

Specification for Drill-through Equipment

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Specification for Drill-through Equipment

1 Scope

This specification defines the requirements for performance, design, materials, testing and inspection, welding, marking, handling, storing, and shipping of drill-through equipment used for drilling for oil and gas. It also defines service conditions in terms of pressure, temperature, and wellbore fluids for which the equipment is designed.

This specification is applicable to and establishes requirements for the following specific equipment:

- a) ram blowout preventers;
- b) ram blocks, packers, and top seals;
- c) annular blowout preventers;
- d) annular packing units;
- e) hydraulic wellbore connectors (wellhead, riser, or LMRP);
- f) drilling spools and spacer spools;
- g) adapters;
- h) mandrels (for wellbore connectors);
- i) loose connections;
- j) clamps.

Dimensional interchangeability is limited to end and outlet connections.

A simplified example of drill-through equipment defined by this specification is shown in Figures 1 and 2.

Repair and remanufacture of 16A equipment is covered in API 16AR, *Standard for Repair and Remanufacturing of Drill-through Equipment*.

This specification does not apply to field use or field testing of drill-through equipment.

If a product is supplied bearing the API Monogram and manufactured at a facility licensed by API, the requirements of Annex A apply.

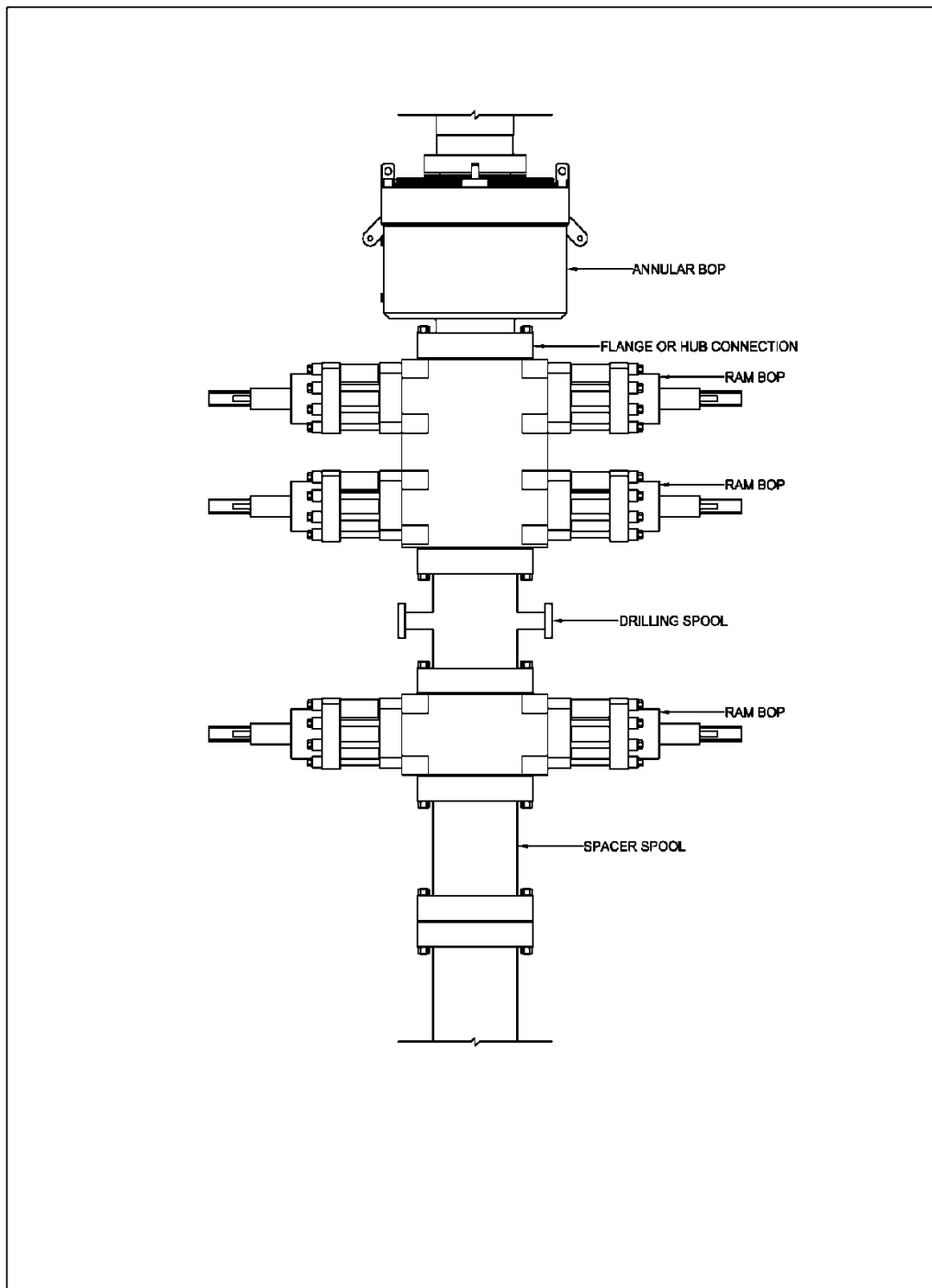


Figure 1—Simplified Example of Surface Drill-through Equipment

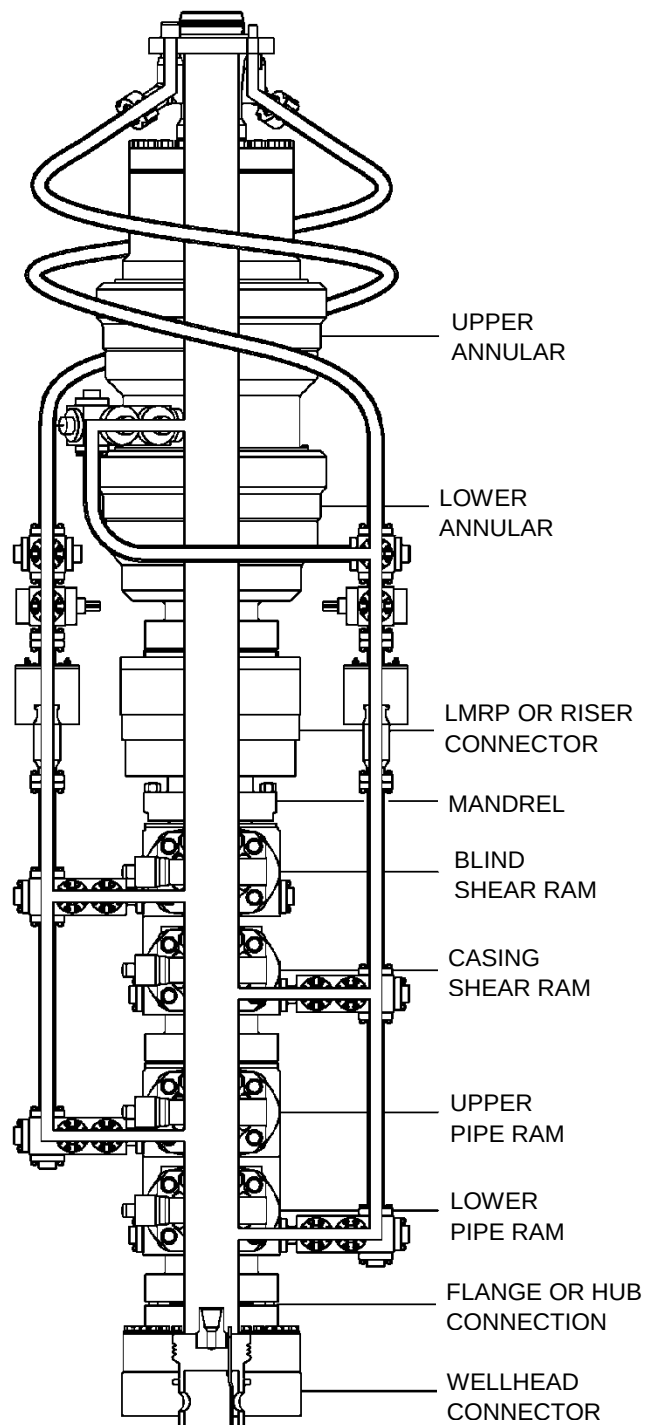


Figure 2—Simplified Example of Subsea Drill-through Equipment

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Specification 5CT, *Specification for Casing and Tubing*

API Specification 5DP, *Specification for Drill Pipe*

API Specification 6A, *Specification for Wellhead and Christmas Tree Equipment*, 20th edition, April 2011

API Technical Report 6AF2, *Capabilities of API Flanges Under Combinations of Load*

API Standard 6X, *Design Calculations for Pressure Containing Equipment*

API Specification 7-1, *Specification for Rotary Drill Stem Elements*

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

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

API TR 6MET, *Metallic Material Limits for Wellhead Equipment*

ASME¹ Boiler and Pressure Vessel Code, Section V, *UT Examination Methods for Materials and Fabrication*

ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Appendix 4, *Rounded Indication Charts Acceptance Standard for Radiographically Determined Rounded Indications in Welds*

ASME Boiler and Pressure Vessel Code, Section VIII, Division 2, Annex 5-F, *Experimental Stress and Fatigue Analysis*

ASME Boiler and Pressure Vessel Code, Section IX, Articles I, II, III, and IV

ASTM² A388, *Standard Practice for Ultrasonic Examination of Steel Forgings*

ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers—Tension*

ASTM D471, *Standard Test Method for Rubber Property—Effect of Liquids*

ASTM D1414, *Standard Test Methods for Rubber O-Rings*

ASTM D1415, *Standard Test Method for Rubber Property—International Hardness*

ASTM D1418, *Standard Practice for Rubber and Rubber Lattices—Nomenclature*

ASTM D2240, *Test Method for Rubber Property—Durometer Hardness*

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

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

ASTM E94, *Standard Guide for Radiographic Examination*

¹ American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016

² ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428

ASTM E110, *Standard Test Method for Indentation Hardness of Metallic Materials by Portable Hardness Testers*

