE PSL does not apply to all products of this specification.

A supplemental designation of PSL 3G shall apply to PSL 3 products that have satisfied the PSL 3 requirements (except hydrostatic seat test) in addition to the requirements of gas testing (See Section 11).

4.3.4.2 PSL Application

The product specification level (PSL) applied to equipment shall be limited to those listed in Table 5 for the combination of material class and rated working pressure of the equipment.

NOTE Annex B provides guidelines (not requirements) for selecting a PSL.

For crossover connectors, the PSL shall be based on the higher-pressure rating and material class.

For mandrel hangers, the PSL should be based on the pressure rating and material class of the spool or tubing-head adapter placed over the suspended hanger.

Table 4—Applicability of Product Specification Levels

Equipment Category and Type (Reference Section)	Applicable PSLs	Equipment Category and Type (Reference Section)	Applicable PSLs
Plugs, Connectors, Gaskets		Valves and Chokes	
Flanges (all types)[a] (see 14.1)	1, 2, 3, 4	Valves (gate, plug, ball) (see 14.11)	1, 2, 3 [e], 4
Ring gaskets [b] (see 10.4.5 and 14.2)	NA	Valves (prepared for/and actuated) (see 14.11)	1, 2, 3 [e], 4
Threaded connectors [a] (see 14.3)	1, 2, 3, 4	Check valves (see 14.11)	1, 2, 3 [e], 4
Tees and crosses (see 14.4)	1, 2, 3 [e], 4	Back-pressure valves [b] (see 14.12)	NA
Bullplugs [b] (see 14.5)	NA	SSVs and USVs [c] (see 14.18)	2, 3 [e], 4
Valve-removal plugs [b] (see 14.6)	NA	BSDVs [d] (see 14.18)	3 [e], 4
Top connectors (see 14.7)	1, 2, 3 [e], 4	Chokes (adjustable and positive) (see 14.16)	1, 2, 3 [e], 4
Crossover connectors (see 14.8)	1, 2, 3 [e], 4	Casing and Tubing Heads	
Other end connectors [a] (see 14.9)	1, 2, 3, 4	Housings (see 14.14)	1, 2, 3 [e], 4
Spools (adapter, spacer) (see 14.10)	1, 2, 3 [e], 4	Casing Head and Tubing Head Spools (see 14.14)	1, 2, 3 [e], 4
Tubing-head adapters (see 14.15)	1, 2, 3 [e], 4	Other Equipment	
Weld-neck flanges [a] (see J.1)	1, 2, 3, 4	Actuators [b] (see 14.17)	NA
Non-integral metal seals [a] (see 10.4.5)	NA	Tree assemblies [b] (see 14.19)	NA
Casing and Tubing Hangers		Packing mechanisms [b] (see 9.1)	NA
Slip-type [a] (see 14.13)	1, 2, 3, 4	Pressure boundary penetrations [b] (see 9.2)	NA
Mandrel-type [a] (see 14.13)	1, 2, 3, 4	Test and gauge ports [b] (see 9.3)	NA

FOOTNOTES

[a] Gas testing is not required, so PSL 3G designation is not applicable.

[b] There is only one level of requirements for these products, so PSLs are not applicable (NA).

[c] PSL 1 is not applicable to SSVs and USVs.

[d] PSL 1 and PSL 2 are not applicable to BSDVs.

[e] For products eligible for gas testing, PSL 3G designation and marking may apply.

Table 5—Minimum PSL

Material Class	Rated Working Pressure					
	13.8 MPa (2000 psi)	20.7 MPa (3000 psi)	34.5 MPa (5000 psi)	69.0 MPa (10,000 psi)	103.5 MPa (15,000 psi)	138.0 MPa (20,000 psi)
AA, BB, CC	PSL 1, PSL 2, PSL 3, PSL 4	PSL 1, PSL 2, PSL 3, PSL 4	PSL 1, PSL 2, PSL 3, PSL 4	PSL 2, PSL 3, PSL 4	PSL 2, PSL 3, PSL 4	PSL 3, PSL 4
DD, EE, FF	PSL 1, PSL 2, PSL 3, PSL 4	PSL 1, PSL 2, PSL 3, PSL 4	PSL 1, PSL 2, PSL 3, PSL 4	PSL 2, PSL 3, PSL 4	PSL 3, PSL 4	PSL 3, PSL 4
HH, ZZ	PSL 3, PSL 4	PSL 3, PSL 4	PSL 3, PSL 4	PSL 3, PSL 4	PSL 3, PSL 4	PSL 4

NOTE 1 For RWP/Material Class combinations that may have more than one applicable PSL, only one PSL is marked on products that satisfy the material, welding, quality, and testing requirements for that specific PSL (see 4.3.4.1)

NOTE 2 For products eligible for gas testing, PSL 3G may be applied wherever PSL 3 is listed (see Table 37, Note "c")

5 Design

5.1 Design Methods

5.1.1 End and Outlet Connectors

End and outlet connectors shall be an integral part of the body or attached by welding that meets the requirements of Section 7.

NOTE 1 Information on design analysis and load capacities of flanges specified in this specification can be found in API 6AF, API 6AF1, and API 6AF2.

Design of 16B and 16BX end and outlet clamp hub connectors used on equipment specified in this specification shall conform to the material strength and dimensional requirements of API 16A.

NOTE 2 Clamps conforming to the requirements of API 16A are acceptable for installation on equipment specified in this specification with clamp hub end connectors meeting the requirements of API 16A.

5.1.2 Hangers, Back-pressure Valves, Lock Screws, and Stems

Casing hangers, tubing hangers, back-pressure valves, lock screws, and stems shall be designed to satisfy the manufacturer's documented performance characteristics and service conditions in conformance with 4.3. The manufacturer shall document engineering practices and acceptance criteria on which the design is based.

5.1.3 Additive Manufacturing

Additively manufactured material shall not be used in the design of:

— pressure-containing components; or,

— equipment with material classes DD, EE, FF, or HH; or,

— equipment with a pressure rating greater than 5,000 PSI (34.5 MPa).

Additive manufacturing of pressure-controlling components shall be limited to DED Wire or PBF.

When used in sour service applications, additively manufactured materials shall conform to 4.3.3.3.

The use of materials data for the same alloy (based on chemical composition) from conventional methods of manufacture shall not be permitted. New or existing designs shall be validated using materials data from laboratory testing.

Threads shall not be additively manufactured to the final thread form. Threads shall be machined, tapped, or otherwise finished to meet the dimensional and surface requirements of the applicable design standard and shall be limited to material produced using DED wire.

Additive Manufacturing shall not be used for springs.

Designs shall satisfy the manufacturer's documented performance characteristics and service conditions in conformance with 4.3. The manufacturer shall document engineering practices, acceptance criteria and design validation on which the design is based.

NOTE 1: For other components, additively manufactured material may be used at the discretion of the manufacturer unless otherwise prohibited by API 6A.

NOTE 2: When additively manufactured material is used, the associated equipment and components should be designed to account for anisotropy and minimize the effects of material deposition on geometric discontinuities.

5.1.4 Bodies, Bonnets, and Other End Connectors

5.1.4.1 General

OECs, bodies, and bonnets (in designs other than those specified in this specification) shall be designed in conformance with one or both of the methods given in 5.1.4.2 and 5.1.4.3.

If stress levels calculated by the methods in 5.1.4.2 and 5.1.4.3 exceed the allowable stresses, other methods identified by the manufacturer shall be used to justify these stresses.

NOTE Fatigue analysis and localized bearing stress values are outside the scope of this specification.

5.1.4.2 API Standard 6X

If used, design calculations for pressure-containing equipment shall conform to the design methodology of API 6X. The use of von Mises equivalent stress shall be permitted.

5.1.4.3 Distortion Energy Theory

If used, design calculations for pressure-containing equipment shall conform to the von Mises yield criterion (also known as the maximum distortion energy theory of failure). Rules for the use and impact of discontinuities and stress concentrations are outside the scope of this method. However, the basic pressure-vessel wall thickness may be sized by combining triaxial stresses based on hydrostatic shell test pressure and limited by the criterion in Equation 1:

$$S_{\mathrm{E}} = S_{\mathrm{Y}} \qquad \text{Equation (1)}$$

where

S_{E} is the maximum allowable equivalent stress at the most highly stressed distance into the pressure vessel wall, computed by the distortion energy theory method;

S_{Y} is the material-specified minimum yield strength.

5.1.4.4 Tapped Holes for Studded Connections Other Than Flanges

The stud thread-anchoring configuration shall be designed to sustain a tensile load equivalent to the load that can be transferred to the stud through a fully engaged nut.

5.1.5 Other Parts

All other pressure-containing parts and all pressure-controlling parts shall be designed to satisfy the manufacturer's documented performance characteristics and the service conditions in 4.3. The manufacturer shall document engineering practices and acceptance criteria on which the design is based.

5.1.6 Lifting Threads

NOTE Threads added for lifting purposes are outside the scope of this specification.

5.2 Design Tolerances

Where values are specified in this specification without tolerance, the tolerances shown in Table 6 shall apply for the units in use. Table 6 shall not apply for the conversion between units.

5.3 Design Documentation

Documentation of designs shall include methods, assumptions, calculations, and design requirements. Design requirements shall include, but not be limited to, those criteria for size, test and operating pressures, material, environmental, and other pertinent requirements on which the design is based.

Design documentation media shall be clear, legible, reproducible, and retrievable.

Design documentation shall be retained for 5 years after the last unit of that model, size, and rated working pressure is manufactured.

Table 6—Tolerances, Unless Otherwise Stated

SI		USC	
Dimension	Tolerance mm	Dimension	Tolerance in.
x.x	± 0.5	x.xx	± 0.02
x.xx	± 0.13	x.xxx	± 0.005

5.4 Design Review and Verification

Design documentation shall be reviewed and verified by a competent individual other than the individual who created the original design.

5.5 Design Validation

Manufacturers shall document their design validation procedures and the results of design validation, including designs using additively manufactured materials.

Design validation shall be performed in conformance with Annex F when specified by the manufacturer or purchaser.

6 Materials

6.1 Applicability

6.1.1 General

Materials used for bodies, bonnets, end and outlet connectors, clamp hub end connectors, hangers, and pressure boundary penetrations shall conform to the requirements of Section 6 with alloy specific requirements given in 6.1.2, 6.1.3, 6.1.4, and 6.1.5.

PSL 1, PSL 2, and PSL 3 bodies, bonnets, end and outlet connectors (including clamp hub end connectors) shall be manufactured from either wrought materials or cast materials.

PSL 4 bodies, bonnets, end and outlet connectors (including clamp hub end connectors) shall be manufactured from wrought materials.

Materials used for other pressure-containing and pressure-controlling parts, excluding additively manufactured materials, shall be made of materials that satisfy 6.2 and the requirements of Section 4 and Section 5. Pressure controlling parts manufactured from additively manufactured materials shall conform to additively manufactured-specific requirements in Section 6.

Note: Equipment specific material requirements are given in Section 14.

6.1.2 Carbon Steel, Low-alloy Steel, and Martensitic Stainless Steel

Material requirements in Section 6 shall apply to carbon steels, low-alloy steels, martensitic stainless steels (other than precipitation-hardening types).

6.1.3 Solution Annealed Austenitic Alloys

Material requirements in Section 6 shall apply to solution annealed austenitic stainless steels (e.g., 304, 316) and solution annealed austenitic nickel-based alloys (e.g., 625, 825) with the exemption that these alloys shall not require Charpy impact testing.

6.1.4 Corrosion Resistant Alloys

6.1.4.1 General

For the purposes of this Specification, the use of CRAs defined in 3.1.22 and listed in Table 3 shall be limited to alloys that conform to either of the following requirements:

a) A non-ferrous alloy in which any one or the sum of the specified amount of the elements titanium, nickel, cobalt, chromium, and molybdenum exceeds 50 % mass fraction, or

b) A Highly Alloyed Stainless Steel (HASS) having an austenitic microstructure, Cr % ≥ 19.0, (Ni % + 2(Mo %)) ≥ 35.0 (where Mo % is a minimum of 5%), and PREN ≥ 45.0.

For alloys that conform to 6.1.4.1.b), PREN shall be calculated as follows:

$$PREN = Cr\,\% + 3.3(Mo\,\% + 0.5(W\,\%)) + 16(N\,\%)$$

6.1.4.2 Age Hardened Nickel Based Alloys

In addition to meeting the requirements of Section 6, age-hardened nickel-based alloys used in components listed in Table 3 that are addressed in API 6ACRA shall conform to API 6ACRA. When additional surface heat treatment is performed on a component manufactured from 6ACRA, the process shall be validated to demonstrate that it does not detrimentally affect the base material performance.

NOTE: See NACE MR0175/ISO 1015156 for definitions and information on surface treatment.

Validation of the process for an API 6ACRA grade shall demonstrate that after all thermal treatment, the material properties still meet the mechanical and microstructural requirements of the API 6ACRA grade.

Validation of the process for other nickel alloys shall, as a minimum, demonstrate that the required mechanical properties of the base material are satisfied after treatment. The QTC (see 6.4) of the age-hardened nickel alloy that was subjected to the same surface treatment process shall be used to demonstrate the final mechanical properties and microstructure are still within 6ACRA requirements.

Validation of the process for other age-hardened nickel alloys shall, as a minimum, demonstrate that the required mechanical properties and microstructure of the base material are satisfied after treatment.

6.1.5 Other Alloy Systems

Material requirements in Section 6 shall apply to all other alloy systems not listed in Section 6.1.2, 6.1.3, or 6.1.4 with the exception that these alloys shall not require Charpy impact testing.

6.1.6 Additive Manufacturing

Additively manufactured materials shall conform to API 20S and the applicable requirements of this specification. For 6A equipment or components manufactured to conform to a specified PSL, the corresponding Additive Manufacturing Specification Level (AMSL) shall conform to Table 7.

Table 7 – PSL and Additive Manufacturing Specification Level (AMSL) Correlation

API 6A	API 20S[a]
None	AMSL 1, AMSL 2 or AMSL 3
PSL 1	AMSL 2 or AMSL 3
PSL 2	AMSL 3
PSL 3	AMSL 3
PSL 4	AMSL 3

FOOTNOTE
[a] For slip hangers see 10.4.9

6.2 Written Specifications

6.2.1 Applicability

All metallic and nonmetallic pressure-containing or pressure-controlling parts shall require a written material specification.

6.2.2 Metallic Requirements

The manufacturer's written specified requirements for metallic materials for bodies, bonnets, end and outlet connectors, stems, valve bore sealing mechanisms, mandrel hangers, and ring gaskets shall define the following, along with accept/reject criteria:

— mechanical property requirements;

— material qualification;

— heat-treatment requirements, including requirements for cycle time, temperatures, and quenching media;

— material composition with tolerances;

— NDE requirements;

— allowable melting practice(s);

— forming practice(s), including hot working, hot isostatic pressing, and cold working practices;

— heat-treating equipment calibration;

— heat-treating equipment qualification;

— substrate requirements conforming to API 20S (for additively manufactured materials only).

6.2.3 Nonmetallic Requirements

Nonmetallic pressure-containing or pressure-controlling seals in contact with retained fluids shall have written material specifications. The manufacturer's written specified requirement for nonmetallic materials shall define the following:

— generic base polymer(s) (see ASTM D1418), if applicable;

NOTE Reference to generic base polymer does not apply to graphite material.

— physical property requirements;

— material qualification that shall conform to the equipment class requirement;

— storage and age-control requirements.

6.3 Bodies, Bonnets, and End and Outlet Connectors

6.3.1 Materials

6.3.1.1 Application

All bodies, bonnets, and end and outlet connectors shall be fabricated from standard or nonstandard (see 6.3.1.2) materials. Standard material qualification testing shall satisfy the requirements of 6.3.2.

6.3.1.2 Non-standard Materials

Non-standard materials for parts shown in Table 8 shall have a specified minimum yield strength at least equal to that of the lowest-strength standard material permitted for that application.

Table 8—Standard and Nonstandard Material Applications for Bodies, Bonnets, and End and Outlet Connectors

Part	Material Designations for Pressure Ratings [a]					
	13.8 MPa (2000 psi)	20.7 MPa (3000 psi)	34.5 MPa (5000 psi)	69.0 MPa (10,000 psi)	103.5 MPa (15,000 psi)	138.0 MPa (20,000 psi)
	Body [b], Bonnet					
	36K, 45K 60K, 75K, NS	36K, 45K 60K, 75K, NS	36K, 45K 60K, 75K, NS	36K, 45K 60K, 75K, NS	45K, 60K 75K, NS	60K, 75K NS
	Integral End Connector					
Flanged	60K, 75K, NS	60K, 75K, NS	60K, 75K, NS	60K, 75K, NS	75K, NS	75K, NS
Threaded	60K, 75K, NS	60K, 75K, NS	60K, 75K, NS	NA	NA	NA
Other [c]	PMR	PMR	PMR	PMR	PMR	PMR
	Loose Connector					
Weld-neck	45K	45K	45K	60K, 75K, NS	75K, NS	75K, NS
Blind	60K, 75K, NS	60K, 75K, NS	60K, 75K, NS	60K, 75K, NS	75K, NS	75K, NS
Threaded	60K, 75K, NS	60K, 75K, NS	60K, 75K, NS	NA	NA	NA
Other [c]	PMR	PMR	PMR	PMR	PMR	PMR

FOOTNOTES

[a] "NS" indicates nonstandard materials as specified in 6.3.1.2.

[b] If end connectors are of the material designation indicated, design is in conformance with Section 5 and welding is in conformance with Section 7.

[c] As specified by the manufacturer.

Non-standard materials shall be materials with properties that do not meet all the requirements of Table 9 for standard material. Non-standard material specifications shall include the following:

— tensile strength (see 6.3.2.2);

— yield strength;

— hardness;

— impact strength, as applicable (see 6.3.2.3);

— a minimum of 15 % elongation;

— a minimum of 20 % reduction of area.

Table 9—Standard Material Property Requirements for Bodies, Bonnets, and End and Outlet Connectors

Material Designation	**0.2 % Offset Yield Strength** min. MPa (psi)	**Tensile Strength** min. MPa (psi)	**Elongation in 50 mm (2 in.)** min. %	**Reduction in Area** min. %
36K	248 (36,000)	483 (70,000)	21	No requirement
45K	310 (45,000)	483 (70,000)	19	32
60K	414 (60,000)	586 (85,000)	17	35
75K	517 (75,000)	655 (95,000)	17	35

6.3.2 Material Qualification Testing

6.3.2.1 General

If minimum tensile and/or impact properties are required for material to be qualified for service, the required tests shall be performed on specimens from a qualification test coupon (QTC) as described in 6.4.

6.3.2.2 Tensile Testing

6.3.2.2.1 Test Method

For wrought and cast materials, tensile tests shall be performed at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F) in conformance with the procedures specified in ISO 6892-1 or ASTM A370.

For additively manufactured materials, tensile tests shall conform to API 20S and the procedures specified in ASTM A370, ASTM E8, or ISO 6892-1.

For wrought and cast materials, a minimum of one tensile test shall be performed. The results of the tensile test(s) shall satisfy the applicable requirements of Table 9.

For additively manufactured materials, the number of samples shall conform to API 20S.

6.3.2.2.2 Retesting

To qualify the material if the results of the tensile test(s) do not satisfy the applicable requirements, the following shall apply, with no additional heat treatment:

a) for wrought and cast materials, two additional tests shall be performed on tensile specimens removed from the required location within the same QTC; and,

b) for additively manufactured materials, retesting shall conform to API 20S.

The results of each of these tests shall satisfy the applicable requirements.

6.3.2.3 Impact Testing

6.3.2.3.1 Test Specimens

Bodies, bonnets and end and outlet connectors shall be impact tested. The acceptance criteria shall conform to Table 10 for full size specimens, or Table 11 when sub-size specimens are being used.

If subsize specimens are used, the Charpy V-notch impact requirements shall be equal to that of the 10 mm x 10 mm specimens multiplied by the adjustment factor listed in Table 11.

For PSL 4, subsize specimens shall not be used.

Table 10—Charpy V-notch Impact Requirements—10 mm x 10 mm

Temperature		Minimum Average Impact Value, J (ft-lb)			
		Transverse Direction [a]		Longitudinal Direction	
		Wrought and Cast Material, Weld Qualification		Alternative for Wrought Materials Only	
Class	Test °C (°F)	PSL 1 and PSL 2	PSL 3 and PSL 4	PSL 1 and PSL 2	PSL 3 and PSL 4
K	–60 (–75)	20 (15)	20 (15)	27 (20)	27 (20)
L	–46 (–50)	20 (15)	20 (15)	27 (20)	27 (20)
N	–46 (–50)	20 (15)	20 (15)	27 (20)	27 (20)
P	–29 (–20)	20 (15)	20 (15)	27 (20)	27 (20)
S	–18 (0)	—	20 (15)	—	27 (20)
T	–18 (0)	—	20 (15)	—	27 (20)
U	–18 (0)	—	20 (15)	—	27 (20)
V	–18 (0)	—	20 (15)	—	27 (20)

FOOTNOTE
[a] Castings have no directionality

Table 11—Adjustment Factors for Subsize Impact Specimens (PSL 1 to PSL 3)

Specimen Dimension	Adjustment Factor	Minimum Average Impact Value	
		Transverse Direction Wrought and Castings J (ft-lb)	Longitudinal Direction Wrought [a] J (ft-lb)
10 mm x 10 mm (full size)	1 (none)	20 (15)	27 (20)
10 mm x 7.5 mm	0.833	17 (13)	23 (17)
10 mm x 6.7 mm	0.780	16 (12)	21 (16)
10 mm x 5.0 mm	0.667	13 (10)	18 (13)
10 mm x 3.3 mm	0.440	9 (7)	12 (9)
10 mm x 2.5 mm	0.333	7 (5)	9 (7)

FOOTNOTE
[a] Castings have no directionality.

6.3.2.3.2 Test Method

For wrought and cast materials, impact tests shall be performed in conformance with the procedures specified in 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.

For additively manufactured materials, CVN impact tests shall conform to ASTM A370, ASTM E23, or ISO 148-1.

NOTE 1 Refer to ISO 148-1 for further details.

To qualify material for a temperature rating, impact tests shall be performed at or below the lowest temperature shown in Table 10 for that temperature range.

For wrought or cast materials, three impact specimens shall be tested. Impact properties as determined from these tests shall satisfy the applicable requirements of Table 10 or Table 11. In no case shall an individual impact value fall below two-thirds of that required as a minimum average. No more than one of the three test results shall be below the required minimum average.

For additively manufactured materials, the number of samples shall conform to API 20S. The acceptance criteria shall conform to the relevant design and material standards as specified in the material specification, product specification, and/or manufacturing procedure specification (MPS). The impact test results at a minimum shall satisfy the applicable requirements of Table 10.

NOTE 2 Where no acceptance criteria are shown in Table 10, impact testing is not required.

6.3.2.3.3 Retesting

To qualify the material if the results of the impact test(s) do not satisfy the applicable requirements, the following shall apply, with no additional heat treatment:

a) for wrought or cast materials, one additional impact test shall be performed, consisting of three specimens removed from the required location within the same QTC; and,

b) for additively manufactured materials, retesting shall conform to API 20S.

Each test specimen shall exhibit an impact value equal to or exceeding the required minimum average value of Table 10 or Table 11.

6.3.2.3.4 Specimen Orientation

The values listed in Table 10 and Table 11 shall be the minimum acceptable values for wrought materials tested in the transverse direction, and for castings and weld qualifications.

Wrought materials may be tested in the longitudinal direction instead of the transverse direction and shall conform to the requirements of Table 10 and Table 11.

Castings have no directionality; the values of the transverse direction of Table 10 and Table 11 shall apply.

For additively manufactured materials, CVN impact specimens shall be oriented as required in API 20S.

6.3.2.4 QTC Hardness Testing (Additively Manufactured Materials Only)

6.3.2.4.1 Test Specimens

For additively manufactured materials, the number of samples shall be based on the applicable PSL and the corresponding AMSL in conformance with the PSL-AMSL cross reference Table 7.

6.3.2.4.2 Test Method

For additively manufactured materials only, hardness testing shall conform to API 20S and the applicable procedures specified in ISO 6506, ASTM E10 (Brinell), ISO 6508, ASTM E18 (Rockwell), ISO 6507, or ASTM E92 or ASTM E384 (Vickers). A specific hardness test method shall be selected based on requirements of relevant material or product specifications.

Acceptance criteria shall conform to the design and material standards as stated in the applicable material specification, product specification, and/or manufacturing procedure specification (MPS).

6.3.3 Processing

6.3.3.1 Casting Practices

For PSL 1, all castings used for bodies, bonnets, and end and outlet connectors shall conform to the applicable requirements of Section 6 and Section 10. The casting practices shall be qualified to casting specification level (CSL) 2 foundry qualification requirements in API 20A, as a minimum.

For PSL 2 and PSL 3, all castings used for bodies, bonnets, and end and outlet connectors shall conform to the applicable requirements of Section 6 and Section 10. The casting practices shall be qualified to CSL 3 foundry qualification requirements in API 20A.

NOTE 1 For PSL 4, this section does not apply as only wrought material is permitted.

NOTE 2 The production sampling in Section 10 for PSL 1 and PSL 2 bodies, bonnets, and end and outlet connectors is intended to monitor control of casting practices.

6.3.3.2 Hot Working Practices

For PSL 1, PSL 2, PSL 3, and PSL 4, all wrought materials shall be formed using hot working practices that produce a wrought structure throughout (see 6.4.3.1.3).

6.3.3.3 Melting Practices

For PSL 1, PSL 2, and PSL 3, the manufacturer shall specify melting practices.

For PSL 4, the melting practice requirements shall be identical to those for PSL 1, PSL 2, and PSL 3 with the addition that the manufacturer shall document the melting practice used for PSL 4 material.

6.3.3.4 Additive Manufacturing

6.3.3.4.1 General

For PSL 1, PSL 2 and PSL 3, equipment and components produced from additively manufactured materials shall conform to the applicable requirements of Section 6 and Section 10. The manufacturing practices shall be qualified to AMSL specified in Table 7.

NOTE Additive manufacturing introduces unique metallurgical and geometrical conditions that may or may not be completely removed in the final part.

NOTE Additional usage restrictions are given in section 5.1.3 for additively manufactured materials.

Supplemental requirements of 6.3.3.4.2 shall apply when specified by the manufacturer or the purchaser.

6.3.3.4.2 Supplementary Requirements

6.3.3.4.2.1 As-Printed Surface and Support Contacts

If a component surface is subject to fatigue or corrosive service, as-printed surface finishing and support contacts shall be removed by machining, or a process otherwise specified by the purchaser, unless the design margin applies based on documented performance testing of surfaces representative of the actual part with as-printed surface.

When practicable, critical regions of the additively manufactured material used in equipment or components shall avoid support structure contacts.

6.3.3.4.2.2 Interfaces

Performance of the intersection of deposition paths (e.g., substrate interface, stitching, change of directionality or build path, change of build angle) shall be assessed during first article qualification in conformance with the applicable AMSL (see API 20S).

6.3.3.4.2.3 Start /Stop

Critical sections shall not include start/stop locations.

6.3.3.4.2.4 Ability to Inspect

All accessible surfaces and volumes (part volume or internal cavities hidden from line-of-sight) shall be inspected in conformance with the quality control requirements in Section 10. Selection and qualification of NDT techniques according to the final part geometry shall be based on ability to satisfy this requirement. If the part cannot be inspected by NDT, then other manufacturing methods shall be used in conformance with manufacturer requirements.

6.3.3.4.3 Post-processing

Post-additive manufacturing processing steps impacting conformance to the applicable part requirements including NDT and materials testing shall be specified in the Manufacturing Process Specification (MPS) in conformance with API 20S. Post-processing shall include, but is not limited to, thermal post processing (see 6.3.4), powder removal and cleaning, separation from the build platform and support structure, surface treatment (e.g., peening, texturing, coating), and machining.

The manufacturer shall qualify the post-processing activities in conformance with first article inspection conforming to API 20S. Qualification Test Coupons for first article and production inspection shall conform to API 20S and 6.4.

NOTE: As-built condition refers to the state of parts fabricated from the additive manufactured process before any post processing, besides the removal from a build platform as well as the removal of support and/or unprocessed feedstock. As-built parts contain residual stress, surface and dimensional conditions that may be undesirable for the part performance.

6.3.4 Heat-treating

6.3.4.1 General

6.3.4.1.1 Furnace and Related Devices

All heat-treatment operations shall be performed using heat-treatment equipment qualified in conformance with the requirements specified by the manufacturer and in 6.5.

6.3.4.1.2 Additive Manufacturing Additional Requirements

Heat treatment of additively manufactured materials shall conform to 6.3.4 and API 20S. Additively manufactured materials used in PSL 3 equipment or components shall conform to the heat treatment requirements for PSL 4 as specified in 6.3.4.

6.3.4.2 Temperature

For PSL 1, PSL 2, and PSL 3, time at temperature and thermal cycles shall conform to the manufacturer's heat-treatment specifications.

For PSL 4, the following shall apply.

— The temperature requirements of PSL 1, PSL 2, and PSL 3 shall apply with the addition that the temperature levels for PSL 4 parts shall be monitored by using a contact thermocouple or heat sink.

— The heat sink shall be made of the same class of material if the parts are made of an alloy of the following classes: carbon steel, alloy steel, stainless steel, titanium-based alloy, nickel-copper alloys, and nickel-based alloys.

— For parts that do not meet one of the preceding classes, the heat sink shall be made from the same alloy as the part. The equivalent round (ER) section of all heat sinks shall be determined in conformance with the methods of 6.4.2. The ER of the heat sink shall be greater than or equal to the largest ER of any single part in a heat-treatment load.

NOTE As an alternative, a production part may serve as the heat sink, provided all the requirements of 6.3.4.2 are satisfied.

The temperature-sensing tip of the thermocouple shall be within the part or heat sink and be no closer than 25 mm (1 in.) to any external or internal surface.

6.3.4.3 Quenching (for Quenched and Tempered Materials)

6.3.4.3.1 Water Quenching

The temperature of the water shall not exceed 38 °C (100 °F) at the start of the quench. For bath-type quenching, the temperature of water shall not exceed 49 °C (120 °F) at any time during the quench cycle.

6.3.4.3.2 Other Quenching Media

The temperature range of other quenching media, such as oil or polymer, shall conform to the manufacturer's written specification.

6.3.5 Chemical Composition

6.3.5.1 General

The manufacturer shall specify the chemical composition limits of the material. For wrought and cast materials, material composition shall be determined on a heat basis (or a remelt-ingot basis for remelt-grade materials) in conformance with a nationally or internationally recognized standard.

For additive manufacturing the number of specimens and testing requirements shall be based on the criticality levels (AMSL 1, AMSL 2 and AMSL 3) as specified in API 20S. Minimally, one specimen per build batch shall be required.

Acceptance criteria shall conform to the manufacturer's materials specification.

6.3.5.2 Composition Limits—Requirements

Bodies, bonnets, and end and outlet connectors manufactured from carbon, low-alloy, and martensitic stainless steels (other than precipitation-hardening types) shall conform to the compositional limits given in Table 12.

Table 12—Phosphorus and Sulfur Composition Limits

Product Specification Level	Part % mass fraction	
	Phosphorus	Sulfur
PSL 1	0.040 max.	0.040 max.
PSL 2	0.040 max.	0.040 max.
PSL 3	0.025 max.	0.025 max.
PSL 4	0.015 max.	0.010 max.

NOTE For guidance on typical steel composition limits, see B.5.2 and Table B.2

6.4 Qualification Test Coupons

6.4.1 General

QTCs shall qualify only material and parts produced from the same heat. The properties exhibited by the QTCs shall conform with the design requirements of the production part, or parts it qualifies.

QTCs shall be one of the following:

— a separately forged or formed coupon,

— a keel block (for castings only),

— a trepanned core,

— a prolongation,

— a sacrificial part,

Trepanned cores shall be extracted after final heat treatment of the part.

When a prolongation is used, it shall remain integrally attached during all heat-treatment operations. Prolongations for parts which require post-weld heat-treatment, stress relief, or any re-tempering or re-aging are not required to be integrally attached during the stated heat treatment operations.

For a production part with a complex shape or varying cross-section, it is not necessary that the prolongation be an extension of the largest cross-section of the part, but the extension shall conform to or exceed the minimum ER required for a separate QTC.

For pipe, tubing, bar stock and mill shapes which are heat-treated in a continuous furnace, the QTC shall be a sacrificial production part or a prolongation removed from a production part. The sacrificial production part or prolongation QTC shall qualify only production parts having an identical size and shape, and from the same heat and heat-treat lot.

NOTE Depending on the hardenability of a given material, the QTC results might not always correspond to the properties of the actual parts at all locations throughout their cross-section. API 6HT provides guidance and good practices for heat-treatment of parts and selection of QTC type, with the goal of achieving the required mechanical properties at the depth below the surface established by the equipment manufacturer.

Additive manufacturing qualification test coupons shall conform to test specimen requirements (AMSL 1 or AMSL 2 or both) or the sacrificial component requirements (AMSL 3) as specified in API 20S.

6.4.2 Equivalent Round

6.4.2.1 ER Methods for Wrought Components

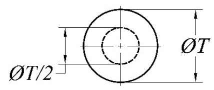
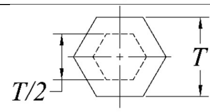
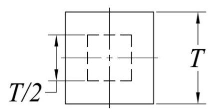
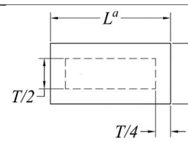
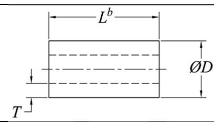
Typical basic models for determining the ER of simple solid and hollow parts and QTCs of wrought materials shall apply as illustrated in Figure 4. ER can be calculated using Equation 2.

$$ER = G \times T \qquad \text{Equation (2)}$$

where:

G is a geometric factor constant to relate the shown simple shape to its equivalent round shape;

T is the thickness of the cross section or critical section at the time of heat treatment, as shown in Figure 4a, defined and documented by the manufacturer.

Shape	Figure [C]	ER	G
Round		T	1
Hexagon		$1.1 \cdot T$	1.1
Square		$1.25 \cdot T$	1.25
Rectangle		$1.5 \cdot T$	1.5
Hollow		$2 \cdot T$	2

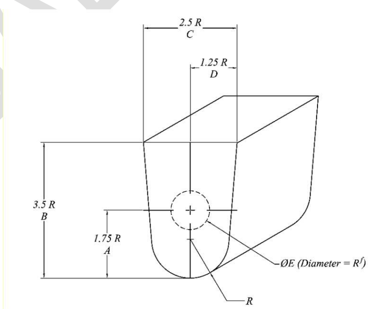
FOOTNOTE

[a] L shall be at least 36% larger than T (i.e., L ≥ 1.36T) to be considered as a rectangular shape; otherwise, a square shall be used as an approximate shape where the L dimension from the rectangle shall be used as T in the square formula.

[b] When L is less than D, consider as a plate of T thickness.

[C] The area inside the dashed lines shows the 1/4 T envelope, except for hollow shape.

a) — Simple Geometric ER Models



[f] This area the center core 1/4 T envelope for test specimen removal.

b) —Keel Block ER Models

Figure 4—Equivalent Round Models

The ER of complex shaped parts (including studded type parts) shall be established as the diameter of the largest circle which can be inscribed at the critical section at the time of heat treatment. When the ER of complex shapes is calculated, the critical section shall be defined and documented by the manufacturer.

NOTE Complex shaped parts are those in which the geometry of the part makes the heat treatment more difficult than those of a simple solid or hollow shape (for example, parts with intricate contours and/or intersecting bores).

6.4.2.2 ER Methods for Cast Components

ER calculations for cast components or parts shall follow 6.4.2.1, except that the ER calculation for a keel block shall be, ER = 2.3×R. Where, R is the radius of the base of the keel block. Keel block dimensions shall be per Figure 4b.

NOTE Table 13 shows dimensions for common ERs based on different values of R.

Table 13—Keel Block Dimensions for Commonly Used QTC ERs

Dimension	ER = 63 mm (2.5 in.) mm (in.)	ER = 127 mm (5 in.) mm (in.)	ER = 254 mm (10 in.) mm (in.)
A	48.45 (1.9075)	96.46 (3.7975)	193.36 (7.6125)
B	96.90 (3.815)	192.91 (7.595)	386.72 (15.225)
C	69.22 (2.725)	137.80 (5.425)	276.23 (10.875)
D	34.61 (1.3625)	68.90 (2.7125)	138.11 (5.4375)
E	27.69 (1.09)	55.12 (2.17)	110.49 (4.35)
R	27.69 (1.09)	55.12 (2.17)	110.49 (4.35)

NOTE Keel block dimensions / configuration is different from API 20A.

6.4.2.3 ER Sizing Requirements

When the size of the QTC is determined by calculating the actual ER of the part, the ER of the part shall be calculated in conformance with 6.4.2.1 or 6.4.2.2. If the actual ER of the part is used as the basis for determining the size of the QTC, the ER of the QTC shall be equal to or greater than the ER of the part it qualifies.

NOTE See 6.1.4 for limitations on castings.

If the actual ER of the part is not being used to determine the size of the QTC, the QTC shall conform to the following minimum size requirements:

For PSL 1 and PSL 2, the ER of the QTC shall be equal to or greater than 63 mm (2.5 in.)

For PSL 3, the ER of the QTC shall be equal to or greater than 127 mm (5 in.)

In addition for PSL 3, carbon and low-alloy steel (excluding 2$^1/_4$ Cr1Mo low-alloy steel) bodies that require a design yield strength of 75K or greater and where the part's weight during heat-treat is greater than 454 kg (1000 lb), the QTC ER shall be 254 mm (10 in.), or greater, unless the following exception applies.

At the manufacturer's option, a 127 mm (5 in.) ER QTC shall be permitted for parts with an ER greater than 127 mm (5 in.) provided that:

— design documentation provides the stress distribution and demonstrates that the part meets the design acceptance criteria of Section 5 where the mechanical properties are lower than the requirements specified in 6.3 for the QTC;

— a qualification forging or a sacrificial part is used to validate the mechanical properties that satisfy the acceptance criteria of the analysis at a depth of 63 mm (2.5 in.) or T/4, whichever is less, at the critical section(s) as identified by the stress distribution in the design documentation;

— a qualification forging or a sacrificial part is used to document that the part meets the Charpy impact requirements of this specification at a depth of 63 mm (2.5 in.) or T/4 of the critical section(s) of the parts, whichever is less; and

— a qualification forging or a sacrificial part having the same heat-treat geometry, material grade, and heat-treat parameters as defined by the manufacturer is used to qualify all the production parts covered by the analysis.

NOTE 3 A QTC larger than 254 mm (10 in.) ER may be used when specified by the manufacturer or purchaser.

For PSL 4, a prolongation or production part shall be used.

6.4.3 Processing

6.4.3.1 Melting, Casting, and Hot Working

6.4.3.1.1 Melting Practices

In no case shall the QTC be processed using a melting practice(s) cleaner than that of the material it qualifies [e.g. a QTC made from a remelt-grade or vacuum-degassed material shall not qualify material from the same primary melt that has not experienced the identical melting practice(s)]. Remelt-grade material removed from a single remelt ingot may be used to qualify other remelt-grade material that is from the same primary melt; no additional alloying shall be performed on the individual remelt ingots. However, remelt-grade (consumable electrode process) material used to fabricate parts having a PSL 4 shall be qualified on a remelt-ingot basis.

6.4.3.1.2 Casting Practices

The manufacturer shall use the same foundry practice(s) for the QTC as those used for the parts it qualifies.

6.4.3.1.3 Hot Working Practices

The manufacturer shall use on the QTC hot work ratios that are equal to or less than those used in processing the production part(s) it qualifies. The total hot work ratio for the QTC shall not exceed the total maximum hot work ratio of the part(s) it qualifies.

NOTE API 20B and API 20C provide guidance on hot work ratios.

6.4.3.2 Welding

Welding on the QTC shall not be permitted, except for attachment-type welds.

6.4.3.3 Heat-treating

6.4.3.3.1 Batch-type Furnace Heat-treatment

Batch heat-treatment shall be performed using heat-treatment equipment qualified in conformance with 6.5.

For PSL 1, PSL 2, and PSL 3, the QTC shall go through the same specified heat-treatment as the part(s) it qualifies. The QTC shall be heat-treated using the manufacturer's specified heat-treating procedure(s).

If the QTC is not heat-treated as part of the same heat-treatment lot as the part(s) it qualifies, the following shall apply.

— The austenitizing, solution-treating, or age-hardening (as applicable) temperatures for the QTC shall be within 14 °C (25 °F) of those for the part(s).

— The tempering temperature for the part(s) shall not be lower than 14 °C (25 °F) below that of the QTC.

— The upper temperature limit shall not be higher than that permitted by the heat-treat procedure for that material.

— The cycle time of the QTC at each temperature shall not exceed that for the part(s).

For PSL 3, for mandrel hangers where the design requires a material designation of 75K or greater and for bodies where the design requires a material designation of 75K or greater and where the weight of the body during heat-treat is greater than 454 kg (1000 lb), the QTC shall be heat-treated in the same or same type of heat-treat furnace and same or same type of quench tank as the production parts that it qualifies.

NOTE The QTC is most representative of the part or parts it qualifies if it accompanies the part or parts through the entire heat-treatment cycle. See API RP 6HT for additional guidance.

For PSL 4 only, the QTC shall be an integral prolongation or sacrificial part applied per heat per heat treat lot. Individual prolongations or production parts corresponding to each quench shall be used for multiple quench batches from the same furnace load.

NOTE The batch heat-treatment requirements of PSL 4 do not apply to PSL 1, PSL 2, and PSL 3.

6.4.3.3.2 Continuous-type Furnace Heat-treatment

Continuous heat-treatment shall be performed using heat-treatment equipment qualified in conformance with 6.5.

For material heat-treated in a continuous furnace, the QTC shall be from the same heat and heat-treat lot as the material it qualifies.

6.4.4 Material Qualification

6.4.4.1 Tensile and Impact Test Specimens

If tensile or impact specimens are required, the following shall apply:

– Test specimens shall be removed from a QTC after the final QTC heat-treatment cycle.

– Test specimen dimensions shall conform to ASTM A370.

– Test specimens shall be removed from the QTC such that their longitudinal centerline axis is wholly within the center core 1/4T envelope for a solid QTC or within 3 mm (1/8 in.) of the mid-thickness of the thickest section of a hollow QTC (see Figure 4).

– If a production part is used as a QTC, the test specimens shall be removed from a section of the part meeting the size requirements for a QTC for that production part as defined in 6.4.2.

NOTE 1 Multiple QTCs may be used, provided that all the applicable QTC requirements of this specification are satisfied.

NOTE 2 For QTCs larger than the size specified in 6.4.2.3, it is not necessary that the test specimens be removed from a location farther from the QTC surface than otherwise if a specified QTC size were used.

When tensile specimens are required, the following shall also apply:

– Test temperature shall conform to the requirements specified in 6.3.2.2

- Standard-sized, 12.5 mm (0.500 in.) diameter round test specimens shall be used. If the physical configuration of the QTC prevents the standard-size, the next smaller standard-sized (i.e. standard subsized) test specimen obtainable shall be used.

– Test specimens shall be removed from the QTC such that the tensile specimen gauge length is at least 1/4T from any heat treated surface of the QTC.

When impact specimens are required, the following shall also apply:

– Test temperature shall conform to the requirements specified in 6.3.2.3.

– Standard-sized, 10 mm x 10 mm Charpy V-Notch test specimens shall be used. If the physical configuration of the QTC prevents the standard-size, the next smaller standard-sized Charpy V-Notch (i.e. standard subsized) test specimen obtainable shall be used. For PSL 4, subsize specimens shall not be used.

– Test specimens shall be removed from the QTC such that the impact specimen notch root is at least 1/4T from any heat treated surface of the QTC.

6.4.4.2 Hardness Testing

At least one Rockwell or Brinell hardness test shall be performed on the QTC after the final heat-treatment cycle.

Hardness testing shall be performed in conformance with the procedures in ISO 6506 or ISO 6508, or ASTM E10, ASTM E18, or ASTM E110.

The QTC heat-treatment cycles prior to hardness testing shall conform with 6.4.3.3.

6.5 Production Heat-treating Equipment

6.5.1 General

Parts and QTCs shall be heat treated with production heat-treating equipment conforming to the requirements of this specification.

Heat-treatment of production parts shall be performed with heat-treating equipment that satisfies one of the following:

— Heat-treatment equipment has been calibrated and surveyed in conformance with API 20H HSL1, HSL2, HSL3 for batch type furnaces; or,

— Heat-treatment equipment has been calibrated and surveyed in conformance with SAE AMS 2750 or SAE AMS-H-6875, for continuous type furnaces.

Automatic controlling and recording instruments shall be used.

Thermocouples shall be placed in the furnace working zone(s) and protected from furnace atmospheres by means of suitable protective devices.

NOTE 1 The equipment calibration and survey requirements for batch furnaces specified in this section are equivalent to those specified in the 21st edition, and earlier, of API 6A (including Annex A). SAE AMS 2750 heat treatment equipment calibration and furnace survey requirements are equivalent to API 20H HSL 3.

NOTE 2 API 20H contains additional batch-type heat treatment processing controls that may be appropriate for the PSLs in this standard. API RP 6HT contains batch-type and continuous-type heat treatment processing information that may be appropriate for the PSLs in this standard.

NOTE 3 Requirements for heat treatment calibration and furnace survey from Annex M prior to the 22nd edition are shown in Annex A.

6.5.2 Production Type Equipment—Batch-type Furnaces

6.5.2.1 Furnace Survey Temperature Variation

Furnace survey temperature variation shall conform to the requirements of Annex A.

6.5.2.2 Temperature Uniformity Survey Frequency

Furnace temperature uniformity survey frequency shall conform to the requirements of Annex A.

6.5.2.3 Furnace Repairs

When a furnace is repaired or rebuilt, a new temperature survey shall be performed 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 previous 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 AMS2750 sections on furnace modifications and furnace repairs shall be used to determine whether a new furnace survey is required. All furnace repairs and modifications shall be documented, and the responsible quality assurance entity shall make determination whether an additional furnace survey and calibration is required based on the repairs or modifications in conformance with SAE AMS2750 or SAE AMS-H-6875.

6.5.3 Production Type Equipment–Continuous-type Furnaces

Continuous-type furnaces shall be operated, maintained, modified, and repaired in conformance with SAE AMS2750 or SAE AMS-H-6875.

Continuous-type furnaces shall be surveyed in conformance with Annex A.

NOTE See API 6HT and API 20N for guidance on continuous heat-treating process.

7 Welding

7.1 Limitation

Section 7 shall not apply to material surface property controls, such as thermal spray processes [e.g. high-velocity oxygen fuel (HVOF)].

7.2 Non-pressure-containing Welds Other Than Weld Overlays

7.2.1 Welding Procedure/Performance

For PSL 1, PSL 2, PSL 3, and PSL 4, welding procedures and performance qualifications shall be in conformance with the following:

— ASME *BPVC*, Section IX, or

— ISO 15609 (procedures), applicable parts of ISO 15614 (qualification testing), and applicable parts of ISO 9606 [welder performance qualification (WPQ)].

7.2.2 Application

For PSL 1, PSL 2, PSL 3, and PSL 4, the following shall apply.

— Welding shall be performed in conformance with qualified procedures by qualified welding personnel. Non-pressure-containing welds shall conform to the manufacturer's design requirements.

— For welding performed in conformance with ISO qualified welding procedures, welding work and related activities should follow requirements in the relevant parts of ISO 3834. As a minimum, ISO 3834-Part 3 shall be adhered to in addition to specific requirements as established in this specification.

7.3 Pressure-containing Fabrication Welds

7.3.1 General

Fabrication welding shall not be performed on bullplugs and valve-removal plugs.

7.3.2 Joint Design

For PSL 1, PSL 2, PSL 3, and PSL 4, design of groove and fillet welds with tolerances shall be documented in the manufacturer's specifications.

7.3.3 Materials

7.3.3.1 Welding Consumables

For PSL 1, PSL 2, PSL 3, and PSL 4, welding consumables shall conform to the requirements of the welding procedure specification (WPS). The manufacturer shall have a written procedure for storage and control of welding consumables. Welding consumables shall be stored and used as recommended by the manufacturer of the welding consumable.

7.3.3.2 Deposited Weld Metal Properties

For PSL 1, PSL 2, PSL 3, and PSL 4, the deposited weld metal mechanical properties, as determined by the procedure qualification record (PQR), shall conform to or exceed the mechanical properties specified for the design of the part.

7.3.4 Welding Procedure Qualifications

7.3.4.1 Written Procedure

For PSL 1, PSL 2, PSL 3, and PSL 4, the following shall apply.

— Welding shall be performed in conformance with WPS, written and qualified in conformance with ASME *BPVC*, Section IX or ISO 15609. The WPS shall be qualified by use of welding procedure test as required in ASME *BPVC*, Section IX or ISO 15614-1. The WPS shall describe all the essential, nonessential, and supplementary essential variables.

— The PQR (ASME *BPVC*, Section IX) or welder performance qualification record (WPQR) (ISO 15614-1) shall record all essential and supplementary essential (if required) variables of the weld procedure used for qualification testing. Both the WPS and the PQR shall be maintained as records in conformance with the requirements of Section 15.

NOTE In this specification, reference to WPQR (ISO 15614-1) is equivalent to PQR (ASME *BPVC*, Section IX).

7.3.4.2 Base Metal Groupings

For PSL 1, PSL 2, PSL 3, and PSL 4, the following shall apply.

— For welding procedures in conformance with ASME *BPVC*, Section IX, base material(s) not listed in P-number grouping shall be specifically qualified by the manufacturer.

— For welding procedures in conformance with applicable parts of ISO 15614, grouping shall be as defined by applicable parts of ISO 15614.

7.3.4.3 Heat-treatment

For PSL 1 and PSL 2, if post-weld heat-treatment is required by the WPS, all testing shall be done with the test weldment in the post-weld heat-treated condition. Post-weld heat-treatment of the test weldment shall conform to manufacture written specifications.

For PSL 3 and PSL 4, in addition to the requirements for PSL 1 and PSL 2, the post-weld heat-treatment of the test weldment shall be in the same temperature range as that specified on the WPS. The difference between the upper and lower allowable temperature limits shall not exceed 28 °C (50 °F).

7.3.4.4 Hardness Testing

For PSL 1, PSL 2, PSL 3, and PSL 4, the following shall apply.

— For material classes DD, EE, FF, and HH, hardness tests across the weld and base-material heat-affected zone (HAZ) cross-section shall be performed and recorded as part of the PQR. Hardness test locations and results shall be in conformance with NACE MR0175/ISO 15156.

— For material classes AA, BB, and CC, the manufacturer shall specify the hardness testing locations. Testing shall be performed on the weld and base-material HAZ cross-section in conformance with ASTM E18 or ISO 6508 , Rockwell method; or ISO 6507, using the 98 N method or ASTM E92 Vickers 10 kgf method. Results shall be converted to Rockwell C, as applicable. ASTM E140 or ISO 18265 shall be used for the conversion of hardness readings for materials within the scope of their application.

NOTE 1 Other correlations may be established for individual materials that are outside the scope of ISO 18265 or ASTM E140.

— When a conversion other than ASTM E140 or ISO 18265 conversion is used, the conversion method shall be documented and shall be based on validated test results. The measured hardness and test scale shall be reported in parentheses.

NOTE 2 For example, 20.0 HRC (228 HBW), where 20.0 HRC is the converted hardness value and 228 HBW is the original measurement value and test scale.

7.3.4.5 Hardness Testing for Minimum Mechanical Properties

When specified by the manufacturer or purchaser, the following shall apply.

— For PSL 1, PSL 2, PSL 3, and PSL 4, for the purposes of hardness inspection and qualifying production welds, a minimum of three hardness tests in the weld metal shall be made and recorded as part of the PQR.

— The three hardness tests shall be made by the same methods as used to inspect production welds.

NOTE These tests may be used to qualify weld metal with a hardness lower than that established in 10.4.2.4.3 in conformance with the methods shown in 10.4.2.4.2.

7.3.4.6 Impact Testing

For PSL 1, PSL 2, PSL 3, and PSL 4, the following shall apply.

— If impact testing is required for the base material, the testing shall be performed in conformance 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.

— Results of testing in the weld and base-material HAZ shall conform to the requirements specified for the design of the part. Records of results shall become part of the PQR. Any retests of impact testing shall be in conformance with ISO 148-1 or ASTM A370.

— If a test fails, then a retest of three additional specimens removed from the required location within the same test coupon (per ASME *BPVC*, Section IX) with no additional heat-treatment may be made, each of which shall exhibit an impact value equal to or exceeding the required minimum average value per Table 10 or Table 11.

For PSL 2, PSL 3, and PSL 4, the following additional impact test requirements apply.

If impact testing is required for the base material, two sets of three test specimens shall be removed: one set from the weld metal and one set from the base-material HAZ. At least one face of each specimen shall be within $^{1}/_{4}T$ of the surface of the material, where T is the thickness of the weld. The root of the notch shall be oriented normal to the surface of the test weld and located as follows:

— weld metal specimens (three each):100 % weld metal;

— HAZ specimens (three each): to include as much HAZ material as possible.

NOTE The additional impact testing requirements do not apply to PSL 1.

7.3.4.7 Chemical Analysis

For PSL 3 and PSL 4, chemical analysis of the base materials and filler metal for the test weld shall be obtained from the supplier or by testing and shall be part of the PQR.

NOTE The requirements of 7.3.4.7 do not apply to PSL 1 and PSL 2.

7.3.5 Welder Performance Qualification

For PSL 1, PSL 2, PSL 3, and PSL 4, welders and welding operators shall be qualified in conformance with ASME *BPVC*, Section IX or ISO 9606. Records of welder WPQ tests shall be in conformance with ASME *BPVC*, Section IX or ISO 9606.

7.3.6 Welding Requirements

For PSL 1, PSL 2, PSL 3, and PSL 4, the following shall apply.

— Welding shall conform to the qualified WPS and shall be performed by qualified welders/welding operators.

— Welders and welding operators shall have access to, and shall conform to, the welding parameters as defined in the WPS.

— All welds that are considered part of the design of a production part shall be specified by the manufacturer to describe the requirements for the intended weld.

— Preheating of assemblies or parts, if required by the WPS, shall be performed in conformance with the manufacturer's written procedures.

7.3.7 Post-weld Heat-treatment

If post-weld heat treatment is required by the qualified WPS, the following shall apply.

For PSL 1,

— Post-weld heat-treatment shall be in conformance with the applicable qualified WPS.

— Welds may be locally post-weld heat-treated. The manufacturer shall specify procedures for the use of local post-weld heat-treatment.

— In the case of low-alloy quenched and tempered steels, the post-weld heat-treatment temperature shall be below the tempering temperature.

For PSL 2,

— The requirements for PSL 1 shall apply.

— Additionally, furnace post-weld heat-treatment shall be performed with equipment meeting the requirements of Annex A.

— Additionally, local post-weld heat-treatment shall consist of heating a circumferential band around the weld at a temperature within the range specified in the qualified WPS. The minimum width of the controlled band, on each side or end of the weld, shall be the widest width of the weld plus either the nominal thickness of the part or 50 mm (2 in.), whichever is less. Heating by direct flame impingement on the material shall not be permitted.

NOTE 1 The additional post-weld heat-treatment requirements of PSL 2 do not apply to PSL 1.

For PSL 3 and PSL 4,

— The requirements of PSL 2 shall apply.

— Additionally, the post-weld heat-treatment of the production weldment shall be in the same temperature range as that specified on the WPS. The stress-relieving heat-treatment time(s) at temperature of production parts shall be equal to or greater than that of the test weld.

NOTE 2 The additional post-weld heat-treatment requirements of PSL 3 and PSL 4 do not apply to PSL 1 and PSL 2.

7.3.8 Welding Controls

For PSL 1 and PSL 2, the following shall apply.

— The manufacturer's welding control system shall include procedures for monitoring, updating, and controlling the qualification of welders/welding operators and the use of WPS.

— For welding performed in conformance with ISO qualified welding procedures, welding work and related activities should follow requirements in the relevant parts of ISO 3834. As a minimum, ISO 3834-Part 3: *Standard Quality Requirements* shall be adhered to in addition to specific requirements as established in this specification.

— Instruments to indicate temperature, voltage, and amperage shall be serviced and calibrated in conformance with the manufacturer's written specifications.

For PSL 3 and PSL 4, the following shall apply.

— In addition to the requirements for PSL 1/PSL 2, instruments, meters, and gauges used to confirm welding parameters shall be serviced and calibrated to the manufacturer's written specifications by devices traceable to a nationally or internationally recognized standard specified by the manufacturer.

— The calibration intervals shall be a maximum of 6 months until recorded calibration history can be established by the manufacturer. Intervals may be lengthened (6-month maximum increment) or shall be shortened based on the recorded history. Written records shall document the calibration date, procedure used, accuracy, frequency, and hardness results.

NOTE The additional welding control requirements of PSL 3 and PSL 4 do not apply to PSL 1 and PSL 2.

7.4 Pressure-containing Repair Welds

7.4.1 General

The requirements of 7.4 shall apply to PSL 1, PSL 2, PSL 3, and PSL 4, unless otherwise noted.

7.4.2 Welding Procedure Qualifications

7.4.2.1 General

All repair welding procedures shall define the WPS and NDE requirements.

Welding shall be performed in conformance with the specified WPS.

7.4.2.2 Base Material

The base material requirements for material composition, material designation as specified in this specification, impact strength (if required), and heat-treatment condition shall be known prior to selecting a qualified WPS.

7.4.2.3 Fusion

The WPS selected and the access for repair shall ensure complete fusion.

7.4.2.4 Procedure Qualification Record

The WPS selected shall be supported by a PQR as described in 7.3.4.

7.4.2.5 Limitation

Repair welding of bullplugs, valve-removal plugs, and back-pressure valves shall not be allowed.

7.4.2.6 Access

There shall be access to evaluate, remove, and inspect the nonconforming condition (see also 10.4.2.15).

7.4.2.7 Welder/Welding Operator Qualification

The welder/welding operator shall possess a valid qualification in conformance with 7.3.5.

7.4.3 Weld Repair of Castings

Weld repair for castings shall conform to the requirements of API 20A, CSL 3.

Weld repairs shall be documented in conformance with API 20A.

7.4.4 Bolt Hole, Tapped Hole, and Machined Blind Hole Repair

For PSL 2 and PSL 3, the following shall apply.

— The welder/welding operator shall perform an additional repair-welding performance-qualification test using a mock-up hole.

— The repair-welding-qualification test hole shall be qualified by radiography in conformance with 10.4.2.16 or shall be cross-sectioned through the centerline of the hole in two places 90° apart and macro-etched to confirm complete fusion. One surface of each of the four matching segments shall be macro-etched. This evaluation shall include the total depth of the hole.

— The repair-weld qualification shall be restricted by the following essential variables for performance controls.

  — The hole diameter used for the performance-qualification test is the minimum diameter qualified. Any hole with a diameter greater than the diameter used for the test shall be considered qualified.

  — The depth-to-diameter ratio of the test hole shall qualify all repairs to holes with a same or smaller depth-to-diameter ratio.

  — The performance-qualification test hole shall have straight parallel walls. If any taper, counterbore, or other aid is used to enhance the hole configuration of the performance test, that configuration shall be considered an essential variable.

— The requirements of 7.3.4, 7.3.7, and 7.3.8 shall also apply.

NOTE 1 The hole repair requirements of PSL 2 and PSL 3 do not apply to PSL 1 and PSL 4.

For PSL 4, weld repair of bolt holes, tapped holes, and machined blind holes shall not be permitted.

NOTE 2 The hole repair requirements of PSL 4 do not apply to PSL 1, PSL 2, and PSL 3.

7.5 Weld Overlay

7.5.1 Corrosion-resistant Overlay (Including Ring Grooves)

7.5.1.1 General

The provisions of 7.5.1 shall apply to use of corrosion-resistant weld overlay for bodies, bonnets, mandrel hangers, clamp hub end connectors, and end and outlet connectors (including ring grooves).

CRAs used as a weld overlay shall be limited to those which conform to 6.1.4.1.a.

NOTE These requirements do not apply to hard facing or to the weld overlay of valve bore sealing mechanisms, choke trim, or valve stems.

7.5.1.2 Welding Procedure/Performance Qualification

7.5.1.2.1 Qualification

Qualification for weld overlay shall conform to ASME *BPVC*, Section IX, for weld overlay or to ISO 15614-7.

7.5.1.2.2 Thickness

For PSL 1, PSL 2, PSL 3, and PSL 4, the following shall apply.

— The minimum thickness of the finished corrosion-resistant weld overlay applied to material class HH equipment and all other full overlay equipment shall be 3 mm (0.12 in.). The minimum thickness for ring grooves in partial overlay equipment shall be 3 mm (0.12 in.) for the outer 23° surface. The minimum thickness for all other ring groove surfaces shall be equal to or greater than the thickness requirements as established by the weld procedure qualification.

— The minimum thickness of the finished corrosion-resistant weld overlay applied to partial overlay equipment shall be equal to or greater than the thickness requirements established by the weld procedure qualification.

7.5.1.2.3 Chemical Analysis

For PSL 1, PSL 2, PSL 3, and PSL 4, chemical analysis shall be performed on the weld metal in conformance with the requirements of ASME *BPVC*, Section IX or ISO 15614-7. For the nickel-based alloy UNS N06625, the chemical composition shall conform to one of the classes given in Table 14.

NOTE Either Fe5 or Fe10 may be used for any material class.

Table 14—Chemical Composition of the Nickel-based Alloy UNS N06625

Class	**Element**	**Composition** % mass fraction
Fe5	Iron	5.0 max.
Fe10	Iron	10.0 max.

Sampling shall be performed using one of the following.

a) Chemical sampling of the overlay shall be performed at or less than the minimum thickness qualified. The minimum thickness qualified shall be established by the manufacturer based on the design of the finished part and within the limits specified in 7.5.1.2.2. or,

b) Chemical analysis measured from the fusion face shall be permitted if the production acceptance criteria measurements for clad thickness using the eddy current or Hall effect methods account for the penetration depth to the approximate weld interface. The chemical composition of the deposited weld metal at that location shall be as specified by the manufacturer.

— For other compositions that are required to conform to the requirements of NACE MR0175/ISO 15156, the chemical analysis of the overlay shall conform to the specification limits of the corresponding NACE MR0175/ISO 15156 approved material(s).

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

7.5.1.2.4 Mechanical Properties

For PSL 1, PSL 2, PSL 3, and PSL 4, the following shall apply.

— The base metal material shall retain the minimum mechanical property requirements after post-weld heat-treatment. The manufacturer shall specify the methods to ensure these required mechanical properties and record the results as part of the PQR.

— If the overlay material is not considered as part of the manufacturer's or this specification's design requirements of Section 5.1, a tensile test and an impact test of the overlay material shall not be required.

— Other than ring grooves, if the overlay material is considered as part of the manufacturer's design requirements of Section 5.1 or where dimensions for the product are specified in this specification, mechanical testing per Section 6 of the overlay material shall be required.

— If overlay material is only part of the manufacturer's design requirements of Section 5.1, acceptance criteria for mechanical testing of the overlay material shall be as specified in Section 6, or as established by design analysis and specified by the manufacturer.

7.5.1.2.5 Weld Conformance with NACE MR0175/ISO 15156

For PSL 1, PSL 2, PSL 3, and PSL 4, welds for use in H_2S service shall conform to the requirements of NACE MR0175/ISO 15156.

7.5.1.2.6 Guided-bend Tests

For PSL 1, PSL 2, PSL 3, and PSL 4, guided-bend tests and acceptance criteria shall be in conformance with ASME *BPVC*, Section IX or ISO 15614-7 to confirm weld overlay/base material bond integrity.

7.5.1.2.7 Welder Performance Qualification

For PSL 2, PSL 3, and PSL 4, WPQs shall conform to ASME *BPVC*, Section IX; the relevant parts of ISO 9606; or ISO 14732.

NOTE The supplemental requirements of 7.5.1.2.7 do not apply to PSL 1.

7.5.1.3 Base Material Conformance with NACE MR0175/ISO 15156

For PSL 1, PSL 2, PSL 3, and PSL 4, where the base material is required to meet NACE MR0175/ISO 15156, the base material shall conform to NACE MR0175/ISO 15156 after weld overlay and any subsequent heat-treatments.

7.5.1.4 Mechanical Properties

For PSL 2, PSL 3, and PSL 4, the base material shall retain the minimum mechanical property requirements after post-weld heat-treatment. The manufacturer shall specify the methods to ensure these mechanical properties and record the results as part of the PQR.

NOTE The mechanical property requirements 7.5.1.4 do not apply to PSL 1.

7.5.1.5 Hardness Testing for Ring Groove Overlay

For PSL 2, PSL 3, and PSL 4, hardness testing shall be performed in the weld metal as part of the procedure qualification testing. Test locations shall be within 3 mm (0.12 in.) of the original base material. The average of three or more test results shall be equal to or greater than 92 HRB and recorded as part of the PQR.

NOTE The hardness testing for ring groove overlay requirements of 7.5.1.5 do not apply to PSL 1.

7.5.2 Weld Overlay for Other Than Corrosion Resistance

For PSL 1, PSL 2, PSL 3, and PSL 4, the following shall apply.

— Weld overlay for purposes other than those covered by 7.5.1 shall require a welding procedure/performance qualification for weld overlay in conformance with ASME *BPVC*, Section IX or ISO 15614-7.

— Hard facing or other types of weld overlay for use in hydrogen-sulfide service shall conform to the requirements of NACE MR0175/ISO 15156.

— The base material shall retain the minimum mechanical property requirements after post-weld heat-treatment.

— The manufacturer shall specify the methods to ensure these mechanical properties and record the results as part of the PQR.

7.5.3 Repair of Weld Overlays

For PSL 1, PSL 2, PSL 3, and PSL 4, repairs of weld overlays, including associated base metal build-up using the overlay material, shall be acceptable provided that:

— the original applicable requirements (see 7.5.1) are adhered to;

NOTE: PWHT is required when specified by the WPS.

— when the manufacture determines that the overlay material and/or base metal build-up is part of the design requirements of Section 5.1 and proves through design analysis the functionality of the finished part, provided that the finished part is in conformance with the dimensions of this specification;

— weld overlay repairs and associated base metal build-up for use in hydrogen-sulfide service conform to the requirements of ISO 15156 (NACE MR0175).

8 Bolting

8.1 Closure Bolting

8.1.1 Tensile Stress

The maximum tensile stress for closure bolting shall be determined considering initial bolt-up, rated operating conditions, and hydrostatic shell test pressure. Bolting stresses shall not exceed the allowable tensile stress, S_A, given in Equation (3):

$$S_A = 0.83\ S_Y \qquad \text{Equation (3)}$$

where

S_Y *is the bolting material-specified minimum yield strength.*

Bolting stresses shall be determined considering all loading on the closure, including pressure acting over the seal area, gasket loads, and any additional mechanical and thermal loads.

NOTE Fatigue analysis is outside the scope of this specification.

8.1.2 Quality

Closure bolting shall be qualified and manufactured in conformance with API 20E or API 20F. Bolting specification levels (BSLs) shall be as specified in Table 15.

Table 15—Minimum Requirements for Closure Bolting

	API 20E	API 20F
PSL 1	BSL-1	BSL-2
PSL 2	BSL-1	BSL-2
PSL 3	BSL-1	BSL-2
PSL 4	BSL-2 (bolt nominal diameter ≤ $2^1/_2$ in.)	BSL-2 (bolt nominal diameter ≤ $2^1/_2$ in.)

PSL 4	BSL-3 (bolt nominal diameter > 2 1/2 in.)	BSL-3 (bolt nominal diameter > 2 1/2 in.)

8.1.3 Studded Connection

Stud thread engagement shall conform to 14.1.2.10.2. Fully threaded or tap end closure bolting shall be permitted.

NOTE The recommendations of Annex I for closure bolting apply only to those used to connect 6B and 6BX flanged and studded connectors as specified in 14.1.

8.1.4 Closure Bolting Records

If BSL-2 or BSL-3 is specified per Table 15, closure bolting records shall be maintained in conformance with the record requirements of API 20E or API 20F, as applicable.

8.1.5 Closure Bolting Marking

Closure bolting shall be marked in conformance with API 20E and API 20F, as applicable.

8.1.6 Impact Test Marking

If the impact test temperature is different from that specified by the ASTM specification, the actual test temperature, expressed in degrees Celsius (or degrees Fahrenheit), shall be metal-stamped directly under the grade as required by the ASTM specification. The impact test temperatures, expressed in degrees Celsius (or degrees Fahrenheit), for all corrosion-resistant alloy (CRA) material studs shall be metal-stamped directly under the “CRA” marking.

8.2 Closure Bolting for Flanged and Studded End and Outlet Connectors

8.2.1 General

The requirements of 8.2 for closure bolting shall apply only to those used to connect 6B and 6BX flanged and studded connectors as specified in 14.1.

NOTE 1 For closure bolting assembly, see Annex H.

NOTE 2 For calculations and recommendations of stud bolt length, see Annex I.

8.2.2 Design

The requirements for closure bolting shall be as shown in Table 16, Table 17, and Table 18. Closure bolting shall conform to the requirements of the applicable ASTM specification.

Threads shall conform to ASME B1.1, Class 2 or 3. Oversizing of nut threads or undersizing of bolt threads shall not be permitted.

8.2.3 Materials

8.2.3.1 General

Bolting shall conform to the requirements of the applicable ASTM specifications as shown in Table 16 and Table 17.

Alternative materials shall be acceptable if they meet the mechanical requirements of Table 16 and Table 17, and the quality requirements of 8.3.4.

Exposed bolting shall be permitted for use in nonexposed bolting applications.

NOTE See 8.3.2.6 for cautionary statements for bolting

8.2.3.2 Exposed Bolting

The following apply:

a) For ASTM A453/A453M Grade 660D

ASTM A453/A453M Grade 660D solution-treated and age-hardened bolting shall be acceptable at a hardness of HRC 35 and lower, and a minimum 0.2 % offset yield strength of 725 MPa (105,000 psi) for diameters up to 63.5 mm (2.5 in.) or 655 MPa (95,000 psi) for sizes larger than 63.5 mm (2.5 in.). Environmental and material limits specified in NACE MR0175/ISO 15156 shall apply.

b) For ASTM A1082/A1082M Duplex (Ferritic-Austenitic) Grades (DSS)

UNS S32750 and UNS S32760 bolting manufactured in conformance with ASTM A1082/A1082M shall be permitted. DSS bolting shall be solution-treated and have a minimum 0.2 % offset yield strength of 550 MPa (80,000 psi) for diameters up to 101.6 mm (4 in.). Environmental and material limits specified in NACE MR0175/ISO 15156 shall apply.

For applications where the temperatures are greater than 60°C (140°F) the bolting strength at temperature shall be verified to satisfy design requirements for the specified temperature and pressure rating of the equipment.

NOTE See Annex G and API 6MET for deration factors.

c) For CRA materials

CRA materials shall be acceptable provided they satisfy the minimum requirements of 8.2.3.2 a) for ASTM A453/A453M Grade 660D bolting, with the exception that the maximum hardness shall conform to NACE MR0175/ISO 15156 requirements for the CRA used. Environmental and material limits specified in NACE MR0175/ISO 15156 shall apply.

8.2.3.3 Low-Alloy Steel Exposed Bolting (Low-strength)

ASTM A193/A193M Grade B7M shall be acceptable at a minimum 0.2 % offset yield strength of 550 MPa (80,000 psi) for the flanges listed in Table 16 for NACE MR0175/ISO 15156 exposed bolting (low-strength).

ASTM A320/A320M Grade L7M shall be acceptable at a minimum 0.2 % offset yield strength of 550 MPa (80,000 psi) for the flanges listed in Table 16 for NACE MR0175/ISO 15156 exposed bolting (low-strength) only. Only flanges having a bolt nominal diameter ≤ 63.5 mm (≤ 2.5 in.) are acceptable for this grade of bolting.

8.2.3.4 Low-Alloy Steel Nonexposed Bolting

ASTM A193/A193M Grade B7 shall be acceptable for nonexposed service for all flanges requiring a nominal bolt diameter ≤ 63.5 mm (≤ 2.5 in.) and with temperature class P, S, T, and U. All bolting > 63.5 mm (> 2.5 in.) diameter shall require impact testing.

ASTM A320/A320M Grade L7 or L43 shall be acceptable for nonexposed service for all flanges.

NOTE Bolting make-up and connection capacity can be affected by mismatching the strength of the nut to the strength of the bolt. Bolting with diameters greater than 38 mm (1.50 in.) are typically affected more than smaller bolting.

8.2.3.5 Exposed Nuts

ASTM A194/A194M Grades 2HM and 7M shall be acceptable for all flange sizes and rated working pressures.

NOTE ASTM A453/A453M Grade 660D, ASTM A1082/1082M DSS, or CRA nuts may be used with NACE MR0175/ISO 15156 exposed bolting only if provisions are made to prevent galling.

Table 16—Acceptable Closure Bolting for 6B and 6BX Flanged and Studded Connections

Pressure		ASTM Bolting Standard(s) and 0.2 % Offset Yield Strength

	Rating MPa (psi)	**Nominal Size** (in.)	**Nonexposed Bolting**		**Exposed / Nonexposed Bolting** [a]	
			A193 GR. B7 (≤ 2.5") A320 GR. L7 (≤ 2.5") A320 GR. L43 (≤ 4.0")	A193 GR. B7 (> 2.5")	A193 GR. B7M (≤ 4.0") A320 GR. L7M (≤ 2.5") A1082 DSS[a] (≤ 4.0")	A453 GR. 660D (≤ 4.0") (See 8.2.3.2 and 8.2.3.5) CRA
			725 MPa (105 ksi)	655 MPa (95 ksi)	550 MPa (80 ksi)	725 MPa (105 ksi) ≤ 2.5" 655 MPa (95 ksi) > 2.5"
Studs, Bolts, and Cap Screws	13.8 (2,000)	All sizes	✓	NA	✓	✓
	20.7 (3,000)	All sizes	✓	NA	✓	✓
	34.5 (5,000)	All sizes	✓	NA	✓	✓
	69.0 (10,000)	1 13/16, 2 1/16, 2 9/16, 3 1/16	✓	NA	✓	✓
		4 1/16	✓	NA	Unacceptable	✓
		5 1/8	✓	NA	Unacceptable	✓
		7 1/16	✓	NA	✓	✓
		9, 11, 13 5/8, 16 3/4, 18 3/4, 21 1/4	✓	NA	Unacceptable	✓
	103.5 (15,000)	1 13/16	✓	NA	✓	✓
		2 1/16, 2 9/16, 3 1/16, 4 1/16	✓	NA	Unacceptable	✓
		5 1/8	✓	NA	✓	✓
		7 1/16, 9, 11, 13 5/8	✓	NA	Unacceptable	✓
		18 3/4	✓ Gr. L43 only	✓	Unacceptable	✓
	138.0 (20,000)	1 13/16, 2 1/16, 2 9/16, 3 1/16, 4 1/16, 5 1/8 7 1/16, 9	✓	NA	✓	✓
		11, 13 5/8	✓ Gr. L43 only	✓	✓ Gr. B7M only	✓
Nuts	All pressure ratings	All sizes	ASTM A194/A194M GR. 2H, 2HM,7, 7M		ASTM A194/A194M ASTM A453/A453M ASTM A1082/1082M CRA	GR 2HM, 7M GR 660D DSS[a]

NOTE ✓ = acceptable.

[a] See 8.2.3.2 for maximum temperature limit

Table 17—Allowable Closure Bolting by Temperature Class

Temperature Class	**P, S, T, U**	**K, L**
Impact testing of studs, bolts, and screws required	Yes for dia. >2.5" No for dia. ≤2.5"	Yes
	A193/A193M GR. B7	—
	A320/A320M GR. L7	A320/A320M GR. L7

Acceptable ASTM or other bolting standards and grades for studs, bolts, and screws	A320/A320M GR. L43	A320/A320M GR. L43
	A193/A193M GR. B7M	—
	A320/A320M GR. L7M	A320/A320M GR. L7M
	A453/A453M GR. 660D [b]	A453/A453M GR. 660D [b]
	A1082/1082M DSS [c d]	A1082/1082M DSS [c d]
	CRA [c]	CRA [c]
Acceptable ASTM or other bolting standards and grades for nuts [a]	ASTM A194/A194M	ASTM A194/A194M
	GR. 2H, 2HM, 7, 7L, 7ML, 7M	GR. 2H, 2HM, 7, 7L, 7ML, 7M
	A453/A453M GR. 660D	A453/A453M GR. 660D
	A1082/1082M DSS [d]	A1082/1082M DSS [d]
	CRA	CRA

FOOTNOTES
[a] Impact testing is not required for nuts unless specified by the ASTM referenced standard.
[b] Impact testing is not required for A453/A453M GR. 660D.
[c] Impact testing per API 20F.
[d] See 8.2.3.2 for maximum temperature limit

Table 18—Threads for Closure Bolting Used on 6B and 6BX Flanged and Studded End or Outlet Connectors

ASME B1.1 Thread Designation Nominal Thread Size-TPI Series
$^{1}/_{2}$-13 UNC
$^{5}/_{8}$-11 UNC
$^{3}/_{4}$-10 UNC
$^{7}/_{8}$-9 UNC
1-8 UNC
$1^{1}/_{8}$-8 UN
$1^{1}/_{4}$-8 UN
$1^{3}/_{8}$-8 UN
$1^{1}/_{2}$-8 UN
$1^{5}/_{8}$-8 UN
$1^{3}/_{4}$-8 UN
$1^{7}/_{8}$-8 UN
2-8 UN
$2^{1}/_{4}$-8 UN
$2^{1}/_{2}$-8 UN
$2^{3}/_{4}$-8 UN
3-8 UN

8.2.3.6 Cautionary Statements for Bolting

ASTM A453/A453M Grade 660D solution-treated and age-hardened bolting as stated in 8.2.3.2 should not be used on pressure-containing and high load-bearing connectors in the following situations:

— wet/dry offshore and coastal applications in the presence of salt air;

— where it is routine to clean/wash equipment with untreated/raw seawater.

NOTE 1 Environmentally assisted cracking, such as stress corrosion cracking (SCC), may result from the presence or accumulation of chlorides from deposited salt on highly stressed austenitic stainless steel bolting, such as Grade 660D.

NOTE 2 API 6ACRA addresses alternative, higher-strength CRA materials suitable for sour exposure.

NOTE 3 NACE MR0175 provides material usage limits for H_2S environments. Other forms of cracking may result from the presence of chlorides (such as seawater) and or hydrogen (such as cathodic protection).

ASTM A1082/A1082M DSS solution-treated bolting as stated in 8.2.3.2 should not be used when exposed to cathodic protection.

8.3 Other Closure Bolting

8.3.1 General

This section shall apply to closure bolting for uses other than API flanged and studded connections specified in 14.1.

8.3.2 Design

The design of other closure bolting shall be per 8.1 and manufacturer's requirements.

8.3.3 Materials

The material requirements shall be specified by the manufacturer. Carbon or alloy-steel bolting shall not exceed 34 HRC.

Impact testing for closure bolting shall conform to the requirements of Table 17.

For exposed service, materials shall conform to NACE MR0175/ISO 15156.

NOTE Carbon steel bolting can be susceptible to environmentally assisted cracking due to material processing such as hydrogen charging during plating operations or during exposure to marine environments.

8.3.4 Quality

Quality control requirements for other closure bolting shall be as specified in 8.1.2.

8.4 Additive Manufacturing

The use of additive manufactured material shall not be permitted for bolting.

9 Packing Mechanisms, Pressure Boundary Penetrations, and Ports

9.1 Packing Mechanisms

9.1.1 Performance Requirements

Packing mechanisms shall conform to the general requirements of 4.2 and, when installed in equipment, shall be capable of performing their intended function to applicable PR1 or PR2 requirements for the equipment in which they are used.

9.1.2 Design

The packing mechanisms shall be capable of maintaining a leak-tight seal at the rated working pressure of the head.

9.2 Fittings and Pressure Boundary Penetrations

9.2.1 General

Pressure boundary penetrations shall be capable of maintaining a leak-tight seal at the rated working pressure and temperatures.

NOTE Fittings are a type of pressure boundary penetration.

9.2.2 Performance Requirements

Pressure boundary penetrations shall be capable of meeting the general requirements of 4.2 and, when installed in equipment, shall be capable of performing their intended function to applicable PR1 or PR2 requirements for the equipment in which they are used.

9.2.3 Design

9.2.3.1 General

NOTE The design of pressure boundary penetrations is outside the scope of this specification.

9.2.3.2 Lock Screws in Tubing Heads

Lock screws, if installed in tubing heads, shall have adequate number, size, and strength to hold a load equivalent to the working pressure of the spool acting on the full area of the largest tubing-hanger primary seal.

9.2.3.3 Penetrations

If penetrations are made in flanged connectors as specified in this specification, it shall be the responsibility of the manufacturer to ensure that the penetrations do not cause the flange stresses to exceed the design criteria.

9.2.3.4 Trapped Pressure

A means shall be provided in the wellhead installation such that any pressure behind a lock screw, alignment pin, and retainer screw can be vented prior to release.

9.2.4 Materials

Material requirements for pressure boundary penetrations shall be as specified by the manufacturer and shall be compatible with the body material. Pressure boundary penetrations used in material classes DD, EE, FF, and HH equipment shall conform to the requirements of NACE MR0175/ISO 15156.

Additively manufactured materials shall not be used for lock screws.

9.2.5 Marking

NOTE There are no marking requirements.

9.2.6 Storing and Shipping

Storing and shipping shall be in conformance with Section 13.

9.2.7 Testing

NOTE Assembled equipment is pressure-tested with all pressure boundary penetrations installed according to 11.2.

9.2.8 Quality Requirements

The quality control requirements for pressure boundary penetrations shall be controlled in conformance with the manufacturer's written specifications. The material properties shall conform to the requirements of 6.1 and 6.2.

9.3 Test, Gauge, Vent, and Injection Connector Ports

9.3.1 Sealing

All test, vent, injection, and gauge connectors shall provide a leak-tight seal at the hydrostatic test pressure of the equipment in which they are installed.

9.3.2 Vent and Injection Connector Ports

Vent and injection ports shall conform to the requirements of the manufacturer's specifications.

9.3.3 Test and Gauge Connector Ports

9.3.3.1 69.0 MPa (10,000 psi) and Below

Test and gauge connector ports for 69.0 MPa (10,000 psi) working pressure and below shall conform to one of the following:

— conform to the requirement of 14.3 and shall not be less than 1/2 in. nominal size;

— conform to the requirements of 9.3.3.2.

9.3.3.2 103.5 MPa and 138.0 MPa (15,000 psi and 20,000 psi)

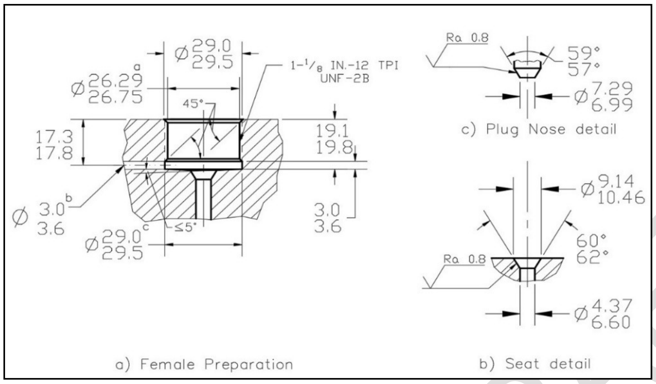
9.3.3.2.1 General

Test and gauge connector ports for use on 103.5 MPa and 138.0 MPa (15,000 psi and 20,000 psi) equipment shall satisfy the requirements of 9.3.3.2.

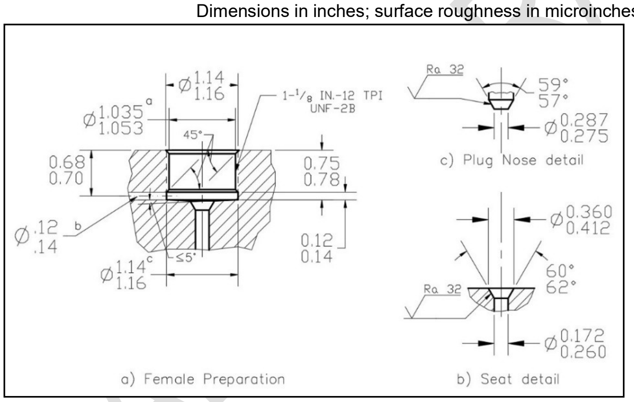
9.3.3.2.2 Design

Connectors shall conform to the dimensions in conformance with Figure 5.

Dimensions in millimeters; surface roughness in micrometers



Dimensions in inches; surface roughness in microinches



Key

[a] Minor diameter of 1[1]/8-12 UNF-2B thread.

[b] Drill for vent optional.

[c] 15.5 mm (0.61 in.) minimum thread length or undercut to thread relief as option.

Figure 5—Test and Gauge Connector Ports for 103.5 MPa and 138.0 MPa (15,000 psi and 20,000 psi) Rated Working Pressure

All parallel threads shall conform to ASME B1.1. Male threads shall be Class 2A; female threads shall be Class 2B.

Parts attached to connectors shall conform to the design methods of 5.1.1 or 5.1.4.

9.3.3.2.3 Materials

For 103.5 MPa or 138.0 MPa (15,000 psi or 20,000 psi) rated working pressure applications, the materials shall be 78 HRB minimum. For material classes DD, EE, FF, and HH, the material shall also conform to NACE MR0175/ISO 15156.

Portions of fittings exposed directly to sour environment shall conform to NACE MR0175/ISO 15156.

For material class HH, retained fluid-wetted surfaces up to and including the seal area of test ports shall be manufactured with CRA materials.

9.3.3.2.4 Testing

This specification does not require equipment furnished under 9.3 to be pressure-tested; however, if hydrostatically tested in assembled equipment, the equipment shall be designed for the hydrostatic shell test pressure.

9.3.3.2.5 Marking

NOTE There are no requirements for marking test and gauge connector ports.

9.3.3.2.6 Storage and Shipping

Connector ports shall be stored and shipped in conformance withSection 13.

10 Quality Control

10.1 Application

Equipment manufactured to this specification shall conform to the quality control and record requirements of Section 10.

Equipment shall be manufactured under the manufacturer's quality management system which shall conform to an internationally recognized standard such as API Q1 or ISO 9001.

The manufacturer shall ensure control over the manufacturing processes that are outsourced.

The manufacturer shall maintain:

— Documented procedure for the controls used for outsourced processes;

— Records that provide evidence of conformity of outsourced processes to the requirements of this specification, and

— When applicable, records of validation for outsourced welding, heat treatment, nondestructive testing, coating and plating.

10.2 Measuring and Testing Equipment

10.2.1 General

Measuring and testing equipment shall be identified, controlled, calibrated, and adjusted at specified intervals in conformance with documented manufacturer instructions, and consistent with nationally or internationally recognized standards specified by the manufacturer, to maintain the accuracy required by this specification.

10.2.2 Pressure-measuring Devices

10.2.2.1 Type and Accuracy

Test pressure-measuring devices shall be accurate to at least ± 2 % of full-scale range. If analog 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.

NOTE Pressure recording devices (see 15.2.1) are outside the scope of 10.2.2 unless used for both measurement and recording.

10.2.2.2 Calibration Procedure

Pressure-measuring devices shall be periodically calibrated with a master pressure-measuring device or a dead-weight tester to at least three equidistant points of full scale. The full scale end points (zero and 100%) are not required calibration points; however, if included in the calibration, the scale end points shall be in addition to the required points used for calibration.

10.2.2.3 Calibration Intervals

Calibration intervals shall be established by the manufacturer based on repeatability and degree of usage. Calibration intervals may be lengthened and shall be shortened based on recorded calibration history.

Calibration intervals shall be a maximum of 3 months until recorded calibration history can be established by the manufacturer. Extension of intervals shall be limited to 3-month increases, with a maximum calibration interval to not exceed 1 year.

Changes to calibration intervals shall be based on recorded calibration history for each pressure measuring device and shall conform to the manufacturer’s documented procedure.

The calibration interval shall start either on the date of calibration or on the date of first use after calibration.

If the manufacturer chooses to start the calibration interval on the date of first use after calibration, the following shall apply:

— the date of first use shall be recorded, and

— the time between the calibration date and date of first use shall not exceed 3 months

10.3 Personnel Qualifications

10.3.1 Nondestructive Examination Personnel

Personnel performing NDE (Including Visual Examination) shall be qualified in conformance withthe manufacturer’s documented training program that is based on the requirements specified in the following:

-- ISO 9712, or

-- ASNT SNT-TC-1A, or

-- a national or international standard that is equivalent to ISO 9712 or ASNT SNT-TC-1A.

10.3.2 Welding Inspectors

Personnel performing visual inspections of welding operations and completed welds shall be qualified and certified in conformance with the manufacturer’s documented training program or a recognized industry program, such as AWS QC1.

10.3.3 Other Personnel

All other personnel performing measurements, inspections, or tests for acceptance shall be qualified in conformance withthe manufacturer's documented procedures and requirements.

10.4 Requirements

10.4.1 General

10.4.1.1 Materials

For wrought and cast material, qualification requirements shall be as provided in Section 6 for mandrel tubing hangers and casing hangers; bodies, bonnets, end and outlet connectors; ring gaskets; bullplugs and valve-removal plugs; back-pressure valves; pressure boundary penetrations; clamp hub end connectors; and QTCs.

For additively manufactured materials, quality requirements for the first article and production parts shall conform to API 20S and the applicable PSL/AMSL (see Table 7).

10.4.1.2 Procedures

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

NDE procedures shall be supported with a documented qualification record as required by the specified normative reference standard (such as API 20D or other applicable standard) to demonstrate the procedure effectiveness. All NDE procedures shall be approved by a level III examiner qualified in conformance with ASNT SNT-TC-1A or ISO 9712.

10.4.1.3 Acceptance Status

The acceptance status of all equipment, parts, and materials shall be indicated either on the equipment, parts, or materials or in records traceable to the equipment, parts, or materials.

10.4.1.4 Material Classes DD, EE, FF, and HH

Each pressure-containing or pressure-controlling part for use in material classes DD, EE, FF, and HH shall be hardness tested individually to confirm that the NACE MR0175/ISO 15156 hardness values have been satisfied (except for ring gaskets, which may be sampled in conformance with10.4.5.5, and choke trim see 10.4.4.1). If the other requirements of 10.4.1 satisfy this requirement, additional testing or examination is not required.

10.4.2 Bodies, Bonnets, End and Outlet Connectors, and Clamp Hub End Connectors

10.4.2.1 Castings

Production castings shall conform to the requirements of API 20A and this specification. The API 20A CSL shall conform to Table 19.

Table 19—Casting Specification Level Cross-reference to PSL

API 6A	API 20A
PSL 1	CSL 2
PSL 2	CSL 3
PSL 3	CSL 3
PSL 4	NA

10.4.2.2 Tensile Testing

For PSL 1, PSL 2, PSL 3, and PSL 4, tensile testing shall conform to 6.3.2.2.

10.4.2.3 Impact Testing

For PSL 1, PSL 2, PSL 3, and PSL 4, impact testing shall conform to 6.3.2.3.

10.4.2.4 Hardness Testing

10.4.2.4.1 Application

The requirements of 10.4.1.4 shall apply.

Additionally, the requirements of 10.4.2.4 shall apply to PSL 1, PSL 2, PSL 3, and PSL 4 as specified in Table 20.

NOTE Conformance to Table 20 provides conformance to 10.4.1.4.

If bodies, end and outlet connectors, and clamp hub ends have different material designations, each part shall be tested.

10.4.2.4.2 Test Method

Hardness testing shall conform to the procedures specified in ISO 6506 or ASTM E10 (Brinell), or ISO 6508, or ASTM E18 (Rockwell).

NOTE 1 Hardness testers meeting the requirements of ASTM E110 and ISO 6506 or ASTM E10, or ISO 6508 or ASTM E18, as applicable, may be used for hardness testing.

ISO 18265 or ASTM E140 shall be used for the conversion of hardness readings for materials within the scope of their application.

NOTE 2 Other correlations may be established for individual materials that are outside the scope of ISO 18265 or ASTM E140.

When a conversion other than ASTM E140 conversion is used, the conversion method shall be documented and shall be based on documented test results.

Tests shall be performed at a location determined as per Table 20 and following the last heat-treatment cycle (including all stress-relieving heat-treatment cycles) and all exterior machining at the test location.

Table 20—Product Hardness Test Requirements

Part Type	PSL	Material Class	Quantity of Parts Tested per Lot	Minimum Number of Tests per Part	Test Location
Pressure-containing: Bodies & End and Outlet connectors	PSL 1	AA, BB, CC	Sampling per Footnote [d]	One	PMR
		DD, EE, FF	100% (all parts)	One	PMR

	PSL 2	AA, BB, CC, DD, EE, FF	100% (all parts)	One	PMR
	PSL 3 PSL 4	AA, BB, CC, DD, EE, FF, HH, ZZ	100% (all parts)	Multiple	One in location PMR One on each integral end/outlet connector face (See Footnotes [a], [b] & [c].)
Pressure-containing: Bonnets, Stems, Loose Connectors	PSL 1	AA, BB, CC	Sampling per Footnote [d]	One	PMR
		DD, EE, FF	100% (all parts)	One	PMR
	PSL 2	AA, BB, CC, DD, EE, FF	100% (all parts)	One	PMR
	PSL 3 PSL 4	AA, BB, CC, DD, EE, FF, HH, ZZ	100% (all parts)	One	PMR
Pressure-controlling: Valve-Bore Sealing Mechanisms, Choke Trim	PSL 1 PSL2	AA, BB, CC	None required	N/A	N/A
		DD, EE, FF	100% (all parts)	One	PMR
	PSL 3 PSL 4	AA, BB, CC, DD, EE, FF, HH, ZZ	100% (all parts)	One	PMR
Pressure-controlling: Mandrel Hangers	PSL 1 PSL 2	AA, BB, CC DD, EE, FF	100% (all parts)	One	PMR
	PSL 3 PSL 4	AA, BB, CC, DD, EE, FF, HH, ZZ	100% (all parts)	Two	One in location PMR + one in location PMR
Ring Gaskets	N/A	N/A	Sampling per 10.4.5.5	One	Location per 10.4.5.5

Footnotes:
[a] If body test location designated by manufacturer ("PMR") is an end/outlet connector face, an additional test on that face is not required.
[b] For end/outlet connectors with a raised face, hardness testing may be performed on the recessed face (the outside face between bolt holes).
[c] Where multiple end connector faces are located on the same finished machined surface, a single hardness punch may be used to represent all end connectors on the same finished machined surface.
[d] Sampling shall conform to ISO 2859-1:1999, level II, 4.0 AQL (acceptance quality limit).[e] Conformance to Table 20 provides conformance to 10.4.1.4

10.4.2.4.3 Acceptance Criteria

Parts manufactured from nonstandard, high-strength materials shall conform to the minimum hardness requirements of the manufacturer's written specification.

Parts manufactured from standard materials shall conform to the requirements of Table 21.

Table 21—Minimum Hardness Values

Material Designation	Minimum Brinell Hardness
36K	HBW 140
45K	HBW 140
60K	HBW 174
75K	HBW 197

For parts manufactured from a standard material that does not conform to the specified minimum hardness value of Table 21, the material shall be acceptable if the measured hardness exceeds the minimum acceptable Brinell hardness value calculated using Equation 4, with results of tensile tests performed per 6.3.2.2 for the material of the part in question:

$$H_{\text{BWc, min.}} = \frac{R_{\text{m, min.}}}{R_{\text{m, QTC}}}\left(H_{\text{BW,QTC}}\right)$$

Equation (4)

where

$H_{\text{BWc, min.}}$ *is the minimum acceptable Brinell hardness according to the HBW method for the part after the final heat-treatment cycle (including stress-relieving cycles);*

$R_{\text{m, min.}}$ *is the minimum acceptable ultimate tensile strength for the applicable material designation*;

$R_{\text{m, QTC}}$ *is the average ultimate tensile strength determined from the QTC tensile tests;*

$H_{\text{BW,QTC}}$ *is the average of the Brinell hardness values according to the HBW method observed among all tests performed on the QTC.*

10.4.2.5 Dimensional Inspection

10.4.2.5.1 Application

Dimensional inspection shall be performed on parts. The manufacturer shall specify critical dimensions.

All end and outlet connector threads conforming to Section 14.3 of this specification on all parts shall be inspected. Critical dimensions on all parts shall be verified.

For PSL 1 and PSL 2, other features shall be checked on sample parts in conformance withISO 2859-1:1999, level II, 1.5 AQL.

For PSL 3 and PSL 4, sampling shall not be allowed; all parts shall be dimensionally inspected.

10.4.2.5.2 Inspection Method and Acceptance Criteria

If a thread gauge is used for inspection, it shall conform to the requirements for working gauges as specified in API 5B. Threads shall be inspected for standoff at hand-tight assembly.

NOTE 1 For threads manufactured in conformance withthis specification, use gauging practices as illustrated in Table D.29/Table E.29 and Table D.30/Table E.30. For threads manufactured in conformance withAPI 5B, use gauging practices as specified in API 5B.

NOTE 2 Threaded end and outlet connectors may be inspected for standoff at hand-tight assembly by use of the gauges and gauging practices illustrated in Table D.29/Table E.29 and Table D.30/Table E.30, or according to API 5B.

The end and outlet connector threads shall conform to Table D.29/Table E.29 and Table D.30/Table E.30, API 5B or ASME B1.20.1, as applicable.

Acceptance criteria for critical dimensions shall be as required by the manufacturer's written specification.

10.4.2.6 Visual Examination

10.4.2.6.1 Application

NOTE Visual examination requirements do not apply to PSL 3 and PSL 4 except for welds (see 10.4.2.13).

For PSL 1 and PSL 2, each part shall be visually examined.

10.4.2.6.2 Test Method and Acceptance Criteria

For PSL 1 and PSL 2, visual examinations of castings shall conform to the procedures specified in API 20A. Visual examination of wrought material and weld preparations shall be performed in conformance with the manufacturer's written specifications.

For PSL 1 and PSL 2, the acceptance criteria shall be as follows:

— for castings, in conformance withAPI 20A;

— for wrought material and weld preparations, in conformance withthe manufacturer's written specifications.

10.4.2.6.3 Supplemental Requirement

For PSL 2, wetted and sealing surfaces shall be examined by surface NDE methods described in 10.4.2.10 for ferromagnetic materials and 10.4.2.11 for nonferromagnetic materials, as applicable.

NOTE This supplemental visual examination requirement does not apply to PSL 1.

10.4.2.7 Chemical Analysis

For PSL 2, PSL 3, and PSL 4, chemical analysis shall be performed on a heat basis (or a remelt-ingot basis for remelt-grade materials) in conformance witha nationally or internationally recognized standard.

The chemical composition shall conform to the requirements of 6.3.5 and the manufacturer's written specification.

NOTE Chemical analysis requirements do not apply to PSL 1.

10.4.2.8 Traceability

10.4.2.8.1 Wrought and Cast Material

For PSL 2, PSL 3, and PSL 4, the following requirements shall apply.

— Job-lot traceability shall be required.

— Identification shall be maintained on materials and parts to facilitate traceability, as required by documented manufacturer requirements.

— Manufacturer-documented traceability requirements shall include provisions for maintenance or replacement of identification marks and identification control records.

For PSL 3 and PSL 4 only, in addition, manufactured parts shall be traceable to a specific heat and heat-treat lot.

NOTE The traceability requirements do not apply to PSL 1.

10.4.2.8.2 Additively Manufactured Material

Job-lot traceability shall be required for all additively manufactured components.

For PSL 1, PSL 2 or PSL 3 components that use AMSL 3 material, shall be traceable in conformance with API 20S.

10.4.2.9 Serialization

10.4.2.9.1 Wrought and Cast Material

For PSL 3 and PSL 4, the following requirements shall apply.

Each individual part or piece of equipment made from wrought or cast material shall be assigned and marked with a unique code to maintain traceability and associated records.

NOTE The serialization requirements do not apply to PSL 1 and PSL 2.

10.4.2.9.2 Additively Manufactured Material

For PSL 1, PSL 2 and PSL 3, each additively manufactured component shall be assigned a unique code to maintain traceability and associated records.

10.4.2.10 Surface NDE—Ferromagnetic Materials

10.4.2.10.1 Castings

For castings, the following shall apply.

For PSL 1, all accessible wetted surfaces and all accessible sealing surfaces for one casting from each heat lot shall be examined by liquid penetrant or magnetic particle methods after final heat-treatment and final machining operations. If the casting fails to meet the surface NDE acceptance criteria (see 10.4.2.10.3), surface NDE shall be performed on all castings from that heat on all accessible wetted surfaces and all accessible sealing surfaces.

NOTE 1 As noted in Table 5, PSL 1 does not apply to bodies, bonnets, end and outlet connectors, and clamp hub end connectors with 69.0 MPa, 103.5 MPa, and 138.0 MPa (10,000 psi, 15,000 psi, and 20,000 psi) working pressures.

For PSL 2 and PSL 3, all accessible wetted surfaces and all accessible sealing surfaces of each finished part shall be examined by liquid penetrant or magnetic particle methods after final heat-treatment and final machining operations.

For PSL 3, additionally all accessible surfaces of each finished part shall be inspected. Surface NDE shall be performed on all surfaces prepared for “weld metal overlay.”

NOTE 2 These additional requirements do not apply to PSL 1 and PSL 2.

10.4.2.10.2 Wrought Material and Additively Manufactured Components

For wrought material and Additively Manufactured Components, the following shall apply.

For PSL 2, PSL 3, and PSL 4, all accessible wetted surfaces and all accessible sealing surfaces of each finished part shall be examined by liquid penetrant or magnetic particle methods after final heat-treatment and final machining operations.

NOTE 1 This requirement does not apply to PSL 1.

For PSL 3 and PSL 4, additionally all accessible surfaces of each finished part shall be inspected. Surface NDE shall be performed on all surfaces prepared for "weld metal overlay."

NOTE 2 These additional requirements do not apply to PSL 1 and PSL 2.

NOTE 3 Use of additively manufactured material is restricted. See section 5.1.3.

10.4.2.10.3 Test Method and Acceptance Criteria

For PSL 1 and PSL 2, all ferromagnetic materials shall be examined in conformance withprocedures specified in ASTM E165 (penetrant test [PT]) or ASTM E709 (magnetic particle test [MT]).

Prods shall not be permitted on wetted surfaces or sealing surfaces.

If any indications are believed to be nonrelevant on the basis that they are not associated with a surface rupture (i.e. magnetic permeability variations, nonmetallic stringers), they shall be examined by liquid penetrant surface NDE methods, or removed and reinspected, to confirm their non-relevancy.

For PSL 3 and PSL 4, all ferromagnetic materials shall be examined in conformance withprocedures specified in ASTM E165 (PT) or only the wet fluorescent method in ASTM E709 (MT) for all magnetic particle examinations.

NOTE The ASTM E709 (MT) wet fluorescent method limitation does not apply to PSL 1 and PSL 2.

The following acceptance criteria shall apply for the ASTM E709 (MT) examination:

— no relevant indication with a major dimension equal to or greater than 5 mm ($^{3}/_{16}$ in.);

— no more than ten relevant indications in any continuous 40 cm^2 (6 $in.^2$) area;

— no four (or more) relevant rounded indications in a line separated by less than 1.6 mm ($^{1}/_{16}$ in.) (edge-to-edge);

— no relevant indications in pressure-contact sealing surfaces.

The acceptance criteria in 10.4.2.11.4 shall apply for the ASTM E165 (PT) examination.

10.4.2.11 Surface NDE—Nonferromagnetic Materials

10.4.2.11.1 Castings

For castings, the following shall apply.

NOTE 1 As noted in Table 5, PSL 1 does not apply to bodies, bonnets, end and outlet connectors and clamp hub end connectors with 69.0 MPa, 103.5 MPa, and 138.0 MPa (10,000 psi, 15,000 psi, and 20,000 psi) working pressures.

For PSL 1, all accessible wetted surfaces and all accessible sealing surfaces for one casting from each heat lot shall be examined by the liquid penetrant method after final heat-treatment and final machining operations. If the casting fails to meet the surface NDE acceptance criteria (see 10.4.2.11.3), surface NDE shall be performed on all castings from that heat on all accessible wetted surfaces and all accessible sealing surfaces.

For PSL 2 and PSL 3, all accessible wetted surfaces and all accessible sealing surfaces of each finished part shall be liquid penetrant inspected after final heat-treatment and final machining operations.

For PSL 3 additionally, all accessible surfaces of each finished part shall be inspected. Surface NDE shall be performed on all surfaces prepared for "weld metal overlay."

NOTE 2 This additional requirement does not apply to PSL 1 and PSL 2.

10.4.2.11.2 Wrought Material and Additively Manufactured Components

For wrought material and Additively Manufactured Components, the following shall apply.

For PSL 2, PSL 3, and PSL 4, all accessible wetted surfaces and all accessible sealing surfaces of each finished part shall be examined by the liquid penetrant method after final heat-treatment and final machining operations.

NOTE 1 This requirement does not apply to PSL 1.

For PSL 3 and PSL 4, additionally all accessible surfaces of each finished part shall be inspected. Surface NDE shall be performed on all surfaces prepared for "weld metal overlay."

NOTE 2 These additional requirements do not apply to PSL 1 and PSL 2.

NOTE 3 Use of additively manufactured material is restricted. See section 5.1.3.

10.4.2.11.3 Test Method and Acceptance Criteria

All nonferromagnetic materials shall be examined in conformance withprocedures specified in ASTM E165.

The acceptance criteria shall be as follows:

— no relevant linear indications allowed;

— no more than ten relevant rounded indications in any continuous 40 cm^2 (6 in.^{2}) area;

— no relevant rounded indication with a major dimension equal to or greater than 5 mm ($^3/_{16}$ in.);

— no four (or more) relevant rounded indications in a line separated by less than 1.6 mm ($^1/_{16}$ in.) (edge-to-edge);

— no relevant indication in pressure-contact sealing surfaces.

10.4.2.12 Volumetric NDE

10.4.2.12.1 Application

For PSL 2 (castings), for bodies, bonnets, and loose connectors with rated working pressure of 69.0 MPa (10,000 psi) or higher, the entire volume of one casting from each heat lot shall be subjected to volumetric NDE, by ultrasonic (UT) or radiographic (RT) examination. If the sample casting fails to meet the volumetric NDE acceptance criteria, volumetric NDE shall be performed on all castings from that heat.

NOTE 1 The sampling requirements for PSL 2 do not apply to PSL 1, PSL 3, and PSL 4.

For PSL 3 and PSL 4 (castings and wrought material) as far as practical, the entire volume of each part shall be volumetrically inspected (radiography or ultrasonic) after heat-treatment for mechanical properties and prior to machining operations that limit effective interpretation of the results of the examination. For quench-and-tempered products, the volumetric inspection shall be performed after heat-treatment for mechanical properties exclusive of stress-relief treatments or re-tempering to reduce hardness.

NOTE 2 The sampling requirements for PSL 3/PSL 4 do not apply to PSL 1 and PSL 2.

10.4.2.12.2 Ultrasonic Examination Test Method

For PSL 2 and PSL 3 castings, ultrasonic examinations of castings shall be performed in conformance withthe flat-bottom hole procedure specified in ASTM A609 (except that the immersion method may be used) and ASTM E127.

For PSL 3 and PSL 4 wrought material, ultrasonic examination shall conform to the procedure requirements of ASTM A388/A388M except straight beam calibration shall be as follows:

— Straight Beam Calibration: For straight beam examination, the distance amplitude curve (DAC) shall be based on a maximum 1.6 mm ($^{1}/_{16}$ in.) flat-bottom hole (straight-beam technique) for metal thicknesses through 38 mm ($1^{1}/_{2}$ in.), on a maximum 3.2 mm ($^{1}/_{8}$ in.) flat-bottom hole for metal thicknesses from 38 mm ($1^{1}/_{2}$ in.) through 150 mm (6 in.), and on a maximum 6.4 mm ($^{1}/_{4}$ in.) flat-bottom hole for metal thicknesses exceeding 150 mm (6 in.).

— Angle Beam Calibration: For angle beam examination, the calibration shall be performed in conformance with the angle beam calibration requirements specified in ASTM A388/A388M.

Where variation in acoustic response of 2 dBs occurs due to surface finish difference between the test block and the part to be examined, a coupling compensation of up to 12 dB maximum shall be performed.

NOTE Ultrasonic examination does not apply to PSL 1.

10.4.2.12.3 Ultrasonic Examination Acceptance Criteria

For PSL 2, PSL 3, and PSL 4, the following shall apply:

— no single indication exceeding reference DAC;

— no multiple indications exceeding 50 % of reference DAC; multiple indications are defined as two or more indications (each exceeding 50 % of the reference DAC) within 13 mm ($^{1}/_{2}$ in.) of each other in any direction.

For PSL 4 only, in addition, no continuous cluster of indications on the same plane, regardless of amplitude, shall be found over an area twice the diameter of the search unit.

NOTE This additional requirement does not apply to PSL 2 or PSL 3.

10.4.2.12.4 Radiographic Examination Test Method

For PSL 2 and PSL 3 castings, and for PSL 3 and PSL 4 wrought material, radiographic examination shall be performed in conformance withmethods specified in ASME BPVC, Section V, Article 2 (or equivalent) using 2T Essential Hole for plaque type IQI or Equivalent Essential wire for wire type IQI. Both X-ray and gamma-ray sources shall be acceptable within the inherent thickness range limitation of each.

NOTE 1 Real time imaging and recording/enhancement methods may be used provided the designated hole image quality indicator or essential wire is displayed as required by ASME *BPVC*, Section V, Article 2.

NOTE 2 Radiographic examination does not apply to PSL 1.

10.4.2.12.5 Radiographic Examination Acceptance Criteria—Wrought Materials

For PSL 3, the following acceptance criteria shall apply:

— no cracks, laps, or bursts;

— no elongated indication with a length greater than that specified in Table 22;

Table 22—Maximum Length of Elongated Indication

Thickness, T		Inclusion Length	
mm	in.	mm	in.
< 19.0	< 0.75	6.4	0.25
19.0 to 57.0	0.75 to 2.25	$0.33T$	$0.33T$
> 57.0	> 2.25	19.0	0.75

— no group of indications in a line that have an aggregate length greater than T in a length of $12T$.

NOTE 1 The PSL 3 requirements do not apply to PSL 4.

For PSL 4 only, the following acceptance criteria shall apply:

— no cracks, laps, or bursts;

— no more than two indications separated by less than 13 mm ($^1/_2$ in.);

— no elongated indication exceeding 6.4 mm ($^1/_4$ in.).

NOTE 2 The PSL 4 requirements do not apply to PSL 3.

10.4.2.12.6 Radiographic Examination Acceptance Criteria—Cast Parts

For PSL 2 and PSL 3, the following shall apply:

— ASTM E186;

— ASTM E280;

— ASTM E446;

— maximum defect classification as follows:

Type Defect	Maximum Defect Class
A	2
B	2
C	2 (all types)
D	None acceptable

E	None acceptable
F	None acceptable
G	None acceptable

10.4.2.13 Weld NDE—General

For PSL 1, PSL 2, PSL 3, and PSL 4, the following shall apply.

Completed welds [a minimum of 13 mm (1/2 in.) of surrounding base metal and the entire accessible weld] shall be examined in conformance withthe methods and acceptance criteria of Table 23.

The manufacturer's written specification for corrosion-resistant weld overlay shall include a technique for measuring the specified overlay thickness. The production acceptance criteria measurements shall account for the depth of penetration to the approximate weld interface when the weld qualification was performed using the fusion face.

10.4.2.14 Weld Examination—Visual

The visual weld examination requirements of 10.4.2.14 shall apply to PSL 1, PSL 2, PSL 3, and PSL 4 as specified in Table 23.

100 % of all welds shall be visually examined after post-weld heat-treatment and machining operations.

Examinations shall include a minimum of 13 mm (1/2 in.) of adjacent base metal on both sides of the weld.

The acceptance criteria shall be as follows.

— All pressure-containing welds shall have complete joint penetration.

— Undercut shall not reduce the thickness in the area (considering both sides) to below the minimum thickness.

— Surface porosity and exposed slag are not permitted on or within 3 mm (1/8 in.) of sealing surfaces.

Weld NDE—Surface

10.4.2.14.1 Application

The surface weld examination requirements of 10.4.2.15 shall apply to PSL 2, PSL 3, and PSL 4.

For PSL 3 and PSL 4, magnetic particle examination shall be performed only by the wet fluorescent method.

NOTE The surface weld examination requirements do not apply to PSL 1.

100% of all pressure-containing fabrication welds and weld overlay shall be examined by either magnetic particle (in the case of ferromagnetic materials) or liquid penetrant (in the case of ferromagnetic or nonferromagnetic materials) methods after all welding, post-weld heat-treatment, and machining operations.

10.4.2.14.1 Test Method/Acceptance—Magnetic Particle Examination

Examinations shall include a minimum of 13 mm (1/2 in.) of adjacent base metal on both sides of the weld.

Magnetic particle examination shall be performed as described in 10.4.2.10.3 with additional acceptance criteria as follows:

— no relevant linear indication;

— no rounded indication greater than 3 mm (1/8 in.) for welds whose depth is 16 mm (5/8 in.) or less, or 5 mm (3/16 in.) for welds whose depth is greater than 16 mm (5/8 in.).

Table 23—Requirements for Welding Bodies, Bonnets, and End and Outlet Connectors

Weld Type	Stages [a,b]	Reference			
		PSL 1	PSL 2	PSL 3	PSL 4
Pressure-containing	Preparation - Visual	—	—	10.4.2.6	10.4.2.6
	Completion - Visual	—	10.4.2.14	10.4.2.14	10.4.2.14
	Completion - Surface NDE	—	10.4.2.15	10.4.2.15	10.4.2.15
	Completion - Volumetric NDE	—	10.4.2.16	10.4.2.16	10.4.2.16
	Completion - Hardness test	—	—	10.4.2.17	10.4.2.17
Non-pressure-containing (including repairs)	Preparation - Visual	—	—	10.4.2.6	10.4.2.6
	Completion - Visual	—	10.4.2.14	10.4.2.14	10.4.2.14
	Completion - Hardness test	—	—	10.4.2.17	10.4.2.17
Pressure-containing repairs	Preparation - Surface NDE	—	10.4.2.15	10.4.2.15	10.4.2.15
	Completion - Visual	—	10.4.2.14	10.4.2.14	10.4.2.14
	Completion - Surface NDE	—	10.4.2.15	10.4.2.15	10.4.2.15
	Completion - Volumetric NDE	—	10.4.2.16	10.4.2.16	10.4.2.16
	Completion - Hardness test	—	—	10.4.2.17	10.4.2.17
Partial weld metal overlay	Preparation - Surface NDE	—	—	10.4.2.10	10.4.2.10
	Completion - Surface NDE	—	10.4.2.15	10.4.2.15	10.4.2.15
	Completion - Volumetric NDE	—	—	10.4.2.18	10.4.2.18
Full weld metal overlay	Preparation - Visual	10.4.2.6	10.4.2.6	—	—
	Preparation - Surface NDE	—	—	10.4.2.10	10.4.2.10
	Completion - Visual	10.4.2.14	10.4.2.14	10.4.2.14	10.4.2.14
	Completion - Surface NDE	—	10.4.2.15	10.4.2.15	10.4.2.15
	Completion - Volumetric NDE	—	—	10.4.2.18	10.4.2.18

FOOTNOTES

[a] "Preparation" refers to surface preparation, joint preparation, fit-up, and preheat.

[b] "Completion" refers to after all welding, post-weld heat-treat, and machining, except for volumetric NDE that shall be done prior to machining that would limit effective interpretation of results.

10.4.2.14.2 Test Method/Acceptance—Liquid Penetrant Examination

Liquid penetrant examination shall be performed as described in 10.4.2.11.3 with additional acceptance criterion of no rounded indications greater than 3 mm ($^{1}/_{8}$ in.) for welds whose depth is 16 mm ($^{5}/_{8}$ in.) or less, or 5 mm ($^{3}/_{16}$ in.) for welds whose depth is greater than 16 mm ($^{5}/_{8}$ in.).

10.4.2.15.4 Pressure Containing Repair Welds

For PSL 2, PSL 3, and PSL 4 pressure containing repair welds, the following requirements shall apply.

— All repair welds shall be examined using the same methods and acceptance criteria as used for examining the base metal or weld metal.

— Examinations shall include 13 mm ($^{1}/_{2}$ in.) of adjacent base metal on all sides of the weld.

— For surfaces prepared for welding, examination shall be performed prior to welding and defects removed to acceptable levels using methods and acceptance conforming to 10.4.2.15.

NOTE The repair weld requirements do not apply to PSL 1.

10.4.2.15 Weld NDE—Volumetric

10.4.2.15.1 Application

The volumetric weld examination requirements of 10.4.2.16 shall apply to PSL 2, PSL 3, and PSL 4.

100 % of all pressure-containing welds shall be examined by either radiography or ultrasonic methods after all welding, post-weld heat-treatment, and machining operations but prior to machining operations that limit effective interpretation of the results of the examination.

Examinations shall include at least 13 mm (1/2 in.) of adjacent base metal on all sides of the weld.

NOTE The volumetric weld examination requirements do not apply to PSL 1.

10.4.2.15.2 Test Method—Radiographic Examination

Radiographic examinations shall be performed in conformance withthe procedures specified in ASME *BPVC* Section V, Article 2 (or equivalent) using 2T Essential Hole for plaque type IQI or Equivalent Essential wire for wire type IQI.

Both X-ray and gamma-ray sources are acceptable within the inherent thickness range limitation of each. Real time imaging and recording/enhancement methods may be used provided the designated hole image quality indicator or essential wire is displayed as required by ASME BPVC, Section V, Article 2.

10.4.2.15.3 Acceptance Criteria—Radiographic Examination

The radiographic examination acceptance criteria shall be as follows:

— no type of crack, zone of incomplete fusion, or incomplete penetration;

— no elongated discontinuity that has a length greater than that given in Table 24;

Table 24—Maximum Length of RT Discontinuities

Weld Thickness, T		Discontinuity Length	
mm	in.	mm	in.
≤ 19.0	≤ 0.75	6.4	0.25
> 19.0 to ≤ 57.0	> 0.75 to ≤ 2.25	0.33T	0.33T
> 57.0	> 2.25	19.0	0.75

— no group of discontinuities in a line having an aggregated length greater than the weld thickness, T, in any total weld length of 12T, except where the distance between successive discontinuities exceeds six times the length of the longest discontinuity;

— no rounded indication in excess of that specified in ASME *BPVC*, Section VIII, Division 1, Appendix 4.

10.4.2.15.4 Test Method—Ultrasonic Examination

Ultrasonic examinations shall be performed in conformance withprocedures specified in ASME *BPVC*, Section V, Subsection A, Article 4 (or equivalent).

10.4.2.15.5 Acceptance Criteria—Ultrasonic Examination

Discontinuities that produce a response greater than 20 % of the reference level shall be investigated to the extent necessary to determine the shape, identity, and location and evaluate them in terms of the acceptance criteria below:

— no linear indication interpreted as cracks, incomplete joint penetration, or incomplete fusion;

— other indications with amplitudes exceeding the reference level whose length exceeds those given in Table 25 are unacceptable.

Table 25—Maximum Length of UT Discontinuities

Weld Thickness, T [a]		Discontinuity Length	
mm	in.	mm	in.
≤ 19.0	≤ 0.75	6.4	0.25
> 19.0 to ≤ 57.0	> 0.75 to ≤ 2.25	0.33T	0.33T
> 57.0	> 2.25	19.0	0.75

FOOTNOTE

[a] T is the thickness of the weld being examined. If a weld joins two members having different thicknesses at the weld, T is the thinner of the two thicknesses.

10.4.2.15.6 Repair Welds

For PSL 2, PSL 3, and PSL 4,. all repair welds where the repair is greater than 25 % of the original wall thickness or 25 mm (1 in.), whichever is less, shall be examined by either radiography or ultrasonic methods after all welding and post-weld heat-treatment. Examinations shall include at least 13 mm (1/2 in.) of adjacent base metal on all sides of the weld.

NOTE The following additional repair weld volumetric weld NDE requirement does not apply to PSL 2:

For PSL 3 and PSL 4 only, all repair welds, if the repair exceeds 20 % of the original wall thickness or 25 mm (1 in.), whichever is the smaller, or if the extent of the cavity exceeds approximately 65 cm^2 (10 $in.^2$), shall be examined by either radiography or ultrasonic methods after all welding and post-weld heat-treatment.

10.4.2.16 Weld NDE—Hardness

The hardness weld NDE requirements of 10.4.2.17 shall apply to PSL 3 and PSL 4.

NOTE The hardness weld NDE requirements do not apply to PSL 1 and PSL 2.

Except for overlays, 100 % of all accessible welds (including repairs) shall be hardness tested.

Hardness testing shall be performed in conformance withISO 6506 or ISO 6508 , or ASTM E10 or ASTM E18.

When the WPS requires PWHT, hardness testing shall be performed after all heat treatment on the weld metal and the base metal within 13 mm (0.5 in.) from the weld to conform to 10.4.2.4. When the WPS does not require PWHT, the weld metal at a minimum shall be hardness tested to conform to 10.4.2.4.

Hardness values shall conform to the base material requirements of 10.4.2.4.

The hardness recorded in the PQR shall be the basis for acceptance if the weld is not accessible for hardness testing.

10.4.2.17 Weld Overlay Volumetric Inspection

10.4.2.17.1 Application

The weld overlay volumetric inspection requirements of 10.4.2.18 shall apply to PSL 3 and PSL 4 except for ring grooves that conform to this specification.

10.4.2.17.2 Design Requirements

For PSL 3 and PSL 4 overlay welds other than ring grooves conforming to this specification, the manufacturer shall document if the overlay material is necessary to meet the design requirements of Section 5.1, and:

— If the overlay material is necessary to meet the design requirements of Section 5.1, volumetric examination shall conform to 10.4.2.18.3.

— If the overlay material is not necessary to meet the design requirements of Section 5.1, a measurement of overlay thickness and testing of bond integrity shall be performed according to the manufacturer's written specifications.

NOTE 1 These requirements do not apply to PSL 1 and PSL 2.

NOTE 2 See Table 23.

10.4.2.17.3 Test Methods and Acceptance Criteria

Weld overlay shall be examined using ultrasonic examination performed in conformance withASME BPVC, Section V, Subsection A, Article 4 technique 1 except that the immersion method may be used.

The acceptance criteria shall be as follows:

— no single indication exceeding reference DAC;

— no multiple indications exceeding 50 % of reference DAC.

NOTE "Multiple indications" is defined as two or more indications (each exceeding 50 % of the reference DAC) within 13 mm (1/2 in.) of each other in any direction.

10.4.3 Stems

10.4.3.1 Quality Control Requirements, Methods, and Acceptance Criteria

Quality control requirements for stems shall conform to Table 26 for PSL 1, PSL 2, PSL 3, and PSL 4. Where reference is made in 10.4.3 to requirements in 10.4.2, those shall be applicable to stems.

10.4.3.2 Volumetric NDE

10.4.3.2.1 Application

The volumetric NDE requirements of 10.4.3.2 shall apply to PSL 3 and PSL 4.

NOTE The volumetric NDE requirements do not apply to PSL 1 and PSL 2.

Each stem, or bar from which stems are machined, shall be volumetrically inspected using ultrasonic or radiographic techniques. The inspection shall be conducted after final heat-treatment (exclusive of stress-relief treatments) and prior to machining operations that limit effective interpretation of the results of the examination.

10.4.3.2.2 Test Method and Acceptance Criteria

Inspection shall be performed in conformance withthe methods of 10.4.2.12 for wrought materials. If ultrasonic inspection is performed, each stem (or bar from which stems are machined) shall be ultrasonically inspected from the outside diameter and ends by the straight-beam technique. Stems that cannot be examined axially using the straight-beam technique shall be examined using the angle-beam technique.

Table 26—Requirements for Stems

Parameter [a,b]	Reference			
	PSL 1	PSL 2	PSL 3	PSL 4
Tensile testing	10.4.2.2	10.4.2.2	10.4.2.2	10.4.2.2
Impact testing	10.4.2.3	10.4.2.3	10.4.2.3	10.4.2.3
Hardness testing NACE MR0175/ISO 15156	10.4.2.4 10.4.1.4	10.4.2.4 10.4.1.4	10.4.2.4 10.4.1.4	10.4.2.4 10.4.1.4
Dimensional inspection	10.4.2.5	10.4.2.5	10.4.2.5	10.4.2.5
Visual examination	10.4.2.6	10.4.2.6	—	—
Chemical analysis	—	10.4.2.7	10.4.2.7	10.4.2.7
Traceability	—	10.4.2.8	10.4.2.8	10.4.2.8
Surface NDE	—	10.4.2.10/10.4.2.11	10.4.2.10/10.4.2.11	10.4.2.10/10.4.2.11
Weld NDE	No welding is permitted except for weld overlays	No welding is permitted except for weld overlays	No welding is permitted except for weld overlays	No welding is permitted except for weld overlays
Weld overlay General Preparation - Visual Preparation - Surface NDE Completion - Visual Completion - Surface NDE	 10.4.3.3 10.4.2.6 — 10.4.2.14 —	 10.4.3.3 — 10.4.2.10/10.4.2.11 10.4.2.14 10.4.2.15	 10.4.3.3 — 10.4.2.10/10.4.2.11 10.4.2.14 10.4.2.15	 10.4.3.3 — 10.4.2.10/10.4.2.11 10.4.2.14 10.4.2.15
Serialization	—	—	10.4.2.9	10.4.2.9
Volumetric NDE	—	—	10.4.3.2	10.4.3.2

FOOTNOTES

[a] "Preparation" refers to surface preparation, joint preparation, fit-up, and preheat.

[b] "Completion" refers to after all welding, post-weld heat-treat, and machining, except for volumetric NDE that shall be done prior to machining that would limit effective interpretation of results

The DAC shall be based on a maximum 3.2 mm ($^1/_8$ in.) flat-bottom hole (straight-beam technique) and a maximum 1.6 mm ($^1/_{16}$ in.) side-drilled hole, 25 mm (1 in.) deep (angle-beam technique).

Acceptance criteria shall conform to 10.4.2.12.3, 10.4.2.12.5, or 10.4.2.12.6.

NOTE The volumetric NDE requirements do not apply to PSL 1 and PSL 2.

10.4.3.3 Weld NDE—General

For PSL 1, PSL 2, PSL 3, and PSL 4, the manufacturer's written specification for corrosion-resistant weld overlay shall include a technique for measuring the specified overlay thickness.

10.4.4 Valve Bore Sealing Mechanisms and Choke Trim

10.4.4.1 Application

Quality control requirements for valve bore sealing mechanisms shall conform to Table 27 for PSL 1, PSL 2, PSL 3, and PSL 4.

Table 27—Requirements for Valve Bore Sealing Mechanisms

	Reference			
	PSL 1	**PSL 2**	**PSL 3**	**PSL 4**
Tensile testing	6.3.2.2	6.3.2.2	6.3.2.2	6.3.2.2
Hardness testing NACE MR0175/ISO 15156	— 10.4.1.4	— 10.4.1.4	10.4.2.4 10.4.1.4	10.4.2.4 10.4.1.4
Dimensional inspection	—	—	10.4.2.5	10.4.2.5
Chemical analysis	—	10.4.2.7	10.4.2.7	10.4.2.7
Traceability	—	—	10.4.2.8	10.4.2.8
Surface NDE	—	—	10.4.2.10/10.4.2.11	10.4.2.10/10.4.2.11
Weld NDE General Visual examination NDE surface Hardness testing Repair welds	 — — — — —	 10.4.4.2 10.4.2.14 10.4.2.15 — 10.4.2.19	 10.4.4.2 10.4.2.14 10.4.2.15 10.4.2.17 10.4.2.19	No welding permitted except for weld overlays
Weld overlay Preparation - Surface NDE Completion - Surface NDE	 — —	 — 10.4.2.15	 10.4.2.10 10.4.2.15	 10.4.2.10 10.4.2.15
Serialization	—	—	10.4.2.9	10.4.2.9

FOOTNOTES

[a] "Preparation" refers to surface preparation, joint preparation, fit-up, and preheat.

[b] "Completion" refers to after all welding, post-weld heat-treat, and machining, except for volumetric NDE that shall be done prior to machining that would limit effective interpretation of results.

For PSL 1, PSL 2, PSL 3 and PSL 4, choke trim quality control requirements shall conform to Table 28.

Table 28—Requirements for Choke Trim

	Reference			
	PSL 1	PSL 2	PSL 3	PSL 4
Surface NDE	PMR	PMR	10.4.2.10 / 10.4.2.11	10.4.2.10 / 10.4.2.11
Serialization	PMR	PMR	10.4.2.9	10.4.2.9

Surface NDE shall not be required on brazed, press-fit, or shrink-fit joints.

NOTE Indications that are restricted to a brazed, press-fit, or shrink-fit joint are not relevant.

10.4.4.2 Weld NDE—General

If examination is required, welding activities shall be controlled in conformance with 7.3.8 and shall be examined in conformance with the methods and acceptance criteria of Table 27.

The manufacturer's written specification for corrosion-resistant weld overlay shall include a technique for measuring the specified overlay thickness.

10.4.5 Ring Gaskets and Non-integral Metal Seals

10.4.5.1 Application

NOTE PSLs are not applicable to ring joint gaskets and non-integral metal seals.

10.4.5.2 Tensile Testing

For non-integral metal seals, tensile testing shall conform to 6.3.2.2 if tensile stress is a design criterion.

NOTE Tensile testing requirements do not apply to ring gaskets.

10.4.5.3 Impact Testing

For non-integral metal seals, impact testing shall conform to 6.3.2.3 if tensile stress is a design criterion.

NOTE Impact testing requirements do not apply to ring gaskets.

10.4.5.4 Dimensional Inspection

10.4.5.4.1 Non-integral Metal Seals

Dimensional inspection shall be performed on non-integral metal seals manufactured according to this specification.

Sampling shall conform to manufacturer's documented requirements.

The manufacturer's documented procedures shall be followed.

Acceptance criteria shall conform to manufacturer's documented requirements.

10.4.5.4.2 Ring Gaskets

10.4.5.4.2.1 General

Dimensional inspection shall be performed on ring gaskets manufactured according to this specification.

10.4.5.4.2.2 Inspection of BX 156 and Smaller, BX 169 and BX 170, R, and RX gaskets

For BX 156 gaskets and smaller, including BX 169, BX 170, R, and RX gaskets, the following shall apply:

Sampling for ring gaskets shall conform to ISO 2859-1:1999, level II, 1.5 AQL.

The manufacturer shall document and maintain a procedure for dimensional inspection.

Acceptance criteria shall conform to 14.2.2.1.

10.4.5.4.2.3 Inspection of BX 157 and Larger Gaskets (Excluding BX 169 and BX 170)

For BX 157 through BX 303, excluding BX 169 and BX 170 gaskets, the following shall apply:

Sampling for ring gaskets shall conform to ISO 2859-1:1999, level II, 1.0 AQL.

Gaskets shall be in the finished condition and measured in the free state when the gasket is between 4 °C and 50 °C (40 °F and 120 °F). The gasket temperature at the time of inspection shall be included with the inspection records. All measured surfaces shall be clean and ungreased.

NOTE 1 Gaskets may be inspected in the uncoated condition.

Ring gasket inspection shall verify that dimensions conform to the dimensional Table D.12/E.12 (Type BX Ring Gaskets) as applicable.

The manufacturer shall document and maintain a procedure for dimensional inspection and measurement.

The process for measuring the 23° angle shall be documented and validated.

NOTE 2 Validation may employ the use of a CMM, a calibrated inspection gauge, or optical device.

The following method shall apply to the BX gasket:

1) Measure the ring width (A) and ring height (H) at a minimum of four equidistant locations. See Table D.12/E.12.

2) Measure the outer ring diameter (Ø OD Table D.12/E.12) at a minimum of four equidistant diameter locations using a validated inspection procedure. See Table D.12/E.12 for inspection locations.

NOTE 3 Additional inspection locations not shown in Table D.12/E.12 may be used.

3) Average the OD dimensions obtained.

4) Calculate the ovality of the ring by subtracting the smallest OD dimension from the largest OD dimension obtained in Step 2).

5) Determine the percentage difference based on the nominal ring diameter.

NOTE 4 See Table D.12/E.12 for reference to ring width (A) and ring height (H).

10.4.5.4.2.4 Acceptance Criteria

The difference in width (A) or height (H) between any two measured locations shall not exceed 0.10 mm (0.004 in)

The average OD shall be within the tolerance specified in Table D.12/E.12.

The OD ovality shall not exceed 0.2 % of the nominal ring outside diameter.

NOTE See Table D.12/E.12 for reference to ring width (A) and ring height (H) and outside diameter (OD).

10.4.5.5 Hardness Testing

10.4.5.5.1 Application

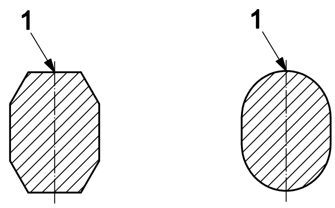
The requirements of 10.4.1.4 shall apply in addition to the requirements of 10.4.5.5.

As a minimum, sampling shall be performed on completed ring gaskets and non-integral metal seals in conformance with ISO 2859-1:1999, level II, 1.5 AQL.

For non-integral metal seals, the hardness testing may be done on the raw material or at any intermediate stage of machining following the last heat-treatment cycle (including stress-relieving heat-treatment).

10.4.5.5.2 Test Method and Acceptance Criteria

A minimum of one hardness test per sample part shall be performed in conformance with procedures specified in ISO 6508 or ASTM E18, geometry permitting. The location of the hardness test for ring gaskets shall conform to Figure 6. The location for non-integral metal seals shall conform to manufacturer's documented requirements.



Key

1 hardness test location

Figure 6—Ring Gasket Hardness Test Location

The acceptance criteria for ring gaskets shall be as given in Table 29.

For non-integral metal seals, the acceptance criteria shall be per the manufacturer's documented requirements.

Table 29—Hardness Requirements

Material	Maximum Hardness HRBW
Soft iron	56
Carbon and low alloys	68
Stainless steel	83
Nickel alloy UNS N08825	92
Other CRAs	a
FOOTNOTE [a] Hardness shall conform to the manufacturer's written specification.	

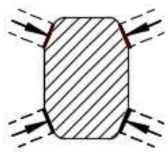
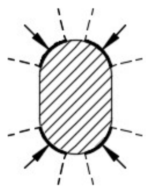
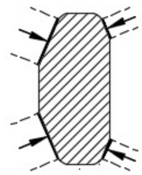
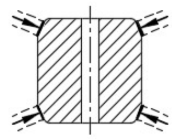
10.4.5.6 Surface Finish

The manufacturer's documented procedures, including the sampling criteria, shall be followed.

The inspection surfaces of ring gaskets as illustrated in Table 30 shall have a surface finish as specified in Annex D and Annex E (See Table 30 NOTE 1).

For non-integral metal seals, the acceptance criteria for the sealing surface finish shall conform to the manufacturer's documented requirements.

Table 30—Inspection Locations for Ring Gaskets

Gasket Type	R (Octagonal)	R (Oval)	RX	BX
Inspection Locations				
NOTE 1 See Annex D.9/E.9, D.10/E.10, and D.12/E.12 for surface finish requirements. NOTE 2 Highlighted dark heavy lines and arrows identify the surfaces subject to visual inspection.				

10.4.5.7 Visual Inspection—Ring Gaskets

All ring gaskets shall be visually inspected in conformance withthe manufacturer’s written specification.

No visible surface defects, as defined in the manufacturer’s written specification, shall be permitted on the inspection surfaces as identified in Table 30.

10.4.5.8 Traceability—Ring Gaskets

Job-lot and heat traceability shall be required.

Identification shall be maintained on materials and parts to facilitate traceability, as required by documented manufacturer requirements.

Manufacturer-documented traceability requirements shall include provisions for maintenance or replacement of identification marks and identification control records.

10.4.6 Nonmetallic Seals

10.4.6.1 Application

This section shall apply to pressure-containing and pressure-controlling seals.

For PSL 1, PSL 2, PSL 3, and PSL 4, the requirements of 10.4.6 shall apply.

10.4.6.2 Hardness Testing

Sampling shall conform to ISO 2859-1:1999, level II, 2.5 AQL for O-rings and 1.5 AQL for other seals.

Hardness testing shall be performed in conformance withprocedures specified in ASTM D2240 or ASTM D1415. For materials not covered by these standards, hardness testing shall be per the manufacturer’s specification.

The hardness shall be controlled in conformance withthe manufacturer’s written specification.

10.4.6.3 Dimensional Inspection

Dimensional inspection shall be performed on nonmetallic seals manufactured in conformance withthis specification.

Sampling shall be performed on nonmetallic seals in conformance withISO 2859-1:1999, level II, 2.5 AQL for O-rings and 1.5 AQL for other seals.

Each piece of the sample shall be dimensionally inspected for conformance to specified tolerances.

If inspection methods produce fewer rejections than allowed in sampling, the batch shall be accepted.

10.4.6.4 Visual Examination

Sampling shall be performed in conformance withISO 2859-1:1999, level II, 2.5 AQL for O-rings and 1.5 AQL for other seals.

Each piece of the sample shall be visually inspected according to manufacturer's written requirements.

If inspection methods produce fewer rejections than allowed in sampling, batch acceptance shall be permitted.

10.4.6.5 Documentation

NOTE 1 The documentation requirements do not apply to PSL 1.

For PSL 2, PSL 3, and PSL 4, the seal supplier shall certify that materials and end products meet manufacturer's specifications. Certification shall include manufacturer's part number, specification number, and compound number.

For PSL 3 and PSL 4, additionally, the following documentation shall be included:

— batch number/traceability;

— cure/mold date;

— shelf-life expiration date.

NOTE 2 These additional documentation requirements do not apply to PSL 2.

For PSL 4 only, the following additional documentation shall be included.

— The seal supplier shall supply a copy of test results of the physical properties of the compound supplied. Physical properties shall conform to manufacturer's written specification.

— Physical property data for qualification of homogeneous elastomers shall include the items given in Table 31.

— Physical property data for other nonmetallic seal materials shall conform to the requirements of the manufacturer's written specification.

NOTE 3 These additional documentation requirements do not apply to PSL 2 and PSL 3.

Table 31—Physical Property Data for Qualification of Homogeneous Elastomers

Data	Documentation in Accordance with
Hardness testing	ASTM D1414 or ASTM D2240
Tensile testing	ASTM D412 or ASTM D1414
Elongation	ASTM D412 or ASTM D1414
Compression set	ASTM D395 or ASTM D1414
Modulus	ASTM D412 or ASTM D1414
Fluid immersion	ASTM D471 or ASTM D1414

10.4.7 General Equipment Requirements

10.4.7.1 Traceability Record

For PSL 3 and PSL 4 assembled equipment, a report identifying the body, bonnet, stem, end and outlet connector, and valve bore sealing mechanisms shall be listed traceable to the assembly.

NOTE The traceability requirements do not apply to PSL 1 and PSL 2.

10.4.7.2 Serialization

The following shall be serialized:

— PSL 2, PSL 3, and PSL 4 Casing Hangers and Tubing Hangers,

— PSL 2, PSL 3 and PSL 4 pressure tested equipment, as per Table 32, and

— Back pressure valves.

10.4.8 Mandrel-type Hangers

10.4.8.1 General

Section 10.4.8 shall apply to mandrel-type hangers, including casing and tubing hanger mandrels.

10.4.8.2 Tensile Testing

For PSL 1, PSL 2, PSL 3, and PSL 4, tensile testing shall conform to 6.3.2.2.

10.4.8.3 Impact Testing

For PSL 1, PSL 2, PSL 3, and PSL 4, impact testing shall conform to 6.3.2.3.

10.4.8.4 Hardness Testing

10.4.8.4.1 Requirements

Hardness testing shall conform with the requirements of Table 20.

10.4.8.4.2 Test Method and Acceptance Criteria

Hardness testing shall be performed in conformance with procedures specified in ISO 6506 or ISO 6508 , or ASTM E10 or ASTM E18. Perform test at a location determined by the manufacturer's specifications and following the last heat-treatment (including all stress-relieving heat-treatment cycles) and all exterior machining.

Acceptance criteria shall conform to manufacturer's specification.

10.4.8.5 Dimensional Inspection

10.4.8.5.1 Application

Dimensional inspection shall be performed on casing and tubing hanger mandrels manufactured in conformance with this specification. The manufacturer shall specify critical dimensions.

All suspension, lift, and back-pressure valve threads or retention profiles shall be gauged.

Critical dimensions on all parts shall be verified. For PSL 1 and PSL 2, other features shall be checked on sample parts in conformance with ISO 2859-1:1999, level II, 1.5 AQL. For PSL 3 and PSL 4, sampling shall not be allowed; all parts shall be dimensionally inspected.

10.4.8.5.2 Test Method and Acceptance Criteria

The connectors shall be gauged for standoff at hand-tight assembly by use of the gauges and gauging practices illustrated in Table D.29/Table E.29 and Table D.30/Table E.30.

Acme and other parallel thread profiles shall be dimensionally inspected in conformance with the manufacturer's specifications.

Acceptance criteria for critical dimensions shall conform to manufacturer's specification. The end and outlet connector threads shall conform to Table D.29/Table E.29 and Table D.30/Table E.30; or with API 5B; or with ASME B1.1, ASME B1.2, and ASME B1.3, as applicable.

10.4.8.6 Visual Examination

The visual examination requirements of 10.4.8.6 shall apply to PSL 1 and PSL 2.

NOTE The visual examination requirements do not apply to PSL 3 and PSL 4.

Each part shall be visually examined.

Visual examination shall be conducted on wrought material in conformance with the manufacturer's written specifications.

Acceptance criteria for wrought material shall be in conformance with the manufacturer's written specifications.

10.4.8.7 Chemical Analysis

The chemical analysis requirements of 10.4.8.7 shall apply to PSL 1, PSL 2, PSL 3, and PSL 4.

Chemical analysis shall be performed on a heat of material.

Chemical analysis shall be performed in conformance with nationally or internationally recognized standards specified by the manufacturer.

The chemical composition shall conform to the requirements of the manufacturer's written specification.

10.4.8.8 Traceability

For PSL 1 and PSL 2, the following shall apply.

— Job-lot traceability shall be required.

— Identification shall be maintained on materials and parts to facilitate traceability, as required by documented manufacturer requirements.

— Manufacturer-documented traceability requirements shall include provisions for maintenance or replacement of identification marks and identification control records.

NOTE 1 The PSL 1 and PSL 2 traceability requirements do not apply to PSL 3 and PSL 4.

For PSL 3 and PSL 4, parts shall be traceable to a specific heat and heat-treat lot.

NOTE 2 The PSL 3 and PSL 4 traceability requirements do not apply to PSL 1 and PSL 2.

10.4.8.9 Serialization

For PSL 3 and PSL 4, serialization requirements shall conform to 10.4.2.9.

NOTE The serialization requirements do not apply to PSL 1 and PSL 2.

10.4.8.10 Surface NDE

For PSL 2, PSL 3, and PSL 4, surface NDE requirements shall conform to 10.4.2.10 for ferromagnetic materials and 10.4.2.11 for nonferromagnetic materials, as applicable.

NOTE The surface NDE requirements do not apply to PSL 1.

10.4.8.11 Volumetric NDE

For PSL 3 and PSL 4, volumetric NDE requirements shall conform to 10.4.2.12.

For PSL 4, additionally, volumetric NDE requirements shall include the following.

1) Acceptance criteria for the UT: Same acceptance criteria as PSL 3, with the addition that no continuous cluster of indications on the same plane, regardless of amplitude, shall be found over an area twice the diameter of the search unit.

2) Acceptance criteria for the radiographic testing shall be as follows:

— no indication interpreted as a crack, lap, or burst;

— no elongated indications exceeding 6.4 mm ($^{1}/_{4}$ in.);

— no more than two indications separated by less than 13 mm ($^{1}/_{2}$ in.).

NOTE The volumetric NDE requirements do not apply to PSL 1 and PSL 2.

10.4.8.12 Weld NDE—General

For PSL 2 only, quality control requirements shall conform to 10.4.2.14, 10.4.2.15, 10.4.2.16, and 10.4.2.19. Repair welding shall be in conformance with 7.4.

For PSL 3 only, general weld NDE requirements shall conform to 10.4.2.13.

For PSL 4, no welding except overlay shall be permitted on PSL 4. Weld NDE requirements for overlay in PSL 4 shall be identical to the requirements for PSL 3.

NOTE The weld NDE requirements do not apply to PSL 1.

10.4.8.13 Weld Examination—Visual

For PSL 2 and PSL 3, visual weld examination requirements shall be -10.4.2.14.

NOTE The visual weld examination requirements do not apply to PSL 1 and PSL 4.

10.4.8.14 Weld NDE—Surface

For PSL 2 and PSL 3, surface weld NDE requirements shall conform to 10.4.2.15.

NOTE The surface weld NDE requirements do not apply to PSL 1 and PSL 4.

10.4.8.15 Weld NDE—Volumetric

For PSL 2 and PSL 3, volumetric weld NDE requirements shall conform to 10.4.2.16.

NOTE The volumetric weld NDE requirements do not apply to PSL 1 and PSL 4.

10.4.8.16 Weld NDE—Hardness

10.4.8.16.1 Application

The hardness weld NDE requirements of 10.4.8.16 shall apply to PSL 2 and PSL 3.

NOTE The hardness weld NDE requirements do not apply to PSL 1 and PSL 4.

100 % of all accessible pressure-containing, non-pressure-containing, and repair welds shall be tested.

10.4.8.16.2 Test Method and Acceptance Criteria

Hardness testing shall be performed in conformance with procedures specified in ISO 6506 or ASTM E10 or procedures specified in ISO 6508 or ASTM E18.

At least one hardness test shall be performed both in the weld and in the adjacent unaffected base metals after all heat-treatment and machining operations.

Acceptance criteria shall conform to manufacturer's specifications.

The hardness recorded in the PQR shall be the basis for acceptance if the weld is not accessible for hardness testing.

10.4.8.17 Weld Overlay

For PSL 3 and PSL 4, surface NDE (preparation) requirements of 10.4.2.10 for ferromagnetic materials and 10.4.2.11 for nonferromagnetic materials shall apply.

NOTE 1 The surface NDE requirements for the weld preparation do not apply to PSL 1 and PSL 2.

For PSL 2, PSL 3, and PSL 4, surface NDE (completion) requirements of 10.4.2.15 shall apply.

NOTE 2 The surface NDE requirements for the weld completion do not apply to PSL 1.

For PSL 3 and PSL 4, volumetric NDE requirements of 10.4.2.18 shall apply.

NOTE 3 The volumetric NDE requirements do not apply to PSL 1 and PSL 2.

10.4.8.18 Repair Welds

For PSL 2 and PSL 3, repair weld requirements shall conform to 10.4.2.15.4.

10.4.9 Slip-type Hangers

10.4.9.1 General

The requirements in 10.4.9 are identical and shall apply to all PSLs of the specified components.

10.4.9.2 Slip Bowls

10.4.9.2.1 Tensile Testing

Tensile testing of slip bowls shall conform to 6.3.2.2.

10.4.9.2.2 Hardness Testing

Sampling shall be per the manufacturer's requirements.

Hardness testing shall be performed in conformance with procedures specified in ISO 6506 or ISO 6508, or ASTM E10 or ASTM E18. Perform test at a location determined by the manufacturer's specifications and following the last heat-treatment (including all stress-relieving heat-treatment cycles) and all exterior machining.

Acceptance criteria shall conform to manufacturer's specification.

10.4.9.2.3 Dimensional Inspection

Manufacturers shall identify critical dimensions for dimensional inspection. Slip bowls shall be inspected on a sample basis in conformance with ISO 2859-1:1999, level II, 1.5 AQL and the manufacturer's specifications.

10.4.9.2.4 Visual Examination

Each slip bowl shall be visually examined.

Visual examination shall be performed in conformance with the manufacturer's written specifications.

10.4.9.2.5 Chemical Analysis

Chemical analysis shall be performed on a heat of material.

Chemical analysis shall be performed in conformance with nationally or internationally recognized standards specified by the manufacturer.

The chemical composition shall conform to the requirements of the manufacturer's written specification.

10.4.9.2.6 Additively Manufactured Slip Bowls

Slip Bowls manufactured using AM methods shall conform to AMSL 2 or AMSL 3.

10.4.9.2.7 Traceability

Job-lot traceability shall be required.

Identification shall be maintained on slip bowls, as specified by the manufacturer's requirements.

10.4.9.2.8 Records Control

Records shall conform to the requirements for PSL 1 specified in 15.2.

10.4.9.3 Slip Segments

10.4.9.3.1 Dimensional Inspection

Manufacturers shall identify critical dimensions for dimensional inspection. Slip segments shall be inspected on a sample basis conforming to ISO 2859-1:1999, level II, 1.5 AQL and the manufacturer's specifications.

10.4.9.3.2 Visual Examination

Each set of slip segments shall be visually examined.

Visual examination shall conform to manufacturer's written specifications.

10.4.9.3.3 Chemical Analysis

Chemical analysis shall be performed on a heat of material.

Chemical analysis shall be performed in conformance with nationally or internationally recognized standards specified by the manufacturer.

The chemical composition shall conform to the requirements of the manufacturer's written specifications.

10.4.9.3.4 Traceability

Job-lot traceability shall be required. Identification shall be maintained on slip segments, as specified by the manufacturer's requirements.

10.4.9.3.5 Slip Hardening

The hardening process shall conform to manufacturer's written specifications.

10.4.9.3.6 Threaded Fasteners

Threaded fasteners passing through or activating seals in slip hangers rated for material classes DD, EE, FF, or HH shall conform to NACE MR0175/ISO 15156.

10.4.9.3.7 Additively Manufactured Slip Segments

Additively manufactured material used to manufacture slip segments shall conform to AMSL 2 or AMSL 3.

10.4.9.3.8 Records Control

Records shall conform to the requirements for PSL 1 specified in 15.2.

10.4.10 Bullplugs, Valve-removal Plugs, Back-pressure Valves, and Fittings

10.4.10.1 Application

Cast iron shall not be used.

Weld repair shall not be allowed.

Requirements for fittings shall conform to manufacturer's written procedures.

NOTE PSLs are not applicable.

10.4.10.2 Tensile Testing

Tensile testing for bullplugs, back-pressure valve bodies, and valve-removal plug bodies shall conform to 6.3.2.2.

10.4.10.3 Impact Testing

Impact testing for bullplugs, back-pressure valve bodies, and valve-removal plug bodies shall conform to 6.3.2.3.

10.4.10.4 Hardness Testing

Hardness testing of bodies shall conform to Table 20: Loose Connectors PSL 1. Hardness testing of metallic valve seal mechanisms on back-pressure valves for material classes DD, EE, FF, and HH shall be performed in conformance with 10.4.1.4.

NOTE Hardness testing is not required for those materials that have no hardness restriction specified by NACE MR0175/ISO 15156 or are excluded by NACE MR0175/ISO 15156, or for those materials that are not heat-treated to obtain a minimum specified strength level.

10.4.10.5 Dimensional Inspection

Dimensional inspection shall conform to 10.4.2.5 for PSL 1. In addition, all threads or retention profiles shall be gauged.

10.4.10.6 Visual Examination

Visual examination shall conform to 10.4.2.6 for PSL 1.

10.4.10.7 Chemical Analysis

Chemical analysis requirements shall conform to 10.4.2.7 for PSL 2.

10.4.10.8 Traceability

Traceability requirements shall conform to 10.4.2.8 for PSL 2.

11 Factory Acceptance Testing

11.1 General

11.1.1 Scope and Applicability

This section specifies pressure testing, drift testing, and functional testing requirements for production units. Equipment listed in column 1 of Table 32 shall be tested in conformance with these requirements.

Table 32—Applicability of Factory Acceptance Testing

Pressure-tested Equipment Factory acceptance testing (FAT) requirements identified in this specification	**Non-pressure-tested Equipment** *No* factory acceptance testing (FAT) requirements identified in this specification
• Valves Gate, plug, ball and check valves SSVs, USVs, BSDVs	• Loose Connectors (including adapter, blind, companion, integral, instrument, spacer, test, threaded and weld-neck flanges) and OECs
• Back-pressure valves • Fittings/pressure boundary penetrations (installed in assembled equipment) • Tees and Crosses	• Bullplugs • Valve-removal plugs • Loose fittings (and other pressure boundary penetrations)
• Chokes • Adapter and spacer spools • Tubing-head adapters	• Casing and tubing hangers — Mandrel-type hangers — Slip-type hangers
• Actuators (for valves or chokes) — Hydraulic actuators — Pneumatic actuators — Electric actuators	• Ring gaskets • Other metal seals • Packing mechanisms for lock screws, alignment pins, and retainer screws
• Casing and tubing heads • Crossover connectors • Top connectors • Tree assemblies	• Replacement parts — Stems — Lock screws — Valve bore sealing mechanisms (gates, seats, plugs, balls, etc.) — Choke trim

Factory acceptance testing for actuators shall be performed in conformance with all applicable requirements of 14.17.4.

NOTE 1 Factory acceptance testing is not required for the equipment listed under the Non-pressure-tested Equipment column of Table 32.

NOTE 2 A summary of the testing required is provided in Table 33. This table is for reference only. The full test requirements for each test type are in Section 11

NOTE 3 A summary of the hydrostatic and gas testing requirements for gate, plug and ball valves is provided in Table 34. This table is for reference only. The full test requirements for each test type are in Section 11

11.1.2 Measurement, Monitoring, and Recording Devices

Pressure-measuring and pressure-recording devices shall be maintained and calibrated in conformance with 10.2.2. The range and resolution of pressure-measuring and pressure-recording devices shall conform to 10.2.2.

If a pressure chart recorder is not calibrated to meet the accuracy required by 10.2.2, it shall be used in parallel with a calibrated pressure gauge, and the pressure indicated by the calibrated gauge at the start and at the end of the hold period shall be written on the chart.

NOTE Pressure charts are not required for gas testing, compared with water, because a large volume change of gas is required to produce a significant change in pressure.

Table 33— Factory Acceptance Testing Requirements by Equipment Type and PSL

Equipment Type	Hydrostatic Testing (PSL)			Gas Testing (PSL)			Drift Test (PSL)
	Shell Test	Seat Test	Function Test	Body [c] Test	Valve Seat Test	Backseat Test	
Valves	1, 2, 3/3G, 4	1, 2, 3/3G, 4	2, 3/3G, 4	3G, 4	3G, 4	3G [d], 4	1, 2, 3/3G, 4
Chokes	1, 2, 3/3G, 4	—	—	3G, 4	—	—	—
Tree assemblies	✓[b]	—	—	—	—	—	✓
Casing Heads, Tubing Heads, and Tubing Head Adapters	1, 2, 3/3G, 4	—	—	3G, 4	—	—	—
Adapter and spacer spools Tees and crosses Crossover connectors Top connectors	1, 2, 3/3G, 4	—	—	3G, 4	—	—	—
Actuators [a,e]	✓	—	✓	—	—	—	—
Back-pressure valves [a]	—	✓	—	—	—	—	—

FOOTNOTES
[a] PSLs are not applicable to this equipment.
[b] See 11.2.3.3 for test pressure requirements.
[c] Body test pressure = rated working pressure.
[d] Optional.
[e] See 14.17.4 for factory acceptance testing requirements.
✓ = test applies/PSL does not apply.

11.1.3 Test Sequence

The tests specified in this section shall be performed in a sequence that conforms to the following requirements.

a) The hydrostatic shell test shall be the first pressure test performed.

b) All hydrostatic pressure tests and functional tests shall be performed prior to any gas testing.

NOTE The sequence of gas testing may be varied at the option of the manufacturer.

c) Drift testing of valves and tree assemblies shall be performed last, after all required pressure tests and functional tests.

d) If a conditional body test is applicable to hydrostatic and/or gas testing (see 11.2.5 and 11.3.6), it shall be completed at a time when the test can be performed with all fittings and other pressure boundary penetrations installed and not removed afterwards.

11.1.4 Leak Detection

For hydrostatic or gas testing, visible leakage (see 3.1.100) shall be any release of test fluid observed during the pressure hold period. Fluid released during pressure build-up or pressure bleed-down shall not be considered leakage. Visible leakage shall be observed directly, including through a window, or by a video monitoring device.

When a video monitoring device is used in place of direct observation, resolution and brightness shall be sufficient to determine whether leakage occurs.

Table 34 – Summary of Hydrostatic and Gas Testing Requirements for Gate, Plug and Ball Valves

Duration in minutes

	Test Pressure	**Sequence of Tests**	**PSL 1**	**PSL 2**	**PSL 3**	**PSL 3G**	**PSL 4**
Hydrostatic Shell Tests (per. 11.2.3)	Table 35	Primary	3	3	3	3	3
		Secondary	3	3	15	15	15
Hydrostatic Seat Test and Functional Test (per 11.2.4)	RWP	Seat Seal Test (Primary)	3	3	3	3	3
		Functional Test (Primary) [a]	-----	Yes	Yes. Record operating input [b]	Yes. Record operating input [b]	Yes. Record operating input [b]
		Seat Seal Test (Secondary)	3	3	15	3	15
		Functional Test (Secondary) [a]	-----	Yes	Yes. Record operating input [b]	Yes. Record operating input [b]	Yes. Record operating input [b]
		Seat Seal Test (Tertiary)	-----	3	15	3	15
Conditional Hydrostatic Body Test (per 11.2.5)	RWP	-----	3. [c]	3 [c]	3 [c]	-----	-----
Gas Body Test (per 11.3.3)	RWP	Primary	----	----	----	15	15
Gas Seat Test (per 11.3.4)	RWP	Primary	----	----	----	15	15
	2.1 MPa (300 psi)	Secondary	----	----	----	15	-----
	See 11.3.4		----	----	----	----	15
Gas Backseat Test (per 11.3.5)	RWP	Primary	----	----	----	**Optional** 15	15
	See 11.3.5	Secondary	----	----	----	----	5
Conditional Gas Body Test (per 11.3.6)	RWP	----	----	----	----	3 [d]	3 [d]
Drift Test (per 11.4)	----	----	Yes	Yes	Yes	Yes	Yes

FOOTNOTES:
a. See 11.2.4 for details.
b. Manual opening torque or actuator pressure or actuator current is recorded. See 11.2.4.2.
c. If required (See 11.2.5), a conditional hydrostatic body test is performed.
d. If required (See 11.3.6), a conditional gas body test is performed.

11.2 Hydrostatic Testing

11.2.1 Hydrostatic Testing—General Requirements

All hydrostatic testing of 11.2 shall conform to the requirements of this section.

— Test fluid shall be water or water with additives.

— If a body includes an integral API flange connector, it shall be acceptable to use a test fixture with nonmetallic seals for the API flange connection. Nonmetallic seals, placed in the flow bore, shall be within half of flange thickness from the bore entrance

— Test fixtures shall not apply additional stress to the body under test.

— All hold periods shall not start until the test article and the pressure measuring/recording device has been isolated from the pressure source and the external surfaces of the shell members have been thoroughly dried.

— All pressure testing shall be conducted prior to the addition of body-filler grease. Lubrication applied for assembly purposes is acceptable.

— Testing shall be performed prior to painting; however, if the body and other pressure-containing parts are constructed of wrought material, tests may be completed after painting.

— Sealing integrity of fittings and other primary pressure boundary penetrations shall be verified, either during the testing specified in this section or by performance of a conditional test as specified in 11.2.5.

NOTE 1 The conditional hydrostatic test does not apply to a redundant secondary seal that can only be exposed to pressure via leakage from a primary seal. Testing of these seals is outside the scope of this specification.

11.2.2 Hydrostatic Test Acceptance Criteria

The acceptable criteria specified below shall be applied to shell tests, seat tests, and conditional hydrostatic body tests. For PSL 1, PSL 2, PSL 3, and PSL 4, the acceptance criteria shall be as follows.

a) The equipment shall be continuously monitored during each hold period, and no visible leakage during the hold period shall be accepted, except as specified otherwise in 11.2.2.c) or 11.2.2.d).

b) For the hold period, the following shall apply:

 — At the start of the hold period, monitored pressure shall not be greater than 5 % above the specified test pressure.

 — During the hold period, the pressure shall not vary from the pressure at the start of the hold period by more than 5% or 3.45 MPa (500 psi), whichever is less.

 — Monitored pressure shall not be less than the specified test pressure.

c) For equipment with a threaded end or outlet connector joined to a threaded test fixture, leakage past the thread shall be acceptable when the test pressure exceeds the rated working pressure of the thread.

d) For metal seating check valves, the maximum allowable through-bore leakage in hydrostatic seat testing shall be in conformance with ISO 5208 Rate E.

e) Threaded connections, non-metallic seals, and proprietary metal seals that leak above working pressure shall have an additional pressure test performed at rated working pressure. This hold period shall be of the same duration as the secondary pressure-holding period, and the acceptance criterion shall be no visible leakage.

11.2.3 Hydrostatic Shell Test

11.2.3.1 Test Method—PSL 1, PSL 2, PSL 3, and PSL 4

For PSL 1, PSL 2, PSL 3, and PSL 4, the following shall apply.

If a shell test is specified in Table 33, each piece of equipment shall be hydrostatically shell tested prior to shipment from the manufacturer's facility. The hydrostatic shell test shall be the first pressure test performed.

The general requirements of 11.1 and 11.2.1 shall apply.

— Valves and chokes closure mechanisms shall be positioned such that the bore and entire pressure cavity are exposed to test pressure; test pressure shall not be applied as a differential pressure across closure mechanisms of valves or chokes.

— For valves that include a stem backseat, the stem backseat shall not be engaged during pressure application and testing.

The hydrostatic shell test for assembled equipment shall consist of three parts:

a) primary pressure-holding period;

b) reduction of the pressure to 0 psi;

c) secondary pressure-holding period.

After testing, the pressure in the test article shall be reduced to 0 psi.

11.2.3.2 Hold Periods

The duration of pressure-holding periods shall be as follows:

— For all PSLs, a primary hold period of no less than 3 minutes;

— For PSL 1 and PSL 2, a secondary hold period of no less than 3 minutes; and

— For PSL 3 and PSL 4, a secondary hold period of no less than 15 minutes.

11.2.3.3 Test Pressure

For PSL 1, PSL 2, PSL 3, and PSL 4, the following shall apply.

The hydrostatic shell test pressure requirement shall be based on the rated working pressure and equipment type in conformance with Table 35, with the following supplemental requirements applied.

a) For equipment with end or outlet connectors having different rated working pressures, the lowest working pressure rating shall be used to determine the hydrostatic shell test pressure (except for crossover connectors and chokes).

b) For a crossover connector, the test pressure shall be based on the rated working pressure for the upper connector. Test pressure shall be applied inside and above the restricted-area packoff of the lower connector. The lower connector shall be tested below the restricted-area packoff with test pressure based on its rated working pressure.

c) For a choke having an inlet connector with a higher rated working pressure than the outlet connector, two hydrostatic shell tests shall be performed. The body portion from the inlet connector to the body-to-bean seal point of the replaceable seat or flow bean shall be tested at the shell test pressure for the inlet connector. The remainder of the body, downstream from the seal point, shall be tested at the shell test pressure for the outlet connector. Temporary seat seals and/or a blank seat may be used to facilitate testing.

d) For trees, the shell test pressure of Table 35 shall apply, with one exception: trees assembled entirely with equipment, excluding loose connectors, that has been previously hydrostatically shell tested, shall be tested either to the test pressure of Table 35 or to rated working pressure.

e) Each bore of multiple-bore equipment shall be tested individually.

11.2.3.4 Acceptance Criteria

For PSL 1, PSL 2, PSL 3, and PSL 4, the acceptance criteria shall be as specified in 11.2.2.

Table 35—Hydrostatic Shell Test Pressure

Working Pressure Rating		**Hydrostatic Shell Test Pressure**											
		Nominal Size of Flange mm (in.)				**Line Pipe and Tubing Threads**		**Casing Threads** mm (in.)					
		346 ($13\frac{5}{8}$) and smaller		425 ($16\frac{3}{4}$) and larger				114.3 to 273.1 ($4\frac{1}{2}$ to $10\frac{3}{4}$)		298.5 to 339.7 ($11\frac{3}{4}$ to $13\frac{3}{8}$)		406.5 to 508.0 (16 to 20)	
MPa	(psi)	MPa	(psi)	MPa	(psi)	MPa	(psi)	MPa	(psi)	MPa	(psi)	MPa	(psi)
13.8	(2000)	27.6	(4000)	20.7	(3000)	27.6	(4000)	27.6	(4000)	27.6	(4000)	15.5	(2250)
20.7	(3000)	41.4	(6000)	31.0	(4500)	41.4	(6000)	41.4	(6000)	31.0	(4500)	—	—
34.5	(5000)	51.7	(7500)	51.7	(7500)	51.7	(7500)	51.7	(7500)	—	—	—	—
69.0	(10,000)	103.5	(15,000)	103.5	(15,000)	103.5	(15,000)	—	—	—	—	—	—
103.5	(15,000)	155.0	(22,500)	155.0	(22,500)	—	—	—	—	—	—	—	—
138.0	(20,000)	207.0	(30,000)	—	—	—	—	—	—	—	—	—	—

11.2.4 Hydrostatic Seat Tests and Functional Tests—Valves

11.2.4.1 Test Method—PSL 1

For PSL 1, the following shall apply.

a) The general requirements of 11.1 and 11.2.1 shall apply.

b) Hydrostatic test pressure shall be not less than the rated working pressure of the valve. Pressure shall be applied to one side of the closed gate, ball, or plug of the valve, with the other side vented to atmosphere. Unidirectional valves shall be tested in the direction indicated on the body, except for check valves, which shall be tested from the downstream side.

NOTE 1 Split-gate valves may have both seats tested simultaneously.

c) Pressure shall be monitored for a hold period of no less than 3 minutes.

d) Test pressure shall be reduced to 0 psi.

e) Steps b) through d) shall be repeated. During the (secondary) hold period, pressure shall be monitored and the valve monitored for visible leakage.

f) For a bidirectional valve, steps b) through e) shall be performed on the other side of the gate, ball, or plug using the same procedure outlined above.

NOTE 2 PSL 1 hydrostatic seat test method requirements do not apply to PSL 2, PSL 3, PSL 3G, or PSL 4.

NOTE 3 Methods other than direct observation of the valve bore sealing mechanism may be used for visual leak detection provided that the visual monitoring method has been validated to show fluid leakage when present.

11.2.4.2 Test Method—PSL 2, PSL 3, and PSL 4

For PSL 2, PSL 3, and PSL 4, the following shall apply.

a) The general requirements of 11.1 and 11.2.1 shall apply.

b) Hydrostatic test pressure shall be not less than the rated working pressure of the valve. Pressure shall be applied through one side of the flow bore to the closed gate, ball, or plug of the valve, with the other side vented to atmosphere. Unidirectional valves shall be tested in the direction indicated on the body, except for check valves, which shall be tested from the downstream side.

c) Pressure shall be monitored for the primary hold period of no less than 3 minutes.

d) The valve, except for check valves, shall be opened while still under full differential pressure. For PSL 3and PSL 4 only, the operating input required to open the valve while operating under full differential pressure shall be measured.

- For manual valves, the operating input shall be torque.
- For valves with hydraulic or pneumatic actuators, the operating input shall be pressure.
- For valves with electric actuators, the operating input shall be current.
- For fail open valves – Hydraulic, Pneumatic or Electric actuated valves, it shall not be required to measure the operating input. This exception does not apply to valves operated by double acting actuators.

NOTE 1 Measurement of torque or actuator input is not required for PSL 2.

e) Test pressure shall be applied a second time to the same side of the gate, ball, or plug.

f) Pressure shall be monitored for the secondary hold period of no less than 3 minutes for PSL 2 and PSL 3G. Pressure shall be monitored for the secondary hold period of no less than 15 minutes for PSL 3 and PSL 4.

g) The valve, except for check valves, shall be opened a second time while still under full differential pressure. For PSL 3 and PSL 4 only, the operating input required to open the valve while operating under full differential pressure shall be measured.

- For manual valves, the operating input shall be torque.
- For valves with hydraulic or pneumatic actuators, the operating input shall be pressure.
- For valves with electric actuators, the operating input shall be current.
- For fail open valves – hydraulic, pneumatic or electric actuated valves, it shall not be required to

measure the operating input. This exception does not apply to valves operated by double acting actuators.

h) Test pressure shall be applied a third time to the same side of the gate, ball, or plug.

i) Pressure shall be monitored, and the valve shall be monitored for visible leakage, for the tertiary hold period of no less than 3 minutes for PSL 2 and PSL 3G. Pressure shall be monitored, and the valve shall be monitored for visible leakage, for the tertiary hold period of no less than 15 minutes for PSL 3 and PSL 4.

NOTE 2 Methods other than direct observation of the valve bore sealing mechanism may be used for visual leak detection, provided that the visual monitoring method has been validated to show fluid leakage when present.

j) Test pressure throughout the valve shall be reduced to 0 psi.

NOTE 3 The valve is not opened under differential pressure after the tertiary seat test.

k) For a bidirectional valve, steps b) through j) shall be performed on the other side of the gate, ball, or plug using the same procedure outlined above.

NOTE 4 PSL 2, PSL 3, and PSL 4 hydrostatic valve seat test requirements do not apply to PSL 1.

11.2.4.3 Acceptance Criteria

For PSL 1, PSL 2, PSL 3, and PSL 4, the acceptance criteria shall be as specified in 11.2.2.

Additionally, for PSL 3 and PSL 4 valves only, the measured operating torque for manual valves or supply pressure/electric current for actuated valves, while operating under full differential pressure, shall be within the manufacturer's specified requirements.

11.2.5 Conditional Hydrostatic Body Test—PSL 1, PSL 2, and PSL 3

11.2.5.1 Application

If any fitting or pressure boundary penetration was not installed during the last pressure-holding period, the following shall apply:

a) a conditional hydrostatic body test shall be performed with all fittings or pressure boundary penetrations installed conforming to 11.2.5.2 shall be performed, or

b) a conditional gas body test in conformance with 11.3.6 shall be performed. The acceptance criteria of 11.3.6.2 shall apply for conditional gas body testing of PSL 1, PSL 2 or PSL 3.

NOTE The conditional hydrostatic body test requirements do not apply to PSL 3G and PSL 4 equipment.

11.2.5.2 Procedure

The conditional hydrostatic body test procedure shall be as follows:

— The general requirements of 11.1 and 11.2.1 shall apply.

— If a pressure boundary penetration contains an independent secondary barrier as defined by the manufacturer, the secondary barrier shall not be used during the conditional body test.

— A single pressure-holding period of no less than 3 min shall be performed.

— The test pressure shall be no less than the rated working pressure of the equipment.

— Acceptance criteria shall be in conformance with 11.2.2.

11.2.6 Hydrostatic Testing of Back-pressure Valves

Each back-pressure valve shall be hydrostatically tested by applying pressure across the full sealing bore of the back-pressure valve.

— The general requirements of 11.1 and 11.2.1 shall apply.

— Test pressure shall be the rated working pressure as a minimum.

— A single pressure-holding period is required and shall be no less than 3 min.

— Acceptance criteria shall be in conformance with 11.2.2.

NOTE Seals may be replaced after testing.

11.3 Gas Testing—PSL 3G and PSL 4

11.3.1 Gas Testing—General Requirements

All gas testing shall conform to the requirements of this section.

— The test medium shall be air, nitrogen, or other gas mixture that will remain in the gas phase at test pressure.

— Gas testing shall be performed at ambient temperature and with the tested equipment completely submerged in a water bath, with exception per NOTE 1.

NOTE 1 Actuator components (e.g. electric motors) and manual valve drivetrain components (e.g. thrust bearings) may be excluded from submersion completely if all retained fluid pressure-containing parts, seals, and other potential leak points or the outlet of vent ports are submerged to ensure that leakage is observable.

— Hold periods shall not start until the test article and the pressure measuring/recording device has been isolated from the pressure source and the pressure source bled to zero.

— All pressure testing shall be conducted prior to the addition of body-filler grease. Lubrication applied during assembly shall be acceptable. Testing shall be performed prior to painting, unless pressure-containing parts are constructed of wrought material. If body constructed of wrought material, testing after painting shall be permitted.

— If possible, all fittings and other pressure boundary penetrations should be installed during testing, with the secondary sealing device removed or compromised if the design has that capability. If any fitting or pressure boundary penetration was not installed during the last pressure-holding period, a conditional gas body test of 11.3.6 shall be performed.

NOTE 2 The conditional gas body test does not apply to a redundant secondary seal that can only be exposed to pressure via leakage from a primary seal. Testing of these seals is outside the scope of this specification.

— Nonmetallic seals shall not be used in body gas testing on API flange connectors of equipment with API flange connectors.

11.3.2 Gas Test Acceptance Criteria—General Requirements

The acceptance criteria specified below shall be applied to gas body tests, seat tests, backseat tests, and conditional gas body tests.

For PSL 3G and PSL 4 equipment the following shall apply.

a) No visible leakage (bubbles) shall appear in the water bath during the pressure-holding period.

b) The maximum acceptable reduction of the gas test pressure shall be 2.1 MPa (300 psi) if there is no visible leakage in the water bath during the hold period.

c) Pressure during the hold period shall not be less than the specified test pressure.

PSL 3G metal-sealing check valves, the maximum allowable leakage shall be in conformance with ISO 5208 Rate C.

11.3.3 Gas Body Test

11.3.3.1 Test Method—PSL 3G and PSL 4

PSL 3G and PSL 4 equipment for which a gas body test is specified in Table 33 shall be subjected to the test of this section in addition to the hydrostatic shell test.

— The general requirements of 11.1 and 11.3.1 shall apply.

— Valves and chokes closure mechanisms shall be positioned such that the bore and entire pressure cavity are exposed to test pressure; test pressure shall not be applied as a differential pressure across closure mechanisms of valves or chokes. For valves that include a stem backseat, the stem backseat shall not be engaged during pressure application and testing.

— The gas body test shall consist of a single pressure-holding period of not less than 15 min.

— The test pressure shall not be less than the rated working pressure of the equipment.

NOTE The gas body test requirements do not apply to PSL 1, PSL 2 and PSL 3.

11.3.3.2 Acceptance Criteria

For PSL 3G and PSL 4, the acceptance criteria shall conform to 11.3.2.

11.3.4 Gas Seat Test—Valves

11.3.4.1 Test Method—PSL 3G and PSL 4

For PSL 3G and PSL 4, gas seat testing shall be performed as follows.

a) The general requirements of 11.1 and 11.3.1 shall apply.

b) Primary (RWP) gas seat test:

   1) Gas test pressure shall be not less than the rated working pressure of the valve. Pressure shall be applied to one side, including connection, of the closed gate, ball, or plug, with the other side vented to the water bath. Unidirectional valves shall be tested in the direction indicated on the body, except for check valves, which shall be tested from the downstream side.

NOTE Split-gate valves may have both seats tested simultaneously.

2) Pressure shall be monitored, and the valve shall be monitored for leakage, for a minimum of 15 min.

3) Test pressure shall be reduced to 0 psi.

4) The valve, except for check valves, shall be fully opened and fully closed between primary and secondary tests.

c) Secondary (low-pressure) gas seat test:

1) The applicable test pressure specified below shall be applied to the same side, including connection, of the closed gate, ball, or plug.

2) For PSL 3G valves, the secondary seat test pressure shall be 2.1 MPa (300 psi) ± 10 %.

3) For PSL 4 valves, the secondary seat test pressure shall be greater than 5 % and less than 10 % of the rated working pressure.

4) Pressure shall be monitored, and the valve shall be monitored for leakage, for a minimum of 15 min.

5) Test pressure shall be reduced to 0 psi.

d) For a bidirectional valve, steps b) and c) shall be performed on the other side of the gate, ball, or plug using the same procedure outlined above.

11.3.4.2 Acceptance Criteria

For PSL 3G and PSL 4 gate valves, ball valves, and plug valves, acceptance criteria for the primary gas seat test shall conform to 11.3.2.

For PSL 3G and PSL 4 gate valves, ball valves, and plug valves, acceptance criteria for the secondary gas seat test shall be no visible leakage in the water bath during the holding periods with a maximum allowable reduction of gas test pressure of 0.2 MPa (30 psi).

11.3.5 Gas Backseat Test—Gate Valves

11.3.5.1 Applicability

If required by the manufacturer or purchaser, the test shall be performed as specified in this section.

For PSL 4 gate valves, a gas backseat test shall be performed on all gate valves.

NOTE 1 For PSL 3G gate valves, a gas backseat test is optional.

NOTE 2 The backseat test may be performed in conjunction with other gas tests if the gas pressure is applied to the backseat without restriction and any leakage is observable.

NOTE 3 The backseat gas test requirements do not apply to PSL 1, PSL 2, or PSL 3 (see NOTE 1).

11.3.5.2 Test Method—PSL 3G and PSL 4

For PSL 3G (when applicable) and PSL 4, gas backseat testing shall be performed as follows.

a) The general requirements of 11.1 and 11.3.1 shall apply.

b) Primary (RWP) gas backseat test—PSL 3G and PSL 4:

1) Gas test pressure shall be not less than the rated working pressure of the valve. Pressure shall be applied to the valve such that the body cavity will be pressurized.

   NOTE 1 If necessary to ensure that the full test pressure is applied to the backseat, both end connectors may be blanked off and the valve pressurized with the gate partially open when the backseat is engaged.

2) The area between the primary packing and the backseat, or other means for repacking the stuffing box, shall be vented during the test.

3) Pressure shall be monitored, and the valve shall be monitored for leakage, for a minimum of 15 min.

4) Test pressure shall be reduced to 0 psi.

c) Secondary (low-pressure) gas backseat test—PSL 4 only:

   NOTE 2 The secondary gas backseat test is not applicable to PSL 3G valves.

   1) The applicable test pressure specified below shall be applied such that the body cavity will be pressurized.

   2) The secondary seat test pressure shall be greater than 5 % and less than 10 % of the rated working pressure.

   3) Pressure shall be monitored, and the valve shall be monitored for leakage, for a minimum of 5 min.

   4) Test pressure shall be reduced to 0 psi.

11.3.5.3 Acceptance Criteria

For PSL 3G and PSL 4 gate valves, acceptance criteria shall conform to 11.3.2.

11.3.6 Conditional Gas Body Test

11.3.6.1 Applicability and Test Method—PSL 3G and PSL 4

If any fitting or pressure boundary penetration was not installed during the last gas test pressure-holding period, a conditional gas body test shall be performed with all fittings or pressure boundary penetrations installed.

— The general requirements of 11.1 and 11.3.1 shall apply.

— If a pressure boundary penetration contains an independent secondary barrier as defined by the manufacturer, the secondary barrier shall not be used during the conditional body test.

— A single pressure-holding period shall be performed. The hold period shall be no less than 3 min.

— The test pressure shall be no less than the rated working pressure of the equipment.

NOTE 1 A conditional gas body test conforming to 11.3.6 may be performed for PSL 1, PSL 2, or PSL 3 equipment in lieu of the conditional hydrostatic body test of 11.2.5.

NOTE 2 If a fitting or other pressure boundary penetration was removed during both the last hydrostatic test and the last gas test, a single conditional gas body test is sufficient to verify the seal integrity of all fittings and pressure boundary penetrations.

11.3.6.2 Acceptance Criteria

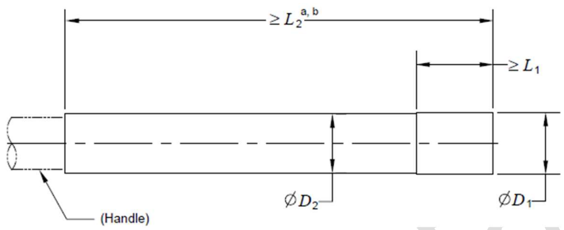
For PSL 3G and PSL 4 equipment acceptance criteria shall conform to 11.3.2.

11.4 Drift Testing

11.4.1 Full-bore Valves

For PSL 1, PSL 2, PSL 3, and PSL 4, a drift mandrel conforming to Table 36 for valves shall be passed completely through the valve bore after the valve has been assembled, operated, and pressure-tested.

Table 36—Drift Dimensions for Individual Valves and Trees



Dimensions in millimeters (inches) [c]

Nominal Bore Size	L_1 minimum		D_1 $^{+0.69}_{-0}$ mm ($^{+0.027}_{-0}$ in.)		D_2 $^{+0.69}_{-0}$ mm ($^{+0.027}_{-0}$ in.)	
in.	mm	(in.)	mm	(in.)	mm	(in.)
$1^{13}/_{16}$	76	(3.00)	45.21	(1.78)	38.6	(1.52)
$2^{1}/_{16}$	76	(3.00)	51.56	(2.03)	48.3	(1.90)
$2^{9}/_{16}$	76	(3.00)	64.26	(2.53)	59.7	(2.35)
$3^{1}/_{16}$	78	(3.06)	76.96	(3.03)	73.2	(2.88)
$3^{1}/_{8}$	79	(3.12)	78.49	(3.09)	73.2	(2.88)
$4^{1}/_{16}$	103	(4.06)	102.36	(4.03)	97.3	(3.83)
$4^{1}/_{8}$	105	(4.12)	103.89	(4.09)	100.8	(3.97)
$4^{1}/_{4}$	108	(4.25)	107.19	(4.22)	101.6	(4.00)
$5^{1}/_{8}$	130	(5.12)	129.29	(5.09)	126.2	(4.97)
6	152	(6.00)	151.64	(5.97)	148.6	(5.85)
$6^{1}/_{8}$	155	(6.12)	154.69	(6.09)	151.6	(5.97)
$6^{3}/_{8}$	162	(6.38)	161.04	(6.34)	158.0	(6.22)
$6^{5}/_{8}$	168	(6.62)	167.39	(6.59)	164.3	(6.47)
$7^{1}/_{16}$	179	(7.06)	178.56	(7.03)	175.5	(6.91)
$7^{1}/_{8}$	181	(7.12)	180.09	(7.09)	177.0	(6.97)
9	229	(9.00)	227.84	(8.97)	224.8	(8.85)
11	279	(11.00)	278.64	(10.97)	275.6	(10.85)

FOOTNOTES

[a] For valves, L_2 = valve face-to-face length.

[b] For trees, L_2 = 1065 mm (42 in.).

[c] For USV and BSDV valves with nonstandard bores, see 11.4.2.

11.4.2 Valves with Nonstandard Bore Sizes

For USV and BSDV valves with nonstandard bore sizes, drift testing is optional. When a drift test is specified by the manufacturer, the drift tool dimensions shall be as follows:

where

B is nominal bore size,

F is the maximum face-to-face length of the valve (for valves per Table D.22/Table E.22 and Table D.23/Table E.23), and

L_1, L_2, D_1, and D_2 are drift dimensions shown in Table 36,

the following shall apply:

$L_1 \geq B$

$L_2 \geq F$

$D_1 = B - 0.76$ mm ($= B - 0.03$ in.)

$D_2 = D_1 - 3.30$ mm ($= D_1 - 0.13$ in.)

+ tolerance for D_1 & D_2 = +0.69 mm (= +0.027 in.)

– tolerance for D_1 & D_2 = –0

11.4.3 Tree Assemblies

For PSL 1, PSL 2, PSL 3, and PSL 4, a drift mandrel conforming to Table 36 for trees shall be passed completely through the main bore of a tree assembly.

12 Equipment Marking

12.1 Marking Requirements

12.1.1 General

Equipment shall be marked on the exterior surface as specified in Table 37 and the product-specific requirements in Section 14 as a minimum. The nominal size for equipment shall be marked with US Customary (USC) units.

Additional marking, other than what is specified in the product-specific requirements in Section 14, shall be permitted in conformance with the manufacturer's marking requirements.

12.1.2 Additively Manufactured Components

In addition to the requirements of API 6A and API 20S, components manufactured from additively manufactured materials shall be marked to identify the applicable AMSL applied.

12.2 Marking Method

Marking shall be performed using low-stress (e.g. dot stamping, vibration engraving, or rounded V-stamping) methods except that conventional sharp V-stamping shall be acceptable only in low-stress areas, such as the outside diameter of flanges.

NOTE 1 Superficial marking and identification methods are permitted provided they are also low-stress or low-energy (e.g. acid etching, laser marking).

NOTE 2 The method used for marking on nameplates is not specified.

12.3 Nameplates

Unless nameplates are specified, marking shall be applied on the nameplate and/or the body or the connector.

Table 37—Guide to Marking Requirements [a,b,c,d]

Equipment Type	Nameplate Required?	Marking Requirements
Loose Fittings and Connectors		
• Loose flanges	Optional	14.1.5
• Ring gaskets	Not applicable	14.2.5
• Threaded connectors	Optional	14.3.5
• Tees and crosses	Optional	14.4.5
• Bullplugs	Not applicable	14.5.5
• Valve-removal plugs	Not applicable	14.6.5
• Top connectors	Optional	14.7.5
• Crossover connectors	Optional	14.8.5
• Other end connectors	Not applicable	14.9.5
• Spools (adapter and spacer)	Optional	14.10.5
Valves		
• Complete assemblies	Optional	14.11.5
• Prepared for actuator	Optional	14.11.5
Back-pressure Valves	Not applicable	14.12.5
Slip-type and Mandrel-type Hangers	Not applicable	14.13.5
Casing and Tubing Heads	Optional	14.14.5
Tubing-head Adapters	Optional	14.15.5
Chokes		
• Choke assemblies, adjustable	Optional	14.16.5
• Choke assemblies, positive (fixed)	Optional	14.16.5
• Choke beans, positive chokes	Not applicable	14.16.5
Actuators (for Valves and Chokes)	Optional	14.17.5
Safety Valves		
• Safety valves (SSV, USV, BSDV)	Required	14.18.5
• Safety valves prepared for actuator	Required	14.18.5
• Safety valve actuators (SSV, USV, BSDV)	Required	14.18.5
Tree Assemblies	Optional	14.19.5
Other		
• Fittings/pressure boundary penetrations	Not applicable	Section 9

FOOTNOTES

[a] Valves that satisfy the requirements of API 6FA can be marked per the requirements therein in addition to the requirements of this section.

[b] Marking for features that do not exist on a product is not applicable.

[c] PSL 3 products may be marked "PSL 3G" when the additional requirements of gas testing have been satisfied.

d PR2 products may be marked "PR2F" when the validation requirements of Annex F testing have been satisfied.

12.4 Hidden Marking

Marking required on a connector outside diameter that would be covered by clamps or other parts of the connector assembly shall be stamped in a visible location near the connector.

12.5 Thread Marking

The thread type marking shall include the following, as applicable:

— line pipe: LP
— casing (short thread): STC
— casing (long thread): LC
— casing (buttress): BC
— casing (extreme line): XC
— tubing (nonupset): NU
— tubing (external-upset): EU

12.6 Size Marking

The size marking shall include the nominal size and, if applicable, the restricted or oversize bore.

12.7 Temperature Marking

Temperature classes (see 4.3.2) or maximum and minimum temperature ratings shall be marked at the location specified.

12.8 Hardness Tests

If hardness tests are required for bodies, bonnets, or end and outlet connectors, the actual value of the hardness test shall be:

a) stamped on the part adjacent to the test location or

b) documented by the manufacturer.

12.9 Ring Grooves

The following shall apply.

a) Type 6B flanged and studded connectors shall be marked “R XX,” where “XX” is the ring groove number.

NOTE 1 This applies to connectors to be assembled with either “R” or “RX” ring gaskets.

NOTE 2 Some previous editions of this specification included extra-deep ring grooves for use only with Type RX gaskets.

b) Type 6BX flanged and studded connectors shall be marked “BX YYY,” where “YYY” is the ring groove number.

c) Ring groove marking on Type 16A clamp hub connectors shall conform to API 16A.

d) Ring groove marking on Type 17SS and 17SV connectors shall conform to API 17D.

e) If equipment has metal-overlaid, corrosion-resistant ring grooves, the ring groove type and number shall be followed by “CRA” to designate a corrosion-resistant alloy.

12.10 Clamp Hub End Connectors

Clamp hub end connectors shall be marked with the size and pressure rating followed by “API 16A.”

13 Storing and Shipping

13.1 Draining after Testing

All equipment shall be drained and lubricated after testing and prior to storage or shipment.

13.2 Corrosion Protection

Corrosion protection shall be applied to exposed (bare) metallic surfaces of steels with less than 15 % chromium on flange faces, weld bevel ends, exposed stems, and internal surfaces of the equipment using the manufacturer's documented requirements. Corrosion protection provided by a corrosion inhibitor shall resist runoff at temperatures less than 50 °C (125 °F).

NOTE Corrosion protection is not required on CRA surfaces.

13.3 Sealing-surface Protection

Exposed sealing surfaces and seals shall be protected from damage or deterioration for shipping.

13.4 Assembly and Maintenance Instructions

The manufacturer shall furnish to the purchaser suitable drawings and instructions concerning field assembly and maintenance of wellhead and tree equipment, if requested.

13.5 Ring Gaskets

Ring gaskets shall be individually wrapped or boxed for shipment and storage. Ring gaskets with an outside diameter greater than 356 mm (14 in.) should be shipped and stored horizontally (flat).

13.6 Age Control and Storage of Nonmetallic Seals

The following shall apply.

a) The manufacturer's written specified requirements for nonmetallic seals that are not assembled into equipment shall include the following minimum provisions:

- — age control;
- — indoor storage;
- — maximum temperature not to exceed 49 °C (120 °F);
- — protected from direct natural light;
- — stress conditions (see text below);
- — stored away from contact with liquids;
- — protected from ozone and radiographic damage.

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

NOTE Recommendations are typically available from seal manufacturers. 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.

c) The manufacturer's written specified requirements for nonmetallic seals that are assembled into equipment shall include a procedure to document the preservation of seals assembled in PSL 4 product during storage until delivery.

14 Equipment-specific Requirements

14.1 Flanges

14.1.1 Flange Classification and Types

Flanges shall be classified as integral or loose, and through-bolted or studded.

Flange types shall be as follows:

- Integral
  - 6B Type Flange
  - 6BX Type Flange
  - Weld-neck Flange
- Loose
  - Adapter Flange
  - Blind Flange
  - Companion/Threaded Flange
  - Instrument Flange
  - Test Flange
  - Spacer Flange
  - Weld-neck Flange

14.1.2 Design

14.1.2.1 Pressure Ratings and Size Ranges of Flange Types

Types 6B and 6BX shall be used in the combinations of nominal size ranges and rated working pressures as shown in Table 38.

14.1.2.1 Type 6B Flanges

14.1.2.1.1 General

The Type 6B flange shall be of the through-bolted or studded design. For bolting, the requirements 14.1.2.10 shall apply.

NOTE Type 6B flanges are of the ring joint type and are not designed for face-to-face make-up. The connection make-up bolting force reacts on the metallic ring gasket.

Table 38—Rated Working Pressures and Size Ranges of Flanges

Rated Working Pressure MPa (psi)	**Flange Size Range** mm (in.)	
	Type 6B	**Type 6BX**
13.8 (2000)	52 to 540 (2 $^{1}/_{16}$ to 21 $^{1}/_{4}$)	679 to 762 (26 $^{3}/_{4}$ to 30)
20.7 (3000)	52 to 527 (2 $^{1}/_{16}$ to 20 $^{3}/_{4}$)	679 to 762 (26 $^{3}/_{4}$ to 30)
34.5 (5000)	52 to 279 (2 $^{1}/_{16}$ to 11)	346 to 540 (13 $^{5}/_{8}$ to 21 $^{1}/_{4}$)
69.0 (10,000)	—	46 to 540 (1 $^{13}/_{16}$ to 21 $^{1}/_{4}$)
103.5 (15,000)	—	46 to 476 (1 $^{13}/_{16}$ to 18 $^{3}/_{4}$)
138.0 (20,000)	—	46 to 346 (1 $^{13}/_{16}$ to 13 $^{5}/_{8}$)

14.1.2.1.2 Dimensions

14.1.2.1.2.1 Standard

Standard dimensions for Type 6B flanges shall conform to Table D.1 (13.8 MPa)/Table E.1 (2000 psi), Table D.2 (20.7 MPa)/Table E.2 (3000 psi), or Table D.3 (34.5 MPa)/Table E.3 (5000 psi), except when 14.1.2.2.2.2 applies.

Raised face or counterbore or both shall be optional.

14.1.2.1.2.2 Exceptions

When flanges are welded to equipment covered by this specification and serve as end or outlet connectors, they shall conform to the integral flange dimensions in Table D.1 (13.8 MPa)/Table E.1 (2000 psi), Table D.2 (20.7 MPa)/Table E.2 (3000 psi), or Table D.3 (34.5 MPa)/Table E.3 (5000 psi).

When Type 6B flanges are used as end connectors on casing heads and tubing heads, the flanges shall be permitted to have entrance bevels, counterbores, or recesses to receive casing and tubing hangers and shall be permitted to exceed the B dimension of the tables specified in 14.1.2.2.2.1.

NOTE The dimensions of such entrance bevels, counterbores, and recesses are not covered by this specification.

For studded end connectors, the requirements of 14.1.2.9 shall apply.

14.1.2.1.3 Flange Face

The flange face shall be flat or raised on the ring-joint side and shall be fully machined.

The flange back face shall be either fully machined or spot-faced at the bolt holes.

The flange back face or spot faces shall be parallel to the front face within 1°. The thickness after facing shall conform to the dimensions of Table D.1 (13.8 MPa)/Table E.1 (2000 psi), Table D.2 (20.7 MPa)/Table E.2 (3000 psi), or Table D.3 (34.5 MPa)/Table E.3 (5000 psi).

14.1.2.1.4 Gaskets

Type 6B flanges shall use Type R or Type RX gaskets in conformance with 14.2.

14.1.2.1.5 Ring Grooves

Dimensions for ring grooves shall conform to Table D.8 (Type R)/Table E.8 (Type R).

When the 6B flange is manufactured with a corrosion-resistance weld overlay in the ring roove, CRA overlay thickness of the ring grooves shall conform to 7.5.1.2.2.

All 23° surfaces on R ring grooves shall have a surface finish no rougher than 1.6 μm Ra or 63 μin. RMS.

14.1.2.1.6 Dimensional Interchangeability

Where dimensions specified in this document apply to two different pressure ratings, marking of both ratings shall be permitted if:

— the design, materials, and testing requirements have been satisfied for the higher pressure rating, and

— for valves that require seat testing, seat test requirements have been satisfied for both pressure ratings.

14.1.2.2 Type 6BX Flanges

14.1.2.2.1 General

The Type 6BX flange shall be of the through-bolted or studded design. For bolting, the requirements 14.1.2.10 shall apply.

NOTE 1 Type 6BX flanges are of the ring-joint type and are designed with a raised face. Depending on tolerances, the connection make-up bolting force can react on the raised face of the flange when the gasket has been properly seated. This support prevents damage to the flange or gasket from excessive bolt torque.

NOTE 2 Face-to-face contact is not necessary for the proper functioning of Type 6BX flanges.

14.1.2.2.2 Dimensions

14.1.2.2.2.1 Standard

Standard dimensions for 6BX integral flanges shall conform to Table D.7 (13.8–34.5 MPa)/Table E.7 (2000 to 5000 psi), Table D.4 (69.0 MPa)/Table E.4 (10,000 psi), Table D.5 (103.5 MPa)/Table E.5 (15,000 psi), or Table D.6 (138.0 MPa)/Table E.6 (20,000 psi), except when 14.1.2.3.2.2 applies.

14.1.2.2.2.2 Exception

When Type 6BX flanges are used as end connectors on casing heads and tubing heads, the flanges shall be permitted to have entrance bevels, counterbores, or recesses to receive casing and tubing hangers and shall be permitted to exceed the *B* dimension of the tables specified in 14.1.2.3.2.1.

NOTE The dimensions of such entrance bevels, counterbores, and recesses are not covered by this specification.

For studded end connectors, the requirements of 14.1.2.9 shall apply.

14.1.2.2.3 Flange Face

The flange face on the ring-joint side shall be raised, except for studded flanges, which may have flat faces. Front faces shall be fully machined. The nut-bearing surface shall be parallel to the flange gasket face within 1°.

The flange back face shall be either fully machined or spot-faced at the bolt holes.

The thickness after facing shall conform to the dimensions of Table D.7 (13.8–34.5 MPa)/Table E.7 (2000 to 5000 psi), Table D.4 (69.0 MPa)/Table E.4 (10,000 psi), Table D.5 (103.5 MPa)/Table E.5 (15,000 psi), or Table D.6 (138.0 MPa)/Table E.6 (20,000 psi), as applicable.

14.1.2.2.4 Gaskets

Type 6BX flanges shall use BX gaskets in conformance with 14.2.

14.1.2.2.5 Ring Grooves

Dimensions for ring grooves for 6BX flanges shall conform to Table D.11 (Type BX)/Table E.11 (Type BX).

When the 6BX flange is manufactured with a corrosion-resistance weld overlay in the ring groove, the CRA overlay thickness shall conform to 7.5.1.2.2.

All 23° surfaces on BX ring grooves shall have a surface finish no rougher than 0.8 µm *Ra* or 32 µin. RMS.

14.1.2.4 Weld-neck Flanges

For weld-neck flanges, the requirements of Annex J shall apply.

14.1.2.5 Loose Adapter/Spacer Flanges

14.1.2.5.1 Adapter Flange Dimensions

For adapter flanges, the following shall apply:

— OD shall not be less than the minimum OD of the smaller connector

— End connectors shall conform to 6B or 6BX as defined in Annex D or Annex E

— Minimum through bore shall satisfy the bore requirements for the smaller connection size

Note: An adapter flange may contain gauge connector ports from the outside to the through bore.

14.1.2.5.2 Spacer Flange Dimensions

For spacer flanges, the following shall apply:

— OD shall be the same from one end connector face to the other end connector face

— End connectors shall conform to 6B or 6BX as defined in Annex D or Annex E and shall be of the same size on both ends.

14.1.2.6 Loose Blind and Test Flanges

The dimensions for 6B blind and test flanges shall conform to 14.1.2.2.2.1.

Dimensions for R ring grooves of blind and test flanges shall conform to 14.1.2.2.5.

Dimensions for 6BX blind and test flanges shall conform to 14.1.2.3.2.1.

Dimensions for BX ring grooves of blind and test flanges shall conform to 14.1.2.3.5.

Gauge ports of a test flange:

— shall not be greater than 1" nominal and shall satisfy design requirements of the manufacturer, or

— shall conform to 9.3.3

14.1.2.7 Loose Companion/Threaded Flanges

Threads shall conform to the requirements of 4.3.1.2.

Dimensions for companion and threaded flanges shall conform to 14.1.2.2.2.1.

Dimensions for R ring grooves shall conform to 14.1.2.2.5.

14.1.2.8 Loose Instrument Flanges

The instrument flange OD shall conform to the flange OD requirements of Annex D or Annex E of the specified flange size for the entire length of the flange.

Instrument flange size shall conform to a size specified in Table 38.

Gauge ports of an instrument flange:

— shall not be greater than 1" nominal and shall satisfy design requirements of the manufacturer, or

— shall conform to 9.3.3

14.1.2.9 Studded End Connectors

14.1.2.9.1 Dimensions

NOTE Studded end and outlet connections are of the ring-joint type and are designed with a flat face.

Referring to Table D.1 (13.8 MPa)/Table E.1 (2000 psi), Table D.2 (20.7 MPa)/Table E.2 (3000 psi), Table D.3 (34.5 MPa)/Table E.3 (5000 psi), Table D.7 (13.8–34.5 MPa)/Table E.7 (2000 to 5000 psi), Table D.4 (69.0 MPa)/Table E.4 (10,000 psi), Table D.5 (103.5 MPa)/Table E.5 (15,000 psi), or Table D.6 (138.0 MPa)/Table E.6 (20,000 psi), the following dimensions shall apply to studded outlet connectors (with the exception noted for maximum bore, see following note):

— *B*: maximum bore;

NOTE Studded outlets in casing or tubing spools may have a preparation for a valve-removal plug, in which case the maximum bore dimension *B* does not apply.

— *BC: diameter of bolt circle;*

— *N: number of bolts;*

— *Bolt size and threads per inch*

Threaded bolt holes shall conform to ASME B1.1, Class 2B or 3B. Threads per inch (TPI) shall conform to the tables of Annex D or Annex E. The minimum depth of full thread shall conform to 14.1.2.10.2.

Ring groove dimensions shall conform to:

— Table D.8/Table E.8 for 6B studded outlet connectors; or

— Table D.11/Table E.11 for 6BX studded outlet connectors.

14.1.2.9.2 Outlet Face

The outlet face shall be fully machined and shall allow for assembly of the corresponding 6B or 6BX flange. The raised face diameter shall not be required for 6B or 6BX studded connectors.

NOTE It is permissible for the outlet face to be in a circular counterbore that accepts the mating flange, with counterbore dimensions as specified by the manufacturer.

14.1.2.9.3 Gaskets

Studded outlet connections shall use R, RX or BX gaskets conforming to 14.2.

14.1.2.9.4 Ring Grooves

NOTE Studded outlet connectors may be manufactured with corrosion-resistant weld overlays in the ring grooves.

CRA overlay thickness of the ring grooves shall conform to 7.5.1.2.2.

The 23° surface on R ring grooves shall have a surface finish no rougher than 1.6 µm Ra or 63 µin. RMS.

The 23° surface on BX ring grooves shall have a surface finish no rougher than 0.8 µm Ra or 32 µin. RMS.

14.1.2.10 End and Outlet Bolting

14.1.2.10.1 Hole Alignment

End and outlet bolt holes for flanges shall be equally spaced and shall straddle common centerlines.

14.1.2.10.2 Stud Thread Engagement

Stud thread-engagement length into the body for studded flanges shall be a minimum of one times the outside diameter of the stud.

14.1.2.10.3 Closure Bolting

All end and outlet closure bolting shall conform to Section 8. The stud length shall allow assembly of the corresponding 6B or 6BX flange with full thread engagement of the nut. For 6B outlets, stud length shall also include allowance for the standoff for the R or RX gasket.

NOTE See Annex I for recommended stud lengths for outlet connectors

14.1.3 Materials

Material requirements for flanges shall conform to the requirements in Section 6.

Material requirements for studded outlet connectors shall be as specified in Section 6 for the corresponding 6B or 6BX flange.

14.1.4 Quality Control/Testing

Loose flanges shall not require a hydrostatic shell test prior to final acceptance.

14.1.5 Marking

Loose flanges shall be marked as specified in Section 12 and Table 39.