ASTM E140, *Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness*

ASTM E165/E165M, *Standard Practice for Liquid Penetrant Examination for General Industry*

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

ASTM E384, *Standard Test Method for Microindentation Hardness of Materials*

ASTM D395, *Standard Test Methods for Rubber Property—Compression Set*

ASTM E428, *Standard Practice for Fabrication and Control of Metal, Other than Aluminum, Reference Blocks Used in Ultrasonic Testing*

ASTM E569, *Standard Practice for Acoustic Emission Monitoring of Structures During Controlled Simulation*

ASTM E709, *Standard Guide for Magnetic Particle Testing*

ASTM E747, *Standard Practice for Design, Manufacture, and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiography*

ASNT-SNT-TC-1A³, *Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing*

AWS D17.1/D17.1M⁴, *Specification for Fusion Welding for Aerospace Applications*

AWS QC1, *Standard for AWS Certification of Welding Inspectors*

CSWIP-WI-6-92⁵, *Requirements for the Certification of Visual Welding Inspectors (Level 1), Welding Inspectors (Level 2) and Senior Welding Inspectors (Level 3) (fusion welding) in accordance with the requirements of BS EN ISO 17637:2011*

ISO 2859-1⁶, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptable quality level (AQL) for lot-by-lot inspection*

ISO 6506-1, *Metallic Materials — Brinell Hardness Test — Part 1: Test Method*

ISO 6507-1, *Metallic Materials — Vickers Hardness Test — Part 1: Test Method*

ISO 6508-1, *Metallic Materials — Rockwell hardness test — Part 1: Test Method*

ISO 6892, *Metallic Materials — Tensile Testing at Ambient Temperature*

ISO 9712, *Nondestructive Testing — Qualification and Certification of NDT Personnel*

ISO 18265, *Metallic Materials — Conversion of Hardness Values*

³ American Society for Nondestructive Testing, PO Box 28518, 1711 Arlingate Lane, Columbus OH 43228

⁴ American Welding Society, 8669 NW 36th Street, #130, Miami, FL 33166

⁵ TWI Certification Ltd, Granta Park, Great Abington, Cambridge, CB21 6AL, United Kingdom

⁶ International Organization for Standardization, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland

NACE MR0175/ISO 15156⁷, *Petroleum and Natural Gas Industries—Materials for Use in H₂S-containing Environments in Oil and Gas Production, Parts 1, 2 and 3*

SAE AMS2750⁸, *Pyrometry*

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

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

3.1.1

acceptance criteria

Defined limits placed on characteristics of materials, products, equipment, processes, or services

3.1.2

adapter

Pressure-containing piece of equipment having end connections of different nominal size and/or pressure ratings; used to connect other pieces of equipment of different nominal sizes and/or pressure ratings

3.1.3

annular blowout preventer

Blowout preventer that uses an annular-shaped elastomeric sealing element to seal the space between the tubular and the wellbore or an open hole

3.1.4

blind connection

End or outlet connection with no center bore, used to completely close off an outlet

3.1.5

blind shear ram

Closing and sealing component in a ram blowout preventer that first shears the tubular in the wellbore and then seals off the bore or acts as a blind ram if there is no tubular in the wellbore

3.1.6

blind ram

Closing and sealing component in a ram blowout preventer that seals the open wellbore

3.1.7

blowout preventer

BOP

Equipment installed at the wellhead or wellhead assemblies to contain wellbore fluids, either in the annular space between the casing and the tubulars or in an open hole during drilling, completion, testing, or workover operations

3.1.8

blowout preventer stack

BOP stack

Complete assembly of well control equipment, including preventers, spools, valves, and nipples, connected to the top of the wellhead or wellhead assemblies

3.1.9

body

portion of equipment between end connections, with or without internal parts, that contains wellbore pressure

⁷ NACE International, 15835 Park Ten Place, Houston, TX 77084

⁸ SAE International, 400 Commonwealth Drive, Warrendale, PA 15096

3.1.10**bolting**

All threaded fasteners, including studs, tap-end studs, double-ended studs, headed bolts, cap screws, screws, and nuts

3.1.11**calibration**

Comparison to a standard of known accuracy and making any needed adjustment(s)

3.1.12**cast** (*verb*)

To pour molten metal into a mold to produce an object of desired shape

3.1.13**casting** (*noun*)

Object at or near finished shape obtained by solidification of a molten metal in a mold

3.1.14**Certificate of Conformance****COC**

Document in which the manufacturer certifies that the assembly or part is in conformance to the mentioned standard(s), specifications, and guidelines in accordance with the original product definition

3.1.15**chemical analysis**

Determination of the chemical composition of material

3.1.16**clamp** (*noun*)

Device with internal angled shoulders used to fasten mating hubs

3.1.17**clamping load**

Axial load applied to clamp hubs by the clamp due to bolt tightening

3.1.18**closing ratio**

Area of the operator piston exposed to the close operating pressure, divided by the cross-sectional area of the piston shaft exposed to wellbore pressure

3.1.19**closure bolting**

Bolting used to assemble or join wellbore pressure-containing parts, including end and outlet connections

NOTE Examples of closure bolting include flange bolting, bonnet bolting, end connection bolting on BOPs, ram door bolting, and hub clamp bolting.

3.1.20**conformance**

Satisfying all of the requirements of the referenced specification, specification section, or document

3.1.21**corrosion-resistant alloy****CRA**

Nonferrous-based alloys where any one or the sum of the specified amount of the elements titanium, nickel, cobalt, chromium, and molybdenum exceeds 50 % mass fraction

NOTE This definition is different from that in ISO 15156 (NACE MR0175/ISO 15156; see Clause 2).

3.1.22**corrosion-resistant ring groove**

Ring groove lined with a CRA or an austenitic stainless steel to resist metal-loss corrosion

3.1.23**critical areas**

Part(s) of a product that require specific operational control in service life; includes sealing surfaces and locations of high stress and strain under static and/or cycling loads

3.1.24**critical dimension**

Dimension(s) identified by the manufacturer as requiring verification and documentation

3.1.25**data acquisition system**

System for capturing and storing data

NOTE Examples include strip chart recorders, circular chart recorders, or computer systems.

3.1.26**date of manufacture**

Date of the manufacturer's final acceptance of finished equipment

3.1.27**design validation results**

Document or dataset created and maintained that provides objective evidence of activities performed, results achieved, or statements made during the design validation

3.1.28**drilling spool**

Pressure-containing piece of equipment having end connections and outlets, used below or between drill-through equipment

3.1.29**end connection**

Integral male or female thread, clamp hub end connector, flange (studded or through-bolted), or any other means used to join together equipment that contains or controls pressure

3.1.30**equipment**

Components or assemblies to which this specification is applicable

3.1.31**exposed bolting**

Bolting exposed directly to a sour environment or that is buried, insulated, equipped with flange protectors, or is otherwise denied open atmosphere or open seawater exposure

3.1.32**extended range**

Range outside the rated range in which the manufacturer defines the operational characteristics based on test data

3.1.33**fabrication weld**

Weld joining two or more parts

3.1.34**flange**

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

3.1.35**forging** (*noun*)

Shaped metal part formed by the forging method

3.1.36**full penetration weld**

Weld that extends throughout the complete wall section of the parts joined

3.1.37**gasket-retaining load**

Portion of the clamping load required to offset the separating force the gasket exerts on the hubs when pressurized

3.1.38**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

3.1.39**heat treatment****heat treating**

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

3.1.40**heat treatment load**

- For batch furnaces: material placed on loading or carry devices and moved as a batch through one heat treat cycle
- For continuous furnaces: group of pieces of material with the same nominal size that is moved sequentially through the heat treatment process using the same process parameters

3.1.41**hot-work** (*verb*)

Deform metal plastically at a temperature above the recrystallization temperature

3.1.42**hub**

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

3.1.43**hub face separation**

Occurs when all preload is lost between the two hubs, flanges, or OEC faces, and the two faces have lost contact from OD to ID or ID to OD

3.1.44**hydraulic connector**

Hydraulically actuated drill-through equipment that locks and seals on end connections

3.1.45**indication**

Visual sign of cracks, pits, or other abnormalities found during nondestructive examination

3.1.46**integral** (*adjective*)

⟨Parts⟩ joined by the forging, casting, or welding process

3.1.47**leakage**

Visible passage of fluid during pressurization or a hold period from the inside to the outside of the pressure-containment area of the equipment being tested

3.1.48**linear indication**

Liquid penetrant or magnetic particle examination indication whose length is equal to or greater than three times its width

3.1.49**loose connection**

Flange (studded or open-face), hub connection, or other end connection used to join together equipment, but not integral to the equipment

3.1.50**manufacturing data book****MDB**

Composite file of records from a traceable API product that includes records associated with the original API product manufacturing, including certification records as required by this specification

3.1.51**non-pressure-containing weld**

Weld whose failure will not reduce the pressure-containing integrity of the component

3.1.52**non-sealing shear ram**

Closing component in a ram blowout preventer that is capable of shearing or cutting certain tubulars, but does not seal

3.1.53**original equipment manufacturer****OEM**

Design owner or manufacturer of the traceable assembled equipment, single equipment unit, or component part

3.1.54**other end connection****OEC**

Connection that is not specified in an API specification or standard

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

3.1.55**outlet connection**

Clamp hub end connector and flange, studded or through bolted, or any other end connection with a bore that intersects the vertical drill-through bore

3.1.56**part**

Individual piece used in the assembly of a single unit of equipment

3.1.57**performance requirement level****PR**

Designation determined by the extent of testing successfully performed in accordance with minimum performance criteria identified by this specification

3.1.58**pipe ram**

Closing and sealing component in a ram blowout preventer that seals around tubulars in the wellbore

3.1.59**post-weld heat treatment****PWHT**

Heat treatment subsequent to welding, including stress relief

3.1.60**pressure**

Ratio of force to the area over which that force is distributed (i.e. pound force to an area (in²), measured in "psi", etc.)

absolute pressure

Internal pressure that the equipment is designed to contain and/or control, or that is zero-referenced against a perfect vacuum; measured in "psia"

differential pressure

Difference in pressure between any two points (p1 and p2); measured in "psid"

gauge pressure

Measured relative to the ambient pressure (e.g. atmospheric for surface application, hydrostatic for subsea application), measured in "psig"

3.1.61**pressure-containing part**

Part exposed to wellbore fluids whose failure to function as intended would result in a release of wellbore fluid to the environment

NOTE 1 Examples include bodies and bonnets.