Table 39—Marking for Loose Flanges

Required Markings	Required Location(s)
API 6A or 6A Temperature class(es) or ratings Material class Product specification level (PSL) Date of manufacture Manufacturer's name or mark Serial number (if applicable) Nominal bore size (if applicable) End and outlet connector size Rated working pressure Ring groove type and number	Outside diameter of connector
Hardness test values (if applicable) (see 12.8)	Adjacent to test location

Integral flanged and studded end and outlet connectors shall be marked as specified in Section 12 and Table 40.

Table 40—Marking for Studded and Flanged End and Outlet Connectors

Required Markings	Required Location(s)
End and outlet connector size Rated working pressure Ring groove type and number	Outside diameter of flange or face of studded outlet

14.1.6 Storing and Shipping

All flanges shall be stored and shipped in conformance with Section 13.

14.2 Ring Gaskets

14.2.1 General

Types R or RX gaskets shall be used on 6B flanges with type R grooves. Only BX gaskets shall be used with 6BX flanges with type BX grooves.

NOTE RX and BX gaskets provide a pressure-energized seal but are not interchangeable. RX gaskets provide additional clearance between the flanges.

Ring gaskets have a limited amount of positive interference, which ensures that the gaskets are coined into a sealing relationship in the grooves and therefore gaskets shall not be reused.

14.2.2 Design

14.2.2.1 Dimensions

Ring gaskets shall conform to the dimensions and tolerances specified in Table D.9/Table E.9, Table D.10/Table E.10, and Table D.12/Table E.12 and shall be flat within a tolerance of 0.2 % of ring outside diameter to a maximum of 0.38 mm (0.015 in.).

14.2.2.2 R and RX Gaskets

For oval type R gaskets, the surface finish shall be no rougher than 1.6 µm Ra or 63 µin. RMS on the radiused surfaces.

For octagonal type R and RX gaskets, all 23° surfaces shall have a surface finish no rougher than 1.6 µm Ra or 63 µin. RMS.

14.2.2.3 BX Gaskets

All 23° surfaces on BX gaskets shall have a surface finish no rougher than 0.8 µm Ra or 32 µin. RMS.

Each BX gasket shall have one pressure-passage hole drilled through its height as shown in Table D.12/Table E.12.

14.2.3 Materials

14.2.3.1 General

14.2.3.1.1 Gasket Material

Ring gasket material shall conform to the requirements of Section 6, except that the use of additively manufactured materials shall not be permitted.

Ring gasket material shall conform to the manufacturer's written specification.

14.2.3.1.2 Coatings and Platings

When used, coating and plating thicknesses shall be 0.013 mm (0.0005 in.) maximum.

NOTE Coatings and plating may be employed to aid the seal engagement while minimizing galling and to extend shelf life.

14.2.3.2 Material Qualification Testing

The following requirements shall apply:

— tensile testing: none required;

— impact testing: none required;

— hardness requirements shall be as given in Table 29.

14.2.3.3 Processing

14.2.3.3.1 Melting, Casting, Hot Working, and Welding

The following requirements shall apply.

— The manufacturer shall specify melting practices that produce material that is homogeneous, free from cracks, banding, piping, and flakes.

— Casting practices: Centrifugal casting shall be the only acceptable method of casting ring gaskets.

— Hot working practices: Wrought materials shall be hot worked throughout. Ring gaskets may be made from pierced tubing or pipe, rolled rings, or rolled and welded bar or plate.

— Gaskets that are rolled and welded: The manufacturer's welding process shall be documented and validated.

14.2.3.3.2 Heat-treating

All heat-treating of parts shall be performed with equipment meeting the requirements of 6.5.

Heat-treatment operations shall conform to manufacturer written specifications.

Ring gaskets manufactured from soft iron or carbon or low-alloy steel shall be either normalized or annealed as the last stage of material processing prior to final machining.

Ring gaskets manufactured from 304 stainless steel, 316 stainless steel, nickel alloy UNS N08825, or other CRA materials with an austenitic microstructure shall be solution annealed and quenched to maintain the required microstructure as the last stage of material processing prior to final machining. The applicable ASTM standards or manufacturer's specification shall be followed for heat treatment.

14.2.3.3.3 Chemical Composition

The chemical composition of ring gaskets shall be specified in the manufacturer’s material specification (see 6.2).

For stainless steel and CRA materials manufactured by the centrifugal casting method, a process validation shall be performed and documented for a sample heat for each material and each manufacturing process. The analysis shall be performed at the OD and ID of the ring gaskets. The chemical composition at the gasket OD and ID dimensions shall conform to the manufacturer’s specified tolerances. Revalidation shall be required for any changes in process controls.

14.2.4 Quality Control/Testing

The requirements of 10.4.5 shall apply.

14.2.5 Marking

Ring gaskets shall be marked as specified in Table 41.

Table 41—Marking for Ring Gaskets

Marking Requirement	Marking	Location
Date of manufacture	(Month/Year)	Outside diameter of gasket
Traceability to heat and job lot	Traceability Code(s)	Outside diameter of gasket
Manufacturer's name or mark	PMR	Outside diameter of gasket
Ring gasket type and number	Example: "BX 155"	Outside diameter of gasket
Ring gasket manufacturing method [wrought (F), cast (C), or welded (W)]	F	Outside diameter of gasket, following gasket material code, with or without a dash
	C	
	W	
Ring gasket material code:		Outside diameter of gasket, following gasket type and number, with or without a dash Examples: "R 24-D-W" "RX 39 316 F" "BX 169-825-C"
Soft iron	D	
Carbon or low-alloy steel	S	
304 stainless steel	304	
316 stainless steel	316	
Nickel alloy UNS N08825	825	
Other CRA materials	(UNS number)	

14.2.6 Storing and Shipping

Gaskets shall be stored and shipped in conformance with Section 13.

14.3 Threaded Connectors

14.3.1 General

The requirements for integral threaded end and outlet connectors, including those on tubing and casing hangers, shall apply only to those that are threaded according to API 5B.

Other loose threaded end and outlet connectors shall be specified by the manufacturer.

14.3.2 Design

14.3.2.1 General

Internal and external thread dimensions and tolerances shall conform to API 5B or ASME B1.20.1, if applicable (see 14.3.2.3).

— Thread lengths: The length of internal threads shall not be less than the effective thread length, L_2, of the external thread as specified in the figure belonging to Table D.29/Table E.29 and Table D.30/Table E.30 and as stipulated in API 5B.

— Internal and external NPT threads meeting the requirements of ASME B1.20.1.

NOTE 1 Pipe threads, general-purpose (inch), may be used for line pipe thread sizes 38 mm ($1^{1}/_{2}$ in.) and smaller.

NOTE 2 Although line pipe threads conforming to API 5B and NPT threads are basically interchangeable, the slight variation in thread form can increase wear and tendency for galling after several make-ups.

14.3.2.2 Thread Clearance

A clearance of minimum length, J, as illustrated in API 5B, shall be provided on all internal threaded equipment.

14.3.2.3 Thread Counterbores

NOTE 1 End and outlet connectors, equipped with internal threads, may be supplied with or without a thread-entrance counterbore.

Internal threads, furnished without a counterbore, should have an outer angle of 45° to a minimum depth of P/2, as illustrated in the figure belonging to Table D.29/Table E.29 and Table D.30/Table E.30.

Internal threads, furnished with a counterbore, should conform to the counterbore dimensions specified in Table D.29/Table E.29 and Table D.30/Table E.30, and the bottom of the counterbore should be chamfered at an angle of 45°.

NOTE 2 As an alternative, counterbore dimensions may be as specified in API 5B.

14.3.2.4 Thread Alignment

Threads shall align with the axis of the end connector within a tolerance of ± 5.0 mm/m (± 0.06 in./ft) or 0.3° of the projected axis.

14.3.2.5 End/Outlet Coupling Diameter

The outlet coupling diameter shall provide structural integrity of the threaded part at the rated working pressure. This diameter shall not be less than the tabulated joint or coupling diameter for the specified thread.

14.3.3 Materials

Material requirements for threaded connectors shall conform to the requirements in Section 6.

14.3.4 Quality Control/Testing

Threaded connectors shall conform to the applicable requirements of 10.4.2.

14.3.5 Marking

Threaded connectors shall be marked as specified in 12.5 and 12.6.

14.3.6 Storing and Shipping

Threaded connectors shall be stored and shipped in conformance with Section 13.

14.4 Tees and Crosses

14.4.1 General

NOTE Studded Cross and Tees can be supplied with or without closure bolting.

14.4.2 Design

14.4.2.1 Nominal Size and Pressure Rating

Nominal sizes and pressure ratings for tees and crosses shall be as specified in Table D.13/Table E.13 and Table D.14/Table E.14, with the following exception: oversize entrance bores of 81 mm [+0.8/0 mm] and 108 mm [+0.8/0 mm] ($3^{3}/_{16}$ in. [+0.03/0 in.] and $4^{1}/_{4}$ in. [+0.03/0 in.]) are allowable for 79 mm and 103 mm ($3^{1}/_{8}$ in. and $4^{1}/_{16}$ in.) nominal sizes for rated working pressures of 13.8 MPa; 20.7 MPa and 34.5 MPa (2000 psi; 3000 psi and 5000 psi) for use with valves with oversize bores as listed in Table D.22/Table E.22 and Table D.23/Table E.23.

14.4.2.2 End Connectors

All end connectors shall conform to 14.1 or 14.9.

14.4.2.3 Dimensions

Bore and center-to-face dimensions shall conform to those shown in Table D.13/Table E.13 and Table D.14/Table E.14.

14.4.3 Materials

Materials for tees and crosses shall conform to Section 6.

14.4.4 Quality Control/Testing

Tees and crosses shall successfully complete the tests required and described in Section 11.

14.4.5 Marking

Tees and crosses shall be marked as specified in Section 12 and Table 42.

Table 42—Marking for Tees and Crosses

Required Markings	Required Location(s)
API 6A or 6A Temperature class(es) or ratings Material class Product specification level (PSL) Date of manufacture Manufacturer's name or mark Serial number (if applicable)	Nameplate and/or body
Bore size (if applicable) End and outlet connector size Rated working pressure	Nameplate and/or body and at each connector
Ring groove type and number	Near each connector or thread
Hardness test values (if applicable) (see 12.8)	Adjacent to test location
FOOTNOTE Performance requirement marking is not required for tees and crosses.	

14.4.6 Storing and Shipping

Tees and crosses shall be stored and shipped in conformance with Section 13.

14.5 Bullplugs

14.5.1 General

Bullplugs shall conform to the applicable requirements specified for loose connectors.

14.5.2 Design

14.5.2.1 General

The materials and design of bullplugs and threaded connectors shall be considered in determining the working pressure and external load capacity.

14.5.2.2 Dimensions

Bullplugs shall conform to the dimensions and tolerances in Table D.15/Table E.15. Threaded connectors shall conform to 14.3.

This specification shall apply to bullplugs 1/2 in. line pipe or NPT size and larger up to 4 in. line pipe size.

NOTE Other sizes are outside the scope of this specification.

14.5.2.3 Rated Working Pressure

The rated working pressure for bullplugs with line pipe or NPT threads 1/2 in. to 4 in. shall be as specified in Table 1.

NOTE Bullplugs of stronger materials, larger thread dimensions and/or larger designs that are rated for higher working pressures are outside the scope of this specification.

14.5.2.4 Thread Engagement

Threaded connectors shall conform to 14.3. Bullplugs with API 5B line pipe threads shall be assembled with mating parts in conformance with Table 43. Thread compounds tested in conformance with API 5A3 shall be used.

NOTE API 5A3 does not require the use of a specific compound, but only the testing of the compound.

Table 43—Recommended Bullplug Installation Procedure

Size in.	**Minimum Recommended Turns** **Past Hand-tight Condition** [a]
1/2, 3/4, and 1	1 1/2
2 through 4	2

FOOTNOTES

Thread compounds shall be in serviceable condition to provide leak-free performance.

[a] Recommended turns past hand-tight is normally sufficient to contain rated working pressure and test pressures up to 103.5 MPa (15,000 psi). However, retightening up to an additional one or two turns may be required in some cases.

14.5.3 Materials

Bullplug material shall, as a minimum, meet the requirements of 6.2, PSL 3 and 6.3, PSL 3. Material shall conform to material designation 60K for 13.8 MPa (2000 psi) to 69.0 MPa (10,000 psi) rated working pressure. Bullplugs shall be material class DD, FF, or HH.

14.5.4 Quality Control/Testing

14.5.4.1 General

Bullplugs shall conform to the requirements of 10.4.10.

NOTE PSLs are not applicable to bullplugs.

14.5.4.2 Coating

Bullplug threads shall be coated to minimize galling and develop maximum leak resistance. The threads shall be gauged after coating.

14.5.5 Marking

Bullplugs shall be marked with "API 6A" or "6A" followed by the nominal size, material class, and manufacturer's name or mark, as a minimum.

NOTE 1 Bullplugs may be marked on the exposed end or on the flat of the hex, as applicable.

NOTE 2 Bullplugs with an internal hex may be marked on the smaller, nonexposed hex.

14.5.6 Storing and Shipping

Bullplugs shall be stored and shipped in conformance with Section 13.

14.6 Valve-removal Plugs

14.6.1 General

NOTE 1 Valve-removal preparations and valve-removal plugs are specified in 14.6.

NOTE 2 Valve-removal plugs in this specification are not designed for use with test and blind flanges manufactured with the standard dimensions of 14.1.

NOTE 3 High-pressure valve removal (HPVR) preparations may be used for all working pressure outlets.

14.6.2 Design

14.6.2.1 General

The VR design shall not be used for outlets rated above 69.0 MPa (10,000 psi).

Internal pressure-relief check valves, internal threaded connectors, and other internal devices shall be permitted for valve-removal plugs but are not specified in this specification.

14.6.2.2 Dimensions

VR preparation dimensions shall conform to Table D.17/Table E.17. Included thread taper for all sizes shall be 1-in-16 on the diameter (reference 1° 47´ 24˝ with the centerline).

VR plug dimensions shall conform to Table D.16/Table E.16. Included thread taper for all sizes shall be 1-in-16 on the diameter (reference 1° 47´ 24˝ with the centerline).

HPVR preparation dimensions shall conform to Table D.21/Table E.21.

HPVR plug dimensions shall conform to Table D.20/Table E.20.

HPVR plug thread form dimensions shall conform to Table D.20/Table E.20. All diameters shall be concentric within 0.13 mm (0.005 in.) total indicator reading. HPVR plug thread form dimensions shall be Stub Acme in conformance with ASME B1.8.

14.6.3 Materials

Valve-removal-plug body material shall, as a minimum, meet PSL 3 material requirements of 6.2 and 6.3. Material shall conform to material designation 60K for VR plugs and 75K for HPVR plugs. Valve-removal plugs shall be material class DD, FF, or HH.

The materials for VR and HPVR preparations shall conform to the material designations for flanged integral end connectors in Table 8.

14.6.4 Quality Control/Thread Gauging

14.6.4.1 Thread Gauging

VR plugs and plug preparations shall be dimensionally inspected.

NOTE 1 VR plug preparations may be inspected in conformance with Table D.19/Table E.19.

NOTE 2 VR plugs may be inspected in conformance with Table D.18/Table E.18.

HPVR plugs and plug preparations shall be dimensionally inspected. Inspection methods shall conform to manufacture documented procedures.

14.6.4.2 Coating

VR plug threads shall be coated to minimize galling and develop maximum leak resistance. The threads shall be gauged after coating.

14.6.4.3 Quality Control

Valve-removal plugs shall conform to the requirements of 10.4.10.

NOTE 1 PSLs are not applicable to valve-removal plugs.

NOTE 2 This specification does not require pressure testing for valve-removal preparations and valve-removal plugs.

14.6.5 Marking

Valve-removal plugs shall be marked with “API 6A” or “6A” followed by the nominal size and “VR” for 69.0 MPa (10,000 psi) working pressure or “HPVR” for 138.0 MPa (20,000 psi) working pressure, material class, and manufacturer’s name or mark, as a minimum.

14.6.6 Storing and Shipping

Valve-removal plugs shall be stored and shipped in conformance with Section 13.

14.7 Top Connectors

14.7.1 General

NOTE 1 Top connectors that provide access to the tree bore are covered in 14.7.

NOTE 2 Threads added to top connectors for lifting purposes are outside the scope of this specification.

14.7.2 Design

14.7.2.1 General

Top connectors shall be designed to satisfy the service conditions specified in 4.3.

Top connectors shall be designed to satisfy the requirements of 5.1.4 and 5.1.5.

Top connectors shall conform to the requirements of 5.3, 5.4, and 5.5.

A means shall be provided such that any pressure underneath the top connector can be vented prior to top connector release.

14.7.2.2 Dimensions

Top connectors that use end connectors as specified in this specification shall conform to the requirements of 14.1, 14.2, and 14.3.

Top connectors that use OECs shall conform to the requirements of 14.9.

NOTE For a recommended standard design of top connector parts and assemblies, see Annex K.

14.7.3 Materials

Pressure-containing parts of the top connector that come into contact with internal fluids shall conform to all the requirements of Section 6.

If hammer nuts are part of the top connector assembly, hammer nuts shall not be manufactured using additively manufactured materials.

Structural and sealing members of the top connector, such as caps, collars, hammer nuts, clamps, and bolting, shall conform to the manufacturer's written specification in conformance with 6.2.

14.7.4 Quality Control/Testing/Welding

14.7.4.1 Welding

Any welding performed on the pressure-containing parts of the top connector shall conform to the requirements of 7.3 and 7.4. Welding shall not be performed on components that are made from additively manufactured materials.

Any welding performed on the structural members of the top connector shall conform to the requirements of 7.2.

14.7.4.2 Quality Control

Quality control requirements for pressure-containing parts of the top connector (e.g. bodies and blanking plugs) shall conform to the requirements of 10.4.2.

Quality control requirements for structural members of the top connector members (e.g. bonnet nuts, clamps, and other load-bearing parts) shall conform to the applicable requirements of ASTM A370, ASTM E10, and ASTM E18 for the following:

— tensile testing;

— impact testing;

— hardness testing.

Acceptance criteria shall be in conformance with the manufacturer's material specification.

Quality control requirements for chemical composition analysis and dimensional inspection shall be in conformance with the manufacturer's material specification and other documented design requirements.

Quality control for closure bolting shall conform to 8.3.

Quality control for non-integral metal seals shall conform to 10.4.5.

Quality control for nonmetallic seals shall conform to 10.4.6.

14.7.4.3 Testing

Top connector assemblies shall be tested in conformance with Section 11 (see Table 33).

14.7.5 Marking

Top connectors shall be marked as specified in Section 12 and Table 44.

Table 44—Marking for Top Connectors

Required Markings	Required Location(s)
API 6A or 6A Temperature class(es) or ratings Material class Product specification level (PSL) Date of manufacture Manufacturer's name or mark Serial number (if applicable) Minimum vertical bore	Nameplate and/or body
End and outlet connector size Rated working pressure Ring groove type and number (if applicable)	Nameplate and/or body and outside diameter of connector
Thread size (threaded products only)	Nameplate and/or body or near thread
Hardness test values (if applicable) (see 12.8)	Adjacent to test location
FOOTNOTE Performance requirement marking is not required for top connectors.	

14.7.6 Storage and Shipping

Top connectors shall be stored and shipped in conformance with the requirements of Section 13.

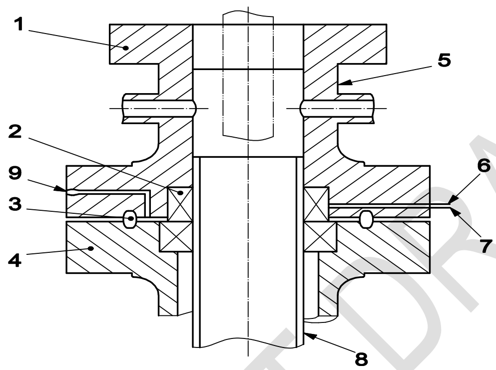
14.8 Crossover Connectors

14.8.1 General

Crossover connector types shall include crossover spools, multistage crossover spools, crossover adapters, and crossover tubing-head adapters.

The following shall apply.

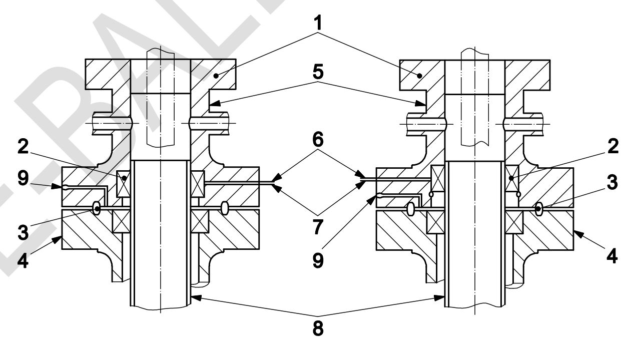
a) Crossover spool: A crossover spool shall suspend and seal around a string of casing or tubing and shall be identified as either a casing spool or a tubing spool. The spool shall contain a restricted-area sealing means at or near the face of the lower connector, permitting a pressure rating greater than the pressure rating of the lower connector in the section above the restricted-area sealing means (see Figure 7 and Figure 8 for examples of crossover spools).



Key

1	upper connector of the spool	4	lower connector	7	lower-pressure rating
2	restricted-area packoff	5	spool	8	inner casing
3	ring gasket	6	upper-pressure rating	9	test port

Figure 7—Crossover Spool with Restricted-area Packoff Supported by the Lower Head

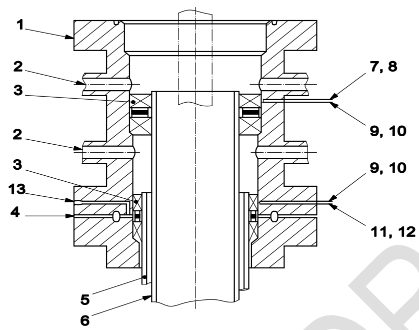


Key

1	upper connector of the spool	4	lower connector	7	lower-pressure rating
2	restricted-area packoff	5	spool	8	inner casing
3	ring gasket	6	upper-pressure rating	9	test port

Figure 8—Crossover Spool with Restricted-area Packoff Supported by the Upper Spool

b) Multistage crossover spool: A multiple stage crossover spool shall suspend and seal around multiple strings of casing and/or tubing. The multistage crossover spool shall contain a restricted-area sealing means at each stage, permitting an increase of one or more pressure ratings greater than the stage or connector immediately below. The upper connector shall be at least one pressure rating greater than the lower connector (see Figure 9 for an example of a multistage crossover spool).

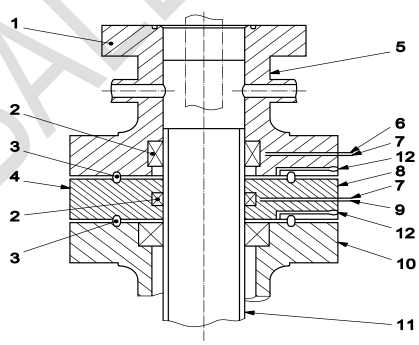


Key

1	upper connector of the spool	7	stage 3
2	outlet	8	higher-pressure rating
3	restricted-area packoff	9	stage 2
4	lower connector	10	intermediate pressure rating
5	inner string 1	11	stage 1
6	inner string 2	12	lower-pressure rating
		13	test port

Figure 9—Multistage Crossover Spool

c) Crossover adapter: A crossover adapter shall be used between two casing spools, or between casing and tubing spools, to allow an increase in pressure rating between the spools (see Figure 10 for an example of a crossover adapter).



Key

1	upper connector of the spool	7	second pressure rating
2	restricted-area packoff	8	crossover
3	ring gasket	9	lower-pressure rating
4	second connector	10	lower connector
5	spool	11	inner casing
6	upper-pressure rating	12	test port

Figure 10—Crossover Adapter

d) Crossover tubing-head adapter: A crossover tubing-head adapter shall be used between a tree and the tubing head to allow an increase in pressure rating between the two (see 14.15).

14.8.2 Design

14.8.2.1 Performance Requirements

Crossover connectors shall be designed to be used in an assembly as illustrated in Figure 7, Figure 8, Figure 9, or Figure 10.

Crossover connectors shall conform to the general requirements of 4.2 and shall be capable of performing as outlined in Table 45.

Table 45—Performance Requirements for Crossover Connectors

Performance Requirement Level	Pressure Integrity [a]
PR1	1 cycle
PR2	3 cycles

FOOTNOTE
[a] Shall seal rated working pressure internally.

14.8.2.2 End Connectors

End connectors shall conform to the requirements of 14.1, 14.3, or 14.9.

The upper connector of a crossover spool shall be at least one pressure rating above the lower connector.

14.8.2.3 Rated Working Pressure—Body

The section of the body above the restricted-area packoff of a crossover connector shall be designed to sustain the rated working pressure of the upper connector. Sections below the restricted-area packoff shall be designed to sustain the working pressure of that section plus any pressure-induced loads resulting from the upper pressure acting on the restricted-area packoff.

The restricted-area packoff and its retention means shall be designed so that the pressure-induced loads transferred from containment of the full working pressure by the upper connector and/or any upper stage do not exceed the requirements of 5.1.4 at any part of the body or lower connector.

14.8.2.4 Restricted-area Packoffs

Each crossover spool, multistage crossover spool, crossover adapter, and crossover tubing-head adapter shall have at least one restricted-area packoff. Restricted-area packoffs to seal on casing or tubing shall be designed to accommodate the outside-diameter pipe tolerances.

For casing or tubing sizes defined by API 5CT, the tolerances in API 5CT shall apply. For sizes not covered by API 5CT, the tolerances shall be per an industry standard used (for example, API 5L).

NOTE The tolerances of casing and tubing outside diameters vary substantially between the various editions of API 5CT. In general, the tolerance has increased over time; this can affect equipment interchangeability.

14.8.2.5 Crossover Connectors and Restricted-area Packoffs

Crossover connectors and restricted-area packoffs shall be designed to conform to 5.1.3.

14.8.2.6 Test, Vent, Gauge, and Injection Connectors

Test, vent, gauge, and injection connectors, located above the restricted-area packoff in crossover connectors, shall have a pressure rating equal to or greater than the highest rated working pressure.

14.8.3 Materials

14.8.3.1 General

Pressure-containing parts that come into contact with internal fluids shall conform to the requirements of Section 6.

Structural and sealing members shall conform to the manufacturer's written specification in conformance with 6.2.

14.8.3.2 Multiple Material Classes

Crossover connectors with multiple material classes, each applicable to either a portion of the equipment or the whole equipment, shall be acceptable. Each material class shall conform to 4.3.3. Restricted-area packoffs used in crossover connectors shall conform to both designated material classes, as per Table 3, on each side of the restricted area packoff.

14.8.4 Quality Control/Testing

Crossover connectors shall successfully complete the testing required and described in Section 11.

14.8.5 Marking

Crossover connectors shall be marked as specified in Section 12 and Table 46.

Table 46—Marking for Crossover Connectors

Required Markings	Required Location(s)
API 6A or 6A Temperature class(es) or ratings Product specification level (PSL) Performance requirement (PR) Date of manufacture Manufacturer's name or mark Serial number (if applicable)	Nameplate and/or body
End and outlet connector size Rated working pressure	Nameplate and/or body and outside diameter of connector
Material class (Single)	Nameplate and/or body
Material class (Multiple)[a]	Nameplate and/or body and outside diameter of each connector
Thread size (threaded products only)	Nameplate, body, or near thread
Ring groove type and number	Near each connector
Hardness test values (if applicable) (see 12.8)	Adjacent to test location

FOOTNOTES

[a] For crossover connectors having multiple material classes, all material classes designated shall be marked.

14.8.6 Storing and Shipping

All crossover connectors shall be stored and shipped in conformance with Section 13.

14.9 Other End Connectors

14.9.1 General

NOTE OECs that may be used for joining pressure-containing or pressure-controlling equipment and whose dimensions are not specified in this specification are covered in 14.9.

14.9.2 Design

14.9.2.1 General

OECs shall be capable of performing as outlined in Table 47.

14.9.2.2 Nominal Size and Pressure Rating

OECs shall be designed with the same nominal sizes and pressure ratings shown in 14.1 or, if appropriate, the sizes shown in 14.3.

14.9.2.3 Dimensions

No dimensional requirements for OECs shall apply except as in 14.9.2.2.

Table 47—Performance Requirements for Other End Connectors

Performance Requirement Level	Pressure Integrity [a]	Bending Moments	Make-and-break
PR1	1 cycle	b	c
PR2	3 cycles	b	c

FOOTNOTES

[a] Shall seal rated working pressure internally.

[b] Shall withstand manufacturer's rated bending moments.

[c] Shall withstand manufacturer's make-and-break cycles.

14.9.3 Materials

OEC materials shall conform to the requirements of Section 6.

14.9.4 Quality Control/Testing

Equipment that uses OECs shall successfully complete the tests required in Section 11 and the appropriate subsection of Section 14.

NOTE Hydrostatic testing is not required for loose OECs.

14.9.5 Marking

OECs shall be marked with the size and/or pressure rating followed by "OEC."

14.9.6 Storing and Shipping

OECs shall be stored and shipped in conformance with Section 13.

14.10 Spools (Adapter and Spacer)

14.10.1 General

Spacer spools shall have end connectors of the same size, rated working pressure, and design.

Adapter spools shall have end connectors of different sizes, or different pressure ratings, or different designs, or any combination thereof.

14.10.2 Design

14.10.2.1 Performance Requirements

Performance requirements shall not apply to spacer spools or adapter spools.

14.10.2.2 End and Outlet Connectors

NOTE For adapter spools and spacer spools, end and outlet connectors may be flanged or studded in conformance with 14.1, threaded in conformance with 14.3, or have OECs in conformance with 14.9 or clamp hubs in conformance with API 16A.

14.10.2.3 Rated Working Pressure

The rated working pressure of adapter spools and spacer spools shall be the lowest rating of the end and outlet connectors.

14.10.2.4 Pressure Boundary Penetrations and Connection Ports

The products with penetrations shall conform to the requirements of 9.2. Testing, gauge, vent, and injection connectors used in adapter or spacer spools shall be in conformance with 9.3.

14.10.3 Materials

Materials shall conform to Section 6.

14.10.4 Quality Control/Testing

All adapter spools and spacer spools shall pass the tests of Section 11.

14.10.5 Marking

Spools shall be marked as specified in Section 12 and Table 48.

14.10.6 Storing and Shipping

All adapter spools and spacer spools shall be stored and shipped in conformance with Section 13.

14.11 Valves

14.11.1 General

14.11.1.1 Single Valves

Valves, except safety and boarding shutdown valves, with rated working pressures as specified in 4.3.1, shall satisfy the requirements specified in 14.11.2 to 14.11.6. Valves shall conform to the requirements of Section 4 and Section 5.

NOTE Safety valves are addressed in 14.18.

Table 48—Marking for Adapter and Spacer Spools

Required Markings	Required Location(s)
API 6A or 6A Temperature class(es) or ratings Material class Product specification level (PSL) Date of manufacture Manufacturer's name or mark Serial number (if applicable)	Nameplate and/or body
End and outlet connector size Rated working pressure	Nameplate and/or body and outside diameter of connector
Thread size (threaded products only)	Nameplate, body, or near thread
Ring groove type and number	Near each connector
Hardness test values (if applicable) (see 12.8)	Adjacent to test location
FOOTNOTE Performance requirement marking is not required for spools.	

14.11.1.2 Multiple Cavity Valves

Multiple cavity valves shall satisfy the requirements of Section 4 and Section 5 and 14.11.2 to 14.11.6.

Multiple cavity valves which contain multiple bores (either dual, triple, quadruple, or quintuple) shall have parallel bores terminating in single or multiple connectors at each end.

NOTE 1 Valves with multiple cavities or bores may incorporate outlet bores and outlet connectors in addition to the end connectors and may include integral wing valves in the outlet bores. Outlet bores are typically at 90° or 45° with respect to the main conduit bores.

NOTE 2 An example of a multiple cavity valve configuration is shown in Figure 11.

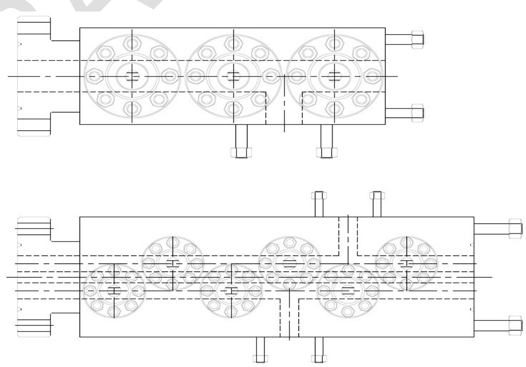


Figure 11—Single bore and Dual bore Multiple Cavity Valve Assemblies

14.11.1.3 Valves Prepared for Actuators

Valves prepared for actuators shall include all parts required to properly function when assembled with the actuator. The valve bonnet assembly, including associated parts, such as stem and seals, shall be part of either the valve or actuator.

A valve prepared for actuator shall satisfy all the requirements of actuated valves (see 14.11.1.4) if assembled with the actuator.

14.11.1.4 Actuated Valves

Single or multiple actuated valves shall be provided with an actuator to automatically open or close the valve. Actuators shall conform to 14.17.

NOTE Actuated valves may be full-bore or reduced-opening

14.11.1.5 Check Valves

Check valves shall be of the swing and lift check types (see Note 2) to permit flow in only one direction.

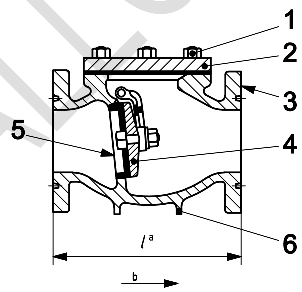
NOTE 1 Check valves may be full-opening or reduced-opening.

NOTE 2 Check valves may be furnished in the following types:

— regular swing check (see Figure 12);

— full-opening swing check (see Figure 13);

— regular lift check (see Figure 14).



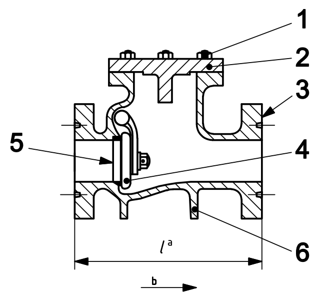
Key

1 cover closure bolting
2 cover
3 body
4 disc
5 seat ring
6 support ribs or legs

[a] Face-to-face dimension.

[b] Direction of flow.

Figure 12—Regular Swing Check Valve

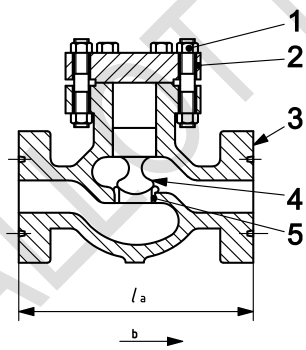


Key

1 cover closure bolting
2 cover
3 body
4 disc
5 seat ring
6 support ribs or legs

[a] Face-to-face dimension.
[b] Direction of flow.

Figure 13—Full-opening Swing Check Valve



Key

1 cover closure bolting
2 cover
3 body
4 piston
5 seat ring

[a] Face-to-face dimension.
[b] Direction of flow.

Figure 14—Regular Lift Check Valve

14.11.2 Design

14.11.2.1 Performance Requirements

All valves, including valves prepared for actuators, shall conform to the general performance requirements of 4.2 when operating as indicated in Table 49. Performance requirement levels shall apply to both manual valves and actuated valves.

Table 49—Operating Cycle Requirements for Valves

Performance Requirement Level	Operating Cycles
PR1	3 cycles
PR2	200 cycles

For valves that use pressure controlling components manufactured from additively manufactured materials, the valve design with such materials shall be validated to PR2.

14.11.2.2 Dimensions

14.11.2.2.1 Single Valves

For single valves the following shall apply:

a) Nominal size: Valves shall be identified by the nominal valve size in Table D.22/Table E.22 and Table D.23/Table E.23.

b) Face-to-face dimensions.

   1) General: The face-to-face dimension shall be defined as the longest overall distance measured on the horizontal centerline of the valve between machined surfaces.

   2) Flanged Valves: Unless exempted per 14.11.2.2.1.b.3, flanged face-to-face dimensions shall conform to the dimensions shown in Table D.22/Table E.22, Table D.23/Table E.23, and Table D.24/Table E.24, as applicable.

   Face-to-face dimensions listed in the tables as “PMR” shall be per manufacturer requirements.

   NOTE Where face-to-face dimensions are listed in the tables as “—“, valves of that combination of size and pressure rating are outside the scope of this specification.

   3) Face-to-face dimensions shall not apply to the following:

   -- Valves with studded, threaded, or OEC,

   — Reduced-opening ball valve, Reduced-opening gate valve, reduced opening plug valve

c) Full-bore Valves: All full-bore valves shall have round passageways (bores) through the bodies, seats, gates or plugs, and end connectors. Body bore diameter shall conform to the bore dimensions given in Table D.22/Table E.22 and Table D.23/Table E.23. The bore diameter of seats, gates, plugs, or other related internal parts shall have the same dimensions or larger.

14.11.2.2.2 Multiple Cavity Valves

For multiple cavity valves, the following shall apply.

a) End-to-end dimensions shall not apply to multiple cavity valves.

b) Bore locations: Dimensions shall be measured from end-connector center.

For multiple cavity valves containing multiple bores, the following shall apply.

1) Bore Spacing: Bores shall be located according to Table D.25/Table E.25 and Table D.26/Table E.26. Bores shall be arranged on an equal angular spacing.

NOTE Smaller nominal-sized valves may be furnished on the specified center-to-center. The flange shown is the minimum required for a specified center-to-center. A larger flange may be used.

2) Test Port: The lower end connector shall have a test port extending from a point on the connector face, between the bore seals and end connector seal, to an accessible location on the outside of the connector body. This test port shall conform to 9.3.

14.11.2.2.3 Valves Prepared for Actuators

Valves prepared for actuators shall conform to the applicable requirements for actuated valves.

14.11.2.2.4 Actuated Valves

The valve of an actuated valve shall conform to the requirements of 14.11.2.2.1. The actuator of an actuated valve shall conform to the requirements of 14.17.2.

NOTE A provision for relief of pressure build-up may be included in the valve bonnet assembly (and associated parts) as part of either the valve or actuator.

14.11.2.2.5 Check Valves

The following shall apply.

a) Nominal size: Check valves shall be identified by the nominal valve size specified in column 1 of Table D.24/Table E.24.

b) Face-to-face dimension: The face-to-face dimension for flanged end check valves shall conform to the dimensions specified in Table D.24/Table E.24.

c) Bores, of the following types.

— Full-opening valves shall have round passageways through the body and seats. The bore diameter shall conform to the bore dimensions specified in Table D.24/Table E.24.

— Reduced-opening, Regular lift and swing check valves shall be sized at the option of the manufacturer.

14.11.2.3 End and Outlet Connectors

14.11.2.3.1.1 General

Valves shall be a gate, plug or ball configuration with end connectors that are flanged (14.1), threaded (14.3), OEC (14.9), clamp hubs conforming to API 16A, or swivel flanges conforming to API 17D.

14.11.2.3.1.2 Integral Flanges

Valve end flanges shall conform to 14.1.

Studded end connectors shall conform to 14.1.2.9.

For valves with multiple bores, a pair of bolt holes in both end flanges shall straddle the common centerline. The individual bore seals used in end connectors of valves with multiple bores shall be specified by the manufacturer.

NOTE End connectors of multiple cavity valves with multiple bores may have a larger nominal size than the conduit bore(s). The bottom end connector size is typically determined by the nominal size of the tubing head or tubing-head adapter to which the lowermost tree valve is being attached.

14.11.2.3.1.3 Threaded Connectors

Threaded valves shall have line pipe, casing, or tubing threads conforming to 14.3.

Threaded valves shall be supplied only in sizes of 52 mm to 103 mm ($2^1/_{16}$ in. to $4^1/_{16}$ in.) and for rated working pressures of 13.8 MPa, 20.7 MPa, and 34.5 MPa (2000 psi; 3000 psi and 5000 psi) in conformance with 4.3.1.

14.11.2.3.1.4 Other End Connectors

Other end connectors shall conform to 14.9.

14.11.2.4 Stuffing Boxes

Open slots in glands or stuffing box flanges shall not be permitted.

14.11.2.5 Valve Operation

14.11.2.5.1 Direction of Operation

Mechanically operated valves shall be turned in the counterclockwise direction to open and the clockwise direction to close.

14.11.2.5.2 Operating Mechanisms

Manually operated gate valves shall be supplied with a handwheel that permits opening and closing of the valve at the rated working pressure without the aid of tools or bars. Manually operated plug and ball valves shall be furnished with a wrench-operated (or bar-operated) mechanism or with a handwheel-actuated gear mechanism. All handwheels shall be replaceable while in service.

14.11.2.5.3 Operating Gears

Design of the geared operating mechanism shall permit opening and closing of the valve at the rated working pressure differential without aid of tools or bars.

14.11.2.5.4 Backseat – Gate Valves

For gate valves, a backseat or other means for re-establishing a stem seal shall be provided.

14.11.2.5.5 Reduced-opening Valves

Manufacturers shall document flow characteristics and pressure drop for reduced-opening valves.

14.11.3 Materials

14.11.3.1 General

Materials for bodies, bonnets, end connectors, valve bore sealing mechanisms and stems of single valve, multiple cavity valves, check valves and valves prepared for actuators shall conform to Section 6.

14.11.3.2 Actuated Valves

Material for actuated valves shall conform to 14.11.3.1 for components listed therein. Material for the actuator shall conform to 14.17.3.

14.11.4 Quality Control/Testing

14.11.4.1 Single Valves

14.11.4.1.1 Drift Test

All assembled full-bore valves shall pass a drift test as described in 11.4.

14.11.4.1.2 Factory Acceptance Testing

All assembled valves shall successfully complete all applicable tests required and described in Section 11.

14.11.4.2 Multiple Cavity Valves

The requirements of 14.11.4.1 shall apply.

Additionally, each conduit bore of a valve with multiple bores shall pass a drift test as described in 11.4.

14.11.4.3 Valves Prepared for Actuators

Valves prepared for actuators shall successfully pass all applicable tests specified in Section 11. If a bonnet assembly is not included with the valve as a unit, backseat testing shall not be required.

NOTE Required testing may be performed using the test fixtures in lieu of the bonnet and actuator.

14.11.4.4 Actuated Valves

Assembled actuated valves shall successfully complete all applicable tests required by and described in Section 11, subject to the following:

— Hydrostatic shell tests and gas body tests required by Section 11 may be completed before or after the actuator is assembled on the valve; and

— Seat tests, functional tests, backseat tests, and drift tests required by Section 11 shall be completed after the actuator is assembled on the valve.

14.11.4.5 Check Valves

14.11.4.5.1 Drift Test

Check valves shall not require a drift test.

14.11.4.5.2 Factory Acceptance Testing

All assembled check valves shall successfully complete all applicable tests required and described in Section 11.

14.11.5 Marking and Serialization

14.11.5.1 General

Valves, multiple cavity valves, actuated valves, valves prepared for actuators, and check valves shall be marked as specified in Section 12 and Table 50.

Table 50—Marking for Valves

Required Markings	Required Location(s)
API 6A or 6A Temperature class(es) or ratings Material class Product specification level (PSL) Performance requirements (PR) Date of manufacture Manufacturer's name or mark Serial number (if applicable)	Nameplate and/or body
Rated working pressure Nominal bore size(s) End and outlet connector size	Nameplate and/or body and outside diameter of each connector
Thread size (threaded products only)	Nameplate, body, or near thread
Ring groove type and number	Near each connector
Flow direction (check and unidirectional valves only)	On body
Direction of movement to open	On handwheel
Hardness test values (if applicable) (see 12.8)	Adjacent to test location

Valve components fabricated using additively manufactured materials shall each be marked with the AMSL that applies to that part.

14.11.5.2 Serialization

For PSL 2, PSL 3, and PSL 4, serialization shall be required for single valves, valves prepared for actuators and actuated valves.

For PSL2, PSL 3, and PSL 4, serialization shall be required for multiple cavity valves as follows:

a) each individual valve shall be serialized in a location adjacent to each respective valve bonnet, or

b) a single serial number shall be applied to the valve, unless specified otherwise in this specification (see 14.18, Safety Valves)

14.11.5.3 Valves Prepared for Actuators

For valves prepared for actuators, the requirements of 14.11.5.1 shall apply except that the "API 6A" or "6A" (line one of Table 50) shall be replaced with "API 6AV" or "6AV":

If an actuator is subsequently attached to a valve once it has already been marked with a date of manufacture as "Prepared for Actuators", the resulting actuated valve assembly shall retain the "API 6AV" or "6AV" as previously marked (i.e., the "V" shall not be removed from the previous markings).

14.11.5.4 Actuated Valves

For actuated valves the requirements of 14.11.5.1 shall apply, with additional marking specified in Table 51.

Table 51—Supplemental Marking for Actuated Valves

Required Markings	Required Location(s)
Date of valve and actuator integration Name of manufacturer Location of manufacturer	Tag or nameplate

NOTE 1 The requirements of Table 51 may be on a separate tag or supplemental nameplate or may be integrated with the nameplate markings of Table 50.

The date of manufacture (Table 50) and date of valve and actuator integration (Table 51) shall both be identified.

NOTE 2 The date of manufacture of the actuated valve may be different from the date of manufacture of the valve prepared for actuator.

14.11.5.5 Fire Test Marking

Valves that satisfy the requirements of API 6FA shall be marked as specified in 14.11.5 and can be also marked per the requirements of 6FA.

14.11.6 Storing and Shipping

All valves shall be stored and shipped in conformance with Section 13.

14.12 Back-pressure Valves

14.12.1 General

Back-pressure valves shall conform to the applicable requirements of tubing hangers (see 14.13).

14.12.2 Design

Back-pressure valve design shall conform to the manufacturer's specified requirements. A back-pressure valve shall have a feature to enable detection of internal pressure. An operating procedure for the back-pressure valve shall be furnished to the purchaser.

14.12.3 Materials

Body material shall, as a minimum, meet the applicable requirements of 14.13.3, PSL 3 tubing hangers. Material for other parts shall conform to manufacturer written specifications.

14.12.4 Quality Control/Testing

Back-pressure valves shall conform to the requirements of Section 10.4.10.

NOTE PSLs are not applicable to back-pressure valves.

14.12.5 Marking

Back-pressure valves shall be marked with “API 6A” or “6A” followed by the nominal size, working pressure, material class and manufacturer’s name or mark, as a minimum.

Back-pressure valve components fabricated using additively manufactured materials shall each be marked with the AMSL that applies to that part.

14.12.6 Storing and Shipping

Storing and shipping shall be in conformance with Section 13.

14.13 Casing and Tubing Hangers (Slip- and Mandrel-type)

14.13.1 General

The following features shall apply.

a) Group 1:
   - hangs pipe;
   - no annular seal.

b) Group 2:
   - hangs pipe;
   - seals pressure from one direction.

c) Group 3:
   - hangs pipe;
   - seals pressure from top and bottom with or without ring-joint isolation seal and downhole lines.

d) Group 4:
   - same as group 3, with the hanger held in place by mechanical means applied to a retention feature;
   - retention of the hanger is independent of any subsequent member or wellhead part.

e) Group 5:
   - same as group 4, with the hanger receiving back-pressure valve.

14.13.2 Design

14.13.2.1 Performance Requirements

14.13.2.1.1 General

The following shall apply.

a) Group 1:

— shall be able to suspend manufacturer's rated load without collapsing the tubulars or hangers below drift diameter;

b) Group 2:

— same as group 1 with the addition that the pressure load shall be considered with the hanging load.

c) Group 3:

— same as group 2 with the addition that:

1) all seals shall retain rated working pressure from either direction;

2) if a crossover seal is included on the hanger, then it shall hold the higher rated working pressure from above;

3) if downhole lines are included, they shall hold the rated working pressure of the hanger and any effects of the pressure load shall be included in the load rating.

d) Group 4:

— same as group 3 with the addition that the minimum retention load capacity of the hanger's retention feature shall be equal to the force generated by the working pressure on the annular area.

e) Group 5:

— same as group 3 with the addition that:

1) minimum retention load capacity of the hanger's retention feature shall be equal to the force generated by the working pressure acting on the full area of the largest hanger seal;

2) back-pressure valve preparations shall be capable of holding rated working pressure from below.

NOTE 1 The load and pressure ratings for casing and tubing hangers may be a function of the tubular grade of material and wall section as well as the wellhead equipment in which it is installed.

Manufacturers shall be responsible for supplying information about the load/pressure ratings of such hangers.

NOTE 2 Field test pressures may be different from the rated working pressure of a hanger due to casing-collapse restrictions or load-shoulder limits.

Nothing in 14.13.2.1.1 shall be interpreted as being a requirement for a wrap-around seal type tubing hanger.

14.13.2.1.2 Slip Hangers

The following shall apply.

a) Load capacity: The load capacity for slip hangers shall conform to the general requirements of 4.2 and slip hangers shall be capable of performing as outlined in Table 52.

b) Temperature rating: The temperature rating of slip hangers shall be in conformance with 4.3.2.

c) Performance requirements for group 1 slip hangers: Group 1 slip hangers shall conform to the general requirements of 4.2 and shall be capable of performing as outlined in Table 52, except that they are not required to have pressure integrity.

d) Performance requirements for group 2 slip hangers: Group 2 slip hangers shall conform to the general requirements of 4.2 and shall be capable of performing as outlined in Table 52. They shall seal the rated working pressure in one direction across the annular seal at the rated load capacity for that pressure.

e) Performance requirements for group 3 slip hangers: Group 3 slip hangers shall conform to the general requirements of 4.2 and shall be capable of performing as outlined in Table 52. They shall seal the rated working pressure above and below the annular seal at the rated load capacity for that pressure. If a crossover packoff is included on the hanger, then it shall hold the higher rated working pressure from above. If downhole lines are included, they shall hold the rated working pressure of the hanger. Any effect of the pressure load shall be included in the load rating.

f) Performance requirements for group 4 slip hangers: Group 4 slip hangers shall conform to the general requirements of 4.2 and shall be capable of performing as outlined in Table 52. They shall seal the rated working pressure above and below the annular seal at the rated load capacity for that pressure. They shall also seal rated working pressure from below the annular seal while the hanger is retained in the bowl with the hanger retention feature. If a crossover packoff is included on the hanger, then it shall hold the higher rated working pressure from above. If downhole lines are included, they shall hold the rated working pressure of the hanger and any effect of the pressure load shall be included in the load rating.

Table 52—Performance Requirements for Slip Hangers

Performance Requirement Level	Load Capacity
PR1	1 cycle at minimum [a] rated load to maximum rated load
PR2	3 cycles at minimum [a] rated load to maximum rated load

FOOTNOTE
[a] Minimum rated load may be upward or compressive.

14.13.2.1.3 Mandrel Hangers

The following shall apply.

a) Load capacity: The load capacity for mandrel hangers shall conform to the general requirements of 4.2 and mandrel hangers shall be capable of performing as outlined in Table 53. They shall seal the rated working pressure internally at the rated load capacity.

Table 53—Performance Requirements for Mandrel Hangers

Performance Requirement Level	Load Capacity
PR1	1 cycle at minimum [a] rated load to maximum rated load
PR2	3 cycles at minimum [a] rated load to maximum rated load

FOOTNOTE
[a] Minimum rated load may be upward or compressive.

b) Performance requirements for group 1 mandrel hangers: Group 1 mandrel hangers shall conform to the general requirements of 4.2, except that they are not required to have pressure integrity.

c) Performance requirements for group 2 mandrel hangers: Group 2 mandrel hangers shall conform to the general requirements of 4.2. They shall seal the rated working pressure in one direction across the annular seal at the rated load capacity for that pressure.

d) Performance requirements for group 3 mandrel hangers: Group 3 mandrel hangers shall conform to the general requirements of 4.2. They shall seal the rated working pressure above and below the annular seal at the rated load capacity for that pressure. If a crossover packoff is included on the hanger, then it shall hold the higher rated working pressure from above. If downhole lines are included, they shall hold the rated working pressure from above and shall hold the rated working pressure of the hanger. Any effect of the pressure load shall be included in the load rating.

e) Performance requirements for group 4 mandrel hangers: Group 4 mandrel hangers shall conform to the general requirements of 4.2. They shall seal the rated working pressure above and below the annular seal at the rated load capacity for that pressure. They shall also seal the rated working pressure from below the annular seal while the hanger is retained in the bowl with the hanger retention feature. If a crossover packoff is included on the hanger, then it shall hold the higher rated working pressure from above. If downhole lines are included, they shall hold the rated working pressure of the hanger and any effect of the pressure load shall be included in the load rating.

f) Performance requirements for group 5 mandrel hangers: Group 5 mandrel hangers shall conform to the general requirements of 4.2. They shall seal the rated working pressure above and below the annular seal at the rated load capacity for that pressure. They shall also seal the rated working pressure from below with the ID of the hanger blanked off with no pipe suspended while the hanger is retained in the bowl with the hanger-retention feature. Back-pressure valve preparations shall be capable of holding rated working pressure from below. If a crossover packoff is included on the hanger, then it shall hold the higher rated working pressure from above. If downhole lines are included, they shall hold the rated working pressure of the hanger and any effect of the pressure load shall be included in the load rating.

14.13.2.2 Loads

The following loads shall be considered when designing any hanger:

— radial loads on hanger body due to tapered landing shoulder;

— tensile loads throughout hanger body due to weight of suspended tubulars;

— loads imparted to hanger due to field pressure test.

14.13.2.3 Threaded Connectors

Threads on threaded mandrel-type casing and tubing hangers shall conform to 14.3. Other threaded connectors shall conform to 14.9.

Material selection shall provide a joint strength in the hanger threads equal to, or greater than, that of the casing or tubing.

14.13.2.4 Maximum Diameter

The maximum outside diameter of any hanger that it is intended to run through a blowout preventer shall not exceed that shown in Table D.27/Table E.27.

14.13.2.5 Vertical Bore

The vertical through-bore of a tubing hanger shall provide full-opening to the drift diameter of the suspended tubular or tree drift bar, whichever is smaller. The minimum vertical bore of casing hangers shall be at least 0.8 mm (0.03 in.) larger than the drift diameter of the suspended casing. Back-pressure valve preparation shall also meet this through-bore requirement.

14.13.2.6 Rated Working Pressure

14.13.2.6.1 Slip-type Hangers

NOTE There is no requirement for slip hangers to have a pressure rating.

14.13.2.6.2 Mandrel-type Hangers

The following shall apply.

a) With no extended seal neck: The rated working pressure for hanger body and primary seal shall be equal to the working pressure of the head in which it is landed, if no extended seal neck is provided.

b) With extended seal neck: Maximum pressure rating for the hanger body and extended neck seal, if a crossover type seal is provided, shall be the working pressure of the next casing or tubing head or tubing-head adapter above the hanger.

c) Limitation: Hangers can have a limitation on the pressure rating due to the pressure limitations of the threaded connectors.

14.13.2.7 Welds

The design of any weld shall be such that it satisfies all the design requirements of 14.13.2.

14.13.2.8 Pipe Dimensions

Slip-type hangers and sealing systems to seal on casing or tubing shall be designed to accommodate the outside diameter pipe tolerance.

For casing or tubing sizes defined by API 5CT, the tolerances in API 5CT shall apply. For sizes not covered by API 5CT, the tolerances shall be per an industry standard (for example, API 5L).

NOTE The tolerances of casing and tubing outside diameters vary substantially between the various editions of API 5CT. In general, the tolerance has increased over time; this can affect equipment interchangeability.

14.13.3 Materials

14.13.3.1 Slip-type Hangers

Materials for slip hangers shall conform to the manufacturer's requirements. If additively manufactured materials are used, the material shall conform to AMSL 2, at a minimum.

14.13.3.2 Mandrel-type Hangers

Materials for mandrel type hangers shall conform to the manufacturer's requirements, and the following:

- Materials shall conform to the requirements for bodies, bonnets, and end and outlet connectors specified in 6.3.2 through 6.3.5;
- QTCs for the qualification of materials shall conform to 6.4;
- Castings and Additively Manufactured materials are not permitted for mandrel-type hangers.

14.13.4 Quality Control/Testing

Hangers shall conform to the quality control requirements of section 10.4.8 or 10.4.9, as applicable.

NOTE It is not a requirement of this specification to hydrostatically test hangers.

14.13.5 Marking

14.13.5.1 General

Hangers shall be marked in conformance with Section 12 and Table 54.

14.13.5.2 Marking of Mandrel Hangers

If mandrel hangers have different top and bottom threads, both threads shall be listed with the bottom thread first, followed by the top thread description plus the word "TOP." Any hanger that can be installed upside down shall have the word "DOWN" on the end that faces downhole when properly installed. Marking of rated working pressure and load rating is optional for mandrel hangers. Mandrel hangers shall be marked as specified in Table 54.

Table 54—Marking for Hangers

Marking	Location	
	Mandrel-type Hangers	Slip-type Hangers
API 6A or 6A Temperature class(es) or ratings Material class Product specification level (PSL) Performance requirements (PR) Date of manufacture Manufacturer's name or mark Serial number (if applicable)	Nameplate and/or body	Nameplate and/or body
Thread size	Nameplate, body, or near thread	—
Hardness test values (if applicable) (see 12.8)	Adjacent to test location	Adjacent to test location
Back-pressure valve style or model	Nameplate and/or body (tubing hangers only)	—
Bowl size and casing or tubing size	—	Nameplate and/or body
Rated working pressure (optional)	Nameplate and/or body	Nameplate and/or body
Load rating information (optional)	Nameplate and/or body	Nameplate and/or body
Minimum vertical bore	Nameplate and/or body	—
Orientation "DOWN" (if required)	Bottom of body	Bottom of body

14.13.5.3 Marking of Slip Hangers

The slips in a slip hanger shall be sequentially marked if they are not interchangeable.

Any hanger that can be installed upside down shall have the word "DOWN" on the end that faces downhole when properly installed. Marking of rated working pressure and load rating is optional for slip hangers. Slip hangers shall be marked as specified in Table 54.

If additively manufactured materials are used on a component, that component shall be marked with the AMSL that applies.

14.13.6 Storing and Shipping

Hangers shall be stored and shipped in conformance with Section 13.

The slips of a slip hanger shall be stored and shipped as a set.

14.14 Casing and Tubing Heads

14.14.1 General

The following shall apply.

a) Casing-head housings and spools: Casing-head housings are attached to the upper end of the surface casing. Casing-head spools are attached to the top connection of housings or other spools.

b) Tubing-head spools: Tubing-head spools are attached to the top connection of casing-head housings or spools.

14.14.2 Design

14.14.2.1 Performance Requirements

The products in 14.14.1 with penetrations shall conform to the requirements of 9.2 in addition to the requirements of 4.2. Casing-head spools, casing-head housings and tubing-head spools shall be capable of performing according to the performance requirements outlined in Table 55.

Casing-head spools and tubing-head spools shall be capable of performing as outlined in Table 55 for the applicable PR level.

14.14.2.2 Loads

The following loads shall be inputs to the design:

-- hanging loads;

-- pressure loads from blow-out preventer testing and field pressure testing of hanger packing mechanisms;

-- retention loads;

-- additional loads, when specified.

NOTE: Additional specified loads may include external axial, bending, and thermal loads.

Table 55—Performance Requirements for Casing-head Housings and Spools, Tubing-head Spools and Group 1 Tubing-head Adapters [b])

Performance Requirement Level	Pressure Integrity [a]
PR1	1 cycle
PR2	3 cycles

FOOTNOTE

[a] Capable of withstanding the rated working pressure internally.

[b] See section 14.15

14.14.2.3 End Connectors

a) Lower connector: The lower connector shall be;

— flanged or studded conforming to 14.1, or

— threaded conforming to 14.3, or

— an OEC conforming to 14.9, or

— clamp hub end connectors conforming to API 16A or

— swivel flanges conforming to API 17D.

NOTE Housing-to-casing weld preparations are outside the scope of this specification.

b) Upper connector: The upper connector shall be;

— flanged or studded conforming to 14.1, or

— threaded conforming to 14.3, or

— an OEC conforming to 14.9, or

— clamp hub end connectors conforming to API 16A or

— swivel flanges conforming to API 17D.

14.14.2.4 Outlet Connectors

14.14.2.4.1 Pressure Rating

Pressure rating of outlet connectors shall be consistent with that of the upper end connector.

14.14.2.4.2 Flanged or Studded

Flanged or studded outlet connectors shall conform to 14.1. Also, flanged or studded outlets 79 mm ($3^1/_8$ in.) and smaller shall be furnished with valve-removal plug preparation. Flanged or studded outlets 103 mm ($4^1/_{16}$ in.) or larger may be furnished with or without valve-removal plug preparation.

Valve-removal plug preparations shall conform to 14.6.

14.14.2.4.3 API 5B Threaded

API 5B threaded outlets shall conform to 14.3.

14.14.2.4.4 Other End Connectors

OECs shall be conform to 14.9.

14.14.2.5 Flange Counterbores

NOTE The provisions of this specification are not applicable to the diameter and depth of oversize counterbores intended to accept wear bushings and packer mechanisms.

If such counterbores are used in flanged or studded connectors, the manufacturer shall ensure that the oversize preparation does not cause the flange stresses to exceed the design criteria.

14.14.2.6 Vertical Bores

14.14.2.6.1 Full-opening Vertical Bore

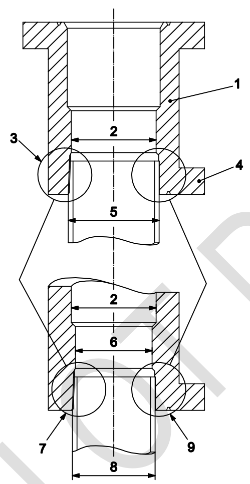
In order to permit internal passage of tools or bottom hole equipment, the minimum vertical bore of wellhead bodies shall be 0.8 mm (0.03 in.) larger than the drift diameter Table D.28/Table E.28 of the largest casing over which the body is being used.

Wellhead bodies conforming to this requirement are referred to as having full-opening bores. The minimum vertical full-opening wellhead body bore, for the maximum casing size with which the bodies can be used, shall be as shown in Table D.28/Table E.28.

14.14.2.6.2 Reduced-opening Vertical Bore

The vertical bores specified in Table D.28/Table E.28 may be adapted to casing sizes smaller than those listed in the tabulation by suitable reducing threads, pilot rings, etc. The through-bore of these elements shall be 0.8 mm (0.03 in.) larger than the drift diameter of the casing over which the unit is used.

Typical illustrations of such adaptations are shown in Figure 15. Reduced vertical bores may also be supplied for weights of casing heavier than those listed in Table D.28/Table E.28. Reduced vertical bores for this application shall be 0.8 mm (0.03 in.) larger than the drift diameter of the heaviest wall casing over which it is being used.



Key

1 wellhead body
2 regular full-opening bore
3 threaded bottom connector
4 bottom connector
5 maximum size casing (attached or beneath the body)
6 reduced full-opening bore
7 casing thread
8 smaller size casing
9 integral bore, adapter, or pilot

Figure 15—Typical Reduced-opening Vertical Bore

14.14.2.6.3 Increased-opening Vertical Bore

In order to accept wear bushings and packer mechanisms, the vertical bore may be increased above the values in column 6 of Table D.28/Table E.28. However, it is the responsibility of the manufacturer to ensure that the oversize preparation does not cause the body stress to exceed the design criteria.

14.14.2.7 Rated Working Pressure

The rated working pressure of heads shall be in conformance with 4.3.1. Account shall be taken of the rated working pressure limitations for threaded connectors based on size and type of thread.

14.14.2.8 Test, Vent, Injection, and Gauge Connectors

14.14.2.8.1 General

Test, vent, injection, and gauge connectors shall conform to 9.3.

14.14.2.8.2 Special Test Port

Casing-head spools and tubing-head spools with either a secondary seal or a crossover seal shall be provided with a test port in the lower connector.

14.14.2.8.3 Trapped Pressure

A means shall be provided such that any pressure behind a test, vent, injection, and gauge connector can be vented prior to opening the connection.

14.14.2.9 Crossover Spools

If casing-head spools or tubing-head spools are used as crossover spools, then they shall satisfy the requirements of 14.8.

14.14.3 Materials

14.14.3.1 General

Material used for bodies, flanges, and other connectors shall conform to Section 6.

Material for lock screws and other parts shall conform to Section 6.

14.14.3.2 Multiple Material Classes

Casing-head housings and spools and tubing-head spools with multiple material classes, each applicable to either a portion of the equipment or the whole equipment, shall be acceptable. Each material class shall conform to 4.3.3.

Packoffs used in casing-head housings and spools and tubing-head spools shall conform to both designated material classes, as per Table 3, on each side of the annular packoff.

14.14.4 Quality Control/Testing

Casing and Tubing heads shall successfully complete the tests required and described in Section 11.

14.14.5 Marking

All wellheads shall be marked in conformance with Section 12 and Table 56.

If additively manufactured materials are used on a wellhead component, that component shall be marked with the AMSL that applies.

All casing-head spools and tubing-head spools used as crossover spools shall additionally be marked in conformance with Section 12 and Table 57.

Casing-head housings, casing-head spools, tubing-head spools, crossover spools, multistage head housings, multistage spools, and adapter and spacer spools shall be marked as specified in Table 56 and Table 57. The bore size shall be preceded by the word “Bore.”

NOTE Performance requirement marking is not required for wellhead connectors.

Wellhead outlets with valve removal preparations shall be marked near the outlet with “API 6A” or “6A” followed by the nominal size and “VR” or “HPVR” as applicable.

Table 56—Marking for Wellhead Equipment

Required Markings	Required Location(s)
API 6A or 6A Temperature class(es) or ratings Product specification level (PSL) Performance requirements (PR) Date of manufacture Manufacturer's name or mark Serial number (if applicable)	Nameplate and/or body
End and outlet connector size Rated working pressure Bottom preparation Minimum vertical bore	Nameplate and/or body and outside diameter of connector
Thread size (threaded products only)	Nameplate, body, or near thread
Material class (Single) [a]	Nameplate and/or body
Material class (Multiple)[a]	Nameplate and/or body and outside diameter of each connector
Ring groove type and number	Near each connector
Hardness test values (if applicable) (see 12.8)	Adjacent to test location
FOOTNOTE [a] For casing-head housings and spools, tubing-head spools, and tubing-head adapters having multiple material classes, all material classes designated shall be marked.	

Table 57—Marking for Wellhead Connectors

Required Markings	Required Location(s)
API 6A or 6A Temperature class(es) or ratings Product specification level (PSL) Date of manufacture Manufacturer's name or mark Serial number (if applicable)	Nameplate and/or body
End and outlet connector size Rated working pressure	Nameplate and/or body and outside diameter of connector
Material class (Single)	Nameplate and/or body
Material class (Multiple)[a]	Nameplate and/or body and outside diameter of each connector
Thread size (threaded products only)	Nameplate, body, or near thread
Packoff casing size	Nameplate or body, and outside diameter of bottom connector
Minimum vertical bore	Nameplate or body, and outside diameter of each connector
Ring groove type and number	Near each connector
Hardness test values (if applicable) (see 12.8)	Adjacent to test location
FOOTNOTE [a] For casing-head and tubing-head spools used as crossovers spools having multiple material classes, all material classes designated shall be marked.	

14.14.6 Storing and Shipping

All heads shall be stored and shipped in conformance with Section 13.

14.15 Tubing-head Adapters

14.15.1 General

Tubing-head adapters shall be either Group 1 or Group 2, where:

a) Group 1 tubing-head adapters seal the well bore from the annulus, or

b) Group 2 tubing-head adapters seal the well bore from the annulus and suspend the tubing.

NOTE Tubing-head adapters may be either integral with a valve body as its lower end connector or an independent piece of equipment that provides a means to connect and seal the tubing bore(s) to the valve bore(s).

14.15.2 Design

14.15.2.1 Performance Requirements

Group 1 tubing-head adapters shall conform to the general requirements of 4.2 and shall be capable of performing as specified in Table 55 (see 14.14.2.2).

Group 2 tubing-head adapters shall conform to the general requirements of 4.2 and shall be capable of performing as specified in Table 58.

Table 58—Performance Requirements for Group 2 Tubing-head Adapters

Performance Requirement Level	Pressure Integrity [a]	Load Capacity [b]
PR1	1 cycle	1 cycle
PR2	3 cycles	3 cycles

FOOTNOTES
[a] Capable of withstanding the rated working pressure internally.
[b] Capable of withstanding the minimum and maximum rated load.
NOTE Minimum rated load may be upward or compressive

14.15.2.2 Loads

The following loads shall be inputs to the Group 2 tubing-head adapter design:

— applied axial tubular loads;

— external axial and bending loads

14.15.2.3 End and Outlet Connectors

The following shall apply to end and outlet connectors:

a) Lower connector: Flanged or studded lower connectors shall conform to 14.1. Other connectors shall conform to 14.9;

b) Upper connector: The upper connector of an independent adapter shall be flanged or studded conforming to 14.1, or threaded conforming to 14.3, or have an OEC conforming to 14.9 or clamp hub end connectors conforming to API 16A or swivel flanges conforming to API 17D;

c) Through-bore tolerances for 5" upper connectors shall be +1.0 mm (+0.04 in.). For all other upper connectors, through-bore tolerances shall be +0.8 mm (+0.03 in.) of the nominal bore dimension;

d) If counterbores are used in flanged or studded connectors, the oversize preparation shall not cause the flange stresses to exceed the design criteria.

Pressure rating of outlet connectors shall be consistent with that of the upper end connector.

14.15.2.1 Flange Counterbores

If counterbores are used in flanged or studded connectors, the oversize preparation shall not cause the flange stresses to exceed the design criteria.

14.15.2.2 Rated Working Pressure

The rated working pressure of tubing-head adapters shall conform to 4.3.1.

NOTE The rated working pressure of threaded connectors may limit the rated working pressure of the tubing-head adapter.

14.15.2.3 Pressure Rating Changes

If a tubing-head adapter is used where the pressure rating is different on the upper and lower connection, (crossover tubing-head adapter), the tubing-head adapter shall conform to 14.8.

14.15.2.4 Test, Vent, Injection, and Gauge Connectors

Testing, vent, injection, and gauge connectors used in tubing-head adapters shall conform to 9.3.

A means shall be provided such that any pressure behind a test, vent, injection, and gauge connector can be vented prior to opening the connection.

14.15.2.5 Special Test Port

Tubing-head adapters with either a secondary seal or a crossover seal shall be provided with a test port in the lower connector.

14.15.3 Materials

14.15.3.1 General

Materials shall conform to Section 6.

14.15.3.2 Multiple Material Classes

Tubing head adapters with multiple material classes, each applicable to either a portion of the equipment or the whole equipment, shall be acceptable. Each material class shall conform to 4.3.3. Packoffs used shall conform to both designated material classes, as per Table 3, on each side of the annular packoff.

14.15.4 Quality Control/Testing

Tubing-head adapters shall pass the tests required in Section 11.

14.15.5 Marking

Tubing-head adapters shall be marked in conformance with Section 12 and Table 56.

14.15.6 Storing and Shipping

Tubing-head adapters shall be stored and shipped in conformance with Section 13.

14.16 Chokes

14.16.1 General

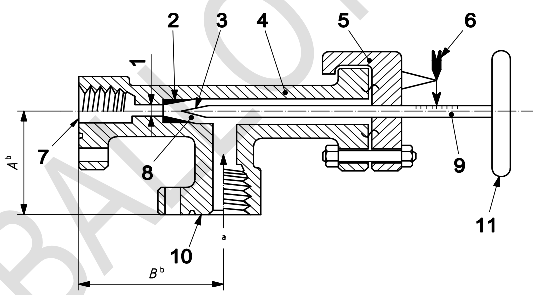
Adjustable chokes shall have an orifice-area-indicating mechanism as shown in Figure 16. Actuators for adjustable chokes shall conform to 14.17.

NOTE Chokes are not intended to be used as shutoff valves.

14.16.2 Design

14.16.2.1 General

Chokes shall conform to the requirements of Section 4 and Section 5, in addition to those in 14.16.2.2 through 14.16.2.9.



Key

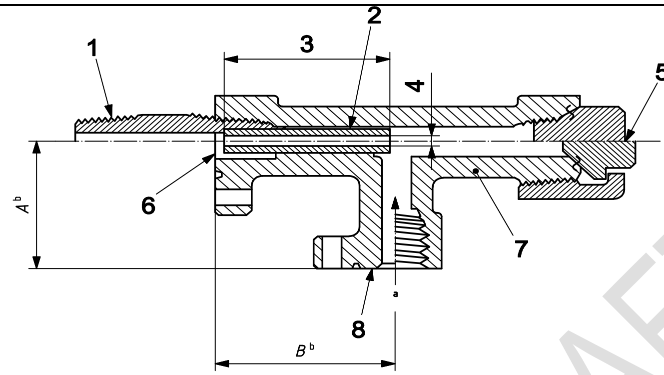
1 maximum orifice diameter
2 removable seat
3 stem tip
4 body
5 bonnet
6 indicating mechanism (type is optional)
7 outlet connector
8 orifice area
9 stem
10 inlet connector
11 handwheel or lever

a Flow direction.

b Dimensions A and B are agreed between manufacturer and purchaser and may be specified using Figure B.11.

Figure 16—Typical Adjustable Choke

NOTE 4 Positive chokes accommodate replaceable parts having fixed orifice dimensions, which are commonly called flow beans, as shown in Figure 17.



Key

1 cage nipple (optional)
2 removable flow bean
3 orifice length
4 orifice diameter
5 plug or cap
6 outlet connector
7 body
8 inlet connector

[a] Flow direction.

[b] Dimensions *A* and *B* are agreed between manufacturer and purchaser and may be specified using Figure B.11.

Figure 17—Typical Positive Choke

14.16.2.2 Performance Requirements

Chokes shall conform to the general performance requirements of 4.2 and shall be capable of performing as outlined in Table 59. This shall include positive chokes, manually actuated chokes, and chokes designed for actuators.

Table 59—Performance Requirements for Chokes

Performance Requirement Level	Operating Cycles [a]	Seat-to-body Sealing
PR1	3 cycles	1 cycle
PR2	200 cycles	3 cycles
FOOTNOTE [a] Operating cycles do not apply to positive chokes.		

For chokes that use pressure controlling components manufactured from additively manufactured materials, the choke design with such materials shall be validated to PR2.

14.16.2.3 End Connectors

End connectors shall conform to 14.1, 14.3, or 14.9.

14.16.2.4 Nominal Size

The nominal size designation of the choke shall be the inlet connector size, followed by the maximum orifice size available for that choke in units of 0.4 mm ($^1/_{64}$ in.). If the choke orifice is not a single circular orifice, the maximum size shown shall be the diameter of a circle, in increments of 0.4 mm ($^1/_{64}$ in.), whose area is equal to the total choke orifice area.

14.16.2.5 Rated Working Pressure

For chokes having end connectors of the same rated working pressure, the rated working pressure of the choke shall be the rated working pressure of the end connectors.

For chokes having an upstream end connector of higher rated working pressure than the downstream end connector, the choke shall have a two-part rated working pressure consisting of the rated working pressure of the upstream end connector and the rated working pressure of the downstream end connector, for example, 20.7 MPa × 13.8 MPa (3000 psi × 2000 psi).

14.16.2.6 Flow Design

Chokes shall be designed to direct flow away from the bonnet of adjustable chokes and the cap, or blanking plug, of positive chokes.

14.16.2.7 Vent Requirement

All chokes shall be designed to vent trapped pressure prior to releasing the body-to-bonnet connector on adjustable chokes or the body-to-cap connector on positive chokes.

14.16.2.8 Flow Beans for Positive Chokes

The orifice size of any individual production flow bean and the increment between sizes are optional with the manufacturer but shall be specified in diameter increments of 0.4 mm ($^1/_{64}$ in.).

Proration beans shall have a net effective orifice length of 152.4 mm ± 1.5 mm (6 in. ± 0.06 in.). The orifice diameters of these beans shall be specified in $^1/_{64}$ in. diametrical increments, i.e. $^5/_{64}$ in., $^6/_{64}$ in., $^7/_{64}$ in., $^8/_{64}$ in.

NOTE The orifice size of any individual production bean and the increment between sizes are optional with the manufacturer.

14.16.2.9 Adjustable Choke Indicating Mechanism

Adjustable chokes shall be equipped with a visible orifice-area-indicating mechanism to define the orifice area at any adjusted choke setting throughout its operating range. This mechanism shall be calibrated to indicate diameters of circular orifices having areas equivalent to the minimum flow areas at any adjustable choke setting.

The markings shall be in diametrical increments of either 0.4 mm ($^1/_{64}$ in.) or 0.8 mm ($^1/_{32}$ in.) for choke settings between 0.0 mm (0 in.) and 19.2 mm ($^3/_4$ in.), inclusive. For choke settings above 19.2 mm ($^3/_4$ in.), diametrical increments of 0.4 mm ($^1/_{64}$ in.), 0.8 mm ($^1/_{32}$ in.), or 1.6 mm ($^1/_{16}$ in.) may be used. It is not required to equip actuated chokes with an indicating mechanism.

14.16.3 Materials

Materials for bodies, bonnets, plugs or caps, and end connectors shall conform to Section 6.

Material for all other parts shall conform to the requirements of Section 6 or 14.17, as applicable. Additionally, special corrosion- and abrasion-resistant materials, coatings, or overlays shall be used for adjustable-choke stem tips and positive-choke flow beans.

14.16.4 Quality Control/Testing

Assembled chokes shall successfully complete the tests required by and described in Section 11.

14.16.5 Marking

Choke marking shall be as specified in Section 12 and Table 60.

Table 60—Marking for Chokes

Required Markings	Required Location(s)
API 6A or 6A Temperature class(es) or ratings Material class Product specification level (PSL) Performance requirements (PR) Date of manufacture Manufacturer’s name or mark Serial number (if applicable) Maximum orifice size End and outlet connector size	Nameplate and/or body
Rated working pressure	Nameplate and/or body and outside diameter of connector
Thread size (threaded products only)	Nameplate, body, or near thread
Flow direction	Body
Direction of movement to open	Handwheel
Ring groove type and number	Near each connector or thread
Hardness test values (if applicable) (see 12.8)	Adjacent to test location

Chokes shall be marked with their nominal size and maximum orifice as specified in 14.16.2.4.

Choke beans shall be marked as specified in Table 61, with the orifice size and the manufacturer’s name or mark on its outside diameter or end.

Table 61—Marking for Choke Beans

Marking	Location
Manufacturer’s name or mark	Outside diameter or end
Size; nominal orifice size; bean size	Outside diameter or end

14.16.6 Storing and Shipping

Chokes shall be stored and shipped in conformance with Section 13.

14.17 Actuators

14.17.1 General

14.17.1.1 Types

This section shall apply to hydraulic, pneumatic, and electric-powered actuators for wellhead and tree equipment including single-acting linear, double-acting linear, and rotary types.

If the actuator is supplied with the associated parts of the valve or choke (bonnet, stem, seals), these parts are not considered part of the actuator and shall conform to the requirements of 14.11 or 14.16, respectively. The actuator, if assembled with a valve prepared for an actuator, shall conform to the requirements of 14.11.1.3 for actuated valves.

NOTE Actuators powered using retained fluid are not within the scope of this document.

14.17.1.2 Temperature Rating

Actuators shall have a temperature rating, for which metallic materials and nonmetallic seals shall be qualified as required by this specification.

The minimum rating shall be a temperature listed under "min" in Table 2, unless specified otherwise by the manufacturer and purchaser.

The maximum rating shall be no less than 65 °C (150 °F).

NOTE The standard upper temperature rating is 65 °C (150 °F).

14.17.2 Design

14.17.2.1 General

Actuators shall conform to the requirements of Section 4 and Section 5, in addition to the requirements in 14.17.2.2 to 14.17.2.8.

14.17.2.2 Performance Requirements

Actuators shall be capable of performing as outlined in Table 62.

Table 62—Performance Requirements for Actuators

Performance Requirement Level	Number of Operating Cycles
PR1	3 cycles
PR2	200 cycles

14.17.2.3 Supply Pressure

The manufacturer shall identify the supply pressure rating of the actuator.

Hydraulic and pneumatic actuators shall be designed to withstand actuator shell test pressure.

14.17.2.4 Fluid Connectors

Hydraulic and pneumatic connectors shall conform to the manufacturer specifications. The connectors shall have a pressure rating equal to or greater than the supply pressure rating of the actuator.

14.17.2.5 Pressure Relief

All actuators shall be designed to prevent pressure build-up within the actuator case due to leakage from the valve, choke, or actuator.

NOTE A provision for relief of pressure build-up may be included in the valve bonnet assembly (and associated parts) as part of either the valve or the actuator.

In pneumatically operated actuators, a relief device shall be provided to relieve at no higher than 120 % of the supply pressure rating of the actuator.

14.17.2.6 Electrical Specifications

Electrical parts shall conform to the requirements of API 14F or the applicable standards of IEC/CENELEC. Control latching (hold-open) power shall conform to manufacturer written specification. Thermal protection for the motor shall be provided.

14.17.2.7 Actuation Forces

Actuator output forces shall conform to or exceed the operating requirements specified by the valve or choke manufacturer.

14.17.2.8 Interface Requirements

Parts shall conform to applicable interface dimensions and other requirements specified by the valve manufacturer.

14.17.3 Materials

14.17.3.1 Pneumatically or Hydraulically Powered Actuators

Metallic and non-metallic materials used in actuators shall have written material specifications.

The manufacturer’s written specifications for metallic materials shall define the following:

— mechanical property requirements;

— chemical compositions;

— heat-treatment.

Impact testing for actuator parts that retain pneumatic/hydraulic control fluid and pressure (e.g. pressure cylinders, pistons, and diaphragm housings) shall conform to 6.3.2.3, PSL 1 requirements.

The manufacturer’s written specifications for nonmetallic materials shall conform to 6.2.3.

14.17.3.2 Electric Actuators

Materials used for electric actuators shall conform to the manufacturer’s written specifications.

14.17.3.3 Traceability

Actuator parts that retain pneumatic/hydraulic control fluid and pressure (e.g. pressure cylinders, pistons, and diaphragm housings) having a rated working pressure greater than 2.6 MPa (375 psi) shall require material traceability. Traceability shall be sufficient if the part can be traced to a job lot that identifies the included heat lot(s). All parts in a multi-heat job lot shall be rejected if any heat lot does not conform to the manufacturer’s written specifications.

NOTE If heat lot traceability is maintained, conforming heat lots may be retained.

14.17.3.4 Nonmetallic Sealing Elements

Nonmetallic seal materials shall be capable of withstanding the supply pressure rating of the actuator within the temperature rating specified by the manufacturer. The manufacturer shall specify the operating fluid(s) and shall have documentation of the compatibility of the fluid with non-metallic seals.

Sealing elements shall be controlled in conformance with 10.4.6, PSL 1.

14.17.3.5 Welding Requirements

Welding shall be in conformance with the PSL 1 applicable requirements of Section 7, except that quality control requirements shall be visual examination for fabrication welds. Repair welds shall include liquid penetrant or magnetic particle examination, as applicable, for material defects only.

14.17.4 Quality Control/Testing

14.17.4.1 Actuator Shell Test

Actuator parts that retain pneumatic or hydraulic control fluid and pressure (e.g. pressure cylinders, pistons, and diaphragm housings) shall be subjected to a shell test to demonstrate structural integrity.

NOTE 1 The parts may be tested simultaneously or separately.

In case the bonnet for the mating valve or choke forms an integral part of a loose actuator, the bonnet shall satisfy the requirements of 14.11 or 14.16, respectively. Testing of the bonnet stem packing shall not be required as part of the actuator shell test.

NOTE 2 Water with or without additives, gas, or hydraulic fluid may be used as the testing fluid.

The test pressure shall be a minimum of 1.5 times the supply pressure rating of the actuator. The test shall consist of four parts:

— primary pressure-holding period;

— reduction of the pressure to zero;

— secondary pressure-holding period;

— reduction of pressure to zero.

Both pressure-holding periods shall not be less than 3 min. The test period shall not begin until the test pressure has been reached and has stabilized, the equipment and the pressure-monitoring device have been isolated from the pressure source, and the external surfaces of the parts have been thoroughly dried.

The actuator pressure test acceptance criteria shall be as specified in 11.2.2.a) with no exception and 11.2.2.b). For gas testing the acceptance criteria of 11.3.2 shall apply.

14.17.4.2 Actuator Seal and Operation Testing

Each actuator shall be subjected to a seal and operation test to demonstrate proper assembly and operation. The actuator may be tested with the equipment for which it is intended or tested separately. Test media for pneumatic actuators shall be a gas, such as air or nitrogen. Test media for hydraulic actuators shall be a suitable hydraulic fluid or a gas, such as air or nitrogen. Test power supplied to electric actuators shall conform to the electrical design requirements.

The following shall apply in the order shown below.

a) Test for hydraulic actuator seal:

— The actuator first seal test shall be 20 % of the actuator supply pressure rating. The actuator second seal test shall be at pressure no less than 100% of the actuator supply pressure rating.

— This test period shall not begin until the test pressure has been reached and has stabilized, and the pressure-monitoring device has been isolated from the pressure source.

— The minimum test duration for each test pressure shall be 3 min at each test pressure for hydraulic actuators.

— The test pressure reading and time at the beginning and at the end of each pressure-holding period shall be recorded.

— No visible leakage shall be allowed. The acceptance criteria shall be as specified in 11.2.2 a) and 11.2.2 b).

b) Test for pneumatic actuator seal:

— The actuator first seal test shall be 20 % of the actuator supply pressure rating. The actuator second seal test shall be at a pressure no less than 100% of the actuator's supply pressure rating.

— This test period shall not begin until the test pressure has been reached and has stabilized, and the pressure-monitoring device has been isolated from the pressure source.

— The minimum test duration for each test pressure shall be 10 minutes at 20% pressure and 5 minutes at 100% pressure for pneumatic actuators.

— The test pressure reading and time at the beginning and at the end of each pressure-holding period shall be recorded.

— No visible leakage shall be allowed. For the hold period, the following shall apply.

  — At the start of the hold period, monitored pressure shall not be greater than 5 % above the specified test pressure.

  — During the hold period, the pressure shall not vary from the pressure at the start of the hold period by more than 5%.

  — Monitored pressure shall not be less than the specified test pressure.

c) Operational test: The actuator shall be tested for proper operation by cycling the actuator, from the normal position to the fully stroked position, a minimum of three times. The actuator shall operate smoothly in both directions and without noticeable stick-slip or chattering behavior. The final assembly of actuator to valve or choke shall be tested in conformance with Section 11 for the appropriate PSL of the equipment.

For BSDVs with actuators sized at differential pressures lower than the valve's rated working pressure, an operational test shall be performed opening the valve against the sizing differential pressure agreed to between the manufacturer and purchaser after all other testing is completed in Section 11. The latching (hold open) mechanism power requirements for electric actuators shall be tested during the tests required by Section 11.

d) Gas backseat test: If the bonnet and actuator are furnished as a unit for PSL 4 valves, a test shall be conducted in conformance with 11.3.

NOTE If the bonnet and actuator are furnished as a unit for PSL 3G valves, a test may be conducted in conformance with 11.3.

14.17.5 Marking

All actuators shall be marked as specified in Section 12 and Table 63. Bonnets attached to actuators shall be considered part of the valve for marking purposes.

Marking for electric actuators may be on a separate nameplate on the actuator and shall include, but not be limited to, area classification, voltage, frequency, amperage (starting and running), and motor insulation requirements.

Table 63—Marking for Actuators

Required Markings	Required Location(s)
API 6A or 6A Temperature class(es) or ratings Performance requirements (PR) Date of manufacture Manufacturer's name or mark Serial number (if applicable) Supply pressure rating [a]	Nameplate and/or body
Hardness test values (if applicable) (see 12.8)	Adjacent to test location
FOOTNOTE [a] See 3.1.89 for definition of Supply Pressure Rating	

14.17.6 Storage and Shipping

Storage and shipping shall be per Section 13.

14.18 Safety Valves, Shutdown Valves, and Actuators

14.18.1 General

14.18.1.1 Valves

Safety valves shall conform to the applicable requirements of 14.11 for actuated valves or valves prepared for actuator.

NOTE The term "safety valve" can refer to surface safety valve (SSV), underwater safety valve (USV), or boarding shutdown valve (BSDV).

SSVs and USVs shall conform to the requirements for PSL 2 as a minimum.

BSDVs shall conform to the requirements for PSL 3 as a minimum.

Record requirements for SSVs/USVs/BSDVs shall be in conformance with Section 15.

14.18.1.2 Actuators

Actuators for SSVs, USVs, and BSDVs shall conform to the requirements of 14.17.

NOTE The term "safety valve actuator" can refer to the actuator of a surface safety valve (SSV), underwater safety valve (USV), or boarding shutdown valve (BSDV).

14.18.2 Design

14.18.2.1 General

Safety valves shall be designed for and constructed of materials conforming to Section 6 and shall perform satisfactorily in the tests required by 14.18.2.3.3.

The safety valve shall be of a normally closed design. The safety valve shall be designed to operate, without damage to the safety valve or safety valve actuator, when the valve is actuated open or closed, pressurized or depressurized, under any internal valve body pressure within its pressure rating, and for USV, under any external pressure up to sea pressure at the maximum depth rating.

If grease or sealant is required in the safety valve body or stem area, provisions shall be made for injecting the grease or sealant without reducing the pressure in the safety valve.

Design criteria for USVs shall include maximum water depth.

Safety valves shall have end connectors conforming to 14.11, except that threaded end connectors shall not be used.

14.18.2.2 Performance Requirements

14.18.2.2.1 Valves

Safety valves shall be designed to satisfy the performance requirements specified in Table 64 and shall be validated as specified in 14.18.2.3.3.

14.18.2.2.2 Actuators

Actuators for safety valves shall be designed to satisfy the PR2 level of 14.17.2 as a minimum.

Table 64—Summary of Validation Requirements for Safety Valves

Safety Valve Service Class	Performance Requirements		Testing Requirements	
	Operating Cycles	Thermal Cycles	Design Validation Testing	6AV1 Sand Slurry Testing
I	200	3	PR2F	Not required [a]
II	200	3	PR2F	API 6AV1 Class II
III	200	3	PR2F	API 6AV1 Class III

FOOTNOTE

[a] Manufacturer may perform an API 6AV1 Class II test replacing the sand slurry with plain water as the test fluid.

14.18.2.3 Product-specific Design Requirements

14.18.2.3.1 SSV Design

NOTE An SSV valve may be a single loose valve or one valve in a multiple cavity valve body.

Valves, including multiple cavity valves, shall be manufactured and supplied in conformance with all other applicable requirements of this specification. Single-unit SSV valves shall conform to the bore diameter, face-to-face length, and other applicable dimensions specified in 14.11.

14.18.2.3.2 USV and BSDV Design

NOTE A USV/BSDV valve may be a single loose valve or one valve in a multiple cavity valve body.

USV and BSDV designs shall conform to the requirements of 14.18.2.3.1 for SSV design, with the following exceptions.

— USV/BSDV may use end connectors as specified in API 17D as well as end connectors in this specification, except as noted in 14.18.2.1.

— USVs may be of nonstandard bores and/or face-to-face lengths. End connectors shall conform to all other requirements of this specification.

— BSDVs may be of nonstandard bores and/or face-to-face lengths. End connectors shall conform to all other requirements of this specification. Reduced-opening BSDV flow ports shall be sized in conformance with the inside diameters of piping upstream or downstream of the BSDV.

14.18.2.3.3 Valve Design Validation Testing

NOTE 1 See Table 64 for a summary of validation requirements.

Validation of a single-unit safety valve shall validate a multiple cavity valve for performance requirement PR2F and Class I, II, or III service, without additional validation testing, if it is of the same internal design as a safety valve within the manufacturer's product line that has passed the required validation testing, and if all other scaling requirements are satisfied.

The following shall apply.

a) Class I service: To validate a Class I safety valve, the PR2F procedures of Annex F shall be completed.

b) Class II and III service: To validate a specific safety valve design for service Class II or III, the Class I requirements (PR2F) shall be satisfied. In addition, the valve shall pass the Class II or Class III testing in conformance with API 6AV1.

c) Test requirements and scaling: For PR2F validation, the scaling provisions of F.1.14 shall apply.

   NOTE 2 This includes scaling by temperature rating, pressure rating, and design family.

   1) For API 6AV1 Class II or III validation, the scaling provisions of API 6AV1 shall apply.

   2) For PR2F and 6AV1 validation: Validation of an SSV or USV or BSDV validates the other two types of safety valve with the same valve bore sealing mechanism and design family. The safety valve shall be tested with an actuator that meets the requirements of 6AV1.

   NOTE 3 It is not required that a single valve be consecutively tested to 6A PR2F and 6AV1. The tests are not cumulative.

14.18.2.3.4 Actuator Design

The actuator closing force shall be sufficient to close the SSV/USV/BSDV safety valve when it is at the most severe design-closing condition specified by the valve manufacturer.

Internal parts should be resistant to environmental corrosion, the operating medium, and the other fluids to which they can be exposed under operating conditions defined by the manufacturer and/or the purchaser.

Permanently attached lock-open features shall not be permitted on SSV or BSDV actuators.

14.18.2.3.5 Heat-sensitive Lock-open Devices (SSVs and BSDVs Only)

14.18.2.3.5.1 General

Heat-sensitive lock-open devices, when included, shall maintain the SSV or BSDV in the fully open position at atmospheric temperatures up to 65 °C (150 °F) with the valve body pressurized to its rated working pressure and the actuator supply pressure bled to atmospheric conditions.

The lock-open device shall be designed such that any part released upon actuation of the device shall not create a potential hazard to personnel.

The following temperature actuation conditions shall be met.

— The lock-open device shall allow the valve to automatically close from actuator forces alone (i.e. no pressure in the valve body or energy supply to the actuator cylinder) within 6 min after being subjected to, and maintained in, a controlled environmental temperature of 540 °C ± 14 °C (1000 °F ± 25 °F).

— Eutectic materials used shall conform to the manufacturer's design requirements for fusing within a temperature range of ± 10 % around the nominal melting point. The heat-sensitive device shall be designed to actuate at a maximum sustained temperature of 200 °C (400 °F).

14.18.2.3.5.2 Validation Testing of Heat-sensitive Lock-open Devices

Tests to confirm the design requirements of 14.18.2.3.5 shall be done in an air environment with air velocity past the SSV actuator due to natural air convection only. The manufacturer shall have data available to show that the device has been sufficiently tested to ensure that it can satisfy the design requirements.

14.18.3 Materials

14.18.3.1 Valves

Pressure-containing and pressure-controlling parts of safety valves shall be designed for and constructed of materials in conformance with Section 6.

14.18.3.2 Actuators

Materials for safety valve actuators shall conform to the requirements of 14.17.3.

14.18.4 Quality Control/Testing

14.18.4.1 Drift Test

All assembled full-bore safety valves and safety valves prepared for actuators shall pass a drift test as described in 11.4. Safety valves prepared for actuators shall be drift tested with the valve bore sealing mechanism installed to verify the capability.

NOTE Drift testing of reduced-bore USVs or BSDVs is not required.

14.18.4.2 Acceptance Testing

All assembled safety valves or safety valves prepared for actuators with simulated bonnets shall pass all applicable tests required and described in Section 11, as a minimum.

For BSDVs with actuators sized at differential pressures lower than the valve's rated working pressure, an operational test shall be performed opening the valve against the sizing differential pressure agreed to between the manufacturer and purchaser after all other testing of Section 11 is completed. All test data shall be recorded on a test data sheet (see 15.4.3).

14.18.5 Marking

Safety valves and safety valve actuators shall have nameplates affixed. Nameplates shall be made of material having corrosion resistance equivalent to or better than 18-8 austenitic stainless steel.

Safety valves shall be marked as specified in Section 12 and Table 65.

14.18.6 Storage and Shipping

14.18.6.1 Valves

All safety valves shall be stored and shipped in conformance with Section 13.

14.18.6.2 Actuators

All safety valve actuators shall be stored and shipped in conformance with Section 13.

14.18.6.3 Assembled SSV/USV/BSDV

All assembled safety valves shall be stored and shipped in conformance with Section 13.

Table 65—Marking for Safety Valves

Required Markings	Required Location(s)
API 6A or 6A and valve type [a,b] Temperature class(es) or ratings Material class Product specification level (PSL) Product class [c] Date of manufacture Manufacturer's name or mark Serial number Nominal bore size (if applicable) End and outlet connector size	Nameplate and/or body
Rated working pressure Maximum valve differential pressure [d]	Nameplate and/or body and outside diameter of each connector
Ring groove type and number	Near each connector
Flow direction (unidirectional valves only)	Body
Hardness test values (if applicable) (see12.8)	Adjacent to test location

FOOTNOTES
[a] Additional allowable markings are SSV, USV, or BSDV.
[b] For valves prepared for actuators, mark the letter "V" after "API 6A" or "6A."
[c] Allowable markings are I, Class I, II, Class II, III, or Class III.
[d] Maximum valve (flow bore sealing mechanism) differential pressure for BSDV only.

14.19 Tree Assemblies

14.19.1 General

NOTE Requirements for tree assemblies are specified in 14.19.

14.19.2 Design

NOTE See design requirements for equipment.

14.19.3 Materials

NOTE See material requirements for equipment.

14.19.4 Quality Control/Testing/Assembly

All parts and equipment shall conform to the requirements of this specification before being assembled into trees.

Trees shall successfully complete the hydrostatic body and drift tests required by and described in Section 11. For trees assembled with components having different PSLs, hold period requirements for the highest PSL shall apply.

14.19.5 Marking

Assembled trees shall be tagged with the information as specified in Table 66.

Table 66—Marking for Trees

Marking	Location
Date of manufacture	Tag or nameplate
Name of manufacturer	Tag or nameplate
Location of manufacturer	Tag or nameplate

14.19.6 Storing and Shipping

Trees shall be stored and shipped in conformance with Section 13. Any disassembly, removal, or replacement of parts or equipment after testing shall be as agreed with the purchaser.

15 Records

15.1 General

15.1.1 NACE MR0175/ISO 15156 Record Requirements

Records required to substantiate conformance of material classes DD, EE, FF, and HH equipment to NACE MR0175/ISO 15156 requirements shall be in addition to those described in 15.2, unless the records required by this specification also satisfy the NACE MR0175/ISO 15156 requirements.

15.1.2 Record Control

Quality control records required by this specification shall be legible, identifiable, retrievable, and protected from damage, deterioration, or loss.

Quality control records required by this specification shall be retained by the manufacturer for a minimum of 10 years following the date of manufacture as marked on the equipment associated with the records.

All quality control records required by this specification shall be signed and dated.

NOTE Signatures may be digital.

15.2 Records Maintained by Manufacturer

15.2.1 Records of Pressure Tests

For PSL 3 and PSL 4, the following records shall be maintained.

— A pressure recording device shall be used on all hydrostatic tests. The record shall identify the recording device, shall be dated, and shall be signed.

— Records of gas testing shall document test parameters and acceptance.

NOTE 1 Pressure recording of gas testing is not required.

— If the pressure recording device is not qualified as a pressure-measuring device in conformance with 10.2.2, it shall be used in parallel with a calibrated pressure-measuring device, and the pressure-measuring device readings at the start and stop of each hold period shall be included as part of the record.

NOTE 2 Both the chart and the signature can be digital or analog.

NOTE 3 The pressure test requirements do not apply to PSL 1 and PSL 2.

15.2.2 Body, Bonnet, End and Outlet Connectors, Stem, Valve Bore Sealing Mechanism, Mandrel Tubing Hanger, Mandrel Casing Hanger, Slip Bowl, and Slip Segment Records

15.2.2.1 PSL 1 Equipment

For PSL 1, the following records shall be maintained for bodies, bonnets, end and outlet connectors, stem, valve bore sealing mechanisms, mandrel tubing hangers, mandrel casing hangers, slip bowls, and slip segments:

1) material test records:
   - chemical analysis,
   - tensile test (if required),
   - impact test (if required),
   - hardness test;
2) welding process records:
   - weld procedure specification,
   - weld PQR,
   - welder qualification record;
3) NDE personnel qualification records, when NDE is required;
4) hardness test (if applicable).

15.2.2.2 PSL 2 Equipment

For PSL 2, the following records shall be maintained for bodies, bonnets, end and outlet connectors, stem, valve bore sealing mechanisms, mandrel tubing hangers, and mandrel casing hangers:

1) all records required for PSL 1 (see 15.2.2.1);
2) NDE records:
   - surface NDE records,
   - weld volumetric NDE records,
   - repair weld NDE records;
3) heat-treatment certification of compliance.

15.2.2.3 PSL 3 Equipment

For PSL 3, the following records shall be maintained for bodies, bonnets, end and outlet connectors, stem, valve bore sealing mechanisms, and mandrel tubing hangers, mandrel casing hangers:

1) all records required for PSL 2 (see 15.2.2.2);

2) all required records shall reference the specific part serial number;

3) volumetric NDE records (except valve bore sealing mechanisms);

4) heat-treatment record:

   — actual temperature,

   — actual times at temperature,

   — certification of compliance is not required;

5) hardness test record, actual hardness;

6) welding process records:

   — welder identification,

   — weld procedures,

   — filler material type,

   — post-weld heat-treatments;

7) records that dimensional inspection was performed (those activities required by 10.4.2.5).

15.2.2.4 PSL 4 Equipment

For PSL 4, the records maintained for bodies, bonnets, end and outlet connectors, stem, valve bore sealing mechanisms, mandrel tubing hangers, and mandrel casing hangers shall be the same as PSL 3 (15.2.2.3).