NOTE 2 Examples of items that are not included are operating cylinders and cylinder heads.

3.1.62**pressure-containing weld**

Weld whose absence or failure will reduce or compromise the pressure-containing integrity of the component

3.1.63**pressure-controlling bolting**

Bolting used to assemble or join pressure-controlling part(s)

NOTE Examples include bolting on ram, seat or seal retainer bolting, shear ram blade bolting

3.1.64**pressure-controlling part**

Part intended to control or regulate the movement of wellbore fluids

NOTE Examples include packing elements, rams, and replaceable seats within a pressure-containing part.

3.1.65**pressure end load**

Axial load resulting from internal pressure applied to the area defined by the maximum seal diameter

3.1.66**pressure-retaining bolting**

Bolting used to assemble or join pressure-retaining parts whose failure would result in a release of wellbore fluid to the environment

NOTE Examples are studs and nuts on top of a hydraulic connector, and clamp bolts.

3.1.67**pressure-retaining part**

Part not exposed to wellbore fluids whose failure to function as intended will result in a release of wellbore fluid to the environment

NOTE An example is a clamp.

3.1.68**procedure qualification record****PQR**

Record of the welding data used to make the test weldment, containing the actual values or ranges of the essential and supplementary essential variables used in preparing the test weldments, including the test results

3.1.69**product family**

Model or type of specific equipment listed in Section 1 of this specification

3.1.70**ram blowout preventer**

Blowout preventer that uses metal blocks assembled with elastomer seals to seal off pressure on a wellbore, with or without tubulars in the bore

3.1.71**rated range**

Range of tubulars that can be sealed up to the full rated working pressure of the BOP

3.1.72**rated working pressure**

Maximum internal pressure that the equipment is designed to contain and/or control on surface

3.1.73**record (noun)**

Retrievable document or dataset created that provides objective evidence of activities performed, results achieved, or statements made

3.1.74**relevant indication**

Surface NDE indication (liquid penetrant or magnetic particle examination) with a major dimension greater than 1.6 mm (0.062 in.)

NOTE Inherent indications not associated with a surface rupture are considered non-relevant indications.

3.1.75**remanufacture**

Process of disassembly, reassembly, and testing of drill-through equipment, with or without the replacement of parts, in which machining, welding, heat treatment, or other manufacturing operation is employed

3.1.76**repair weld**

Welding performed to correct a nonconformance

3.1.77**reportable**

Test performed and the results documented

3.1.78**rounded indication**

- For liquid penetrant or magnetic particle examination: any indication that is approximately circular or elliptical and whose length is less than three times its width
- For radiographic examination: any indication with a maximum length of three times the width or less on the radiograph.

NOTE Indications may be circular, elliptical, conical, or irregular in shape, and may have tails. When evaluating the size of an indication, the tail is included.

3.1.79**serialization**

Assignment of a unique code to individual parts and/or pieces of equipment to maintain records

3.1.80**spacer spool**

Pressure-containing piece of equipment having end connections, used below or between drill-through equipment

NOTE A spool is used to provide separation between two components with equal-sized end connections.

3.1.81**stabilized (pressure testing)**

State in which the initial pressure-decline rate has decreased to within the manufacturer's specified rate

NOTE Pressure decline can be caused by such things as changes in temperature, setting of elastomer seals, or compression of air trapped in the equipment being tested.

3.1.82**stabilized (temperature testing)**

State in which the initial temperature fluctuations have decreased to within the manufacturer's specified range

NOTE Temperature fluctuation can be caused by such things as mixing different-temperature fluids, convection, or conduction.

3.1.83**stress relief**

Controlled heating of material to a predetermined temperature for the purpose of reducing any residual stresses

3.1.84**studded connection**

Connection in which thread-anchored studs are screwed into tapped holes

3.1.85**surface finish**

Ra

Measurement of the average roughness of a surface

3.1.86**test series**

Group of tests at the same load condition (i.e. rated, extreme, survival) that are related to each other in some manner, such as capacity or type of test

EXAMPLE A Rated Capacity Test Series comprises all the tests that are conducted to a load level that corresponds to a rated capacity rating.

3.1.87

trepan (verb)

Produce a hole through a part by boring a narrow band or groove around the circumference of the hole and removing the solid central core of material

3.1.88

utility bolting

All bolting that is required to mount equipment and accessories to the drill-through equipment that is not closure bolting, pressure retaining, or pressure controlling

NOTE Examples include bolting on lifting eyes, pad eyes (non-welded), wear bushing, nameplate, clamps for tubing, guards.

3.1.89

variable bore ram

VBR

Closing and sealing component in a ram blowout preventer that is capable of sealing on a range of tubular sizes

3.1.90

visual examination

Examination of parts and equipment for visible defects in material and workmanship

3.1.91

volumetric nondestructive examination

Examination for internal material defects by radiography, acoustic emission, or ultrasonic testing

3.1.92

weld groove (weld prep)

Area between two metals to be joined that has been prepared to receive weld filler metal; also known as "weld prep"

3.1.93

weld (verb)

Act of fusing materials, with or without the addition of filler materials

3.1.94

welding

Application of any one of a group of welding processes that applies heat energy sufficient to melt and join one or more pieces of metal through localized fusion and coalescence

3.1.95

welding procedure specification

WPS

Document providing the required welding variables for a specific application to assure repeatability by properly trained welders and welding operators

NOTE These variables and their meanings are defined, respectively, in Article II of the ASME Boiler & Pressure Vessel Code, Section IX—Welding and Brazing Qualifications.

3.1.96

weldment

Portion or area of a component on which welding has been performed

NOTE A weldment includes the weld metal, the heat-affected zone (HAZ), and the base metal unaffected by the heat of welding.

3.1.97

wrought structure

Structure that contains no cast dendritic structure

3.1.98

yield strength

Stress level, measured at room temperature, at which material plastically deforms and will not return to its original dimensions when the stress is released

NOTE 1 The term is expressed in newtons per square millimeter (pounds per square inch) of loaded area.

NOTE 2 All yield strengths specified in this standard are considered as being the 0.2 % yield offset strength in accordance with ISO 6892 or ASTM A370.

3.2 Acronyms and Abbreviations

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

AE	acoustic emission
ANSI	American National Standards Institute
API	American Petroleum Institute
AQL	acceptance quality level
ASME	American Society of Mechanical Engineers
ASNT	American Society for Non-destructive Testing
ASTM	American Society for Testing and Materials
AWS	American Welding Society
BOP	blowout preventer
BSL	bolting specification level
CAWI	certified associate welding inspector
COC	certificate of conformance
CRA	corrosion-resistant alloy
CSO	complete shut-off
CWI	certified welding inspector
CSWIP	certification scheme for welding inspection personnel
DAC	distance amplitude curve
DHT	dehydrogenization heat treatments
ER	equivalent round
FAT	factory acceptance test
FCAW	flux-cored arc welding
HAZ	heat-affected zone

ID	inside diameter
ISR	intermediate stress relief
LP	liquid penetrant
LMP	Larsen-Miller parameter
LMRP	lower marine riser package
LVDT	linear variable displacement transformer
MDB	manufacturing data book
MOPFLPS	minimum operator pressure for low pressure sealing
MP	magnetic particle
MT	magnetic particle test
NACE	National Association of Corrosion Engineers
NDE	nondestructive examination
OD	outside diameter
OEC	other end connection
OEM	original equipment manufacturer
OS	operating system
PQR	procedure qualification record
PR	performance requirement
PT	penetrant test
PWHT	post-weld heat treatment
QTC	qualification test coupon
SAW	submerged arc welding
SCWI	senior certified welding inspector
SMAW	shielded metal arc welding
SR	supplemental requirement
SST	[austenitic] stainless steel
VBR	variable bore ram
WPS	welding procedure specification

4 Design Requirements

4.1 Size Designation

Equipment to which this specification is applicable shall have a vertical through-bore dimension corresponding with the size designation as shown in Table 1.

Table 1—Equipment Size

Nominal Bore Size Designation		Minimum Drift Mandrel Diameter	
mm	(in.)	mm	(in.)
179	7 ¹ / ₁₆	178.61	7.032
228	9	227.84	8.970
279	11	278.64	10.970
346	13 ⁵ / ₈	345.31	13.595
425	16 ³ / ₄	424.69	16.720
476	18 ³ / ₄	475.49	18.720
527	20 ³ / ₄	526.29	20.720
540	21 ¹ / ₄	538.99	21.220
680	26 ³ / ₄	678.69	26.720
762	30	761.24	29.970
NOTE 1 tolerance on drift mandrel diameter is +0.25/ -0.00 mm (+0.010 / -0.000 in)			
NOTE 2 nominal bore size tolerance +0.79 / -0.00 mm (+0.031 / -0.000 in)			

4.2 Service Conditions

4.2.1 Rated Working Pressure

Equipment to which this specification is applicable shall be rated in only the rated working pressures shown in Table 2.

Table 2—Equipment Rated Working Pressures

MPa	psia
6.9	1000
13.8	2000
20.7	3000
34.5	5000
69.0	10,000
103.4	15,000
138.0	20,000
172.4	25,000
206.8	30,000

The rated working pressure shall be the maximum internal pressure that the equipment is designed to contain and or control on surface.

4.2.2 Temperature Ratings

Equipment shall be designed for metallic parts to operate within the temperature ranges shown in Table 3.

Table 3—Temperature Ratings for Metallic Materials

Classification	Operating range	
	°C	°F
T-75/250	– 59 to 121	– 75 to 250
T-75/350	– 59 to 177	– 75 to 350
T-20/250	– 29 to 121	– 20 to 250
T-20/350	– 29 to 177	– 20 to 350
T-0/250	– 18 to 121	0 to 250
T-0/350	– 18 to 177	0 to 350
NOTE Information on strength of materials at elevated temperatures is found in API 6A and API 6MET.		

Equipment shall be designed for wellbore elastomeric materials to operate within the temperature classifications of Table 4.

Low temperature shall be the lowest temperature to which the equipment may be subjected.

Continuous elevated temperature limit shall be the minimum fluid temperature achieved per Table 4 over a 10 pressure cycle period.

Extreme temperature limit shall be the maximum fluid temperature allowed in a one hour period.

The overall combined temperature classification shall be designated by a three-digit code as defined in Table 4

Table 4—Temperature Ratings for Nonmetallic Sealing Materials

Low Temperature Limit (first digit)			Continuous Elevated Temperature Limit ^a (second digit)			Extreme Temperature Limit (third digit)		
Code	Temperature		Code	Temperature		Code	Temperature	
	°C	°F		°C	°F		°C	°F
A	– 26	– 15	A	66	150	A	82	180
B	– 18	0	B	82	180	B	93	200
C	– 12	10	C	99	210	C	104	220
D	– 7	20	D	116	240	D	121	250
E	– 1	30	E	132	270	E	149	300
F	4	40	F	149	300	F	177	350
G	Other	Other	G	Other	Other	G	Other	Other
^a not required for PR1 EXAMPLE Material "FDE" has a low temperature rating of 40 °F, a continuous elevated temperature rating of 240 °F, and an extreme temperature limit of 300 ° F.								

All other elastomeric seals shall be designed to operate within the temperatures of the manufacturer's written specifications.

4.2.3 Retained Fluid Ratings

All metallic materials that come in contact with well fluids shall meet the requirements of NACE MR0175 /ISO 15156 for sour service.

4.3 Equipment-specific Design Requirements

4.3.1 Flanged End and Outlet Connections

4.3.1.1 General

Flanged end and outlet connections shall conform to the dimensional requirements of API 6A prior to assembly and testing.

Dimensions shall apply to machining dimensions and shall not apply after test or after flange and ring gasket makeup.

NOTE Type 6B and Type 6BX flange connections may be used as integral connections.

Type 6B and API 6BX flanges integral to drill-through equipment shall not contain test connections.

Type 6B and API 6BX flange connections shall be designed for use in the combination of size designation and pressure ratings shown in Table 5.

4.3.1.2 API Type 6B Flange Connections

The type 6B flange shall have a through-bolted or studded design.

Type 6B flange connections shall have a ring joint type and not be designed for face-to-face make-up.

NOTE 1 The connection make-up bolting force reacts on the metallic gasket.

Table 5—Pressure Rating and Size Ranges of API 6A Flange Connectors

Rated Working Pressure MPa (psi)	Flange Size Range mm (in)		
	Type 6B	Type 6BX	Dual Segmented
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)	35 to 103 x 108 (1 ³ / ₈ to 4 ¹ / ₁₆ x 4 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)	—

Dimensions for type 6B integral flanges shall conform to API 6A.

Dimensions for all ring grooves shall conform to API 6A.

4.3.1.3 API Type 6BX Flange Connections

The type 6BX flange shall be of the through-bolted or studded design.

Type 6BX flanges shall be of the ring joint type and are designed with a raised face.

NOTE 1 Depending on tolerances, the connection makeup force may 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.

Dimensions for type 6BX integral flanges shall conform to API 6A.

Dimensions for all ring grooves shall conform to API 6A.

NOTE 2 Other weld preparations may be employed when the strength of the overlay alloy equals or exceeds the strength of the base material.

4.3.2 Studded End and Outlet Connections

4.3.2.1 General

The two types of studded end and outlet connections (6B and 6BX) referred to in this specification shall conform to API 6A.

NOTE Type 6B and type 6BX studded connections may be used as integral connections.

The design for studded end and outlet connections shall be the same as specified in 4.3.1.1, except as required in 4.3.2.2 and 4.3.2.3.

4.3.2.2 Type 6B Studded Connections

Dimensions for type 6B studded connections shall conform to API 6A as it relates to the bore size, diameter of the bolt circle, and flange OD.

The studded connection shall be fully machined in accordance with API 6A.

Stud bolt holes shall be sized and located to conform to API 6A. The thread form of the tapped hole shall conform to the requirements of API 6A. The minimum depth of the full threads in the hole shall be equal to the diameter of the stud, and the maximum depth shall be in accordance with the manufacturer's written specification.

4.3.2.3 Type 6BX Studded Connections

Dimensions for Type 6BX studded connections shall conform to API 6A concerning bore size, diameter of the bolt circle, and flange OD.

The studded connection shall be fully machined in accordance with API 6A.

Stud bolt holes shall be sized and located in accordance with API 6A. The thread form of the tapped hole shall conform to the requirements of API 6A. The minimum depth of the full threads in the hole shall be equal to the diameter of the stud, and the maximum depth shall be in accordance with the manufacturer's written specification.

4.3.3 Bolting

4.3.3.1 Bolting for Land Service

4.3.3.1.1 General

Manufacturers (OEM) shall have a documented procedure for the qualification of bolting manufacturers that satisfies the requirements of API 20E and API 20F in accordance with Table 6. Exposed bolting shall meet the hardness requirements of NACE MR0175/ISO 15156. Manufacturers (OEM) shall have documented specifications that include the thread form and dimensions of studs, nuts, and bolts. When plating or coating is specified, API 20E plating and coating requirements shall be required.

Table 6—Bolting Requirement

	Material	Land ⁽¹⁾	Offshore ⁽²⁾
Pressure-controlling Bolting	Alloy steel and carbon steel	API 20E BSL-1 ⁽³⁾	API 20E BSL-2 ⁽³⁾
	Stainless steel and CRA	API 20F BSL-2	API 20F BSL-2
Closure Bolting	Alloy steel and carbon steel	API 20E BSL-2 ⁽³⁾	API 20E BSL-3 ⁽³⁾
	Stainless steel and CRA	API 20F BSL-2	API 20F BSL-3
Pressure-retaining Bolting	Alloy steel and carbon steel	API 20E BSL-2 ⁽³⁾	API 20E BSL-3 ⁽³⁾
	Stainless steel and CRA	API 20F BSL-2	API 20F BSL-3
Utility Bolting	Alloy steel and carbon steel	Mfg. Spec. ⁽⁴⁾	Mfg. Spec. ⁽⁴⁾
	Stainless steel and CRA	Mfg. Spec. ⁽⁴⁾	Mfg. Spec. ⁽⁴⁾
NOTE: (1) General requirements listed in 4.3.3.1 apply to all bolting (2) General requirements listed in 4.3.3.2 apply to all bolting (3) Need to conform to API 6A for material class and material testing (4) Based on manufacturer's written specification			

Bolting manufactured from proprietary materials shall conform to API 20E or API 20F, with the exception that the materials meet the manufacturer's written specifications for chemical composition and mechanical properties.

Refer to Table 6 for bolting requirements.

4.3.3.1.2 Pressure-controlling Bolting

Alloy steel and carbon steel bolting shall be in conformance with API 20E BSL-1 minimum and API 6A (for material class and mechanical testing).

Stainless steel and CRA bolting shall be in conformance with API 20F BSL-2 minimum.

4.3.3.1.3 Closure Bolting

Alloy steel and carbon steel closure bolting shall be in conformance with API 20E BSL-2 minimum and API 6A (for material class and mechanical testing).

Stainless steel and CRA closure bolting shall be in conformance with API 20F BSL-2 minimum.

4.3.3.1.4 Pressure-retaining Bolting

Alloy steel and carbon steel pressure-retaining bolting shall be in conformance with API 20E BSL-2 minimum and API 6A (for material class and mechanical testing).

Stainless steel and CRA pressure-retaining bolting shall be in conformance with API 20F BSL-2 minimum.

4.3.3.1.5 Utility Bolting

Alloy steel and carbon steel bolting shall be in conformance with the manufacturer's specification.

Stainless steel and CRA bolting shall be in conformance with the manufacturer's specification.

4.3.3.2 Bolting for Offshore Surface and Subsea Service

4.3.3.2.1 General

Manufacturers (OEM) shall have a documented procedure for the qualification of bolting manufacturers that follows the requirements of API 20E and API 20F.

Bolting manufactured from alloy steel or carbon steel shall be limited to 34 HRC maximum due to concerns about hydrogen embrittlement.

Exposed bolting shall meet the requirements of NACE MR0175/ISO 15156. Manufacturers (OEM) shall have documented specifications that include the thread form and dimensions of studs, nuts, and bolts.

When plating or coating is specified, API 20E plating and coating requirements shall be required.

Bolting manufactured from proprietary materials shall conform to the manufacturer's written specification and the requirements of API 20E or API 20F, with the exception that the material meet the manufacturer's specified chemical composition and mechanical properties.

Refer to Table 6 for bolting requirements.