For bodies, bonnets, end and outlet connectors, stems, mandrel tubing and casing hangers shall require actual heat-treatment temperature charts showing times and temperatures.

The melting practice used (bodies, bonnets, and end and outlet connectors only) shall be identified.

15.2.3 Ring Gaskets and Non-integral Metal Seals Records

For ring gaskets, the following records shall be maintained:

— chemical analysis/heat number;

— hardness test;

— job lot traceability;

— dimensional inspection.

NOTE For non-integral metal seals, no records are required.

15.2.4 Closure Bolting Records

If BSL 2 or BSL 3 is specified per Table 15, closure bolting records that are required by API 20E or API 20F to be submitted to the purchaser shall be maintained.

15.2.5 Nonmetallic Sealing Material Records

Nonmetallic sealing material records are required and shall conform to 10.4.6.

15.2.6 Bullplugs, Valve-removal Plugs, and Back-pressure Valve Records

The following material test records shall be maintained:

— chemical analysis;

— tensile test;

— impact test (if testing is performed);

— hardness test.

15.2.7 Assembled Equipment Records

For PSL 1 assembled equipment, no records shall be required.

For PSL 2 assembled equipment, the following pressure test records shall be maintained:

— actual test pressure;

— holding period duration;

— additionally, for USVs, SSVs, and BSDVs, the requirements of 15.4 shall apply.

For PSL 3 assembled equipment, the following records shall be maintained:

— all records required for PSL 2;

— additionally, the following records shall be maintained:

a) assembly traceability records,

b) hydrostatic pressure test records;

— furthermore, the following gas-test records shall be maintained for equipment designated PSL 3G:

a) actual test pressures,

b) actual holding period durations.

For PSL 4 assembled equipment, the following records shall be maintained:

— all records required for PSL 3;

— additionally, the following gas-test records shall be maintained:

a) actual test pressures,

b) actual holding period durations.

15.2.8 Choke Trim Records

For PSL 1 and PSL 2 choke trim, no records shall be required.

For PSL 3 and PSL 4 choke trim, surface NDE records shall be maintained.

15.3 Records Furnished to Purchaser

15.3.1 General

These records shall be provided by the manufacturer to the original purchaser of equipment made to conform to this specification.

These records, if applicable, shall be identical to or contain the same information as those retained by the manufacturer.

These records provided by the manufacturer shall prominently reference part serial number(s) (PSL 3 and PSL 4).

15.3.2 Body, Bonnet, End and Outlet Connectors, Stem, Valve Bore Sealing Mechanism, Mandrel Tubing Hanger, Casing Hanger, and Back-pressure Valve Records

For PSL 1, PSL 2, and PSL 3, no records shall be required for bodies, bonnets, end and outlet connectors, stem, valve bore sealing mechanisms, mandrel tubing hangers, casing hangers, and back-pressure valves.

For PSL 4 bodies, bonnets, end and outlet connectors, stem, valve bore sealing mechanisms, mandrel tubing hangers, casing hangers, and back-pressure valves, the following records shall be furnished to the purchaser:

— NDE records;

— hardness test records;

— material test records;

— heat-treatment records.

15.3.3 Ring Gasket and Non-integral Metal Seals Records

For BX 157 through BX 303, excluding BX 169 and BX 170, a certificate of conformance stating that equipment meets the requirements of this specification, including the manufacturer's traceability code, shall be furnished to the purchaser.

NOTE For non-integral metal seals, no records are required to be furnished.

15.3.4 Closure Bolting Records

No records shall be required.

15.3.5 Nonmetallic Sealing Material Records

For PSL 1, PSL 2, and PSL 3, no nonmetallic sealing material records shall be required.

For PSL 4, a certificate of conformance stating that nonmetallic seals conform to PSL 4 of this specification shall be furnished to the purchaser.

15.3.6 Slip Hanger Records

A certificate of conformance stating that equipment meets the requirements of this specification, including the temperature class/rating and material class, shall be furnished to the purchaser.

15.3.7 Assembled Equipment Records

NOTE See 15.4 for additional record requirements of BSDVs, USVs, and SSVs.

For PSL 1 and PSL 2 assembled equipment, no records shall be required.

For PSL 3 assembled equipment, the following records shall be furnished to the purchaser:

— certificate of conformance stating that equipment meets the requirements of PSL 3 of this specification, and the temperature and material class;

— assembly traceability records;

— pressure test records (see 15.2.1).

For PSL 3G and PSL 4 assembled equipment, the following records shall be furnished to the purchaser:

— all records/certifications for PSL 3;

— gas-test records (see 15.2.1).

15.4 SSV, USV, and BSDV Records

15.4.1 General

Record requirements for SSV/USV/BSDV valves shall conform to 15.2.7, 15.3.7, and the additional requirements given in 15.4.

15.4.2 Shipping Report

The test agency and test report number for Class II or Class III safety valves shall be identified in the shipping report, as shown in the example of Figure 18. Other shipping report formats are acceptable but shall include the same elements listed in Figure 18, as a minimum.

NOTE Figure 18 is an example of a shipping report.

Safety Valve Assembly Shipping Report

Safety valve data: (circle type) **SSV USV BSDV** Manufacturer ___________________________________

Valve part no. or model _______________________________ Serial no. ________________________________

Size___________ Rated working pressure ______________ PSL ____________ Material class _____________

Temperature class ________________ or Temperature rating: Max._______________ Min. _______________

Service class ___________ Test agency__________________________ Test report no.____________________

Valve differential pressure for actuator sizing (BSDVs only): ___________________________

Accepted by ________________________________ Date of manufacture (month and year) ________________

Actuator data: (circle type): **Hydraulic Pneumatic Electric**

Manufacturer _______________________________ Date of manufacture (month and year) ________________

Part/model no.___________________ Serial no. _________________________ Size ___________________

Max. supply pressure rating ___________________ Temperature rating ________________________________

Accepted by ________________________________ Date of manufacture (month and year) ________________

Safety valve and actuator assembly: (circle type) **SSV USV BSDV**

Assembler/manufacturer ____

Assembly part no. or model __________________________ Serial no.________________________________

Accepted by _______________________________ Date of manufacture (month and year) ________________

Figure 18—Example of a Safety Valve Shipping Report

15.4.3 Test Data Sheet

All test data shall be recorded on a test data sheet. An example is shown in Figure 19.

NOTE Figure 19 is an example of a test data sheet. Other formats of the test data sheet are acceptable but must include the same information as what is showing in Figure 19, as a minimum.

Safety Valve Assembly Factory Acceptance Test Data Sheet

Safety valve data: (circle type) **SSV USV BSDV** / Manufacturer___________________________________

Valve part no. or model _____________________________ Serial no. _______________________________

Size__________ Rated working pressure ________________ Temperature class/rating ___________________

PSL _________ Service class ________ Test agency___________________Test report no.______________

Valve differential pressure for actuator sizing (BSDVs only): _________________________

Actuator data: (circle type): **Hydraulic Pneumatic Electric** / Manufacturer __________________________

Part/model no.__________________________ Serial no. ___________________________Size ___________

Max. supply pressure _______________ Temperature rating __________________________ PSL __________

Actuator seal test: Performed by____________________________________ Date ________________

At 20 % of supply pressure rating:

Start time __________ Pressure at start __________ End time ____________ Pressure at end ___________

At 100 % of supply pressure rating:

Start time __________ Pressure at start __________ End time ____________ Pressure at end___________

Actuator operational test: Performed by _________________________________ Date _______________

Number of cycles completed ____________________________ Comment (opt) _______________________

Valve shell test: Performed by _____________________________________ Date _______________

Primary hold period:

Start time __________ Pressure at start__________ End time ____________ Pressure at end ____________

Secondary hold period:

Start time __________ Pressure at start __________ End time ____________Pressure at end ____________

Valve seat test: Performed by______________________________________ Date _______________

Primary hold period (Side A):

Start time __________ Pressure at start __________ End time ____________ Pressure at end ____________

Secondary hold period (Side A):

Start time __________ Pressure at start__________ End time ____________ Pressure at end ____________

Tertiary hold period (Side A):

Start time __________ Pressure at start__________ End time ____________ Pressure at end ____________

Primary hold period (Side B):

Start time __________ Pressure at start__________ End time ____________ Pressure at end ____________

Secondary hold period (Side B):

Start time __________ Pressure at start__________ End time ____________ Pressure at end ____________

Tertiary hold period (Side B):

Start time __________ Pressure at start__________ End time ____________ Pressure at end ____________

Certified by _______________________________________ Title __________________________________

Company ____ Date __________________________________

Figure 19—Example of a Safety Valve Factory Acceptance Test Data Sheet

15.4.4 Records Furnished to Purchaser

The following shall be furnished to the purchaser for each valve:

— completed functional test data sheet as specified in 14.18.4.2;

— shipping report conforming to the information in Figure 18;

— operating manual meeting the requirements of 15.4.5.4;

— assembly traceability records.

15.4.5 Minimum Contents of Manufacturer's Operating Manual

15.4.5.1 Design Information

The manufacturer's operating manual for safety valves shall include the following:

— type, model, and size for which the manual is applicable;

— performance requirements for which these types, model, and sizes are suitable;

— temperature and working pressure ranges for which the unit(s) is designed;

— drawings and illustrations giving dimensional data of unit(s), as required, for installation or operation;

— parts list.

15.4.5.2 Inspection and Testing

The following minimum inspection and testing information shall be included:

— checklist for visual inspection prior to hook-up;

— written and graphic instructions for field hook-ups;

— appropriate test procedures.

15.4.5.3 Installation

Proper installation methods shall be clearly written and illustrated as necessary. Any necessary preliminary lubrication or greasing shall be specified in detail. Warnings to indicate potential danger to personnel or cautions to indicate potential danger to equipment shall be clearly marked "Warning" or "Caution."

15.4.5.4 Operation and Maintenance

The following minimum operation and maintenance information shall be included in the manufacturer's operating manual:

— maintenance requirements, including recommended intervals of maintenance;

— proper operating techniques;

— disassembly and assembly instructions;

— assembly diagram showing individual parts in proper relationship to one another;

— repair instructions and precautions, including a chart listing symptom, probable cause(s) of the problem, and repairs necessary.

15.4.6 Failure Reporting

NOTE Failure reporting is an essential element of the US federal regulatory program covering gas and oil production in the Outer Continental Shelf.

After receiving a failure report from the operator, the manufacturer of the safety valve equipment shall respond within 6 weeks of receipt, describing progress in the failure analysis. The manufacturer shall also notify the operator in writing of the results of the analysis and the corrective action. If the failure analysis causes the equipment manufacturer to change the design, assembly, or operating procedures of a model of equipment, the manufacturer shall, within 30 days of such changes, report them in writing to all purchasers and known operators of equipment having potential problems.

Annex A
(normative)
Heat-treat Equipment Survey

A.1 Temperature Uniformity Survey Methods for Batch-type Furnaces

NOTE Requirements for heat treatment calibration from Annex M of editions prior to the 22nd edition are now shown in Annex A.

The temperature uniformity survey methods for batch-type furnaces shall conform to API 20H HSL1, HSL2, or HSL3, for the following items:

— Temperature uniformity survey frequency

— Temperature uniformity survey temperature variation

— Temperature uniformity survey method

— Instrumentation calibration and frequency

— System Accuracy Test, when in conformance to API 20H HSL 3

NOTE 2 The requirements of previous API 6A editions for temperature uniformity survey methods for batch-type furnaces are equivalent to API 20H HSL 1. API 20H HSL 3 temperature uniformity survey requirements are equivalent to SAE AMS2750.

A.2 Temperature Survey Method for Continuous-type Furnaces

Furnaces used for continuous heat-treatment shall be validated in conformance with procedures specified in SAE AMS2750 or SAE AMS-H-6875.

Annex B
(informative)

Purchasing and Material Guidelines

B.1 General

Annex B provides guidelines for enquiry and purchase of wellhead and tree equipment that consist of data sheets for completion by the purchaser, a series of wellhead and tree configuration examples, and a decision tree for determining PSLs.

The data sheets are designed to perform two functions:

a) assist the purchaser's decision making process;

b) assist the purchaser in communicating specific needs and requirements, as well as information on the well environment, to the manufacturer for his use in designing and producing equipment.

To use this annex, a copy of the data sheets should be completed as accurately as possible. The typical configurations should be referred to, as needed, to select the required equipment. The decision tree, given in Figure B.15, together with its instructions, provides the recommended practice as to which PSL each piece of equipment should be manufactured. A copy of the data sheet should then be attached to the purchase order or request for proposal.

B.2 Data Sheets

The following pages contain questions and information that can be used to select wellhead equipment, including chokes and actuators. Figure B.1 contains general information that pertains to the entire well. Figure B.2 through Figure B.12 are designed for use with each type of equipment.

The effects of external loads (i.e. bending moments, tensions, etc.) on the assembly of parts are not explicitly addressed by this Specification (see 4.3.1.3). The purchaser should specify any exceptional loading configuration.

The purchaser should identify applications which involve fatigue and take appropriate actions to mitigate risk via alternate design methods or other means which have been proven effective.

The purchaser should specify whether the design validation procedures in Annex F are applicable.

Wellhead Equipment Data Sheet—General

Well name(s) and location(s): ____________________

Maximum operating pressure: ____________________

Anticipated wellhead shut-in pressure: ____________________

Temperature ranges anticipated: ____________________

Minimum ambient temperature: ____________________

Maximum flowing fluid temperature at wellhead: ____________________

Anticipated composition of produced fluids: CO_2 __________ (mg) __________ Chlorides _______ (mg)

__________ H_2S __________ (mg) __________ Other __________

Water or brine pH: ____________________

Does NACE MR0175 / ISO 15156 apply? ____________________

Anticipated production rates: ____________________ m^3/d oil/condensate

____________________ m^3/d gas

____________________ m^3/d S&W[a]

Will erosion be a concern? Cause: ____________________

Will scale, paraffin, corrosion or other types of inhibitors be used? ____________________

Inhibitor type: __________ Inhibitor carrier: __________ Batch or continuous inhibition? __________

Will acidification be performed? __________ Type of acid: __________

Anticipated production rates: __________ m^3/d oil/condensate

__________ m^3/d gas

__________ m^3/d S&W[a]

Will erosion be a concern? __________ Cause: __________

External coating? Yes, type __________ No __________

Internal coating? Yes, type __________ No __________

Delivery requirements: ____________________

Special shipping, packing and storage instructions: ____________________

Casing program

	Top joint in string					
	Size (OD)	**kg/m** (lb/ft)	**Grade**	**Connection**	**Max/Min Casing Load** daN (lbs)	**Bit size** mm (in)
Conductor	____	____	____	____	____	____
Surface casing	____	____	____	____	____	____
Protective casing	____	____	____	____	____	____
Production casing	____	____	____	____	____	____
Tubing	____	____	____	____	____	____
Type of completion: single or multiple		____	____	____	____	____

[a] Sand and water.

Figure B.1—Wellhead Equipment Data Sheet—General

Wellhead Equipment Data Sheet—Casing-head Housing

Casing-head housing	PSL: ____________ PR: ____________
Bottom connector:	Size: ____________
	Rated working pressure: ____________
	Type: ____________
Top connector:	Size: ____________
	Rated working pressure: ____________
	Type: ____________
Outlets:	Size: ____________
	Rated working pressure: ____________
	Type: ____________
	Number: ____________
Equipment for outlets:	Valve-removal plug: ____________
	Valves (right): Qty ____ Typ ___ PSL: ____ PR: _____
	Valves (left): Qty ______ Typ ___ PSL: ____ PR: _____
	Companion flanges: Qty ____ Typ: _____ PSL: _______
	Bullplugs: Qty ____________
	Nipples: Qty ____________
	Needle valves: Qty ____________
	Gauges: Qty ____________
Lock screws? Yes ________ No _____	Lock screw function: ____________

Baseplate requirements: ____________

Special material requirements: ____________

Casing hanger: Size:

Type: ____________

PSL: ____________

PR: ____________

Temperature rating (Table 2): ____________

Material class (Table 3): ____________

Retained fluid corrosivity (Table B.1): ____________

Witness? Yes [a] ____________ No ____________

External coating? No _________ Yes ______ If yes, type ____________

Internal coating? No _________ Yes ______ If yes, type ____________

Flange bolting requirements (Table 16) Nonexposed ______ Exposed _____ Exposed (low strength) ____

Main run (studs): ____________ (nuts): ________

Outlet inboard (studs): ________ (nuts): ________

Outlet other (studs): __________ (nuts): ________

Test and auxiliary equipment:

Wear bushing: ____________

Running and retrieving tools: ____________

Test plug: ____________

Other requirements: ____________

[a] If yes, specify what and by whom.

Figure B.2—Wellhead Equipment Data Sheet—Casing-head Housing

Wellhead Equipment Data Sheet—Casing-head Spool

Casing-head spool — PSL: ______________________ PR: ________________________

Bottom connector: — Size: ____
Rated working pressure: ___________________________________
Type: ____

Top connector: — Size: ____
Rated working pressure: ___________________________________
Type: ____

Outlets: — Size: ____
Rated working pressure: ___________________________________
Type: ____
Number: ____

Equipment for outlets: — Valve-removal plug: _________________________________
Valves (right): Qty _________ Typ ___ PSL: ____ PR: _____
Valves (left): Qty___________ Typ ___ PSL: ____ PR: _____
Companion flanges: Qty _____ Typ: _____ PSL: ___________
Bullplugs: Qty ____
Nipples: Qty ____
Needle valves: Qty _______________________________________
Gauges: Qty ____

Lock screws? Yes ________ No ______ Lock screw function: _______________________________

Special material requirements: ____

Bottom casing spool packoff size: ____
Type: ____
PR: ____

Casing hanger: Size:
Type: ____
PSL: ____
PR: ____

Temperature rating (Table 2): ____

Material class (Table 3): ____

Retained fluid corrosivity (Table B.1): ____

Witness? Yes [a] ________________________ No ______________________

External coating? No _________ Yes _______ If yes, type ____________________________________

Internal coating? No _________ Yes _______ If yes, type ____________________________________

Flange bolting requirements (Table 16) Exposed _________ Nonexposed ________________

Outlet inboard (studs): _________ (nuts): ________

Outlet other (studs): __________ (nuts): ________

Test and auxiliary equipment:

Wear bushing: ___________________________________

Running and retrieving tools: ________________________

Test plug: _____________________________________

Other requirements: ____

[a] If yes, specify what and by whom.

Figure B.3—Wellhead Equipment Data Sheet—Casing-head Spool

Wellhead Equipment Data Sheet—Tubing-head Spool

Tubing-head spool — PSL: ____________ PR: ____________

Bottom connector: — Size: ____________
Rated working pressure: ____________
Type: ____________

Top connector: — Size: ____________
Rated working pressure: ____________
Type: ____________

Outlets: — Size: ____________
Rated working pressure: ____________
Type: ____________
Number: ____________

Equipment for outlets: — Valve-removal plug: ____________
Valves (right): Qty ____ Typ ___ PSL: ____ PR: _____
Valves (left): Qty ____ Typ ___ PSL: ____ PR: _____
Companion flanges: Qty ___ Typ: ____ PSL: ______
Bullplugs: Qty ____________
Nipples: Qty ____________
Needle valves: Qty ____________
Gauges: Qty ____________

Lock screws? Yes ________ No _____ Lock screw function: ____________

Material requirements: ____________

Bottom tubing spool packoff: Size: ____________
Type: ____________
PR: ____________

Tubing hanger: Size: ____________
Type: ____________
PSL: ____________
PR: ____________
Back-pressure valve type: ____________
Surface-controlled subsurface valve control lines: ____________

Temperature rating (Table 2): ____________

Material class (Table 3): ____________

Retained fluid corrosivity (Table B.1): ____________

Witness? Yes [a] ____________ No ____________

External coating? No ________ Yes ______ If yes, type ____________

Internal coating? No ________ Yes ______ If yes, type ____________

Flange bolting requirements (Table 16) Nonexposed ______ Exposed _____ Exposed (low strength) ____

Main run (studs): __________ (nuts): ________
Outlet inboard (studs): ________ (nuts): ________
Outlet other (studs): __________ (nuts): ________

Test and auxiliary equipment:
Wear bushing: ____________
Running and retrieving tools: ____________
Test plug: ____________

Other requirements: ____________

[a] If yes, specify what and by whom.

Figure B.4—Wellhead Equipment Data Sheet—Tubing-head Spool

Wellhead Equipment Data Sheet—Crossover flange

Crossover flange PSL: ____________ PR: ____________
Bottom connector: Size: ____________
Rated working pressure: ____________
Type: ____________
Top connector: Size: ____________
Rated working pressure: ____________
Type: ____________
Packoff type: ____________
Size: ____________
Temperature rating (Table 2): ____________
Material class (Table 3): ____________
Retained fluid corrosivity (Table B.1): ____________
Witness? Yes [a] ____________ No ____________
External coating? No ________ Yes _______ If yes, type ____________
Internal coating? No ________ Yes _______ If yes, type ____________
Flange bolting requirement (Table 16) Nonexposed ______ Exposed _____ Exposed (low strength) ____
Main run (studs): ____________ (nuts): ________

[a] If yes, specify what and by whom.

Figure B.5 — Wellhead Equipment Data Sheet—Crossover Flange

Wellhead Equipment Data Sheet—Tubing-head Adapter

Tubing-head adapter PSL: ____________ PR: ____________
Bottom connector: Size: ____________
Rated working pressure: ____________
Type: ____________
Top connector: Size: ____________
Rated working pressure: ____________
Type: ____________
Surface-controlled subsurface safety valve outlets: ____________
Number: ____________
Size: ____________
Electrical feed-through connection? ____________
Special material requirements: ____________
Temperature rating (Table 2): ____________
Material class (Table 3): ____________
Retained fluid corrosivity (Table B.1): ____________
Witness? Yes [a] ____________ No ____________
External coating? No ________ Yes _______ If yes, type ____________
Internal coating? No ________ Yes _______ If yes, type ____________
Flange bolting requirement (Table 16) Nonexposed ______ Exposed _____ Exposed (low strength) ____
Main run (studs): ____________ (nuts): ________

[a] If yes, specify what and by whom.

Figure B.6—Wellhead Equipment Data Sheet—Tubing-head Adapter

Wellhead Equipment Data Sheet—Tree and Choke

Tree – Single ___ Dual ___ Solid block ___ Stacked ___

	Size	Material[a]	PSL	PR	Witness ?[b]	External coating? If yes, state type	Flanged bolting requirements[c] Studs Nuts	Ring gasket type
Lower master valve								
Upper master valve								
Swab (crown) valve								
Wing valve—inboard								
Wing valve(s)—other								
Tee/cross (circle one)								
Choke								
End flange								
Companion flanges								
Instrument flanges								
Tree cap/top conn.								

Rated working pressure: ____________________

Retained fluid corrosivity (Table B.2): ____________________

Temperature rating (Table 2): ____________________

Material class (Table 3): ____________________

Upper master prepared for actuator: Yes __ No __ If yes, specify class I, II or III below PR column

Wing valve—inboard prepared for actuator: Yes __ No __ If yes, specify class I or II below PR column

Wing valve—other prepared for actuator: Yes __ No __ If yes, specify class I or II below PR column

Choke: adjustable or fixed: ____________________

Orifice size: ____________________ Nominal size: ____________________

Pressure drop: ____________________

Flowline connector: Size: ____________________

Type: ____________________

Special material requirements: ____________________

Other requirements:

Upper master valve type actuator requirements: Pneu./piston __________ Hydr./piston _________ Electric ___

Supply pressure/power _________________ Pneu./diaphragm ______ Hydr./diaphragm _____ Electric ___

Air _____________ Gas ______________

Wing valve type actuator requirements: Pneu./piston __________ Hydr./piston _________ Electric ___

Pneu./diaphragm ______ Hydr./diaphragm _____ Electric ___

Supply pressure: _______________________

Other: ____________________

____

[a] Define or specify material requirements and, if cladding or other corrosion-resistant materials are to be inlaid, state base material type/clad material type, e.g. 4130/625.

[b] If yes, specify what and by whom.

[c] Indicate required bolting for the applicable retained fluid and temperature class specified in Table 16.

Figure B.7—Wellhead Equipment Data Sheet—Tree and Choke

Wellhead Equipment Data Sheet — Multi-Stage Crossover Spool	
Multi-Stage Crossover Spool	PSL: ____________________ PR: _________________
Bottom Connector:	Size: ____
	Rated working pressure: ___________________________
	Type: ____
Outlets lower	Size: ____
	Rated working pressure: ___________________________
	Type: ____
	Number: ____
Equipment for lower outlets:	Valve-removal plug: ______________________________
	Valves (right): Qty:____ Typ:_____ PSL: _______ PR: __
	Valves (left): Qty:____ Typ:_____ PSL: ________ PR: __
	Companion flanges: Qty _______ PSL: _______
	Bullplugs: Qty ____________________________________
	Nipples: Qty ______________________________________
	Needle valves: Qty _______________________________
	Gauges: Qty ______________________________________
Outlets Upper	Size: ____
	Rated working pressure: ___________________________
	Type: ____
	Number: ____
Equipment for upper outlets:	Valve-removal plug: ______________________________
	Valves (right): Qty:____ Typ:_____ PSL: _____ PR: _____
	Valves (left): Qty:____ Typ:_____ PSL: _____ PR: _____
	Companion flanges: Qty ______ PSL: ______
	Bullplugs: Qty ____________________________________
	Nipples: Qty ______________________________________
	Needle valves: Qty _______________________________
	Gauges: Qty ______________________________________
Top Connector:	Size: ____
	Rated working pressure: ___________________________
	Type: ____
Special material requirements:	____
Temperature rating (Table 2):	____
Material class (Table 3):	____
Retained fluid corrosivity (Table B.1):	____
Lock screws? Yes __________________ No ______	Lock screw function: ____________________________

Figure B.8—Wellhead Equipment Data Sheet—Multi-Stage Crossover Spool

Figure B.8 (cont'd)

Casing hanger (lower):	Size:	________________
	Type:	________________
	PR:	________________
	PSL:	________________
Restricted-area packoff (lower)	Size:	________________
	Type:	________________
Temperature rating (Table 2):	________________	
Material class (Table 3):	________________	
Retained fluid corrosivity (Table B.2):	________________	
Casing hanger (upper):	Size:	________________
	Type:	________________
	PR:	________________
	PSL:	________________
Restricted-area packoff (upper)	Size:	________________
	Type:	________________
Temperature rating (Table 2):	________	
Material class (Table 3):	________	
Retained fluid corrosivity (Table B.1):	________	

Flange bolting requirements (Table 16) Nonexposed ________ Exposed _______ Exposed (low strength) ____

Outlet lower (studs): ____________ (nuts): ____________

Outlet upper (studs): ____________ (nuts): ____________

Main Run (studs): ________ (nuts): ____________

Other requirements: ____________________

Witness? No ____________ Yes [a] ____________

External coating? No ________ Yes ________ If yes, type: ____________

Internal coating? No ________ Yes ________ If yes, type: ____________

Test and auxiliary equipment: (top and/or bottom) ____________

Wear bushings: ____________________

Running and retrieving tools: ____________________

Test plugs: ____________________

Other requirements: ____________________

[a] If yes, specify what and by whom.

Figure B.8—Wellhead Equipment Data Sheet—Multi-Stage Crossover Spool

Wellhead Equipment Data Sheet—Wellhead Safety Valves	
Wellhead Safety Valves	
General	
Special environmental conditions ___________	Unusual ambient or operating temperatures, or atmospheric conditions conducive to corrosion or underwater use.
Coating ______________________________	
Shipping instructions ___________________	
SSV/USV Valve	
(Class I, II or III SSV/USV) _____________	
Manufacturer _________________________	Model and type ________________________________
Size _______________________________	
Rated working pressure _________________	
Temperature range _____________________	
SSV/USV Actuator	
Manufacturer _________________________	Model and type ________________________________
Cylinder rated working pressure ____________	
Operating pressure _____________________	Purchaser to specify available supply pressure, if applicable.
Temperature range _____________________	
Lock-open device ______________________	
USV _______________________________	Working water depth ___________________________

Figure B.9—Wellhead Equipment Data Sheet—Wellhead Safety Valves

Equipment Data Sheet—Boarding Shutdown Valves	
General	
Special environmental conditions ____	Unusual ambient or operating temperatures, or atmospheric conditions conducive to corrosion, or use in the offshore splash zone.
Coating ____________________	
Shipping instructions ______________	
BSDV Valve	
(Class I, II or III BSDV) ______________	
Manufacturer ____________________	Model and type ___________________
Size ____________________________	
Rated working pressure ________	
Temperature range _______________	
BSDV Actuator	
Manufacturer ______________________	Model and type
Cylinder rated working pressure ___	
Operating pressure ________________	Purchaser to specify available supply pressure, if applicable.
Temperature range ________________	

Figure B.10—Equipment Data Sheet—Boarding Shutdown Valves

Wellhead Equipment Data Sheet—Choke Sizing

Application			
Fluid			
Quantity			
End connectors / A&B Dimensions [a]			
Pressure rating/Inlet		Outlet	
Temperature rating			
Material class — Body		Trim	
PSL — PR			

Service conditions at		Max. flow (Units)	Normal flow (Units)	Min. flow (Units)
Pressure	Inlet			
	Outlet or ΔP			
Temperature at inlet				
Oil	Flow rate			
	S.G. (if available)			
Gas	Flow rate			
	or G.O.R.			
	S.G. (if available)			
Liquid	Flow rate			
	S.G. (if available)			

Manual/actuated			
Actuator type/make/model			
Power source			
Manual override			
Position indication — Local		Remote/position transmitter	
Positioner			

Additional comments
Adjustable or positive :

maximum orifice diameter:

type of flow bean:

[a] See Figure 16 and Figure 17.

Figure B.11—Wellhead Equipment Data Sheet—Choke Sizing

Wellhead Equipment Data Sheet—Actuator and Bonnet

Pneumatic	Quantity ____	**Hydraulic**	Quantity ____	**Electric**	Quantity ____
Diaphragm	Single Double	Conventional	Rising stem Non-rising stem		
Piston	Single Double	Wirecutter ____ Self-contained ____		Wire/cable size ____ Stand-alone power source ____	

Supply Requirements/specifications

Pneumatic	**Hydraulic**
Availability ____ MPa (psi)	Availability ____ MPa (psi)
Max. ____ Min. ____	Max. ____ Min. ____
Clean air ____	
Nitrogen ____	Self-contained ____
Other ____	Other ____

Electric

Voltage ____

DC ____ AC ____ Phase ____ Frequency ____

Current available ____

Other ____

Actuator Requirements/specifications	**Field Data**
Actuator	Customer ____
Temperature rating (Table 2)	Field location ____
	Platform ____
Materials class (Table 3)	Well No. ____
External coating? No ____ Yes ____	Closed-in tubing-head pressure ____ MPa (psi)
If yes type ____	
	Accessories
	Fusible hold-open device ____
	Manual hold-open device ____
	Quick exhaust valve ____
	Position indication a) local ____
	b) remote ____

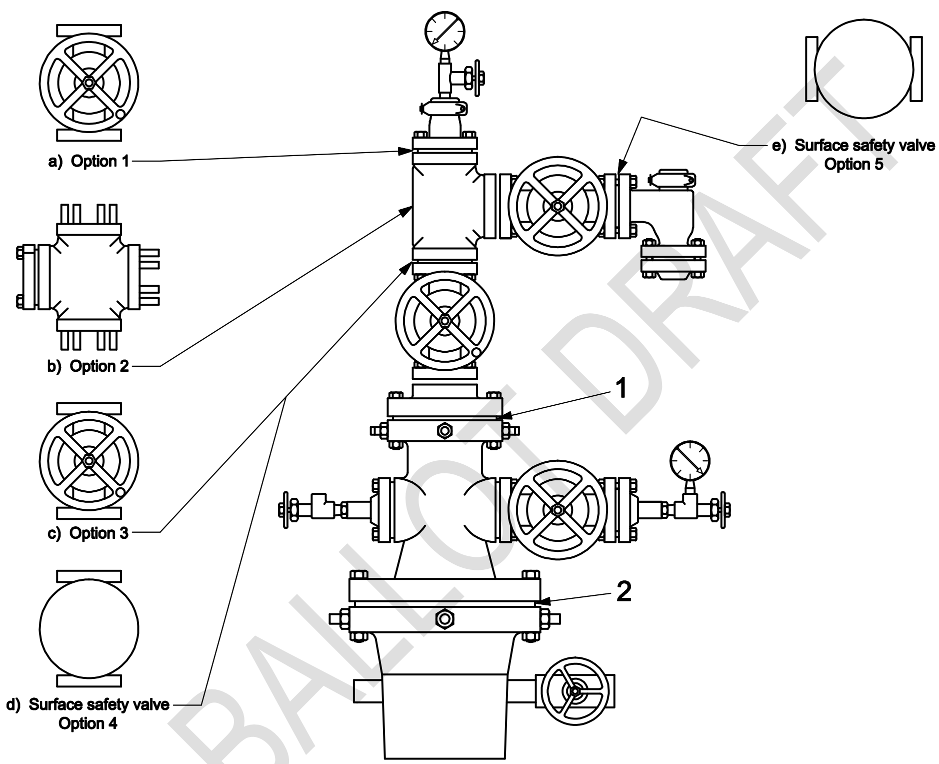
Bonnet Requirements

Size ____	**Specification**	**PSL**
	SSV/USV/BSDV	2 ____
Model ____	PR2 ____	
Rated working pressure ____ MPa (psi)		3 ____
		3G ____
		4 ____
Material Class:	**Temperature Rating:**	

Figure B.12—Wellhead Equipment Data Sheet—Actuator and Bonnet

B.3 Wellhead and Tree Configuration Examples

Examples of typical wellhead and tree configurations are shown in Figure B.13 and Figure B.14. Also included are examples of casing and bit programs that are consistent with the wellheads shown.



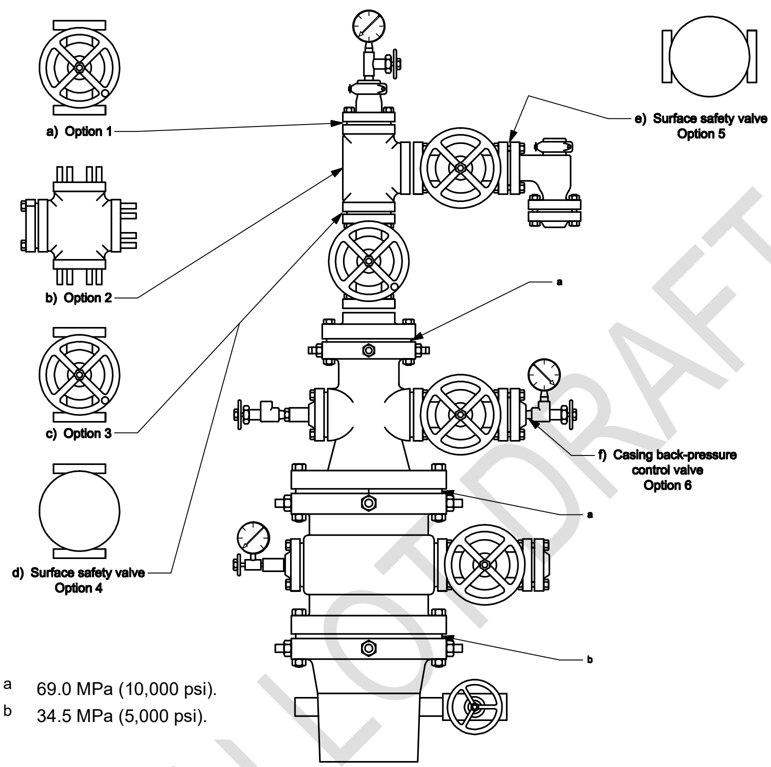
Key

1 tubing-head top flange 34.5 MPa (5,000 psi)

2 casing-head top flange 20.7 MPa (3,000 psi) or 34.5 MPa (5,000 psi)

Typical Programs			
Casing Program mm (in.)	**Bit Program** mm (in.)	**Casing-head Top Flange** mm; MPa (in.; psi)	**Tubing-head Top Flange** mm; MPa (in.; psi)
219.1 (8 $^5/_8$) × 139.7 (5 $^1/_2$)	200.0 (7 $^7/_8$)	279; 20.7 (11; 3,000)	179; 34.5 (7 $^1/_{16}$; 5,000)
244.5 (9 $^5/_8$) × 177.8 (7)	215.9 (8 $^1/_2$) or 222.2 (8 $^3/_4$)	or	
273.1 (10 $^3/_4$) × 193.7 (7 $^5/_8$)	250.8 (9 $^7/_8$)	279; 34.5 (11; 5,000)	

Figure B.13—Typical Wellhead and Tree Configuration for a 34.5 MPa (5,000 psi) Rated Working Pressure



a 69.0 MPa (10,000 psi).
b 34.5 MPa (5,000 psi).

Typical Programs				
Casing Program Mm (in.)	**Bit Program** Mm (in.)	**Casing-head Housing Top Flange** mm; MPa (in., psi)	**Casing-head Spool Top Flange** mm; MPa (in., psi)	**Tubing-head Top Flange** mm; MPa (in., psi)
406.4 × 273.1 × 193.7 (16 × 10 3/4 × 7 5/8)	374.7 × 250.8 or 241.3 (14 3/4 × 9 7/8 or 9 ½)	425; 34.5 (16 3/4; 5,000)	279; 69.0 (11; 10,000)	179; 69.0 (7 1/16; 10,000)
406.4 × 298.5 × 244.5 × 177.8 liner (16 × 11 3/4 × 9 5/8 × 7) liner	374.7 × 269.9 × 215.9 (14 3/4 × 10 5/8 × 8 1/2)	425; 34.5 (16 3/4; 5,000)	346; 69.0 (13 5/8; 10,000) 279; 69.0 (11; 10,000)	179; 69.0 (7 1/16; 10,000)
339.7 × 244.5 × 177.8 (13 3/8 × 9 5/8 × 7)	311.2 × 215.9 × 152.4 (12 1/4 × 8 1/2 × 6)	346; 34.5 (13 5/8; 5,000)	279; 69.0 (11; 10,000)	179; 69.0 (7 1/16; 10,000)
273.1 × 193.7 × 127.0 (10 3/4 × 7 5/8 × 5)	250.8 × 165.1 (9 7/8 × 6 ½)	279; 34.5 (11; 5,000)	279; 69.0 (11; 10,000)	179; 69.0 (7 1/16; 10,000)

Figure B.14—Typical Wellhead and Tree Configuration for a 69.0 MPa (10,000 psi) Rated Working Pressure

B.4 Determining Product Specification Levels

B.4.1 General

This specification establishes requirements for four PSLs. These four PSLs are independent of verification and validation of a product and define different levels of manufacturing requirements. Equipment with a PSL has specific quality control, material, and testing requirements for equipment covered by this specification (see 4.3.4).

PSL 1 represents the set of basic or minimum requirements for quality, material, and testing. All products to which a PSL applies minimally satisfy PSL 1 requirements for conformance with this specification. Higher level PSLs may be applied to the equipment by the manufacturer or may be specified by the purchaser, based on intended use of the equipment. SSVs, USVs, and BSDVs cannot be PSL 1.

PSL 2 contains all the quality and testing requirements of PSL 1 but imposes additional requirements as detailed in this specification. BSDVs cannot be PSL 2. The additional requirements include limitations to variance between the material QTC and the production material. It includes requirements for Charpy testing for service temperature –20 °F and below, volumetric inspection of welds, and magnetic particle inspection of accessible well wetted surfaces.

PSL 3 contains all the quality and testing requirements of PSL 2 but imposes additional requirements as detailed in this specification. The additional requirements include restricted tolerance of material chemistry, changes to the material QTC in relation to the section thickness of the equipment parts. It includes Charpy testing for all service temperatures; volumetric inspection of all material in body, bonnets, flanges, and stems; wet magnetic particle inspection of all accessible surfaces; and extended hydrostatic test times.

NOTE: The designation "PSL 3G" contains the same quality and testing requirements of PSL 3 with the addition of gas testing. End connectors and hangers do not require gas testing, so PSL 3G does not apply.

PSL 4 contains the highest level of quality and testing requirements for any product within this specification. PSL 4 equipment meets all the requirements of PSL 3 and would apply to high-pressure equipment used in sour service.

Figure B.15 shows the recommended specification level for primary equipment. Primary equipment of a wellhead assembly includes the following, as a minimum:

— tubing-head;

— tubing hanger;

— tubing-head adapter;

— lower master valve.

All other wellhead parts are classified as secondary. The specification level for secondary equipment may be different than the level for primary equipment.

The selection of a PSL should be based on a quantitative risk analysis, which is a formal and systematic approach to identifying potentially hazardous events and estimating the likelihood and consequences to people, environment and resources, of accidents developing from these events.

The following comments apply to the basic questions asked in Figure B.15.

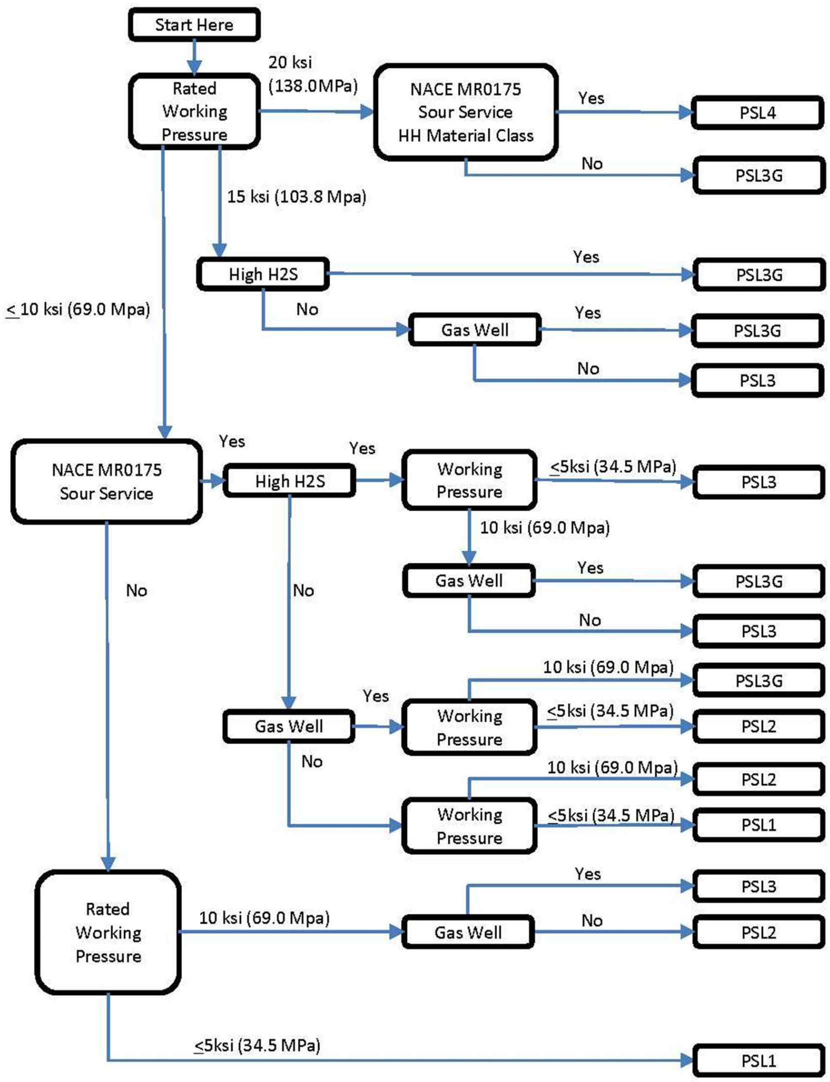


Figure B.15—Recommended Minimum PSL for Primary Parts

B.4.2 NACE MR0175 / ISO 15156

This applies if the partial pressure of hydrogen sulfide (H_2S) in the produced fluid equals or exceeds the minimum amount specified by NACE MR0175 / ISO 15156 for sour service.

B.4.3 High H_2S Concentration

Use "Yes" if the H_2S concentration of the produced fluid is such that in air an H_2S concentration of 70 ml/m3 [70 ppm (parts per million)] can develop in case of a leak (human sense of smell cannot detect concentrations higher than 70 ml/m3).

Alternatively, use "Yes" if the radius of exposure (ROE) to 100 ml/m3 (100 ppm) H_2S is greater than 15 m (50 ft) from the wellhead. ROE is defined in Texas Administrative Code, Title 16, Part 1, Chapter 3, Rule 3.36, b) 3); see B.4.5. Other methods of calculating ROE may apply, depending on local regulations.

The above requires the knowledge of the adjusted open-flow rate of offset wells. If this is not available, but if hydrogen sulfide can be expected, a 100 ml/m3 (100 ppm) ROE equal to 1,000 m (3,000 ft) may be assumed.

B.4.4 Close Proximity

Users who are accustomed to the use of the close-proximity and radius-of-exposure concepts may substitute close-proximity for gas well in Figure B.15.

The potential impact of an uncontrolled emission of H_2S on life and the environment near the wellhead should be evaluated as part of the proximity assessment. The following list of items can be used for determining potential risk:

a) 100 ml/m^3 (100 ppm) ROE of H_2S is greater than 15 m (50 ft) from the wellhead and includes any part of a public area except a public road. ROE is defined in B.4.5. "Public area" means a dwelling, place of business, place of worship, school, hospital, school bus stop, government building, a public road, all or any portion of a park, city, town, village, or other similar area that one can expect to be populated. "Public road" means any street or road owned or maintained for public access or use;

b) 500 ml/m^3 (500 ppm) ROE of H_2S is greater than 15 m (50 ft) from the wellhead and includes any part of a public area including a public road;

c) well is located in any environmentally sensitive area, such as a park, wildlife preserve, city limits, etc.;

d) well is located within 46 m (150 ft) of an open flame or ignition source;

e) well is located within 15 m (50 ft) of a public road;

f) well is located in or near inland navigable waters;

g) well is located in or near surface domestic water supplies;

h) well is located within 107 m (350 ft) of any dwelling.

These conditions are recommended minimums considerations. Any local regulatory requirements should be met.

B.4.5 Radius of Exposure of H_2S

The following information is taken from Texas Railroad Commission Rule 36. SI metric-equivalent rules are not given, as the method of determining the ROE is used in the United States only.

Other methods of calculating ROE may apply, depending on local regulations.

The location, X_{100}, of the 100 ml/m^3 (100 ppm) ROE is determined as given in Equation (B.1):

$$X_{100} = [(1.589)(y_{H_2S})(q)]^{0.625\,8} \quad \text{Equation (B.1)}$$

The location. X_{500}. of the 500 ml/m^3 (500 ppm) ROE is determined as given in Equation (B.2):

$$X_{500} = [(0.454\,6)(y_{H_2S})(q)]^{0.625\,8} \quad \text{Equation (B.2)}$$

where

y_{H_2S} *is the mole fraction H_2S in the gaseous mixture available for escape;*

X *is the radius of exposure, expressed in feet;*

q *is the maximum volume flow rate determined to be available for escape, expressed in cubic feet per day.*

The volume flow rate used as the escape rate in determining the radius of exposure shall be that specified below, as applicable.

a) For new wells in developed areas, the escape rate shall be determined by using the current-adjusted open flow rate of offset wells, or the field-average current-adjusted open flow rate, whichever is larger.

b) The escape rate used in determining the radius of exposure shall be corrected to standard conditions of 0.101 MPa (14.65 psia) and 16 °C (60 °F).

B.5 Impacts on Material Selection

B.5.1 Corrosivity of Retained Fluid

To select the desired material class in Table 3, the purchaser should determine the corrosivity of the retained, produced or injected fluid by considering the various environmental factors and production variables listed in Figure B.1. General corrosion, stress corrosion cracking (SCC), erosion-corrosion and sulfide stress cracking (SSC) are all influenced by the interaction of the environmental factors and the production variables. Other factors and variables not listed in Figure B.1 may also influence fluid corrosivity.

The purchaser should determine whether materials shall conform to NACE MR0175 / ISO 15156 for sour service. NACE MR0175 / ISO 15156 is concerned only with the metallic material requirements to prevent sulfide stress cracking and not with resistance to general corrosion. The impact of the partial pressure of carbon dioxide should be assessed, which generally relates to corrosivity in wells, as shown in Table B.1. This table is a guideline only.

Table B.1—Relative Corrosivity of Retained Fluids as Indicated by CO2 Partial Pressure

Retained Fluids	Relative Corrosivity	Partial Pressure of CO_2	
		MPa	(psia)
General service	non-corrosive	< 0.05	< 7
General service	slightly corrosive	0.05 to 0.21	7 to 30
General service	moderately to highly corrosive	> 0.21	> 30
Sour service	non-corrosive	< 0.05	< 7
Sour service	slightly corrosive	0.05 to 0.21	7 to 30
Sour service	moderately to highly corrosive	> 0.21	> 30

Analysis of produced fluids might not predict the field performance of metallic or non-metallic material.

The minimum partial pressure of carbon dioxide required to initiate corrosion and the relative effect of increasing partial pressures on the corrosion rate are strongly influenced by other environmental factors and production variables, such as

a) temperature;
b) H_2S level;
c) pH;
d) chloride ion concentration;
e) sand production;
f) water production and composition;
g) types and relative amounts of produced hydrocarbons.

Finally, the purchaser should consider future service of the well when selecting a material class. Future servicing needs should include evaluation of anticipated changes in the acid-gas partial pressures for production or increased water production with or without increased chloride content. It also should include anticipated operations such as acidification or other well treatments.

B.5.2 Steel Chemical Composition Limits

All metallic and nonmetallic pressure-containing or pressure-controlling parts should have a written material specification. The manufacturer's written specified requirements define, among other things (see 6.2) the material composition. The composition limits in Table B.2 provide guidelines to the manufacturer and purchaser for use in selection of materials.

Table B.2— Steel Composition Limit Guidelines

Alloying Element	**Composition Limits** % mass fraction		
	Carbon [a] and Low-alloy [b] Steels	**Martensitic Stainless Steels**	**45K Material for Weld-neck Flanges [c]**
Carbon	0.45 max.	0.15 max.	0.35 max.
Manganese	1.80 max.	1.00 max.	1.05 max.
Silicon	1.00 max.	1.50 max.	1.35 max.
Phosphorus	[d]	[d]	0.05 max.
Sulfur	[d]	[d]	0.05 max.
Nickel	1.00 max. [e]	NA	NA
Chromium	2.75 max.	11.0–14.0	NA
Molybdenum	1.50 max.	1.00 max.	NA
Vanadium	0.30 max.	NA	NA

FOOTNOTES

[a] Alloy of carbon and iron containing a maximum of 2 % mass fraction carbon, 1.65 % mass fraction manganese, and residual quantities of other elements, except those intentionally added in specific quantities for deoxidation (usually silicon and/or aluminum).

[b] Steel containing less than 5 % mass fraction total alloying elements, or steels with less than 11 % mass fraction chromium, but more than that specified for carbon steel.

[c] For each reduction of 0.01 % below the specified carbon maximum (0.35 %), an increase of 0.06 % manganese above the specified maximum (1.05 %) is permitted up to a maximum of 1.35 %.

[d] See Table 12

[e] 1.00 max. nickel is for sour-service applications meeting NACE MR0175/ISO 15156. For non-sour service, a nickel content of 3.00 max. is acceptable

Residual elements, trace elements or other elements not specified in the manufacturer's material specifications do not require reporting, even though the elements may be identified as present in the material.

Residual elements are minor elements present as impurities or remnants from original raw materials (such as iron or steel scrap) that are not intentionally added but remain in the final product after metallurgical processes. Trace elements are any chemical element present in very small, measurable quantities, typically less than 0.1% or 1000 parts per million. Neither trace nor residual elements require reporting unless otherwise specified by the manufacturer in the manufacturer's material specification.

B.5.3 Use of Castings

The purchaser should evaluate the use and requirements of cast, pressure-containing parts for an application. The manufacturing methods for forging (wrought) and castings may produce differences in performance, quality, grain structure and corrosion resistance for the same PSL. However, castings may be beneficial for parts of large size or complex shape.

Castings generally have more porosity, cavities and inclusions than fully wrought products. Processes such as hot isostatic pressing (HIP) can be used to reduce or eliminate porosity and cavities. Specifying PSL 2 or PSL 3 will enable application of standard surface and volumetric inspections of castings for intended service.

NOTE ASTM A1080/A1080M provides information on HIP processes for stainless steel and alloy steel castings.

Purchasers may limit applications or increase the PSL for a cast part as deemed appropriate for the equipment's classification (primary / secondary) or service conditions. Table B.3 provides an application guide for pressure-containing parts based on equipment classification and service conditions.

B.5.4 Fire Testing

When fire resistance qualification of equipment in this Specification is required, qualification in conformance with API 6FA (for gate, plug and ball valves), API 6FB (for other end connectors) or API 6FD (for check valves) should be specified or as agreed to between the manufacturer and the purchaser.

Table B.3— Application Guide for Pressure-containing Parts

Rated Working Pressure	Material Class		
	AA, BB, CC	**DD, EE, FF**	**HH**
13.8 MPa (2,000 psi)	Wrought or Cast	Wrought or Cast	Wrought or Cast
20.7 MPa (3,000 psi)	Wrought or Cast	Wrought or Cast	Wrought or Cast
34.5 MPa (5,000 psi)	Wrought or Cast	Wrought or Cast	Wrought or Cast
69.0 MPa (10,000 psi)	Wrought or Cast	**Wrought**	**Wrought**
103.5 MPa (15,000 psi)	**Wrought**	**Wrought**	**Wrought**
138.0 MPa (20,000 psi)	**Wrought**	**Wrought**	**Wrought**
FOOTNOTE See Table 5 for minimum PSL and Figure B.15 for additional PSL guidance.			

Annex C
(informative)

Conversion Procedures—Units of Measure

C.1 General Information

C.1.1 General

These conversion procedures are changed from previous editions. There are two significant conversion changes that affected many dimensions specified in millimeters.

a) With the exception of ring grooves and ring gaskets, the inch dimensions with fractional origin are not converted from the exact decimal equivalent, but from the decimal-format value specified in this edition. For example, 2.56 in. are converted just as written: 2.56 in. x 25.4 = 65.0 mm, whereas previous editions converted as follows:

   2.56 in. $\Rightarrow 2^9/_{16}$ in. = 2.5625 in. = 2.5625 in. x 25.4 = 65.1 mm.

b) Rounding rules for SI dimensions were revised to reduce variations in geometry between equipment. For example, flange ODs are now rounded to 1 mm instead of 5 mm.

C.1.2 Conversion Rules

The dimensions in SI units were obtained by converting from dimensional tables of API 6A in conformance with the following procedures. The conversion is illustrated in the following example.

a) Multiply the published decimal value or the decimal equivalent of a fractional-inch dimension by 25.4 mm/in. to obtain the exact millimeter dimension.

   EXAMPLE 4.31 in. x 25.4 = 109.474 mm.

   NOTE The period is always used as the decimal sign.

b) Then, do the rounding indicated for the particular dimension. Rounding rules may vary for different dimensions, depending on the application of the dimension.

   EXAMPLE

   — If the above dimension were to be rounded to the nearest even 5 mm, the resulting dimension would be 110 mm.

   — If the above dimension were to be rounded to the accuracy nearest to the inch dimension, that would be XXX.X mm, and the resulting dimension would be 109.5 mm.

C.2 6B and 6BX Flanges and Studded Outlets

C.2.1 Pressure Ratings

The selected ratings in megapascals have been converted from the dimensional tables of API 6A in such a way as to preserve the ratio of pressure ratings, expressed in pounds per square inch, while still using convenient simple numbers, as given in Table C.1.

Table C.1—Pressure Rating Conversion between SI and USC for API 6A Equipment

Megapascals (MPa)	Pounds per Square Inch (psi)
13.8	2000
20.7	3000
34.5	5000
69.0	10,000
103.5	15,000
138.0	20,000

C.2.2 Nominal Sizes

Nominal bore sizes for flanges and studded outlets in this specification are expressed in USC unit values only. The nominal size is for identification purposes and is not a manufacturing dimension.

C.2.3 Rounding Rules

The following rules were used to develop flange dimensions.

a) For the maximum bore, round to the nearest 0.1 mm.

EXAMPLE 2.09 in. ⇒ 53.086 mm ⇒ 53.1 mm.

b) For the flange OD, round to the nearest 1 mm.

NOTE This is not consistent with ANSI practice or previous editions of this specification.

EXAMPLE 8.12 in. ⇒ 206.248 mm ⇒ 206 mm.

c) For the maximum chamfer, round to the nearest 1 mm.

EXAMPLE 0.12 in. ⇒ 3.048 mm ⇒ 3 mm;

0.25 in. ⇒ 6.350 mm ⇒ 6 mm.

d) For the raised face diameter, round to the nearest 1 mm.

e) For the thickness of flange, round up to the next 0.1 mm.

f) For the hub dimensions J_1, J_2, J_3, and X, round to the nearest 0.1 mm.

g) For the radius at back face, convert as given in Table C.2.

Table C.2—Conversions for the Radius at Back Face

Millimeters	Inches
3	0.12
10	0.38
16	0.62
19	0.75
21	0.81
25	1.00

h) For the tolerance for the bolt hole location ± 0.8 mm.

i) For the bolt circle, round to the nearest 0.1 mm.

j) For the bolt hole diameter, round up to the next 1 mm.

k) For bolt hole sizes and tolerances, round values as given in Table C.3

Table C.3—Rounding Values for Hole Sizes and Tolerances

Hole Size	Tolerance mm
< 42 mm	+2 –0.5
≥ 42 mm and ≤ 74 mm	+2.5 –0.5
> 74 mm	+3 –0.5

l) For the stud lengths, round to the nearest 5 mm.

m) For the ring gasket and groove dimensions, convert exactly to the nearest 0.01 mm except for the hole size D of the RX and BX ring joints.

C.3 Other Equipment Dimensions

C.3.1 Bore Dimensions

For the maximum or nominal bore diameter, round to the nearest 0.1 mm.

C.3.2 Valve Face-to-face Dimensions

For all valves, the dimension is rounded to the nearest 1 mm.

C.3.3 Cross and Tee Center-to-face Dimensions

These dimensions are rounded to the nearest 0.5 mm.

C.3.4 Multiple Completion Centerline Spacing

These dimensions are converted and expressed to two decimals. The resulting dimension and tolerance shall be selected so that the physical size is always within the tolerance range of ± 0.005 in. when a tolerance of ± 0.12 mm is applied.

EXAMPLE Dimension 1.390 in. from flange center, ± 0.005 in. Alternatives are as follows.

— Lower limit: 1.385 in. ⇒ 35.179 mm (35.18 or 35.19).

— Center: 1.390 in. ⇒ 35.306 mm (35.30 or 35.31).

— Upper limit: 1.395 in. ⇒ 35.433 mm (35.42 or 35.43).

— Choose the first center dimension 35.30 mm, since it is a round number.

C.4 Conversion Factors

C.4.1 Length

1 inch (in.) equals 25.4 millimeters (mm), exactly.

C.4.2 Pressure/Stress

1 pound-force per square inch (psi) = 0.006894757 megapascal (MPa).

1 megapascal (MPa) equals 1 newton per square millimeter (N/mm^2).

NOTE 1 bar = 0.1 MPa.

C.4.3 Impact Energy

1 foot-pound (ft-lb) equals 1.355818 joule (J).

C.4.4 Torque

1 foot-pound (ft-lb) equals 1.355818 newton-meter (N-m).

C.4.5 Temperature

Degrees Celsius equals $^5/_9$ (degrees Fahrenheit minus 32).

C.4.6 Force

1 pound-force (lbf) equals 4.448222 newton (N).

C.4.7 Mass

1 pound-mass (lbm) equals 0.45359237 kilogram (kg) exactly.

Annex D
(normative)

Dimensional Tables—SI Units

Table D.1—Type 6B Flanges for 13.8 MPa

Table D.2—Type 6B Flanges for 20.7 MPa

Table D.3—Type 6B Flanges for 34.5 MPa

Table D.4—Type 6BX Flanges for 69.0 MPa

Table D.5—Type 6BX Flanges for 103.5 MPa

Table D.6—Type 6BX Flanges for 138.0 MPa

Table D.7—Type 6BX Large-bore Flanges for 13.8 MPa, 20.7 MPa, and 34.5 MPa

Table D.8—Type R Ring Grooves

Table D.9—Type R Ring Gaskets

Table D.10—Type RX Ring Gaskets

Table D.11—Type BX Ring Grooves

Table D.12—Type BX Ring Gaskets

Table D.13—Flanged Crosses and Tees

Table D.14—Studded Crosses and Tees

Table D.15—Bullplugs

Table D.16—VR Plug Dimensions, 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa

Table D.17—VR Preparation Dimensions, 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa

Table D.18—VR Plug Thread Gauging Dimensions, 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa

Table D.19—VR Preparation Thread Gauging Dimensions, 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa

Table D.20—HPVR Plug Dimensions, 103.5 MPa and 138.0 MPa

Table D.21—HPVR Preparation Dimensions, 103.5 MPa and 138.0 MPa

Table D.22—Flanged Full-bore Gate Valves

Table D.23—Flanged Plug and Ball Valves

Table D.24—Flanged Swing and Lift Check Valves

Table D.25—Center Spacing of Conduit Bores for Dual Parallel Bore Valves for 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa

Table D.26—Center Spacing of Conduit Bores for Triple, Quadruple, and Quintuple Parallel Bore Valves for 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa

Table D.27—Maximum Hanger Outside Diameter for Wellheads

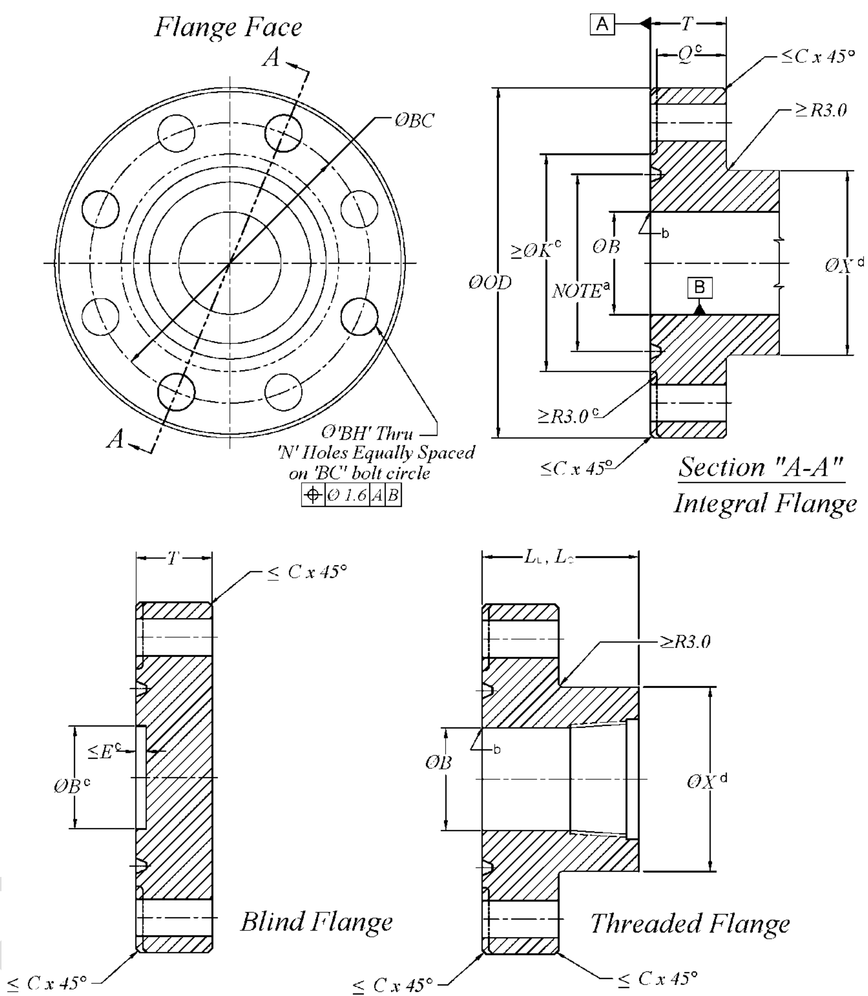
Table D.28—Minimum Vertical Full-opening Wellhead Body Bores and Maximum Casing Sizes

Table D.29—Pipe Thread Counterbore and Standoff Dimensions

Table D.30—Gauging of Casing and Tubing Threads

Table D.1—Type 6B Flanges for 13.8 MPa

Dimensions in millimeters unless noted otherwise



FOOTNOTES

[a] Ring groove shall be concentric with bore *B* within 0.25 mm diametrical runout. See Table D.8 for ring groove dimensions.

[b] Break sharp corner.

[c] Raised face *K* and counterbore *E* are optional features.

[d] Diameter *X* is a reference dimension

Table D.1—Type 6B Flanges for 13.8 MPa *(continued)*

Dimensions in millimeters unless noted otherwise

Nominal Size of Flange [a]	Maximum Bore	Outside Diameter of Flange	Max. Chamfer	Diameter of Raised Face	Total Thickness of Flange	Basic Thickness of Flange	Diameter of Hub	Counter-bore Depth
in.	*B*	*OD*	*C*	*K*	*T*	*Q*	*X*	*E*
Tolerance>	max.	As noted	max.	min.	+3.0/−0	min.	Reference	+0.5/−0
2 1/16	53.1	165 ±2	3	108	33.3	25.4	84.1	7.9
2 9/16	65.8	191 ±2	3	127	36.6	28.4	100.1	7.9
3 1/8	81.8	210 ±2	3	146	39.6	31.8	117.2	7.9
4 1/16	108.7	273 ±2	3	175	46.0	38.1	152.4	7.9
5 1/8	131.1	330 ±2	3	210	52.3	44.5	189.0	7.9
7 1/16	181.9	356 ±3	6	241	55.6	47.8	222.3	7.9
9	229.4	419 ±3	6	302	63.5	55.6	273.1	7.9
11	280.2	508 ±3	6	356	71.4	63.5	342.9	7.9
13 5/8	347.0	559 ±3	6	413	74.7	66.5	400.1	7.9
16 3/4	426.2	686 ±3	6	508	84.1	76.2	495.3	7.9
21 1/4	540.5	813 ±3	6	635	98.6	88.9	609.6	9.7

FOOTNOTE

[a] For flange sizes 26 3/4 in. and 30 in., see Table D.7.

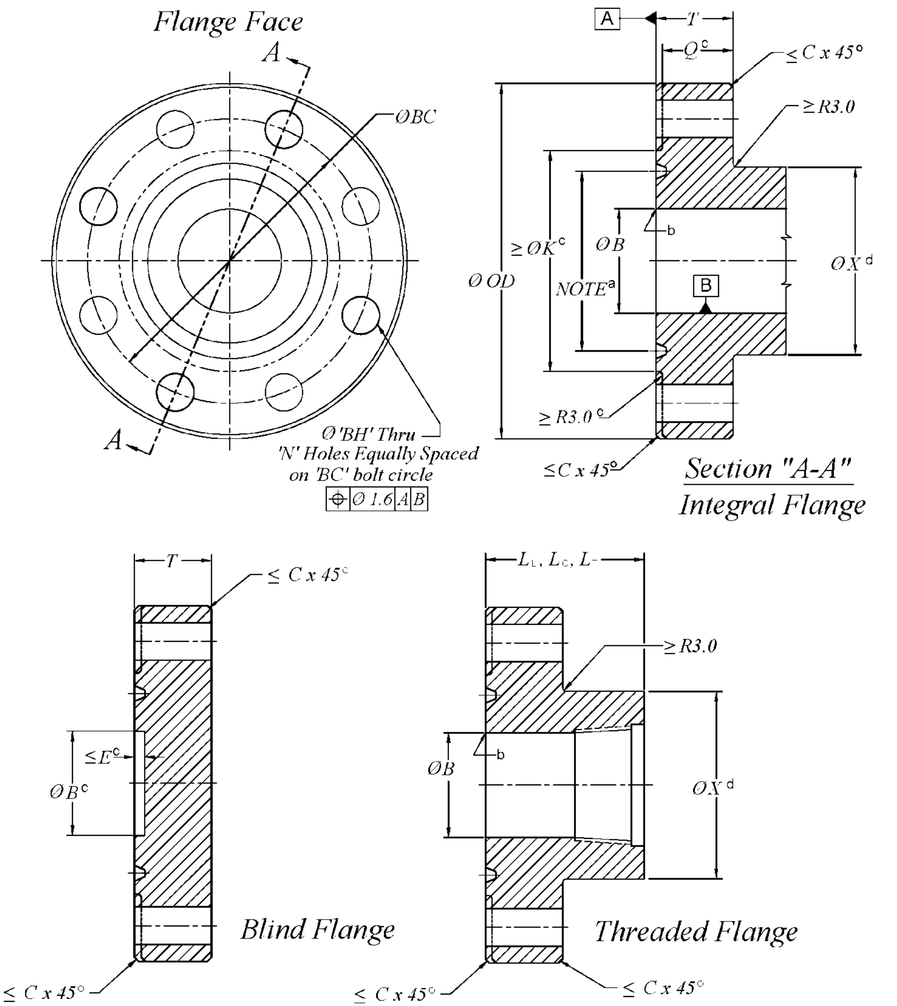
Nominal Size of Flange [a]	Diameter of Bolt Circle	Number of Bolts	Bolt Size and TPI	Bolt Holes		Hub Length, Threaded Flange		Ring Groove Number
						Line Pipe Flange	Casing Flange	
in.	*BC*	*N*	in.	*BH*		L_L	L_C	
Tolerance>	See figure for GDT		(Ref.)	Diameter	Tolerance	min.	min.	
2 1/16	127.0	8	5/8-11	20	+2/−0.5	44	—	R 23
2 9/16	149.4	8	3/4-10	23	+2/−0.5	49	—	R 26
3 1/8	168.1	8	3/4-10	23	+2/−0.5	54	—	R 31
4 1/16	215.9	8	7/8-9	26	+2/−0.5	62	89	R 37
5 1/8	266.7	8	1-8	29	+2/−0.5	68	102	R 41
7 1/16	292.1	12	1-8	29	+2/−0.5	75	114	R 45
9	349.3	12	1 1/8-8	32	+2/−0.5	84	127	R 49
11	431.8	16	1 1/4-8	35	+2/−0.5	94	133	R 53
13 5/8	489.0	20	1 1/4-8	35	+2/−0.5	100	100	R 57
16 3/4	603.2	20	1 1/2-8	42	+2.5/−0.5	114	114	R 65
21 1/4	723.9	24	1 5/8-8	45	+2.5/−0.5	137	137	R 73

FOOTNOTE

[a] For flange sizes 26 3/4 in. and 30 in., see Table D.7.

Table D.2—Type 6B Flanges for 20.7 MPa

Dimensions in millimeters unless noted otherwise



FOOTNOTES

[a] Ring groove shall be concentric with bore *B* within 0.25 mm diametrical runout. See Table D.8 for ring groove dimensions.

[b] Break sharp corner.

[c] Raised face *K* and counterbore *E* are optional features.

[d] Diameter *X* is a reference dimension

Table D.2—Type 6B Flanges for 20.7 MPa *(continued)*

Dimensions in millimeters unless noted otherwise

Nominal Size of Flange [a]	Maximum Bore	Outside Diameter of Flange	Max. Chamfer	Diameter of Raised Face	Total Thickness of Flange	Basic Thickness of Flange	Diameter of Hub	Counter-bore Depth
in.	*B*	*OD*	*C*	*K*	*T*	*Q*	*X*	*E*
Tolerance>	max.	As noted	max.	min.	+3.0/−0	min.	Reference	+0.5/−0
2 1/16	53.1	216 ±2	3	124	46.0	38.1	104.6	7.9
2 9/16	65.8	244 ±2	3	137	49.3	41.1	124.0	7.9
3 1/8	81.8	241 ±2	3	155	46.0	38.1	127.0	7.9
4 1/16	108.7	292 ±2	3	181	52.4	44.4	158.8	7.9
5 1/8	131.1	349 ±2	3	216	58.7	50.8	190.5	7.9
7 1/16	181.9	381 ±3	6	241	63.5	55.6	235.0	7.9
9	229.4	470 ±3	6	308	71.4	63.5	298.5	7.9
11	280.2	546 ±3	6	362	77.8	69.9	368.3	7.9
13 5/8	347.0	610 ±3	6	419	87.4	79.2	419.1	7.9
16 3/4	426.2	705 ±3	6	524	100.1	88.9	508.0	11.2
20 3/4	527.8	857 ±3	6	648	120.7	108.0	622.3	12.7

FOOTNOTE

[a] For flange sizes 26 3/4 in. and 30 in., see Table D.7.

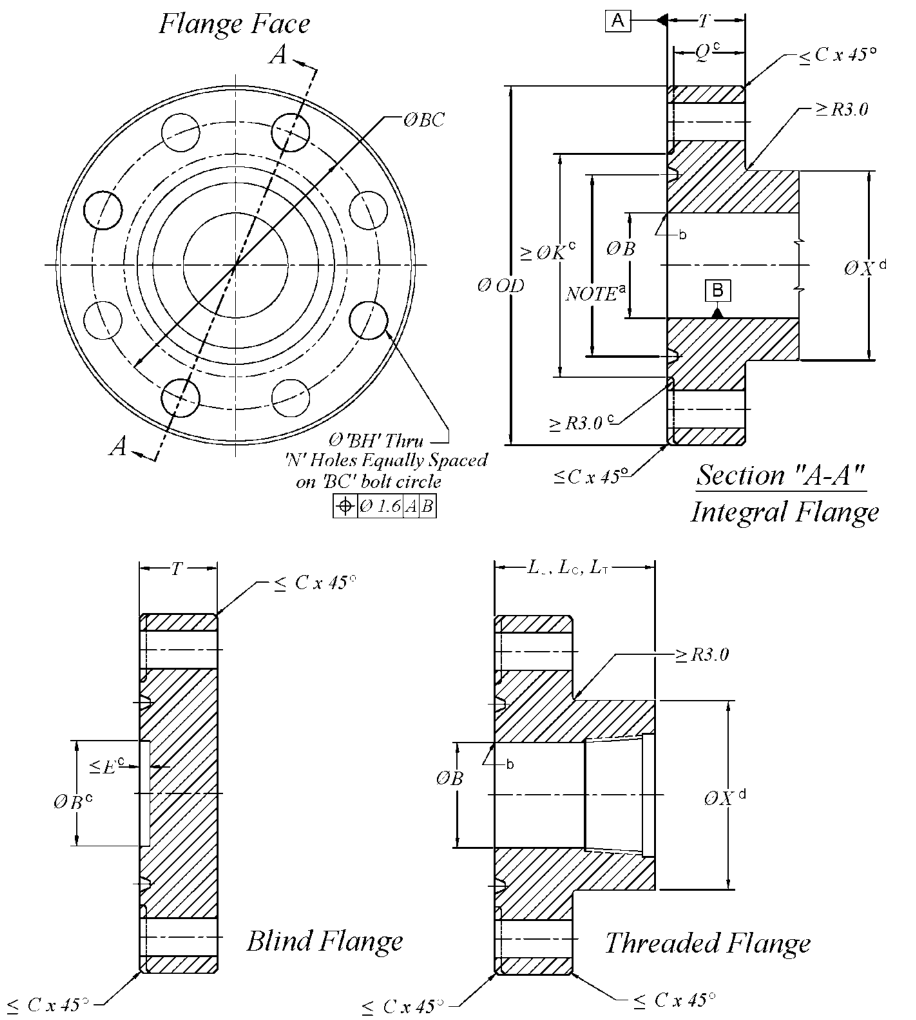
Nominal Size of Flange [a]	Diameter of Bolt Circle	Number of Bolts	Bolt Size and TPI	Bolt Holes		Hub Length, Threaded Flange			Ring Groove
						Line Pipe Flange	Casing Flange	Tubing Flange	
in.	*BC*	*N*	in.	*BH*		L_L	L_C	L_T	
Tolerance>	See figure for GDT		(Ref.)	Diameter	Tolerance	min.	min.	min.	
2 1/16	165.1	8	7/8-9	26	+2/−0.5	65.0	—	65.0	R 24
2 9/16	190.5	8	1-8	29	+2/−0.5	71.4	—	71.4	R 27
3 1/8	190.5	8	7/8-9	26	+2/−0.5	62.0	—	74.7	R 31
4 1/16	235.0	8	1 1/8-8	32	+2/−0.5	77.7	88.9	88.9	R 37
5 1/8	279.4	8	1 1/4-8	35	+2/−0.5	87.4	101.6	—	R 41
7 1/16	317.5	12	1 1/8-8	32	+2/−0.5	93.7	114.3	—	R 45
9	393.7	12	1 3/8-8	39	+2/−0.5	109.5	127.0	—	R 49
11	469.9	16	1 3/8-8	39	+2/−0.5	115.8	133.4	—	R 53
13 5/8	533.4	20	1 3/8-8	39	+2/−0.5	125.5	125.5	—	R 57
16 3/4	616.0	20	1 5/8-8	45	+2.5/−0.5	128.5	144.5	—	R 66
20 3/4	749.3	20	2-8	54	+2.5/−0.5	171.5	171.5	—	R 74

FOOTNOTE

[a] For flange sizes 26 3/4 in. and 30 in., see Table D.7.

Table D.3—Type 6B Flanges for 34.5 MPa

Dimensions in millimeters unless noted otherwise



FOOTNOTES

[a] Ring groove shall be concentric with bore *B* within 0.25 mm diametrical runout. See Table D.8 for ring groove dimensions.

[b] Break sharp corner.

[c] Raised face *K* and counterbore *E* are optional features.

[d] Diameter *X* is a reference dimension

Table D.3—Type 6B Flanges for 34.5 MPa *(continued)*

Dimensions in millimeters unless noted otherwise

Nominal Size of Flange [a]	Maximum Bore	Outside Diameter of Flange	Max. Chamfer	Diameter of Raised Face	Total Thickness of Flange	Basic Thickness of Flange	Diameter of Hub	Counter-bore Depth
in.	*B*	*OD*	*C*	*K*	*T*	*Q*	*X*	*E*
Tolerance >	max.	As noted	max.	min.	+3.0/−0	min.	Reference	+0.5/−0
2 1/16	53.1	216 ±2	3	124	46.0	38.1	104.6	7.9
2 9/16	65.8	244 ±2	3	137	49.3	41.1	124.0	7.9
3 1/8	81.8	267 ±2	3	168	55.7	47.8	133.3	7.9
4 1/16	108.7	311 ±2	3	194	62.0	53.8	162.1	7.9
5 1/8	131.1	375 ±2	3	229	81.0	73.2	196.8	7.9
7 1/16	181.9	394 ±3	6	248	92.0	82.6	228.6	9.7
9	229.4	483 ±3	6	318	103.2	91.9	292.1	11.2
11	280.2	584 ±3	6	371	119.2	108.0	368.3	11.2

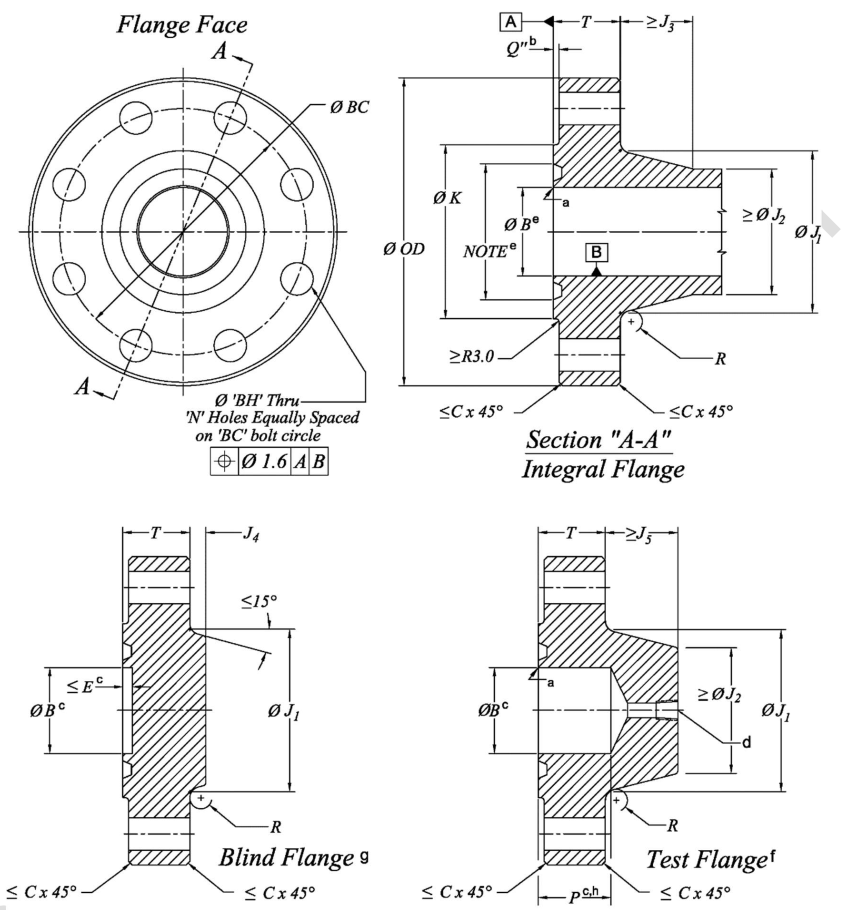
FOOTNOTE
[a] For flange sizes 13 5/8 in., 16 3/4 in., 18 3/4 in., and 21 1/4 in., see Table D.7.

Nominal Size of Flange [a]	Diameter of Bolt Circle	Number of Bolts	Bolt Size and TPI	Bolt Holes		Hub Length, Threaded Flange			Ring Groove
						Line Pipe Flange	Casing Flange	Tubing Flange	
in.	*BC*	*N*	in.	*BH*		L_L	L_C	L_T	
Tolerance>	See figure for GDT		(Ref.)	Diameter	Tolerance	min.	min.	min.	
2 1/16	165.1	8	7/8-9	26	+2/−0.5	65.0	—	65.0	R 24
2 9/16	190.5	8	1-8	29	+2/−0.5	71.4	—	71.4	R 27
3 1/8	203.2	8	1 1/8-8	32	+2/−0.5	81.0	—	81.0	R 35
4 1/16	241.3	8	1 1/4-8	35	+2/−0.5	98.6	98.6	98.6	R 39
5 1/8	292.1	8	1 1/2-8	42	+2.5/−0.5	112.8	112.8	—	R 44
7 1/16	317.5	12	1 3/8-8	39	+2/−0.5	128.5	128.5	—	R 46
9	393.7	12	1 5/8-8	45	+2.5/−0.5	153.9	153.9	—	R 50
11	482.6	12	1 7/8-8	51	+2.5/−0.5	169.9	169.9	—	R 54

FOOTNOTE
[a] For flange sizes 13 5/8 in., 16 3/4 in., 18 3/4 in., and 21 1/4 in., see Table D.7.

Table D.4—Type 6BX Flanges for 69.0 MPa

Dimensions in millimeters unless noted otherwise



FOOTNOTES

[a] Break sharp corner.

[b] Q'' min. = 3 mm. Raised face ($Ø\ K$) may be omitted on studded connectors, but thickness T shall still apply.

[c] Optional feature.

[d] Test connection shall be $^1/_2$ in. NPT or per 9.3 (Figure 5).

[e] Ring groove shall be concentric with bore B within 0.25 mm diametrical runout. See Table D.11 for ring groove dimensions.

[f] Test flange style—applies to sizes $1^{13}/_{16}$ through $5^1/_8$ only.

[g] Blind flange style—applies to sizes $5^1/_8$ through $21^1/_4$ only.

[h] The maximum depth P of the counterbore is based on the specified minimum J_5 dimension. The maximum depth P of the counterbore may be increased provided J_5 exceeds the specified minimum by at least the same amount.

Table D.4—Type 6BX Flanges for 69.0 MPa *(continued)*

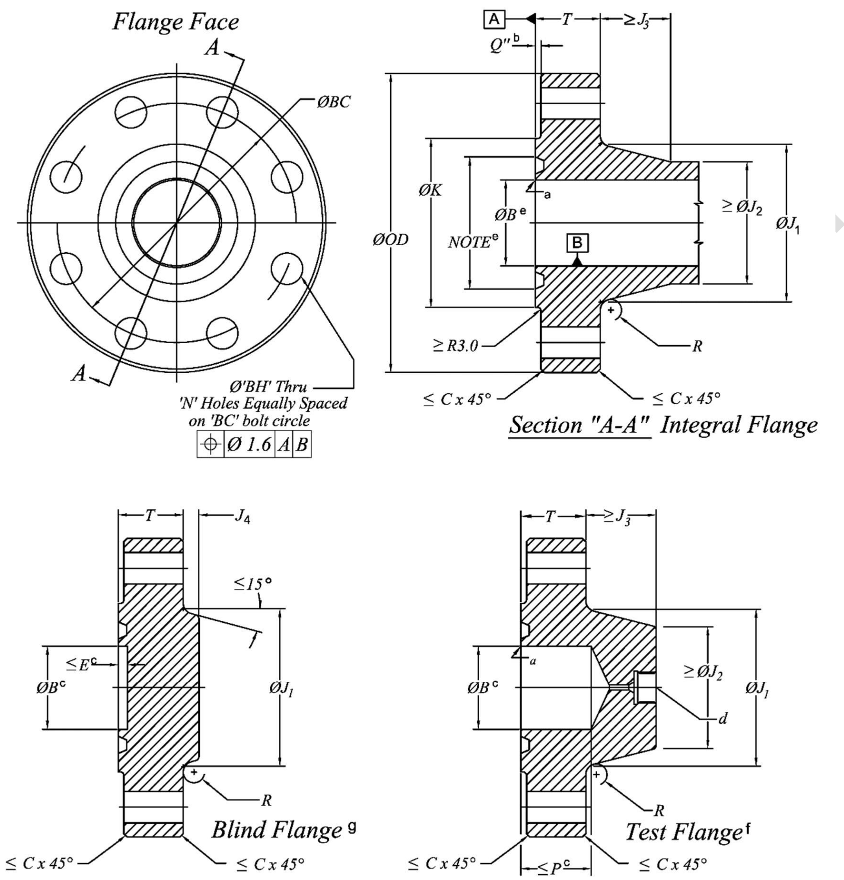
Dimensions in millimeters unless noted otherwise

Nominal Size	Maximum Bore	Outside Diameter of Flange	Diameter of Raised Face	Total Thickness	Max. Chamfer	Large Hub Diameter	Small Hub Diameter	Length of Hub	Hub Height	Hub Height
in.	*B*	*OD*	*K*	*T*	*C*	J_1	J_2	J_3	J_4	J_5
Tolerance>	max.	As noted	± 1.5	+3.0/−0	max.	+0/−3.0	min.	min.	min.	min.
$1^{13}/_{16}$	46.7	187 ±2	105	42.2	3	88.9	65.0	48.5	—	57.4
$2^{1}/_{16}$	53.1	200 ±2	111	44.0	3	100.1	74.7	51.6	—	55.6
$2^{9}/_{16}$	65.8	232 ±2	132	51.3	3	120.7	91.9	57.2	—	57.2
$3^{1}/_{16}$	78.5	270 ±2	152	58.5	3	142.0	110.2	63.5	—	63.5
$4^{1}/_{16}$	103.9	316 ±2	185	70.4	3	182.6	146.1	73.2	—	73.2
$5^{1}/_{8}$	131.1	357 ±2	221	79.3	3	223.8	182.6	81.0	6.4	81.0
$7^{1}/_{16}$	180.1	480 ±2.5	302	103.2	6	301.8	254.0	95.3	9.7	—
9	229.4	552 ±2.5	359	124.0	6	374.7	327.2	93.7	9.7	—
11	280.2	654 ±2.5	429	141.3	6	450.9	400.1	103.1	14.2	—
$13^{5}/_{8}$	347.0	768 ±2.5	518	168.2	6	552.5	495.3	114.3	17.5	—
$16^{3}/_{4}$	426.2	871 ±2.5	576	168.2	6	655.6	601.7	76.2	30.2	—
$18^{3}/_{4}$	477.0	1040 ±2.5	697	223.0	6	752.3	674.6	155.4	25.4	—
$21^{1}/_{4}$	540.5	1143 ±2.5	781	241.3	6	847.9	762.0	165.1	31.8	—

Nominal Size	Raised Face Depth	Radius of Hub	Bolt Circle	Number of Bolts	Bolt Size and TPI	Bolt Holes		Counterbore Depth			Ring Groove
in.	*Q″* [b]	*R*	*BC*	*N*	in.	*BH*		*E* [g]	*P* [h]	*P* [h]	
Tolerance>	max.	± 1	See figure for GDT		(Ref.)	Diameter	Tolerance	max.	min.	max.	
$1^{13}/_{16}$	6.0	10	146.1	8	$^{3}/_{4}$-10	23	+2/−0.5	—	54.4	55.4	BX 151
$2^{1}/_{16}$	6.4	10	158.8	8	$^{3}/_{4}$-10	23	+2/−0.5	—	52.6	53.6	BX 152
$2^{9}/_{16}$	7.2	10	184.2	8	$^{7}/_{8}$-9	26	+2/−0.5	—	54.1	61.5	BX 153
$3^{1}/_{16}$	8.0	10	215.9	8	1-8	29	+2/−0.5	—	54.6	71.9	BX 154
$4^{1}/_{16}$	8.8	10	258.8	8	$1^{1}/_{8}$-8	32	+2/−0.5	—	50.0	87.6	BX 155
$5^{1}/_{8}$	10.0	10	300.0	12	$1^{1}/_{8}$-8	32	+2/−0.5	9.5	—	—	BX 169
$7^{1}/_{16}$	11.6	16	403.4	12	$1^{1}/_{2}$-8	42	+2.5/−0.5	11.1	—	—	BX 156
9	13.2	16	476.3	16	$1^{1}/_{2}$-8	42	+2.5/−0.5	12.7	—	—	BX 157
11	14.7	16	565.2	16	$1^{3}/_{4}$-8	48	+2.5/−0.5	14.3	—	—	BX 158
$13^{5}/_{8}$	16.3	16	673.1	20	$1^{7}/_{8}$-8	51	+2.5/−0.5	15.9	—	—	BX 159
$16^{3}/_{4}$	8.8	19	776.2	24	$1^{7}/_{8}$-8	51	+2.5/−0.5	8.3	—	—	BX 162
$18^{3}/_{4}$	18.7	16	925.6	24	$2^{1}/_{4}$-8	61	+2.5/−0.5	18.3	—	—	BX 164
$21^{1}/_{4}$	19.5	21	1022.4	24	$2^{1}/_{2}$-8	67	+2.5/−0.5	19.1	—	—	BX 166

Table D.5—Type 6BX Flanges for 103.5 MPa

Dimensions in millimeters unless noted otherwise



FOOTNOTES

[a] Break sharp corner.

[b] *Q''* min. = 3 mm. Raised face (*Ø K*) may be omitted on studded connectors, but thickness *T* shall still apply.

[c] Optional feature.

[d] Test connection shall be per 9.3 (Figure 5).

[e] Ring groove shall be concentric with bore *B* within 0.25 mm diametrical runout. See Table D.11 for ring groove dimensions.

[f] Test flange style—applies to sizes $1^{13}/_{16}$ through $5^{1}/_{8}$ only.

[g] Blind flange style—applies to sizes $5^{1}/_{8}$ through $18^{3}/_{4}$ only.

[h] If the minimum value of J_3 is exceeded, the maximum depth *P* of the counterbore may be increased by the same amount or less.

Table D.5—Type 6BX Flanges for 103.5 MPa *(continued)*

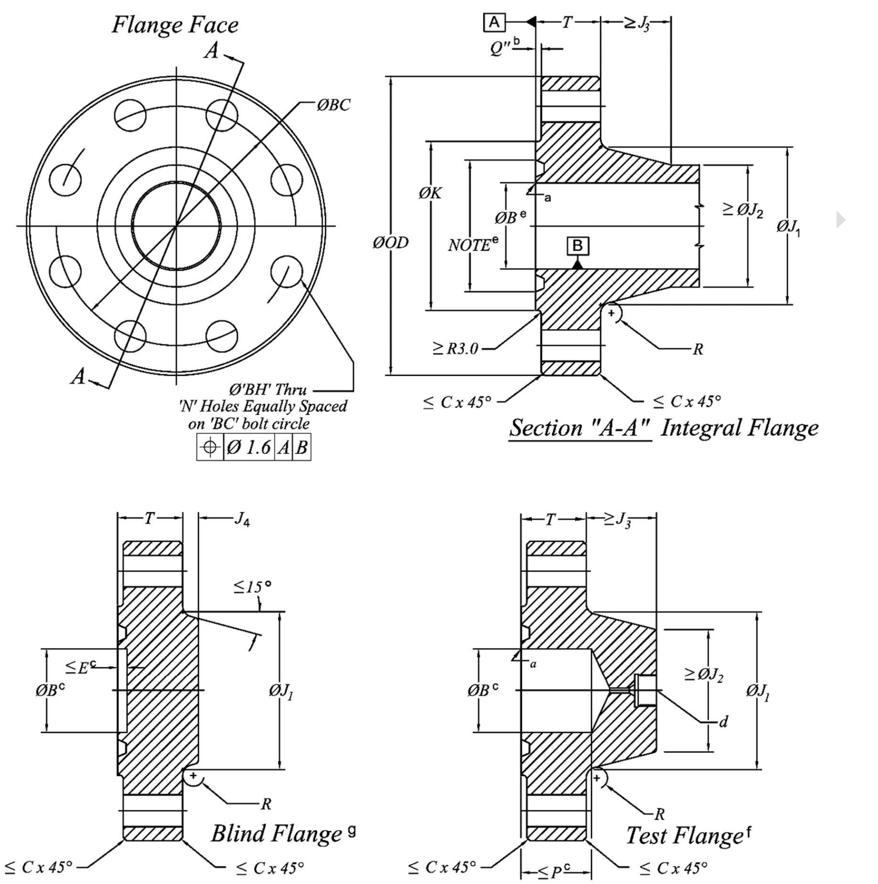
Dimensions in millimeters unless noted otherwise

Nominal Size of Flange	Maximum Bore	Outside Diameter of Flange	Diameter of Raised Face	Total Thickness of Flange	Max. Chamfer	Large Hub Diameter	Small Hub Diameter	Hub Length	Test Flange C'bore Depth
in.	*B*	*OD*	*K*	*T*	*C*	J_1	J_2	J_3	*P* [h]
Tolerance>	max.	As noted	± 1.5	+3.0/−0	max.	+0/−3.0	min.	min.	max. [h]
$1^{13}/_{16}$	46.7	208 ±2	106	45.3	3	97.5	71.4	47.8	50.3
$2^{1}/_{16}$	53.1	222 ±2	114	50.8	3	111.3	82.5	53.8	60.5
$2^{9}/_{16}$	65.8	254 ±2	133	57.2	3	128.5	100.1	57.2	67.3
$3^{1}/_{16}$	78.5	287 ±2	154	64.3	3	153.9	122.2	63.5	77.7
$4^{1}/_{16}$	103.9	360 ±2	194	78.5	3	195.3	158.7	73.2	95.8
$5^{1}/_{8}$	131.1	419 ±2	226	98.6	3	244.3	200.2	81.8	118.1
$7^{1}/_{16}$	180.1	505 ±3	305	119.1	6	325.4	276.4	91.9	—
9	229.4	648 ±3	381	146.1	6	431.8	349.3	124.0	—
11	280.2	813 ±3	454	187.5	6	584.2	427.0	235.7	—
$13^{5}/_{8}$	347.0	886 ±3	541	204.7	6	595.4	528.6	114.3	—
$18^{3}/_{4}$	477.0	1162 ±3	722	255.5	6	812.8	730.2	155.4	—

Nominal Size of Flange	Raised Face Depth	Radius of Hub	Bolt Circle	Number of Bolts	Bolt Size and TPI	Bolt Holes		Blind Flange		Ring Groove
								Counter-bore Depth	Hub Height	
in.	Q'' [b]	*R*	*BC*	*N*	in.	*BH*		*E*	J_4	
Tolerance >	max.	± 1	See figure for GDT		(Ref.)	Diameter	Tolerance	max.	min.	
$1^{13}/_{16}$	6.06	10	160.3	8	$^{7}/_{8}$-9	26	+2/−0.5	—	—	BX 151
$2^{1}/_{16}$	6.45	10	174.8	8	$^{7}/_{8}$-9	26	+2/−0.5	—	—	BX 152
$2^{9}/_{16}$	7.25	10	200.2	8	1-8	29	+2/−0.5	—	—	BX 153
$3^{1}/_{16}$	8.04	10	230.1	8	$1^{1}/_{8}$-8	32	+2/−0.5	—	—	BX 154
$4^{1}/_{16}$	8.83	10	290.6	8	$1^{3}/_{8}$-8	39	+2/−0.5	—	—	BX 155
$5^{1}/_{8}$	10.03	16	342.9	12	$1^{1}/_{2}$-8	42	+2.5/−0.5	9.5	6.4	BX 169
$7^{1}/_{16}$	11.61	16	428.7	16	$1^{1}/_{2}$-8	42	+2.5/−0.5	11.1	7.9	BX 156
9	13.20	16	552.4	16	$1^{7}/_{8}$-8	51	+2.5/−0.5	12.7	14.2	BX 157
11	14.79	16	711.2	20	2-8	54	+2.5/−0.5	14.3	12.7	BX 158
$13^{5}/_{8}$	16.38	25	771.7	20	$2^{1}/_{4}$-8	61	+2.5/−0.5	15.9	17.5	BX 159
$18^{3}/_{4}$	18.76	25	1016.0	20	3-8	80	+3/−0.5	18.3	35.1	BX 164

Table D.6—Type 6BX Flanges for 138.0 MPa

Dimensions in millimeters unless noted otherwise



FOOTNOTES

[a] Break sharp corner.

[b] *Q''* min. = 3 mm. Raised face (*Ø K*) may be omitted on studded connectors, but thickness *T* shall still apply.

[c] Optional feature.

[d] Test connection shall be per 9.3 (Figure 5).

[e] Ring groove shall be concentric with bore *B* within 0.25 mm. diametrical runout. See Table D.11 for ring groove dimensions.

[f] Test flange style—applies to sizes $1^{13}/_{16}$ through $4^{1}/_{16}$ only.

[g] Blind flange style—applies to sizes $5^{1}/_{8}$ through $18^{3}/_{4}$ only.

[h] If the minimum value of J_3 is exceeded, the maximum depth *P* of the counterbore may be increased by the same amount or less.

Table D.6—Type 6BX Flanges for 138.0 MPa *(continued)*

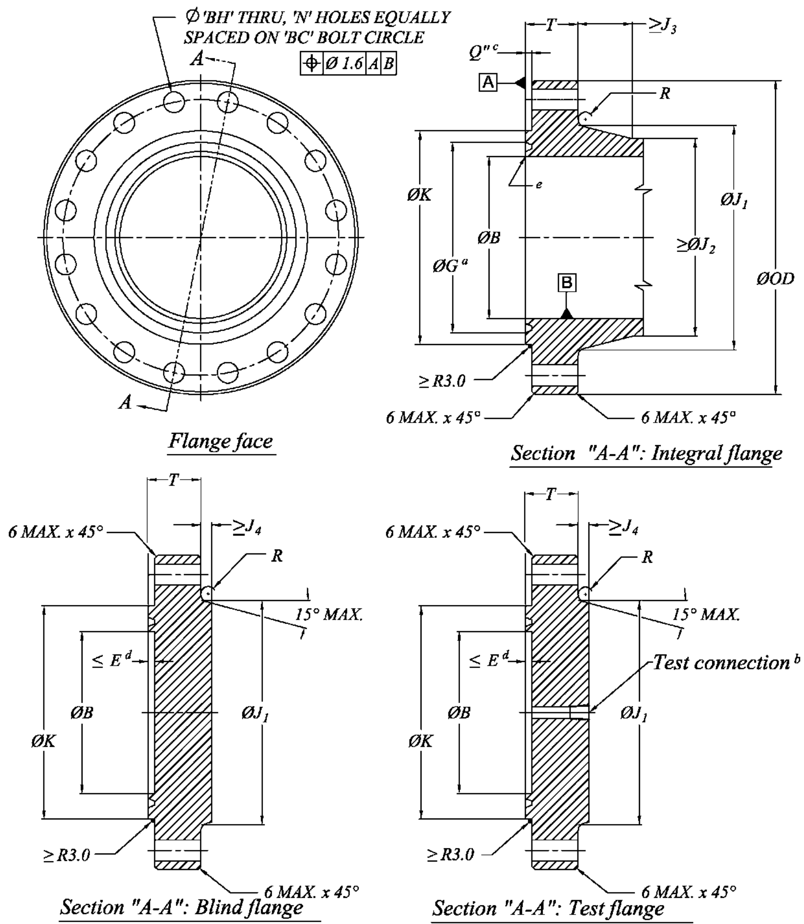
Dimensions in millimeters unless noted otherwise

Nominal Size of Flange in.	Maximum Bore B	Outside Diameter of Flange OD	Diameter of Raised Face K	Total Thickness of Flange T	Max. Chamfer C	Large Hub Diameter J_1	Small Hub Diameter J_2	Hub Length J_3	Test Flange C'bore Depth P^h
Tolerance>	max.	As noted	± 1.5	+3.0/−0	max.	+0/−3.0	min.	min.	max. [h]
1 13/16	46.7	257 ±2	117	63.5	3	133.4	109.5	49.3	63.5
2 1/16	53.1	287 ±2	132	71.4	3	153.9	127.0	52.3	63.5
2 9/16	65.8	325 ±2	151	79.3	3	173.0	144.5	58.7	63.5
3 1/16	78.5	357 ±2	171	85.9	3	192.0	160.3	63.5	63.5
4 1/16	103.9	446 ±2	219	106.5	3	242.8	206.2	73.2	63.5
5 1/8	131.1	516 ±3	264	127.0	3	292.1	247.7	97.5	—
7 1/16	180.1	656 ±3	353	165.1	6	385.8	338.1	96.8	—
9	229.4	805 ±3	441	204.8	6	481.1	428.8	107.9	—
11	280.2	883 ±3	505	223.8	6	566.7	508.0	103.1	—
13 5/8	347.0	1162 ±3	614	292.1	6	693.7	628.6	133.3	—

Nominal Size of Flange in.	Raised Face Depth $Q^{\prime\prime b}$	Radius of Hub R	Bolt Circle BC	Number of Bolts N	Bolt Size and TPI in.	Bolt Holes BH		Blind Flange C'bore Depth E	Blind Flange Hub Height J_4	Ring Groove
Tolerance>	max.	± 1	See figure for GDT		(Ref.)	Diameter	Tolerance	max.	min.	
1 13/16	6.06	10	203.2	8	1-8	29	+2/−0.5	—	—	BX 151
2 1/16	6.45	10	230.1	8	1 1/8-8	32	+2/−0.5	—	—	BX 152
2 9/16	7.25	10	261.9	8	1 1/4-8	35	+2/−0.5	—	—	BX 153
3 1/16	8.04	10	287.3	8	1 3/8-8	39	+2/−0.5	—	—	BX 154
4 1/16	8.83	10	357.1	8	1 3/4-8	48	+2.5/−0.5	—	—	BX 155
5 1/8	10.16	16	430.3	16	1 1/2-8	41	+2.5/−0.5	9.5	15.2	BX 169
7 1/16	11.61	16	554.0	16	2-8	54	+2.5/−0.5	11.1	7.9	BX 156
9	13.20	25	685.8	16	2 1/2-8	67	+2.5/−0.5	12.7	6.4	BX 157
11	14.79	25	749.3	16	2 3/4-8	74	+2.5/−0.5	14.3	12.7	BX 158
13 5/8	16.38	25	1016.0	20	3-8	80	+3/−0.5	15.9	14.2	BX 159

Table D.7—Type 6BX Large-bore Flanges for 13.8 MPa, 20.7 MPa, and 34.5 MPa

Dimensions in millimeters unless noted otherwise



FOOTNOTES

[a] Ring groove shall be concentric with bore B within 0.25 mm diametrical runout. See Table D.11 for ring groove dimensions.

[b] Test connection shall be $^1/_2$ in. NPT or per 9.3 (Figure 5).

[c] Q'' min. = 3 mm (may be omitted for studded flanges).

[d] Counterbore E for blind and test flanges is optional.

[e] Break sharp corner.

Table D.7—Type 6BX Large-bore Flanges for 13.8 MPa, 20.7 MPa, and 34.5 MPa *(continued)*

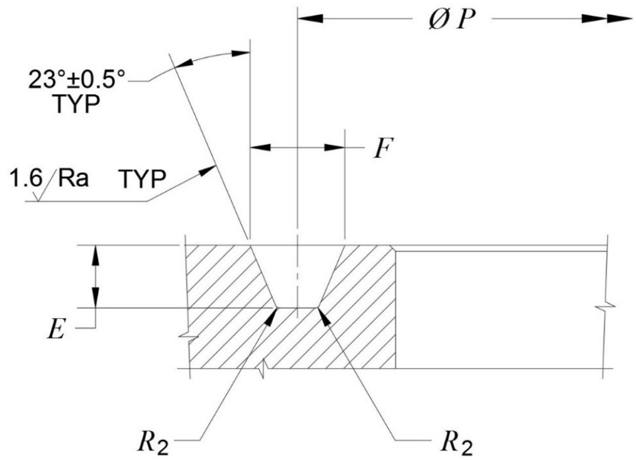
Dimensions in millimeters unless noted otherwise

Nominal Size	Maximum Bore	OD of Flange	Raised Face Depth	Raised Face Diameter	Total Thickness	Large Hub Diameter	Small Hub Diameter	Length of Hub
in.	*B*	*OD*	*Q″*	*K*	*T*	J_1	J_2	J_3
Tolerance>	max.	As noted	max.	± 1.5	+3.0/−0	+0/−3.0	min.	min.
13.8 MPa								
26 3/4	680.2	1041 ±3	6.4	805	126.3	835.9	743.0	185.7
30	762.8	1122 ±3	6.4	908	134.2	931.9	833.1	196.9
20.7 MPa								
26 3/4	680.2	1102 ±3	6.4	832	161.1	870.0	776.2	185.7
30	762.8	1186 ±3	6.4	922	167.2	970.0	871.2	196.9
34.5 MPa								
13 5/8	347.0	673 ±3	6.4	457	112.8	481.1	423.9	114.3
16 3/4	426.2	772 ±3	6.4	535	130.1	555.8	527.1	76.2
18 3/4	477.0	905 ±3	6.4	627	165.9	674.6	598.4	152.4
21 1/4	540.5	991 ±3	6.4	702	180.9	759.0	679.5	165.1

Nominal Size	Radius of Hub	Bolt Circle	Number of Bolts	Bolt Size and TPI	Bolt Hole Diameter	Blind Flange		Ring Groove
						Counter-bore Depth	Hub Height	
in.	*R*	*BC*	*N*	in.	*BH*	*E*	J_4	
Tolerance>	± 1	See figure for GDT		(Ref.)	+2.5/−0.5	max.	min.	
13.8 MPa								
26 3/4	16	952.5	20	1 3/4-8	48	21.4	9.7	BX 167
30	16	1039.9	32	1 5/8-8	45	23.0	17.5	BX 303
20.7 MPa								
26 3/4	16	1000.3	24	2-8	54	21.4	NA	BX 168
30	16	1090.7	32	1 7/8-8	51	23.0	12.7	BX 303
34.5 MPa								
13 5/8	16	590.6	16	1 5/8-8	45	14.3	23.9	BX 160
16 3/4	19	676.1	16	1 7/8-8	51	8.3	17.5	BX 162
18 3/4	16	803.1	20	2-8	54	18.3	19.1	BX 163
21 1/4	18	886.0	24	2-8	54	19.1	22.4	BX 165

Table D.8—Type R Ring Grooves

Dimensions in millimeters, unless noted otherwise, surface roughness in micrometers



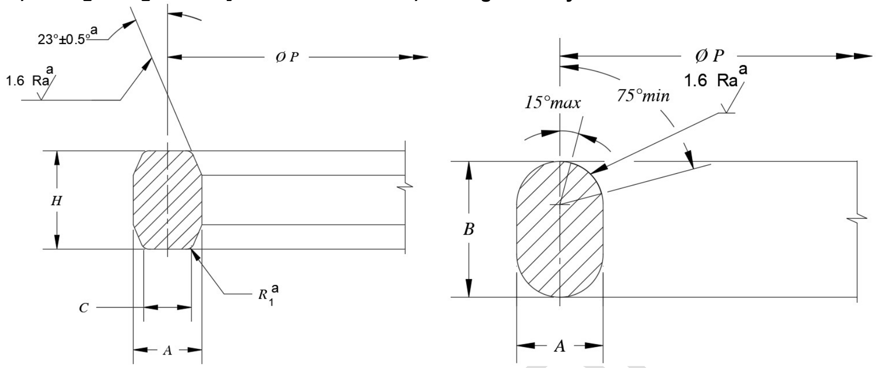
Dimensions in millimeters unless noted otherwise

Groove Number	Nominal Size of Flange in.	Pitch Diameter *P*	Depth of Groove *E*	Width of Groove *F*	Radius in Groove *R*2
Tolerance>	(Ref.)	± 0.13	+0.5/−0	± 0.20	max.
R 23	2 1/16	82.55	7.9	11.91	0.8
R 24	2 1/16	95.25	7.9	11.91	0.8
R 26	2 9/16	101.60	7.9	11.91	0.8
R 27	2 9/16	107.95	7.9	11.91	0.8
R 31	3 1/8	123.83	7.9	11.91	0.8
R 35	3 1/8	136.53	7.9	11.91	0.8
R 37	4 1/16	149.23	7.9	11.91	0.8
R 39	4 1/16	161.93	7.9	11.91	0.8
R 41	5 1/8	180.98	7.9	11.91	0.8
R 44	5 1/8	193.68	7.9	11.91	0.8
R 45	7 1/16	211.15	7.9	11.91	0.8
R 46	7 1/16	211.15	9.7	13.49	1.5
R 49	9	269.88	7.9	11.91	0.8
R 50	9	269.88	11.2	16.66	1.5
R 53	11	323.85	7.9	11.91	0.8
R 54	11	323.85	11.2	16.66	1.5
R 57	13 5/8	381.00	7.9	11.91	0.8
R 65	16 3/4	469.90	7.9	11.91	0.8
R 66	16 3/4	469.90	11.2	16.66	1.5
R 73	21 1/4	584.20	9.7	13.49	1.5
R 74	20 3/4	584.20	12.7	19.84	1.5

Table D.9—Type R Ring Gaskets

Dimensions in millimeters, unless noted otherwise, surface roughness in micrometers.

a) Octagonal gasket style **b) Oval gasket style**



FOOTNOTE

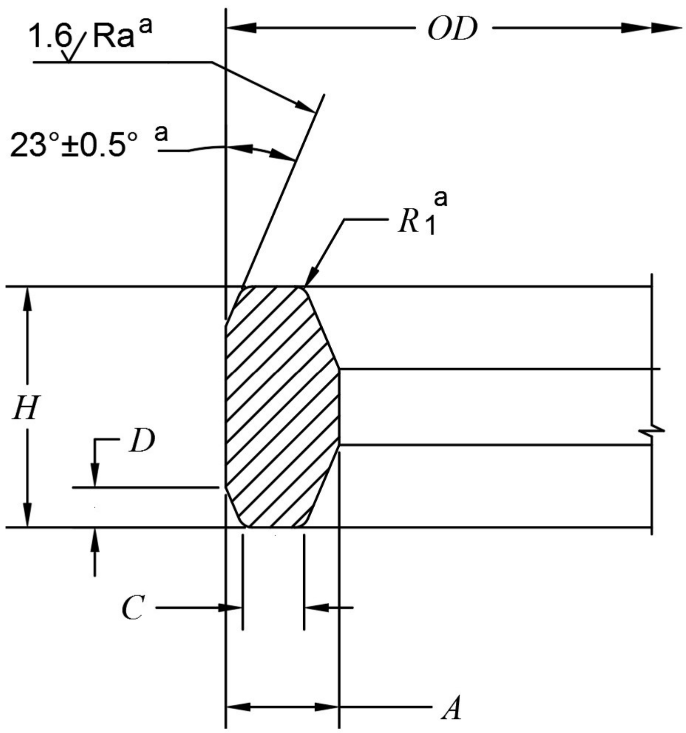
[a] Typical four places.

Dimensions in millimeters

Gasket Number	Pitch Diameter *P*	Width of Ring *A*	Height of Oval Ring *B*	Height of Octagonal Ring *H*	Width of Flat on Octagonal Ring *C*	Radius on Octagonal Ring R_1	Distance between Flanges *S*
Tolerance>	± 0.18	± 0.20	± 0.5	± 0.5	± 0.20	± 0.5	(Approx.)
R 23	82.55	11.13	17.5	15.9	7.75	1.5	4.8
R 24	95.25	11.13	17.5	15.9	7.75	1.5	4.8
R 26	101.6	11.13	17.5	15.9	7.75	1.5	4.8
R 27	107.95	11.13	17.5	15.9	7.75	1.5	4.8
R 31	123.83	11.13	17.5	15.9	7.75	1.5	4.8
R 35	136.53	11.13	17.5	15.9	7.75	1.5	4.8
R 37	149.23	11.13	17.5	15.9	7.75	1.5	4.8
R 39	161.93	11.13	17.5	15.9	7.75	1.5	4.8
R 41	180.98	11.13	17.5	15.9	7.75	1.5	4.8
R 44	193.68	11.13	17.5	15.9	7.75	1.5	4.8
R 45	211.15	11.13	17.5	15.9	7.75	1.5	4.8
R 46	211.15	12.70	19.1	17.5	8.66	1.5	4.8
R 49	269.88	11.13	17.5	15.9	7.75	1.5	4.8
R 50	269.88	15.88	22.4	20.6	10.49	1.5	4.1
R 53	323.85	11.13	17.5	15.9	7.75	1.5	4.8
R 54	323.85	15.88	22.4	20.6	10.49	1.5	4.1
R 57	381.00	11.13	17.5	15.9	7.75	1.5	4.8
R 65	469.90	11.13	17.5	15.9	7.75	1.5	4.8
R 66	469.90	15.88	22.4	20.6	10.49	1.5	4.1
R 73	584.20	12.70	19.1	17.5	8.66	1.5	3.3
R 74	584.20	19.05	25.4	23.9	12.32	1.5	4.8

Table D.10—Type RX Ring Gaskets

Dimensions in millimeters, unless noted otherwise, surface roughness in micrometers.



FOOTNOTE
[a] Typical four places.

Table D.10—Type RX Ring Gaskets *(continued)*

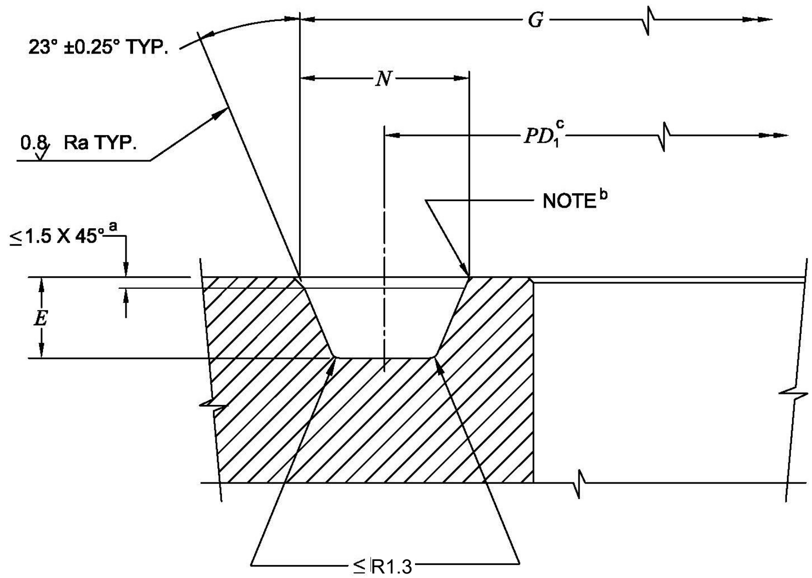
Dimensions in millimeters

Gasket Number	Outside Diameter	Width of Ring	Width of Flat	Height of Ring	Height of OD Bevel	Radius on Ring	Distance between Flanges
	OD	*A* [a]	*C*	*H* [a]	*D*	R_1	*S*
Tolerance>	+0.50/−0	+0.20/−0	+0.15/−0	+0.20/−0	+0/−0.80	± 0.5	(Approx.)
RX 23	93.27	11.91	6.45	25.40	4.24	1.5	11.9
RX 24	105.97	11.91	6.45	25.40	4.24	1.5	11.9
RX 26	111.91	11.91	6.45	25.40	4.24	1.5	11.9
RX 27	118.26	11.91	6.45	25.40	4.24	1.5	11.9
RX 31	134.54	11.91	6.45	25.40	4.24	1.5	11.9
RX 35	147.24	11.91	6.45	25.40	4.24	1.5	11.9
RX 37	159.94	11.91	6.45	25.40	4.24	1.5	11.9
RX 39	172.64	11.91	6.45	25.40	4.24	1.5	11.9
RX 41	191.69	11.91	6.45	25.40	4.24	1.5	11.9
RX 44	204.39	11.91	6.45	25.40	4.24	1.5	11.9
RX 45	221.84	11.91	6.45	25.40	4.24	1.5	11.9
RX 46	222.25	13.49	6.68	28.58	4.78	1.5	11.9
RX 49	280.59	11.91	6.45	25.40	4.24	1.5	11.9
RX 50	283.36	16.66	8.51	31.75	5.28	1.5	11.9
RX 53	334.57	11.91	6.45	25.40	4.24	1.5	11.9
RX 54	337.34	16.66	8.51	31.75	5.28	1.5	11.9
RX 57	391.72	11.91	6.45	25.40	4.24	1.5	11.9
RX 65	480.62	11.91	6.45	25.40	4.24	1.5	11.9
RX 66	483.39	16.66	8.51	31.75	5.28	1.5	11.9
RX 73	596.11	13.49	6.68	31.75	5.28	1.5	15.0
RX 74	600.86	19.84	10.34	41.28	6.88	2.3	18.3

FOOTNOTE
[a] The variation in width *A* or height *H* of any ring shall not exceed 0.10 mm throughout its entire circumference.

Table D.11—Type BX Ring Grooves

Dimensions in millimeters; surface roughness in micrometers



FOOTNOTES

a The 1.5 x 45° chamfer is optional and only applies to the outside (OD) of the groove.

b Break sharp corner 0.8 mm maximum at inside (ID) of the groove.

c Reference dimension.

Table D.11—Type BX Ring Grooves *(continued)*

Dimensions in millimeters unless noted otherwise

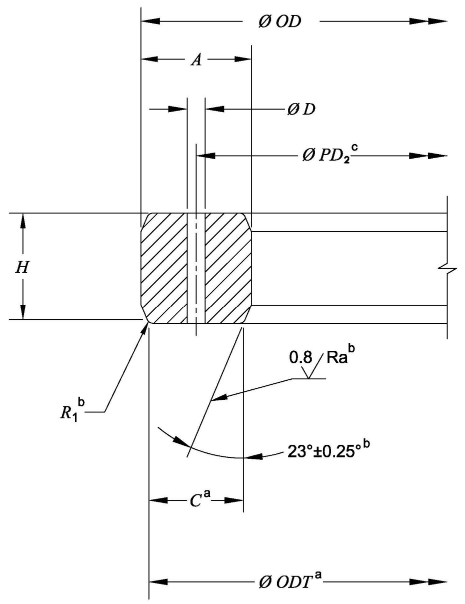
Groove Number	Nominal Size of Flange	Outside Diameter of Groove	Depth of Groove	Width of Groove	Pitch Diameter of Groove	Pitch Diameter of Gasket [a]
	in.	*G*	*E*	*N*	PD_1	PD_2
Tolerance>	(Ref.)	+0.10/−0	+0.50/−0	+0.10/−0	(Ref.)	(Ref.)
BX 151	1 13/16	77.77	5.56	11.84	65.93	66.60
BX 152	2 1/16	86.23	5.95	12.65	73.58	74.27
BX 153	2 9/16	102.77	6.75	14.07	88.70	89.39
BX 154	3 1/16	119.00	7.54	15.39	103.61	104.27
BX 155	4 1/16	150.62	8.33	17.73	132.89	133.57
BX 156	7 1/16	241.83	11.11	23.39	218.44	219.13
BX 157	9	299.06	12.70	26.39	272.67	273.31
BX 158	11	357.23	14.29	29.18	328.05	328.73
BX 159	13 5/8	432.64	15.88	32.49	400.15	400.85
BX 160	13 5/8	408.00	14.29	19.96	388.04	388.68
BX 161	16 3/4	497.94	17.07	23.62	474.32	475.03
BX 162	16 3/4	478.33	8.33	17.91	460.42	461.10
BX 163	18 3/4	563.50	18.26	25.55	537.95	538.62
BX 164	18 3/4	577.90	18.26	32.77	545.13	545.80
BX 165	21 1/4	632.56	19.05	27.20	605.36	606.05
BX 166	21 1/4	647.88	19.05	34.87	613.01	613.72
BX 167	26 3/4	768.33	21.43	22.91	745.42	746.08
BX 168	26 3/4	774.22	21.43	25.86	748.36	749.03
BX 169	5 1/8	176.66	9.53	16.92	159.74	160.41
BX 170	9	220.88	8.33	17.91	202.97	203.64
BX 171	11	270.28	8.33	17.91	252.37	253.05
BX 172	13 5/8	335.92	8.33	17.91	318.01	318.68
BX 303	30	862.30	22.62	27.38	834.92	835.61

FOOTNOTE

[a] PD_2 of gaskets provided for comparison purposes. See Table E.12 for ring gasket dimensions. Pitch diameter calculated using dimensions at middle of tolerance range.

Table D.12—Type BX Ring Gaskets

Dimensions in millimeters; surface roughness in micrometers



FOOTNOTES

a Typical two places (top and bottom).

b Typical four places (all corners).

c Reference dimension (see Table D.11 for value).

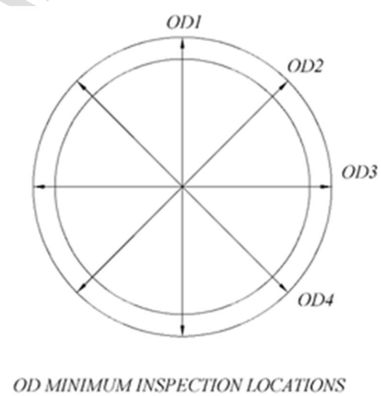


Table D.12—Type BX Ring Gaskets *(continued)*

Dimensions in millimeters

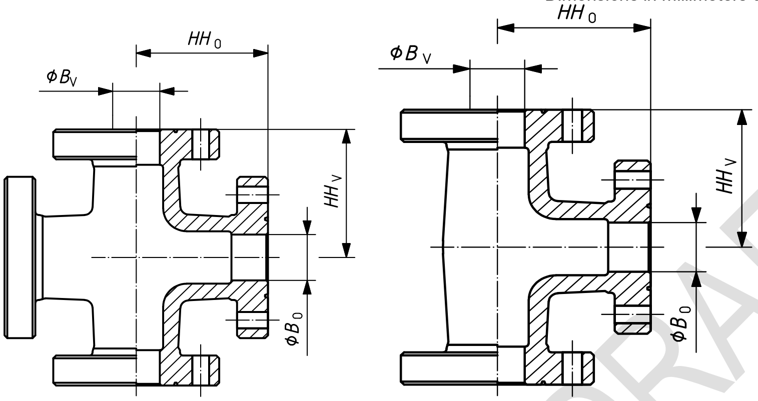
Groove Number	Outside Diameter[a]	Width of Ring	Height of Ring	Diameter of Flat	Width of Flat	Hole Size	Radius on Ring	
	OD	*A*	*H*	*ODT*	*C*	*D*	R_1	
Tolerance>	+0/−0.15	+0.20/−0	+0.20/−0	± 0.05	+0.15/−0	± 0.5	min.	max.
BX 151	76.40	9.63	9.63	75.03	8.26	1.6	0.8	1.2
BX 152	84.68	10.24	10.24	83.24	8.79	1.6	0.8	1.2
BX 153	100.94	11.38	11.38	99.31	9.78	1.6	0.9	1.4
BX 154	116.84	12.40	12.40	115.09	10.64	1.6	1.0	1.5
BX 155	147.96	14.22	14.22	145.95	12.22	1.6	1.1	1.7
BX 156	237.92	18.62	18.62	235.28	15.98	3.2	1.5	2.2
BX 157	294.46	20.98	20.98	291.49	18.01	3.2	1.7	2.5
BX 158	352.04	23.14	23.14	348.77	19.86	3.2	1.9	2.8
BX 159	426.72	25.70	25.70	423.09	22.07	3.2	2.1	3.1
BX 160	402.59	13.74	23.83	399.21	10.36	3.2	1.9	2.9
BX 161	491.41	16.21	28.07	487.45	12.24	3.2	2.2	3.4
BX 162	475.49	14.22	14.22	473.48	12.22	1.6	1.1	1.7
BX 163	556.16	17.37	30.10	551.89	13.11	3.2	2.4	3.6
BX 164	570.56	24.59	30.10	566.29	20.32	3.2	2.4	3.6
BX 165	624.71	18.49	32.03	620.19	13.97	3.2	2.6	3.8
BX 166	640.03	26.14	32.03	635.51	21.62	3.2	2.6	3.8
BX 167	759.36	13.11	35.87	754.28	8.03	1.6	2.9	4.3
BX 168	765.25	16.05	35.87	760.17	10.97	1.6	2.9	4.3
BX 169	173.51	12.93	15.85	171.27	10.69	1.6	1.3	1.9
BX 170	218.03	14.22	14.22	216.03	12.22	1.6	1.1	1.7
BX 171	267.44	14.22	14.22	265.43	12.22	1.6	1.1	1.7
BX 172	333.07	14.22	14.22	331.06	12.22	1.6	1.1	1.7
BX 303	852.75	16.97	37.95	847.37	11.61	1.6	3.0	4.6

FOOTNOTE

[a] The requirements of 10.4.5.4.2.3 and 10.4.5.4.2.4 shall apply.

Table D.13—Flanged Crosses and Tees

Dimensions in millimeters unless noted otherwise



Nominal Sizes In.	Bore Diameter Vertical Run B_V	Bore Diameter Horizontal Run B_O	Center-to-face Vertical Run HH_V	Center-to-face Horizontal Run HH_O
Tolerance>	+0.8/−0	+0.8/−0	± 0.8	± 0.8
13.8 MPa				
2 1/16 x 2 1/16	52.3	52.3	147.5	147.5
2 9/16 x 2 1/16	65.0	52.3	151.0	160.5
2 9/16 x 2 9/16	65.0	65.0	166.5	166.5
3 1/8 x 2 1/16	79.3	52.3	154.0	170.0
3 1/8 x 2 9/16	79.3	65.0	166.5	173.0
3 1/8 x 3 1/8	79.3	79.3	179.5	179.5
4 1/16 x 2 1/16	103.1	52.3	160.5	201.5
4 1/16 x 2 9/16	103.1	65.0	173.0	205.0
4 1/16 x 3 1/8	103.1	79.3	182.5	208.0
4 1/16 x 4 1/16	103.1	103.1	217.5	217.5
20.7 MPa				
2 1/16 x 2 1/16	52.3	52.3	185.5	185.5
2 9/16 x 2 1/16	65.0	52.3	189.0	200.0
2 9/16 x 2 9/16	65.0	65.0	211.0	211.0
3 1/8 x 2 1/16	79.3	52.3	185.5	198.5
3 1/8 x 2 9/16	79.3	65.0	200.0	201.5
3 1/8 x 3 1/8	79.3	79.3	192.0	192.0
4 1/16 x 2 1/16	103.1	52.3	192.0	224.0
4 1/16 x 2 9/16	103.1	65.0	206.5	227.0
4 1/16 x 3 1/8	103.1	79.3	205.0	224.0
4 1/16 x 4 1/16	103.1	103.1	230.0	230.0

Table D.13—Flanged Crosses and Tees *(continued)*

Dimensions in millimeters unless noted otherwise

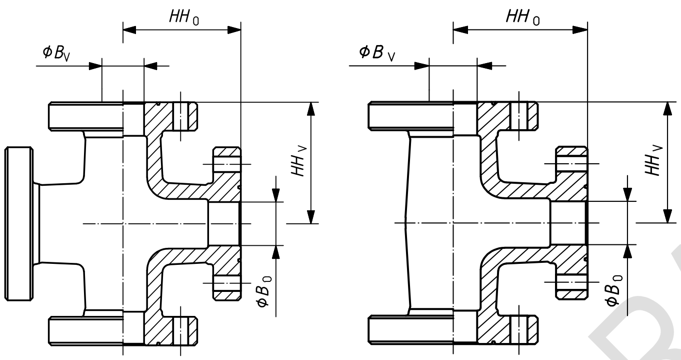
Nominal Sizes in.	Bore Diameter		Center-to-face Vertical Run	Center-to-face Horizontal Run
	Vertical Run B_V	Horizontal Run B_O	HH_V	HH_O
Tolerance>	+0.8/−0	+0.8/−0	± 0.8	± 0.8
34.5 MPa				
2 1/16 x 2 1/16	52.3	52.3	185.5	185.5
2 9/16 x 2 1/16	65.0	52.3	189.0	200.0
2 9/16 x 2 9/16	65.0	65.0	211.0	211.0
3 1/8 x 2 1/16	79.3	52.3	195.5	211.0
3 1/8 x 2 9/16	79.3	65.0	209.5	214.5
3 1/8 x 3 1/8	79.3	79.3	236.5	236.5
4 1/16 x 2 1/16	103.1	52.3	201.5	233.5
4 1/16 x 2 9/16	103.1	65.0	216.0	236.5
4 1/16 x 3 1/8	103.1	79.3	227.0	243.0
4 1/16 x 4 1/16	103.1	103.1	274.5	274.5
5 1/8 x 2 1/16	130.1 [a]	52.3	230.0	268.5
5 1/8 x 2 9/16	130.1 [a]	65.0	244.5	271.5
5 1/8 x 3 1/8	130.1 [a]	79.3	255.5	278.0
5 1/8 x 4 1/16	130.1 [a]	103.1	278.0	284.0
5 1/8 x 5 1/8	130.1 [a]	130.1 [a]	309.5	309.5
69.0 MPa				
2 1/16 x 1 13/16	52.3	46.0	169.5	174.0
2 1/16 x 2 1/16	52.3	52.3	176.0	176.0
2 9/16 x 1 13/16	65.0	46.0	176.5	189.5
2 9/16 x 2 1/16	65.0	52.3	183.0	191.5
2 9/16 x 2 9/16	65.0	65.0	199.0	199.0
3 1/16 x 1 13/16	77.7	46.0	183.5	209.0
3 1/16 x 2 1/16	77.7	52.3	190.0	210.5
3 1/16 x 2 9/16	77.7	65.0	206.0	218.0
3 1/16 x 3 1/16	77.7	77.7	225.0	225.0
4 1/16 x 1 13/16	103.1	46.0	198.5	235.0
4 1/16 x 2 1/16	103.1	52.3	205.0	237.0
4 1/16 x 2 9/16	103.1	65.0	220.5	244.0
4 1/16 x 3 1/16	103.1	77.7	239.5	251.0
4 1/16 x 4 1/16	103.1	103.1	262.5	262.5
5 1/8 x 1 13/16	130.1 [a]	46.0	208.0	255.5
5 1/8 x 2 1/16	130.1 [a]	52.3	214.5	257.0
5 1/8 x 2 9/16	130.1 [a]	65.0	230.0	264.5
5 1/8 x 3 1/16	130.1 [a]	77.7	249.0	271.5
5 1/8 x 4 1/16	130.1 [a]	103.1	272.5	284.0
5 1/8 x 5 1/8	130.1 [a]	130.1 [a]	293.0	293.0

FOOTNOTE

[a] Tolerance on 5 1/8 bore is +1.0/−0.

Table D.13—Flanged Crosses and Tees *(continued)*

Dimensions in millimeters unless noted otherwise



Nominal Sizes In.	Bore Diameter		Center-to-face Vertical Run	Center-to-face Horizontal Run
	Vertical Run B_V	Horizontal Run B_O	HH_V	HH_O
Tolerance>	+0.8/−0	+0.8/−0	± 0.8	± 0.8
103.5 MPa				
$2^{1}/_{16}$ x $1^{13}/_{16}$	52.3	46.0	186.5	188.0
$2^{1}/_{16}$ x $2^{1}/_{16}$	52.3	52.3	193.5	193.5
$2^{9}/_{16}$ x $1^{13}/_{16}$	65.0	46.0	193.0	204.0
$2^{9}/_{16}$ x $2^{1}/_{16}$	65.0	52.3	200.0	209.5
$2^{9}/_{16}$ x $2^{9}/_{16}$	65.0	65.0	216.0	216.0
$3^{1}/_{16}$ x $1^{13}/_{16}$	77.7	46.0	199.5	220.5
$3^{1}/_{16}$ x $2^{1}/_{16}$	77.7	52.3	207.0	226.0
$3^{1}/_{16}$ x $2^{9}/_{16}$	77.7	65.0	223.0	232.5
$3^{1}/_{16}$ x $3^{1}/_{16}$	77.7	77.7	239.5	239.5
$4^{1}/_{16}$ x $1^{13}/_{16}$	103.1	46.0	220.5	260.5
$4^{1}/_{16}$ x $2^{1}/_{16}$	103.1	52.3	228.0	266.0
$4^{1}/_{16}$ x $2^{9}/_{16}$	103.1	65.0	243.5	272.5
$4^{1}/_{16}$ x $3^{1}/_{16}$	103.1	77.7	260.5	279.5
$4^{1}/_{16}$ x $4^{1}/_{16}$	103.1	103.1	297.0	297.0
$5^{1}/_{8}$ x $1^{13}/_{16}$	130.1 [a]	46.0	238.0	290.5
$5^{1}/_{8}$ x $2^{1}/_{16}$	130.1 [a]	52.3	244.5	295.5
$5^{1}/_{8}$ x $2^{9}/_{16}$	130.1 [a]	65.0	260.5	301.5
$5^{1}/_{8}$ x $3^{1}/_{16}$	130.1 [a]	77.7	278.0	309.5
$5^{1}/_{8}$ x $4^{1}/_{16}$	130.1 [a]	103.1	314.5	324.0
$5^{1}/_{8}$ x $5^{1}/_{8}$	130.1 [a]	130.1 [a]	343.0	343.0

FOOTNOTE

[a] Tolerance on $5^{1}/_{8}$ bore is +1.0/−0.

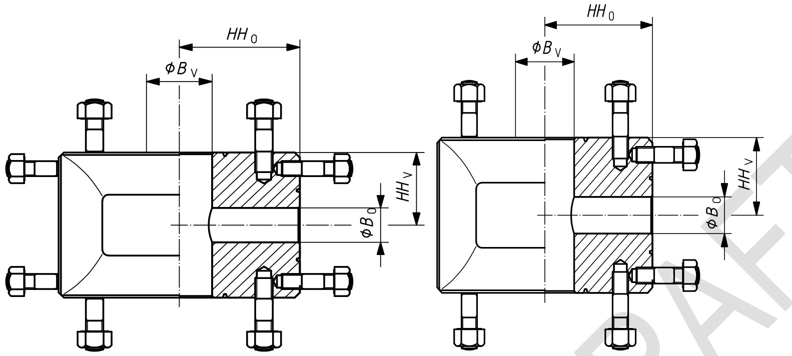
Table D.13—Flanged Crosses and Tees *(continued)*

Dimensions in millimeters unless noted otherwise

Nominal Sizes in.	Bore Diameter Vertical Run B_V	Bore Diameter Horizontal Run B_O	Center-to-face Vertical Run HH_V	Center-to-face Horizontal Run HH_O
Tolerance>	+0.8/−0	+0.8/−0	± 0.8	± 0.8
138.0 MPa				
$1^{13}/_{16}$ x $1^{13}/_{16}$	46.0	46.0	227.0	227.0
$2^{1}/_{16}$ x $1^{13}/_{16}$	52.3	46.0	235.0	242.0
$2^{1}/_{16}$ x $2^{1}/_{16}$	52.3	52.3	250.0	250.0
$2^{9}/_{16}$ x $1^{13}/_{16}$	65.0	46.0	243.0	261.0
$2^{9}/_{16}$ x $2^{1}/_{16}$	65.0	52.3	258.0	269.0
$2^{9}/_{16}$ x $2^{9}/_{16}$	65.0	65.0	277.0	277.0
$3^{1}/_{16}$ x $1^{13}/_{16}$	77.7	46.0	252.5	277.0
$3^{1}/_{16}$ x $2^{1}/_{16}$	77.7	52.3	267.5	259.5
$3^{1}/_{16}$ x $2^{9}/_{16}$	77.7	65.0	286.5	293.0
$3^{1}/_{16}$ x $3^{1}/_{16}$	77.7	77.7	302.5	302.5
$4^{1}/_{16}$ x $1^{13}/_{16}$	103.1	46.0	282.5	321.5
$4^{1}/_{16}$ x $2^{1}/_{16}$	103.1	52.3	297.5	321.5
$4^{1}/_{16}$ x $2^{9}/_{16}$	103.1	65.0	316.5	337.5
$4^{1}/_{16}$ x $3^{1}/_{16}$	103.1	77.7	332.5	347.0
$4^{1}/_{16}$ x $4^{1}/_{16}$	103.1	103.1	377.0	377.0

Table D.14—Studded Crosses and Tees

Dimensions in millimeters unless noted otherwise



Nominal Sizes In.	Bore Diameter Vertical Run B_V	Bore Diameter Horizontal Run B_O	Center-to-face Vertical Run HH_V	Center-to-face Horizontal Run HH_O
Tolerance>	+0.8/−0	+0.8/−0	± 0.8	± 0.8
13.8 MPa				
2 1/16 x 2 1/16	52.3	52.3	89.0	89.0
2 9/16 x 2 1/16	65.0	52.3	89.0	101.5
2 9/16 x 2 9/16	65.0	65.0	114.5	114.5
3 1/8 x 2 1/16	79.3	52.3	89.0	114.5
3 1/8 x 2 9/16	79.3	65.0	114.5	114.5
3 1/8 x 3 1/8	79.3	79.3	114.5	114.5
4 1/16 x 2 1/16	103.1	52.3	114.5	139.5
4 1/16 x 2 9/16	103.1	65.0	114.5	139.5
4 1/16 x 3 1/8	103.1	79.3	114.5	139.5
4 1/16 x 4 1/16	103.1	103.1	139.5	139.5
7 1/16 x 2 1/16	179.3	52.3	137.2	190.5
7 1/16 x 2 9/16	179.3	65.0	137.2	190.5
7 1/16 x 3 1/8	179.3	79.3	137.2	190.5
7 1/16 x 4 1/16	179.3	103.1	161.3	190.5
7 1/16 x 5 1/8	179.3	130.1 [a]	177.8	190.5
7 1/16 x 7 1/16	179.3	179.3	190.5	190.5

FOOTNOTE

[a] Tolerance on 5 1/8 bore is +1.0/−0.

Table D.14—Studded Crosses and Tees *(continued)*

Dimensions in millimeters unless noted otherwise

Nominal Sizes in.	Bore Diameter Vertical Run B_V	Bore Diameter Horizontal Run B_O	Center-to-face Vertical Run HH_V	Center-to-face Horizontal Run HH_O
Tolerance>	+0.8/−0	+0.8/−0	± 0.8	± 0.8
20.7 MPa				
2 1/16 x 2 1/16	52.3	52.3	114.5	114.5
2 9/16 x 2 1/16	65.0	52.3	114.5	127.0
2 9/16 x 2 9/16	65.0	65.0	127.0	127.0
3 1/8 x 2 1/16	79.3	52.3	114.5	127.0
3 1/8 x 2 9/16	79.3	65.0	127.0	127.0
3 1/8 x 3 1/8	79.3	79.3	127.0	127.0
4 1/16 x 2 1/16	103.1	52.3	114.5	155.5
4 1/16 x 2 9/16	103.1	65.0	127.0	155.5
4 1/16 x 3 1/8	103.1	79.3	127.0	155.5
4 1/16 x 4 1/16	103.1	103.1	155.5	155.5
7 1/16 x 2 1/16	179.3	52.3	135.1	210.1
7 1/16 x 2 9/16	179.3	65.0	147.8	215.1
7 1/16 x 3 1/8	179.3	79.3	147.8	215.1
7 1/16 x 4 1/16	179.3	103.1	173.2	215.1
7 1/16 x 5 1/8	179.3	130.1 [a]	196.1	215.1
7 1/16 x 7 1/16	179.3	179.3	215.1	215.1
34.5 MPa				
2 1/16 x 2 1/16	52.3	52.3	114.5	114.5
2 9/16 x 2 1/16	65.0	52.3	114.5	127.0
2 9/16 x 2 9/16	65.0	65.0	127.0	127.0
3 1/8 x 2 1/16	79.3	52.3	114.5	139.5
3 1/8 x 2 9/16	79.3	65.0	139.5	139.5
3 1/8 x 3 1/8	79.3	79.3	139.5	139.5
4 1/16 x 2 1/16	103.1	52.3	114.5	165.0
4 1/16 x 2 9/16	103.1	65.0	127.0	165.0
4 1/16 x 3 1/8	103.1	79.3	139.5	165.0
4 1/16 x 4 1/16	103.1	103.1	165.0	165.0
5 1/8 x 2 1/16	130.1 [a]	52.3	155.5	193.5
5 1/8 x 2 9/16	130.1 [a]	65.0	155.5	193.5
5 1/8 x 3 1/8	130.1 [a]	79.3	155.5	193.5
5 1/8 x 4 1/16	130.1 [a]	103.1	202.5	202.5
5 1/8 x 5 1/8	130.1 [a]	130.1 [a]	202.5	202.5
7 1/16 x 2 1/16	179.3	52.3	167.1	217.9

7 1/16 x 2 9/16	179.3	65.0	167.1	217.9
7 1/16 x 3 1/8	179.3	79.3	167.1	217.9
7 1/16 x 4 1/16	179.3	103.1	188.7	217.9
7 1/16 x 5 1/8	179.3	130.1 [a]	217.9	217.9
7 1/16 x 7 1/16	179.3	179.3	217.9	217.9

FOOTNOTE
[a] Tolerance on 5 1/8 bore is +1.0/-0.

Table D.14—Studded Crosses and Tees *(continued)*

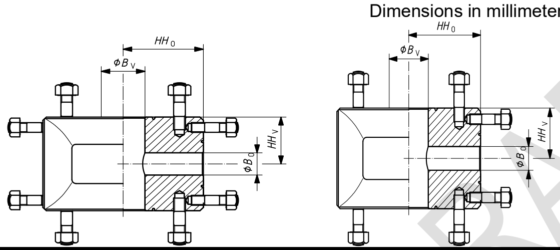
Dimensions in millimeters unless noted otherwise

Nominal Sizes in.	Bore Diameter		Center-to-face Vertical Run	Center-to-face Horizontal Run
	Vertical Run B_V	Horizontal Run B_O	HH_V	HH_O
Tolerance>	+0.8/−0	+0.8/−0	± 0.8	± 0.8
		69.0 MPa		
1 13/16 x 1 13/16	46.0	46.0	111.0	111.0
2 1/16 x 1 13/16	52.3	46.0	111.0	111.0
2 1/16 x 2 1/16	52.3	52.3	111.0	111.0
2 9/16 x 1 13/16	65.0	46.0	114.5	130.0
2 9/16 x 2 1/16	65.0	52.3	114.5	130.0
2 9/16 x 2 9/16	65.0	65.0	130.0	130.0
3 1/16 x 1 13/16	77.7	46.0	114.5	149.0
3 1/16 x 2 1/16	77.7	52.3	114.5	149.0
3 1/16 x 2 9/16	77.7	65.0	130.0	149.0
3 1/16 x 3 1/16	77.7	77.7	149.0	149.0
4 1/16 x 1 13/16	103.1	46.0	114.5	174.5
4 1/16 x 2 1/16	103.1	52.3	114.5	174.5
4 1/16 x 2 9/16	103.1	65.0	130.0	174.5
4 1/16 x 3 1/16	103.1	77.7	149.0	174.5
4 1/16 x 4 1/16	103.1	103.1	174.5	174.5
5 1/8 x 1 13/16	130.1 [a]	46.0	133.5	197.0
5 1/8 x 2 1/16	130.1 [a]	52.3	133.5	197.0
5 1/8 x 2 9/16	130.1 [a]	65.0	133.5	197.0
5 1/8 x 3 1/16	130.1 [a]	77.7	171.5	197.0
5 1/8 x 4 1/16	130.1 [a]	103.1	171.5	197.0
5 1/8 x 5 1/8	130.1 [a]	130.1 [a]	197.0	197.0
7 1/16 x 1 13/16	179.3	46.0	152.9	260.4
7 1/16 x 2 1/16	179.3	52.3	152.9	260.4
7 1/16 x 2 9/16	179.3	65.0	152.9	260.4
7 1/16 x 3 1/16	179.3	77.7	175.3	260.4
7 1/16 x 4 1/16	179.3	103.1	196.9	260.4
7 1/16 x 5 1/8	179.3	130.1 [a]	222.3	260.4
7 1/16 x 7 1/16	179.3	179.3	260.4	260.4

FOOTNOTE
[a] Tolerance on 5 1/8 bore is +1.0/−0.

Table D.14—Studded Crosses and Tees *(continued)*

Dimensions in millimeters unless noted otherwise



Nominal Sizes in.	Bore Diameter Vertical Run B_V	Bore Diameter Horizontal Run B_O	Center-to-face Vertical Run HH_V	Center-to-face Horizontal Run HH_O
Tolerance>	+0.8/−0	+0.8/−0	± 0.8	± 0.8
103.5 MPa				
$1^{13}/_{16}$ x $1^{13}/_{16}$	46.0	46.0	127.0	127.0
$2^{1}/_{16}$ x $1^{13}/_{16}$	52.3	46.0	127.0	127.0
$2^{1}/_{16}$ x $2^{1}/_{16}$	52.3	52.3	127.0	127.0
$2^{9}/_{16}$ x $1^{13}/_{16}$	65.0	46.0	139.5	139.5
$2^{9}/_{16}$ x $2^{1}/_{16}$	65.0	52.3	139.5	139.5
$2^{9}/_{16}$ x $2^{9}/_{16}$	65.0	65.0	139.5	139.5
$3^{1}/_{16}$ x $1^{13}/_{16}$	77.7	46.0	160.5	160.5
$3^{1}/_{16}$ x $2^{1}/_{16}$	77.7	52.3	160.5	160.5
$3^{1}/_{16}$ x $2^{9}/_{16}$	77.7	65.0	160.5	160.5
$3^{1}/_{16}$ x $3^{1}/_{16}$	77.7	77.7	160.5	160.5
$4^{1}/_{16}$ x $1^{13}/_{16}$	103.1	46.0	193.5	193.5
$4^{1}/_{16}$ x $2^{1}/_{16}$	103.1	52.3	193.5	193.5
$4^{1}/_{16}$ x $2^{9}/_{16}$	103.1	65.0	193.5	193.5
$4^{1}/_{16}$ x $3^{1}/_{16}$	103.1	77.7	193.5	193.5
$4^{1}/_{16}$ x $4^{1}/_{16}$	103.1	103.1	193.5	193.5
$5^{1}/_{8}$ x $1^{13}/_{16}$	130.1 [a]	46.0	168.0	222.0
$5^{1}/_{8}$ x $2^{1}/_{16}$	130.1 [a]	52.3	168.0	222.0
$5^{1}/_{8}$ x $2^{9}/_{16}$	130.1 [a]	65.0	168.0	222.0
$5^{1}/_{8}$ x $3^{1}/_{16}$	130.1 [a]	77.7	168.0	222.0
$5^{1}/_{8}$ x $4^{1}/_{16}$	130.1 [a]	103.1	235.0	235.0
$5^{1}/_{8}$ x $5^{1}/_{8}$	130.1 [a]	130.1 [a]	235.0	235.0
$7^{1}/_{16}$ x $1^{13}/_{16}$	179.3	46.0	152.9	279.4
$7^{1}/_{16}$ x $2^{1}/_{16}$	179.3	52.3	152.9	279.4
$7^{1}/_{16}$ x $2^{9}/_{16}$	179.3	65.0	175.3	279.4

7 1/16 x 3 1/16	179.3	77.7	175.3	279.4
7 1/16 x 4 1/16	179.3	103.1	215.9	279.4
7 1/16 x 5 1/8	179.3	130.1 [a]	250.2	279.4
7 1/16 x 7 1/16	179.3	179.3	279.4	279.4

FOOTNOTE
[a] Tolerance on 5 1/8 bore is +1.0/−0.

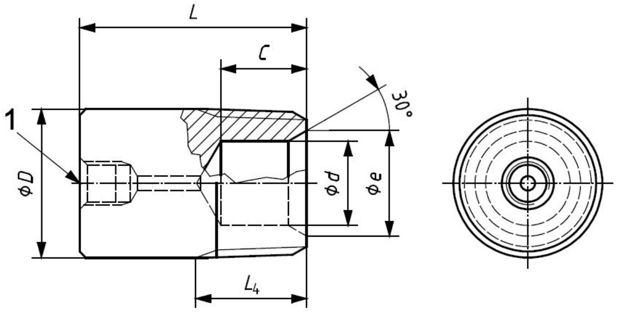
Table D.14—Studded Crosses and Tees *(continued)*

Dimensions in millimeters unless noted otherwise

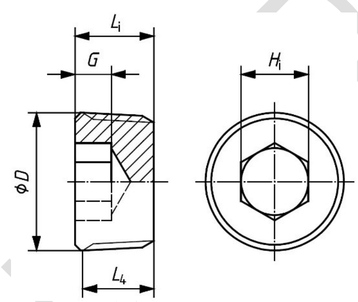
Nominal Sizes in.	Bore Diameter		Center-to-face Vertical Run HH_V	Center-to-face Horizontal Run HH_O
	Vertical Run B_V	Horizontal Run B_O		
Tolerance>	+0.8/−0	+0.8/−0	± 0.8	± 0.8
138.0 MPa				
1 13/16 x 1 13/16	46.0	46.0	164.5	164.5
2 1/16 x 1 13/16	52.3	46.0	164.5	164.5
2 1/16 x 2 1/16	52.3	52.3	164.5	164.5
2 9/16 x 1 13/16	65.0	46.0	185.0	185.0
2 9/16 x 2 1/16	65.0	52.3	185.0	185.0
2 9/16 x 2 9/16	65.0	65.0	185.0	185.0
3 1/16 x 1 13/16	77.7	46.0	202.5	202.5
3 1/16 x 2 1/16	77.7	52.3	202.5	202.5
3 1/16 x 2 9/16	77.7	65.0	202.5	202.5
3 1/16 x 3 1/16	77.7	77.7	202.5	202.5
4 1/16 x 1 13/16	103.1	46.0	251.5	251.5
4 1/16 x 2 1/16	103.1	52.3	251.5	251.5
4 1/16 x 2 9/16	103.1	65.0	251.5	251.5
4 1/16 x 3 1/16	103.1	77.7	251.5	251.5
4 1/16 x 4 1/16	103.1	103.1	251.5	251.5

Table D.15—Bullplugs

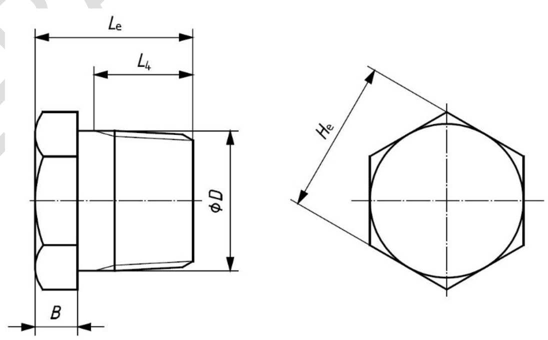
Dimensions in millimeters unless noted otherwise



a) Round plug



b) Plug with internal hex



c) Plug with external hex

Key

1 test or gauge port (optional)

NOTE See API 5B for thread dimensions and tolerances.

Table D.15—Bullplugs *(continued)*

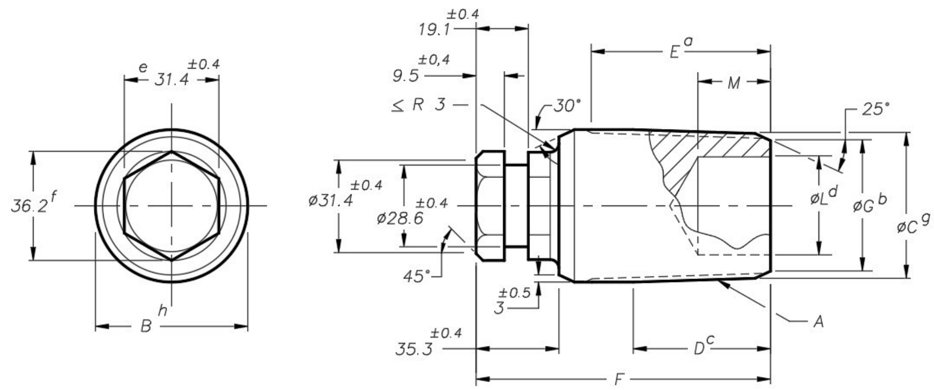
Dimensions in millimeters unless noted otherwise

	a), b), c) All Styles of Bullplugs						a) Round Plugs
Nominal Size in.	**Outside Diameter** *D*		**Minimum Length of Thread to Vanish Point** L_4	**Depth of Counterbore** *C*	**Diameter of Counterbore** *d*	**Diameter of Chamfer** *e*	**Overall Length** *L*
Tolerance>	Value	Tolerance	min.	± 0.5	+1.0/−0	+0.5/−0	+1.0/−0
1/2	21.43	+0.20/−0	19.85	None	None	None	51.0
3/4	26.59	+0.20/−0	20.15	None	None	None	51.0
1	33.34	+0.25/−0	25.01	None	None	None	51.0
1 1/4	42.07	+0.25/−0	25.62	27.0	22.4	None	51.0
1 1/2	48.42	+0.25/−0	26.04	27.0	25.4	None	51.0
2	60.33	+0.25/−0	26.88	64.0	41.0	50.8	102.0
2 1/2	73.03	+0.25/−0	39.91	41.5	44.5	None	102.0
3	88.90	+0.25/−0	41.50	41.5	57.2	None	102.0
3 1/2	101.60	+0.25/−0	42.77	44.5	69.9	None	102.0
4	114.30	+0.25/−0	44.04	44.5	76.2	None	102.0

	b) Plugs with Internal Hex				c) Plugs with External Hex			
Nominal Size in.	**Hex Size (Across Flats)** H_i		**Depth of Hex** *G*	**Overall Length** L_i	**Hex Size (Across Flats)** H_e		**Height of Hex** *B*	**Overall Length** L_e
Tolerance>	Value	Tolerance	+1.0/−0	+1.0/−0	Value	Tolerance	+1.0/−0	+1.0/−0
1/2	9.70	+0/−0.10	7.9	25.4	22.20	+0/−0.64	7.9	28.7
3/4	14.20	+0/−0.13	7.9	25.4	27.00	+0/−0.79	9.7	31.8
1	16.00	+0/−0.15	9.7	25.4	34.90	+0/−1.04	9.7	35.1

Table D.16—VR Plug Dimensions, 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa

Dimensions in millimeters, unless noted otherwise, surface roughness in micrometers



FOOTNOTES

a Full thread.

b Chamfer at end.

c End of taper.

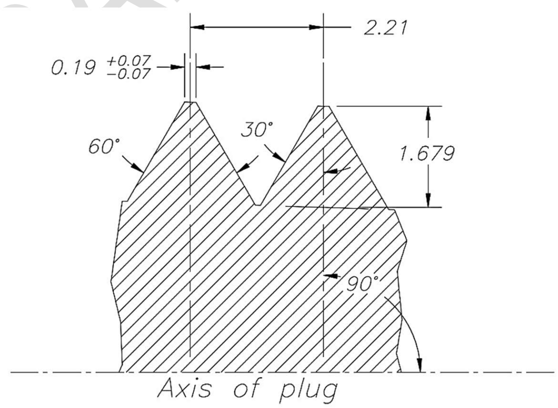
d Drill *L* diameter, *M* deep.

e Across flats.

f Across corners.

g Diameter at face.

h Equal to nominal diameter *A*.



VR Plug Thread Form Detail

Table D.16—VR Plug Dimensions, 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa *(continued)*

Dimensions in millimeters unless noted otherwise

Nominal Outlet Size in.	**Nominal Thread OD** in. *A*	**Threads per Inch** TPI	**Thread Type**	**Diameter at Large End** *B*	**Diameter at Small End** *C*	**Length of Taper** *D*	**Length of Full Thread** *E*	**Overall Length of Plug** *F*	**Chamfer Diameter** *G*	**Counter-bore Diameter** *L*	**Counter-bore Depth** *M*
Tolerance>		(Ref.)	NA	± 0.12	± 0.12	(Ref.)	(Ref.)	± 0.8	± 0.4	± 0.4	± 0.8
1 13/16	1.660	11 1/2	Line pipe	42.16	41.15	16.26	25.62	72.1	37.8	22.4	26.9
2 1/16	1.900	11 1/2	Sharp vee	48.26	46.59	26.70	34.93	80.3	43.2	25.4	26.9
2 9/16	2 3/8	11 1/2	Sharp vee	60.33	58.26	33.04	41.28	86.6	54.9	38.1	26.9
3 1/8 [a]	2 7/8	11 1/2	Sharp vee	73.03	70.26	44.18	52.39	97.5	66.9	44.5	41.4
4 1/16	3 1/2	11 1/2	Sharp vee	88.90	85.74	50.52	58.74	103.9	82.4	69.9	44.5

FOOTNOTES

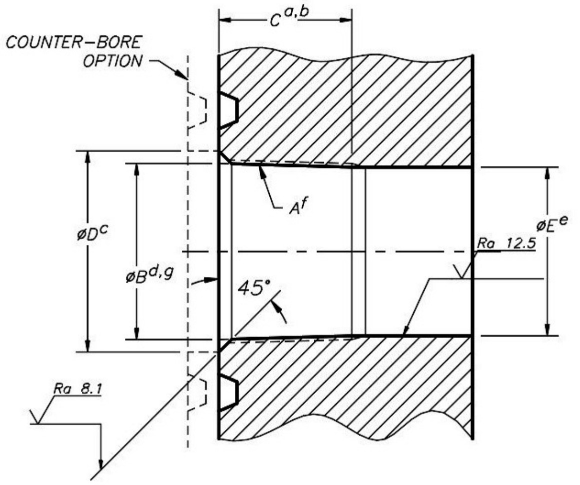
[a] 3 1/16 in. bore for 69.0 MPa RWP.

NOTE 1 Thread taper for all sizes shall be 1-in-16 (reference 1° 47' 24" with the centerline).

NOTE 2 Tolerances on angles, unless otherwise noted, shall be ± 0.5 degrees.

Table D.17—VR Preparation Dimensions, 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa

Dimensions in millimeters, unless noted otherwise, surface roughness in micrometers.



FOOTNOTES

[a] Full thread.

[b] Reference.

[c] Diameter of counterbore or chamfer.

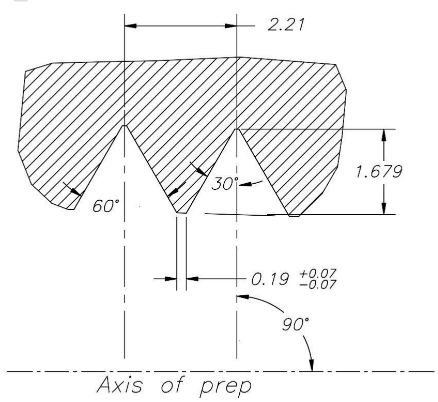
[d] Thread bore.

[e] Standard bore.

[f] Thread.

[g] Thread bore taken at face of flange, gauge thread from bottom of chamfer, counterbore is optional.

NOTE Line pipe and sharp vee plugs and preparations are not interchangeable.



VR Preparation Thread Form Detail

Table D.17—VR Preparation Dimensions, 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa *(continued)*

Dimensions in millimeters unless noted otherwise

Nominal Outlet Size in.	Nominal Thread OD in. *A*	Threads per Inch TPI	Thread Type	Thread Bore *B*	Full Thread Length *C*	Chamfer and Counterbore Diameter *D*	Straight Bore *E*
Tolerance>		(Ref.)	NA	± 0.13	(Ref.)	± 0.8	± 0.4
1 13/16	1.660	11 1/2	Line pipe	38.96	27.4	49.3	36.8
2 1/16	1.900	11 1/2	Sharp vee	45.03	38.4	55.6	42.2
2 9/16	2 3/8	11 1/2	Sharp vee	57.00	44.7	65.0	53.8
3 1/8 [a]	2 7/8	11 1/2	Sharp vee	69.65	55.9	77.7	65.7
4 1/16	3 1/2	11 1/2	Sharp vee	85.83	62.2	103.1	81.5

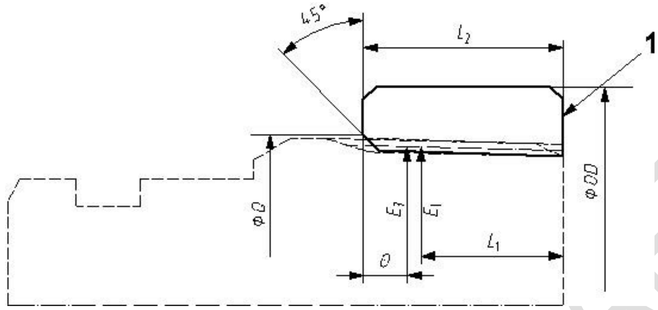
FOOTNOTES

[a] 3 1/16 in. bore for 69.0 MPa RWP.

NOTE Thread taper for all sizes shall be 1-in-16 (reference 1° 47' 24" with the centerline).

Table D.18—VR Plug Thread Gauging Dimensions, 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa

Dimensions in millimeters



Key

1 gauge standoff with end of VR plug: flush ± 1p

NOTE "p" is defined as the distance from a point on a nominal thread form to a corresponding point on the next thread, measured parallel to the axis. This value can be calculated by dividing 1 mm by the number of threads per millimeter.

Dimensions in millimeters unless noted otherwise

Nominal Size in.	Ring Gauge Outside Diameter OD	Ring Gauge Chamfer Diameter Q	Ring Gauge Length L_2	Face of Ring Gauge to Plane of Gauge Point θ
1 13/16	55.9	43.7	17.953	4.417
2 1/16	63.5	49.8	28.918	5.037
2 9/16	77.7	62.0	35.268	5.037
3 1/8 [a]	93.2	74.7	46.380	5.037
4 1/16	114.3	90.4	52.730	5.037

FOOTNOTES

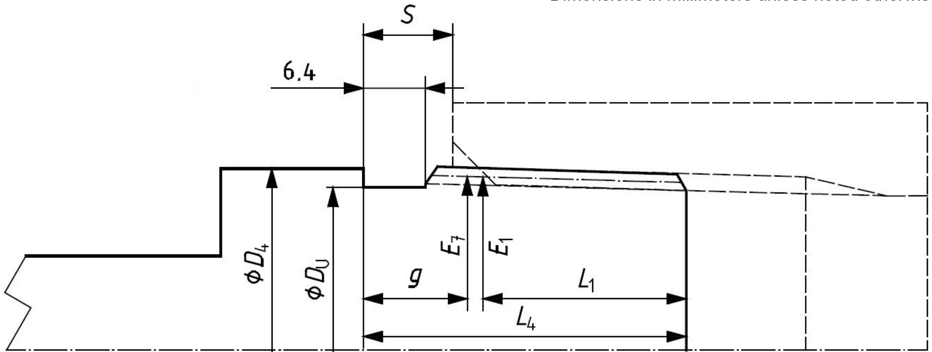
[a] 3 1/16 in. bore for 69.0 MPa RWP.

NOTE 1 See Table D.18 for location of dimensions.

NOTE 2 See Table D.19 for E_7, E_1, and L_1.

Table D.19—VR Preparation Thread Gauging Dimensions, 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa

Dimensions in millimeters unless noted otherwise



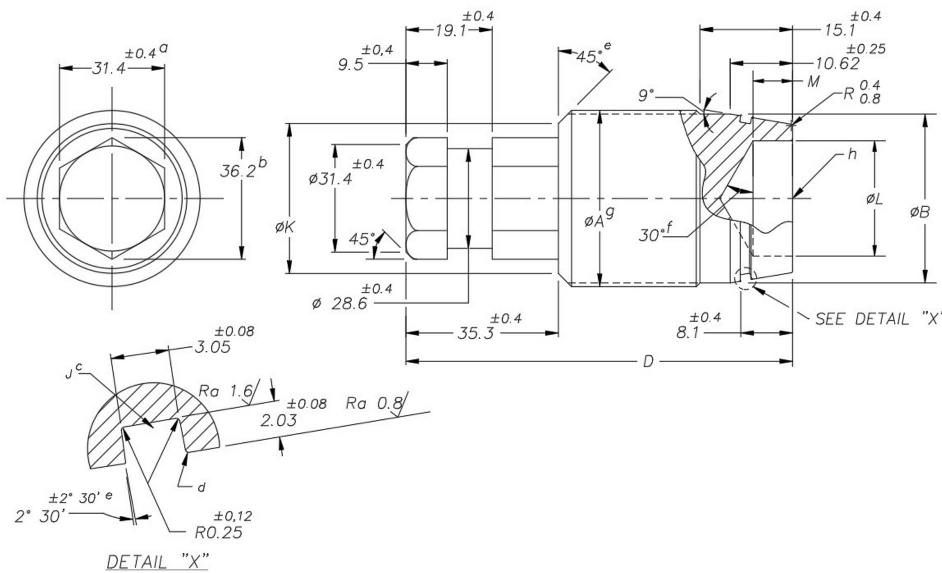
Nominal Outlet Size in.	Major Diameter D_4	Diameter of Plug Gauge Groove D_U	Threads per Inch	Length: End of Pipe to Hand-tight Plane L_1	Pitch Diameter at Hand-tight Plane E_1	Total Length: End of Pipe to Vanish Point L_4	Length: Gauge Point to Vanish Point g	Pitch Diameter at Gauge Point E_7	Standoff S ± 2.21
1 13/16	42.2	37.1	11 1/2	10.670	40.2179	25.616	12.080	39.0916	10.419
2 1/16	48.3	43.1	11 1/2	20.589	46.2874	34.925	11.044	46.4929	9.667
2 9/16	60.3	55.4	11 1/2	26.507	58.3255	41.275	11.044	58.5579	11.417
3 1/8 [a]	73.0	68.1	11 1/2	36.927	70.9821	52.388	11.044	71.2579	12.090
4 1/16	88.9	83.8	11 1/2	43.277	86.8571	58.738	11.044	87.1329	7.328

FOOTNOTE

[a] 3 1/16 in. bore for 69.0 MPa RWP.

Table D.20—HPVR Plug Dimensions, 103.5 MPa and 138.0 MPa

Dimensions in millimeters, unless noted otherwise, surface roughness in micrometers.



FOOTNOTES

a Across flats.

b Across corners.

c Install (SAE AS568A O-ring size number).

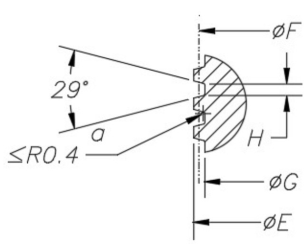
d Break corners approx. *R* 0.12.

e Typical.

f Optional.

g Thread.

h Drill *L* diameter, *M* deep.



Thread Form Detail

FOOTNOTE

a Typical for all full threads.

Table D.20—HPVR Plug Dimensions, 103.5 MPa and 138.0 MPa *(continued)*

Dimensions in millimeters unless noted otherwise

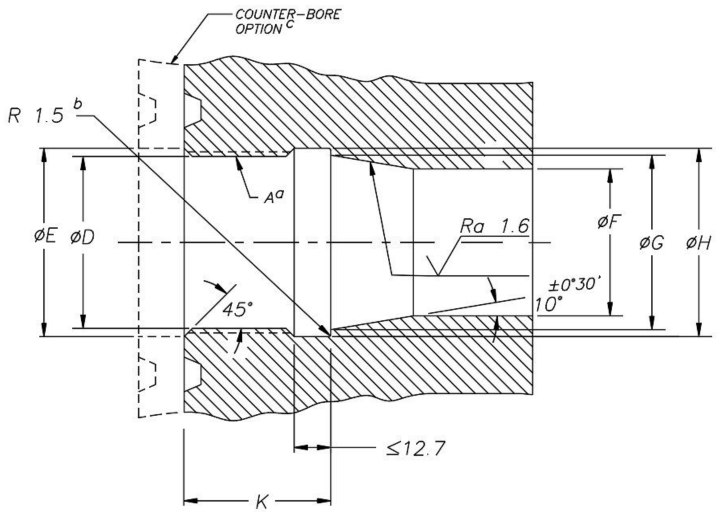
Nominal Outlet Size in.	Nominal Thread Size in. *A*	Threads per Inch TPI	Large Taper Diameter *B*	Overall Length *D*	SAE AS568A O-ring Size No. *J*	Chamfer Diameter *K*	Counterbore Diameter *L*	Counterbore Depth *M*
Tolerance>		(Ref.)	± 0.25	± 0.8	NA	± 0.8	± 0.4	± 0.4
1 13/16	1 3/4	6	40.64	95.3	126	38.1	NA	NA
2 1/16	2	6	46.99	95.3	130	44.5	NA	NA
2 9/16	2 1/2	6	59.66	106.4	138	59.2	23.8	15.9
3 1/16	3	6	72.36	106.4	146	72.1	28.6	15.9

Dimensions in millimeters unless noted otherwise

Nominal Outlet Size in.	Nominal Thread Size in.	Threads per Inch	Stub Acme Class 2G Thread Form Dimensions			
			Thread Major Diameter	Thread Pitch Diameter	Thread Minor Diameter	Width of Thread at Root
	A	TPI	*E*	*F*	*G*	*H*
Tolerance>			± 0.10	± 0.3	± 0.3	(Ref.)
1 13/16	1 3/4	6	44.35	42.6	41.1	1.73
2 1/16	2	6	50.70	49.0	47.5	1.73
2 9/16	2 1/2	6	63.40	61.6	60.2	1.73
3 1/16	3	6	76.10	74.3	72.9	1.73

Table D.21—HPVR Preparation Dimensions, 103.5 MPa and 138.0 MPa

Dimensions in millimeters, unless noted otherwise, surface roughness in micrometers.

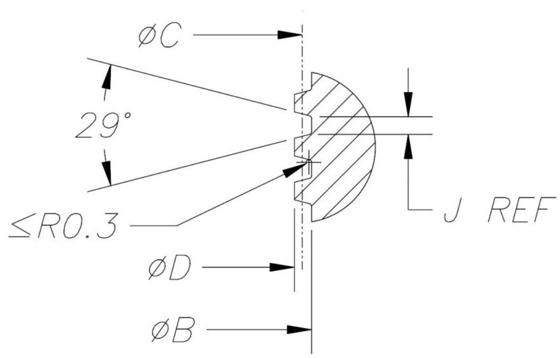


FOOTNOTES

a Thread.

b Typical two places.

c Optional counterbore (12.7 mm deep max.).



Thread Form Detail

NOTE 1 Features and dimensions are typical for all full threads.

NOTE 2 Tolerances on angles, unless otherwise noted, are ± 0.5 degrees.

NOTE 3 All diameters are to be concentric within 0.13 mm (0.005 in.) total indicator reading.

Table D.21—HPVR Preparation Dimensions, 103.5 MPa and 138.0 MPa *(continued)*

Dimensions in millimeters unless noted otherwise

Nominal Outlet Size in.	Chamfer and Counterbore Diameter *E*	Straight Through Bore *F*	Large Diameter of Taper *G*	Thread Relief Diameter *H*	Depth to Taper *K*
Tolerance>	± 0.4	± 0.12	± 0.12	± 0.4	± 0.4
1 13/16	46.4	37.47	41.28	46.2	39.70
2 1/16	52.7	43.82	47.63	53.0	39.70
2 9/16	66.7	56.49	60.33	65.7	53.14
3 1/16	78.1	69.22	73.03	78.2	53.14

Dimensions in millimeters unless noted otherwise

Nominal Outlet Size in.	Nominal Thread Size in.	Threads per Inch	Stub Acme Class 2G Thread Form Dimensions			
			Thread Major Diameter	Thread Pitch Diameter	Thread Minor Diameter	Width of Thread at Root
	A	TPI	*B*	*C*	*D*	*J*
Tolerance>			± 0.25	± 0.25	± 0.10	(Ref.)
1 13/16	1 3/4	6	45.21	43.43	42.01	1.65
2 1/16	2	6	51.56	49.78	48.36	1.65
2 9/16	2 1/2	6	64.29	62.51	61.06	1.65
3 1/16	3	6	76.99	75.21	73.76	1.65

Table D.22—Flanged Full-bore Gate Valves

Dimensions in millimeters unless noted otherwise

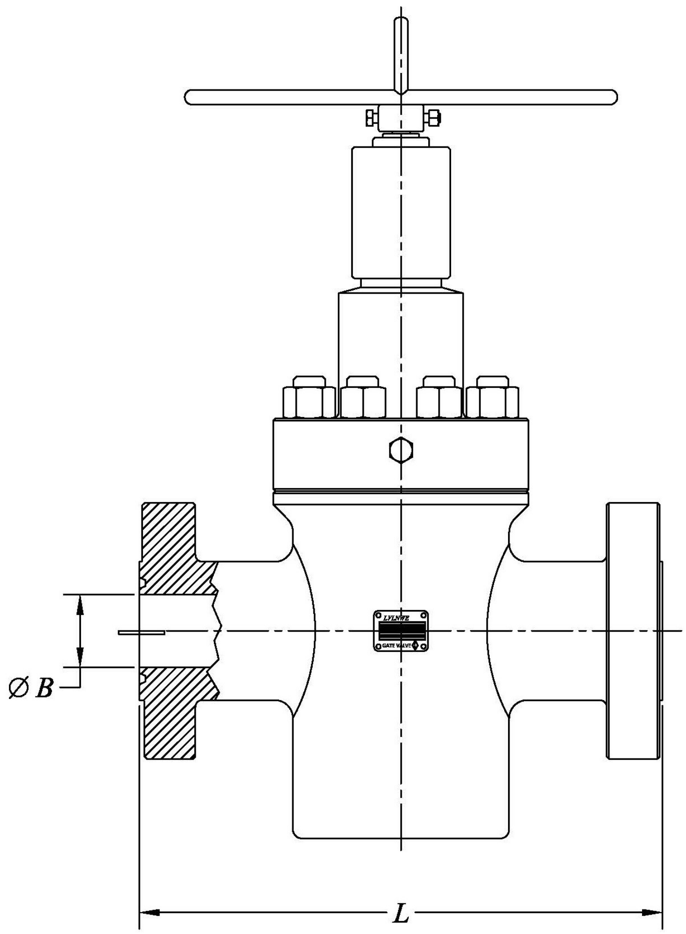


Table D.22—Flanged Full-bore Gate Valves *(continued)*

Dimensions in millimeters unless noted otherwise

Nominal size in.	Bore	*L*, Face-to-face Length, millimeters					
	B	13.8 MPa	20.7 MPa	34.5 MPa	69.0 MPa	103.5 MPa	138.0 MPa
Tolerance>	+ 0.8/−0	± 2	± 2	± 2	± 2	± 2	± 2
$1^{13}/_{16}$	46.0	—	—	—	464	457	533
$2^{1}/_{16}$ x $1^{13}/_{16}$	46.0	295	371	371	521	483	584
$2^{1}/_{16}$	52.3	295	371	371	521	483	584
$2^{9}/_{16}$	65.0	333	422	422	565	533	673
$3^{1}/_{16}$	77.7	—	—	—	619	598	775
$3^{1}/_{8}$	79.3	359	435	473	—	—	—
$3^{1}/_{8}$ x $3^{3}/_{16}$	81.0	359	435	473	—	—	—
$4^{1}/_{16}$	103.1	435	511	549	670	737	965
$4^{1}/_{16}$ x $4^{1}/_{8}$	104.7	435	511	549	PMR	PMR	PMR
$4^{1}/_{16}$ x $4^{1}/_{4}$	108.0	435	511	549	PMR	PMR	PMR
$5^{1}/_{8}$ [a]	130.1 [a]	562	613	727	737	889	PMR
$7^{1}/_{16}$ x $5^{1}/_{8}$	130.1 [a]	—	—	737	889	1041	PMR
$7^{1}/_{16}$ x 6	152.4	562	613	737	889	1041	PMR
$7^{1}/_{16}$ x $6^{1}/_{8}$	155.5	—	—	737	889	1041	PMR
$7^{1}/_{16}$ x $6^{3}/_{8}$	162.1	562	613	737	889	1041	PMR
$7^{1}/_{16}$ x $6^{5}/_{8}$	168.2	562	613	737	889	1041	PMR
$7^{1}/_{16}$	179.3	664	714	813	889	1041	PMR
$7^{1}/_{16}$ x $7^{1}/_{8}$	180.9	664	714	813	PMR	PMR	PMR
9	228.6	PMR	PMR	1041	PMR	PMR	PMR
11	279.4	PMR	PMR	PMR	PMR	PMR	PMR
$13^{5}/_{8}$	347.0	PMR	PMR	—	PMR	PMR	PMR
$16^{3}/_{4}$	426.2	PMR	PMR	—	PMR	—	—
$18^{3}/_{4}$	477.0	—	—	—	PMR	PMR	—
$20^{3}/_{4}$	527.8	—	PMR	—	—	—	—
$21^{1}/_{4}$	540.5	PMR	—	—	PMR	—	—

FOOTNOTE

[a] Bore tolerance for $5^{1}/_{8}$ in. size is +1.0/−0.

Table D.23—Flanged Plug and Ball Valves

Dimensions in millimeters unless noted otherwise

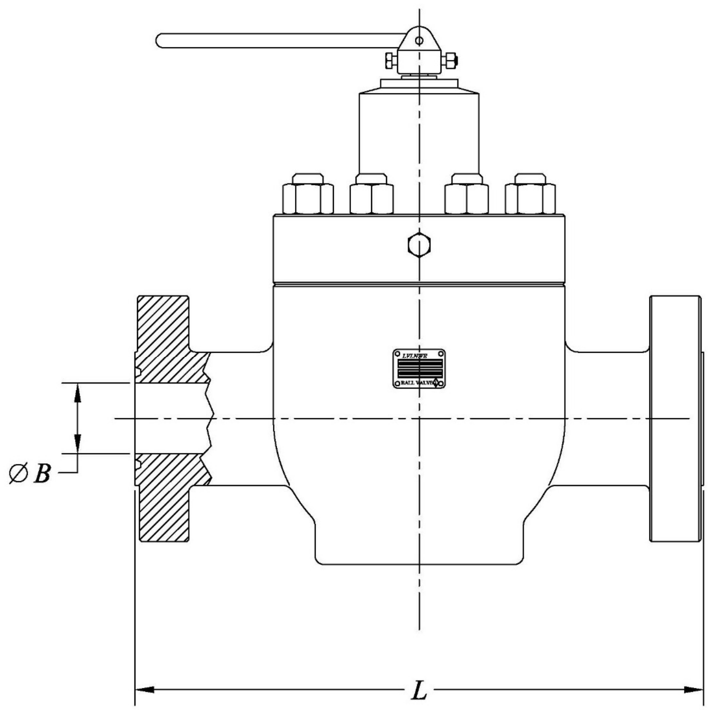


Table D.23—Flanged Plug and Ball Valves *(continued)*

Dimensions in millimeters unless noted otherwise

a) Flanged Full-bore Plug Valves

Nominal Size in.	Bore	*L*, Face-to-face Length					
	B	13.8 MPa	20.7 MPa	34.5 MPa	69.0 MPa	103.5 MPa	138.0 MPa
Tolerance>	+0.8/−0	± 2	± 2	± 2	± 2	± 2	± 2
$1^{13}/_{16}$	46.0	—	—	—	464	457	533
$2^{1}/_{16}$	52.3	333	384	394	521	483	584
$2^{9}/_{16}$	65.0	384	435	457	565	533	673
$3^{1}/_{16}$	77.7	—	—	—	619	598	775
$3^{1}/_{8}$	79.3	448	473	527	—	—	—
$3^{1}/_{8} \times 3^{3}/_{16}$	81.0	448	473	527	—	—	—
$4^{1}/_{16}$	103.1	511	562	629	670	737	965
$4^{1}/_{16} \times 4^{1}/_{8}$	104.7	511	562	629	PMR	PMR	PMR
$4^{1}/_{16} \times 4^{1}/_{4}$	108.0	511	562	629	PMR	PMR	PMR
$5^{1}/_{8}$	130.1 [b]	638	664	—	737	889	—
$7^{1}/_{16} \times 6$	152.4	727	765	—	889	1041	PMR
$7^{1}/_{16} \times 6^{3}/_{8}$	162.1	—	—	—	889	1041	PMR
$7^{1}/_{16}$	179.3	740	803	978	889	1041	PMR
$7^{1}/_{16} \times 7^{1}/_{8}$	180.9	740	803	978	PMR	PMR	PMR
9	228.6	PMR	PMR	PMR	PMR	1041	PMR
11	279.2	PMR	PMR	PMR	PMR	PMR	PMR
$13^{5}/_{8}$	347.0	PMR	PMR	-	PMR	PMR	PMR
$16^{3}/_{4}$	426.2	PMR	PMR	-	PMR	-	-
$18^{3}/_{4}$	477.0	-	-	-	PMR	PMR	-
$20^{3}/_{4}$	527.8	-	PMR	-	-	-	-
$21^{1}/_{4}$	540.5	PMR	-	-	PMR	-	-

b) Flanged Full-bore and Reduced-opening Ball Valves

Nominal Size in.	Bore	*L*, Face-to-face Length					
	B	13.8 MPa	20.7 MPa	34.5 MPa	69.0 MPa	103.5 MPa [a]	138.0 MPa [a]
Tolerance>	+0.8/−0	± 2	± 2	± 2	± 2	± 2	± 2
$1^{13}/_{16}$	46.0	—	—	—	464	457	533
$2^{1}/_{16}$	52.3	295	371	371	521	483	584
$2^{9}/_{16}$	65.0	333	422	473	565	533	673
$3^{1}/_{16}$	77.7	—	—	—	619	598	775
$3^{1}/_{8}$	79.3	359	384	473	—	—	—
$4^{1}/_{16}$	103.1	435	460	549	670	737	—
$5^{1}/_{8}$	130.1 [b]	—	—	—	737	889	PMR
$7^{1}/_{16} \times 6$	152.4	562	613	711	889	1041	PMR
$7^{1}/_{16} \times 6^{3}/_{8}$	162.1	—	—	711	889	1041	PMR
$7^{1}/_{16}$	179.3	—	—	711	889	1041	PMR
9	228.6	PMR	PMR	PMR	PMR	PMR	PMR
11	279.4	PMR	PMR	PMR	PMR	PMR	PMR
13 $^{5}/_{8}$	346.1	PMR	PMR	PMR	PMR	PMR	PMR
16 ¾	425.5	PMR	PMR	PMR	PMR	PMR	PMR
18 ¾	476.3	PMR	PMR	PMR	PMR	PMR	PMR
20 ¾	527.8	-	PMR	-	-	-	-
21 $^{1}/_{4}$	616.0	PMR	PMR	PMR	PMR	PMR	PMR

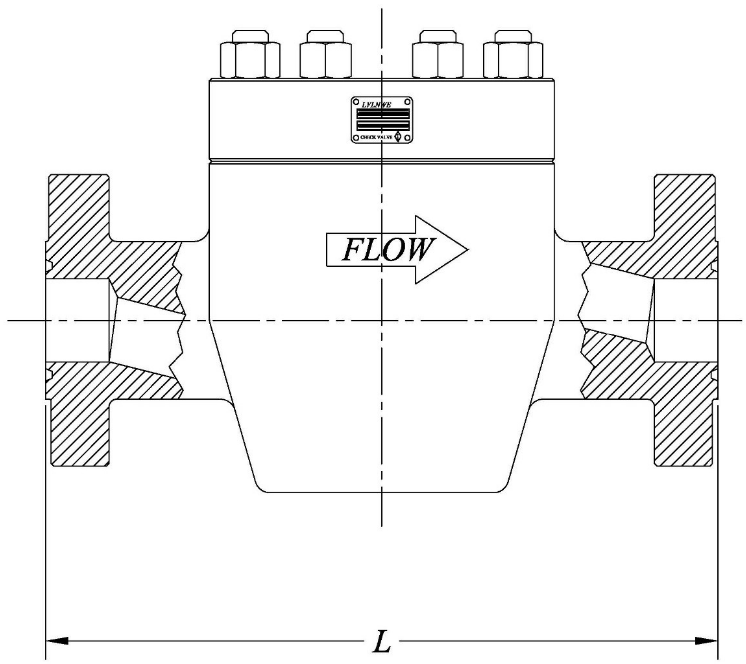
FOOTNOTE

[a] Applies to full bore only.

[b] Bore tolerance for $5^{1}/_{8}$ in. size is +1.0/-0.

Table D.24—Flanged Swing and Lift Check Valves

Dimensions in millimeters unless noted otherwise



Dimensions in millimeters unless noted otherwise

a) Minimum Bore Sizes for Full-opening Check Valves, 13.8 MPa, 20.7 MPa, and 34.5 MPa			
Nominal Size	**Minimum Bore Size**		
in.	13.8 MPa	20.7 MPa	34.5 MPa
Tolerance>	+1.6/−0	+1.6/−0	+1.6/−0
2 1/16	52.5	49.3	42.9
2 9/16	62.7	59.0	54.0
3 1/8	77.9	73.7	66.6
4 1/16	102.3	97.2	87.3
7 1/16	146.3	146.3	131.8
9	198.5	189.0	173.1
11	247.7	236.6	215.9
13 5/8	PMR	PMR	-
16 ¾	PMR	PMR	-
18 ¾	-	--	-
20 ¾	-	PMR	-
21 1/4	PMR	-	=

Table D.24—Flanged Swing and Lift Check Valves *(continued)*

Dimensions in millimeters unless noted otherwise

b) Regular and Full-opening Flanged Swing and Lift Check Valves, 13.8 MPa, 20.7 MPa, and 34.5 MPa RWP					
Nominal Size in.	***L*, Short Pattern Face-to-face Length, mm**			***L*, Long Pattern Face-to-face Length, mm**	
	13.8 MPa	20.7 MPa	34.5 MPa	20.7 MPa	34.5 MPa
Tolerance>	± 2	± 2	± 2	± 2	± 2
$2^{1}/_{16}$	295	371	371	—	—
$2^{9}/_{16}$	333	422	422	—	—
$3^{1}/_{8}$	359	384	473	435	—
$4^{1}/_{16}$	435	460	549	511	—
$7^{1}/_{16}$	562	613	711	PMR	737
9	664	740	841	PMR	— PMR
11	790	841	1000	— PMR	— PMR
$13\ ^{5}/_{8}$	PMR	PMR	PMR	PMR	PMR
16 ¾	PMR	PMR	PMR	PMR	PMR
18 ¾	-	-	-	-	-
20 ¾	-	-	PMR	-	PMR
$21\ ^{1}/_{4}$	PMR	PMR	-	PMR	-

Dimensions in millimeters unless noted otherwise

c) Regular and Full-opening Flanged Swing and Lift Check Valves, 69.0 MPa, 103.5 MPa, and 138.0 MPa RWP			
Nominal Size in.	***L*, Face-to-face Length, in.**		
	69.0 MPa	103.5 MPa	138.0 MPa
Tolerance>	± 2	± 2	± 2
$1^{13}/_{16}$	464	457	533
$2^{1}/_{16}$	521	483	584
$2^{9}/_{16}$	565	533	673
$3^{1}/_{16}$	619	598	775
$4^{1}/_{16}$	670	737	—
$5^{1}/_{8}$	737	PMR	PMR
$7^{1}/_{16}$	889	PMR	PMR
9	PMR	PMR	PMR
11	PMR	PMR	PMR
13-5/8	PMR	PMR	PMR
16-3/4	PMR	-	PMR
18-3/4	PMR	PMR	-
20-3/4	-	-	-
21-1/4	PMR	PMR	-

Table D.25—Center Spacing of Conduit Bores for Dual Parallel Bore Valves for 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa

Dimensions in millimeters unless noted otherwise

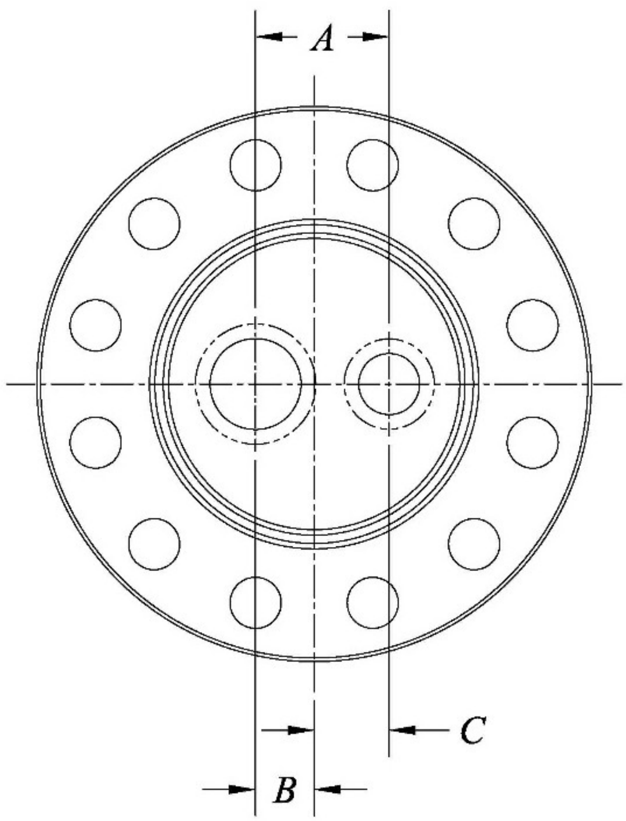


Table D.25—Center Spacing of Conduit Bores for Dual Parallel Bore Valves for 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa *(continued)*

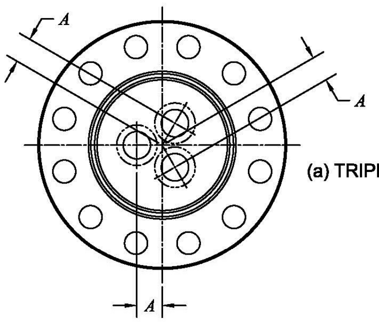
Dimensions in millimeters unless noted otherwise

Maximum Nominal Valve Size in.	Bore Center to Bore Center	Large-bore to End-connector Center	Small-bore to End-Connector Center	Minimum End-connector Size	Basic Casing Size	
						Lineic Mass kg/m
	A (REF)	*B*	*C*		*OD*	
13.8 MPa, 20.7 MPa, and 34.5 MPa RWP						
$1^{13}/_{16}$	70.64	35.32	35.32	$7^{1}/_{16}$	139.7	25
$2^{1}/_{16}$	90.10	45.05	45.05	$7^{1}/_{16}$	177.8	57
$2^{9}/_{16}$ x $2^{1}/_{16}$	90.09	41.91	48.18	$7^{1}/_{16}$	177.8	43
$2^{9}/_{16}$ x $2^{1}/_{16}$	101.61	47.63	53.98	9	193.7	58
$2^{9}/_{16}$	101.60	50.80	50.80	9	193.7	44
$2^{9}/_{16}$	114.30	57.15	57.15	9	219.1	73
$3^{1}/_{8}$ x $2^{1}/_{16}$	116.28	51.00	65.28	9	219.1	73
$3^{1}/_{8}$ x $2^{9}/_{16}$	128.20	64.10	64.10	11	244.5	80
$3^{1}/_{8}$	128.20	64.10	64.10	11	244.5	80
69.0 MPa RWP						
$1^{13}/_{16}$	70.64	35.32	35.32	$7^{1}/_{16}$	139.7	25
$2^{1}/_{16}$	90.10	45.05	45.05	$7^{1}/_{16}$	177.8	57
$2^{9}/_{16}$ x $2^{1}/_{16}$	90.09	41.91	48.18	$7^{1}/_{16}$	177.8	43
$2^{9}/_{16}$ x $2^{1}/_{16}$	101.61	47.63	53.98	9	193.7	58
$2^{9}/_{16}$	101.60	50.80	50.80	9	193.7	44
$2^{9}/_{16}$	114.30	57.15	57.15	9	219.1	73
$3^{1}/_{16}$	128.20	64.10	64.10	11	244.5	80

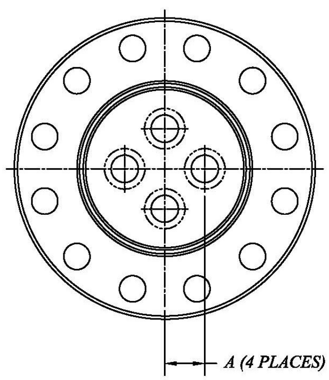
FOOTNOTE
Nominal sizes for valves and end connectors are in inches.

Table D.26—Center Spacing of Conduit Bores for Triple, Quadruple, and Quintuple Parallel Bore Valves for 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa

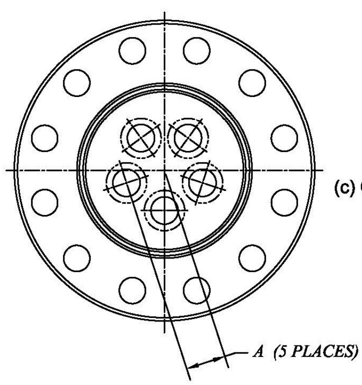
Dimensions in millimeters unless noted otherwise



(a) TRIPLE CONDUIT



(b) QUADRUPLE CONDUIT



(c) QUINTUPLE CONDUIT

Table D.26—Center Spacing of Conduit Bores for Triple, Quadruple, and Quintuple Parallel Bore Valves for 13.8 MPa, 20.7 MPa, 34.5 MPa, and 69.0 MPa *(continued)*

Dimensions in millimeters unless noted otherwise

Maximum Valve Size in.	**Flange Center to Bore Center** *A*	**Minimum End-connector Size** in.	**Basic Casing Size** *OD*	**Lineic Mass** kg/m
13.8 MPa; 20.7 MPa and 34.5 MPa RWP				
Triple-conduit Valve				
1 13/16	47.63	7 1/16	168.3	35.7
2 1/16	49.21	9	177.8	38.7
2 1/16	53.98	9	193.7	58.0
2 9/16	71.44	11	244.5	79.6
Quadruple-conduit Valve				
1 13/16	73.03	11	219.1	53.6
1 13/16	77.79	11	244.5	All
2 1/16	77.79	11	244.5	79.6
2 9/16	87.31	11	273.1	82.6
2 9/16	101.60	13 5/8	298.5	80.4
Quintuple-conduit Valve				
2 1/16	77.79	11	244.5	79.6
69.0 MPa RWP				
Triple-conduit Valve				
1 13/16	47.63	7 1/16	168.3	35.7
2 1/16	49.21	9	177.8	38.7
2 1/16	53.98	9	193.7	58.0
2 9/16	71.44	11	244.5	79.6
Quadruple-conduit Valve				
2 9/16	87.31	11	273.1	82.6

FOOTNOTE
Nominal sizes for valves and end connectors are in inches.

Table D.27—Maximum Hanger Outside Diameter for Wellheads

Dimensions in millimeters unless noted otherwise

Nominal Size [a] and Minimum Through-bore of Drill-through Equipment in.	Rated Working Pressure MPa	Maximum Outside Diameter of Hanger mm
7 1/16	13.8, 20.7, and 34.5	178.05
7 1/16	69.0, 103.5, and 138.0	178.05
9	13.8, 20.7, and 34.5	226.90
9	69.0 and 103.5	226.90
11	13.8, 20.7, and 34.5	277.32
11	69.0 and 103.5	277.32
13 5/8	13.8 and 20.7	343.48
13 5/8	34.5 and 69.0	343.48
16 3/4	13.8 and 20.7	422.28
16 3/4	34.5 and 69.0	422.28
18 3/4	34.5 and 69.0	473.08
21 1/4	13.8	536.58
20 3/4	20.7	523.88
21 1/4	34.5 and 69.0	536.58

FOOTNOTE

[a] Nominal size of upper end connector of wellhead body in which the hanger is used.

Table D.28—Minimum Vertical Full-opening Wellhead Body Bores and Maximum Casing Sizes

Dimensions in millimeters unless noted otherwise

Nominal Connector [a]		Casing Beneath Body			Minimum Vertical Full-opening Wellhead Body Bore
Nominal Size of Connector	Rated Working Pressure	Label [b]	Nominal Lineic Mass [b]	Specified Drift Diameter	
in.	MPa	*OD*	kg/m	mm	mm
$7^{1}/_{16}$	13.8	7	25.30	162.89	163.8
$7^{1}/_{16}$	20.7	7	29.76	160.81	161.5
$7^{1}/_{16}$	34.5	7	34.23	158.52	159.5
$7^{1}/_{16}$	69.0	7	43.16	153.90	154.7
$7^{1}/_{16}$	103.5	7	56.55	147.19	148.1
$7^{1}/_{16}$	138.0	7	56.55	147.19	148.1
9	13.8	$8^{5}/_{8}$	35.72	202.49	203.2
9	20.7	$8^{5}/_{8}$	47.62	198.02	198.9
9	34.5	$8^{5}/_{8}$	53.57	195.58	196.3
9	69.0	$8^{5}/_{8}$	59.53	193.04	193.5
9	103.5	$8^{5}/_{8}$	72.92	187.60	188.2
11	13.8	$10^{3}/_{4}$	60.27	251.31	252.0
11	20.7	$10^{3}/_{4}$	60.27	251.31	252.0
11	34.5	$10^{3}/_{4}$	75.90	246.23	247.1
11	69.0	$9^{5}/_{8}$	79.62	212.83	213.6
11	103.5	$9^{5}/_{8}$	79.62	212.83	213.6
$13^{5}/_{8}$	13.8	$13^{3}/_{8}$	81.10	316.46	317.5
$13^{5}/_{8}$	20.7	$13^{3}/_{8}$	90.78	313.92	314.7
$13^{5}/_{8}$	34.5	$13^{3}/_{8}$	107.15	309.65	310.4
$13^{5}/_{8}$	69.0	$11^{3}/_{4}$	89.29	269.65	270.8
$16^{3}/_{4}$	13.8	16	96.73	382.58	383.3
$16^{3}/_{4}$	20.7	16	125.01	376.48	377.4
$16^{3}/_{4}$	34.5	16	125.01	376.48	377.4
$16^{3}/_{4}$	69.0	16	125.01	376.48	377.4
$18^{3}/_{4}$	34.5	$18^{5}/_{8}$	130.21	446.20	446.8
$18^{3}/_{4}$	69.0	$18^{5}/_{8}$	130.21	446.20	446.8
$20^{3}/_{4}$	20.7	20	139.89	480.97	481.8
$21^{1}/_{4}$	13.8	20	139.89	480.97	481.8
$21^{1}/_{4}$	34.5	20	139.89	480.97	481.8
$21^{1}/_{4}$	69.0	20	139.89	480.97	481.8

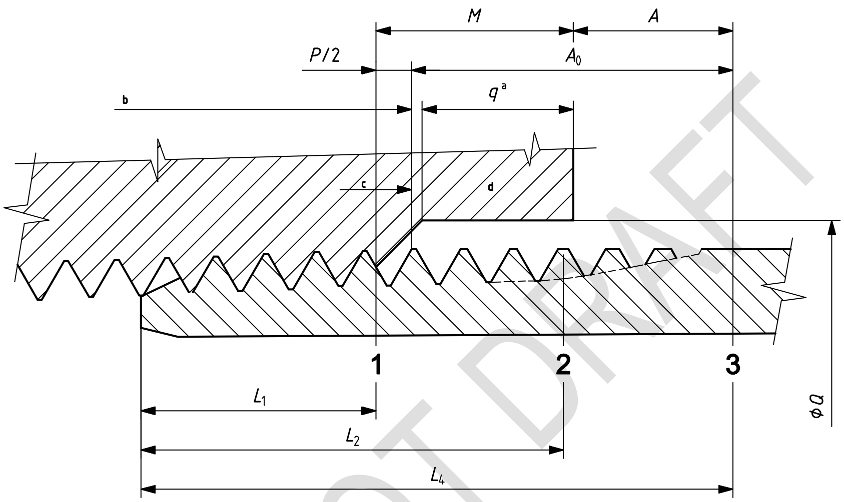
FOOTNOTES

[a] Upper end connectors of wellhead body.

[b] Maximum size and minimum mass of casing on which bore is based.

Table D.29—Pipe Thread Counterbore and Standoff Dimensions

Dimensions in millimeters unless noted otherwise



Key

1 plane of hand-tight engagement

2 plane of effective thread length

3 plane of vanish point

[a] See 14.3.2.3.

[b] Internal thread length.

[c] Without counterbore.

[d] With counterbore.

NOTE See API 5B for dimensions L_1, L_2, and L_4.

NOTE Line pipe and sharp vee plugs and preparations are not interchangeable.

5B plugs are compatible with both 5B and 6A line pipe preparations provided the standoff, counterbores, and transition angles, from the respective specifications, are followed.