4.3.3.2.2 Pressure-controlling Bolting

Alloy steel and carbon steel bolting shall conform to API 20E BSL-2 minimum and API 6A (for material class and mechanical testing).

Stainless steel and CRA bolting shall conform to API 20F BSL-2 minimum and API 6A (for material class and mechanical testing).

Bolting that attaches the shear ram blade to the ram block shall conform to:

- the requirements of API 20E BSL-3 or API 20F BSL3 and API 6A as appropriate for the material type;
- the manufacturer's written specification and requirements for the chemical composition and mechanical properties.

4.3.3.2.3 Closure Bolting

Alloy steel and carbon steel closure bolting shall conform to API 20E BSL-3 and API 6A (for material class and mechanical testing).

Stainless steel and CRA closure bolting shall conform to API 20F BSL-3 and API 6A (for material class and mechanical testing).

4.3.3.2.4 Pressure-retaining Bolting

Alloy steel and carbon steel pressure-retaining bolting shall conform to API 20E BSL-3 minimum and API 6A (for material class and mechanical testing).

Stainless steel and CRA pressure-retaining bolting shall conform to API 20F BSL-3 minimum.

4.3.3.2.5 Utility Bolting

Alloy steel and carbon steel bolting shall conform to the manufacturer's specifications.

Stainless steel and CRA bolting shall conform to the manufacturer's specifications.

4.3.4 Hub End and Outlet Connections

4.3.4.1 General

End and outlet hubs (Type 16B and Type 16BX) shall be in accordance with this specification.

NOTE Type 16B and Type 16BX hubs may be used as integral connections.

Type 16B and Type 16BX hubs integral to drill-through equipment shall not contain test connections. Type 16B and Type 16BX hubs are designed for use in the combination of designated sizes and pressure ranges shown in Table 7.

Table 7—Pressure Ratings and Size Ranges of Type 16B and 16BX Hubs

Pressure Rating MPa (psi)	Type 16B mm (in.)	Type 16BX mm (in.)
13.8 (2000)	179 (7 ¹ / ₁₆), 425 (16 ³ / ₄), 540 (21 ¹ / ₄)	—
20.7 (3000)	279 (11), 346 (13 ⁵ / ₈), 425 (16 ³ / ₄)	—
34.5 (5000)	—	52 to 540 (2 ¹ / ₁₆ 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 279 (1 ¹³ / ₁₆ to 11)

4.3.4.2 Type 16B Hubs

Type 16B hubs shall be of the ring joint type and designed for face-to-face makeup. The type RX ring gasket shall be used for these connections.

In order to accomplish a face-to-face makeup, the special type SR ring grooves shall be used as listed in Table 8 and Table 9.

Dimensions for type 16B integral hubs shall conform to Table 8 or Table 9, and to Figure 3.

Dimensions for type 16B blind hubs shall conform to Table 8 or Table 9, and to Figure 4.

Type 16B hubs shall use type RX gaskets in accordance with 4.3.6.

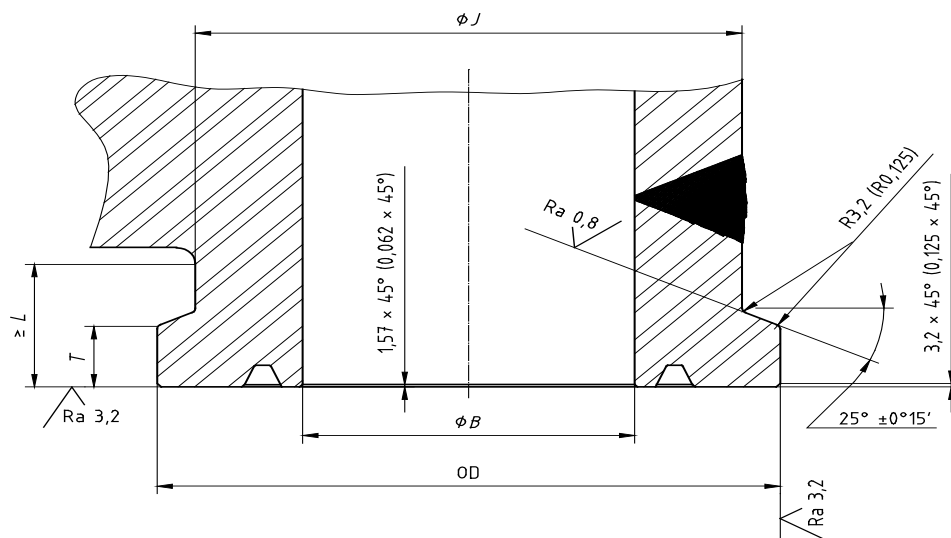
NOTE 1 Type 16B hub connections may be manufactured with corrosion-resistant overlays in the ring grooves.

Table 8—Type 16B Integral Hub Connections for 13.8 MPa (2,000 psi) Rated Working Pressure

Nominal Size mm (in.)	Bore <i>B</i> mm (in.)	Outside Diameter OD mm (in.)	Total Thickness <i>T</i> mm (in.)	Large Diameter of Neck <i>J</i> mm (in.)	Minimum Neck Length <i>L</i> mm (in.)	Ring Groove Number	Clamp Number
179 (7 ¹ / ₁₆)	179.40 (7.062)	263.52 (10.375)	36.64 (1.443)	225.40 (8.875)	63.5 (2.50)	SR-45	25
425 (16 ³ / ₄)	425.45 (16.750)	517.52 (20.375)	32.22 (1.269)	482.60 (19.000)	79.5 (3.13)	SR-65	12
540 (21 ¹ / ₄)	539.75 (21.250)	669.92 (26.375)	47.54 (1.872)	622.30 (24.500)	127.0 (5.00)	SR-73	18
Tolerance mm	+0.79 0	+0.13 -0.13	+0.0 -0.25	+0.0 -0.79	-1.52		
(in)	(+0.031) (-0)	(+0.005) (-0.005)	(+0) (-0.010)	(+0) (-0.031)	(-0.06)		

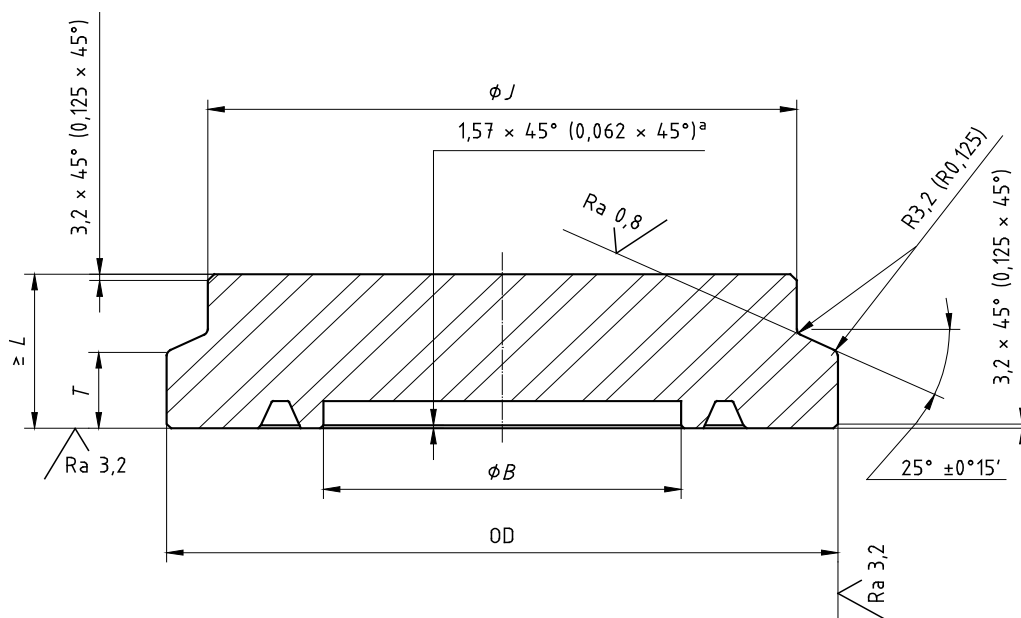
Table 9—Type 16B Integral Hub Connections for 20.7 MPa (3,000 psi) Rated Working Pressure

Nominal Size	Bore	Outside Diameter	Total Thickness	Large Diameter of Neck	Minimum Neck Length	Ring Groove Number	Clamp Number
mm (in.)	<i>B</i> mm (in.)	OD mm (in.)	<i>T</i> mm (in.)	<i>J</i> mm (in.)	<i>L</i> mm (in.)		
279 (11)	279.40 (11.000)	396.88 (15.626)	35.52 (1.399)	355.60 (14.000)	79.5 (3.13)	SR-53	9
346 (13 5/8)	346.10 (13.625)	466.72 (18.375)	33.92 (1.336)	425.45 (16.750)	81.0 (3.19)	SR-57	11
425 (16 3/4)	425.45 (16.750)	539.76 (21.250)	37.04 (1.459)	498.45 (19.625)	93.4 (3.68)	SR-65	14
Tolerance mm	+0.79 0	+0.13 -0.13	+0 -0.25	+0.0 -0.79	-1.52		
(in)	(+0.031) (-0)	(+0.005) (-0.005)	(+0) (-0.010)	(+0) (-0.031)	(-0.06)		



Dimensions in millimeters (inches) / Surface roughness in micrometers

Figure 3—Type 16B and 16BX Integral Hub Connections



Dimensions in millimeters (inches) / Surface roughness in micrometers

NOTE 1 For 13.8 MPa (2000 psi) and 20.7 MPa (3000 psi) type 16B blind hubs, refer to Table 8 and Table 9 for hub dimensions, ring groove dimensions, and tolerances. If corrosion-resistant inlay is used in ring grooves, refer to Table 10 for rough machining detail.

NOTE 2 For 34.5 MPa (5000 psi), 69.0 MPa (10,000 psi), 103.5 MPa (15,000 psi), and 138.0 MPa (20,000 psi) type 16BX blind hubs, refer to Table 12, Table 13, Table 14, or Table 15 for hub dimensions, ring groove dimensions, and tolerances. If corrosion-resistant inlay is used in ring grooves, refer to API 6A for rough machining details.

NOTE 3 The counterbore of a type 16B or type 16BX blind hub is optional. If the counterbore is used, the depth of the counterbore cannot exceed the dimension and tolerance of E or C as shown in the appropriate ring groove dimension table.

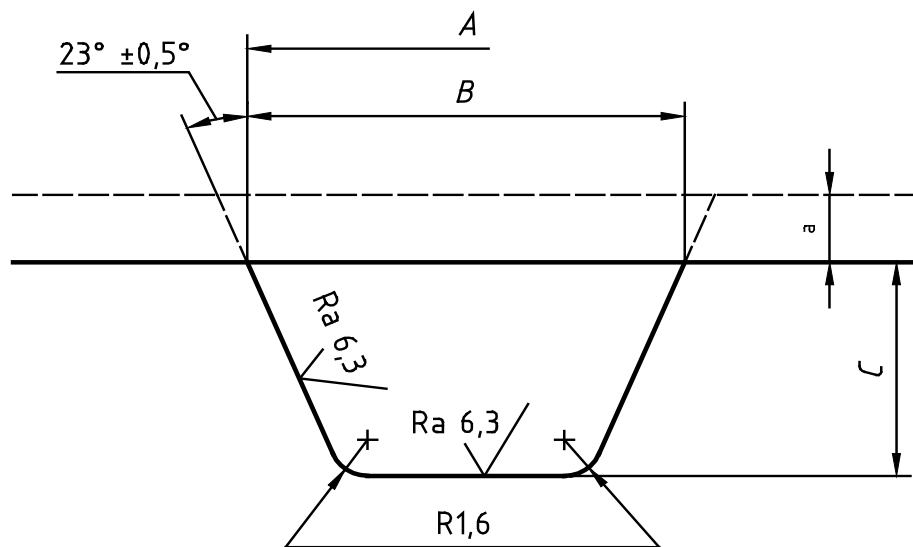
^a length of chamfer on optional counterbore "B"

Figure 4—Type 16B and 16BX Blind Hubs

Prior to overlay, the ring groove shall be prepared as specified in Table 10 and Figure 5.

Table 10—Rough Machining of Type SR Ring Grooves

Ring Groove Number	Outside Diameter of Groove A		Width of Groove B		Depth of Groove C	
	mm	(in.)	mm	(in.)	mm	(in.)
SR-45	237	(9.4)	24	(1.0)	18	(0.7)
SR-53	350	(13.8)	24	(1.0)	18	(0.7)
SR-57	406	(16.0)	24	(1.0)	18	(0.7)
SR-65	495	(19.5)	24	(1.0)	18	(0.7)
SR-73	612	(24.1)	27	(1.1)	21	(0.9)
Tolerance	+7 / 0	(+0.3) / (0)	+7 / 0	(+0.3) / (0)	+7 / 0	(+0.3) / (0)



Dimensions in millimeters (inches) / Surface roughness in micrometers

^a Allow 3.2 mm (¹/₈ in.) or greater for final machining of overlay.

Figure 5—Rough Machining of Type SR Ring Grooves

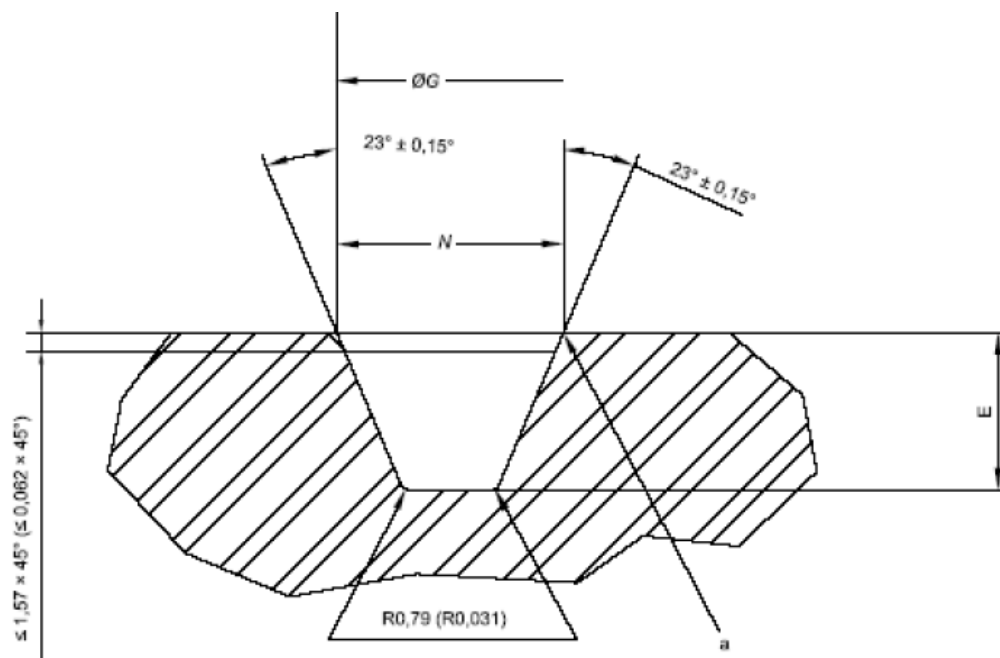
Dimensions for ring grooves shall conform to Table 11 and Figure 6. All 23° surfaces of ring grooves shall have a surface finish no rougher than $Ra = 1.6 \mu\text{m}$ [63 μin (micro-inch) RMS].

NOTE 2 Other weld preparations may be employed when the strength of the overlay alloy equals or exceeds the strength of the base metal.

Dimensions shall apply to machining dimensions and shall not apply to post-test or post-hub and ring gasket makeup.

Table 11—Finish of Machining of Type SR Ring Grooves

Ring Groove Number	Outside Diameter of Groove <i>G</i>		Width of Groove <i>N</i>		Depth of Groove <i>E</i>	
	mm	(in.)	mm	(in.)	mm	(in.)
SR-45	228.27	(8.987)	16.97	(0.668)	14.28	(0.562)
SR-53	340.49	(13.405)	16.97	(0.668)	14.28	(0.562)
SR-57	397.13	(15.635)	16.97	(0.668)	14.28	(0.562)
SR-65	486.03	(19.135)	16.97	(0.668)	14.28	(0.562)
SR-73	603.33	(23.753)	19.92	(0.784)	17.48	(0.688)
Tolerance	+0.09 / -0.0	(+0.004) / (-0.0)	+0.09 / -0.0	(+0.004) / (-0.0)	+0.38 / -0.0	(+0.016) / (-0.0)



All ring groove surfaces shall have a surface finish no rougher than 63 micro-inch RMS.

a Break Sharp Corner

Dimensions in millimeters (inches)

Figure 6—Finish Machining of Type SR Ring Grooves

4.3.4.3 Type 16BX Hubs

Type 16BX hubs shall be of the ring joint type and are designed for face-to-face makeup. Type BX ring gaskets shall be used for these connections.

Dimensions for type 16BX integral hubs shall conform to Table 12, Table 13, Table 14, or Table 15, and Figure 3.

Dimensions for type 16BX blind hubs shall conform to Table 12, Table 13, Table 14, or Table 15, and Figure 4.

Dimensions for all ring grooves shall conform to API 6A.

Type 16BX hubs shall use type BX gaskets in accordance with 4.3.6.

NOTE 1 Type 16BX hubs may be manufactured with corrosion-resistant overlays in the ring grooves.

NOTE 2 Other weld preparations may be employed when the strength of the overlay alloy equals or exceeds the strength of the base material.

NOTE 3 The counterbore in a type 16BX blind hub is optional.

NOTE 4 Friction inhibits makeup and assists in holding the connection at operating and test conditions.

NOTE 5 The coefficient of friction stated here is that used for clamp and hub design. This specification is not applicable to materials or coatings which have different coefficients of friction.

If the counterbore is used, the depth of the counterbore shall not exceed the dimension and tolerance of the ring groove depth, *C* or *E*, as shown in the appropriate ring groove dimension table.