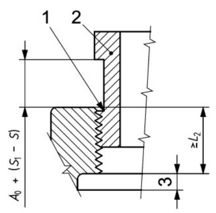
Table D.29—Pipe Thread Counterbore and Standoff Dimensions *(continued)*

Dimensions in millimeters unless noted otherwise

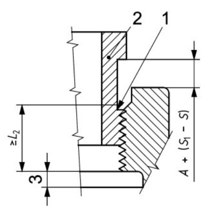
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Nominal Thread Size	**Length: Plane of Vanish Point to Hand-tight Plane**	**Hand-tight Standoff**		**Length: Face of Counterbore to Hand-tight Plane**	**Counterbore**	
		Thread without Counterbore	**Thread with Shallow Counterbore**		**Diameter**	**Depth**
in.	$A + M$	A_0	A	M	Q	q
Line Pipe Threads						
1/8	5.40	4.93	1.01	4.38	11.9	3.3
1/4	10.02	9.32	5.45	4.57	15.2	3.3
3/8	9.16	8.45	4.55	4.61	18.8	3.3
1/2	11.72	10.82	3.45	8.28	23.6	6.4
3/4	11.54	10.64	3.27	8.27	29.0	6.4
1	14.85	13.74	6.32	8.53	35.8	6.4
1 1/4	14.95	13.84	6.48	8.47	44.5	6.4
1 1/2	15.37	14.27	6.89	8.48	50.5	6.4
2	15.80	14.70	6.87	8.94	63.5	6.4
2 1/2	22.59	21.00	10.04	12.55	76.2	9.7
3	22.04	20.45	9.45	12.59	92.2	9.7
3 1/2	21.91	20.33	9.32	12.59	104.9	9.7
4	22.60	21.01	9.99	12.61	117.6	9.7
5	22.94	21.35	10.35	12.58	144.5	9.7
6	25.10	23.51	12.48	12.62	171.5	9.7
8	27.51	25.93	14.81	12.70	222.3	9.7
10	29.18	27.59	16.36	12.81	276.4	9.7
12	30.45	28.86	16.83	13.62	328.7	9.7
14D	28.49	26.90	14.94	13.56	360.4	9.7
16D	27.22	25.63	13.71	13.52	411.2	9.7
18D	27.53	25.94	14.00	13.53	462.0	9.7
20D	29.43	27.84	15.85	13.58	512.8	9.7

Table D.30—Gauging of Casing and Tubing Threads

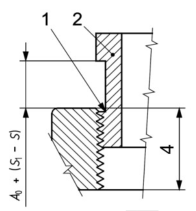
Dimensions in millimeters unless noted otherwise



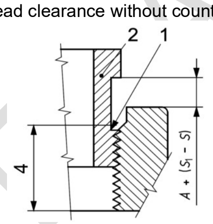
a) Internal recess without counterbore



b) Internal recess with shallow counterbore



c) Thread clearance without counterbore



d) Thread clearance with shallow counterbore

Key

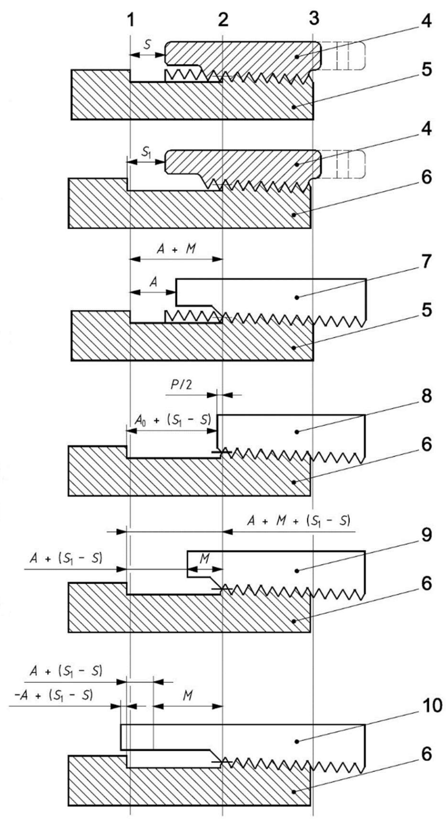
1 gauge notch, alignment—chamfer bottom, within tolerance

2 working plug gauge

3 recess clearance

4 L_2 (min.) plus thread clearance

Application of Working Plug Gauge



Key

1 plane of vanish point

2 plane of hand-tight engagement

3 plane of end of pipe

4 master ring gauge

5 master plug gauge

6 working plug gauge

7 product thread

8 product thread without counterbore

9 product thread with shallow counterbore

10 product thread with deep counterbore

NOTE See API 5B for dimensions of S and S_1.

Gauging Line Pipe, Casing and Tubing Internal Threads, Hand-tight Assembly

Table D.30—Gauging of Casing and Tubing Threads *(continued)*

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Nominal Thread Size	**Length: Plane of Vanish Point to Hand-tight Plane**	**Hand-tight Standoff**		**Length: Face of Counterbore to Hand-tight Plane**	**Counterbore**	
		Thread without Counterbore	**Thread with Shallow Counterbore**		**Diameter**	**Depth**
in.	$A + M$	A_0	A	M	Q	q
Long and Short Casing Threads Dimensions in millimeters except nominal size						
4 1/2	27.41	25.82	15.00	12.40	117.6	9.7
5	27.41	25.82	15.00	12.40	130.3	9.7
5 1/2	27.41	25.82	15.00	12.40	143.0	9.7
6 5/8	27.41	25.82	15.07	12.34	171.5	9.7
7	27.41	25.82	15.00	12.40	181.1	9.7
7 5/8	29.11	27.52	16.72	12.39	196.9	9.7
8 5/8	29.11	27.52	16.72	12.39	222.3	9.7
9 5/8	29.11	27.52	16.72	12.39	247.7	9.7
10 3/4 [a]	29.11	27.52	16.65	12.46	276.4	9.7
11 3/4 [a]	29.11	27.52	16.65	12.46	301.8	9.7
13 3/8 [a]	29.11	27.52	15.95	13.15	344.4	9.7
16 [a]	29.11	27.52	15.89	13.22	411.2	9.7
20 [a]	29.11	27.52	15.89	13.22	512.8	9.7
Non-upset Tubing Threads Dimensions in millimeters except nominal size						
1.050	16.41	15.14	8.13	8.28	29.0	6.4
1.315	16.41	15.14	8.07	8.34	35.8	6.4
1.660	16.41	15.14	8.13	8.28	44.5	6.4
1.900	16.41	15.14	8.13	8.28	50.5	6.4
2 3/8	16.41	15.14	7.69	8.72	63.5	6.4
2 7/8	16.41	15.14	4.51	11.90	76.2	9.7
3 1/2	16.41	15.14	4.45	11.96	92.2	9.7
4	19.91	18.33	7.65	12.27	104.9	9.7
4 1/2	19.91	18.33	7.65	12.27	117.6	9.7
External Upset Tubing Threads Dimensions in millimeters except nominal size						
1.050	16.41	15.14	8.07	8.34	35.8	6.4
1.315	16.41	15.14	7.99	8.42	39.9	6.4
1.660	16.41	15.14	8.04	8.37	48.5	6.4
1.900	16.41	15.14	8.05	8.36	55.6	6.4
2 3/8	19.91	18.33	10.87	9.04	69.1	6.4
2 7/8	19.91	18.33	7.69	12.22	81.8	9.7
3 1/2	19.91	18.33	7.65	12.27	98.6	9.7
4	19.91	18.33	7.65	12.27	111.3	9.7
4 1/2	19.91	18.33	7.65	12.27	124.0	9.7

FOOTNOTE
[a] Short casing threads only (long casing threads not covered).

Annex E
(normative)

Dimensional Tables—USC Units

Table E.23—Flanged Plug and Ball Valves

Table E.24—Flanged Swing and Lift Check Valves

Table E.25—Center Spacing of Conduit Bores for Dual Parallel Bore Valves, 2000 psi, 3000 psi, 5000 psi, and 10,000 psi

Table E.26—Center Spacing of Conduit Bores for Triple, Quadruple, and Quintuple Parallel Bore Valves, 2000 psi, 3000 psi, 5000 psi, and 10,000 psi

Table E.27—Maximum Hanger Outside Diameter for Wellheads

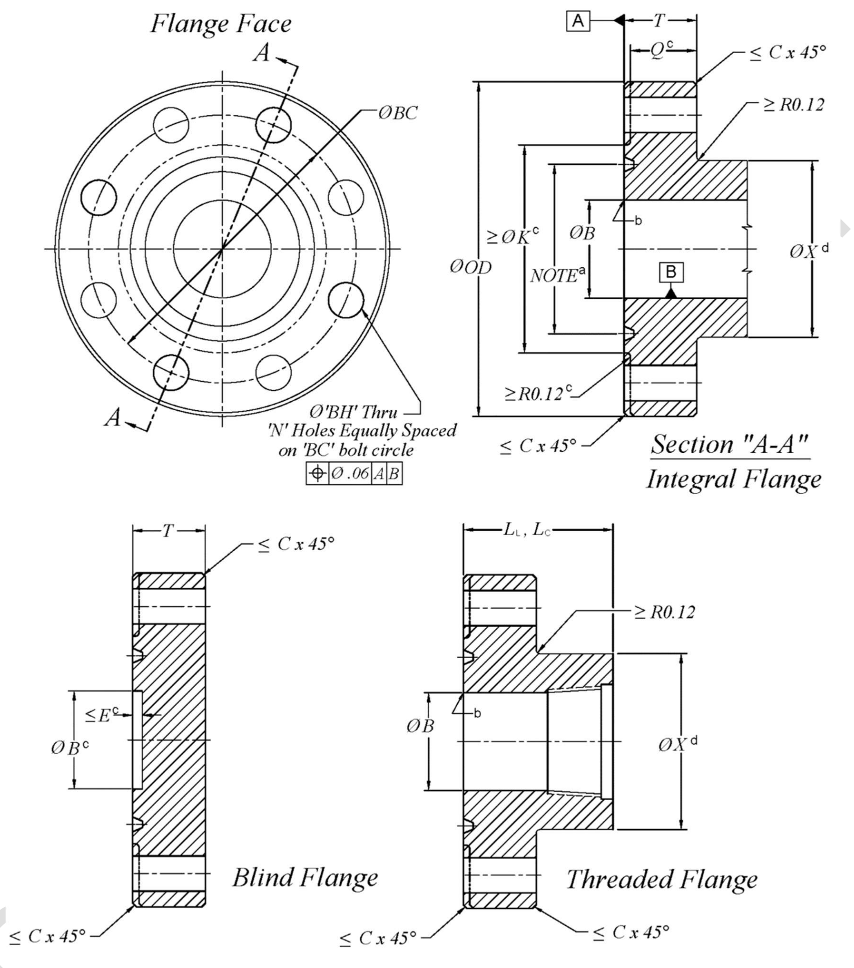
Table E.28—Minimum Vertical Full-opening Wellhead Body Bores and Maximum Casing Sizes

Table E.29—Pipe Thread Counterbore and Standoff Dimensions

Table E.30—Gauging of Casing and Tubing Threads

Table E.1—Type 6B Flanges for 2000 psi

Dimensions in inches



FOOTNOTES

a Ring groove shall be concentric with bore *B* within 0.010 in. diametrical runout. See Table E.8 for ring groove dimensions.

b Break sharp corner.

c Raised face *K* and counterbore *E* are optional features.

d Diameter *X* is a reference dimension.

Table E.1—Type 6B Flanges for 2000 psi *(continued)*

Dimensions in inches

Nominal Size of Flange [a]	Maximum Bore	Outside Diameter of Flange	Max. Chamfer	Diameter of Raised Face	Total Thickness of Flange	Basic Thickness of Flange	Diameter of Hub	Counter-bore Depth
	B	*OD*	*C*	*K*	*T*	*Q*	*X*	*E*
Tolerance	max.	As noted	max.	min.	+0.12/−0	min.	Reference	+0.02/−0
$2^1/_{16}$	2.09	6.50 ±0.06	0.12	4.25	1.31	1.00	3.31	0.31
$2^9/_{16}$	2.59	7.50 ±0.06	0.12	5.00	1.44	1.12	3.94	0.31
$3^1/_8$	3.22	8.25 ±0.06	0.12	5.75	1.56	1.25	4.62	0.31
$4^1/_{16}$	4.28	10.75 ±0.06	0.12	6.88	1.81	1.50	6.00	0.31
$5^1/_8$	5.16	13.00 ±0.06	0.12	8.25	2.06	1.75	7.44	0.31
$7^1/_{16}$	7.16	14.00 ±0.12	0.25	9.50	2.19	1.88	8.75	0.31
9	9.03	16.50 ±0.12	0.25	11.88	2.50	2.19	10.75	0.31
11	11.03	20.00 ±0.12	0.25	14.00	2.81	2.50	13.50	0.31
$13^5/_8$	13.66	22.00 ±0.12	0.25	16.25	2.94	2.62	15.75	0.31
$16^3/_4$	16.78	27.00 ±0.12	0.25	20.00	3.31	3.00	19.50	0.31
$21^1/_4$	21.28	32.00 ±0.12	0.25	25.00	3.88	3.50	24.00	0.38

FOOTNOTE
[a] For flange sizes $26^3/_4$ in. and 30 in., see Table E.7.

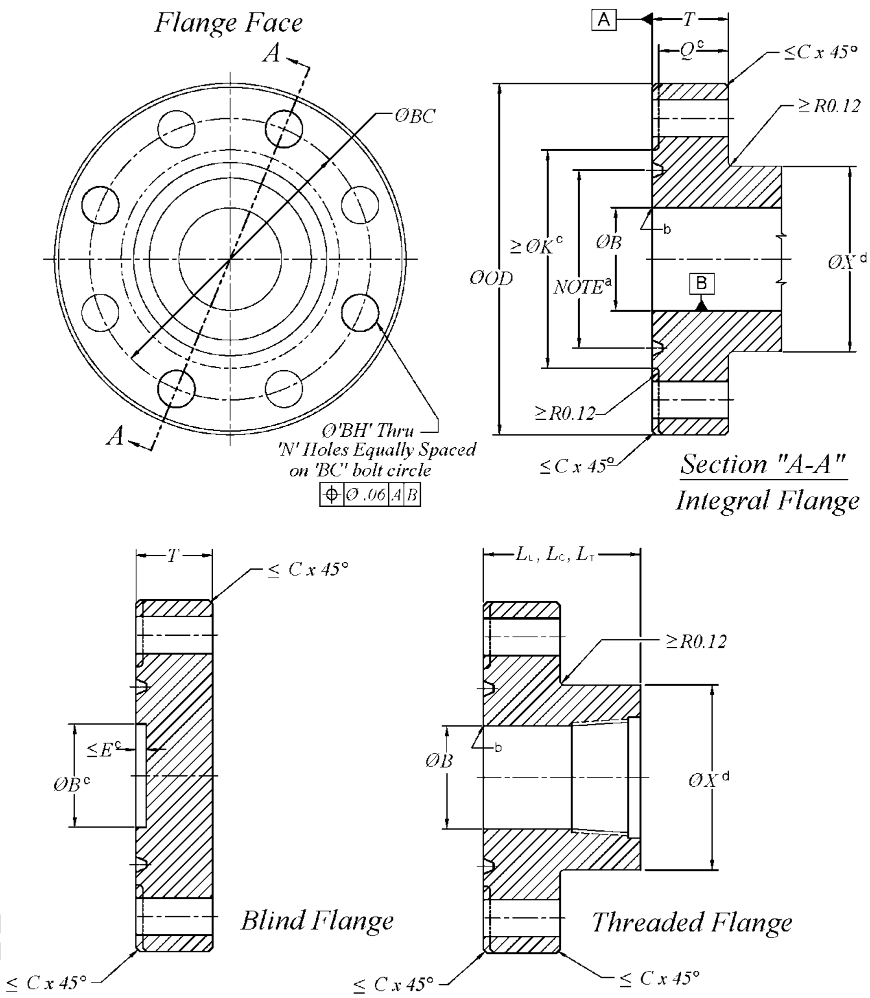
Dimensions in inches

Nominal Size of Flange [a]	Diameter of Bolt Circle	Number of Bolts	Bolt Size and TPI	Bolt Holes		Hub Length, Threaded Flange		Ring Groove Number
						Line Pipe Flange	Casing Flange	
	BC	*N*		*BH*		L_L	L_C	
Tolerance>	See figure for GDT		(Ref.)	Diameter	Tolerance	min.	min.	
$2^1/_{16}$	5.00	8	$^5/_8$-11	0.75	+0.06/−0.02	1.75	—	R 23
$2^9/_{16}$	5.88	8	$^3/_4$-10	0.88	+0.06/−0.02	1.94	—	R 26
$3^1/_8$	6.62	8	$^3/_4$-10	0.88	+0.06/−0.02	2.12	—	R 31
$4^1/_{16}$	8.50	8	$^7/_8$-9	1.00	+0.06/−0.02	2.44	3.50	R 37
$5^1/_8$	10.50	8	1-8	1.12	+0.06/−0.02	2.69	4.00	R 41
$7^1/_{16}$	11.50	12	1-8	1.12	+0.06/−0.02	2.94	4.50	R 45
9	13.75	12	$1^1/_8$-8	1.25	+0.06/−0.02	3.31	5.00	R 49
11	17.00	16	$1^1/_4$-8	1.38	+0.06/−0.02	3.69	5.25	R 53
$13^5/_8$	19.25	20	$1^1/_4$-8	1.38	+0.06/−0.02	3.94	3.94	R 57
$16^3/_4$	23.75	20	$1^1/_2$-8	1.62	+0.09/−0.02	4.50	4.50	R 65
$21^1/_4$	28.50	24	$1^5/_8$-8	1.75	+0.09/−0.02	5.38	5.38	R 73

FOOTNOTE
[a] For flange sizes $26^3/_4$ in. and 30 in., see Table E.7.

Table E.2—Type 6B Flanges for 3000 psi

Dimensions in inches



FOOTNOTES

a Ring groove shall be concentric with bore *B* within 0.010 in. diametrical runout. See Table E.8 for ring groove dimensions.

b Break sharp corner.

c Raised face *K* and counterbore *E* are optional features.

d Diameter *X* is a reference dimension

Table E.2—Type 6B Flanges for 3000 psi *(continued)*

Dimensions in inches

Nominal Size of Flange [a]	**Maximum Bore**	**Outside Diameter of Flange**	**Max. Chamfer**	**Diameter of Raised Face**	**Total Thickness of Flange**	**Basic Thickness of Flange**	**Diameter of Hub**	**Counter-bore Depth**
	B	*OD*	*C*	*K*	*T*	*Q*	*X*	*E*
Tolerance	max.	As noted	max.	min.	+0.12/−0	min.	Reference	+0.02/−0
$2^1/_{16}$	2.09	8.50 ±0.06	0.12	4.88	1.81	1.50	4.12	0.31
$2^9/_{16}$	2.59	9.62 ±0.06	0.12	5.38	1.94	1.62	4.88	0.31
$3^1/_8$	3.22	9.50 ±0.06	0.12	6.12	1.81	1.50	5.00	0.31
$4^1/_{16}$	4.28	11.50 ±0.06	0.12	7.12	2.06	1.75	6.25	0.31
$5^1/_8$	5.16	13.75 ±0.06	0.12	8.50	2.31	2.00	7.50	0.31
$7^1/_{16}$	7.16	15.00 ±0.12	0.25	9.50	2.50	2.19	9.25	0.31
9	9.03	18.50 ±0.12	0.25	12.12	2.81	2.50	11.75	0.31
11	11.03	21.50 ±0.12	0.25	14.25	3.06	2.75	14.50	0.31
$13^5/_8$	13.66	24.00 ±0.12	0.25	16.50	3.44	3.12	16.50	0.31
$16^3/_4$	16.78	27.75 ±0.12	0.25	20.62	3.94	3.50	20.00	0.44
$20^3/_4$	20.78	33.75 ±0.12	0.25	25.50	4.75	4.25	24.50	0.50

FOOTNOTE

[a] For flange sizes $26^3/_4$ in. and 30 in., see Table E.7.

Dimensions in inches

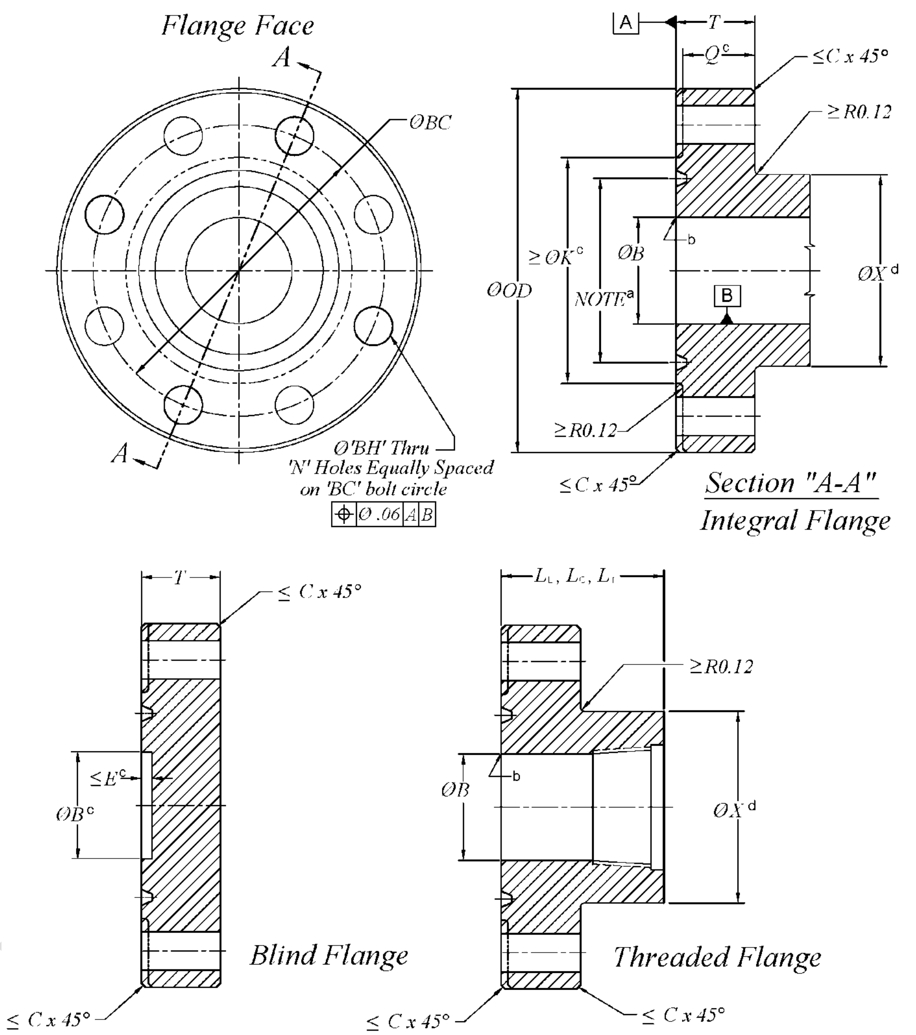
Nominal Size of Flange [a]	**Diameter of Bolt Circle**	**Number of Bolts**	**Bolt Size and TPI**	**Bolt Holes**		**Hub Length, Threaded Flange**			**Ring Groove**
						Line Pipe Flange	**Casing Flange**	**Tubing Flange**	
	BC	*N*		*BH*		L_L	L_C	L_T	
Tolerance>	See figure for GDT		(Ref.)	Diameter	Tolerance	min.	min.	min.	
$2^1/_{16}$	6.50	8	$^7/_8$-9	1.00	+0.06/−0.02	2.56	—	2.56	R 24
$2^9/_{16}$	7.50	8	1-8	1.12	+0.06/−0.02	2.81	—	2.81	R 27
$3^1/_8$	7.50	8	$^7/_8$-9	1.00	+0.06/−0.02	2.44	—	2.94	R 31
$4^1/_{16}$	9.25	8	$1^1/_8$-8	1.25	+0.06/−0.02	3.06	3.50	3.50	R 37
$5^1/_8$	11.00	8	$1^1/_4$-8	1.38	+0.06/−0.02	3.44	4.00	—	R 41
$7^1/_{16}$	12.50	12	$1^1/_8$-8	1.25	+0.06/−0.02	3.69	4.50	—	R 45
9	15.50	12	$1^3/_8$-8	1.50	+0.06/−0.02	4.31	5.00	—	R 49
11	18.50	16	$1^3/_8$-8	1.50	+0.06/−0.02	4.56	5.25	—	R 53
$13^5/_8$	21.00	20	$1^3/_8$-8	1.50	+0.06/−0.02	4.94	4.94	—	R 57
$16^3/_4$	24.25	20	$1^5/_8$-8	1.75	+0.09/−0.02	5.06	5.69	—	R 66
$20^3/_4$	29.50	20	2-8	2.12	+0.09/−0.02	6.75	6.75	—	R 74

FOOTNOTE

[a] For flange sizes $26^3/_4$ in. and 30 in., see Table E.7.

Table E.3—Type 6B Flanges for 5000 psi

Dimensions in inches



FOOTNOTES

a Ring groove shall be concentric with bore *B* within 0.010 in. diametrical runout. See Table E.8 for ring groove dimensions.

b Break sharp corner.

c Raised face *K* and counterbore *E* are optional features.

d Diameter *X* is a reference dimension

Table E.3—Type 6B Flanges for 5000 psi *(continued)*

Dimensions in inches

Nominal Size of Flange [a]	Maximum Bore *B*	Outside Diameter of Flange *OD*	Max. Chamfer *C*	Diameter of Raised Face *K*	Total Thickness of Flange *T*	Basic Thickness of Flange *Q*	Diameter of Hub *X*	Counter-bore Depth *E*
Tolerance	max.	As noted	max.	min.	+0.12/−0	min.	Reference	+0.02/−0
$2^1/_{16}$	2.09	8.50 ±0.06	0.12	4.88	1.81	1.50	4.12	0.31
$2^9/_{16}$	2.59	9.62 ±0.06	0.12	5.38	1.94	1.62	4.88	0.31
$3^1/_8$	3.22	10.50 ±0.06	0.12	6.62	2.19	1.88	5.25	0.31
$4^1/_{16}$	4.28	12.25 ±0.06	0.12	7.62	2.44	2.12	6.38	0.31
$5^1/_8$	5.16	14.75 ±0.06	0.12	9.00	3.19	2.88	7.75	0.31
$7^1/_{16}$	7.16	15.50 ±0.12	0.25	9.75	3.62	3.25	9.00	0.38
9	9.03	19.00 ±0.12	0.25	12.50	4.06	3.62	11.50	0.44
11	11.03	23.00 ±0.12	0.25	14.63	4.69	4.25	14.50	0.44

FOOTNOTE

[a] For flange sizes $13^5/_8$ in., $16^3/_4$ in., $18^3/_4$ in., and $21^1/_4$ in., see Table E.7.

Dimensions in inches

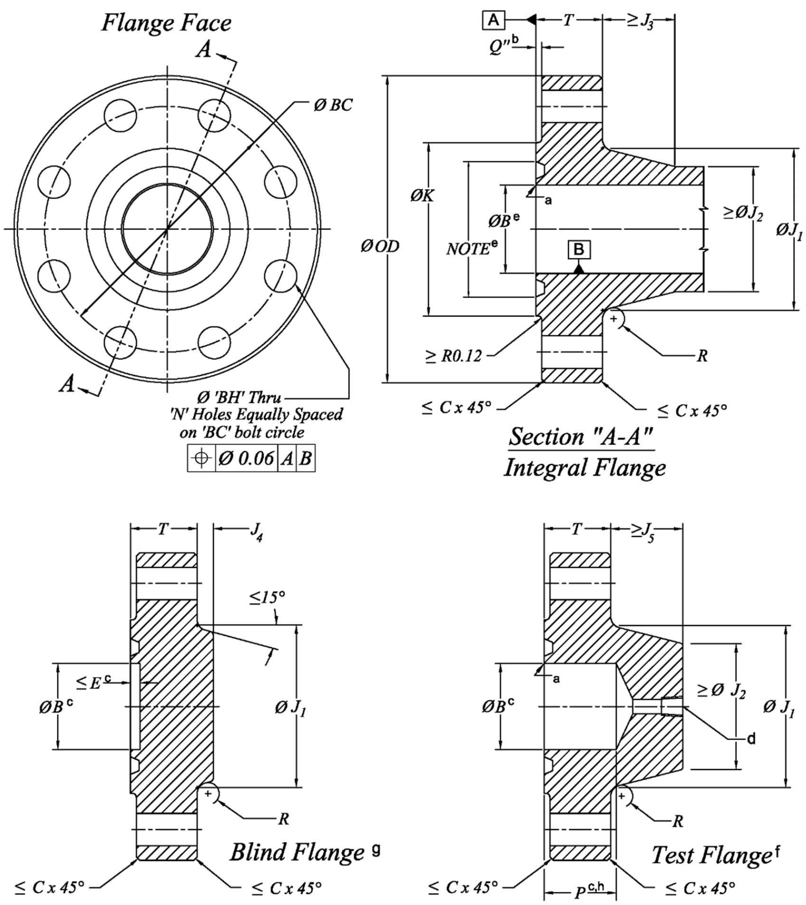
Nominal Size of Flange [a]	Diameter of Bolt Circle *BC*	Number of Bolts *N*	Bolt Size and TPI	Bolt Holes *BH*		Hub Length, Threaded Flange: Line Pipe Flange L_L	Casing Flange L_C	Tubing Flange L_T	Ring Groove
Tolerance>	See figure for GDT		(Ref.)	Diameter	Tolerance	min.	min.	min.	
$2^1/_{16}$	6.50	8	$^7/_8$-9	1.00	+0.06/−0.02	2.56	—	2.56	R 24
$2^9/_{16}$	7.50	8	1-8	1.12	+0.06/−0.02	2.81	—	2.81	R 27
$3^1/_8$	8.00	8	$1^1/_8$-8	1.25	+0.06/−0.02	3.19	—	3.19	R 35
$4^1/_{16}$	9.50	8	$1^1/_4$-8	1.38	+0.06/−0.02	3.88	3.88	3.88	R 39
$5^1/_8$	11.50	8	$1^1/_2$-8	1.62	+0.06/−0.02	4.44	4.44	—	R 44
$7^1/_{16}$	12.50	12	$1^3/_8$-8	1.50	+0.06/−0.02	5.06	5.06	—	R 46
9	15.50	12	$1^5/_8$-8	1.75	+0.09/−0.02	6.06	6.06	—	R 50
11	19.00	12	$1^7/_8$-8	2.00	+0.09/−0.02	6.69	6.69	—	R 54

FOOTNOTE

[a] For flange sizes $13^5/_8$ in., $16^3/_4$ in., $18^3/_4$ in., and $21^1/_4$ in., see Table E.7.

Table E.4—Type 6BX Flanges for 10,000 psi

Dimensions in inches



FOOTNOTES

[a] Break sharp corner.

[b] Q'' min. = 0.12 in. Raised face (Ø K) may be omitted on studded connectors, but thickness T shall still apply.

[c] Optional feature.

[d] Test connection shall be $^1/_2$ in. NPT or per 9.3 (Figure 5).

[e] Ring groove shall be concentric with bore B within 0.010 in. diametrical runout. See Table E.11 for ring groove dimensions.

[f] Test flange style—applies to sizes $1^{13}/_{16}$ through $5^1/_8$ only.

[g] Blind flange style—applies to sizes $5^1/_8$ through $21^1/_4$ only.

[h] The maximum depth P of the counterbore is based on the specified minimum J_5 dimension. The maximum depth P of the counterbore may be increased provided J_5 exceeds the specified minimum by at least the same amount.

Table E.4—Type 6BX Flanges for 10,000 psi *(continued)*

Dimensions in inches

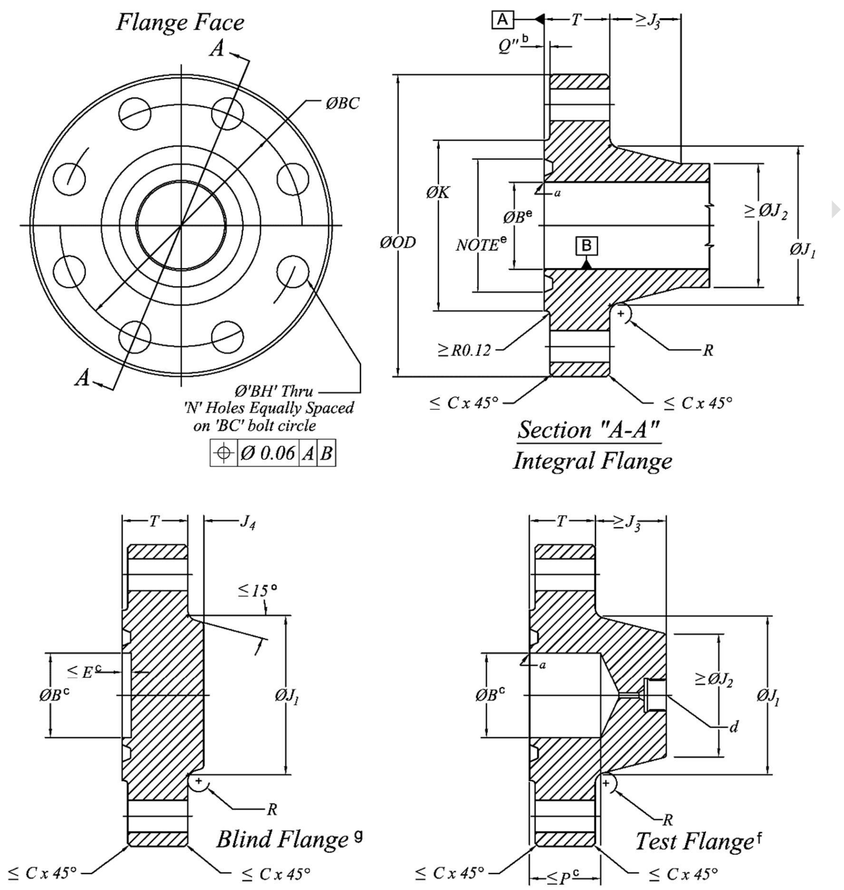
Nominal Size	Maximum Bore *B*	Outside Diameter of Flange *OD*	Diameter of Raised Face *K*	Total Thickness *T*	Max. Chamfer *C*	Large Hub Diameter J_1	Small Hub Diameter J_2	Length of Hub J_3	Hub Height J_4	Hub Height J_5
Tolerance	max.	As noted	± 0.06	+0.12/−0	max.	+0/−0.12	min.	min.	min.	min. [h]
1 13/16	1.84	7.38 ±0.06	4.12	1.66	0.12	3.50	2.56	1.91	—	2.26
2 1/16	2.09	7.88 ±0.06	4.38	1.73	0.12	3.94	2.94	2.03	—	2.19
2 9/16	2.59	9.12 ±0.06	5.19	2.02	0.12	4.75	3.62	2.25	—	2.25
3 1/16	3.09	10.62 ±0.06	6.00	2.30	0.12	5.59	4.34	2.50	—	2.50
4 1/16	4.09	12.44 ±0.06	7.28	2.77	0.12	7.19	5.75	2.88	—	2.88
5 1/8	5.16	14.06 ±0.06	8.69	3.12	0.12	8.81	7.19	3.19	0.25	3.19
7 1/16	7.09	18.88 ±0.12	11.88	4.06	0.25	11.88	10.00	3.75	0.38	—
9	9.03	21.75 ±0.12	14.12	4.88	0.25	14.75	12.88	3.69	0.38	—
11	11.03	25.75 ±0.12	16.88	5.56	0.25	17.75	15.75	4.06	0.56	—
13 5/8	13.66	30.25 ±0.12	20.38	6.62	0.25	21.75	19.50	4.50	0.69	—
16 3/4	16.78	34.31 ±0.12	22.69	6.62	0.25	25.81	23.69	3.00	1.19	—
18 3/4	18.78	40.94 ±0.12	27.44	8.78	0.25	29.62	26.56	6.12	1.00	—
21 1/4	21.28	45.00 ±0.12	30.75	9.50	0.25	33.38	30.00	6.50	1.25	—

Dimensions in inches

Nominal Size	Raised Face Depth *Q"* [b]	Radius of Hub *R*	Bolt Circle *BC*	Number of Bolts *N*	Bolt Size and TPI	Bolt Holes *BH*		Counterbore Depth *E* [g]	*P* [h]	*P* [h]	Ring Groove
Tolerance	max.	± 0.06	See figure for GDT		(Ref.)	Diameter	Tolerance	max.	min.	max.	
1 13/16	0.24	0.38	5.75	8	3/4-10	0.88	+0.06/−0.02	—	2.14	2.18	BX 151
2 1/16	0.25	0.38	6.25	8	3/4-10	0.88	+0.06/−0.02	—	2.07	2.11	BX 152
2 9/16	0.29	0.38	7.25	8	7/8-9	1.00	+0.06/−0.02	—	2.13	2.42	BX 153
3 1/16	0.32	0.38	8.50	8	1-8	1.12	+0.06/−0.02	—	2.15	2.83	BX 154
4 1/16	0.35	0.38	10.19	8	1 1/8-8	1.25	+0.06/−0.02	—	1.97	3.45	BX 155
5 1/8	0.40	038	11.81	12	1 1/8-8	1.25	+0.06/−0.02	0.375	—	—	BX 169
7 1/16	0.46	0.62	15.88	12	1 1/2-8	1.62	+0.09/−0.02	0.438	—	—	BX 156
9	0.52	0.62	18.75	16	1 1/2-8	1.62	+0.09/−0.02	0.500	—	—	BX 157
11	0.58	0.62	22.25	16	1 3/4-8	1.88	+0.09/−0.02	0.562	—	—	BX 158
13 5/8	0.64	0.62	26.50	20	1 7/8-8	2.00	+0.09/−0.02	0.625	—	—	BX 159
16 3/4	0.35	0.75	30.56	24	1 7/8-8	2.00	+0.09/−0.02	0.328	—	—	BX 162
18 3/4	0.74	0.62	36.44	24	2 1/4-8	2.38	+0.09/−0.02	0.719	—	—	BX 164
21 1/4	0.77	0.81	40.25	24	2 1/2-8	2.62	+0.09/−0.02	0.750	—	—	BX 166

Table E.5—Type 6BX Flanges for 15,000 psi

Dimensions in inches



FOOTNOTES

a Break-sharp corner.

b *Q''* min. = 0.12 in. Raised face (*Ø K*) may be omitted on studded connectors, but thickness *T* shall still apply.

c Optional feature.

d Test connection shall be per 9.3 (Figure 5).

e Ring groove shall be concentric with bore *B* within 0.010 in. diametrical runout. See Table E.11 for ring groove dimensions.

f Test flange style—applies to sizes 1 13/16 through 5 1/8 only.

g Blind flange style—applies to sizes 5 1/8 through 18 3/4 only.

h If the minimum value of J_3 is exceeded, the maximum depth *P* of the counterbore may be increased by the same amount or less.

Table E.5—Type 6BX Flanges for 15,000 psi *(continued)*

Dimensions in inches

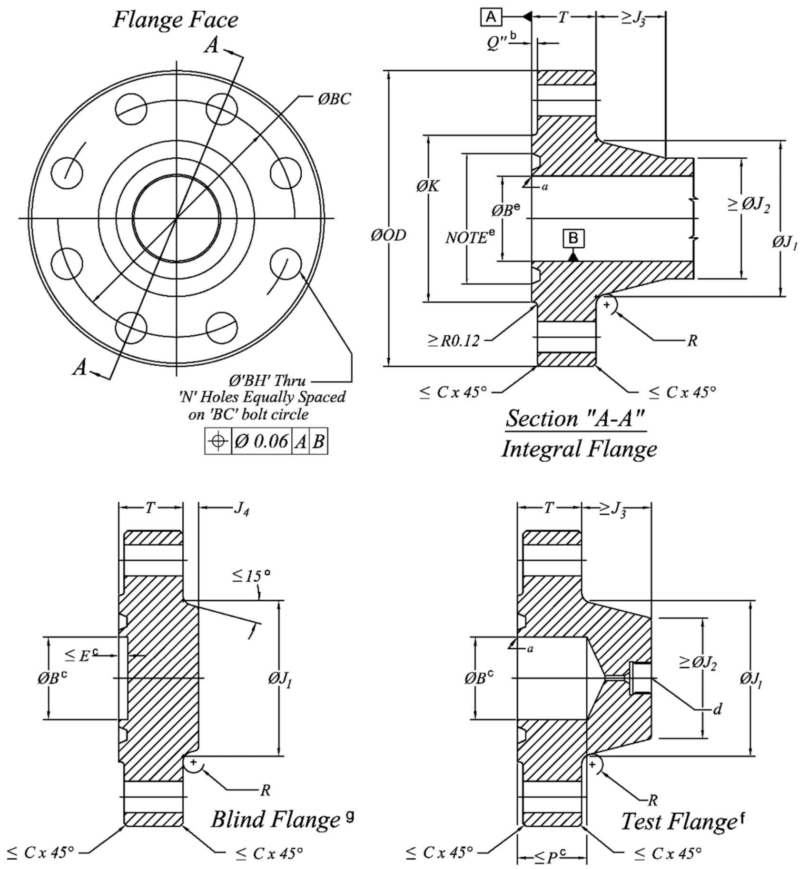
Nominal Size of Flange	Maximum Bore	Outside Diameter of Flange	Diameter of Raised Face	Total Thickness of Flange	Max. Chamfer	Large Hub Diameter	Small Hub Diameter	Hub Length	Test Flange C'bore Depth
	B	*OD*	*K*	*T*	*C*	J_1	J_2	J_3	*P* [h]
Tolerance	max.	As noted	± 0.06	+0.12/−0	max.	+0/−0.12	min.	min.	max. [h]
$1^{13}/_{16}$	1.84	8.19 ±0.06	4.19	1.78	0.12	3.84	2.81	1.88	1.98
$2^{1}/_{16}$	2.09	8.75 ±0.06	4.50	2.00	0.12	4.38	3.25	2.12	2.38
$2^{9}/_{16}$	2.59	10.00 ±0.06	5.25	2.25	0.12	5.06	3.94	2.25	2.65
$3^{1}/_{16}$	3.09	11.31 ±0.06	6.06	2.53	0.12	6.06	4.81	2.50	3.06
$4^{1}/_{16}$	4.09	14.19 ±0.06	7.62	3.09	0.12	7.69	6.25	2.88	3.77
$5^{1}/_{8}$	5.16	16.50 ±0.06	8.88	3.88	0.12	9.62	7.88	3.22	4.65
$7^{1}/_{16}$	7.09	19.88 ±0.12	12.00	4.69	0.25	12.81	10.88	3.62	—
9	9.03	25.50 ±0.12	15.00	5.75	0.25	17.00	13.75	4.88	—
11	11.03	32.00 ±0.12	17.88	7.38	0.25	23.00	16.81	9.28	—
$13^{5}/_{8}$	13.66	34.88 ±0.12	21.31	8.06	0.25	23.44	20.81	4.50	—
$18^{3}/_{4}$	18.78	45.75 ±0.12	28.44	10.06	0.25	32.00	28.75	6.12	—

Dimensions in inches

Nominal Size of Flange	Raised Face Depth	Radius of Hub	Bolt Circle	Number of Bolts	Bolt Size and TPI	Bolt Holes		Blind Flange		Ring Groove
								Counter-bore Depth	Hub Height	
	Q'' [b]	*R*	*BC*	*N*		*BH*		*E* [g]	J_4	
Tolerance	max.	± 0.06	See figure for GDT		(Ref.)	Diameter	Tolerance	max.	min.	
$1^{13}/_{16}$	0.24	0.38	6.31	8	$^{7}/_{8}$-9	1.00	+0.06/−0.02	—	—	BX 151
$2^{1}/_{16}$	0.25	0.38	6.88	8	$^{7}/_{8}$-9	1.00	+0.06/−0.02	—	—	BX 152
$2^{9}/_{16}$	0.29	0.38	7.88	8	1-8	1.12	+0.06/−0.02	—	—	BX 153
$3^{1}/_{16}$	0.32	0.38	9.06	8	$1^{1}/_{8}$-8	1.25	+0.06/−0.02	—	—	BX 154
$4^{1}/_{16}$	0.35	0.38	11.44	8	$1^{3}/_{8}$-8	1.50	+0.06/−0.02	—	—	BX 155
$5^{1}/_{8}$	0.40	0.62	13.50	12	$1^{1}/_{2}$-8	1.62	+0.09/−0.02	0.375	0.25	BX 169
$7^{1}/_{16}$	0.46	0.62	16.88	16	$1^{1}/_{2}$-8	1.62	+0.09/−0.02	0.438	0.31	BX 156
9	0.52	0.62	21.75	16	$1^{7}/_{8}$-8	2.00	+0.09/−0.02	0.500	0.56	BX 157
11	0.58	0.62	28.00	20	2-8	2.12	+0.09/−0.02	0.562	0.50	BX 158
$13^{5}/_{8}$	0.64	1.00	30.38	20	$2^{1}/_{4}$-8	2.38	+0.09/−0.02	0.625	0.69	BX 159
$18^{3}/_{4}$	0.74	1.00	40.00	20	3-8	3.12	+0.12/−0.02	0.719	1.38	BX 164

Table E.6—Type 6BX Flanges for 20,000 psi

Dimensions in inches



FOOTNOTES

a Break sharp corner.

b *Q''* min. = 0.12 in. Raised face (Ø *K*) may be omitted on studded connectors, but thickness *T* shall still apply.

c Optional feature.

d Test connection shall be per 9.3 (Figure 5).

e Ring groove shall be concentric with bore *B* within 0.010 in. diametrical runout. See Table E.11 for ring groove dimensions.

f Test flange style—applies to sizes 1 13/16 through 4 1/16 only.

g Blind flange style—applies to sizes 5 1/8 through 18 3/4 only.

h If the minimum value of J_3 is exceeded, the maximum depth *P* of the counterbore may be increased by the same amount or less.

Table E.6—Type 6BX Flanges for 20,000 psi *(continued)*

Dimensions in inches

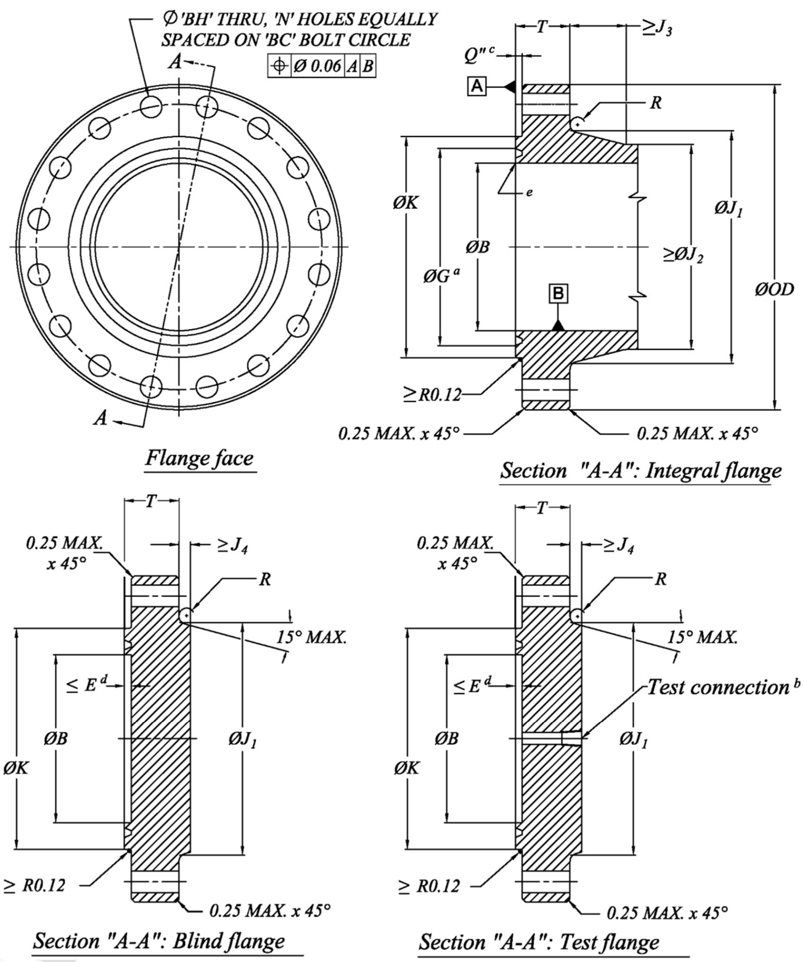
Nominal Size of Flange	Maximum Bore	Outside Diameter of Flange	Diameter of Raised Face	Total Thickness of Flange	Max. Chamfer	Large Hub Diameter	Small Hub Diameter	Hub Length	Test Flange C'bore Depth
	B	*OD*	*K*	*T*	*C*	J_1	J_2	J_3	*P* [h]
Tolerance	max.	As noted	± 0.06	+0.12/−0	max.	+0/−0.12	min.	min.	max. [h]
$1^{13}/_{16}$	1.84	10.12 ±0.06	4.62	2.50	0.12	5.25	4.31	1.94	2.50
$2^{1}/_{16}$	2.09	11.31 ±0.06	5.19	2.81	0.12	6.06	5.00	2.06	2.50
$2^{9}/_{16}$	2.59	12.81 ±0.06	5.94	3.12	0.12	6.81	5.69	2.31	2.50
$3^{1}/_{16}$	3.09	14.06 ±0.06	6.75	3.38	0.12	7.56	6.31	2.50	2.50
$4^{1}/_{16}$	4.09	17.56 ±0.06	8.62	4.19	0.12	9.56	8.12	2.88	2.50
$5^{1}/_{8}$	5.16	20.31 ±0.12	10.38	5.00	0.12	11.50	9.75	3.84	—
$7^{1}/_{16}$	7.09	25.81 ±0.12	13.88	6.50	0.25	15.19	13.31	3.81	—
9	9.03	31.69 ±0.12	17.38	8.06	0.25	18.94	16.88	4.25	—
11	11.03	34.75 ±0.12	19.88	8.81	0.25	22.31	20.00	4.06	—
$13^{5}/_{8}$	13.66	45.75 ±0.12	24.19	11.50	0.25	27.31	24.75	5.25	—

Dimensions in inches

Nominal Size of Flange	Raised Face Depth	Radius of Hub	Bolt Circle	Number of Bolts	Bolt Size and TPI	Bolt Holes		Blind Flange		Ring Groove
								C'bore Depth	Hub Height	
	Q” [b]	*R*	*BC*	*N*		*BH*		*E*	J_4	
Tolerance	max.	± 0.06	See figure for GDT		(Ref.)	Diameter	Tolerance	max.	min.	
$1^{13}/_{16}$	0.24	0.38	8.00	8	1-8	1.12	+0.06/−0.02	—	—	BX 151
$2^{1}/_{16}$	0.25	0.38	9.06	8	$1^{1}/_{8}$-8	1.25	+0.06/−0.02	—	—	BX 152
$2^{9}/_{16}$	0.29	0.38	10.31	8	$1^{1}/_{4}$-8	1.38	+0.06/−0.02	—	—	BX 153
$3^{1}/_{16}$	0.32	0.38	11.31	8	$1^{3}/_{8}$-8	1.50	+0.06/−0.02	—	—	BX 154
$4^{1}/_{16}$	0.35	0.38	14.06	8	$1^{3}/_{4}$-8	1.88	+0.09/−0.02	—	—	BX 155
$5^{1}/_{8}$	0.40	0.62	16.94	16	$1^{1}/_{2}$-8	1.62	+0.09/−0.02	0.375	0.60	BX 169
$7^{1}/_{16}$	0.46	0.62	21.81	16	2-8	2.12	+0.09/−0.02	0.438	0.31	BX 156
9	0.52	1.00	27.00	16	$2^{1}/_{2}$-8	2.62	+0.09/−0.02	0.500	0.25	BX 157
11	0.58	1.00	29.50	16	$2^{3}/_{4}$-8	2.88	+0.09/−0.02	0.562	0.50	BX 158
$13^{5}/_{8}$	0.64	1.00	40.00	20	3-8	3.12	+0.12/−0.02	0.625	0.56	BX 159

Table E.7—Type 6BX Large-bore Flanges for 2000 psi, 3000 psi, and 5000 psi

Dimensions in inches



FOOTNOTES

a Ring groove shall be concentric with bore *B* within 0.010 in. diametrical runout. See Table E.11 for ring groove dimensions.

b Test connection shall be 1/2 in. NPT or per 9.3 (Figure 5).

c *Q''* min. = 0.12 in. (may be omitted for studded flanges).

d Counterbore *E* for blind and test flanges is optional.

e Break sharp corner.

Table E.7—Type 6BX Large-bore Flanges for 2000 psi, 3000 psi, and 5000 psi *(continued)*

Dimensions in inches

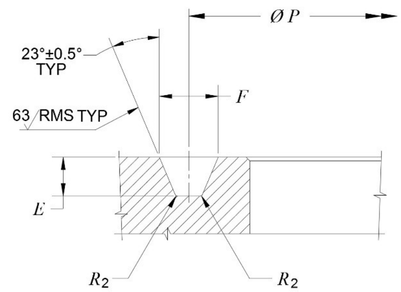
Nominal Size	Maximum Bore *B*	Outside Diameter of Flange *OD*	Raised Face Depth *Q″*	Raised Face Diameter *K*	Total Thickness *T*	Large Hub Diameter J_1	Small Hub Diameter J_2	Length of Hub J_3
Tolerance	max.	As noted	max.	± 0.06	+0.12/−0	+0/−0.12	min.	min.
2000 psi								
26 3/4	26.78	41.00 ±0.12	0.25	31.69	4.97	32.91	29.25	7.31
30	30.03	44.19 ±0.12	0.25	35.75	5.28	36.69	32.80	7.75
3000 psi								
26 3/4	26.78	43.38 ±0.12	0.25	32.75	6.34	34.25	30.56	7.31
30	30.03	46.68 ±0.12	0.25	36.31	6.58	38.19	34.30	7.75
5000 psi								
13 5/8	13.66	26.50 ±0.12	0.25	18.00	4.44	18.94	16.69	4.50
16 3/4	16.78	30.38 ±0.12	0.25	21.06	5.12	21.88	20.75	3.00
18 3/4	18.78	35.62 ±0.12	0.25	24.69	6.53	26.56	23.56	6.00
21 1/4	21.28	39.00 ±0.12	0.25	27.62	7.12	29.88	26.75	6.50

Dimensions in inches

Nominal Size	Radius of Hub *R*	Bolt Circle *BC*	Number of Bolts *N*	Bolt Size and TPI	Bolt Hole Diameter *BH*	Blind Flange Counter-bore Depth *E*	Blind Flange Hub Height J_4	Ring Groove
Tolerance	± 0.06	See figure for GDT		(Ref.)	+0.09/−0.02	max.	min.	
2000 psi								
26 3/4	0.62	37.50	20	1 3/4-8	1.88	0.844	0.38	BX 167
30	0.62	40.94	32	1 5/8-8	1.75	0.906	0.69	BX 303
3000 psi								
26 3/4	0.62	39.38	24	2-8	2.12	0.844	0.00	BX 168
30	0.62	42.94	32	1 7/8-8	2.00	0.906	0.50	BX 303
5000 psi								
13 5/8	0.62	23.25	16	1 5/8-8	1.75	0.562	0.94	BX 160
16 3/4	0.75	26.62	16	1 7/8-8	2.00	0.328	0.69	BX 162
18 3/4	0.62	31.62	20	2-8	2.12	0.719	0.75	BX 163
21 1/4	0.69	34.88	24	2-8	2.12	0.750	0.88	BX 165

Table E.8—Type R Ring Grooves

Dimensions in inches; surface roughness in microinches

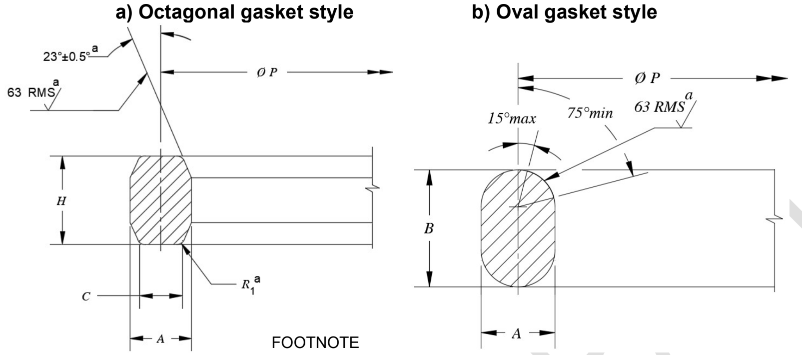


Dimensions in inches

Groove Number	Nominal Size of Flange	Pitch Diameter	Depth of Groove	Width of Groove	Radius in Groove
	in.	*P*	*E*	*F*	R_2
Tolerance>	(Ref.)	± 0.005	+0.02/−0	± 0.008	max.
R 23	2 1/16	3.250	0.31	0.469	0.03
R 24	2 1/16	3.750	0.31	0.469	0.03
R 26	2 9/16	4.000	0.31	0.469	0.03
R 27	2 9/16	4.250	0.31	0.469	0.03
R 31	3 1/8	4.875	0.31	0.469	0.03
R 35	3 1/8	5.375	0.31	0.469	0.03
R 37	4 1/16	5.875	0.31	0.469	0.03
R 39	4 1/16	6.375	0.31	0.469	0.03
R 41	5 1/8	7.125	0.31	0.469	0.03
R 44	5 1/8	7.625	0.31	0.469	0.03
R 45	7 1/16	8.313	0.31	0.469	0.03
R 46	7 1/16	8.313	0.38	0.531	0.06
R 49	9	10.625	0.31	0.469	0.03
R 50	9	10.625	0.44	0.656	0.06
R 53	11	12.750	0.31	0.469	0.03
R 54	11	12.750	0.44	0.656	0.06
R 57	13 5/8	15.000	0.31	0.469	0.03
R 65	16 3/4	18.500	0.31	0.469	0.03
R 66	16 3/4	18.500	0.44	0.656	0.06
R 73	21 1/4	23.000	0.38	0.531	0.06
R 74	20 3/4	23.000	0.50	0.781	0.06

Table E.9—Type R Ring Gaskets

Dimensions in inches; surface roughness in microinches



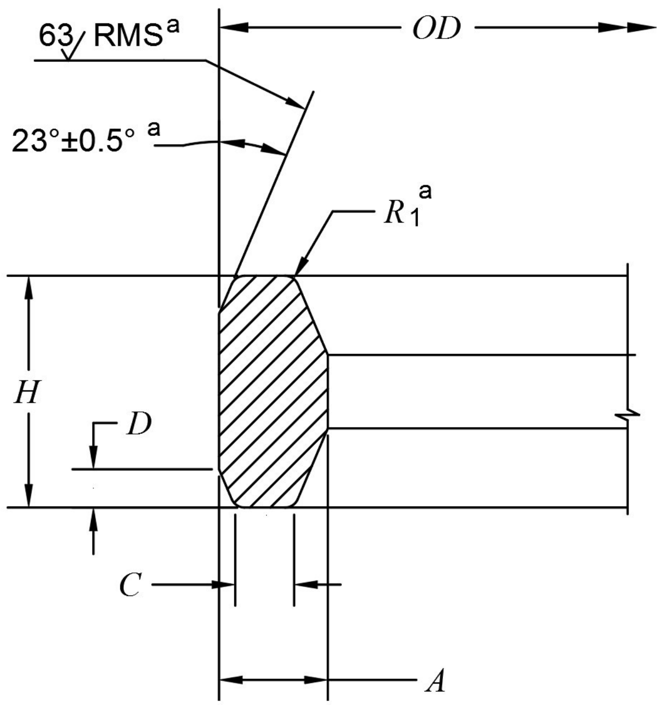
FOOTNOTE
[a] Typical four places.

Dimensions in inches

Gasket Number	Pitch Diameter	Width of Ring	Height of Oval Ring	Height of Octagonal Ring	Width of Flat on Octagonal Ring	Radius on Octagonal Ring	Distance between Flanges
	P	*A*	*B*	*H*	*C*	R_1	*S*
Tolerance>	± 0.007	± 0.008	± 0.02	± 0.02	± 0.008	± 0.02	(Approx.)
R 23	3.250	0.438	0.69	0.63	0.305	0.06	0.19
R 24	3.750	0.438	0.69	0.63	0.305	0.06	0.19
R 26	4.000	0.438	0.69	0.63	0.305	0.06	0.19
R 27	4.250	0.438	0.69	0.63	0.305	0.06	0.19
R 31	4.875	0.438	0.69	0.63	0.305	0.06	0.19
R 35	5.375	0.438	0.69	0.63	0.305	0.06	0.19
R 37	5.875	0.438	0.69	0.63	0.305	0.06	0.19
R 39	6.375	0.438	0.69	0.63	0.305	0.06	0.19
R 41	7.125	0.438	0.69	0.63	0.305	0.06	0.19
R 44	7.625	0.438	0.69	0.63	0.305	0.06	0.19
R 45	8.313	0.438	0.69	0.63	0.305	0.06	0.19
R 46	8.313	0.500	0.75	0.69	0.341	0.06	0.19
R 49	10.625	0.438	0.69	0.63	0.305	0.06	0.19
R 50	10.625	0.625	0.88	0.81	0.413	0.06	0.16
R 53	12.750	0.438	0.69	0.63	0.305	0.06	0.19
R 54	12.750	0.625	0.88	0.81	0.413	0.06	0.16
R 57	15.000	0.438	0.69	0.63	0.305	0.06	0.19
R 65	18.500	0.438	0.69	0.63	0.305	0.06	0.19
R 66	18.500	0.625	0.88	0.81	0.413	0.06	0.16
R 73	23.000	0.500	0.75	0.69	0.341	0.06	0.13
R 74	23.000	0.750	1.00	0.94	0.485	0.06	0.19

Table E.10—Type RX Ring Gaskets

Dimensions in inches; surface roughness in microinches



FOOTNOTE

[a] Typical four places.

Table E.10—Type RX Ring Gaskets *(continued)*

Dimensions in inches

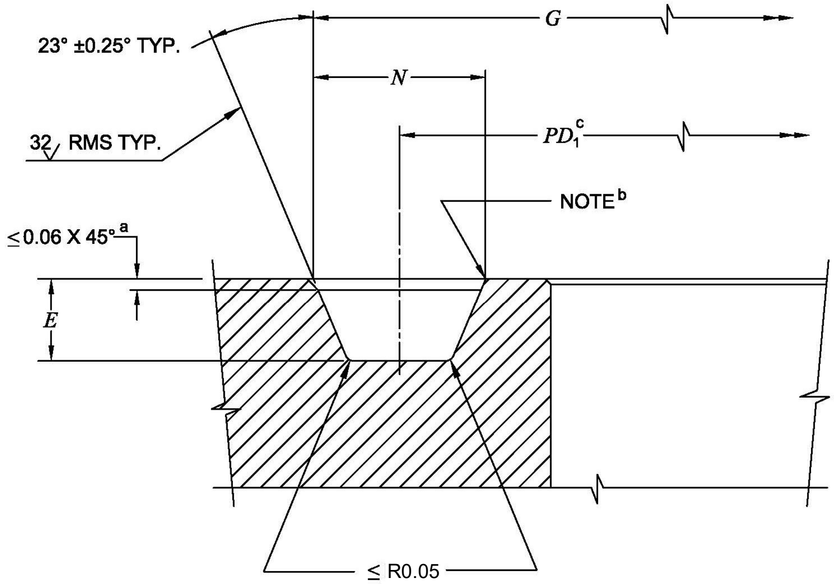
Groove Number	Outside Diameter *OD*	Width of Ring *A* [a]	Width of Flat *C*	Height of Ring *H* [a]	Height of OD Bevel *D*	Radius on Ring R_1	Distance between Flanges *S*
Tolerance>	+0.020/−0	+0.008/−0	+0.006/−0	+0.008/−0	+0/−0.030	± 0.02	(Approx.)
RX 23	3.672	0.469	0.254	1.000	0.167	0.06	0.47
RX 24	4.172	0.469	0.254	1.000	0.167	0.06	0.47
RX 26	4.406	0.469	0.254	1.000	0.167	0.06	0.47
RX 27	4.656	0.469	0.254	1.000	0.167	0.06	0.47
RX 31	5.297	0.469	0.254	1.000	0.167	0.06	0.47
RX 35	5.797	0.469	0.254	1.000	0.167	0.06	0.47
RX 37	6.297	0.469	0.254	1.000	0.167	0.06	0.47
RX 39	6.797	0.469	0.254	1.000	0.167	0.06	0.47
RX 41	7.547	0.469	0.254	1.000	0.167	0.06	0.47
RX 44	8.047	0.469	0.254	1.000	0.167	0.06	0.47
RX 45	8.734	0.469	0.254	1.000	0.167	0.06	0.47
RX 46	8.750	0.531	0.263	1.125	0.188	0.06	0.47
RX 49	11.047	0.469	0.254	1.000	0.167	0.06	0.47
RX 50	11.156	0.656	0.335	1.250	0.208	0.06	0.47
RX 53	13.172	0.469	0.254	1.000	0.167	0.06	0.47
RX 54	13.281	0.656	0.335	1.250	0.208	0.06	0.47
RX 57	15.422	0.469	0.254	1.000	0.167	0.06	0.47
RX 65	18.922	0.469	0.254	1.000	0.167	0.06	0.47
RX 66	19.031	0.656	0.335	1.250	0.208	0.06	0.47
RX 73	23.469	0.531	0.263	1.250	0.208	0.06	0.59
RX 74	23.656	0.781	0.407	1.625	0.271	0.09	0.72

FOOTNOTE

[a] The variation in width *A* or height *H* of any ring shall not exceed 0.004 in. throughout its entire circumference.

Table E.11—Type BX Ring Grooves

Dimensions in inches; surface roughness in microinches



FOOTNOTES

a The 0.06 x 45° chamfer is optional and only applies to the outside (OD) of the groove.

b Break sharp corner 0.03 in. maximum at inside (ID) of the groove.

c Reference dimension.

Table E.11—Type BX Ring Grooves *(continued)*

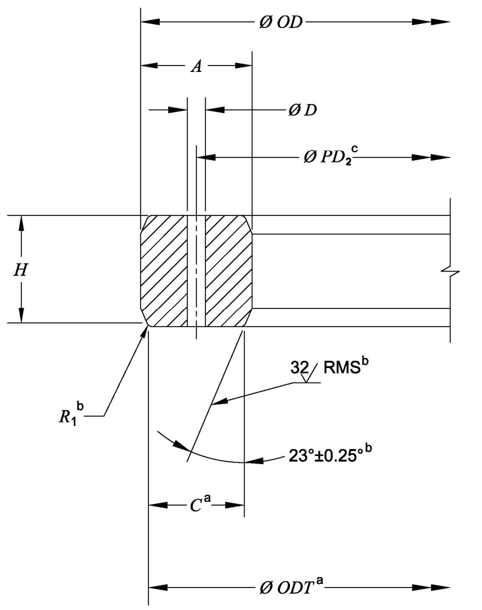
Dimensions in inches

Groove Number	Nominal Size of Flange	Outside Diameter	Depth of Groove	Width of Groove	Pitch Diameter of Groove	Pitch Diameter of Gasket [a]
	in.	*G*	*E*	*N*	PD_1	PD_2
Tolerance>	(Ref.)	+0.004/−0	+0.02/−0	+0.004/−0	(Ref.)	(Ref.)
BX 151	1 13/16	3.062	0.22	0.466	2.596	2.622
BX 152	2 1/16	3.395	0.23	0.498	2.897	2.924
BX 153	2 9/16	4.046	0.27	0.554	3.492	3.519
BX 154	3 1/16	4.685	0.30	0.606	4.079	4.105
BX 155	4 1/16	5.930	0.33	0.698	5.232	5.253
BX 156	7 1/16	9.521	0.44	0.921	8.600	8.627
BX 157	9	11.774	0.50	1.039	10.735	10.760
BX 158	11	14.064	0.56	1.149	12.915	12.942
BX 159	13 5/8	17.033	0.62	1.279	15.754	15.781
BX 160	13 5/8	16.063	0.56	0.786	15.277	15.302
BX 161	16 3/4	19.604	0.67	0.930	18.674	18.702
BX 162	16 3/4	18.832	0.33	0.705	18.127	18.153
BX 163	18 3/4	22.185	0.72	1.006	21.179	21.205
BX 164	18 3/4	22.752	0.72	1.290	21.462	21.488
BX 165	21 1/4	24.904	0.75	1.071	23.833	23.860
BX 166	21 1/4	25.507	0.75	1.373	24.134	24.162
BX 167	26 3/4	30.249	0.84	0.902	29.347	29.373
BX 168	26 3/4	30.481	0.84	1.018	29.463	29.489
BX 169	5 1/8	6.955	0.38	0.666	6.289	6.315
BX 170	9	8.696	0.33	0.705	7.991	8.017
BX 171	11	10.641	0.33	0.705	9.936	9.962
BX 172	13 5/8	13.225	0.33	0.705	12.520	12.546
BX 303	30	33.949	0.89	1.078	32.871	32.898

FOOTNOTE
[a] PD_2 of gaskets provided for comparison purposes. See Table E.12 for ring gasket dimensions.
Pitch diameter calculated using dimensions at middle of tolerance range.

Table E.12—Type BX Ring Gaskets

Dimensions in inches; surface roughness in microinches

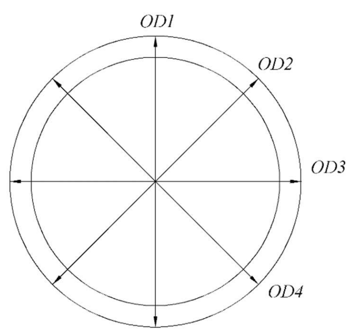


FOOTNOTES

[a] Typical two places (top and bottom).

[b] Typical four places (all corners).

[c] Reference dimension (see Table E.11 for value).



OD MINIMUM INSPECTION LOCATIONS

Table E.12—Type BX Ring Gaskets *(continued)*

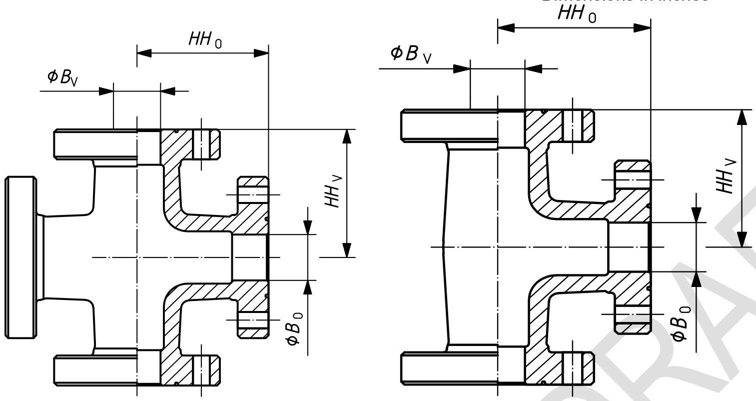
Dimensions in inches

Groove Number	Outside Diameter[a]	Width of Ring	Height of Ring	Diameter of Flat	Width of Flat	Hole Size	Radius on Ring	
	OD	*A*	*H*	*ODT*	*C*	*D*	R_1	
Tolerance>	+0 −0.006	+0.008 −0	+0.008 −0	± 0.002	+0.006 −0	± 0.02	min.	max.
BX 151	3.008	0.379	0.379	2.954	0.325	0.06	0.03	0.05
BX 152	3.334	0.403	0.403	3.277	0.346	0.06	0.03	0.05
BX 153	3.974	0.448	0.448	3.910	0.385	0.06	0.04	0.05
BX 154	4.600	0.488	0.488	4.531	0.419	0.06	0.04	0.06
BX 155	5.825	0.560	0.560	5.746	0.481	0.06	0.04	0.07
BX 156	9.367	0.733	0.733	9.263	0.629	0.12	0.06	0.09
BX 157	11.593	0.826	0.826	11.476	0.709	0.12	0.07	0.10
BX 158	13.860	0.911	0.911	13.731	0.782	0.12	0.07	0.11
BX 159	16.800	1.012	1.012	16.657	0.869	0.12	0.08	0.12
BX 160	15.850	0.541	0.938	15.717	0.408	0.12	0.08	0.11
BX 161	19.347	0.638	1.105	19.191	0.482	0.12	0.09	0.13
BX 162	18.720	0.560	0.560	18.641	0.481	0.06	0.04	0.07
BX 163	21.896	0.684	1.185	21.728	0.516	0.12	0.09	0.14
BX 164	22.463	0.968	1.185	22.295	0.800	0.12	0.09	0.14
BX 165	24.595	0.728	1.261	24.417	0.550	0.12	0.10	0.15
BX 166	25.198	1.029	1.261	25.020	0.851	0.12	0.10	0.15
BX 167	29.896	0.516	1.412	29.696	0.316	0.06	0.11	0.17
BX 168	30.128	0.632	1.412	29.928	0.432	0.06	0.11	0.17
BX 169	6.831	0.509	0.624	6.743	0.421	0.06	0.05	0.07
BX 170	8.584	0.560	0.560	8.505	0.481	0.06	0.04	0.07
BX 171	10.529	0.560	0.560	10.450	0.481	0.06	0.04	0.07
BX 172	13.113	0.560	0.560	13.034	0.481	0.06	0.04	0.07
BX 303	33.573	0.668	1.494	33.361	0.457	0.06	0.12	0.18

FOOTNOTE
[a] The requirements of 10.4.5.4.2.3 and 10.4.5.4.2.4 shall apply.

Table E.13—Flanged Crosses and Tees

Dimensions in inches



Dimensions in inches

Nominal Sizes	Bore Diameter Vertical Run B_V	Bore Diameter Horizontal Run B_O	Center-to-face Vertical Run HH_V	Center-to-face Horizontal Run HH_O
Tolerance>	+0.03/−0.0	+0.03/−0.0	± 0.03	± 0.03
2000 psi				
$2^{1}/_{16}$ x $2^{1}/_{16}$	2.06	2.06	5.81	5.81
$2^{9}/_{16}$ x $2^{1}/_{16}$	2.56	2.06	5.94	6.31
$2^{9}/_{16}$ x $2^{9}/_{16}$	2.56	2.56	6.56	6.56
$3^{1}/_{8}$ x $2^{1}/_{16}$	3.12	2.06	6.06	6.69
$3^{1}/_{8}$ x $2^{9}/_{16}$	3.12	2.56	6.56	6.81
$3^{1}/_{8}$ x $3^{1}/_{8}$	3.12	3.12	7.06	7.06
$4^{1}/_{16}$ x $2^{1}/_{16}$	4.06	2.06	6.31	7.94
$4^{1}/_{16}$ x $2^{9}/_{16}$	4.06	2.56	6.81	8.06
$4^{1}/_{16}$ x $3^{1}/_{8}$	4.06	3.12	7.19	8.19
$4^{1}/_{16}$ x $4^{1}/_{16}$	4.06	4.06	8.56	8.56
3000 psi				
$2^{1}/_{16}$ x $2^{1}/_{16}$	2.06	2.06	7.31	7.31
$2^{9}/_{16}$ x $2^{1}/_{16}$	2.56	2.06	7.44	7.88
$2^{9}/_{16}$ x $2^{9}/_{16}$	2.56	2.56	8.31	8.31
$3^{1}/_{8}$ x $2^{1}/_{16}$	3.12	2.06	7.31	7.81
$3^{1}/_{8}$ x $2^{9}/_{16}$	3.12	2.56	7.88	7.94
$3^{1}/_{8}$ x $3^{1}/_{8}$	3.12	3.12	7.56	7.56
$4^{1}/_{16}$ x $2^{1}/_{16}$	4.06	2.06	7.56	8.81
$4^{1}/_{16}$ x $2^{9}/_{16}$	4.06	2.56	8.12	8.94
$4^{1}/_{16}$ x $3^{1}/_{8}$	4.06	3.12	8.06	8.81
$4^{1}/_{16}$ x $4^{1}/_{16}$	4.06	4.06	9.06	9.06

Table E.13—Flanged Crosses and Tees *(continued)*

Dimensions in inches

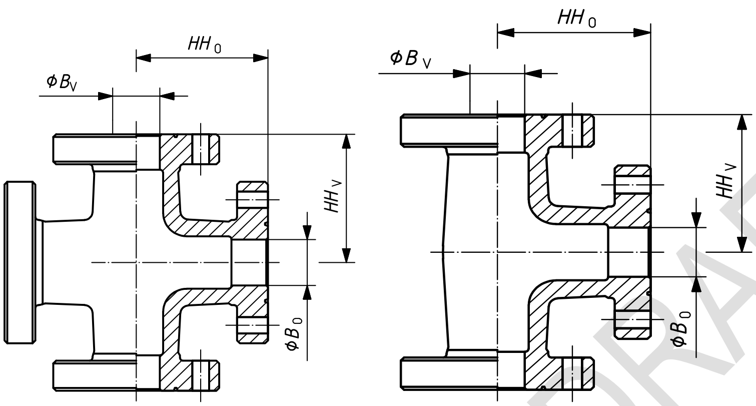
Nominal Sizes	Bore Diameter		Center-to-face Vertical Run	Center-to-face Horizontal Run
	Vertical Run B_V	Horizontal Run B_O	HH_V	HH_O
Tolerance>	+0.03/−0.0	+0.03/−0.0	± 0.03	± 0.03
5000 psi				
$2^{1}/_{16}$ x $2^{1}/_{16}$	2.06	2.06	7.31	7.31
$2^{9}/_{16}$ x $2^{1}/_{16}$	2.56	2.06	7.44	7.88
$2^{9}/_{16}$ x $2^{9}/_{16}$	2.56	2.56	8.31	8.31
$3^{1}/_{8}$ x $2^{1}/_{16}$	3.12	2.06	7.69	8.31
$3^{1}/_{8}$ x $2^{9}/_{16}$	3.12	2.56	8.25	8.44
$3^{1}/_{8}$ x $3^{1}/_{8}$	3.12	3.12	9.31	9.31
$4^{1}/_{16}$ x $2^{1}/_{16}$	4.06	2.06	7.94	9.19
$4^{1}/_{16}$ x $2^{9}/_{16}$	4.06	2.56	8.50	9.31
$4^{1}/_{16}$ x $3^{1}/_{8}$	4.06	3.12	8.94	9.56
$4^{1}/_{16}$ x $4^{1}/_{16}$	4.06	4.06	10.81	10.81
$5^{1}/_{8}$ x $2^{1}/_{16}$	5.12 [a]	2.06	9.06	10.56
$5^{1}/_{8}$ x $2^{9}/_{16}$	5.12 [a]	2.56	9.62	10.69
$5^{1}/_{8}$ x $3^{1}/_{8}$	5.12 [a]	3.12	10.06	10.94
$5^{1}/_{8}$ x $4^{1}/_{16}$	5.12 [a]	4.06	10.93	11.19
$5^{1}/_{8}$ x $5^{1}/_{8}$	5.12 [a]	5.12 [a]	12.19	12.19
10,000 psi				
$2^{1}/_{16}$ x $1^{13}/_{16}$	2.06	1.81	6.67	6.84
$2^{1}/_{16}$ x $2^{1}/_{16}$	2.06	2.06	6.92	6.92
$2^{9}/_{16}$ x $1^{13}/_{16}$	2.56	1.81	6.95	7.47
$2^{9}/_{16}$ x $2^{1}/_{16}$	2.56	2.06	7.20	7.55
$2^{9}/_{16}$ x $2^{9}/_{16}$	2.56	2.56	7.83	7.83
$3^{1}/_{16}$ x $1^{13}/_{16}$	3.06	1.81	7.23	8.22
$3^{1}/_{16}$ x $2^{1}/_{16}$	3.06	2.06	7.48	8.30
$3^{1}/_{16}$ x $2^{9}/_{16}$	3.06	2.56	8.11	8.58
$3^{1}/_{16}$ x $3^{1}/_{16}$	3.06	3.06	8.86	8.86
$4^{1}/_{16}$ x $1^{13}/_{16}$	4.06	1.81	7.81	9.25
$4^{1}/_{16}$ x $2^{1}/_{16}$	4.06	2.06	8.06	9.33
$4^{1}/_{16}$ x $2^{9}/_{16}$	4.06	2.56	8.69	9.61
$4^{1}/_{16}$ x $3^{1}/_{16}$	4.06	3.06	9.44	9.89
$4^{1}/_{16}$ x $4^{1}/_{16}$	4.06	4.06	10.34	10.34
$5^{1}/_{8}$ x $1^{13}/_{16}$	5.12 [a]	1.81	8.19	10.06
$5^{1}/_{8}$ x $2^{1}/_{16}$	5.12 [a]	2.06	8.44	10.12
$5^{1}/_{8}$ x $2^{9}/_{16}$	5.12 [a]	2.56	9.06	10.42
$5^{1}/_{8}$ x $3^{1}/_{16}$	5.12 [a]	3.06	9.81	10.69
$5^{1}/_{8}$ x $4^{1}/_{16}$	5.12 [a]	4.06	10.72	11.19
$5^{1}/_{8}$ x $5^{1}/_{8}$	5.12 [a]	5.12 [a]	11.53	11.53

FOOTNOTE

[a] Tolerance on $5^{1}/_{8}$ bore is +0.04/−0.00.

Table E.13—Flanged Crosses and Tees *(continued)*

Dimensions in inches



Dimensions in inches

Nominal Sizes	Bore Diameter		Center-to-face Vertical Run	Center-to-face Horizontal Run
	Vertical Run B_V	Horizontal Run B_O	HH_V	HH_O
Tolerance>	+0.03/−0.0	+0.03/−0.0	± 0.03	± 0.03
15,000 psi				
$2^1/_{16}$ x $1^{13}/_{16}$	2.06	1.81	7.34	7.41
$2^1/_{16}$ x $2^1/_{16}$	2.06	2.06	7.62	7.62
$2^9/_{16}$ x $1^{13}/_{16}$	2.56	1.81	7.59	8.03
$2^9/_{16}$ x $2^1/_{16}$	2.56	2.06	7.88	8.25
$2^9/_{16}$ x $2^9/_{16}$	2.56	2.56	8.50	8.50
$3^1/_{16}$ x $1^{13}/_{16}$	3.06	1.81	7.86	8.69
$3^1/_{16}$ x $2^1/_{16}$	3.06	2.06	8.16	8.91
$3^1/_{16}$ x $2^9/_{16}$	3.06	2.56	8.78	9.16
$3^1/_{16}$ x $3^1/_{16}$	3.06	3.06	9.44	9.44
$4^1/_{16}$ x $1^{13}/_{16}$	4.06	1.81	8.69	10.25
$4^1/_{16}$ x $2^1/_{16}$	4.06	2.06	8.97	10.47
$4^1/_{16}$ x $2^9/_{16}$	4.06	2.56	9.59	10.72
$4^1/_{16}$ x $3^1/_{16}$	4.06	3.06	10.25	11.00
$4^1/_{16}$ x $4^1/_{16}$	4.06	4.06	11.69	11.69
$5^1/_8$ x $1^{13}/_{16}$	5.12 [a]	1.81	9.38	11.44
$5^1/_8$ x $2^1/_{16}$	5.12 [a]	2.06	9.63	11.63
$5^1/_8$ x $2^9/_{16}$	5.12 [a]	2.56	10.25	11.88
$5^1/_8$ x $3^1/_{16}$	5.12 [a]	3.06	10.94	12.18
$5^1/_8$ x $4^1/_{16}$	5.12 [a]	4.06	12.38	12.75
$5^1/_8$ x $5^1/_8$	5.12 [a]	5.12 [a]	13.50	13.50

FOOTNOTE

[a] Tolerance on $5^1/_8$ bore is +0.04/−0.00.

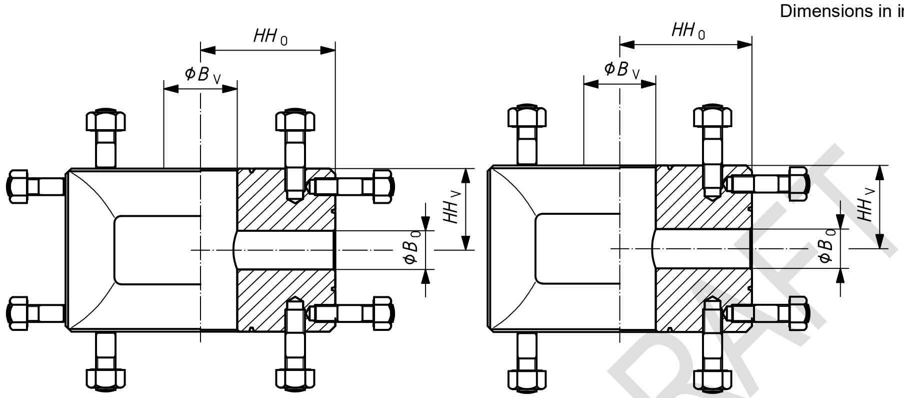
Table E.13—Flanged Crosses and Tees *(continued)*

Dimensions in inches

Nominal Sizes	Bore Diameter		Center-to-face Vertical Run	Center-to-face Horizontal Run
	Vertical Run B_V	Horizontal Run B_O	HH_V	HH_O
Tolerance>	+0.03/−0.0	+0.03/−0.0	± 0.03	± 0.03
20,000 psi				
$1^{13}/_{16}$ x $1^{13}/_{16}$	1.81	1.81	8.94	8.94
$2^{1}/_{16}$ x $1^{13}/_{16}$	2.06	1.81	9.25	9.53
$2^{1}/_{16}$ x $2^{1}/_{16}$	2.06	2.06	9.84	9.84
$2^{9}/_{16}$ x $1^{13}/_{16}$	2.56	1.81	9.56	10.28
$2^{9}/_{16}$ x $2^{1}/_{16}$	2.56	2.06	10.16	10.59
$2^{9}/_{16}$ x $2^{9}/_{16}$	2.56	2.56	10.91	10.91
$3^{1}/_{16}$ x $1^{13}/_{16}$	3.06	1.81	9.94	10.91
$3^{1}/_{16}$ x $2^{1}/_{16}$	3.06	2.06	10.53	10.22
$3^{1}/_{16}$ x $2^{9}/_{16}$	3.06	2.56	11.28	11.53
$3^{1}/_{16}$ x $3^{1}/_{16}$	3.06	3.06	11.91	11.91
$4^{1}/_{16}$ x $1^{13}/_{16}$	4.06	1.81	11.12	12.66
$4^{1}/_{16}$ x $2^{1}/_{16}$	4.06	2.06	11.72	12.66
$4^{1}/_{16}$ x $2^{9}/_{16}$	4.06	2.56	12.47	13.28
$4^{1}/_{16}$ x $3^{1}/_{16}$	4.06	3.06	13.09	13.66
$4^{1}/_{16}$ x $4^{1}/_{16}$	4.06	4.06	14.84	14.84

Table E.14—Studded Crosses and Tees

Dimensions in inches



Dimensions in inches

Nominal Sizes	Bore Diameter		Center-to-face Vertical Run	Center-to-face Horizontal Run
	Vertical Run B_V	Horizontal Run B_O	HH_V	HH_O
Tolerance>	+0.03/−0.0	+0.03/−0.0	± 0.03	± 0.03
2000 psi				
$2^1/_{16}$ x $2^1/_{16}$	2.06	2.06	3.50	3.50
$2^9/_{16}$ x $2^1/_{16}$	2.56	2.06	3.50	4.00
$2^9/_{16}$ x $2^9/_{16}$	2.56	2.56	4.50	4.50
$3^1/_8$ x $2^1/_{16}$	3.12	2.06	3.50	4.50
$3^1/_8$ x $2^9/_{16}$	3.12	2.56	4.50	4.50
$3^1/_8$ x $3^1/_8$	3.12	3.12	4.50	4.50
$4^1/_{16}$ x $2^1/_{16}$	4.06	2.06	4.50	5.50
$4^1/_{16}$ x $2^9/_{16}$	4.06	2.56	4.50	5.50
$4^1/_{16}$ x $3^1/_8$	4.06	3.12	4.50	5.50
$4^1/_{16}$ x $4^1/_{16}$	4.06	4.06	5.50	5.50
$7^1/_{16}$ x $2^1/_{16}$	7.06	2.06	5.40	7.50
$7^1/_{16}$ x $2^9/_{16}$	7.06	2.56	5.40	7.50
$7^1/_{16}$ x $3^1/_8$	7.06	3.12	5.40	7.50
$7^1/_{16}$ x $4^1/_{16}$	7.06	4.06	6.35	7.50
$7^1/_{16}$ x $5^1/_8$	7.06	5.12 [a]	7.00	7.50
$7^1/_{16}$ x $7^1/_{16}$	7.06	7.06	7.50	7.50

FOOTNOTE

[a] Tolerance on $5^1/_8$ bore is +0.04/−0.00.

Dimensions in inches

Nominal Sizes	Bore Diameter Vertical Run B_V	Bore Diameter Horizontal Run B_O	Center-to-face Vertical Run HH_V	Center-to-face Horizontal Run HH_O
Tolerance>	+0.03/−0.0	+0.03/−0.0	± 0.03	± 0.03
3000 psi				
$2^1/_{16}$ x $2^1/_{16}$	2.06	2.06	4.50	4.50
$2^9/_{16}$ x $2^1/_{16}$	2.56	2.06	4.50	5.00
$2^9/_{16}$ x $2^9/_{16}$	2.56	2.56	5.00	5.00
$3^1/_8$ x $2^1/_{16}$	3.12	2.06	4.50	5.00
$3^1/_8$ x $2^9/_{16}$	3.12	2.56	5.00	5.00
$3^1/_8$ x $3^1/_8$	3.12	3.12	5.00	5.00
$4^1/_{16}$ x $2^1/_{16}$	4.06	2.06	4.50	6.12
$4^1/_{16}$ x $2^9/_{16}$	4.06	2.56	5.00	6.12
$4^1/_{16}$ x $3^1/_8$	4.06	3.12	5.00	6.12
$4^1/_{16}$ x $4^1/_{16}$	4.06	4.06	6.12	6.12
$7^1/_{16}$ x $2^1/_{16}$	7.06	2.06	5.32	8.27
$7^1/_{16}$ x $2^9/_{16}$	7.06	2.56	5.82	8.47
$7^1/_{16}$ x $3^1/_8$	7.06	3.12	5.82	8.47
$7^1/_{16}$ x $4^1/_{16}$	7.06	4.06	6.82	8.47
$7^1/_{16}$ x $5^1/_8$	7.06	5.12 [a]	7.72	8.47
$7^1/_{16}$ x $7^1/_{16}$	7.06	7.06	8.47	8.47
5000 psi				
$2^1/_{16}$ x $2^1/_{16}$	2.06	2.06	4.50	4.50
$2^9/_{16}$ x $2^1/_{16}$	2.56	2.06	4.50	5.00
$2^9/_{16}$ x $2^9/_{16}$	2.56	2.56	5.00	5.00
$3^1/_8$ x $2^1/_{16}$	3.12	2.06	4.50	5.50
$3^1/_8$ x $2^9/_{16}$	3.12	2.56	5.50	5.50
$3^1/_8$ x $3^1/_8$	3.12	3.12	5.50	5.50
$4^1/_{16}$ x $2^1/_{16}$	4.06	2.06	4.50	6.50
$4^1/_{16}$ x $2^9/_{16}$	4.06	2.56	5.00	6.50
$4^1/_{16}$ x $3^1/_8$	4.06	3.12	5.50	6.50
$4^1/_{16}$ x $4^1/_{16}$	4.06	4.06	6.50	6.50
$5^1/_8$ x $2^1/_{16}$	5.12 [a]	2.06	6.12	7.62
$5^1/_8$ x $2^9/_{16}$	5.12 [a]	2.56	6.12	7.62
$5^1/_8$ x $3^1/_8$	5.12 [a]	3.12	6.12	7.62
$5^1/_8$ x $4^1/_{16}$	5.12 [a]	4.06	7.97	7.97
$5^1/_8$ x $5^1/_8$	5.12 [a]	5.12 [a]	7.97	7.97
$7^1/_{16}$ x $2^1/_{16}$	7.06	2.06	6.58	8.58
$7^1/_{16}$ x $2^9/_{16}$	7.06	2.56	6.58	8.58
$7^1/_{16}$ x $3^1/_8$	7.06	3.12	6.58	8.58
$7^1/_{16}$ x $4^1/_{16}$	7.06	4.06	7.43	8.58
$7^1/_{16}$ x $5^1/_8$	7.06	5.12 [a]	8.58	8.58
$7^1/_{16}$ x $7^1/_{16}$	7.06	7.06	8.58	8.58

FOOTNOTE

[a] Tolerance on $5^1/_8$ bore is +0.04/−0.00.

Table E.14—Studded Crosses and Tees *(continued)*

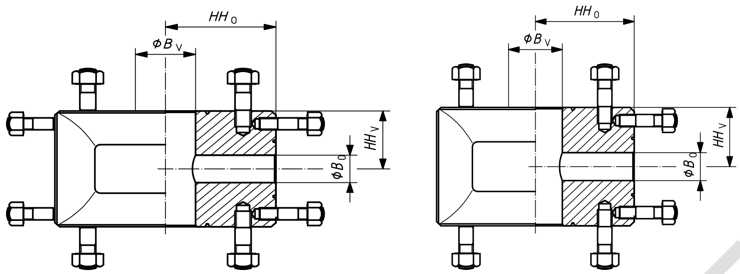
Dimensions in inches

Nominal Sizes	Bore Diameter Vertical Run B_V	Bore Diameter Horizontal Run B_O	Center-to-face Vertical Run HH_V	Center-to-face Horizontal Run HH_O
Tolerance>	+0.03/−0.0	+0.03/−0.0	± 0.03	± 0.03
10,000 psi				
1 13/16 x 1 13/16	1.81	1.81	4.38	4.38
2 1/16 x 1 13/16	2.06	1.81	4.38	4.38
2 1/16 x 2 1/16	2.06	2.06	4.38	4.38
2 9/16 x 1 13/16	2.56	1.81	4.50	5.12
2 9/16 x 2 1/16	2.56	2.06	4.50	5.12
2 9/16 x 2 9/16	2.56	2.56	5.12	5.12
3 1/16 x 1 13/16	3.06	1.81	4.50	5.88
3 1/16 x 2 1/16	3.06	2.06	4.50	5.88
3 1/16 x 2 9/16	3.06	2.56	5.12	5.88
3 1/16 x 3 1/16	3.06	3.06	5.88	5.88
4 1/16 x 1 13/16	4.06	1.81	4.50	6.88
4 1/16 x 2 1/16	4.06	2.06	4.50	6.88
4 1/16 x 2 9/16	4.06	2.56	5.12	6.88
4 1/16 x 3 1/16	4.06	3.06	5.88	6.88
4 1/16 x 4 1/16	4.06	4.06	6.88	6.88
5 1/8 x 1 13/16	5.12 [a]	1.81	5.25	7.75
5 1/8 x 2 1/16	5.12 [a]	2.06	5.25	7.75
5 1/8 x 2 9/16	5.12 [a]	2.56	5.25	7.75
5 1/8 x 3 1/16	5.12 [a]	3.06	6.75	7.75
5 1/8 x 4 1/16	5.12 [a]	4.06	6.75	7.75
5 1/8 x 5 1/8	5.12 [a]	5.12 [a]	7.75	7.75
7 1/16 x 1 13/16	7.06	1.81	6.02	10.25
7 1/16 x 2 1/16	7.06	2.06	6.02	10.25
7 1/16 x 2 9/16	7.06	2.56	6.02	10.25
7 1/16 x 3 1/16	7.06	3.06	6.90	10.25
7 1/16 x 4 1/16	7.06	4.06	7.75	10.25
7 1/16 x 5 1/8	7.06	5.12 [a]	8.75	10.25
7 1/16 x 7 1/16	7.06	7.06	10.25	10.25

FOOTNOTE
[a] Tolerance on 5 1/8 bore is +0.04/−0.00.

Table E.14—Studded Crosses and Tees *(continued)*

Dimensions in inches



Dimensions in inches

Nominal Sizes	Bore Diameter		Center-to-face Vertical Run	Center-to-face Horizontal Run
	Vertical Run B_V	Horizontal Run B_O	HH_V	HH_O
Tolerance>	+0.03/−0.0	+0.03/−0.0	± 0.03	± 0.03
15,000 psi				
1 13/16 x 1 13/16	1.81	1.81	5.00	5.00
2 1/16 x 1 13/16	2.06	1.81	5.00	5.00
2 1/16 x 2 1/16	2.06	2.06	5.00	5.00
2 9/16 x 1 13/16	2.56	1.81	5.50	5.50
2 9/16 x 2 1/16	2.56	2.06	5.50	5.50
2 9/16 x 2 9/16	2.56	2.56	5.50	5.50
3 1/16 x 1 13/16	3.06	1.81	6.31	6.31
3 1/16 x 2 1/16	3.06	2.06	6.31	6.31
3 1/16 x 2 9/16	3.06	2.56	6.31	6.31
3 1/16 x 3 1/16	3.06	3.06	6.31	6.31
4 1/16 x 1 13/16	4.06	1.81	7.62	7.62
4 1/16 x 2 1/16	4.06	2.06	7.62	7.62
4 1/16 x 2 9/16	4.06	2.56	7.62	7.62
4 1/16 x 3 1/16	4.06	3.06	7.62	7.62
4 1/16 x 4 1/16	4.06	4.06	7.62	7.62
5 1/8 x 1 13/16	5.12 [a]	1.81	6.62	8.75
5 1/8 x 2 1/16	5.12 [a]	2.06	6.62	8.75
5 1/8 x 2 9/16	5.12 [a]	2.56	6.62	8.75
5 1/8 x 3 1/16	5.12 [a]	3.06	6.62	8.75
5 1/8 x 4 1/16	5.12 [a]	4.06	9.25	9.25
5 1/8 x 5 1/8	5.12 [a]	5.12 [a]	9.25	9.25
7 1/16 x 1 13/16	7.06	1.81	6.02	11.00
7 1/16 x 2 1/16	7.06	2.06	6.02	11.00
7 1/16 x 2 9/16	7.06	2.56	6.90	11.00
7 1/16 x 3 1/16	7.06	3.06	6.90	11.00
7 1/16 x 4 1/16	7.06	4.06	8.50	11.00
7 1/16 x 5 1/8	7.06	5.12 [a]	9.85	11.00
7 1/16 x 7 1/16	7.06	7.06	11.00	11.00

FOOTNOTE

[a] Tolerance on 5 1/8 bore is +0.04/−0.00.

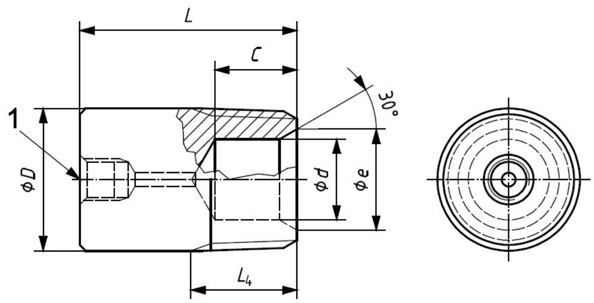
Table E.14—Studded Crosses and Tees *(continued)*

Dimensions in inches

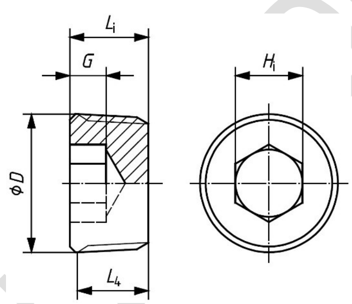
Nominal Sizes	Bore Diameter		Center-to-face Vertical Run	Center-to-face Horizontal Run
	Vertical Run B_V	Horizontal Run B_O	HH_V	HH_O
Tolerance>	+0.03/−0.0	+0.03/−0.0	± 0.03	± 0.03
20,000 psi				
$1^{13}/_{16}$ x $1^{13}/_{16}$	1.81	1.81	6.47	6.47
$2^{1}/_{16}$ x $1^{13}/_{16}$	2.06	1.81	6.47	6.47
$2^{1}/_{16}$ x $2^{1}/_{16}$	2.06	2.06	6.47	6.47
$2^{9}/_{16}$ x $1^{13}/_{16}$	2.56	1.81	7.28	7.28
$2^{9}/_{16}$ x $2^{1}/_{16}$	2.56	2.06	7.28	7.28
$2^{9}/_{16}$ x $2^{9}/_{16}$	2.56	2.56	7.28	7.28
$3^{1}/_{16}$ x $1^{13}/_{16}$	3.06	1.81	7.97	7.97
$3^{1}/_{16}$ x $2^{1}/_{16}$	3.06	2.06	7.97	7.97
$3^{1}/_{16}$ x $2^{9}/_{16}$	3.06	2.56	7.97	7.97
$3^{1}/_{16}$ x $3^{1}/_{16}$	3.06	3.06	7.97	7.97
$4^{1}/_{16}$ x $1^{13}/_{16}$	4.06	1.81	9.91	9.91
$4^{1}/_{16}$ x $2^{1}/_{16}$	4.06	2.06	9.91	9.91
$4^{1}/_{16}$ x $2^{9}/_{16}$	4.06	2.56	9.91	9.91
$4^{1}/_{16}$ x $3^{1}/_{16}$	4.06	3.06	9.91	9.91
$4^{1}/_{16}$ x $4^{1}/_{16}$	4.06	4.06	9.91	9.91

Table E.15—Bullplugs

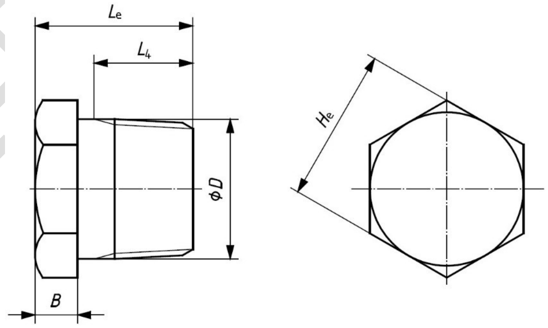
Dimensions in inches



a) Round plug



b) Plug with internal hex



c) Plug with external hex

Key

1 test or gauge port (optional)

NOTE See API 5B for thread dimensions and tolerances.