Table 12—Type 16BX Integral Hub Connections for 34.5 MPa (5,000 psi) Rated Working Pressure

Nominal Size	Bore	Outside Diameter	Total Thickness	Large Diameter of Neck	Minimum Neck Length	Ring Groove Number	Clamp Number
mm (in.)	<i>B</i> mm (in.)	OD mm (in.)	<i>T</i> mm (in.)	<i>J</i> mm (in.)	<i>L</i> mm (in.)		
52 (2 ¹ / ₁₆)	52.40 (2.063)	127.78 (5.031)	29.60 (1.166)	92.85 (3.656)	56.3 (2.22)	BX-152	1
65 (2 ⁹ / ₁₆)	65.10 (2.563)	146.84 (5.781)	29.60 (1.166)	111.90 (4.406)	57.6 (2.27)	BX-153	2
79 (3 ¹ / ₈)	79.40 (3.125)	160.32 (6.312)	29.60 (1.166)	125.40 (4.938)	59.9 (2.36)	BX-154	4
103 (4 ¹ / ₁₆)	103.20 (4.063)	193.68 (7.625)	30.40 (1.197)	158.75 (6.250)	60.4 (2.38)	BX-155	5
130 (5 ¹ / ₈)	130.20 (5.125)	276.23 (10.875)	37.06 (1.459)	234.95 (9.250)	85.85 (3.38)	BX-169	7
178 (7 ¹ / ₁₆)	179.40 (7.063)	336.54 (13.250)	41.18 (1.622)	295.25 (11.625)	85.8 (3.38)	BX-156	8
228 (9)	228.60 (9.000)	336.54 (13.250)	41.18 (1.622)	295.25 (11.625)	85.8 (3.38)	BX-157	8
279 (11)	279.40 (11.000)	412.76 (16.250)	42.00 (1.654)	371.45 (14.625)	104.9 (4.13)	BX-158	10
346 (13 ⁵ / ₈)	346.10 (13.625)	523.88 (20.625)	47.52 (1.871)	482.60 (19.000)	123.9 (4.88)	BX-160	13
425 (16 ³ / ₄)	425.45 (16.750)	650.88 (25.625)	45.16 (1.778)	609.60 (24.000)	139.7 (5.50)	BX-162	19
540 (21 ¹ / ₄)	539.75 (21.250)	793.76 (31.250)	92.20 (3.630)	708.00 (27.875)	171.4 (6.75)	BX-165	27
Tolerance mm	+0.79 -0	+0.13 -0.13	+0 -0.25	+0.0 -0.79	-1.52		
(in)	(+0.031) (-0)	(+0.005) (-0.005)	(+0) (-0.010)	(+0) (-0.031)	(-0.06)		

Table 13—Type 16BX Integral Hub Connections for 69.0 MPa (10,000 psi) Rated Working Pressure

Nominal Size	Bore	Outside Diameter	Total Thickness	Large Diameter of Neck	Minimum Neck Length	Ring Groove Number	Clamp Number
<i>B</i>	<i>B</i>	OD	<i>T</i>	<i>J</i>	<i>L</i>		
mm (in.)	mm (in.)	mm (in.)	mm (in.)	mm (in.)	mm (in.)		
46 (1 ¹³ / ₁₆)	46.05 (1.813)	127.78 (5.031)	29.60 (1.166)	92.85 (3.656)	56.3 (2.22)	BX-151	1
52 (2 ¹ / ₁₆)	52.40 (2.063)	146.84 (5.781)	29.60 (1.166)	111.90 (4.406)	57.6 (2.27)	BX-152	2
65 (2 ⁹ / ₁₆)	65.10 (2.563)	160.32 (6.312)	29.60 (1.166)	125.40 (4.938)	59.9 (2.36)	BX-153	4
78 (3 ¹ / ₁₆)	77.80 (3.063)	193.68 (7.625)	30.40 (1.197)	158.75 (6.250)	60.4 (2.38)	BX-154	5
103 (4 ¹ / ₁₆)	103.20 (4.063)	214.30 (8.437)	33.26 (1.310)	173.00 (6.812)	71.6 (2.82)	BX-155	6
130 (5 ¹ / ₈)	130.20 (5.125)	276.23 (10.875)	37.06 (1.459)	234.95 (9.250)	85.85 (3.38)	BX-169	7
178 (7 ¹ / ₁₆)	179.40 (7.063)	412.76 (16.250)	41.98 (1.653)	371.45 (14.625)	104.9 (4.13)	BX-156	10
228 (9)	228.60 (9.000)	412.76 (16.250)	41.98 (1.653)	371.45 (14.625)	104.9 (4.13)	BX-157	10
279 (11)	279.40 (11.000)	523.88 (20.625)	51.68 (2.035)	473.05 (18.625)	120.6 (4.75)	BX-158	22
346 (13 ⁵ / ₈)	346.10 (13.625)	565.16 (22.250)	58.64 (2.309)	523.85 (20.625)	134.8 (5.31)	BX-159	15
425 (16 ³ / ₄)	425.45 (16.750)	711.20 (28.000)	76.32 (3.005)	635.00 (25.000)	156.7 (6.17)	BX-162	28
476 (18 ³ / ₄)	476.25 (18.750)	793.76 (31.250)	92.20 (3.630)	708.00 (27.875)	171.4 (6.75)	BX-164	27
540 (21 ¹ / ₄)	539.75 (21.250)	863.60 (34.000)	101.72 (4.005)	774.70 (30.500)	208.7 (8.22)	BX-166	26
Tolerance mm	+0.79 -0	+0.13 -0.13	+0.0 -0.25	+0.0 -0.79	-1.52		
(in)	(+0.031) (-0)	(+0.005) (-0.005)	(+0) (-0.010)	(+0) (-0.031)	(-0.06)		

Table 14—Type 16BX Integral Hub Connections for 103.5 MPa (15,000 psi) Rated Working Pressure

Nominal Size	Bore	Outside Diameter	Total Thickness	Large Diameter of Neck	Minimum Neck Length	Ring Groove Number	Clamp Number
mm (in.)	B mm (in.)	OD mm (in.)	T mm (in.)	J mm (in.)	L mm (in.)		
46 (1 ¹³ / ₁₆)	46.05 (1.813)	146.84 (5.781)	29.60 (1.166)	111.90 (4.406)	57.6 (2.27)	BX-151	2
52 (2 ¹ / ₁₆)	52.40 (2.063)	155.58 (6.125)	41.18 (1.622)	114.30 (4.500)	81.7 (3.22)	BX-152	3
65 (2 ⁹ / ₁₆)	65.10 (2.563)	155.58 (6.125)	41.18 (1.622)	114.30 (4.500)	81.7 (3.22)	BX-153	3
78 (3 ¹ / ₁₆)	77.80 (3.063)	214.30 (8.437)	33.26 (1.310)	173.00 (6.812)	71.6 (2.82)	BX-154	6
103 (4 ¹ / ₁₆)	103.20 (4.063)	336.54 (13.250)	41.18 (1.622)	295.25 (11.625)	85.8 (3.38)	BX-155	8
130 (5 ¹ / ₈)	130.20 (5.125)	336.54 (13.250)	41.18 (1.622)	295.25 (11.625)	85.8 (3.38)	BX-169	8
179 (7 ¹ / ₁₆)	179.40 (7.063)	523.90 (20.626)	51.68 (2.035)	473.05 (18.625)	120.6 (4.75)	BX-156	22
279 (11)	279.40 (11.000)	565.16 (22.250)	58.64 (2.309)	523.85 (20.625)	134.8 (5.31)	BX-158	15
346 (13 ⁵ / ₈)	346.10 (13.625)	711.20 (28.000)	76.32 (3.005)	635.00 (25.000)	156.7 (6.17)	BX-159	28
476 (18 ³ / ₄)	476.25 (18.750)	863.60 (34.000)	101.72 (4.005)	774.70 (30.500)	208.7 (8.22)	BX-164	26
Tolerance mm	+0.79 -0	+0.13 -0.13	+0.0 -0.25	+0.0 -0.79	-1.52		
(in)	(+0.031) (-0)	(+0.005) (-0.005)	(+0) (-0.010)	(+0) (-0.031)	(-0.06)		

Table 15—Type 16BX Integral Hub Connections for 138.0 MPa (20,000 psi) Rated Working Pressure

Nominal Size	Bore	Outside Diameter	Total Thickness	Large Diameter of Neck	Minimum Neck Length	Ring Groove Number	Clamp Number
<i>B</i>	OD	<i>T</i>	<i>J</i>	<i>L</i>			
mm (in.)	mm (in.)	mm (in.)	mm (in.)	mm (in.)	mm (in.)		
46 (1 ¹³ / ₁₆)	46.05 (1.813)	155.58 (6.125)	41.18 (1.622)	114.30 (4.500)	81.7 (3.22)	BX-151	3
52 (2 ¹ / ₁₆)	52.40 (2.063)	155.58 (6.125)	41.18 (1.622)	114.30 (4.500)	81.7 (3.22)	BX-152	3
65 (2 ⁹ / ₁₆)	65.10 (2.563)	214.30 (8.437)	33.26 (1.310)	173.00 (6.812)	71.6 (2.82)	BX-153	6
78 (3 ¹ / ₁₆)	77.80 (3.063)	336.54 (13.250)	41.18 (1.622)	295.25 (11.625)	85.8 (3.38)	BX-154	8
103 (4 ¹ / ₁₆)	103.20 (4.063)	412.76 (16.250)	41.98 (1.653)	371.45 (14.625)	104.9 (4.13)	BX-155	10
179 (7 ¹ / ₁₆)	179.40 (7.063)	565.16 (22.250)	58.64 (2.309)	523.85 (20.625)	134.8 (5.31)	BX-156	15
279 (11)	279.40 (11.000)	711.20 (28.000)	76.32 (3.005)	635.00 (25.000)	171.4 (6.17)	BX-158	28
Tolerance mm	+0.79 -0	+0.13 -0.13	-0.0 -0.25	-0.0 -0.79	-1.52		
(in)	(+0.031) (-0)	(+0.005) (-0.005)	(+0) (-0.010)	(+0) (-0.031)	(-0.06)		

The dimensions shall apply to machining dimensions and shall not apply to post-test or post-hub and ring gasket makeup.

Consideration shall be given to the application to determine the appropriate use of blind or target flanges.

The coefficient of friction shall be considered and shall be + 0.1 at makeup and – 0.1 while operating.

Prior to overlay, the ring grooves shall be rough machined to conform to API 6A.

If materials with other coefficients of friction are used, the manufacturer shall include those coefficients in the design.

4.3.5 Clamps

4.3.5.1 General

This subsection provides the minimum design, material, and dimensional requirements for clamps that shall be used in conjunction with type 16B and type 16BX hubs conforming to 4.3.4.

4.3.5.2 Design

Clamps shall be designed for use in the combination of designated size ranges and pressure ratings shown in Table 16. Clamps shall be designated by the clamp number shown in Table 16.

Clamp connectors shall be designed according to 4.4.2. Each clamp shall be designed for the highest loading that may be induced by any hub it is intended to fit.