Table E.15—Bullplugs *(continued)*

Dimensions in inches

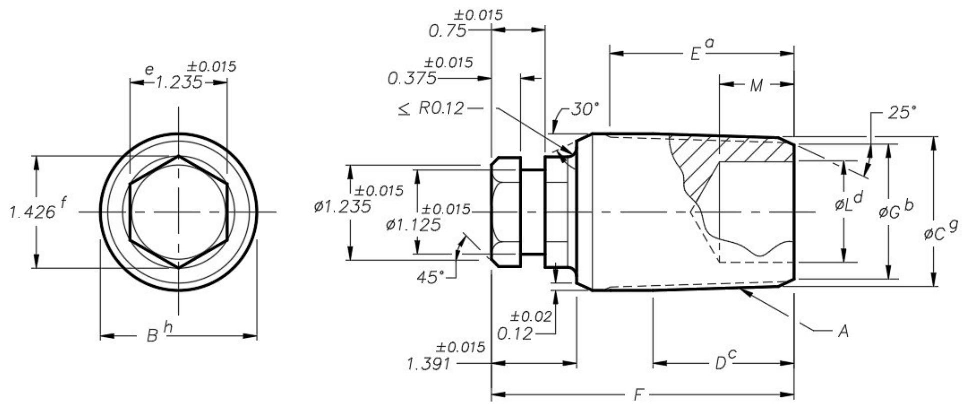
	a), b), c) All Styles of Bullplugs						a) Round Plugs
Nominal Size in.	**Outside Diameter** *D*		**Minimum Length of Thread to Vanish Point** L_4	**Depth of Counterbore** *C*	**Diameter of Counterbore** *d*	**Diameter of Chamfer** *e*	**Overall Length** *L*
Tolerance>	Value	Tolerance	Minimum	± 0.02	+0.04/−0	+0.02/−0	+0.04/−0
1/2	0.840	+0.008/−0	0.7815	None	None	None	2.00
3/4	1.050	+0.008/−0	0.7935	None	None	None	2.00
1	1.320	+0.010/−0	0.9845	None	None	None	2.00
1 1/4	1.660	+0.010/−0	1.0085	1.06	0.88	None	2.00
1 1/2	1.900	+0.010/−0	1.0252	1.06	1.00	None	2.00
2	2.380	+0.010/−0	1.0582	2.52	1.61	2.00	4.00
2 1/2	2.880	+0.010/−0	1.5712	1.63	1.75	None	4.00
3	3.500	+0.010/−0	1.6337	1.63	2.25	None	4.00
3 1/2	4.000	+0.010/−0	1.6837	1.75	2.75	None	4.00
4	4.500	+0.010/−0	1.7337	1.75	3.00	None	4.00

Dimensions in inches

	b) Plugs with Internal Hex				c) Plugs with External Hex			
Nominal Size in.	**Hex Size (Across Flats)** H_i		**Depth of Hex** *G*	**Overall Length** L_i	**Hex Size (Across Flats)** H_e		**Height of Hex** *B*	**Overall Length** L_e
Tolerance>	Value	Tolerance	+0.04/−0	+0.04/−0	Value	Tolerance	+0.04/−0	+0.04/−0
1/2	0.38	+0/−0.004	0.31	1.00	0.88	+0/−0.025	0.31	1.13
3/4	0.56	+0/−0.005	0.31	1.00	1.06	+0/−0.031	0.38	1.25
1	0.63	+0/−0.006	0.38	1.00	1.38	+0/−0.041	0.38	1.38

Table E.16—VR Plug Dimensions, 2000 psi, 3000 psi, 5000 psi, and 10,000 psi

Dimensions in inches; surface roughness in microinches



FOOTNOTES

a Full thread.

b Chamfer at end.

c End of taper.

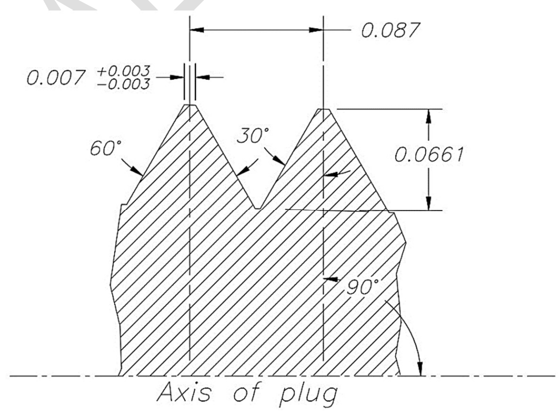
d Drill *L*, *M* deep.

e Across flats.

f Across corners.

g Diameter at face.

h Equal to nominal diameter *A*.



VR Plug Thread Form Detail

Table E.16—VR Plug Dimensions, 2000 psi, 3000 psi, 5000 psi, and 10,000 psi *(continued)*

Dimensions in inches

Nominal Outlet Size	Nominal Thread OD	Threads per Inch	Thread Type	Diameter at Large End	Diameter at Small End	Length of Taper	Length of Full Thread	Overall Length of Plug	Chamfer Diameter	Counter-bore Diameter	Counter-bore Depth
	A	TPI		*B*	*C*	*D*	*E*	*F*	*G*	*L*	*M*
Tolerance>		(Ref.)	NA	± 0.005	± 0.005	(Ref.)	(Ref.)	± 0.03	± 0.015	± 0.015	± 0.03
$1^{13}/_{16}$	1.660	$11^{1}/_{2}$	Line pipe	1.660	1.620	0.640	1.009	2.84	1.488	0.88	1.06
$2^{1}/_{16}$	1.900	$11^{1}/_{2}$	Sharp vee	1.900	1.834	1.051	1.375	3.16	1.702	1.00	1.06
$2^{9}/_{16}$	$2^{3}/_{8}$	$11^{1}/_{2}$	Sharp vee	2.375	2.294	1.301	1.625	3.41	2.162	1.50	1.06
$3^{1}/_{8}$	$2^{7}/_{8}$	$11^{1}/_{2}$	Sharp vee	2.875	2.766	1.739	2.063	3.84	2.634	1.75	1.63
$4^{1}/_{16}$	$3^{1}/_{2}$	$11^{1}/_{2}$	Sharp vee	3.500	3.376	1.989	2.313	4.09	3.244	2.75	1.75

FOOTNOTES

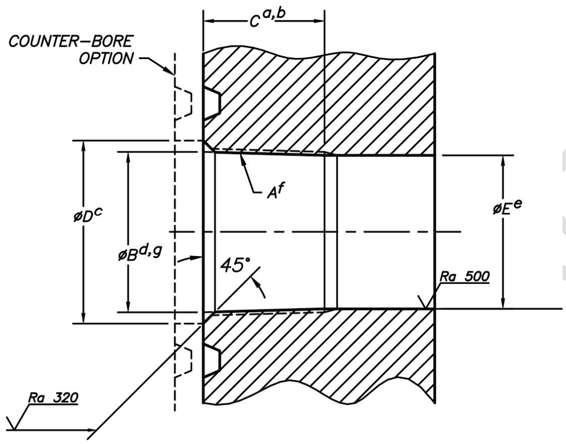
[a] $3^{1}/_{16}$ in. bore for 10,000 psi RWP.

NOTE 1 Thread taper for all sizes shall be 1-in-16 (reference 1° 47' 24" with the centerline).

NOTE 2 Tolerances on angles, unless otherwise noted, are ± 0.5 degrees.

Table E.17—VR Preparation Dimensions, 2000 psi, 3000 psi, 5000 psi, and 10,000 psi

Dimensions in inches; surface roughness in microinches



FOOTNOTES

a Full thread.

b Reference.

c Diameter of counterbore or chamfer.

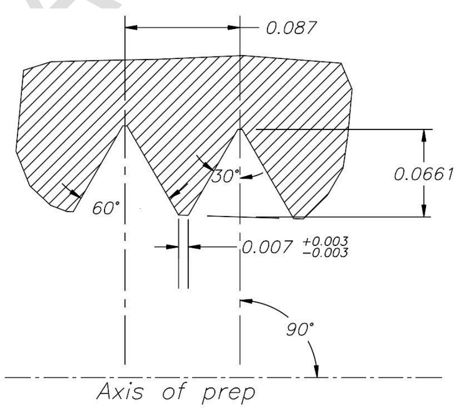
d Thread bore.

e Standard bore.

f Thread.

g Thread bore taken at face of flange, gauge thread from bottom of chamfer, counterbore is optional.

NOTE Line pipe and sharp vee plugs and preparations are not interchangeable.



VR Preparation Thread Form Detail

Table E.17—VR Preparation Dimensions, 2000 psi, 3000 psi, 5000 psi, and 10,000 psi *(continued)*

Dimensions in inches

Nominal Outlet Size	Nominal Thread OD *A*	Threads per Inch TPI	Thread Type	Thread Bore *B*	Full Thread Length *C*	Chamfer and Counterbore Diameter *D*	Straight Bore *E*
Tolerance>		(Ref.)	NA	± 0.005	(Ref.)	± 0.03	± 0.015
1 13/16	1.660	11 1/2	Line pipe	1.532	1.08	1.94	1.449
2 1/16	1.900	11 1/2	Sharp vee	1.771	1.51	2.19	1.662
2 9/16	2 3/8	11 1/2	Sharp vee	2.242	1.76	2.56	2.117
3 1/8 [a]	2 7/8	11 1/2	Sharp vee	2.740	2.20	3.06	2.588
4 1/16	3 1/2	11 1/2	Sharp vee	3.377	2.45	4.06	3.209

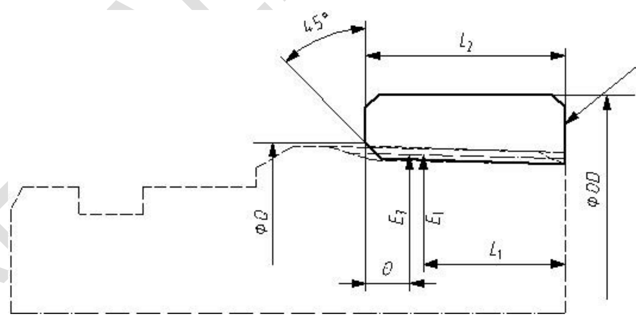
FOOTNOTES

[a] 3 1/16 in. bore for 10,000 psi RWP.

Thread taper for all sizes shall be 1-in-16 (reference 1° 47' 24" with the centerline).

Table E.18—VR Plug Thread Gauging Dimensions, 2000 psi, 3000 psi, 5000 psi, and 10,000 psi

Dimensions in inches



Key

1 gauge standoff with end of VR plug: flush ± 1p

NOTE “p” is defined as the distance from a point on a nominal thread form to a corresponding point on the next thread, measured parallel to the axis. This value can be calculated by dividing 1 mm by the number of threads per millimeter.

Nominal Size	Ring Gauge Outside Diameter *OD*	Ring Gauge Chamfer Diameter *Q*	Ring Gauge Length L_2	Face of Ring Gauge to Plane of Gauge Point θ
1 13/16	2.20	1.72	0.7068	0.1739
2 1/16	2.50	1.96	1.1385	0.1983
2 9/16	3.06	2.44	1.3885	0.1983
3 1/8 [a]	3.67	2.94	1.8260	0.1983
4 1/16	4.50	3.56	2.0760	0.1983

FOOTNOTES

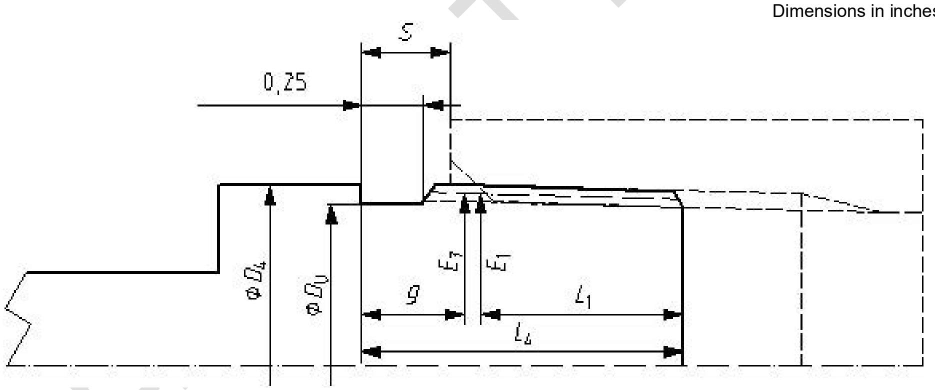
[a] 3 1/16 in. bore for 10,000 psi RWP.

NOTE 1 See Table E.18 for location of dimensions.

NOTE 2 See Table E.19 for E_7, E_1, and L_1.

Table E.19—VR Preparation Thread Gauging Dimensions, 2000 psi, 3000 psi, 5000 psi, and 10,000 psi

Dimensions in inches



Dimensions in inches

Nominal Outlet Size	Major Diameter D_4	Diameter of Plug Gauge Groove D_U	Threads per Inch	Length: End of Pipe to Hand-tight Plane L_1	Pitch Diameter at Hand-tight Plane E_1	Total Length: End of Pipe to Vanish Point L_4	Length: Gauge Point to Vanish Point g	Pitch Diameter at Gauge Point E_7	Standoff S ± 0.087
1 13/16	1.660	1.46	11 1/2	0.4200	1.58338	1.0085	0.4756	1.59043	0.4102
2 1/16	1.900	1.70	11 1/2	0.8106	1.82234	1.3750	0.4348	1.83043	0.3806
2 9/16	2.375	2.18	11 1/2	1.0436	2.29628	1.6250	0.4348	2.30543	0.4495

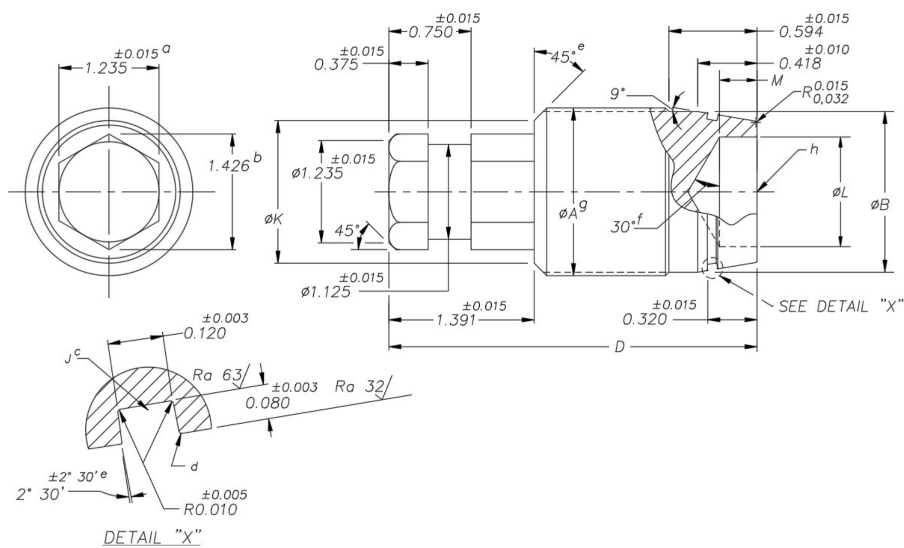
3[1]/8 [a]	2.875	2.68	11[1]/2	1.4538	2.79457	2.0625	0.4348	2.80543	0.4760
4[1]/16	3.500	3.30	11[1]/2	1.7038	3.41957	2.3125	0.4348	3.43043	0.2885

FOOTNOTE

[a] 3[1]/16 in. bore for 10,000 psi RWP.

Table E.20—HPVR Plug Dimensions, 15,000 psi and 20,000 psi

Dimensions in inches surface roughness in microinches



FOOTNOTES

[a] Across flats.

[b] Across corners.

[c] Install (SAE AS568A O-ring size number).

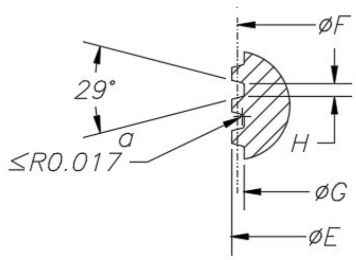
[d] Break corners approx. *R* 0.005.

[e] Typical.

[f] Optional.

[g] Thread.

[h] Drill *L* diameter, *M* deep.



Thread Form Detail

FOOTNOTE

[a] Typical for all full threads.

Table E.20—HPVR Plug Dimensions, 15,000 psi and 20,000 psi *(continued)*

Dimensions in inches

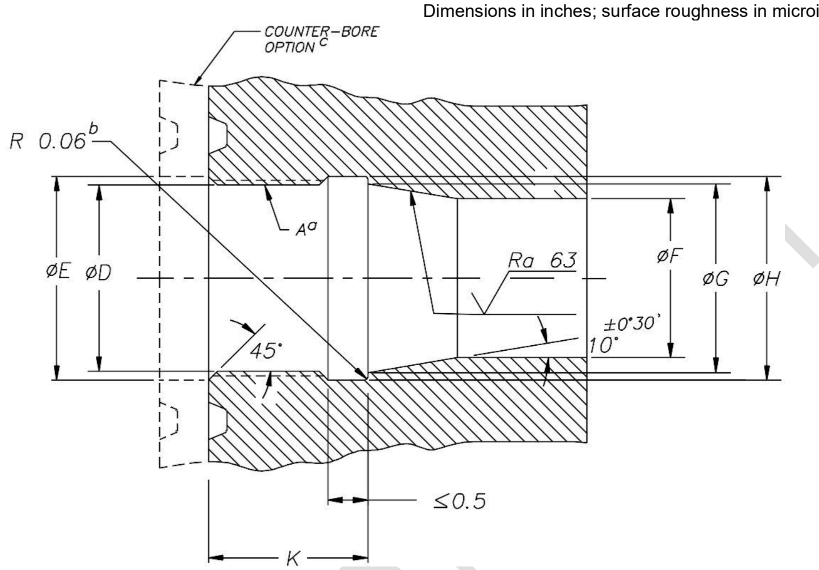
Nominal Outlet Size in.	**Nominal Thread Size** in.	**Threads per Inch**	**Large Taper Diameter**	**Overall Length**	**SAE AS568A O-ring Size No.**	**Chamfer Diameter**	**Counterbore Diameter**	**Counterbore Depth**
	A	TPI	*B*	*D*	*J*	*K*	*L*	*M*
Tolerance>		(Ref.)	± 0.010	± 0.03	NA	± 0.03	± 0.015	± 0.015
1 13/16	1 3/4	6	1.600	3.75	126	1.50	NA	NA
2 1/16	2	6	1.850	3.75	130	1.75	NA	NA
2 9/16	2 1/2	6	2.349	4.19	138	2.33	0.938	0.625
3 1/16	3	6	2.849	4.19	146	2.84	1.125	0.625

Dimensions in inches

Nominal Outlet Size in.	**Nominal Thread Size** in.	**Threads per Inch**	**Thread Major Diameter**	**Thread Pitch Diameter**	**Thread Minor Diameter**	**Width of Thread at Root**
	A	TPI	*E*	*F*	*G*	*H*
Tolerance>		(Ref.)	± 0.004	± 0.010	± 0.010	(Ref.)
1 13/16	1 3/4	6	1.746	1.679	1.620	0.068
2 1/16	2	6	1.996	1.928	1.869	0.068
2 9/16	2 1/2	6	2.496	2.427	2.369	0.068
3 1/16	3	6	2.996	2.925	2.869	0.068

Table E.21—HPVR Preparation Dimensions, 15,000 psi and 20,000 psi

Dimensions in inches; surface roughness in microinches.

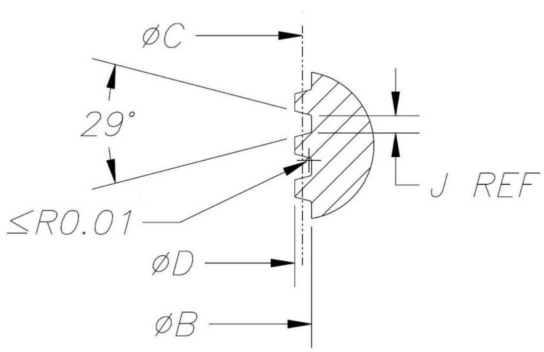


FOOTNOTES

a Thread.

b Typical two places.

c Optional counterbore (0.50 in. deep) max.



Thread Form Detail

NOTE 1 Features and dimensions are typical for all full threads.

NOTE 2 Tolerances on angles, unless otherwise noted, shall be ± 0.5 degrees.

NOTE 3 All diameters shall be concentric within 0.005 in. total indicator reading.

Table E.21—HPVR Preparation Dimensions, 15,000 psi and 20,000 psi *(continued)*

Dimensions in inches

Nominal Outlet Size	Chamfer and Counterbore Diameter *E*	Straight Through Bore *F*	Large Diameter of Taper *G*	Thread Relief Diameter *H*	Depth to Taper *K*
Tolerance>	± 0.015	± 0.005	± 0.005	± 0.015	± 0.015
$1^{13}/_{16}$	1.825	1.475	1.625	1.820	1.563
$2^{1}/_{16}$	2.075	1.725	1.875	2.086	1.563
$2^{9}/_{16}$	2.625	2.224	2.375	2.585	2.092
$3^{1}/_{16}$	3.075	2.725	2.875	3.080	2.092

Dimensions in inches

Nominal Outlet Size	Nominal Thread Size in.	Threads per Inch	Stub Acme Class 2G Thread Form Dimensions			
			Thread Major Diameter	Thread Pitch Diameter	Thread Minor Diameter	Width of Thread at Root
	A	TPI	*B*	*C*	*D*	*J*
Tolerance>		(Ref.)	± 0.010	± 0.010	± 0.004	(Ref.)
$1^{13}/_{16}$	$1^{3}/_{4}$	6	1.780	1.710	1.654	0.065
$2^{1}/_{16}$	2	6	2.030	1.960	1.904	0.065
$2^{9}/_{16}$	$2^{1}/_{2}$	6	2.531	2.461	2.404	0.065
$3^{1}/_{16}$	3	6	3.031	2.961	2.904	0.065

Table E.22—Flanged Full-bore Gate Valves

Dimensions in inches

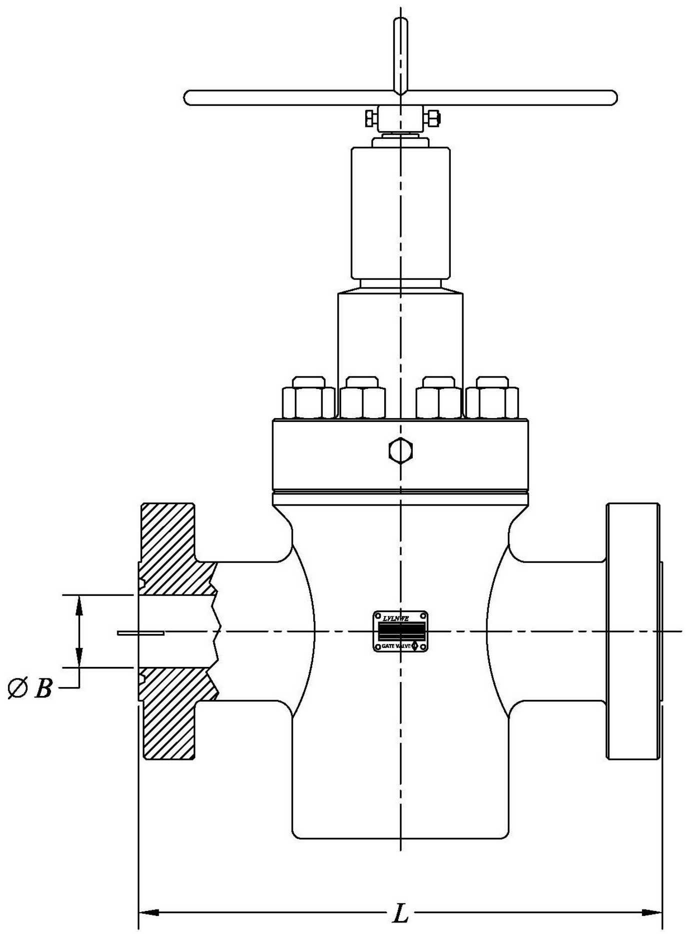


Table E.22—Flanged Full-bore Gate Valves *(continued)*

Dimensions in inches

Nominal Size in.	**Bore**	*L,* **Face-to-face Length,** in.					
	B	2000 psi	3000 psi	5000 psi	10,000 psi	15,000 psi	20,000 psi
Tolerance>	+0.03/−0	± 0.06	± 0.06	± 0.06	± 0.06	± 0.06	± 0.06
$1^{13}/_{16}$	1.81	—	—	—	18.25	18.00	21.00
$2^{1}/_{16}$ x $1^{13}/_{16}$	1.81	11.62	14.62	14.62	—	—	—
$2^{1}/_{16}$	2.06	11.62	14.62	14.62	20.50	19.00	23.00
$2^{9}/_{16}$	2.56	13.12	16.62	16.62	22.25	21.00	26.50
$3^{1}/_{16}$	3.06	—	—	—	24.38	23.56	30.50
$3^{1}/_{8}$	3.12	14.12	17.12	18.62	—	—	—
$3^{1}/_{8}$ x $3^{3}/_{16}$	3.19	14.12	17.12	18.62	—	—	—
$4^{1}/_{16}$	4.06	17.12	20.12	21.62	26.38	29.00	38.00
$4^{1}/_{16}$ x $4^{1}/_{8}$	4.12	17.12	20.12	21.62	PMR	PMR	PMR
$4^{1}/_{16}$ x $4^{1}/_{4}$	4.25	17.12	20.12	21.62	PMR	PMR	PMR
$5^{1}/_{8}$ [a]	5.12 [a]	22.12	24.12	28.62	29.00	35.00	PMR
$7^{1}/_{16}$ x $5^{1}/_{8}$	5.12 [a]	22.12	24.12	29.00	35.00	41.00	PMR
$7^{1}/_{16}$ x 6	6.00	22.12	24.12	29.00	35.00	41.00	PMR
$7^{1}/_{16}$ x $6^{1}/_{8}$	6.12	22.12	24.12	29.00	35.00	41.00	PMR
$7^{1}/_{16}$ x $6^{3}/_{8}$	6.38	22.12	24.12	29.00	35.00	41.00	PMR
$7^{1}/_{16}$ x $6^{5}/_{8}$	6.62	22.12	24.12	29.00	35.00	41.00	PMR
$7^{1}/_{16}$	7.06	26.12	28.12	32.00	35.00	41.00	PMR
$7^{1}/_{16}$ x $7^{1}/_{8}$	7.12	26.12	28.12	32.00	PMR	PMR	PMR
9	9.00	PMR	PMR	41.00	PMR	PMR	PMR
11	11.00	PMR	PMR	PMR	PMR	PMR	—
$13^{5}/_{8}$	13.62	PMR	PMR	-	PMR	PMR	PMR
$16^{3}/_{4}$	16.75	PMR	PMR	-	PMR	-	-
$18^{3}/_{4}$	18.75	-	-	-	PMR	PMR	-
$20^{3}/_{4}$	20.75	-	PMR	-	-	-	-
$21^{1}/_{4}$	21.25	PMR	-	-	PMR	-	-

FOOTNOTE

[a] Bore tolerance for $5^{1}/_{8}$ in. size is +0.04/−0.

Table E.23—Flanged Plug Valves and Ball Valves

Dimensions in inches

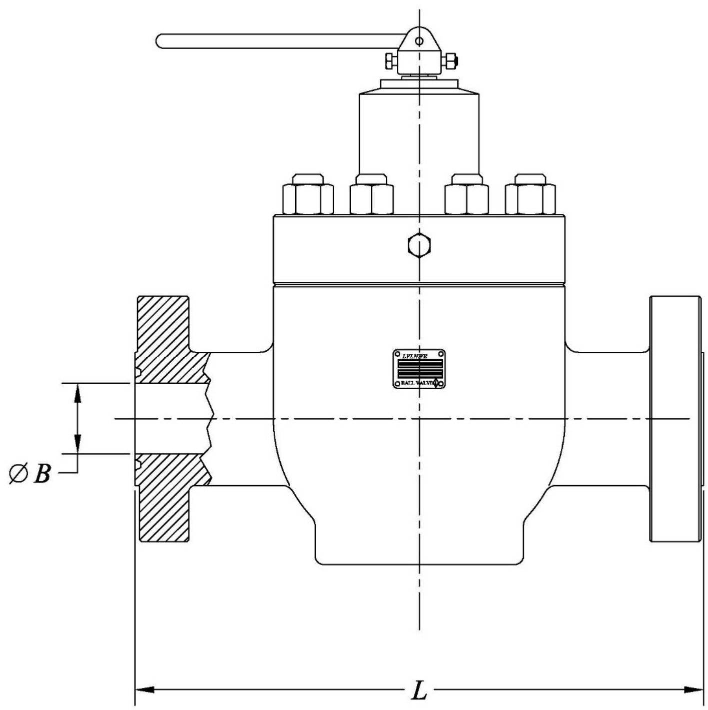


Table E.23—Flanged Plug Valves and Ball Valves *(continued)*

Dimensions in inches

a) Flanged Full-bore Plug Valves

Nominal Size in.	**Bore**	*L*, **Face-to-face Length**					
	B	2000 psi	3000 psi	5000 psi	10,000 psi	15,000 psi	20,000 psi
Tolerance>	+0.03/−0	± 0.06	± 0.06	± 0.06	± 0.06	± 0.06	± 0.06
$1^{13}/_{16}$	1.81	—	—	—	18.25	18.00	21.00
$2^{1}/_{16}$	2.06	13.12	15.12	15.50	20.50	19.00	23.00
$2^{9}/_{16}$	2.56	15.12	17.12	18.00	22.25	21.00	26.50
$3^{1}/_{16}$	3.06	—	—	—	24.38	23.56	30.50
$3^{1}/_{8}$	3.12	17.62	18.62	20.75	—	—	—
$3^{1}/_{8} \times 3^{3}/_{16}$	3.19	17.62	18.62	20.75	—	—	—
$4^{1}/_{16}$	4.06	20.12	22.12	24.75	26.38	29.00	38.00
$4^{1}/_{16} \times 4^{1}/_{8}$	4.12	20.12	22.12	24.75	PMR	PMR	PMR
$4^{1}/_{16} \times 4^{1}/_{4}$	4.25	20.12	22.12	24.75	PMR	PMR	PMR
$5^{1}/_{8}$	5.12 [b]	25.12	26.12	—	29.00	35.00	—
$7^{1}/_{16} \times 6$	6.00	28.62	30.12	—	35.00	41.00	PMR
$7^{1}/_{16} \times 6^{3}/_{8}$	6.38	—	—	—	35.00	41.00	PMR
$7^{1}/_{16}$	7.06	29.12	31.62	38.50	35.00	41.00	PMR
$7^{1}/_{16} \times 7^{1}/_{8}$	7.12	29.12	31.62	38.50	PMR	PMR	PMR
9	9.00	PMR	PMR	PMR	PMR	41.00	PMR
11	11.00	PMR	PMR	PMR	PMR	PMR	PMR
$13^{5}/_{8}$	13.56	PMR	PMR	-	PMR	PMR	PMR
$16^{3}/_{4}$	16.75	PMR	PMR	-	PMR	-	-
$18^{3}/_{4}$	18.75	-	-	-	PMR	PMR	-
$20^{3}/_{4}$	20.75	-	PMR	-	-	-	-
$21^{1}/_{4}$	21.25	PMR	-	-	PMR	-	-

b) Flanged Full-bore and Reduced-opening Ball Valves

Nominal Size in.	**Bore**	*L*, **Face-to-face Length**					
	B	2000 psi	3000 psi	5000 psi	10,000 psi	15,000 psi [a]	20,000 psi [a]
Tolerance>	+0.03/−0	± 0.06	± 0.06	± 0.06	± 0.06	± 0.06	± 0.06
$1^{13}/_{16}$	1.81	—	—	—	18.25	18.00	21.00
$2^{1}/_{16}$	2.06	11.62	14.62	14.62	20.50	19.00	23.00
$2^{9}/_{16}$	2.56	13.12	16.62	18.62	22.25	21.00	26.50
$3^{1}/_{16}$	3.06	—	—	—	24.38	23.56	30.50
$3^{1}/_{8}$	3.12	14.12	15.12	18.62	—	—	—
$4^{1}/_{16}$	4.06	17.12	18.12	21.62	26.38	29.00	—
$5^{1}/_{8}$	5.12 [b]	—	—	—	29.00	35.00	PMR
$7^{1}/_{16} \times 6$	6.00	22.12	24.12	28.00	35.00	41.00	PMR
$7^{1}/_{16} \times 6^{3}/_{8}$	6.38	—	—	28.00	35.00	41.00	PMR
$7^{1}/_{16}$	7.06	—	—	—	35.00	41.00	PMR
9	9.00	PMR	PMR	PMR	PMR	PMR	PMR
11	11.00	PMR	PMR	PMR	PMR	PMR	PMR
$13\ ^{5}/_{8}$	13.63	PMR	PMR	-	PMR	PMR	PMR
16 ¾	16.75	PMR	PMR	-	PMR	-	PMR
18 ¾	18.75	-	-	-	-	PMR	-
$20\ ^{3}/_{4}$	20.75	-	PMR	-	-	-	-
$21\ ^{1}/_{4}$	21.25	PMR	PMR	PMR	PMR	PMR	PMR

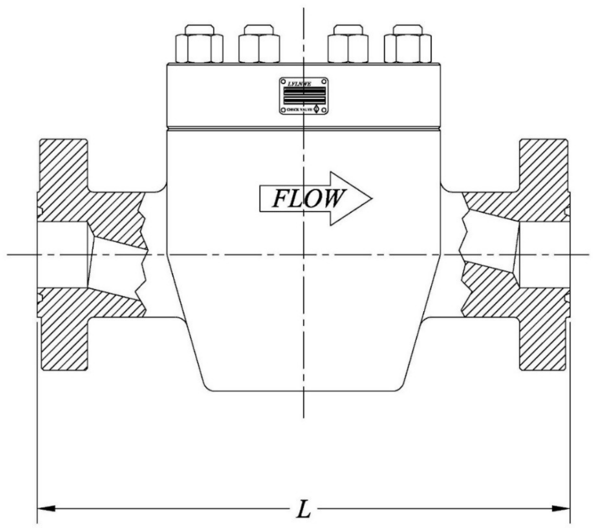
FOOTNOTE

[a] Applies to full bore only.

[b] Bore tolerance for $5^{1}/_{8}$ in. size is +0.04/-0.

Table E.24—Flanged Swing and Lift Check Valves

Dimensions in inches



Dimensions in inches

a) Minimum Bore Sizes for Full-opening Check Valves, 2000 psi, 3000 psi, and 5000 psi			
Nominal Size in.	**Minimum Bore Size**		
	2000 psi	3000 psi	5000 psi
Tolerance>	+0.06/−0	+0.06/−0	+0.06/−0
2 1/16	2.067	1.939	1.689
2 9/16	2.469	2.323	2.125
3 1/8	3.068	2.900	2.624
4 1/16	4.026	3.826	3.438
7 1/16	5.761	5.761	5.189
9	7.813	7.439	6.813
11	9.750	9.314	8.500
13 5/8	PMR	PMR	-
16 ¾	PMR	PMR	-
18 ¾	-	-	-
20 3/4	-	PMR	-
21 1/4	PMR	-	-

Table E.24—Flanged Swing and Lift Check Valves *(continued)*

Dimensions in inches

b) Regular and Full-opening Flanged Swing and Lift Check Valves, 2000 psi, 3000 psi, and 5000 psi RWP					
Nominal Size in.	***L*, Short Pattern Face-to-face Length**			***L*, Long Pattern Face-to-face Length**	
	2000 psi	3000 psi	5000 psi	3000 psi	5000 psi
Tolerance>	± 0.06	± 0.06	± 0.06	± 0.06	± 0.06
2 1/16	11.62	14.62	14.62	—	
2 9/16	13.12	16.62	16.62	—	—
3 1/8	14.12	15.12	18.62	17.12	—
4 1/16	17.12	18.12	21.62	20.12	—
7 1/16	22.12	24.12	28.00	—	29.00
9	26.12	29.12	33.12	PMR	PMR
11	31.12	33.12	39.36	PMR	PMR
13 5/8	PMR	PMR	PMR	PMR	PMR
16 ¾	PMR	PMR	PMR	PMR	PMR
18 ¾	-	-	-	-	-
20 3/4	-	-	PMR	-	PMR
21 1/4	PMR	PMR	-	PMR	-

Dimensions in inches

c) Regular and Full-opening Flanged Swing and Lift Check Valves, 10,000 psi, 15,000 psi, and 20,000 psi RWP			
Nominal Size in.	*L*, Face-to-face Length, in.		
	10,000 psi	15,000 psi	20,000 psi
Tolerance>	± 0.06	± 0.06	± 0.06
1 13/16	18.25	18.00	21.00
2 1/16	20.50	19.00	23.00
2 9/16	22.25	21.00	26.50
3 1/16	24.38	23.56	30.50
4 1/16	26.38	29.00	—
5 1/8	29.00	—	PMR
7 1/16	35.00	—	PMR
9	PMR	PMR	PMR
11	PMR	PMR	PMR
13 5/8	PMR	PMR	PMR
16 ¾	PMR	-	PMR
18 ¾	PMR	PMR	-
20 3/4	-	-	-
21-1/4	PMR	PMR	-

Table E.25—Center Spacing of Conduit Bores for Dual Parallel Bore Valves for 2000 psi, 3000 psi, 5000 psi, and 10,000 psi

Dimensions in inches

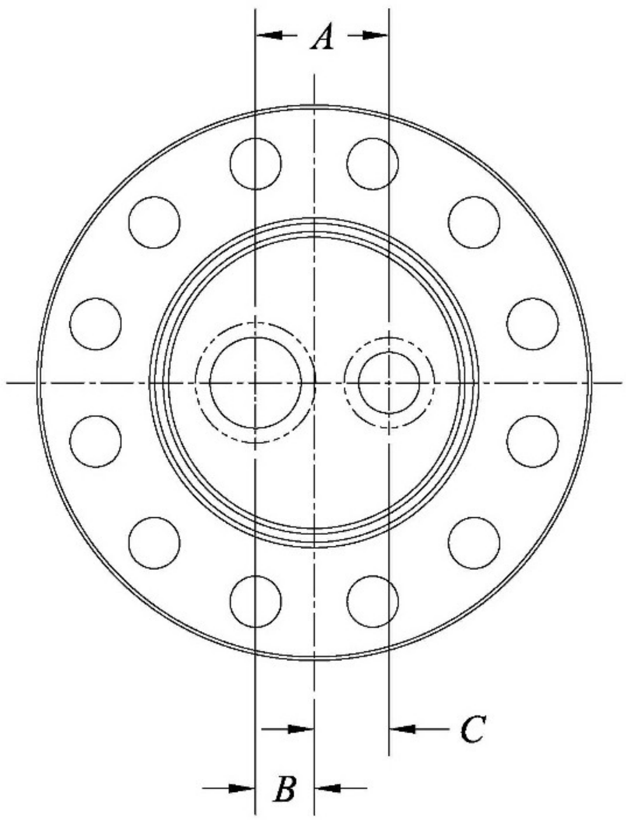


Table E.25—Center Spacing of Conduit Bores for Dual Parallel Bore Valves for 2000 psi, 3000 psi, 5000 psi, and 10,000 psi *(continued)*

Dimensions in inches

Maximum Nominal Valve Size	Bore Center to Bore Center	Large-bore to End-connector Center	Small-bore to End-connector Center	Minimum End-connector Size	Basic Casing Size	
						Lineic Mass lb/ft
	A (REF)	*B*	*C*		*OD*	
2000 psi, 3000 psi, and 5000 psi						
1 13/16	2.780	1.390	1.390	7 1/16	5 1/2	17
2 1/16	3.548	1.774	1.774	7 1/16	7	38
2 9/16 x 2 1/16	3.547	1.650	1.897	7 1/16	7	29
2 9/16 x 2 1/16	4.000	1.875	2.125	9	7 5/8	39
2 9/16	4.000	2.000	2.000	9	7 5/8	29.7
2 9/16	4.500	2.250	2.250	9	8 5/8	49
3 1/8 x 2 1/16	4.578	2.008	2.570	9	8 5/8	49
3 1/8 x 2 9/16	5.048	2.524	2.524	11	9 5/8	53.5
3 1/8	5.048	2.524	2.524	11	9 5/8	53.5
10,000 psi						
1 13/16	2.780	1.390	1.390	7 1/16	5 1/2	17
2 1/16	3.548	1.774	1.774	7 1/16	7	38
2 9/16 x 2 1/16	3.547	1.650	1.897	7 1/16	7	29
2 9/16 x 2 1/16	4.000	1.875	2.125	9	7 5/8	39
2 9/16	4.000	2.000	2.000	9	7 5/8	29.7
2 9/16	4.500	2.250	2.250	9	8 5/8	49
3 1/16	5.048	2.524	2.524	11	9 5/8	53.5

Table E.26—Center Spacing of Conduit Bores for Triple, Quadruple, and Quintuple Parallel Bore Valves for 2000 psi, 3000 psi, 5000 psi, and 10,000 psi

Dimensions in inches

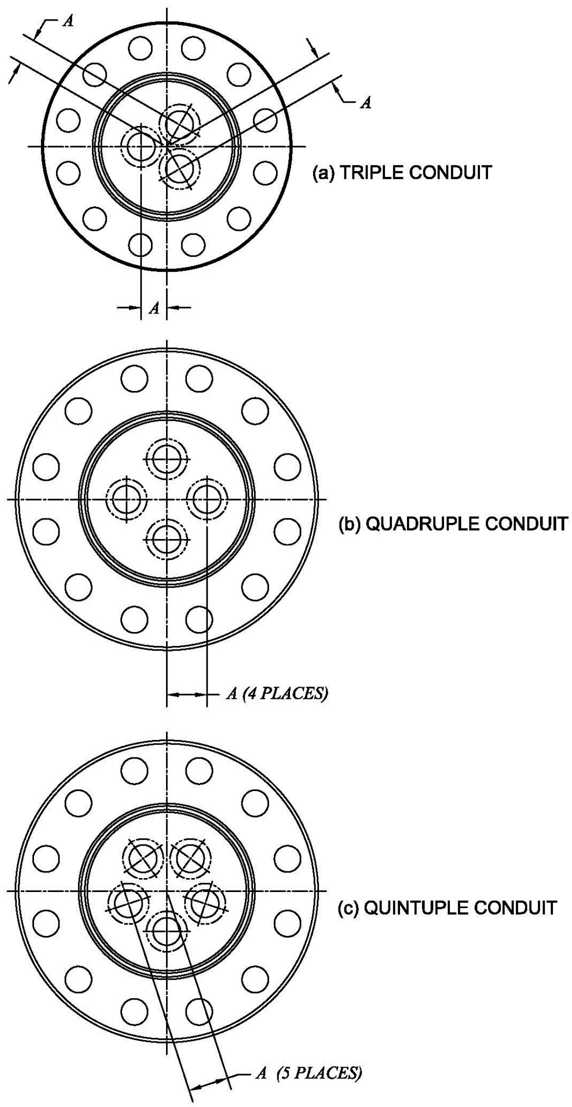


Table E.26—Center Spacing of Conduit Bores for Triple, Quadruple, and Quintuple Parallel Bore Valves for 2000 psi, 3000 psi, 5000 psi, and 10,000 psi *(continued)*

Dimensions in inches

Maximum Valve Size	Flange Center to Bore Center	Minimum End-connector Size	Basic Casing Size	
	A		OD	Lineic Mass lb/ft
2000 psi; 3000 psi and 5000 psi RWP				
Triple-conduit Valve				
1 13/16	1.875	7 1/16	6 5/8	24
2 1/16	1.938	9	7	26
2 1/16	2.125	9	7 5/8	39
2 9/16	2.812	11	9 5/8	53.5
Quadruple-conduit Valve				
1 13/16	2.875	11	8 5/8	36
1 13/16	3.062	11	9 5/8	All
2 1/16	3.062	11	9 5/8	53.5
2 9/16	3.438	11	10 3/4	55.5
2 9/16	4.000	13 5/8	11 3/4	54
Quintuple-conduit Valve				
2 1/16	3.062	11	9 5/8	53.5
10,000 psi RWP				
Triple-conduit Valve				
1 13/16	1.875	7 1/16	6 5/8	24
2 1/16	1.938	9	7	26
2 1/16	2.125	9	7 5/8	39
2 9/16	2.812	11	9 5/8	53.5
Quadruple-conduit Valve				
2 9/16	3.438	11	10 3/4	55.5

Table E.27—Maximum Hanger Outside Diameter for Wellheads

Dimensions in inches

Nominal Size [a] and Minimum Through-bore of Drill-through Equipment in.	Rated Working Pressure psi	Maximum Outside Diameter of Hanger in.
7 1/16	2000, 3000, and 5000	7.010
7 1/16	10,000, 15,000, and 20,000	7.010
9	2000, 3000, and 5000	8.933
9	10,000 and 15,000	8.933
11	2000, 3000, and 5000	10.918
11	10,000 and 15,000	10.918
13 5/8	2000 and 3000	13.523
13 5/8	5000 and 10,000	13.523
16 3/4	2000 and 3000	16.625
16 3/4	5000 and 10,000	16.625
18 3/4	5000 and 10,000	18.625
21 1/4	2000	21.125
20 3/4	3000	20.625
21 1/4	5000 and 10,000	21.125

FOOTNOTE

[a] Nominal size of upper end connector of wellhead body in which the hanger is used.

Table E.28—Minimum Vertical Full-opening Wellhead Body Bores and Maximum Casing Sizes

Dimensions in inches

Nominal Connector [a]		Casing Beneath Body			Minimum Vertical Full-opening Wellhead Body Bore
Nominal Size of Connector	Rated Working Pressure	Label [b]	Nominal Lineic Mass [b]	Specified Drift Diameter	
in.	psi	*OD*	lb/ft	in.	in.
7 1/16	2000	7	17	6.413	6.45
7 1/16	3000	7	20	6.331	6.36
7 1/16	5000	7	23	6.241	6.28
7 1/16	10,000	7	29	6.059	6.09
7 1/16	15,000	7	38	5.795	5.83
7 1/16	20,000	7	38	5.795	5.83
9	2000	8 5/8	24	7.972	8.00
9	3000	8 5/8	32	7.796	7.83
9	5000	8 5/8	36	7.700	7.73
9	10,000	8 5/8	40	7.600	7.62
9	15,000	8 5/8	49	7.386	7.41
11	2000	10 3/4	40.5	9.894	9.92
11	3000	10 3/4	40.5	9.894	9.92
11	5000	10 3/4	51.0	9.694	9.73
11	10,000	9 5/8	53.5	8.379	8.41
11	15,000	9 5/8	53.5	8.379	8.41
13 5/8	2000	13 3/8	54.5	12.459	12.50
13 5/8	3000	13 3/8	61.0	12.359	12.39
13 5/8	5000	13 3/8	72.0	12.191	12.22
13 5/8	10,000	11 3/4	60.0	10.616	10.66
16 3/4	2000	16	65	15.062	15.09
16 3/4	3000	16	84	14.822	14.86
16 3/4	5000	16	84	14.822	14.86
16 3/4	10,000	16	84	14.822	14.86
18 3/4	5000	18 5/8	87.5	17.567	17.59
18 3/4	10,000	18 5/8	87.5	17.567	17.59
20 3/4	3000	20	94	18.936	18.97
21 1/4	2000	20	94	18.936	18.97
21 1/4	5000	20	94	18.936	18.97
21 1/4	10,000	20	94	18.936	18.97

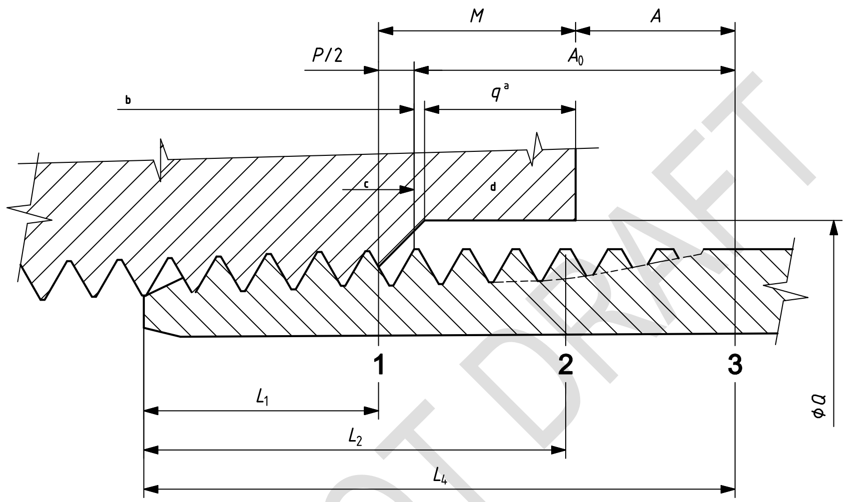
FOOTNOTES

[a] Upper end connectors of wellhead body.

[b] Maximum size and minimum mass of casing on which bore is based.

Table E.29—Pipe Thread Counterbore and Standoff Dimensions

Dimensions in inches



Key

1 plane of hand-tight engagement

2 plane of effective thread length

3 plane of vanish point

a See 14.3.2.3.

b Internal thread length.

c Without counterbore.

d With counterbore.

NOTE See API 5B for dimensions L_1, L_2, and L_4.

Line pipe and sharp vee plugs and preparations are not interchangeable.

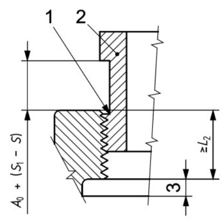
API 5B plugs are compatible with both API 5B and API 6A line pipe preparations provided the standoff, counterbores, and transition angles, from the respective specifications, are followed.

Table E.29—Pipe Thread Counterbore and Standoff Dimensions *(continued)*

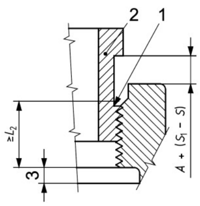
Dimensions in inches

Nominal Thread Size	Length: Plane of Vanish Point to Hand-tight Plane	Hand-tight Standoff		Length: Face of Counterbore to Hand-tight Plane	Counterbore	
		Thread without Counterbore	Thread with Shallow Counterbore		Diameter	Depth
	$A + M$	A_0	A	M	Q	q
Line Pipe Threads						
1/8	0.2124	0.1939	0.0398	0.1726	0.47	0.13
1/4	0.3946	0.3668	0.2145	0.1801	0.60	0.13
3/8	0.3606	0.3328	0.1791	0.1815	0.74	0.13
1/2	0.4615	0.4258	0.1357	0.3258	0.93	0.25
3/4	0.4545	0.4188	0.1289	0.3256	1.14	0.25
1	0.5845	0.5410	0.2488	0.3357	1.41	0.25
1 1/4	0.5885	0.5450	0.2552	0.3333	1.75	0.25
1 1/2	0.6052	0.5617	0.2714	0.3338	1.99	0.25
2	0.6222	0.5787	0.2703	0.3519	2.50	0.25
2 1/2	0.8892	0.8267	0.3953	0.4939	3.00	0.38
3	0.8677	0.8052	0.3719	0.4958	3.63	0.38
3 1/2	0.8627	0.8002	0.3671	0.4956	4.13	0.38
4	0.8897	0.8272	0.3933	0.4964	4.63	0.38
5	0.9030	0.8405	0.4076	0.4954	5.69	0.38
6	0.9882	0.9257	0.4912	0.4970	6.75	0.38
8	1.0832	1.0207	0.5832	0.5000	8.75	0.38
10	1.1487	1.0862	0.6442	0.5045	10.88	0.38
12	1.1987	1.1362	0.6626	0.5361	12.94	0.38
14D	1.1217	1.0592	0.5880	0.5337	14.19	0.38
16D	1.0717	1.0092	0.5396	0.5321	16.19	0.38
18D	1.0837	1.0212	0.5512	0.5325	18.19	0.38
20D	1.1587	1.0962	0.6239	0.5348	20.19	0.38

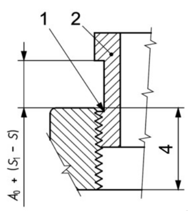
Table E.30—Gauging of Casing and Tubing Threads



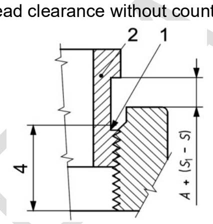
a) Internal recess without counterbore



b) Internal recess with shallow counterbore



c) Thread clearance without counterbore



d) Thread Clearance with Shallow Counterbore

Key

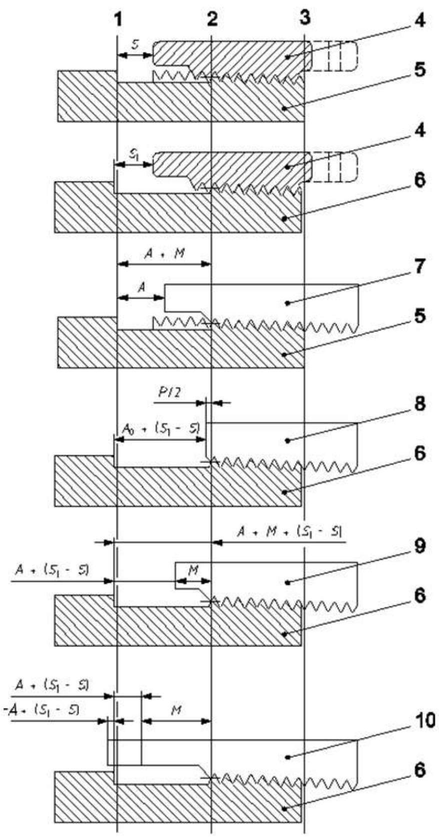
1 gauge notch, alignment—chamfer bottom, within tolerance

2 working plug gauge

3 recess clearance

4 L_2 (min.) plus thread clearance

Application of Working Plug Gauge



Key

1 plane of vanish point
2 plane of hand-tight engagement
3 plane of end of pipe
4 master ring gauge
5 master plug gauge
6 working plug gauge
7 product thread
8 product thread without counterbore
9 product thread with shallow counterbore
10 product thread with deep counterbore

NOTE See API 5B for dimensions of S and S_1.

Gauging Line Pipe, Casing and Tubing Internal Threads, Hand-tight Assembly

Table E.30—Gauging of Casing and Tubing Threads *(continued)*

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Nominal Thread Size	**Length: Plane of Vanish Point to Hand-tight Plane**	**Hand-tight Standoff**		**Length: Face of Counterbore to Hand-tight Plane**	**Counterbore**	
		Thread without Counterbore	**Thread with Shallow Counterbore**		**Diameter**	**Depth**
	$A + M$	A_0	A	M	Q	q
				Long and Short Casing Threads		Dimensions in inches
4 1/2	1.079	1.0165	0.5907	0.4883	4.63	0.38
5	1.079	1.0165	0.5907	0.4883	5.13	0.38
5 1/2	1.079	1.0165	0.5907	0.4883	5.63	0.38
6 5/8	1.079	1.0165	0.5932	0.4858	6.75	0.38
7	1.079	1.0165	0.5907	0.4883	7.13	0.38
7 5/8	1.146	1.0835	0.6581	0.4879	7.75	0.38
8 5/8	1.146	1.0835	0.6581	0.4879	8.75	0.38
9 5/8	1.146	1.0835	0.6581	0.4879	9.75	0.38
10 3/4 [a]	1.146	1.0835	0.6556	0.4904	10.88	0.38
11 3/4 [a]	1.146	1.0835	0.6556	0.4904	11.88	0.38
13 3/8 [a]	1.146	1.0835	0.6281	0.5179	13.56	0.38
16 [a]	1.146	1.0835	0.6256	0.5204	16.19	0.38
20 [a]	1.146	1.0835	0.6256	0.5204	20.19	0.38
				Nonupset Tubing Threads		Dimensions in inches
1.050	0.646	0.5960	0.3201	0.3259	1.14	0.25
1.315	0.646	0.5960	0.3176	0.3284	1.41	0.25
1.660	0.646	0.5960	0.3201	0.3259	1.75	0.25
1.900	0.646	0.5960	0.3201	0.3259	1.99	0.25
2 3/8	0.646	0.5960	0.3026	0.3434	2.50	0.25
2 7/8	0.646	0.5960	0.1776	0.4684	3.00	0.38
3 1/2	0.646	0.5960	0.1751	0.4709	3.63	0.38
4	0.784	0.7215	0.3010	0.4830	4.13	0.38
4 1/2	0.784	0.7215	0.3010	0.4830	4.63	0.38
				External Upset Tubing Threads		Dimensions in inches
1.050	0.646	0.5960	0.3176	0.3284	1.41	0.25
1.315	0.646	0.5960	0.3145	0.3315	1.57	0.25
1.660	0.646	0.5960	0.3164	0.3296	1.91	0.25
1.900	0.646	0.5960	0.3170	0.3290	2.19	0.25
2 3/8	0.784	0.7215	0.4279	0.3561	2.72	0.25
2 7/8	0.784	0.7215	0.3029	0.4811	3.22	0.38
3 1/2	0.784	0.7215	0.3010	0.4830	3.88	0.38
4	0.784	0.7215	0.3010	0.4830	4.38	0.38
4 1/2	0.784	0.7215	0.3010	0.4830	4.88	0.38

FOOTNOTE

[a] Short casing threads only (long casing threads not covered).

Annex F
(informative)

Design Validation Procedures for PR2 (PR2F Level)

F.1 Design Validation—General Requirements

F.1.1 Application

F.1.1.1 General

This annex provides design validation procedures for qualification of equipment specified by this specification, which shall be applied if specified by the manufacturer or purchaser.

NOTE 1 PR2F is to designate a product validated to PR2 level according to this annex.

The performance requirements shall apply to all products being manufactured and delivered for service (see 4.2). If this annex is applied, the design validation procedures in this annex shall be applied to designs of products, including design changes. It is intended that the validation specified in this annex shall be performed on prototypes or production models (see also 5.5).

NOTE 2 Design validation testing is not required for specified designs or features that are completely specified (dimensions and material strength) in this specification.

F.1.1.2 Alternative Procedures

NOTE Other procedures may be used, provided the test requirements of this annex are met or exceeded.

F.1.2 General

F.1.2.1 Previous Validation Conformance

NOTE Validation tests that have been completed in conformance with PR2 validation requirements of Appendix/Annex F of previous editions of API 6A during their validity are in conformance with the requirements of PR2F.

F.1.2.2 Effect of Changes in Product

F.1.2.2.1 Design Changes

A design that undergoes a substantive change shall become a new design requiring design validation. A substantive change shall be a change identified by the manufacturer that affects the performance of the product in the intended service condition.

NOTE This may include changes in fit, form, function, or material.

Fit, when defined as the geometric relationship between parts, shall include the tolerance criteria used during the design of a part and its mating parts. Fit, when defined as the state of being adjusted to or shaped for, shall include the tolerance criteria used during the design of a seal and its mating parts.

F.1.2.2.2 Metallic Materials

NOTE A change in metallic materials might not require new design validation if the suitability of the new material can be substantiated by other means.

F.1.2.2.3 Nonmetallic Seals

Substantive changes in the original, documented design configuration of nonmetallic seals resulting in a new design, shall require design validation in conformance with F.1.13.

NOTE A change in nonmetallic materials might not require new design validation if the suitability of the new material can be substantiated by other means.

F.1.3 Conformance

All products evaluated in design validation tests shall conform to the applicable design requirements of this specification. As a minimum, test articles shall be hydrostatically tested to PSL 1 prior to validation.

F.1.4 Products for Design Validation

F.1.4.1 General

Design validation, if applicable, shall be performed on prototypes or production models of equipment made in conformance with this specification to confirm that the performance requirements specified for pressure, temperature, load, mechanical cycles, and standard test fluids are met in the design of the product.

F.1.4.2 Testing Product

Design validation shall be conducted on full-size products or fixtures that represent the specified dimensions for the relevant parts of the end product being validated, unless otherwise specified in this annex.

F.1.4.3 Product Dimensions

The actual dimensions of equipment subjected to validation shall be within the allowable tolerance range for dimensions specified for normal production equipment. Worst-case conditions for dimensional tolerances should be addressed by the manufacturer, including impacts on sealing and mechanical functioning.

F.1.4.4 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.1.4.5 Maintenance Procedures

Maintenance shall be limited to the manufacturer's published maintenance procedures. Maintenance should not be performed during pressure hold periods. Maintenance procedures under this clause shall not include repairs.

NOTE Maintenance procedures may include lubrication of bearings and greasing of valves.

F.1.5 Safety

Due consideration shall be given to the safety of personnel and equipment.

F.1.6 Acceptance Criteria

F.1.6.1 Structural Integrity

The product tested shall not permanently deform to the extent that any other performance requirement cannot be met. Products that support tubulars shall be capable of supporting the rated load without collapsing the tubulars below the drift diameter.

F.1.6.2 Pressure Integrity

F.1.6.2.1 Hydrostatic Test at Ambient Temperature

The hydrostatic test at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F) shall be identified as passed if no visible leakage occurs during the specified pressure hold periods of the test. The pressure change observed on the pressure-measuring device during the hold period shall be less than 5 % of the test pressure or 3.45 MPa (500 psi), whichever is less.

F.1.6.2.2 Gas Test at Ambient Temperature

The gas test at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F) shall be acceptable if no sustained bubbles are observed. If leakage is observed, the rate shall be less than the rates shown in Table F.1, measured at atmospheric pressure, during specified pressure-hold periods.

Table F.1—Ambient Temperature Gas Leakage Acceptance Criteria

Equipment	Seal Type	Allowable Leakage
Valves, gate, ball, and plug	Through-bore	30 cm^3/h/25.4 mm of nominal bore size
	Stem seal	60 cm^3/h
	Static (bonnet seal, end connectors)	20 cm^3/h
Valves, check	Through-bore	5 cm^3/min/25.4 mm of nominal bore size
	Stem seal	60 cm^3/h
	Static (bonnet seal, end connectors)	20 cm^3/h
Chokes	Dynamic (stem seal)	60 cm^3/h
	Static (bonnet seal, end connectors)	20 cm^3/h
Actuators	All actuator fluid retaining seals	60 cm^3/h
Hangers	Annular packoff or bottom casing/tubing packoff	10 cm^3/h/25.4 mm of tubing/casing size
Tubing-head adapter, other end connectors, closures according to this specification	External closure	20 cm^3/h

F.1.6.2.3 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 3.45 MPa (500 psi), whichever is less.

F.1.6.3 Fluid Compatibility of Nonmetallic Seals

The acceptance criteria for the standard test fluid compatibility of nonmetallic seals shall be as specified in F.1.13.5.4.

F.1.6.4 Post-test Examination

The tested prototype shall be disassembled and inspected. All relevant items should be photographed. The examination shall include a written statement that neither the final product nor part design contains defects to the extent that any performance requirement is not satisfied.

F.1.7 Hydrostatic Testing

F.1.7.1 Test Medium

The test medium shall be a fluid suitable for the testing temperatures. Water with or without additives, gas, hydraulic fluid, or other mixtures of fluids may be used as the test medium. The test medium shall be a fluid that remains in the liquid or gaseous state throughout the test.

F.1.7.2 Substitution of Gas

The manufacturer may substitute gas for liquid if hydrostatic testing is specified, provided the testing method and acceptance criteria for gas testing are used.

F.1.8 Gas Testing

F.1.8.1 Test Medium

NOTE Air, nitrogen, methane, or other gases or mixtures of gases may be used.

F.1.8.2 Equipment for 69.0 MPa (10,000 psi) and Above

Equipment with rated working pressures of 69.0 MPa (10,000 psi) and higher shall be gas tested.

F.1.8.3 Leak Detection

Gas testing at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F) shall be conducted with a method for leak detection.

NOTE For gas testing, 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. The product may be assembled with one end of a tube connected to a blind connector enclosing all possible leak paths being validated.

The other end of the tube shall be immersed in a liquid or attached to a leakage measurement device. Other methods that can detect leakage accurately are acceptable.

F.1.9 Temperature Testing

F.1.9.1 Location of Temperature Measurement

The temperature shall be measured in contact with the equipment being tested and within 13 mm ($^1/_2$ in.) of the through-bore, where applicable, and within 13 mm ($^1/_2$ in.) of the surface wetted by the retained fluid on equipment that does not have a through-bore.

NOTE As an alternative for maximum-temperature measurement, the temperature of the fluid used for heating may be employed, as long as the part is not artificially cooled.

Ambient conditions shall be at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F).

F.1.9.2 Application of Heating for Maximum Temperature Testing

NOTE The heating for maximum-temperature testing may be applied internally in the through-bore or externally.

The heating shall be applied such that the entire through-bore or equivalent wetted surface is at or above the maximum temperature, or such that all fluid used for heating contained within the test articles is at or above the maximum temperature.

F.1.9.3 Application of Cooling for Minimum Temperature Testing

The cooling for minimum temperature testing shall be applied to the entire external surface of the equipment.

F.1.10 Hold Periods

F.1.10.1 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 time specified for hold times shall be a minimum.

F.1.10.2 Pressure Stabilization

Pressure shall be considered stabilized when the rate of change is no more than 5 % of the test pressure per hour or 3.45 MPa (500 psi), whichever is less. Pressure shall remain within 5 % of the test pressure or within 3.45 MPa (500 psi), whichever is less, during the hold period.

F.1.10.3 Temperature Stabilization

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.1.11 Pressure and Temperature Cycles

F.1.11.1 Pressure/Temperature Cycles

Pressure/temperature cycles shall be performed as specified in F.1.11.3, unless otherwise specified in F.2 for the specific product being tested.

F.1.11.2 Test Pressure and Temperature

The test pressure and temperature extremes shall be as specified in 4.3.

F.1.11.3 Test Procedure

Pressure shall be monitored and controlled during temperature change. The procedure specified in Figure F.1 shall be followed.

F.1.12 Load and Mechanical Cycles

Load testing and mechanical cycles shall be performed as specified in F.2 for the specific product being tested.

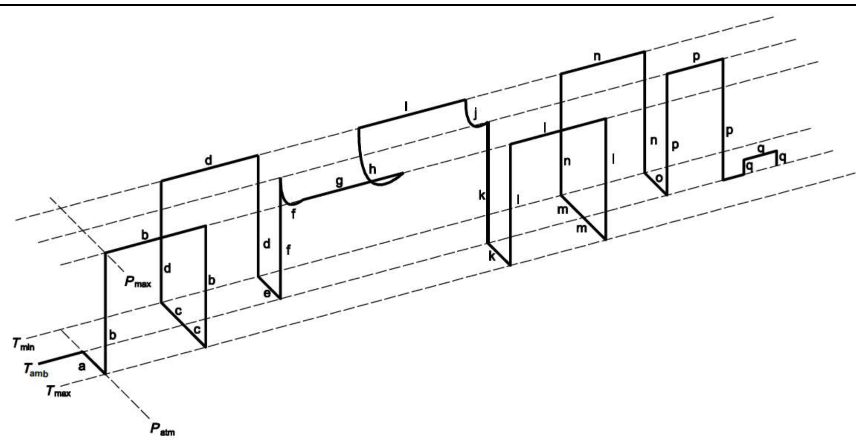


Figure F.1—Test Procedure

NOTE Letters correspond to the steps in the following list. There are three thermal cycles identified in the procedure of F.1.11.3: 1st thermal cycle is steps a) through e); 2nd thermal cycle is steps f) through j); and 3rd thermal cycle is steps k) through o).

a) Start at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F) with atmospheric pressure and raise temperature to the maximum.

b) Apply the test pressure, hold for a minimum period of 1 h, and then release the pressure.

c) Lower temperature to the minimum.

d) Apply the test pressure, hold for a minimum period of 1 h, and then release the pressure.

e) Raise the temperature to a temperature between 4 °C and 50 °C (between 40 °F and 120 °F).

f) Apply pressure of 50 % to 100 % of test pressure and maintain while raising temperature to the maximum.

g) Increase to test pressure (if not already at 100% of test pressure) and hold for a minimum period of 1 h.

h) Reduce the temperature to the minimum while maintaining 50 % to 100 % of test pressure.

i) Hold for a minimum period of 1 h at test pressure.

j) Raise the temperature to a temperature between 4 °C and 50 °C (between 40 °F and 120 °F) while maintaining 50 % to 100 % of test pressure.

k) Release the pressure, then raise the temperature to the maximum.

l) Apply the test pressure, hold for a minimum period of 1 h, and then release the pressure.

m) Reduce the temperature to the minimum.

n) Apply the test pressure, hold for a minimum period of 1 h, and then release the pressure.

o) Raise the temperature to a temperature between 4 °C and 50 °C (between 40 °F and 120 °F).

p) Apply the test pressure, hold for a minimum period of 1 h, and then release the pressure.

q) Apply 5 % to 10 % of the test pressure, hold for a minimum period of 1 h, and then release the pressure.

F.1.13 Testing of Nonmetallic Seals

F.1.13.1 Nonmetallic Seals

Nonmetallic seals that are exposed to retained fluids shall undergo the design validation procedure described in F.1.13.

F.1.13.2 Intent of Procedure

The intent of this procedure is to validate the performance of the seal for the standard test fluid rating as specified in F.1.13.4, not the performance of products containing the seal. The full-size seals shall be tested as specified in F.1 or F.2 to determine temperature and pressure performances.

F.1.13.3 Temperature of Record

The temperature of record shall be the stabilized temperature measured in contact with the fixture as specified in F.1.9.

F.1.13.4 Test Medium

The test medium shall be the standard test fluid specified in Table F.2 for the material's class rating.

F.1.13.5 Thermochemical Performance of Seal Materials

F.1.13.5.1 General

The fluid compatibility of the seal materials for the intended service shall be validated by a test demonstrating the response of the seal material to exposure to the standard test fluid, at or above the maximum rated temperature of the seal.

F.1.13.5.2 Immersion Testing

F.1.13.5.2.1 General

A sample immersion test, comparing physical and mechanical properties prior to and after exposure to the standard test fluids, temperature, and pressure as stated below, shall be performed. This test shall be in addition to the full-scale pressure and temperature testing of F.1 or F.2, as specified.

F.1.13.5.2.2 Test Fluid

The standard test fluids for the material classes are listed in Table F.2. The nonmetallic material being evaluated shall be totally immersed in the hydrocarbon liquid. A hydrocarbon liquid quantity equal to 60 % of the test vessel volume shall be charged in the test vessel. Water equal to 5 % of the test vessel volume shall also be charged in the test vessel. The hydrocarbon liquid shall be over-pressurized with the appropriate gas or gas mixture for the standard test fluid.

F.1.13.5.2.3 Temperature

The test temperature shall be either the maximum specified temperature rating for the temperature class being tested or the maximum temperature at the seal location (see F.1.9) for the equipment at the maximum test temperature class of the test product, as established by product testing and/or design analysis.

During the exposure period, the rate of temperature change shall be less than 0.5 °C (1 °F) per minute and shall not exceed the extreme by more than 11 °C (20 °F).

Table F.2—Standard Test Fluids for Nonmetallic Seals

Material Class	Hydrocarbon Liquid Phase [a]	Gas Phase
AA/BB	[b]	5 % vol. fraction CO_2/95 % vol. fraction CH_4
CC	[b]	80 % vol. fraction CO_2/20 % vol. fraction CH_4
DD/EE	[b]	10 % vol. fraction H_2S/5 % vol. fraction CO_2/85 % vol. fraction CH_4
FF/HH	[b]	10 % vol. fraction H_2S/80 % vol. fraction CO_2/10 % vol. fraction CH_4

FOOTNOTES

[a] Water shall be added to the liquid phase.

[b] Hydrocarbon liquid phase selected at the manufacturer's discretion may include, but is not limited to, jet fuel, diesel, kerosene, etc.

F.1.13.5.2.4 Pressure

The test pressure, after heating to the test temperature, shall be maintained at 6.9 MPa ± 0.7 MPa (1000 psi ± 100 psi), with adjustments made as necessary.

F.1.13.5.2.5 Exposure Period

The test exposure period shall be a minimum of 160 h (see F.1.10).

F.1.13.5.3 Fixture Testing

F.1.13.5.3.1 General

NOTE Alternatively, the standard test fluid tests may be run at or above the maximum rated temperature and pressure with a reduced or full-size seal in fixtures or products that represent the nominal specified clearances and extrusion gaps specified on the manufactured part.

F.1.13.5.3.2 Exposure Test Conditions

The following shall apply.

a) Test fluid: The standard test fluids for the material classes are listed in Table F.2. The fixture shall be positioned so the seal is partially exposed to both the liquid and gas phases. A hydrocarbon liquid quantity equal to 60 % of the test fixture volume shall be charged in the test fixture. Water equal to 5 % of the test fixture volume shall also be charged in the test fixture. The hydrocarbon liquid shall be overpressurized with the appropriate gas or gas mixture for the material class being tested.

b) Temperature: The test temperature shall be either the maximum specified temperature rating for the temperature class being tested (see F.1.9) or the maximum temperature at the seal location for the equipment at the maximum test temperature class of the test product, as established by product testing and/or design analysis.

   The temperature shall remain at or beyond the extreme during the exposure period but shall not exceed the extreme by more than 11 °C (20 °F) with a rate of change less than 0.5 °C (1 °F) per minute.

c) Pressure: The test pressure, after heating to the test temperature, shall be the rated working pressure of the seal.

d) Time period: The test exposure period shall be a minimum of 160 h.

F.1.13.5.3.3 Exposure Test Requirements

The following shall apply.

a) High-temperature pressure test: After the completion of a minimum of 160 h of exposure, monitor for leakage for a minimum of 1 h.

b) Room-temperature pressure test: At the completion of the high-temperature pressure test, cool the test fixture and release the pressure. At a temperature of 25 ± 5 °C (75 ± 10 °F) and no pressure in the test fixture, pressurize the test fixture using air, nitrogen, methane, or other gases or mixture of gases to the rated working pressure of the seal. Hold for a minimum of 1 h (see F.1.10). At the end of the hold period, reduce the pressure to zero.

c) Low-temperature pressure test: Lower the temperature of the test fixture to the minimum specified temperature rating for the temperature class being tested (see F.1.9). Pressurize the test fixture using air, nitrogen, methane, or other gases or mixture of gases to the rated working pressure of the seal. Hold for a minimum of 1 h (see F.1.10). At the end of the hold period, reduce the pressure to zero and let the test fixture temperature return to a temperature between 4 °C and 50 °C (between 40 °F and 120 °F).

F.1.13.5.4 Acceptance Criteria—Thermochemical Performance

F.1.13.5.4.1 Acceptance Criteria

The acceptance criteria for the standard test fluid compatibility of nonmetallic seals exposed to sample immersion testing of F.1.13.5.2 shall be documented. The acceptance criteria for the nonmetallic seals exposed to the fixture testing of F.1.13.5.3 shall be as follows.

F.1.13.5.4.2 160-hour Exposure Period

The pressure change recorded on the pressure-measuring device during the exposure period shall be less than 5 % of the test pressure or 3.45 MPa (500 psi), whichever is less.

F.1.13.5.4.3 High-temperature Pressure Test

The pressure change recorded on a pressure-measuring device during the high-temperature hold period shall be less than 5 % of the test pressure or 3.45 MPa (500 psi), whichever is less. Fluid displacement for fixture leak detector (bubble-type indicator) shall be less than 100 cm^3. Sustained leakage of bubbles shall not exceed 20 cm^3/h.

F.1.13.5.4.4 Room-temperature Pressure Test

The pressure change recorded on the pressure-measuring device during the hold period shall be less than 5 % of the test pressure or 3.45 MPa (500 psi), whichever is less. Fluid displacement for fixture leak detector (bubble-type indicator) shall be less than 20 cm^3. Sustained leakage of bubbles shall not exceed 20 cm^3/h.

F.1.13.5.4.5 Low-temperature Pressure Test

The pressure change recorded on the pressure-measuring device during the hold period shall be less than 5 % of the test pressure or 3.45 MPa (500 psi), whichever is less. Fluid displacement for fixture leak detector (bubble type indicator) shall be less than 20 cm^3. Sustained leakage of bubbles shall not exceed 20 cm^3/h.

F.1.13.5.4.6 Alternative Testing Acceptance

Material that passes the immersion testing of F.1.13.5.2 shall be acceptable without running the fixture testing of F.1.13.5.3.

Material that passes the fixture testing of F.1.13.5.3 shall be acceptable even if it fails the immersion testing of F.1.13.5.2.

Material that fails the fixture testing of F.1.13.5.3 shall not be acceptable.

F.1.14 Scaling

F.1.14.1 Scaling

NOTE Scaling may be used to validate the members of a product family in conformance with the requirements and limitations described in F.1.14.

F.1.14.2 Product Family

A product family shall conform to the following design requirements.

a) Configuration: The design principles of physical configuration and functional operation are the same.

b) Design stress levels: The design stress levels in relation to material mechanical properties are based on the same criteria.

F.1.14.3 Limitations of Scaling

F.1.14.3.1 Design Validation by Pressure Rating

NOTE The test product may be used to validate products of the same family having equal or lower-pressure ratings.

F.1.14.3.2 Design Validation by Size

F.1.14.3.2.1 General

Testing of one size of a product family shall validate products one nominal size larger and one nominal size smaller than the tested size.

NOTE Testing of two sizes also validates all nominal sizes between the two sizes tested.

F.1.14.3.2.2 Determination of Choke Nominal Size

The choke nominal size shall be defined as the size of the maximum orifice that can be used in that choke (orifice sizes smaller than the nominal size do not require testing). Choke nominal sizes are in 25 mm (1 in.) increments.

F.1.14.3.2.3 Determination of Valve Nominal Size

The valve nominal size shall be defined as the nominal size of the end connectors, as defined in F.1.14.3.2.6.

NOTE For valves of the same product family (as defined in F.1.14.2), where entries in Table F.3 group two sizes together, such as "1 $^{13}/_{16}$ in. or 2 $^{1}/_{16}$ in.," the size groupings may be considered as one size for scaling purposes.

F.1.14.3.2.4 Determination of Other End-connector Nominal Sizes

The nominal sizes of OECs shall be defined as the nominal size of the end connector, as defined in F.1.14.3.2.6 1).

F.1.14.3.2.5 Determination of Hanger and Packoff Nominal Sizes

The nominal size of hangers and packoffs that are sized by pipe ODs and wellhead IDs shall be defined by either the wellhead connector or the pipe. The manufacturer shall choose whether the size is determined by the connector or the pipe. The manufacturer shall be consistent in the practice of choosing sizes.

F.1.14.3.2.6 Nominal Sizes

The following shall apply.

1) Nominal connector sizes shall be as given in Table F.3.

Table F.3—Nominal End Connector Sizes

Inches
$1^{13}/_{16}$ or $2^{1}/_{16}$
$2^{9}/_{16}$
$3^{1}/_{16}$ or $3^{1}/_{8}$
$4^{1}/_{16}$ or $4^{1}/_{8}$
$5^{1}/_{8}$
$7^{1}/_{16}$
9
11
$13^{5}/_{8}$
$16^{3}/_{4}$
$18^{3}/_{4}$
$20^{3}/_{4}$ or $21^{1}/_{4}$
$26^{3}/_{4}$
30

2) Nominal pipe sizes shall be as given in Table F.4.

Table F.4—Nominal Pipe Sizes

Inches
$2^{1}/_{16}$
$2^{3}/_{8}$
$2^{7}/_{8}$
$3^{1}/_{2}$
4
$4^{1}/_{2}$
5
$5^{1}/_{2}$
$6^{5}/_{8}$
7
$7^{5}/_{8}$
$8^{5}/_{8}$
$9^{5}/_{8}$
$10^{3}/_{4}$
$11^{3}/_{4}$
$13^{3}/_{8}$
16
$18^{5}/_{8}$
20

F.1.14.3.2.7 Determination of Actuator Nominal Size

Determination of Actuator Nominal Size (for pneumatic and hydraulic types): Actuator size is determined by the pressure acting area of an actuator. An actuator is identified as one size larger to the tested size, if its pressure acting area is less than or equal to 4 times that of the tested actuator. An actuator is identified as one size smaller to the tested size, if its pressure acting area is greater than or equal to 25% that of the tested actuator.

Actuator sizes for electric actuators shall be defined by the manufacturer.

F.1.14.3.3 Design Validation by Temperature Rating

The temperature range validated by the test product shall validate all temperature classes that fall entirely within that range.

F.1.14.3.4 Design Validation by Standard Test Fluid Rating for Nonmetallic Seals

The standard test fluid rating validated by the test product shall validate all products of the same product family and material properties as the test product (see Table F.5).

Table F.5—Scaling for Nonmetallic Seals

Material of Products Tested	Classes of Products Validated
AA/BB	AA, BB
CC	AA, BB, CC
DD/EE	AA, BB, DD, EE
FF/HH	AA through HH

F.1.14.3.5 Design Validation by PSL

Validation of equipment shall be independent of the PSL of the production equipment.

F.1.15 Documentation

F.1.15.1 Design Validation Files

The manufacturer shall maintain a file on each design validation.

F.1.15.2 Contents of Validation Files

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, including identification of product family, if applicable;

c) date of test completion;

d) test results and post-test examination conclusions (see F.1.6.4);

e) maintenance performed on tested equipment.

NOTE This may include a record that identifies the test phase in which the maintenance was performed.

EXAMPLE Examples include quantity/type of lubricant, plastic packing, applied maintenance torque, lubrication of fittings, or pressure boundary penetrations.

f) model numbers and other pertinent identifying data on all other sizes, rated working pressures, temperature ranges, and standard test fluid ratings of products of the same product family that are qualified by the validation of this particular product;

g) class of seal designs (static, dynamic);

h) all detailed dimensional drawings and material specifications applicable to the tested product, including seals and non-extrusion devices;

i) sketch of test fixture, product and seal or sample; temperature and pressure measurement locations should be shown;

j) actual sealing-surface dimensions;

k) all test data specified in this annex, including actual test conditions (pressure, temperature, etc.) and observed leakages or other acceptance parameters;

l) identification of testing media used;

m) measuring and test equipment identification and calibration status;

n) certification of manufacturer report, including the supplier of test seals, molding dates, compound identifications, and batch numbers for nonmetallic materials;

o) certificate of conformance that the tested equipment is in conformance with the design requirements of this specification.

F.1.16 Measuring and Test Equipment Calibration

Measuring and test equipment for pressure-measuring, load-measuring, temperature-measuring, torque-measuring, elastomer physical and mechanical-property-measurement, and any other measuring and test equipment shall be calibrated in conformance with 10.2.

F.2 Product-specific Design Validation

F.2.1 General

F.2.1.1 Design Validation

NOTE Procedures that are specific and unique to the product being tested are contained in F.2.

The procedures shall be in addition to the procedures of F.1, unless otherwise specified in Annex F.

F.2.1.2 Acceptance Criteria

Unless noted otherwise, acceptance criteria for specific steps in F.2 shall be in conformance with F.1.

F.2.1.3 Re-energization

Any seal requiring re-energization during the test, except as specified in the product operating procedures, shall be retested.

F.2.1.4 Actuated Valves, Chokes, or Other Actuated Products

Valves, chokes, or other products designed for actuators shall have the same design validation as the manually actuated products.

Design validation of a manual valve or choke shall validate an actuated valve or choke and design validation of actuated valve or choke shall validate a manual valve or choke, provided that the basic design is the same, and functional differences between manual and actuated designs are subjected to appropriate validation through fixture testing or product testing. These functional differences shall include, but not be limited to, the following:

— stem-seal design;

— stem size;

— stem movement (linear vs. rotary);

— bonnet design;

— relative speed of operation (hydraulic vs. pneumatic).

The manufacturer shall have documentation and/or validation to support the application of the actuated valve, choke, or other product to the type of actuator, hydraulic or pneumatic.

F.2.1.5 Bottom Casing Packoff

NOTE Bottom casing packoffs are considered part of the hanger but may be tested separately.

F.2.2 Design Validation for PR2F Valves

F.2.2.1 General

NOTE See Table F.6 for a summary of design validation requirements for valves.

Acceptance criteria, unless noted otherwise for specific steps in F.2.2, shall be in conformance with F.1.

Table F.6—Summary of Design Validation Requirements for Valves

Performance Requirement	PR2F
Open/close cycling dynamic pressure test at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F)	160 cycles as specified in F.2.2
Low-pressure seat test at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F)	1 h hold period at 5 % to 10 % of rated working pressure as specified in F.2.2
Open/close cycling dynamic pressure gas test at maximum and minimum temperatures	20 cycles at each extreme as specified in F.2.2
Low-pressure seat test at maximum and minimum temperatures	1 h hold period at 5 % to 10 % of rated working pressure as specified in F.2.2
Operating force or torque	As specified in F.2.2
Pressure/temperature cycling	As specified in F.1.11
Testing of nonmetallic seals	As specified in F.1.13

F.2.2.2 Design Validation Procedure

F.2.2.2.1 Force or Torque Measurement

F.2.2.2.1.1 General

The break-away and running torques or forces shall be measured.

NOTE 1 This is not applicable to check valves.

NOTE 2 The torque or forces may be determined by direct or indirect measurements (i.e. pressure applied to an area).

F.2.2.2.1.2 Procedure

The procedure shall be determined and documented by the manufacturer.

F.2.2.2.1.3 Acceptance Criteria

The operating forces or torques shall be within the manufacturer's specifications.

F.2.2.2.2 Dynamic Test at Ambient Temperature

F.2.2.2.2.1 Procedure for Gate, Ball, and Plug Valves

Gate, ball, and plug 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 rated working pressure against the upstream side of the gate, ball, or plug. 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 initial partial opening. 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) Repeat the above steps until a minimum of 160 open-and-close cycles have been carried out.

F.2.2.2.2.2 Procedure for Check Valves

Check valves shall be tested as follows.

a) Apply pressure equal to the rated working pressure to the downstream side of the valve, while the upstream side is vented to atmosphere.

b) Relieve the pressure to 1 % or less of test pressure and unseat the valve.

Repeat F.2.2.2.2.2 a) and F.2.2.2.2.2 b) until a minimum of 160 pressure cycles have been carried out.

F.2.2.2.3 Dynamic Test at Maximum Rated Temperature

This test shall be performed at maximum rated temperature in conformance with F.2.2.2.2, except that the minimum number of open-and-close cycles shall be 20 and the test medium shall be gas.

F.2.2.2.4 Gas Body Test at Maximum Rated Temperature

This test shall be performed at maximum rated temperature as follows.

a) Gate, ball, and plug valves shall be in the partially open position during testing. Test check valves from the upstream side.

b) Test pressure shall be the rated working pressure.

c) The hold period shall be as specified in F.1.11.3 b), but do not release the pressure at the end of the hold period.

F.2.2.2.5 Gas Seat Test at Maximum Rated Temperature

At the end of the hold period of F.2.2.2.4, the valve shall be closed. The rated working pressure shall be maintained on the upstream side of the gate, ball, or plug and release it on the downstream side. Check valves shall be tested from the downstream side. There shall be one hold period of not less than 1 h duration; then release the pressure.

F.2.2.2.6 Low-pressure Seat Test at Maximum Rated Temperature

The valves shall be subjected to a differential pressure of no less than 5 % and no more than 10 % of the rated working pressure. The pressure shall be applied on the upstream side of the gate, ball, or plug and released on the downstream side for one hold period of a minimum of 1 h. 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.

F.2.2.2.7 Dynamic Test at Minimum Rated Temperature

A dynamic test at minimum rated temperature shall be performed as specified in F.2.2.2.2, except that the minimum number of open-and-close cycles shall be 20, and the test medium shall be gas.

F.2.2.2.8 Gas Body at Minimum Rated Temperature

This test shall be performed in conformance with F.2.2.2.4, except at minimum rated temperature.

F.2.2.2.9 Gas Seat Test at Minimum Rated Temperature

This test shall be performed in conformance with F.2.2.2.5, except at minimum rated temperature.

F.2.2.2.10 Low-pressure Seat Test at Minimum Rated Temperature

This test shall be performed in conformance with F.2.2.2.6, except at minimum rated temperature.

F.2.2.2.11 Body Pressure-temperature Cycles

Steps F.1.11.3 e) through F.1.11.3 o) shall be performed with gate, ball, and plug valves partially open.

F.2.2.2.12 Body Pressure Holding Test at Ambient Temperature

Step F.1.11.3 p) shall be performed with gate, ball, and plug valves partially open, but do not release the pressure.

F.2.2.2.13 Gas Seat Test at Ambient Temperature

The valve shall be closed. The rated working pressure shall be maintained on the upstream side of the gate, ball, or plug and released on the downstream side. Check valves shall be tested from the downstream side. There shall be one pressure-holding period of not less than 15 min duration; then release the pressure.

F.2.2.2.14 Body Low-pressure Holding Test at Ambient Temperature

Step F.1.11.3 q) shall be performed on gate, ball, and plug valves with the valve partially open.

F.2.2.2.15 Low-pressure Seat Test at Ambient Temperature

Valves shall be subjected to a differential pressure of no less than 5 % and no more than 10 % of the rated working pressure. One hold period of a minimum of 1 h duration shall be applied (in each direction, for bidirectional valves). 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 atmosphere.

F.2.2.2.16 Final Force or Torque Measurement

This test shall be performed in conformance with F.2.2.2.1.

F.2.3 Design Validation for PR2F Actuators

F.2.3.1 General

NOTE See Table F.7 for a summary of design validation requirements for actuators.

Table F.7—Summary of Design Validation Requirements for Actuators

Performance Requirement	PR2F
Operating force or torque measurement	As specified in F.2.2.2.1
Actuator seal test at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F)	3 cycles as specified in F.2.3.2.1
Dynamic open/close pressure cycling at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F)	160 cycles as specified in F.2.3.2.2
Dynamic open/close cycling test at maximum temperature	20 cycles as specified in F.2.3.2.3
Dynamic open/close cycling at minimum temperature	20 cycles as specified in F.2.3.2.4
Pressure/temperature cycles	As specified in F.2.3.2.5

Actuators, including electric actuators, shall be subjected to a functional test to demonstrate proper assembly and operation. Test medium for pneumatic actuators shall be a gas. Test medium for hydraulic actuators shall be a suitable hydraulic fluid.

The actuator shall be tested either on a valve/choke or on a fixture that simulates the opening/closing dynamic force profile of a valve/choke. A fixture test of a valve operator shall include the reduction in resisting force and resulting motion of the stem that occur when the valve is opened against differential pressure.

If the bonnet assembly is part of the actuator, a validation of the stem seal and bonnet design shall be performed to validate these design elements to the requirements for valves.

F.2.3.2 Testing

F.2.3.2.1 Actuator Seal Test at Ambient Temperature

Actuator seals shall be pressure-tested in two steps by applying a pressure of 20 % and of 100 % of the rated working pressure to the actuator. The minimum hold period for each test pressure shall be 10 min at 20 % pressure and 5 min at 100 % pressure for pneumatic actuators and 3 min at each test pressure for hydraulic actuators. This actuator seal test shall be repeated a minimum of three times.

F.2.3.2.2 Dynamic Open/Close Cycling Test at Ambient Temperature

The actuator shall be tested for proper operation by cycling the actuator an equivalent of 160 open-close valve cycles. The acceptance criteria shall be within the manufacturer's specifications. The pressure applied shall be equal to the rated working pressure of the actuator. Test power supplied to electric actuators shall be in conformance with the electrical design requirements.

F.2.3.2.3 Dynamic Open/Close Cycling Test at Maximum Rated Actuator Temperature

The actuator shall be tested for proper operation by cycling the actuator an equivalent of 20 open-close valve cycles at the maximum rated temperature of the actuator. The acceptance criteria shall be within the manufacturer's specifications. The pressure applied shall be equal to the rated working pressure of the actuator. Test power supplied to electric actuators shall be in conformance with the electrical design requirements.

F.2.3.2.4 Dynamic Open/Close Cycling Test at Minimum Rated Actuator Temperature

The actuator shall be tested for proper operation by cycling the actuator an equivalent of 20 open-close valve cycles, at minimum rated temperature of the actuator. The acceptance criteria shall be within the manufacturer's specifications. The pressure applied shall be equal to the rated working pressure of the actuator. Test power supplied to electric actuators shall be in conformance with the electrical design requirements.

F.2.3.2.5 Pressure/Temperature Cycles

The pressure/temperature cycles shall be steps F.1.11.3 e) through F.1.11.3 q).

F.2.4 Design Validation for PR2F Chokes

F.2.4.1 General

NOTE 1 Design validation of an adjustable choke also validates a positive choke which has the same body design and seat seal design. For positive choke testing, the dynamic test cycles (F.2.4.4, F.2.4.5, and F.2.4.7) are not required.

NOTE 2 See Table F.8 for a summary of design validation requirements for chokes.

Table F.8—Summary of Design Validation Requirements for Chokes

Performance Requirement	PR2F
Operating force or torque measurement	As specified in F.2.4.2
Body static pressure test	Not applicable
Seat-to-body seal test at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F)	As specified in F.2.4.3
Dynamic open/close cycling pressure test at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F) [a]	160 cycles as specified in F.2.4.4
Dynamic open/close cycling pressure test at maximum temperature [a]	20 cycles as specified in F.2.4.5
Gas body test at maximum rated temperature	As specified in F.2.4.6
Dynamic open/close cycling pressure test at minimum temperature [a]	20 cycles as specified in F.2.4.7
Gas body at minimum rated temperature	As specified in F.2.4.8
Body pressure/temperature cycling	As specified in F.2.4.9
Body pressure-holding test at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F)	As specified in F.2.4.10
Body low-pressure holding test	As specified in F.2.4.11
Second seat-to-body at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F)	As specified in F.2.4.12
Testing of nonmetallic seals	As specified in F.1.13

FOOTNOTE

[a] Does not apply to a positive choke.

F.2.4.2 Force or Torque Measurement

F.2.4.2.1 General

The break-away and running torques or forces shall be measured.

NOTE The forces may be determined by direct or indirect measurements (i.e. pressure applied to an area).

F.2.4.2.2 Procedure

The procedure shall be determined and documented by the manufacturer.

F.2.4.2.3 Acceptance Criteria

The operating forces or torque shall be within the manufacturer's specifications.

F.2.4.3 Hydrostatic Seat-to-body Seal Test

The hydrostatic seat-to-body seal test shall be performed at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F) by applying rated working pressure and holding for a minimum of 1 h to confirm the integrity of the seat-to-body seal.

NOTE 1 A blind seat may be used for this test at the manufacturer's option.

NOTE 2 For an adjustable choke, a separate test or fixture test may be performed to confirm the integrity of the seat-to-body seal, in conformance with F.2.4.3, F.2.4.9, F.2.4.10, and F.2.4.11. In this case, F.2.4.12 may be omitted.

F.2.4.4 Dynamic Open/Close Cycling Pressure Test at Ambient Temperature

The rated working pressure shall be applied, and the stem cycled at rated working pressure a minimum 160 times open-close-open. The mating parts shall be free of all lubrication not specified in the manufacturer's part or assembly specifications or maintenance procedures. The acceptance criteria shall be within the manufacturer's written specifications. Adjust the internal pressure to compensate for expansion and contraction of the test fluid chamber.

F.2.4.5 Dynamic Open/Close Cycling Pressure Test at Maximum Rated Temperature

A dynamic cycling test shall be performed at the maximum rated temperature by repeating F.2.4.4, except as follows.

— The temperature shall be equal to the maximum temperature.

— The test medium shall be gas.

— Cycle the stem 20 times open to close and back to open.

F.2.4.6 Gas Body at Maximum Rated Temperature

A gas body test shall be performed at maximum rated temperature as follows.

— The choke shall be in the partially open position during testing.

— Test pressure shall be the rated working pressure.

— One hold period of a minimum of 1 h duration shall be applied.

F.2.4.7 Dynamic Test at Minimum Rated Temperature

A dynamic test shall be performed at the minimum rated temperature by repeating F.2.4.5, except at the minimum rated temperature.

F.2.4.8 Gas Body at Minimum Rated Temperature

A gas body test shall be performed at the minimum rated temperature as follows.

— The choke shall be in the partially open position during testing.

— Test pressure shall be the rated working pressure.

— One hold period of a minimum of 1 h duration shall be applied.

F.2.4.9 Body Pressure/Temperature Cycles

Steps F.1.11.3 e) through F.1.11.3 o) shall be performed with the seat open.

F.2.4.10 Body Pressure Holding Test at Ambient Temperature

Step F.1.11.3 p) shall be performed with the seat open, but do not release the pressure.

F.2.4.11 Body Low-pressure Holding Test at Ambient Temperature

Step F.1.11.3 q) shall be performed with the seat open.

F.2.4.12 Second Seat-to-body Seal Test at Ambient Temperature

A second hydrostatic seat-to-body seal test shall be performed by applying rated working pressure at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F) and holding for a minimum of 1 h to confirm the integrity of the seat-to-body seal after pressure/temperature cycle testing.

NOTE A blind seat may be used for this test at the manufacturer's option.

F.2.5 Design Validation for PR2F Casing-head Housings, Casing-head Spools, Tubing-head Spools, Crossover Connectors, and Adapter and Spacer Spools

F.2.5.1 General

NOTE See Table F.9 for a summary of design validation requirements for casing-head housings, casing-head spools, tubing-head spools, crossover connectors, and adapter and spacer spools.

Table F.9—Summary of Design Validation Requirements for Casing-head Housings, Casing-head Spools, Tubing-head Spools, Crossover Connectors, and Adapter and Spacer Spools

Performance Requirement	PR2F
Pressure	As specified in F.2.5.4
Thermal cycles	Objective evidence
Penetrations	As specified in F.2.15
Fluid compatibility	Objective evidence

F.2.5.2 Deformation

NOTE The deformation of casing-head housings, casing-head spools, and tubing-head spools due to hanger loading is outside the scope of this annex.

Products shall be capable of sustaining rated loads without deformation to the extent that other required performance characteristics cannot be met.

F.2.5.3 Penetrations

NOTE 1 Penetrations for lock screws, hanger pins, and retainer screws are not addressed in performance testing of these members but are addressed in F.2.15.

NOTE 2 Fittings and pressure boundary penetrations are addressed in F.2.20.

F.2.5.4 Testing

Design validation shall be achieved through production hydrostatic pressure testing as required for the PSL to which the equipment is manufactured (see 10.4.7).

F.2.6 Design Validation for PR2F Group 1 Slip-type Hangers

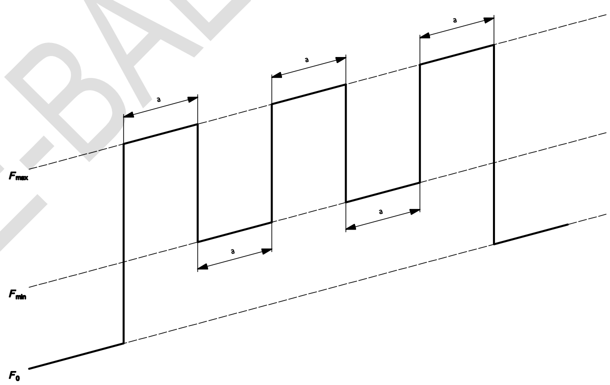
F.2.6.1 General

Load cycling capacity testing shall consist of three hold periods at maximum rated load capacity, and two hold periods at the minimum rated load capacity, with 5 min minimum for each hold period, as shown in Figure F.2.

NOTE The pressure/temperature cycles of F.1.11 are not required.

F.2.6.2 Load Cycling

The load cycle test in conformance with Figure F.2 shall be performed.



FOOTNOTE

[a] Five minutes.

Figure F.2—Load Cycle Testing for Hangers

F.2.7 Design Validation for PR2F Group 2 Slip-type Hangers

F.2.7.1 General

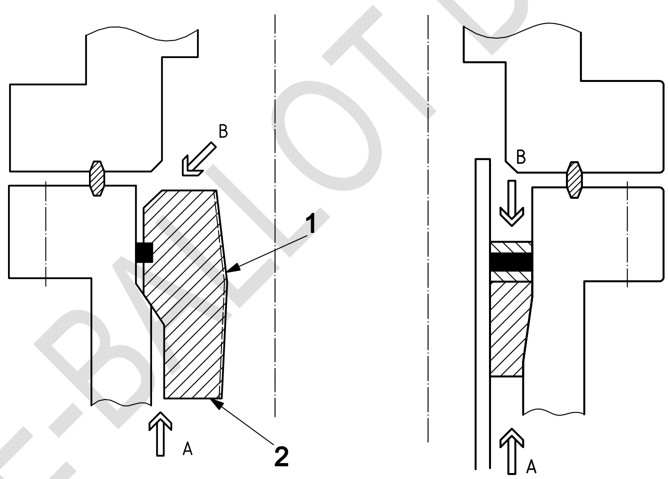
NOTE See Table F.10 for a summary of design validation requirements for Group 2 slip-type hangers.

Table F.10—Summary of Design Validation Requirements for Group 2 Slip-type Hangers

Performance Requirement	PR2F
Load cycling	As specified in F.2.6
Pressure seal(s)	As specified in F.1.11
Fluid compatibility	As specified in F.1.13

F.2.7.2 Pressure/Temperature Testing with Load

Cycle testing shall be performed in conformance with F.1.11 from either direction A or direction B (see Figure F.3). If the manufacturer's pressure rating at the maximum rated load is not equal to the rated working pressure, the test shall be repeated using the rated working pressure of the hanger with the manufacturer's rated hanging load at that pressure.



Key

1 well bore pressure area

2 annular pressure area

A, B Directions of pressure application (see text).

Figure F.3—Group 2 and Group 3 Hangers

F.2.8 Design Validation for PR2F Group 3 Slip-type Hangers

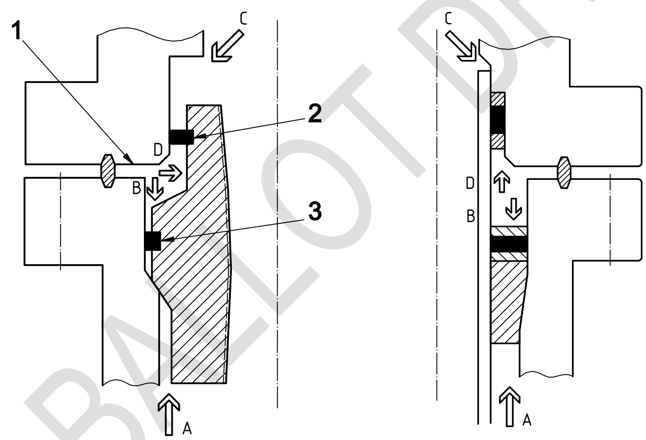
NOTE See Table F.11 for a summary of design validation requirements for Group 3 slip-type hangers.

Table F.11—Summary of Design Validation Requirements for Group 3 Slip-type Hangers

Performance Requirement	PR2F
Load cycling	As specified in F.2.6
Pressure from above seal(s)	As specified in F.1.11 and F.2.8
Thermal cycle	As specified in F.1.11 and F.2.8
Fluid compatibility	As specified in F.1.13
Pressure from below seal(s)	As specified in F.1.11 and F.2.8

Validation testing shall be the same as for PR2F Group 2 slip-type hangers, with the addition of a separate test in the same manner but with external pressure across the annular packoff in the other direction, as identified in Figure F.3.

The bottom casing packoff shall be tested from above in the same manner. The ring joint pressure area shall be hydrostatically tested, as identified in Figure F.4, at the rated working pressure at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F), one time for a 5 min minimum hold period.



Key

1 ring-gasket pressure area

2 bottom casing packoff

3 annular seal

A, B, C, D Directions of pressure application (see text).

Figure F.4—Group 3 Hangers with Crossover Seal

If the manufacturer's pressure rating from below is different from the pressure rating from above, a test at the appropriate pressure for each direction shall be performed.

NOTE The bottom casing packoff may be cycle-tested separately, as shown in Figure F.6, or concurrently with the packoff, as shown in Figure F.7 or Figure F.8.

F.2.9 Design Validation for PR2F Group 4 Slip Hangers

NOTE See Table F.12 for a summary of design validation requirements for group 4 slip-type hangers.

Table F.12—Summary of Design Validation Requirements for Group 4 Slip-type Hangers

Performance Requirement	PR2F
Load cycling	As specified in F.2.6
Pressure from above seal(s)	As specified in F.1.11
Thermal cycle	As specified in F.1.11
Fluid compatibility	As specified in F.1.13
Pressure from below seal(s)	As specified in F.1.11
Retention feature test by annular pressure	As specified in F.1.11 with the hanger held in place by a retention feature with minimum rated tubular load and maximum annular pressure from below only

Validation testing shall be the same as PR2F group 3 hangers, with an additional test of the retention feature in conformance with Table F.12.

F.2.10 Design Validation for PR2F Group 1 Mandrel-type Hangers

F.2.10.1 General

NOTE See Table F.13 for a summary of design validation requirements for group 1 mandrel-type hangers.

Table F.13—Summary of Design Validation Requirements for Group 1 Mandrel-type Hangers

Performance Requirement	PR2F
Load cycling	As specified in F.2.10
Internal pressure test	As specified in F.2.10

F.2.10.2 Internal Pressure Test

One internal pressure test shall be performed at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F) with a hold period of 15 min at rated working pressure.

If the product does not meet the thread manufacturer's dimensional and material strength requirements, then the threaded connector shall be tested.

NOTE The test may be performed in a fixture separate from the hanger.

F.2.10.3 Load Cycling

The hanger shall be load-tested in conformance with F.2.6. Load testing of the end connectors shall not be required.

F.2.11 Design Validation for PR2F Group 2 Mandrel-type Hangers

F.2.11.1 General

NOTE See Table F.14 for a summary of design validation requirements for group 2 mandrel-type hangers.

Table F.14—Summary of Design Validation Requirements for Group 2 Mandrel-type Hangers

Performance Requirement	PR2F
Load cycling	As specified in F.2.11
Pressure seal(s)	As specified in F.1.11
Thermal cycling seal(s)	As specified in F.1.11
Fluid compatibility	As specified in F.1.13
Internal pressure test	As specified in F.2.11

F.2.11.2 Load Cycling

The load cycle test shall be performed as specified in F.2.6.

F.2.11.3 Internal Pressure Test

The hangers shall be internally pressure-tested as specified for PR2F group 1 mandrel hangers (see F.2.10.2).

F.2.12 Design Validation for PR2F Group 3 Mandrel-type Hangers

F.2.12.1 General

NOTE See Table F.15 for a summary of design validation requirements for group 3 mandrel-type hangers.

Table F.15—Summary of Design Validation Requirements for Group 3 Mandrel-type Hangers

Performance Requirement	PR2F
Load cycling	As specified in F.2.12
Internal pressure tests	As specified in F.2.12
Thermal cycling seal(s)	As specified in F.1.11 and F.2.12
Fluid compatibility	As specified in F.1.13
Pressure from below seal(s)	As specified in F.1.11 and F.2.12
Pressure from above seal(s)	As specified in F.1.11 and F.2.12

F.2.12.2 Downhole Control Line

If downhole control-line or electric-cable preparations are included, they shall hold the rated working pressure and be subjected to the same testing requirements as the hanger.

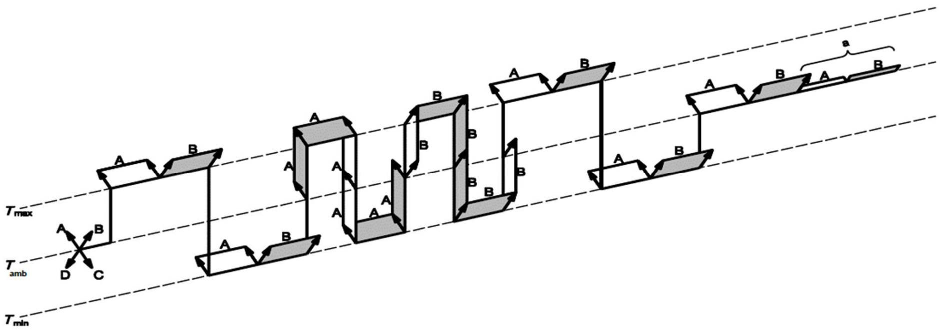
F.2.12.3 Pressure Cycle

Validation testing shall be the same as for PR2F group 2 mandrel-type hangers, with the addition of a separate test in the same manner, but with external pressure from the opposite side of the annular seal, as identified in Figure F.3.

NOTE 1 For extended-neck hangers, see Figure F.4.

The bottom casing packoff shall be tested in the same manner from the top and the bottom. The ring-gasket pressure area shall be hydrostatically tested for extended-neck hangers at the rated working pressure at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F), one time for a 5 min minimum hold period.

NOTE 2 Figures F.5, F.6, F.7, and F.8 show schematic representations of the pressure and temperature cycle test requirements.

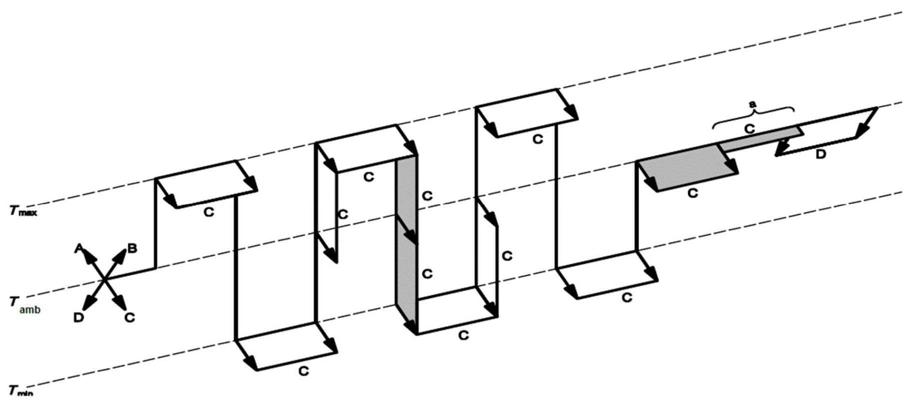


FOOTNOTES

[a] 5 % to 10 %.

NOTE Pressure directions A and B are shown in Figures F.3 and F.4.

Figure F.5—Pressure/Temperature Cycles for Group 3 Slip and Mandrel-type Hangers without Bottom Casing Packoff

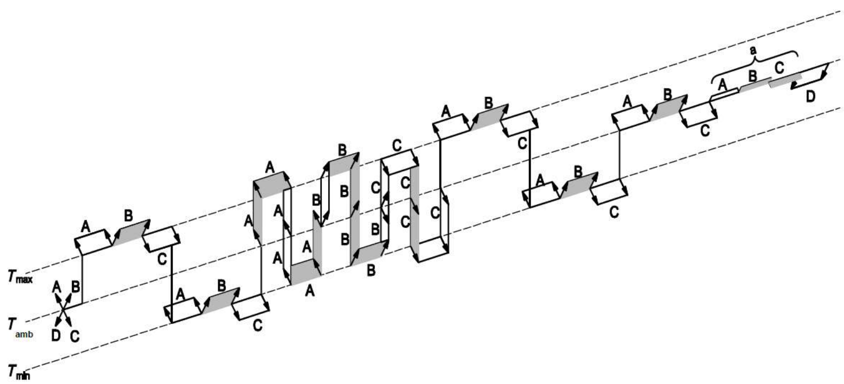


FOOTNOTES

[a] 5 % to 10 %.

NOTE Pressure directions C and D are shown in Figure F.4.

Figure F.6—Pressure/Temperature Cycles for Group 3 Slip and Mandrel-type Hangers with Bottom Casing Packoff Tested Separately

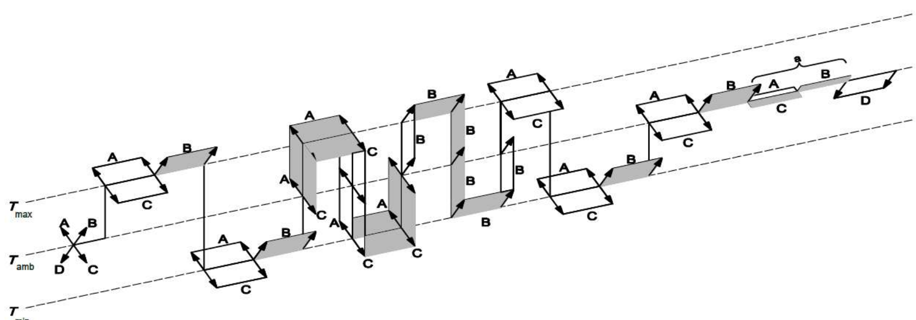


FOOTNOTES

[a] 5 % to 10 %.

NOTE Pressure directions A, B, C, and D are shown in Figure F.4.

Figure F.7—Pressure/Temperature Cycles for Group 3 Slip and Mandrel-type Hangers with Bottom Casing Packoff Tested Concurrently



FOOTNOTES

[a] 5 % to 10 %.

NOTE Pressure directions A, B, C, and D are shown in Figure F.4, with A and C tested together.

Figure F.8—Pressure/Temperature Cycles for Group 3 Slip and Mandrel-type Hangers with Bottom Casing Packoff Tested Concurrently

F.2.12.4 Internal Pressure Test

Hangers shall be internally pressure-tested as specified for PR2F group 1 mandrel-type hangers in F.2.10.2.

F.2.12.5 Load Cycling

The load cycle test shall be performed as specified in F.2.6.

F.2.13 Design Validation for PR2F Group 4 Mandrel Hangers

F.2.13.1 General

NOTE See Table F.16 for a summary of design validation requirements for group 4 mandrel hangers.

Table F.16—Summary of Design Validation Requirements for Group 4 Mandrel-type Hangers

Performance Requirement	PR2F
Load cycling	As specified in F.2.6
Internal pressure test	As specified in F.2.13
Thermal cycling seal(s)	As specified in F.1.11 and F.2.13
Fluid compatibility	As specified in F.1.13
Pressure from below seal(s)	As specified in F.1.11 and F.2.13
Pressure from above seal(s)	As specified in F.1.11 and F.2.13
Retention feature test by annular pressure	As specified in F.1.11 and F.2.13 with the hanger held in place by a retention feature with minimum rated tubular load and maximum annular pressure from below only

F.2.13.2 Pressure/Temperature Cycling

Validation testing shall be the same as for PR2F group 3 hangers. Three pressure/temperature cycles shall be performed as specified in F.1.11 while the hanger is held in place by the retention feature.

F.2.13.3 Internal Pressure Test

Hangers shall be internally pressure-tested as specified for PR2F group 1 mandrel hangers in F.2.10.2.

F.2.14 Design Validation for PR2F Group 5 Mandrel-type Hangers

F.2.14.1 General

NOTE See Table F.17 for a summary of design validation requirements for group 5 mandrel-type hangers.

Table F.17—Summary of Design Validation Requirements for Group 5 Mandrel-type Hangers

Performance Requirement	PR2F
Load cycling	As specified in F.2.6
Internal pressure test	As specified in F.2.14
Thermal cycling	As specified in F.1.11 and F.2.14
Fluid compatibility	As specified in F.1.13
Pressure from below seal(s)	As specified in F.1.11 and F.2.14
Pressure from above annular seal(s)	As specified in F.1.11 and F.2.14
Retention feature test by full blind pressure	As specified in F.1.11 and F.2.14 with the hanger held in place by a retention feature with minimum rated tubular load and maximum full blind pressure from below only
Back-pressure valve preparation test	As specified in F.2.14

F.2.14.2 Pressure/Temperature Cycling

Validation testing shall be the same as for PR2F group 4 hangers, except for the test hanger retention feature with a full blind annular seal load as specified in F.1.11 with pressure from below. The back-pressure valve preparation shall be independently pressure-tested at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F) to rated working pressure of the hanger, cycled from atmospheric to rated working pressure three times with 5 min minimum hold periods with the pressure applied against the lower end of the back-pressure valve preparation.

F.2.14.3 Internal Pressure Test

Hangers shall be internally pressure-tested as specified for PR2F group 1 mandrel-type hangers in F.2.10.2.

F.2.15 Design Validation for Packing Mechanisms for PR2F Lock Screws, Alignment Pins, and Retainer Screws

NOTE See Table F.18 for a summary of design validation requirements for packing mechanisms for lock screws, alignment pins, and retainer screws.

Table F.18—Summary of Design Validation Requirements for Packing Mechanisms for Lock Screws, Alignment Pins, and Retainer Screws

Performance Requirement	PR2F
Pressure and thermal cycling	As specified in F.1.11
Operating force or torque	Shall withstand manufacturer’s rated force or torque as specified in F.2.15

A simulated maximum load shall be applied at the manufacturer’s recommended torque and then the pressure/temperature cycle test of F.1.11 shall be performed.

F.2.16 Design Validation for PR2F Group 1 Tubing-head Adapters

Design validation shall be achieved through production hydrostatic pressure testing as required for the PSL to which the equipment is manufactured (see 11.2).

F.2.17 Design Validation for PR2F Group 2 Tubing-head Adapters

F.2.17.1 General

NOTE See Table F.19 for a summary of design validation requirements for group 2 tubing-head adapters.

Table F.19—Summary of Design Validation Requirements for Group 2 Tubing-head Adapters

Performance Requirement	PR2F
Load cycling	As specified in F.2.17
Internal pressure test	As specified in F.2.17
Thermal cycling	Objective evidence
Fluid compatibility	Objective evidence

F.2.17.2 Load Cycling

The load cycle test shall be performed as specified in F.2.11.

F.2.17.3 Internal Pressure Test

The internal pressure test of the tubing-head adapter shall be performed, including the end connectors, as specified in F.2.16.

One internal pressure test shall be performed at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F) with a hold period of 15 min at rated working pressure.

If the product does not meet the thread manufacturer's dimensional and material strength requirements, then the threaded connector shall be tested.

NOTE The test may be performed in a fixture separate from the hanger.

F.2.18 Design Validation for PR2F Other End Connectors

F.2.18.1 General

NOTE See Table F.20 for a summary of design validation requirements for OECs.

Table F.20—Summary of Design Validation Requirements for Other End Connectors

Performance Requirement	PR2F
Pressure and thermal cycles	As specified in F.1.11
Bending moments	Subject connector to manufacturer's rated load that produces the highest stress case for one cycle
Make-and-break	Subject connector to manufacturer's rated make-and-break cycles (if applicable)
Fluid compatibility	As specified in F.1.13

F.2.18.2 PR2F Validation Test

The entire connector shall be tested as specified in F.1.11.

F.2.18.3 Make-and-break Cycles

The connector shall be subjected to the manufacturer's rated make-and-break cycles independent of the test in F.2.18.2. The working pressure shall be applied to the connector for a 5 minute hold period after each make-up of the connector.

F.2.18.4 Bending Moments

The connector shall be subjected to the manufacturer's rated load case for one cycle to the highest stress case determined for the connector, independent of the tests in F.2.18.2 and F.2.18.3.

F.2.19 Design Validation for Ring Gaskets, Bolting, and Other Specified Products

NOTE Validation testing is not required for specified flanged or studded end and outlet connectors, threaded end and outlet connectors, closure bolting, ring joint gaskets, bullplugs, tees and crosses, test and gauge connector ports, and other specified products that are completely specified (dimensions and materials) by this specification.

F.2.20 Qualification for Fittings and Pressure Boundary Penetrations

F.2.20.1 General

Fittings and pressure boundary penetrations shall be validated either separately or installed on the equipment.

Fittings and pressure boundary penetrations shall be free of all lubrication, unless specified in the manufacturer's specifications or maintenance procedures.

If validation of the fittings is performed independently from the equipment, the test pressure shall be, at a minimum, the rated working pressure of the fitting. If validation of the fitting is performed installed on equipment, the test pressure shall be, at a minimum, the rated working pressure of the equipment.

F.2.20.2 Test Procedure

This test shall be performed with the secondary sealing device removed or compromised if allowed by the design. An additional step shall be completed to validate the sealing capability of the secondary device. If there is more than one sealing device in series, they shall be qualified separately.

Test the complete assembly as follows.

a) Apply test pressure to the fitting.

b) Bleed pressure. If the fitting function requires bleeding or equalizing pressure, bleed pressure to zero by unseating the fitting.

c) Reseat the primary sealing device, if applicable.

d) Apply test pressure, hold for a period of 15 min, then release the pressure.

e) Test the complete assembly in conformance with F.1.11.

f) Apply test pressure to the fitting.

g) Bleed pressure. If the fitting function requires bleeding or equalizing pressure, bleed pressure to zero by unseating the fitting.

h) Reseat the primary sealing device, if applicable.

i) Apply test pressure, hold for a period of 15 min, then release the pressure.

If a secondary barrier is included in the design, defeat the primary sealing device, replace the secondary sealing device to the fitting and repeat steps a) through i) for the secondary sealing device.

Annex G
(informative)

Design and Rating of Equipment for Use at Elevated Temperatures

G.1 General

In conformance with 4.3.2, the design of equipment for temperatures above 121 °C (250 °F) shall include the effects of temperature on material strength.

NOTE 1 This annex provides two methods that may be used for the design and rating of equipment for use at elevated temperatures. The first is to de-rate the working pressure of the equipment at the elevated temperature to a pressure less than the room-temperature full-rated working pressure of the equipment. The second is to design the equipment for full-rated working pressure at the elevated temperature.

NOTE 2 Data on the performance of flanged end connectors, as specified in this specification, at elevated temperatures are available in API 6AF1.

Caution—Annex G is not intended as a material selection guide for high-temperature use. Some alloys are embrittled after repeated or prolonged exposure to elevated temperatures. Care should be used in selection of alloys for these ratings. If plated or coated materials are used at temperatures greater than 180 °C (350 °F), the cracking potential can be increased.

G.2 Elevated Temperature Ratings

NOTE The temperature ratings given in Table G.1 may be used for equipment for service temperatures in excess of those covered by Section 4.

Table G.1—Temperature Ratings

Classification	Temperature Range	
	°C	°F
X	−18 to 180	0 to 350
Y	−18 to 345	0 to 650

G.3 Pressure-temperature De-rating

NOTE 1 The rated working pressure of equipment may be de-rated for temperature ratings X and Y.

De-rated equipment shall be marked in conformance with G.4.

NOTE 2 The de-rated temperatures and pressures of Table G.2 may be used for equipment with 6B flanges. Alternative de-rated pressures may be used for OECs, or for flanges specified in this specification based on the data of API 6AF1.

Table G.2—Optional Pressure-temperature Ratings for 6B Flanges

Pressure Rating for Classes K to U	De-rated Pressure	
MPa (psi)	**Class X,** MPa (psi)	**Class Y,** MPa (psi)
13.8 (2000)	13.1 (1905)	9.9 (1430)
20.7 (3000)	19.7 (2860)	14.8 (2145)
34.5 (5000)	32.8 (4765)	24.7 (3575)
FOOTNOTE See Table G.1 for temperature ratings.		

G.4 Marking of De-rated Equipment

In addition to the marking requirements of Section 12, equipment supplied for temperature ratings above 250° F (121° C) that is de-rated shall have the de-rated working pressure for the applicable maximum temperature marked on the equipment.

G.5 Design of Equipment for Use at Elevated Temperature

G.5.1 General

It has been demonstrated that some flanges specified in this specification are capable of being used at full working pressure at elevated temperatures. In addition, some OECs are capable of being used at full-rated working pressure at elevated temperature. One purpose of this annex is to provide rules for the design of equipment for operation at full-rated working pressure at elevated temperature.

A second purpose of this annex is to provide rules for the design of de-rated equipment for use at elevated temperatures.

G.5.2 Procedure

G.5.2.1 General

De-rated equipment may be designed in conformance with the rules of API 6X, extended to include high-temperature cases as follows.

There is no change to the rules of design for hydrostatic test conditions, since shell testing is carried out at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F).

For the operating conditions that include rated working pressure and loading at rated temperature, an S_m value may be used equal to two-thirds of a de-rated material yield strength, S_e, at rated temperature. De-rated yield strength may be determined by one of the methods given in G.5.2.2 or G.5.2.3, except that De-rated strength for AM materials shall be established by the method given in G.5.2.2.

Elevated-temperature tensile strength shall be determined in the same manner as the elevated-temperature yield strength.

G.5.2.2 Testing at Elevated Temperature

G.5.2.2.1 QTC Testing

S_e at temperature shall be the minimum measured yield strength of the material tested at the rated temperature of the equipment. The room-temperature mechanical properties of the material shall equal or exceed the minimum requirements for the strength class of Table 9. The elevated-temperature tensile test(s) shall be performed on specimens removed from the required location within the same QTC used for room-temperature tensile testing. At least one elevated-temperature tensile test shall be performed at the rated temperature of the equipment, using the methods of ASTM E21 or equivalent methods.

If the elevated-temperature yield strength, E_{ty}, meets or exceeds the minimum specified room-temperature yield strength, S_{my}, of Table 9, then S_{my} may be used as S_e for the design. If the E_{ty} is less than the S_{my}, then a value no greater than E_{ty} shall be used as S_e for the design.

If the elevated-temperature test fails to meet the above requirements on the first attempt, two additional tensile tests may be performed to qualify the material. The results of each of these tests shall satisfy the required yield strength.

G.5.2.2.2 Material Grade Qualification Testing

S_e at temperature shall be minimum yield strength of the material strength class of Table 9, reduced by the amount of de-rating of yield strength at the elevated temperature compared to the measured yield strength at a temperature between 4 °C and 50 °C (between 40 °F and 120 °F).

Qualification testing shall be performed on a minimum of five heats of the material grade (same UNS alloy number or individual material composition and same heat-treat condition) for a particular strength class at elevated temperature and at room temperature. In addition, the room-temperature and elevated-temperature tensile specimens shall be obtained from the required location within the same QTC for a given heat. The yield strength values, E_{ty} and R_{ty}, shall each be averaged for use in determining the amount of yield de-rating at a particular temperature.

The yield reduction ratio at temperature, Y_r, shall be calculated as given in Equation (G.1):

$$Y_r = \frac{E_{ty}}{R_{ty}} \qquad \text{(G.1)}$$

where

R_{ty} is the room-temperature yield strength (measured, 5 heats minimum);

E_{ty} is the elevated-temperature yield strength (measured, 5 heats minimum).

The elevated-temperature yield strength, S_e, is then calculated as given in Equation (G.2):

$$S_e = Y_r \, S_y \qquad \text{(G.2)}$$

where

S_y is the minimum specified room-temperature yield strength for the material.

The elevated-temperature tensile data along with the room-temperature data for the material grade shall be contained in a material qualification file for each material grade, and it is not necessary that this test be performed on a heat lot basis.

G.5.2.3 Reference Sources

G.5.2.3.1 API 17TR8

Technical Report API 17TR8 provides guidance regarding HPHT applications that are beyond the scope of this specification.

G.5.2.3.2 API TR 6AF1

The material may be de-rated using the de-rating factors, Y_r, shown in Table G.3, which, in part, are taken from API 6AF1, Table 1.

Table G.3—Optional Material De-rating Factors for Elevated Temperature

Material	De-rating Factor, Y_r	
	180 °C (350 °F)	345 °C (650 °F)
Carbon and low-alloy steels	0.85	0.75
Martensitic, ferritic, and precipitation-hardened stainless steels	0.85	0.75
Austenitic and duplex stainless steels	0.80	0.73
Corrosion-resistant alloys (CRAs)	0.95	0.85

Caution—This table does not constitute a recommendation of the use of any specific alloy at high temperature. Some materials are embrittled after repeated or prolonged exposure to elevated temperatures. Care should be taken when choosing a material for use at temperatures permitted by temperature classes X and Y in Table G.1.

G.5.2.3.3 ASME *Boiler and Pressure Vessel Code*

S_e can be found for some materials in ASME *BPVC*:2004 with 2005 and 2006 addenda, Section II, Part D, Table Y-1.

G.5.2.3.4 Other Data

The material may be de-rated using the de-rating factors, Y_r, shown in Table G.4.

Table G.4—Optional Material De-rating Factors for Elevated Temperature

Material	De-rating Factor, Y_r		
	149 °C (300 °F)	177 °C (350 °F)	232 °C (450 °F)
25 Cr super duplex	0.81	0.78	0.73
ASTM 453/453M Gr 660D (UNS S66286)	0.97	0.96	0.94
718 (as per API 6ACRA) (UNS N07718)	0.94	0.93	0.91
925 (UNS N09925)	0.92	0.92	0.90
AISI 4130	0.91	0.90	0.88
AISI 8630 (Modified)	0.92	0.90	0.87
2-1/4 Cr 1 Mo (UNS K21590)	0.92	0.91	0.89
AISI 4140	0.92	0.90	0.88
AISI 410 SS (UNS S41000)	0.91	0.90	0.88
F6NM (UNS S42400)	0.92	0.91	0.88
725/625 Plus (UNS N07725 and UNS N07716)	0.93	0.92	0.89

FOOTNOTES

[a] Section size affects hardenability.

CAUTION—This table does not constitute a recommendation of the use of any specific alloy at high temperature. Some materials are embrittled after repeated or prolonged exposure to elevated temperatures. Care should be taken when choosing a material for use at temperatures permitted by temperature classes X and Y in Table G.1.

Annex H
(informative)

Recommended Assembly of Closure Bolting

H.1 Lubrication

H.1.1 Gasket Lubrication

Ring gaskets installed in 6B or 6BX flanged and studded connectors should be lightly lubricated prior to assembly. Appropriate lubricants include mineral-base oil (20 W or higher), synthetic motor oil (5W or higher) or a general-purpose grease suitable for high-pressure metal-to-metal application. Greases or thread compounds with metallic additives shall not be used. Lubricant, if applied, shall be applied as a thin film, never in sufficient amount to have any possibility of filling the grooves.

This is recommended to avoid galling of the gasket and/or ring groove mating seal surfaces and is particularly important for stainless steel or CRA ring grooves. The connections are designed to achieve a mechanical preload between the gasket OD seal surface and the outside flank of the groove on initial assembly. To ensure a reliable metal seal, the 6B and 6BX connector designs produce contact bearing stresses at the 23° mating surfaces that are many times higher than the rated working pressure.

As the flange bolting is made up, the narrow 23° gasket seal surfaces must slide along the 23° flanks of the grooves, under very high load. Without lubrication, this could cause damage to the seal surfaces. If the connection is disassembled and re-assembled for service, lubrication of the metal gasket for assembly is essential to allow repeated use of the equipment without repair of the ring grooves. Because of the high bearing stress, the film thickness of lubricant initially applied to the gasket is not critical.

H.1.2 Bolting Lubrication

To achieve the desired tensile preload in the studs, the stud threads and the bearing face of the nuts should be well lubricated. Paint thickness should be minimal (e.g. primer coat only) in the bearing areas of the flange back-face where the nuts contact it. Multipart coating systems have been known to creep over time under the high crushing loads of the nuts, resulting in leakage.

H.2 Bolt Tightening Pattern

Flange bolting shall be tightened gradually, repeatedly working around the bolt pattern in a “crisscross” or “star” pattern. As an alternative, multi-head tools may be used per the manufacturer’s procedures.

NOTE Examples of bolt make-up sequence are shown in Figure H.1 and in ASME PCC-1.

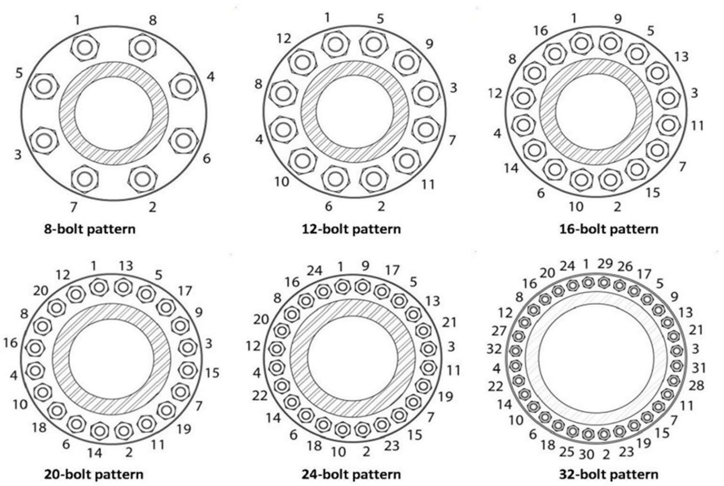


Figure H.1—Recommended Bolting Make-up Patterns

H.3 Recommended Make-up Torque

H.3.1 General Principles

It has been shown that the torque values given in Table H.1 and Table H.2 are acceptable values for use in type 6B and 6BX flanges in some applications.

NOTE Refer to API TR 6AF, API TR 6AF1, or API TR 6AF2 for data on the effects on flange performance of bolt preload stress and other factors.

It should be recognized that torque applied to a nut is only one of several ways to approximate the tension and stress in a fastener.

Table H.1 and Table H.2 are based on calculations that assume certain friction coefficients for the friction between the studs and nuts, and between the nuts and the flange face.

Some factors that affect the relationship between nut torque and stud stress are as follows:

— thread dimensions and form;

— surface finish of studs, nuts, and flange face;

— degree of parallelism between nut face and flange face;

— type of lubrication and coatings of the threads and nut bearing surface areas.

Table H.1—Recommended Torques for Flange Bolting (SI Units)

Stud Diameter	**Threads per in.**	**Studs with** S_y = 550 MPa **Bolt Stress Equal to** 275 MPa			**Studs with** S_y = 720 MPa **Bolt Stress Equal to** 360 MPa			**Studs with** S_y = 655 MPa **Bolt Stress Equal to** 327.5 MPa		
		Tension	**Torque**	**Torque**	**Tension**	**Torque**	**Torque**	**Tension**	**Torque**	**Torque**
D	N	F	f = 0.07	f = 0.13	F	f = 0.07	f = 0.13	F	f = 0.07	f = 0.13
in.	1/in.	kN	N-m	N-m	kN	N-m	N-m	kN	N-m	N-m
0.500	13	25	36	61	33	48	80	—	—	—
0.625	11	40	70	118	52	92	155	—	—	—
0.750	10	59	122	206	78	160	270	—	—	—
0.875	9	82	193	328	107	253	429	—	—	—
1.000	8	107	288	488	141	376	639	—	—	—
1.125	8	140	413	706	184	540	925	—	—	—
1.250	8	177	569	981	232	745	1285	—	—	—
1.375	8	219	761	1320	286	996	1727	—	—	—
1.500	8	265	991	1727	346	1297	2261	—	—	—
1.625	8	315	1263	2211	412	1653	2894	—	—	—
1.750	8	369	1581	2777	484	2069	3636	—	—	—
1.875	8	428	1947	3433	561	2549	4493	—	—	—
2.000	8	492	2366	4183	644	3097	5476	—	—	—
2.250	8	631	3375	5997	826	4418	7851	—	—	—
2.500	8	788	4635	8271	1032	6068	10,828	—	—	—
2.625	8	—	—	—	—	—	—	1040	6394	11,429
2.750	8	—	—	—	—	—	—	1146	7354	13,168
3.000	8	—	—	—	—	—	—	1375	9555	17,156
3.250	8	—	—	—	—	—	—	1624	12,154	21,878
3.750	8	—	—	—	—	—	—	2185	18,685	33,766
3.875	8	—	—	—	—	—	—	2338	20,620	37,293
4.000	8	—	—	—	—	—	—	2496	22,683	41,057

Table H.2—Recommended Torques for Flange Bolting (USC Units)

Stud Diameter	Threads per in.	Studs with S_y = 80 ksi Bolt Stress Equal to 40 ksi			Studs with S_y = 105 ksi Bolt Stress Equal to 52.5 ksi			Studs with S_y = 95 ksi Bolt Stress Equal to 47.5 ksi		
		Tension	Torque	Torque	Tension	Torque	Torque	Tension	Torque	Torque
D	N	F	f = 0.07	f = 0.13	F	f = 0.07	f = 0.13	F	f = 0.07	f = 0.13
in.	1/in.	lbf	ft-lbf	ft-lbf	lbf	ft-lbf	ft-lbf	lbf	ft-lbf	ft-lbf
0.500	13	5676	27	45	7,450	35	59	—	—	—
0.625	11	9040	52	88	11,865	68	115	—	—	—
0.750	10	13,378	90	153	17,559	118	200	—	—	—
0.875	9	18,469	143	243	24,241	188	319	—	—	—
1.000	8	24,230	213	361	31,802	279	474	—	—	—
1.125	8	31,618	305	523	41,499	401	686	—	—	—
1.250	8	39,988	421	726	52,484	553	953	—	—	—
1.375	8	49,340	563	976	64,759	739	1281	—	—	—
1.500	8	59,674	733	1278	78,322	962	1677	—	—	—
1.625	8	70,989	934	1635	93,173	1226	2146	—	—	—
1.750	8	83,286	1169	2054	109,313	1534	2696	—	—	—
1.875	8	96,565	1440	2539	126,741	1890	3332	—	—	—
2.000	8	110,825	1750	3094	145,458	2297	4061	—	—	—
2.250	8	142,292	2496	4436	186,758	3276	5822	—	—	—
2.500	8	177,685	3429	6118	233,212	4500	8030	—	—	—
2.625	8	—	—	—	—	—	—	233,765	4716	8430
2.750	8	—	—	—	—	—	—	257,694	5424	9712
3.000	8	—	—	—	—	—	—	309,050	7047	12,654
3.250	8	—	—	—	—	—	—	365,070	8965	16,136
3.750	8	—	—	—	—	—	—	491,099	13,782	24,905
3.875	8	—	—	—	—	—	—	525,521	15,208	27,506
4.000	8	—	—	—	—	—	—	561,108	16,730	30,282

Two coefficients of friction are used in the tables. A coefficient of friction of 0.13 approximates the friction with threads and nut bearing surfaces being bare metal, well lubricated. For applications above 260 °C (500 °F), lubrication shall not contain lead, tin, antimony or bismuth. A coefficient of friction of 0.07 approximates threads and nut face coated with fluoropolymer material.

Lubricants, surface finishes, etc., may influence the accuracy of the actual bolt tension when measuring torque. Therefore, the torque values listed in Table H.1 and Table H.2 are provided only as an informative guide. The torque and the make-up practices employed should be verified by the manufacturer.

The tables show material properties equivalent to ASTM A193/A193M grades B7 and B7M, which are the most commonly used. Values of torque for materials having other strength levels may be obtained by multiplying the tabulated torque value by the ratio of the new material's yield strength to the tabulated material's yield strength.

H.3.2 Equations

For the values in Table H.1 and Table H.2, the stress area, A_s, expressed in square millimeters (square inches), is calculated as given in Equation (H.1); the force per stud, F, expressed in newtons (pound-force), is calculated as given in Equation (H.2); the torque, τ, is calculated as given in Equation (H.3):

$$A_s = \tfrac{1}{4} \times \pi \, [D - (0.9743 \times P)]^2 \tag{H.1}$$

$$F = \sigma A_s \tag{H.2}$$

$$\tau = \frac{F \cdot E \left[P + \dfrac{\pi f \cdot E}{\cos(\pi/6)} \right]}{2 \left[\pi E - \dfrac{P \cdot f}{\cos(\pi/6)} \right]} + F \cdot f \left[\frac{H + D + K}{4} \right] \tag{H.3}$$

where

D is the thread major diameter, expressed in millimeters (inches);

E is the pitch diameter of thread, expressed in millimeters (inches);

f is the friction coefficient;

H is the hex size (nut), equal to 1.5 D + 3.175 mm (0.125 in.);

K is the nut internal chamfer, equal to 3.175 mm (0.125 in.);

P is the thread pitch, equal to $\dfrac{1}{\text{number of threads per unit length}}$, expressed in millimeters (inches);

σ is the stress in the stud/bolt.

The torque obtained using units of millimeters and newtons is in units of newton-millimeters and is divided by 1000 to obtain newton-meters (N-m). The torque obtained using units of inches and pounds is in units of inches-pound-force and is divided by 12 to obtain foot-pound-force (ft-lbf).

H.3.3 Recommendation for Specific Flanges

The following flanges should not be assembled with a make-up torque that would produce a bolt stress greater than 275 MPa (40,000 psi):

— $13^5/_8$ in.: 13.8 MPa (2000 psi);

— $16^3/_4$ in.: 13.8 MPa (2000 psi);

— $21^1/_4$ in.: 13.8 MPa (2000 psi);

— $13^5/_8$ in.: 20.7 MPa (3000 psi).

Annex I
(informative)

Recommended Bolt Lengths

I.1 Calculation

I.1.1 General

NOTE 1 Closure bolting for studded connections can be of tap end type or all thread type.

NOTE 2 Figure I.1 and Figure I.2 are provided for illustration of flange bolting and studded bolting configurations, respectively.

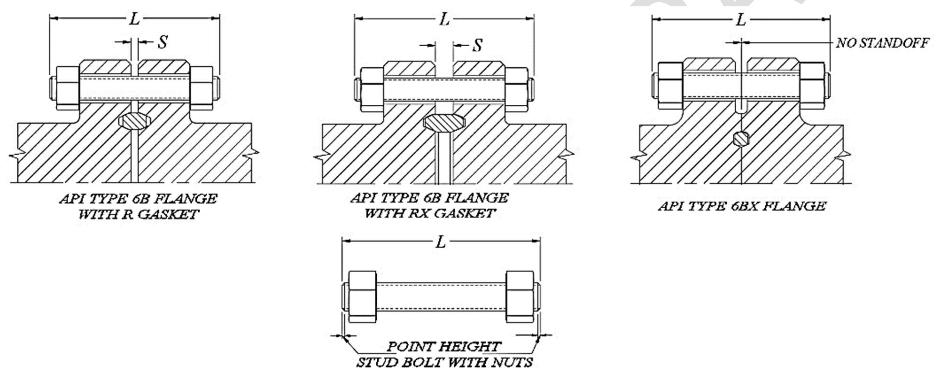


Figure I.1—Flange Bolting Configurations

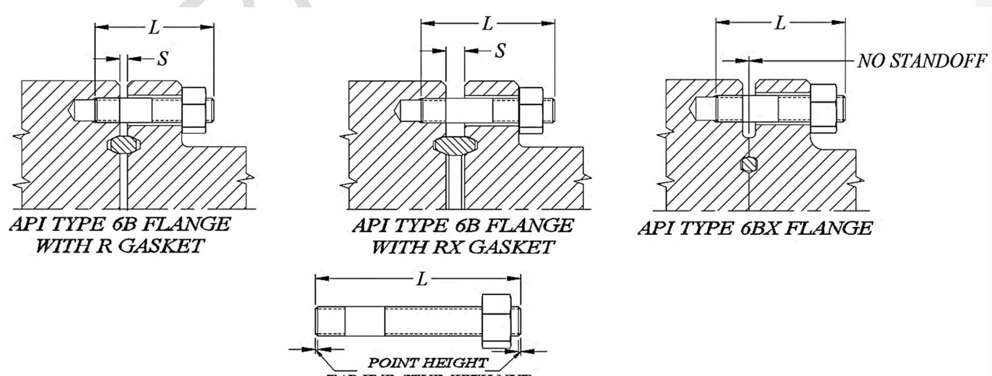


Figure I.2—Studded Bolting Configurations

Equation (I.1) is used in establishing stud bolt lengths listed in Table I.1 and Table I.2 and is included here for the convenience of industry. Length shown in tables results from rounding as specified in I.1.2.

$$L = 2(T + t + d) + S + 2(P) \quad (I.1)$$

where

L is calculated stud bolt length;

T is total flange thickness;

t is plus tolerance for flange thickness;

d is heavy hex nut thickness (equals nominal bolt diameter; see ASME B18.2.2);

S is flange face standoff; $S = 0$ for BX assemblies [see Table D.9 (gasket)/Table E.9 (gasket)—Type R and Table D.10 (gasket)/Table E.10 (gasket)—Type RX];

P is maximum end point height (1.5 x pitch of thread).

I.1.2 Rounding Procedure

0.010 in. (or more) greater than any 1/4 in. increment, round upward to the next 1/4 in. increment; if less than 0.010 in., round downward to the next 1/4 in. increment.

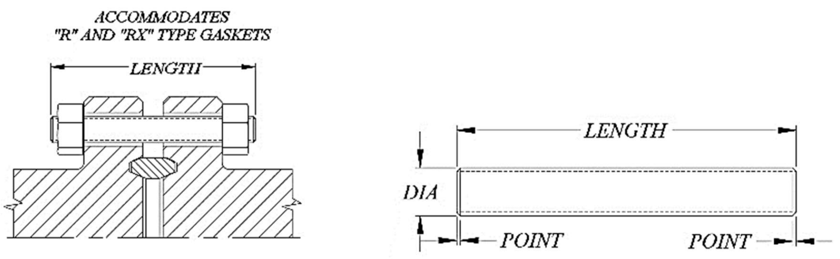
I.1.3 End Point-height of Stud Bolts

The end point is the end portion of a stud bolt beyond the complete thread and may be chamfered, rounded, or sheared. The maximum height of each end point shall be 1.5 x pitch of thread.

I.1.4 Flange Face Standoff Values, *S*

The approximate distance between faces of made-up flanges, S (see Figure I.1) is given in Table D.9/Table E.9—Type R gasket and Table D.10/Table E.10—Type RX gasket.

Table I.1—Stud Bolt Length Table for 6B Flange Connectors with "R" and "RX" Gaskets



LENGTH = 2(T + t + d) + S + 2(P)

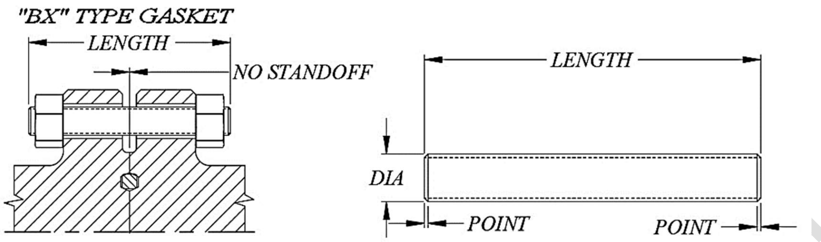
T is total flange thickness;
t is plus tolerance for flange thickness;
d is heavy hex nut thickness;
S is flange face standoff (with "RX" gasket);
P is point max. (1.5 x pitch).

Dimensions in inches

Flange Size and Pressure	Bolt Size and Thread	Length*	Flange Size and Pressure	Bolt Size and Thread	Length*
$2^1/_{16}$ 2000	$^5/_8$-11 UNC	5.000	$7^1/_{16}$ 2000	1-8 UNC	7.500
$2^1/_{16}$ 3000	$^7/_8$-9 UNC	6.500	$7^1/_{16}$ 3000	$1^1/_8$-8 UN	8.500
$2^1/_{16}$ 5000	$^7/_8$-9 UNC	6.500	$7^1/_{16}$ 5000	$1^3/_8$-8 UN	11.250
$2^9/_{16}$ 2000	$^3/_4$-10 UNC	5.500	9 2000	$1^1/_8$-8 UN	8.500
$2^9/_{16}$ 3000	1-8 UNC	7.000	9 3000	$1^3/_8$-8 UN	9.500
$2^9/_{16}$ 5000	1-8 UNC	7.000	9 5000	$1^5/_8$-8 UN	12.500
$3^1/_8$ 2000	$^3/_4$-10 UNC	5.750	11 2000	$1^1/_4$-8 UN	9.250
$3^1/_8$ 3000	$^7/_8$-9 UNC	6.500	11 3000	$1^3/_8$-8 UN	10.000
$3^1/_8$ 5000	$1^1/_8$-8 UN	7.750	11 5000	$1^7/_8$-8 UN	14.250
$4^1/_{16}$ 2000	$^7/_8$-9 UNC	6.500	$13^5/_8$ 2000	$1^1/_4$-8 UN	9.500
$4^1/_{16}$ 3000	$1^1/_8$-8 UN	7.500	$13^5/_8$ 3000	$1^3/_8$-8 UN	10.750
$4^1/_{16}$ 5000	$1^1/_4$-8 UN	8.500	$16^3/_4$ 2000	$1^1/_2$-8 UN	10.750
$5^1/_8$ 2000	1-8 UNC	7.250	$16^3/_4$ 3000	$1^5/_8$-8 UN	12.250
$5^1/_8$ 3000	$1^1/_4$-8 UN	8.250	$21^1/_4$ 2000	$1^5/_8$-8 UN	12.250
$5^1/_8$ 5000	$1^1/_2$-8 UN	10.500	$20^3/_4$ 3000	2-8 UN	15.000

FOOTNOTES
* Tolerance on bolt length:
+0.125/−0 in. for lengths up to 12 in.
+0.250/−0 in. for lengths over 12 in.

Table I.2—Stud Bolt Length Table for 6BX Flange Connectors



LENGTH = 2(T + t + d) + S + 2(P)

T is total flange thickness;
t is plus tolerance for flange thickness;
d is heavy hex nut thickness;
S is flange face standoff (NOTE S = 0 for BX connection which has no standoff height);
P is point max. (1.5 x pitch).

Dimensions in inches

Flange Size and Pressure		Bolt Size and Thread	Length*	Flange Size and Pressure		Bolt Size and Thread	Length*
$1^{13}/_{16}$	10,000	$^{3}/_{4}$-10 UNC	5.500	9	10,000	$1^{1}/_{2}$-8 UN	13.500
$1^{13}/_{16}$	15,000	$^{7}/_{8}$-9 UNC	6.000	9	15,000	$1^{7}/_{8}$-8 UN	16.000
$1^{13}/_{16}$	20,000	1-8 UNC	7.750	9	20,000	$2^{1}/_{2}$-8UN	21.750
$2^{1}/_{16}$	10,000	$^{3}/_{4}$-10 UNC	5.500	11	10,000	$1^{3}/_{4}$-8 UN	15.250
$2^{1}/_{16}$	15,000	$^{7}/_{8}$-9 UNC	6.500	11	15,000	2-8 UN	19.500
$2^{1}/_{16}$	20,000	$1^{1}/_{8}$-8 UN	8.500	11	20,000	$2^{3}/_{4}$-8 UN	23.750
$2^{9}/_{16}$	10,000	$^{7}/_{8}$-9 UNC	6.500	$13^{5}/_{8}$	5000	$1^{5}/_{8}$-8 UN	12.750
$2^{9}/_{16}$	15,000	1-8 UN	7.250	$13^{5}/_{8}$	10,000	$1^{7}/_{8}$-8 UN	17.750
$2^{9}/_{16}$	20,000	$1^{1}/_{4}$-8 UN	9.500	$13^{5}/_{8}$	15,000	$2^{1}/_{4}$-8 UN	21.250
$3^{1}/_{16}$	10,000	1-8 UNC	7.250	$13^{5}/_{8}$	20,000	3-8 UN	29.750
$3^{1}/_{16}$	15,000	$1^{1}/_{8}$-8 UN	8.000	$16^{3}/_{4}$	5000	$1^{7}/_{8}$-8 UN	14.750
$3^{1}/_{16}$	20,000	$1^{3}/_{8}$-8 UN	10.250	$16^{3}/_{4}$	10,000	$1^{7}/_{8}$-8 UN	17.750
$4^{1}/_{16}$	10,000	$1^{1}/_{8}$-8 UN	8.500	$18^{3}/_{4}$	5000	2-8 UN	17.750
$4^{1}/_{16}$	15,000	$1^{3}/_{8}$-8 UN	9.750	$18^{3}/_{4}$	10,000	$2^{1}/_{4}$-8 UN	22.750
$4^{1}/_{16}$	20,000	$1^{3}/_{4}$-8UN	12.500	$18^{3}/_{4}$	15,000	3-8 UN	26.750
$5^{1}/_{8}$	10,000	$1^{1}/_{8}$-8 UN	9.250	$21^{1}/_{4}$	5000	2-8 UN	19.000
$5^{1}/_{8}$	15,000	$1^{1}/_{2}$-8 UN	11.500	$21^{1}/_{4}$	10,000	$2^{1}/_{2}$-8 UN	24.750
$5^{1}/_{8}$	20,000	$1^{1}/_{2}$-8 UN	13.750	$26^{3}/_{4}$	2000	$1^{3}/_{4}$-8 UN	14.250
$7^{1}/_{16}$	10,000	$1^{1}/_{2}$-8 UN	11.750	$26^{3}/_{4}$	3000	2-8 UN	17.500
$7^{1}/_{16}$	15,000	$1^{1}/_{2}$-8 UN	13.000	30	2000	$1^{5}/_{8}$-8 UN	14.500
$7^{1}/_{16}$	20,000	2-8 UN	17.750	30	3000	$1^{7}/_{8}$-8 UN	17.750

FOOTNOTES
* Tolerance on bolt length:
+0.125/−0 in. for lengths up to 12 in.
+0.250/−0 in. for lengths over 12 in.

I.2 Method of Calculating Tap End Stud Lengths for Type 6B and 6BX Flanges

I.2.1 Calculation

Equation (I.2) is used in establishing tap end stud lengths listed in Table I.3, Table I.4, Table I.5, and Table I.6 and is included here for convenience of industry. Length shown in tables results from rounding as specified in I.2.2.

$$L = T + t + d + S + P + \text{TL} + \text{RF} \quad \text{(I.2)}$$

where

L is calculated tap end stud length;

T is total flange thickness;

t is plus tolerance for flange thickness;

d is heavy hex nut thickness (equals nominal bolt diameter; see ASME B18.2.2);

S is flange face standoff; S = 0 for BX assemblies [see Table D.8 (groove)/Table E.8 (groove) and Table D.9 (gasket)/Table E.9 (gasket)—Type R and Table D.10 (gasket)/Table E.10 (gasket)—Type RX];

P is maximum end point height (1.5 x pitch of thread);

TL is tap end thread length, maximum [(one diameter + 1.5 pitch) + $^1/_{16}$];

RF add amount of raised face present on studded flanges, if not omitted, to the length of studs in table.

I.2.2 Rounding off Procedure

Add $^1/_{16}$ in. to the calculated length and then round up to the next $^1/_8$ in. increment after this addition. This rounding procedure allows for variation in stud installation methods and ensures sufficient extension for full nut engagement.

I.2.3 Endpoint Height of Tap End Studs

The endpoint is the end portion of a stud bolt beyond the complete thread and may be chamfered, rounded, or sheared. The maximum height of each endpoint shall be 1.5 x pitch of thread.

I.2.4 Tap End Thread Length

One diameter of tap end stud + 1.5 pitch of thread, with a tolerance of +$^1/_{16}$/−0 (this includes point height).

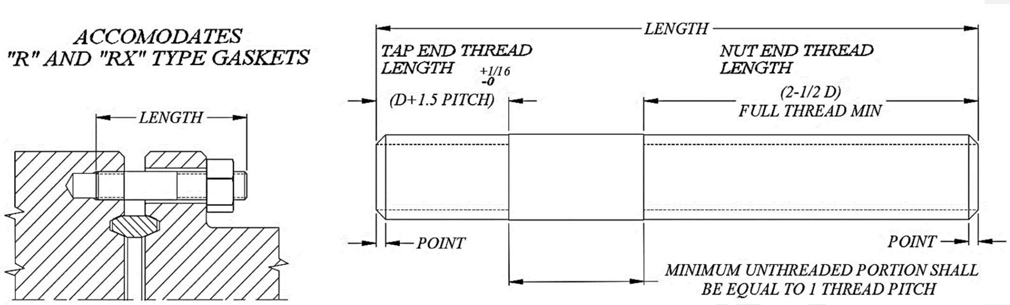
I.2.5 Nut End Thread Length

2.5 x diameter of tap end stud minimum. However, if necessary, this length shall be limited to provide minimum unthreaded portion equal to one thread pitch between the tap end threads and nut end threads.

I.2.6 Flange Face Standoff Values, *S*

The approximate distance between faces of made-up flanges, S (see Figure I.2) is given in Table D.9/Table E.9—Type R gasket and Table D.10/Table E.10—Type RX gasket.

Table I.3—Tap End Stud Length Table for 6B Studded Flange Connectors with “R” and “RX” Gaskets



LENGTH = $T + t + d + S + P$ + TL + RF

T is total flange thickness;

t is plus tolerance for flange thickness;

d is heavy hex nut thickness;

S is flange face standoff (with “RX” gasket);

P is point, max. (1.5 x pitch);

TL is tap end thread length, max. [(one diameter + 1.5 pitch) + $^{1}/_{16}$];

RF add amount of raised face present on studded flanges, if not omitted, to the length of studs in table.

Dimensions in inches

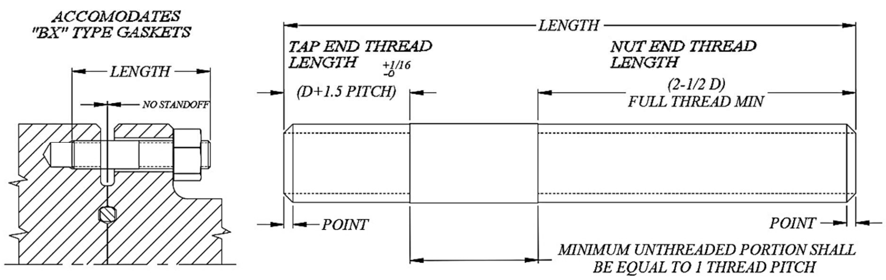
Flange Size and Pressure	Bolt Size and Thread	Tap End Length*	Nut End Length	Length**	Flange Size and Pressure	Bolt Size and Thread	Tap End Length*	Nut End Length	Length**
$2^{1}/_{16}$ 2000	$^{5}/_{8}$-11 UNC	0.761	1.563	3.625	$7^{1}/_{16}$ 2000	1-8 UNC	1.188	2.500	5.375
$2^{1}/_{16}$ 3000	$^{7}/_{8}$-9 UNC	1.042	2.188	4.625	$7^{1}/_{16}$ 3000	$1^{1}/_{8}$-8 UN	1.313	2.813	5.875
$2^{1}/_{16}$ 5000	$^{7}/_{8}$-9 UNC	1.042	2.188	4.625	$7^{1}/_{16}$ 5000	$1^{3}/_{8}$-8 UN	1.563	3.438	7.500
$2^{9}/_{16}$ 2000	$^{3}/_{4}$-10 UNC	0.900	1.875	4.000	9 2000	$1^{1}/_{8}$-8 UN	1.313	2.813	5.875
$2^{9}/_{16}$ 3000	1-8 UNC	1.188	2.500	5.125	9 3000	$1^{3}/_{8}$-8 UN	1.563	3.438	6.750
$2^{9}/_{16}$ 5000	1-8 UNC	1.188	2.500	5.125	9 5000	$1^{5}/_{8}$-8 UN	1.813	4.063	8.500
$3^{1}/_{8}$ 2000	$^{3}/_{4}$-10 UNC	0.900	1.875	4.125	11 2000	$1^{1}/_{4}$-8 UN	1.438	3.125	6.500
$3^{1}/_{8}$ 3000	$^{7}/_{8}$-9 UNC	1.042	2.188	4.625	11 3000	$1^{3}/_{8}$-8 UN	1.563	3.438	7.000
$3^{1}/_{8}$ 5000	$1^{1}/_{8}$-8 UN	1.313	2.813	5.625	11 5000	$1^{7}/_{8}$-8 UN	2.063	4.688	9.625
$4^{1}/_{16}$ 2000	$^{7}/_{8}$-9 UNC	1.042	2.188	4.625	$13^{5}/_{8}$ 2000	$1^{1}/_{4}$-8 UN	1.438	3.125	6.625
$4^{1}/_{16}$ 3000	$1^{1}/_{8}$-8 UN	1.313	2.813	5.500	$13^{5}/_{8}$ 3000	$1^{3}/_{8}$-8 UN	1.563	3.438	7.375
$4^{1}/_{16}$ 5000	$1^{1}/_{4}$-8 UN	1.438	3.125	6.125	$16^{3}/_{4}$ 2000	$1^{1}/_{2}$-8 UN	1.688	3.750	7.500
$5^{1}/_{8}$ 2000	1-8 UNC	1.188	2.500	5.250	$16^{3}/_{4}$ 3000	$1^{5}/_{8}$-8 UN	1.813	4.063	8.375
$5^{1}/_{8}$ 3000	$1^{1}/_{4}$-8 UN	1.438	3.125	6.000	$21^{1}/_{4}$ 2000	$1^{5}/_{8}$-8 UN	1.813	4.063	8.375
$5^{1}/_{8}$ 5000	$1^{1}/_{2}$-8 UN	1.688	3.750	7.375	$20^{3}/_{4}$ 3000	2-8 UN	2.188	5.000	10.125

FOOTNOTES

* Tolerance on tap end thread length: +0.063/−0 in.

** Tolerance on tap end stud length: +0.125/−0 in.

Table I.4—Tap End Stud Length Table for 6BX Studded Flange Connectors



LENGTH = $T + t + d + S + P$ + TL + RF

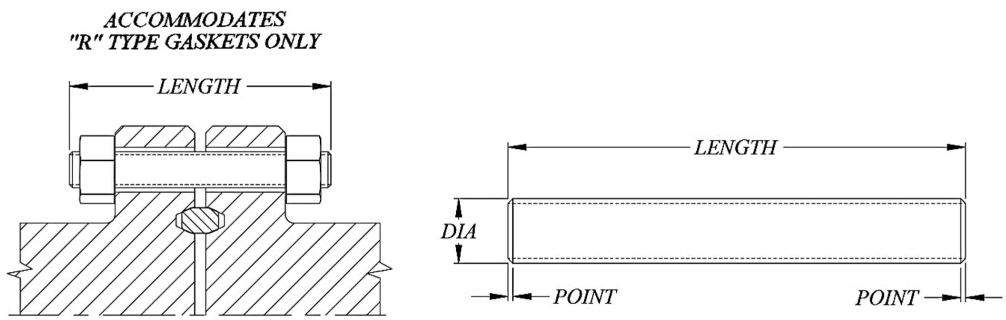
T is total flange thickness;
t is plus tolerance for flange thickness;
d is heavy hex nut thickness;
S is flange face standoff;
P is point, max. (1.5 x pitch);
TL is tap end thread length, max. [(one diameter + 1.5 pitch) + $^{1}/_{16}$];
RF add amount of raised face present on studded flanges, if not omitted, to the length of studs in table.

Dimensions in inches

Flange Size and Pressure	Bolt Size and Thread	Tap End Length*	Nut End Length	Length**	Flange Size and Pressure	Bolt Size and Thread	Tap End Length*	Nut End Length	Length**
$1^{13}/_{16}$ 10,000	$^{3}/_{4}$-10 UNC	0.900	1.875	3.750	9 10,000	$1^{1}/_{2}$-8 UN	1.688	3.750	8.500
$1^{13}/_{16}$ 15,000	$^{7}/_{8}$-9 UNC	1.042	2.188	4.125	9 15,000	$1^{7}/_{8}$-8 UN	2.063	4.688	10.125
$1^{13}/_{16}$ 20,000	1-8 UNC	1.188	2.500	5.125	9 20,000	$2^{1}/_{2}$-8 UN	2.688	6.250	13.750
$2^{1}/_{16}$ 10,000	$^{3}/_{4}$-10 UNC	0.900	1.875	3.875	11 10,000	$1^{3}/_{4}$-8 UN	1.938	4.375	9.750
$2^{1}/_{16}$ 15,000	$^{7}/_{8}$-9 UNC	1.042	2.188	4.375	11 15,000	2-8 UN	2.188	5.000	12.000
$2^{1}/_{16}$ 20,000	$1^{1}/_{8}$-8 UN	1.313	2.813	5.750	11 20,000	$2^{3}/_{4}$-8 UN	2.938	6.875	15.000
$2^{9}/_{16}$ 10,000	$^{7}/_{8}$-9 UNC	1.042	2.188	4.375	$13^{5}/_{8}$ 5000	$1^{5}/_{8}$-8 UN	1.813	4.063	8.375
$2^{9}/_{16}$ 15,000	1-8 UNC	1.188	2.500	4.875	$13^{5}/_{8}$ 10,000	$1^{7}/_{8}$-8 UN	2.063	4.688	11.000
$2^{9}/_{16}$ 20,000	$1^{1}/_{4}$-8 UN	1.438	3.125	6.250	$13^{5}/_{8}$ 15,000	$2^{1}/_{4}$-8 UN	2.438	5.625	13.250
$3^{1}/_{16}$ 10,000	1-8 UNC	1.188	2.500	5.000	$13^{5}/_{8}$ 20,000	3-8 UN	3.188	7.500	18.125
$3^{1}/_{16}$ 15,000	$1^{1}/_{8}$-8 UN	1.313	2.813	5.500	$16^{3}/_{4}$ 5000	$1^{7}/_{8}$-8 UN	2.063	4.688	9.500
$3^{1}/_{16}$ 20,000	$1^{3}/_{8}$-8 UN	1.563	3.438	6.750	$16^{3}/_{4}$ 10,000	$1^{7}/_{8}$-8 UN	2.063	4.688	11.000
$4^{1}/_{16}$ 10,000	$1^{1}/_{8}$-8 UN	1.313	2.813	5.750	$18^{3}/_{4}$ 5000	2-8 UN	2.188	5.000	11.250
$4^{1}/_{16}$ 15,000	$1^{3}/_{8}$-8 UN	1.563	3.438	6.500	$18^{3}/_{4}$ 10,000	$2^{1}/_{4}$-8 UN	2.438	5.625	14.000
$4^{1}/_{16}$ 20,000	$1^{3}/_{4}$-8 UN	1.938	4.375	8.375	$18^{3}/_{4}$ 15,000	3-8 UN	3.188	7.500	16.750
$5^{1}/_{8}$ 10,000	$1^{1}/_{8}$-8 UN	1.313	2.813	6.000	$21^{1}/_{4}$ 5000	2-8 UN	2.188	5.000	11.750
$5^{1}/_{8}$ 15,000	$1^{1}/_{2}$-8 UN	1.688	3.750	7.625	$21^{1}/_{4}$ 10,000	$2^{1}/_{2}$-8 UN	2.688	6.250	15.125
$5^{1}/_{8}$ 20,000	$1^{1}/_{2}$-8 UN	1.688	3.750	8.625	$26^{3}/_{4}$ 2000	$1^{3}/_{4}$-8 UN	1.938	4.375	9.125
$7^{1}/_{16}$ 10,000	$1^{1}/_{2}$-8 UN	1.688	3.750	7.750	$26^{3}/_{4}$ 3000	2-8 UN	2.188	5.000	11.000
$7^{1}/_{16}$ 15,000	$1^{1}/_{2}$-8 UN	1.688	3.750	8.375	30 2000	15/8-8 UN	1.813	4.063	9.250
$7^{1}/_{16}$ 20,000	2-8 UN	2.188	5.000	11.125	30 3000	17/8-8 UN	2.063	4.688	11.000

FOOTNOTES
* Tolerance on tap end thread length: + 0.063/−0 in.
** Tolerance on tap end stud length: + 0.125/−0 in.

Table I.5—Stud Bolt Length Table for 6B Flange Connectors with “R” Gaskets (USC Units)



LENGTH = 2(T + t + d) + S + 2(P)

T is total flange thickness;

t is plus tolerance for flange thickness;

d is heavy hex nut thickness;

S is flange face standoff (with “R” gasket);

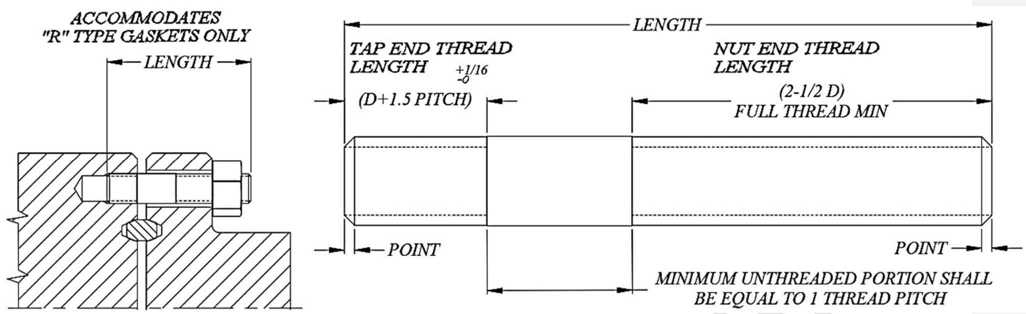
P is point max. (1.5 x pitch).

Dimensions in inches

Flange Size and Pressure		Bolt Size and Thread	Length*	Flange Size and Pressure		Bolt Size and Thread	Length*
$2^{1}/_{16}$	2000	$^{5}/_{8}$-11 UNC	4.750	$7^{1}/_{16}$	2000	1-8 UNC	7.250
$2^{1}/_{16}$	3000	$^{7}/_{8}$-9 UNC	6.250	$7^{1}/_{16}$	3000	$1^{1}/_{8}$-8 UN	8.250
$2^{1}/_{16}$	5000	$^{7}/_{8}$-9 UNC	6.250	$7^{1}/_{16}$	5000	$1^{3}/_{8}$-8 UN	11.000
$2^{9}/_{16}$	2000	$^{3}/_{4}$-10 UNC	5.250	9	2000	$1^{1}/_{8}$-8 UN	8.250
$2^{9}/_{16}$	3000	1-8 UNC	6.750	9	3000	$1^{3}/_{8}$-8 UN	9.250
$2^{9}/_{16}$	5000	1-8 UNC	6.750	9	5000	$1^{5}/_{8}$-8 UN	12.250
$3^{1}/_{8}$	2000	$^{3}/_{4}$-10 UNC	5.500	11	2000	$1^{1}/_{4}$-8 UN	9.000
$3^{1}/_{8}$	3000	$^{7}/_{8}$-9 UNC	6.250	11	3000	$1^{3}/_{8}$-8 UN	9.750
$3^{1}/_{8}$	5000	$1^{1}/_{8}$-8 UN	7.500	11	5000	$1^{7}/_{8}$-8 UN	14.000
$4^{1}/_{16}$	2000	$^{7}/_{8}$-9 UNC	6.250	$13^{5}/_{8}$	2000	$1^{1}/_{4}$-8 UN	9.250
$4^{1}/_{16}$	3000	$1^{1}/_{8}$-8 UN	7.250	$13^{5}/_{8}$	3000	$1^{3}/_{8}$-8 UN	10.500
$4^{1}/_{16}$	5000	$1^{1}/_{4}$-8 UN	8.250	$16^{3}/_{4}$	2000	$1^{1}/_{2}$-8 UN	10.500
$5^{1}/_{8}$	2000	1-8 UNC	7.000	$16^{3}/_{4}$	3000	$1^{5}/_{8}$-8 UN	12.000
$5^{1}/_{8}$	3000	$1^{1}/_{4}$-8 UN	8.000	$21^{1}/_{4}$	2000	$1^{5}/_{8}$-8 UN	11.750
$5^{1}/_{8}$	5000	$1^{1}/_{2}$-8 UN	10.250	$20^{3}/_{4}$	3000	2-8 UN	14.500

FOOTNOTES
* Tolerance on bolt length:
+0.125, −0 in. for lengths up to 12 in.
+0.250, −0 in. for lengths over 12 in.

Table I.6—Tap End Stud Length Table for 6B Studded Flange Connectors with "R" Gaskets



LENGTH = $T + t + d + S + P$ + TL + RF

- T is total flange thickness;
- t is plus tolerance for flange thickness;
- d is heavy hex nut thickness;
- S is flange face standoff (with "R" gasket);
- P is point, max. (1.5 x pitch);
- TL is tap end thread length, max. [(one diameter + 1.5 pitch) + $^{1}/_{16}$];
- RF add amount of raised face present on studded flanges, if not omitted, to the length of studs in table.

Dimensions in inches

Flange Size and Pressure	Bolt Size and Thread	Tap End Length*	Nut End Length	Length**	Flange Size and Pressure	Bolt Size and Thread	Tap End Length*	Nut End Length	Length**
$2^{1}/_{16}$ 2000	$^{5}/_{8}$-11 UNC	0.761	1.563	3.375	$7^{1}/_{16}$ 2000	1-8 UNC	1.188	2.500	5.000
$2^{1}/_{16}$ 3000	$^{7}/_{8}$-9 UNC	1.042	2.188	4.375	$7^{1}/_{16}$ 3000	$1^{1}/_{8}$-8 UN	1.313	2.813	5.625
$2^{1}/_{16}$ 5000	$^{7}/_{8}$-9 UNC	1.042	2.188	4.375	$7^{1}/_{16}$ 5000	$1^{3}/_{8}$-8 UN	1.563	3.438	7.250
$2^{9}/_{16}$ 2000	$^{3}/_{4}$-10 UNC	0.900	1.875	3.750	9 2000	$1^{1}/_{8}$-8 UN	1.313	2.813	5.625
$2^{9}/_{16}$ 3000	1-8 UNC	1.188	2.500	4.750	9 3000	$1^{3}/_{8}$-8 UN	1.563	3.438	6.375
$2^{9}/_{16}$ 5000	1-8 UNC	1.188	2.500	4.750	9 5000	$1^{5}/_{8}$-8 UN	1.813	4.063	8.125
$3^{1}/_{8}$ 2000	$^{3}/_{4}$-10 UNC	0.900	1.875	3.875	11 2000	$1^{1}/_{4}$-8 UN	1.438	3.125	6.125
$3^{1}/_{8}$ 3000	$^{7}/_{8}$-9 UNC	1.042	2.188	4.375	11 3000	$1^{3}/_{8}$-8 UN	1.563	3.438	6.625
$3^{1}/_{8}$ 5000	$1^{1}/_{8}$-8 UN	1.313	2.813	5.250	11 5000	$1^{7}/_{8}$-8 UN	2.063	4.688	9.250
$4^{1}/_{16}$ 2000	$^{7}/_{8}$-9 UNC	1.042	2.188	4.375	$13^{5}/_{8}$ 2000	$1^{1}/_{4}$-8 UN	1.438	3.125	6.250
$4^{1}/_{16}$ 3000	$1^{1}/_{8}$-8 UN	1.313	2.813	5.125	$13^{5}/_{8}$ 3000	$1^{3}/_{8}$-8 UN	1.563	3.438	7.000
$4^{1}/_{16}$ 5000	$1^{1}/_{4}$-8 UN	1.438	3.125	5.750	$16^{3}/_{4}$ 2000	$1^{1}/_{2}$-8 UN	1.688	3.750	7.125
$5^{1}/_{8}$ 2000	1-8 UNC	1.188	2.500	4.875	$16^{3}/_{4}$ 3000	$1^{5}/_{8}$-8 UN	1.813	4.063	8.000
$5^{1}/_{8}$ 3000	$1^{1}/_{4}$-8 UN	1.438	3.125	5.625	$21^{1}/_{4}$ 2000	$1^{5}/_{8}$-8 UN	1.813	4.063	8.000
$5^{1}/_{8}$ 5000	$1^{1}/_{2}$-8 UN	1.688	3.750	7.000	$20^{3}/_{4}$ 3000	2-8 UN	2.188	5.000	9.625

FOOTNOTES

* Tolerance on tap end thread length: +0.063/−0 in.

** Tolerance on tap end stud length; +0.125/−0 in.

Annex J
(normative)

Weld-neck Flanges

J.1 General

J.1.1 Application

There shall be two applications of weld-neck flanges as follows.

— Standard: Weld-neck flanges designed and manufactured to be welded to equipment covered by this specification, with or without additional machining, to meet the requirements of 14.1 for integral flanges when completed.

— Nonstandard: Weld-neck flanges designed and manufactured to be welded to piping or other parts or components not covered by this specification.

J.1.2 Type and Pressure Rating

There shall be two types of weld-neck flanges.

— Type 6B weld-neck flanges shall be designed and manufactured such that they can be bolted to a matching 6B flanged or studded connector with a rated working pressure of 13.8 MPa, 20.7 MPa, or 34.5 MPa (2000 psi, 3000 psi, or 5000 psi).

— Type 6BX weld-neck flanges shall be designed and manufactured such that they can be bolted to a matching 6BX flanged or studded connector with a rated working pressure of 69.0 MPa, 103.5 MPa, or 138.0 MPa (10,000 psi, 15,000 psi, or 20,000 psi).

J.1.3 Marking

NOTE See Table 39 for marking of weld-neck flanges as applicable.

J.2 Design

J.2.1 Design Responsibility

NOTE A loose weld-neck flange has two distinct sections as shown in Figure J.1, a flange (rim) section and a hub (neck) section.

The following shall apply.

— Design of the flange section in the finished state as an integral flange shall be fully established by the requirements in part 14.1.

— Design of the hub section shall be the responsibility of the manufacturer.

Dimensions in inches (millimeters)

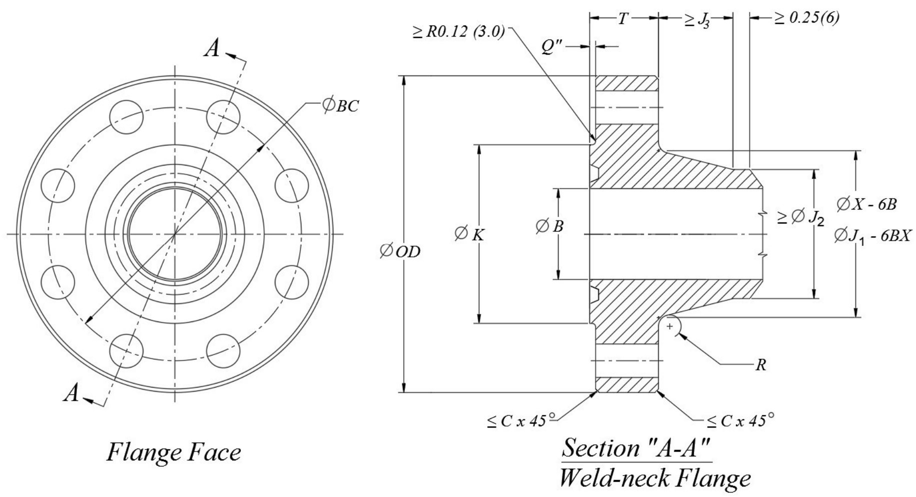


Figure J.1—Weld-neck Flange Dimensions

J.2.2 Flange Dimensions

Dimensions of the weld-neck flange section shall conform to Table D.1/Table E.1, Table D.2/Table E.2, Table D.3/Table E.3, Table D.4/Table E.4, Table D.5/Table E.5, Table D.6/Table E.6 or Table D.7/Table E.7 for the following from Figure J.1:

B is maximum bore diameter;

OD is outside diameter of flange;

C is chamfers (2) on flange OD;

K is raised face diameter (if applicable);

T is total thickness of flange;

BC is bolt circle diameter;

N is number of bolt holes;

BH is diameter of bolt holes;

Q is height of raised face (if applicable).

J.2.3 Hub Dimensions

J.2.3.1 Hub Dimensions for Standard Applications

For weld-neck flanges that are welded to a body or a piece of equipment and subsequently completed as integral flanges, dimensions of the hub section should conform to Table D.1/Table E.1, Table D.2/Table E.2, Table D.3/Table E.3, Table D.4/Table E.4, Table D.5/Table E.5, Table D.6/Table E.6 or Table D.7/Table E.7 for the following from Figure J.1:

X is hub diameter (at flange), 6B flanges;

J_1 is hub diameter (at flange), 6BX flanges;

J_2 is reduced (optional) hub diameter for 6BX flanges;

J_3 is minimum length of optional taper from J_1 to J_2 for 6BX flanges;

R is fillet radius (between hub section and flange section).

NOTE The taper dimensions J_2 and J_3 are minimum values; a more gradual taper or a straight hub diameter of J_1 is permitted.

For Type 6BX flanges, hub dimensions beyond the J_3 length shall be established by the manufacturer in conformance with Section 5.

For Type 6B flanges, hub dimensions beyond the radius, R, at diameter X shall be established by the manufacturer in conformance with Section 5.

Hub dimensions on equipment for which reduced bores are permitted (for example, chokes, check valves) shall be established by the manufacturer in conformance with Section 5.

J.2.3.2 Hub Dimensions for Nonstandard Applications

For weld-neck flanges designed to be welded to piping or other types of equipment outside the scope of this specification, hub dimensions shall be established by the manufacturer in conformance with Section 5 or other design standard that is applicable to the equipment.

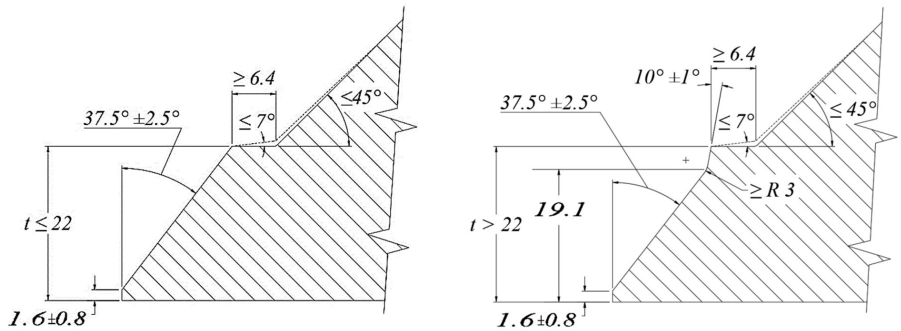
If the nominal bore of the welding end is smaller than the nominal bore of the pipe by a difference of 4.8 mm (0.18 in.) or more, the flange shall be taper bored from the weld end at a slope not exceeding 3 to 1. However, requirements for minimum wall thickness shall apply.

J.2.4 Weld End Preparation

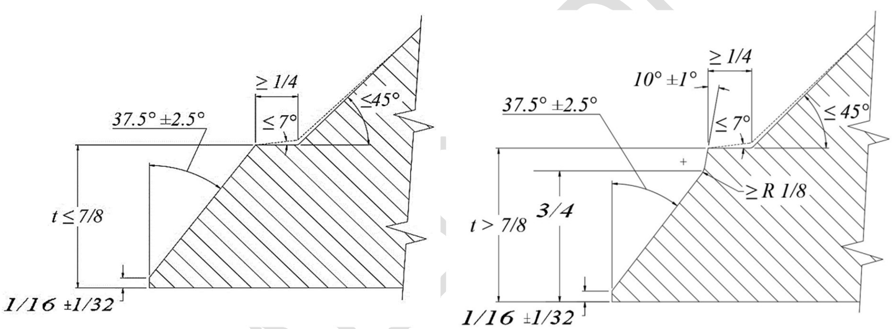
The weld end preparation shall be designed to achieve full penetration of the pressure wall after all machining.

NOTE A recommended preparation design is shown in Figure J.2.

Other preparations shall be acceptable.



a) Dimensions in millimeters



b) Dimensions in inches

Figure J.2—Recommended Weld End Preparation for Type 6B and 6BX Weld-end Flanges

Annex K
(informative)

Top Connectors

K.1 General

Annex K recommends dimensions and material strengths for top connectors, also known as tree caps, for the most common sizes and pressure ratings. The dimensions and material specifications indicated allow for conformance with all other requirements for top connectors, as specified in this specification.

If this annex is applied, the following requirements shall be met.

K.2 Materials

Materials shall conform to the requirements of 6.2 and have a minimum 0.2 % offset yield strength of 517 MPa (75,000 psi) and a maximum hardness of 237 HBW to be suitable for H_2S service. The appropriate material selection shall be made in conformance with Table 3.

K.3 Design

NOTE 1 The top connectors are designed for use in combinations of nominal size ranges and rated working pressure as shown in Table K.1 and Table K.2 and Figure K.1 and Figure K.2.

NOTE 2 Provisions on the bonnet nut other than those indicated in Figure K.1 and Figure K.2 for transfer of make-up torque may be provided but are not specified in this specification.

The threads shall conform to ASME B1.5 Acme screw threads, as specified in Table K.1.

Table K.1—Standard Top Connector Sizes

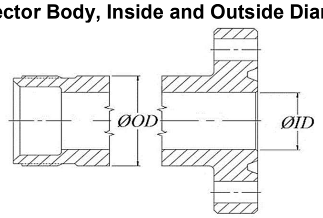
Nominal Tree Cap Bore Size	Rated Working Pressure		Thread Size A [a]	Seal Bore Diameter	
in.	MPa	psi	in.	mm	in.
$2^{9}/_{16}$	103.5	15,000 [b]	$5^{3}/_{4}$ — 4THD Acme-2G	101.60	4.000
$2^{9}/_{16}$	138.0	20,000	$6^{1}/_{4}$ — 4THD Acme-2G	101.60	4.000
$3^{1}/_{8}$	34.5	5000 [b]	$5^{3}/_{4}$ — 4THD Acme-2G	101.60	4.000
$3^{1}/_{16}$	69.0	10,000	$5^{3}/_{4}$ — 4THD Acme-2G	101.60	4.000
$3^{1}/_{16}$	103.5	15,000	$7^{1}/_{2}$ — 4THD Acme-2G	139.70	5.500
$4^{1}/_{16}$	34.5	5000 [b]	$8^{3}/_{8}$ — 4THD Acme-2G	133.35	5.250
$4^{1}/_{16}$	69.0	10,000	$8^{3}/_{8}$ — 4THD Acme-2G	133.35	5.250
$4^{1}/_{16}$	103.5	15,000	$9^{1}/_{2}$ — 4THD Acme-2G	158.75	6.250
$5^{1}/_{8}$	34.5	5000 [b]	9 — 4THD Acme-2G	171.45	6.750
$5^{1}/_{8}$	69.0	10,000	9 — 4THD Acme-2G	171.45	6.750
$5^{1}/_{8}$	103.5	15,000	$12^{1}/_{4}$ — 4THD Acme-2G	177.80	7.000
$6^{3}/_{8}$	34.5	5000 [b]	$9^{1}/_{2}$ — 4THD Acme-2G	203.20	8.000
$6^{3}/_{8}$	69.0	10,000	$11^{1}/_{2}$ — 4THD Acme-2G	209.55	8.250

FOOTNOTES

[a] See Figure K.1 and Figure K.2.

[b] Pressures up to and including this rated working pressure.

Table K.2—Top Connector Body, Inside and Outside Diameter Combinations



Nominal Size	Rated Working Pressure		ID Maximum Inside Diameter [a]		OD Minimum Outside Diameter	
in.	MPa	psi	mm	in.	mm	in.
2 9/16	103.5	15,000	65.8	2.59	109.0	4.29
2 9/16	138.0	20,000	65.8	2.59	144.5	5.69
3 1/8	34.5	5000	81.8	3.22	94.5	3.72
3 1/16	69.0	10,000	78.5	3.09	104.6	4.12
3 1/16	103.5	15,000	78.5	3.09	126.7	4.99
4 1/16	34.5	5000	108.7	4.28	125.7	4.95
4 1/16	69.0	10,000	103.9	4.09	139.2	5.48
4 1/16	103.5	15,000	103.9	4.09	166.4	6.55
5 1/8	34.5	5000	131.1	5.16	157.0	6.18
5 1/8	69.0	10,000	131.1	5.16	174.0	6.85
5 1/8	103.5	15,000	131.1	5.16	212.1	8.35
6 3/8	34.5	5000	162.8	6.41	200.2	7.88
6 3/8	69.0	10,000	162.8	6.41	221.7	8.73

FOOTNOTE

[a] See Figure K.1 and Figure K.2.

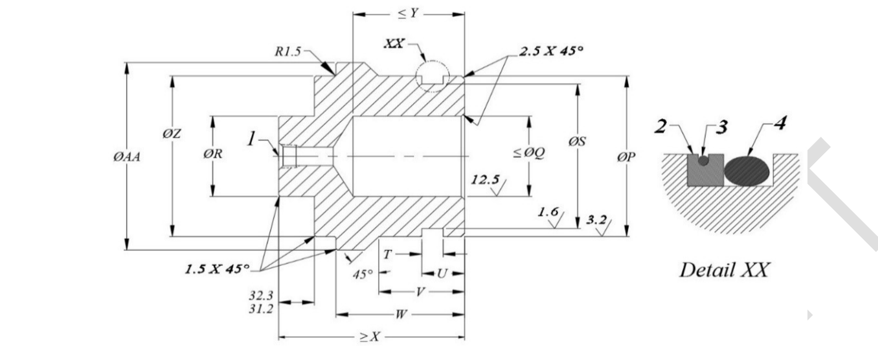
K.4 Dimensions—Top Connector, Seal, Bleeder Connector

Dimensions for top connectors shall conform to Table K.1, Table K.2, Table K.3 and Table K.4; flanges shall conform to the appropriate tables and requirements of 14.1, and 16B and 16BX clamp hubs shall conform to API 16A.

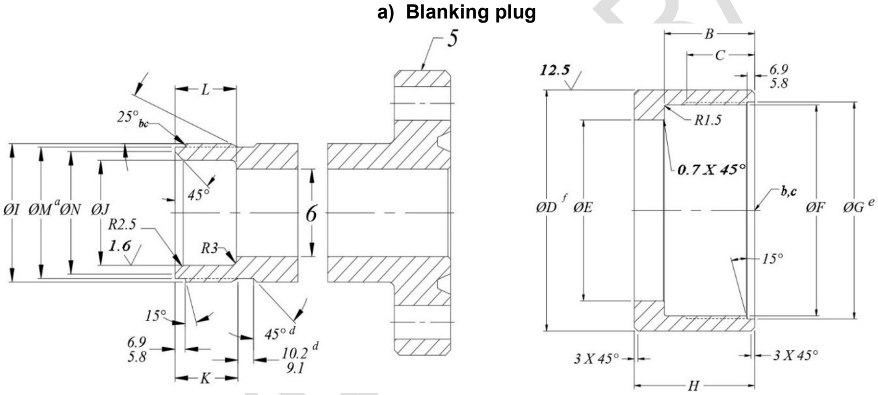
The dimensions and materials of the “O”-ring seals of the caps are specified in Table K.5, Table K.6, and Table K.7 and shall conform to SAE AS568A.

The dimensions of the bleeder connector shall conform to 9.3 depending on the pressure rating of the top connector.

Dimensions in millimeters unless noted otherwise;
surface roughness in micrometers



a) Blanking plug



b) Body **c) Bonnet nut**

Key

1 bleed port connector
2 back-up ring (if used)
3 O-ring (if back-up ring is used)
4 seal
5 flange in conformance with 14.1
6 ID in conformance with Table K.2

a Use 1.5 x 45° for radial wall thickness less than 10.16 mm.
b A-4 thread 29° Acme 2G.
c Remove feather edge (see Table K.1).
d If applicable.
e Thread relief.
f Gripping grooves 1.5 ± 0.5 wide x 1.0 ± 0.5 deep x 45° walls. Typically, there are 36 grooves along entire length equally spaced around OD. Visually inspect grooves only.

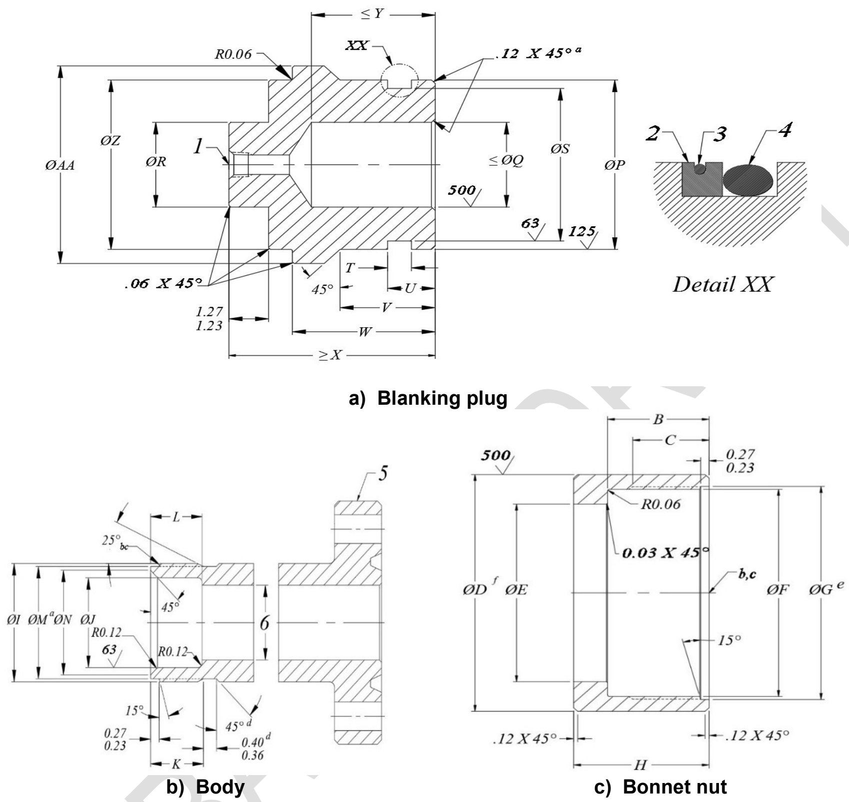
Figure K.1—Top Connector for Tree—SI Units

Table K.3—Dimensions for Top Connectors—SI Units
(See Figure K.1 for Location of Dimensions)

Dimensions in millimeters

Dimensions	Nominal Size			
	$2^{9}/_{16}$ $3^{1}/_{8}$ $3^{1}/_{16}$	$2^{9}/_{16}$	$3^{1}/_{16}$	$4^{1}/_{16}$ $4^{1}/_{16}$
	Rated Working Pressure MPa			
	103.5 34.5 69.0	138.0	103.5	34.5 69.0
B	113.3/114.3	114.3/115.3	113.8/114.3	118.6/119.1
C	88.9/91.9	91.9/92.5	88.9/89.4	92.2/92.7
D	166.1/165.1	191.5/190.5	216.9/215.9	242.6/242.1
E	115.6/116.1	134.6/135.1	155.2/155.7	182.1/182.6
F	139.70/140.00	152.40/152.70	184.15/184.45	206.38/206.68
G	147.57/148.08	160.27/160.78	192.02/192.53	214.25/214.76
H	140.7/139.7	140.7/139.7	140.7/139.7	140.0/138.9
I	146.05/145.72	158.75/158.42	190.50/190.17	212.73/212.39
J	101.60/101.75	101.60/101.75	139.70/139.85	133.35/133.50
K	86.9/85.9	82.8/81.8	91.4/90.4	95.8/94.7
L	75.7/76.7	91.4/92.5	75.7/76.7	67.6/68.6
M	137.52/137.01	150.16/149.68	181.81/181.31	203.96/203.45
N	126.5/127.5	145.5/146.6	164.6/165.6	188.5/189.5
P	101.50/101.35	101.50/101.35	139.60/139.45	133.25/133.10
Q	66.5	66.5	91.7	102.1
R	51.3/50.3	51.3/50.3	51.3/50.3	51.3/50.3
S	92.35/92.20	92.35/92.20	130.45/130.30	121.46/121.31
T	6.6/7.6	17.0/18.0	17.5/18.5	9.1/10.2
U	18.5/19.6	34.5/35.6	34.5/35.6	18.5/19.6
V	60.5/61.5	60.5/61.5	60.5/61.5	36.1/37.1
W	106.2/105.2	114.8/113.8	106.2/105.2	97.0/96.0
X	166.9	174.5	165.4	148.3
Y	76.2	88.9	76.2	70.4
Z	114.8/114.3	133.9/133.4	154.4/153.9	178.3/177.8
AA	139.4/138.9	151.9/151.4	181.9/181.4	204.7/204.2

Dimensions in inches unless noted otherwise;
surface roughness in microinches



Key

1 bleed port connector
2 back-up ring (if used)
3 O-ring (if back-up ring is used)
4 seal
5 flange in conformance with 14.1
6 ID in conformance with Table K.2

[a] Use 0.06 x 45° for radial wall thickness less than 0.40 in.
[b] A-4 THD 29° Acme 2G.
[c] Remove feather edge (see Table K.1).
[d] If applicable.
[e] Thread relief.
[f] Gripping grooves 0.06 ± 0.02 wide x 0.04 ± 0.02 deep x 45° walls. Typically, there are 36 grooves along entire length equally spaced around OD. Visually inspect grooves only.

Figure K.2—Top Connector for Tree—USC Units

Table K.4—Dimensions for Top Connectors—USC Units
(See Figure K.2 for Location of Dimensions)

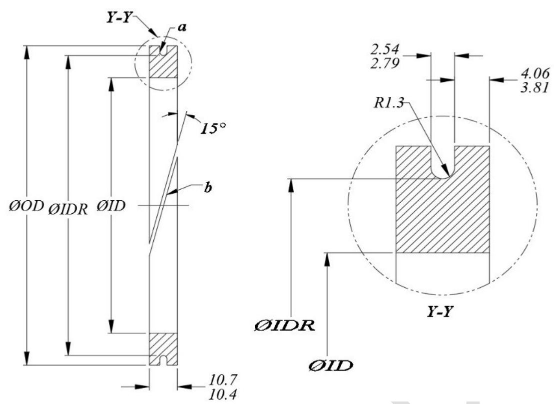
Dimensions in inches

Dimensions	**Nominal Size**			
	$2^{9}/_{16}$ $3^{1}/_{8}$ $3^{1}/_{16}$	$2^{9}/_{16}$	$3^{1}/_{16}$	$4^{1}/_{16}$ $4^{1}/_{16}$
	Rated Working Pressure psi			
	15,000 5000 10,000	20,000	15,000	5000 10,000
B	4.46/4.50	4.50/4.54	4.48/4.50	4.67/4.69
C	3.50/3.62	3.62/3.64	3.50/3.52	3.63/3.65
D	6.54/6.50	7.54/7.50	8.54/8.50	9.55/9.53
E	4.55/4.57	5.30/5.32	6.11/6.13	7.17/7.19
F	5.500/5.512	6.000/6.012	7.250/7.262	8.125/8.137
G	5.810/5.830	6.310/6.330	7.560/7.580	8.435/8.455
H	5.54/5.50	5.54/5.50	5.54/5.50	5.51/5.47
I	5.750/5.737	6.250/6.237	7.500/7.487	8.375/8.362
J	4.000/4.006	4.000/4.006	5.500/5.506	5.250/5.256
K	3.42/3.38	3.26/3.22	3.60/3.56	3.77/3.73
L	2.98/3.02	3.60/3.64	2.98/3.02	2.66/2.70
M	5.414/5.394	5.912/5.893	7.158/7.138	8.030/8.010
N	4.98/5.02	5.73/5.77	6.48/6.52	7.42/7.46
P	3.996/3.990	3.996/3.990	5.496/5.490	5.246/5.240
Q	2.62	2.62	3.61	4.02
R	2.02/1.98	2.02/1.98	2.02/1.98	2.02/1.98
S	3.636/3.630	3.636/3.630	5.136/5.130	4.782/4.776
T	0.26/0.30	0.67/0.71	0.69/0.73	0.36/0.40
U	0.73/0.77	1.36/1.40	1.36/1.40	0.73/0.77
V	2.38/2.42	2.38/2.42	2.38/2.42	1.42/1.46
W	4.18/4.14	4.52/4.48	4.18/4.14	3.82/3.78
X	6.57	6.87	6.51	5.84
Y	3.00	3.50	3.00	2.77
Z	4.52/4.50	5.27/5.25	6.08/6.06	7.02/7.00
AA	5.49/5.47	5.98/5.96	7.16/7.14	8.06/8.04

The dimensions and materials of the “O”-ring seals of the caps are specified in Table K.5, Table K.6, and Table K.7 and shall conform to SAE AS568A.

The dimensions of the bleeder connector shall conform to 9.3 depending on the pressure rating of the top connector.

Dimensions in millimeters unless noted otherwise



FOOTNOTES

[a] For O-ring size, see Table K.5.

[b] Make 1 cut as shown 0.8 mm wide flush; steps not allowed.

NOTE Material is nylon. Prior to installation, soften by boiling in water for 4 h.

Figure K.3—Back-up Ring for Seal—SI Units

Table K.5—Back-up Ring for Seal—SI Units
(See Figure K.3 for Location of Dimensions)

Dimensions in millimeters unless noted otherwise

Nominal Size in.	**Rated Working Pressure** MPa	*OD*	*IDR*	*ID*
2 9/16	138.0	102.84/102.95	97.79/98.04	93.65/93.75
3 1/16	103.5	140.94/141.10	135.64/136.14	131.80/131.95
4 1/16	103.5	159.94/160.10	154.69/154.94	148.31/148.46
5 1/8	103.5	178.59/178.74	172.97/173.23	166.70/166.85
6 3/8	69.0	210.34/210.49	204.72/204.98	198.45/198.60

Table K.6—Seals for Top Connector Plugs for H_2S Service
(See Figure K.3 for Location of Dimensions)

Nominal Size in.	Rated Working Pressure		Seals [a]	Back-up Ring Required [b]
	MPa	psi		
2 9/16	103.5	15,000	SAE AS 568-342-90 FKM	—
3 1/8	34.5	5000	SAE AS 568-342-90 FKM	—
3 1/16	69.0	10,000	SAE AS 568-342-90 FKM	—
2 9/16	138.0	20,000	SAE AS 568-342-90 FKM SAE AS 568-153-80 FKM [c]	Yes
3 1/16	103.5	15,000	SAE AS 568-354-90 FKM SAE AS 568-159-80 FKM [c]	Yes
4 1/16	34.5	5000	SAE AS 568-427-90 FKM	—
4 1/16	69.0	10,000	SAE AS 568-427-90 FKM	—
4 1/16	103.5	15,000	SAE AS 568-435-90 FKM SAE AS 568-161-80 FKM [c]	Yes
5 1/8	34.5	5000	SAE AS 568-438-90 FKM	—
5 1/8	69.0	10,000	SAE AS 568-438-90 FKM	—
5 1/8	103.5	15,000	SAE AS 568-439-90 FKM SAE AS 568-166-80 FKM [c]	Yes
6 3/8	34.5	5000	SAE AS 568-443-90 FKM	—
6 3/8	69.0	10,000	SAE AS 568-444-90 FKM SAE AS 568-168-80 FKM [c]	Yes

FOOTNOTES

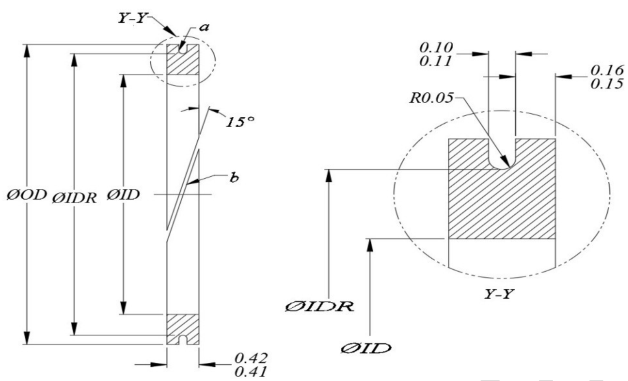
All O-rings specified are suitable for H_2S service.

[a] FKM according to ASTM D1418.

[b] See Figure K.3 and Table K.6 for back-up ring details and dimensions.

[c] The O-rings marked 80 (durometer) are used on the outside of a back-up ring.

Dimensions in inches unless noted otherwise



FOOTNOTES

[a] For O-ring size, see Table K.5.

[b] Make 1 cut as shown 0.03 in. wide flush; steps not allowed.

Material is nylon. Prior to installation, soften by boiling in water for 4 h.

Figure K.4—Back-up Ring for Seal—USC Units

Table K.7—Back-up Ring for Seal—USC Units
(See Figure K.4 for Location of Dimensions)

Dimensions in inches

Nominal Size in.	**Rated Working Pressure** psi	*OD*	*IDR*	*ID*
2 9/16	20,000	4.049/4.053	3.85/3.86	3.687/3.691
3 1/16	15,000	5.549/5.555	5.34/5.36	5.189/5.195
4 1/16	15,000	6.297/6.303	6.09/6.10	5.839/5.845
5 1/8	15,000	7.031/7.037	6.81/6.82	6.563/6.569
6 3/8	10,000	8.281/8.287	8.06/8.07	7.813/7.819

K.5 Quality Control

The quality control requirements shall conform to 14.7.4.

K.6 Marking

Marking shall be as specified in Section 12.

K.7 Storing and Shipping

Storing and shipping shall be as specified in Section 13.

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[7] API Standard 6AV2, *Installation, Maintenance, and Repair of Surface Safety Valves and Underwater Safety Valves Offshore*

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[9] API Specification 6FB, *Specification for Fire Test for End Connectors*

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[25] ASME *Boiler and Pressure Vessel Code*:2004 with 2005 and 2006 addenda, *Section VIII, Division 3, Alternative Rules for Construction of High Pressure Vessels*

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[31] ASTM F3301, *Standard for Additive Manufacturing – Post Processing Methods – Standard Specification for Thermal Post-Processing Metal Parts Made Via Powder Bed Fusion*

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[6] Out of print; included to deal with old equipment made to obsolete standards.