Table 16—Clamps for Type 16B and 16BX Hub Connections

Clamp No.	Hub				Clamp No.	Hub			
	Designated Size A		Working Pressure			Designated Size A		Working Pressure	
	mm	(in.)	MPa	(psi)		mm	(in.)	MPa	(psi)
1	46	(1 ¹³ / ₁₆)	68.95	(10,000)	10	103	(4 ¹ / ₁₆)	137.9	(20,000)
	52	(2 ¹ / ₁₆)	34.45	(5000)		179	(7 ¹ / ₁₆)	68.95	(10,000)
2	46	(1 ¹³ / ₁₆)	103.4	(15,000)		228	(9)	68.95	(10,000)
	52	(2 ¹ / ₁₆)	68.95	(10,000)		279	(11)	34.45	(5000)
	65	(2 ⁹ / ₁₆)	34.45	(5000)	11	346	(13 ⁵ / ₈)	20.68	(3000)
3	46	(1 ¹³ / ₁₆)	137.9	(20,000)	12	425	(16 ³ / ₄)	13.79	(2000)
	52	(2 ¹ / ₁₆)	103.4	(15,000)	13	346	(13 ⁵ / ₈)	34.45	(5000)
	52	(2 ¹ / ₁₆)	137.9	(20,000)	14	425	(16 ³ / ₄)	20.68	(3000)
	65	(2 ⁹ / ₁₆)	103.4	(15,000)	15	179	(7 ¹ / ₁₆)	137.9	(20,000)
4	65	(2 ⁹ / ₁₆)	68.95	(10,000)		279	(11)	103.4	(15,000)
	79	(3 ¹ / ₈)	34.45	(5000)		346	(13 ⁵ / ₈)	68.95	(10,000)
5	78	(3 ¹ / ₁₆)	68.95	(10,000)	18	540	(21 ¹ / ₄)	13.79	(2000)
	103	(4 ¹ / ₁₆)	34.45	(5000)	19	425	(16 ³ / ₄)	34.45	(5000)
6	65	(2 ⁹ / ₁₆)	137.9	(20,000)	22	179	(7 ¹ / ₁₆)	103.4	(15,000)
	78	(3 ¹ / ₁₆)	103.4	(15,000)		279	(11)	68.95	(10,000)
	103	(4 ¹ / ₁₆)	68.95	(10,000)	25	179	(7 ¹ / ₁₆)	13.79	(2000)
7	130	(5 ¹ / ₈)	34.45	(5000)	26	476	(18 ³ / ₄)	103.4	(15,000)
	130	(5 ¹ / ₈)	68.95	(10,000)		540	(21 ¹ / ₄)	68.95	(10,000)
8	78	(3 ¹ / ₁₆)	137.9	(20,000)	27	476	(18 ³ / ₄)	68.95	(10,000)
	103	(4 ¹ / ₁₆)	103.4	(15,000)		540	(21 ¹ / ₄)	34.45	(5000)
	130	(5 ¹ / ₈)	103.4	(15,000)	28	279	(11)	137.9	(20,000)
	179	(7 ¹ / ₁₆)	34.45	(5000)		346	(13 ⁵ / ₈)	103.4	(15,000)
	228	(9)	34.45	(5000)		425	(16 ³ / ₄)	68.95	(10,000)
9	279	(11)	20.68	(3000)					

The clamp bore shall provide a minimum of 3 mm (0.125 in.) radial clearance around the hub neck in the made-up condition on all hubs it is designed to fit.

All clamps shall have one or more bolts at each connecting point.

Spherical-face heavy hexagonal nuts or spherical washers shall be used to minimize potential bending in bolts.

Clamp-bolting stresses shall conform to 4.4.2. Torque values and lubricant for clamp bolting shall be determined by the manufacturer to assure sufficient preload in the connection. Stresses shall be calculated at makeup, operating, and test conditions. The coefficient of friction shall be considered and shall be + 0.1 at makeup and – 0.1 while operating.

NOTE 1 Friction inhibits makeup and assists in holding the connection at operating and test conditions.



Documents

Document Sharing Hub

NOTE 2 The coefficient of friction stated here is that used for clamp and hub design. This specification is not applicable to materials or coatings that have different coefficients of friction.

If materials with other coefficients of friction are used, the manufacturer shall include those coefficients in the design.

Makeup stresses are directly proportional to the bolt loads and shall be determined based on the greater of:

- the bolt load required to seat the gasket and bring the hub faces into contact, or
- the bolt load required to retain the sum of the rated working pressure end load and the gasket retaining load.

Makeup of the clamp shall be sufficient such that the hub faces meet and there is no change in facial separation at the hub OD at rated working pressure.

Operating stresses shall be determined using the stresses resulting from the sum of the rated working pressure end load and the gasket-retaining load.

Test condition stresses shall be determined using the stresses resulting from the sum of the test pressure end load and the gasket-retaining load.

The stresses shall be determined using the outside diameter of the gasket as the sealing diameter.

All clamps shall have grooves in their bores with angles of $25^\circ \pm 0^\circ 15'$ to fit type 16B and type 16BX hubs (see Figure 7).

All 25° surfaces in clamp grooves shall have a surface finish R_a of $0.8 \mu\text{m}$ ($32 \mu\text{in RMS}$) or less.

4.3.5.3 Material

Clamps shall be manufactured from material conforming to this specification. Material requirements of NACE MR0175/ISO 15156 are not necessary.

Bolting shall conform to 4.3.3.

Material for washers shall meet the manufacturer's written material specification.

4.3.6 Ring Gaskets

Gaskets used for equipment manufactured to this specification shall meet all the requirements of API 6A.

Type R, RX, and BX ring-joint gaskets are used in flanged, studded, and hub connections. Types R and RX gaskets are interchangeable in type R ring grooves. Only type RX gaskets shall be used with SR ring grooves. Only type BX gaskets shall be used with 6BX ring grooves. Type RX and BX gaskets are not interchangeable. See Table 17 for a summary of groove and gasket usage.

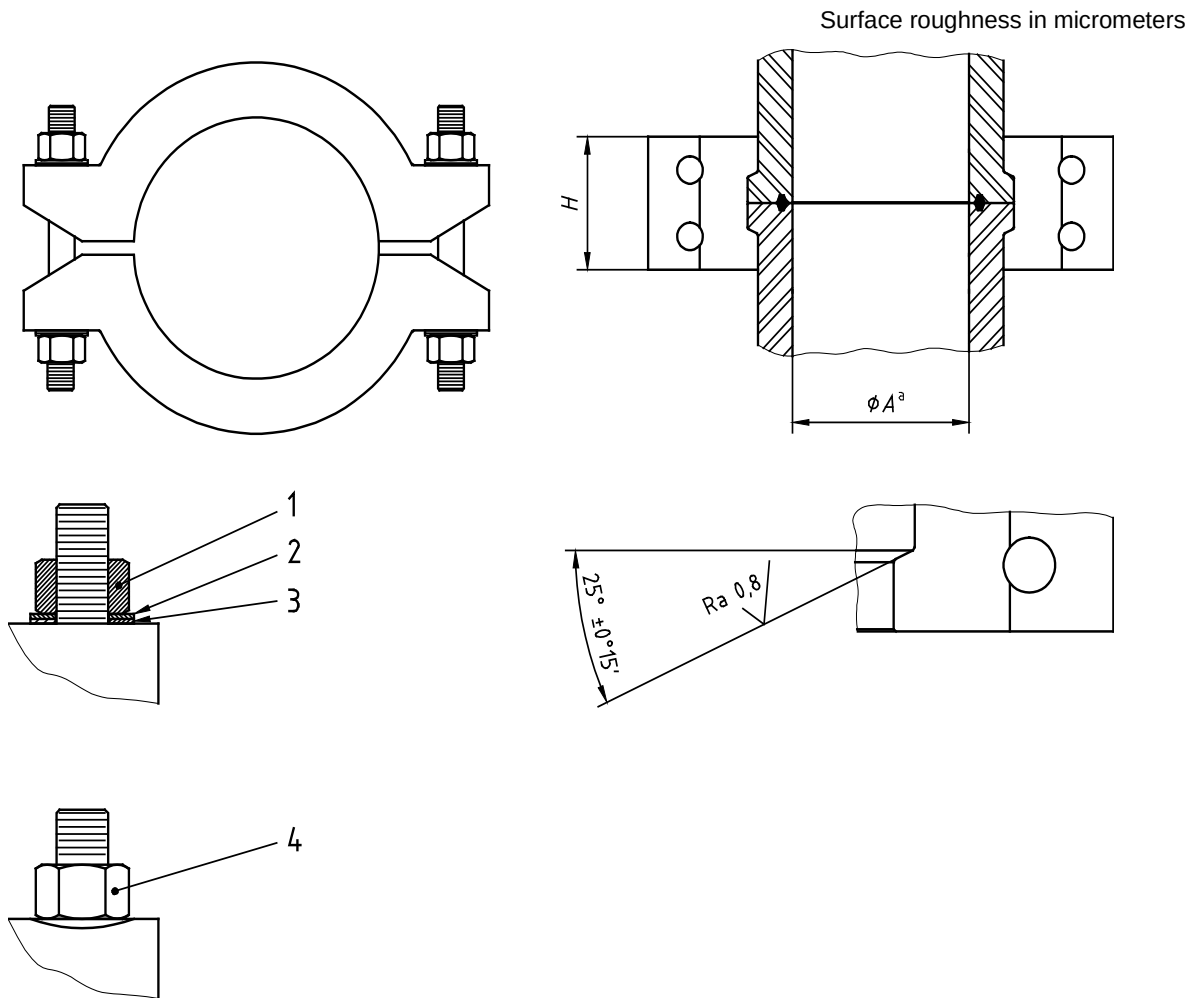
4.3.7 Blowout Preventers and Drilling Spools

4.3.7.1 Dimensions

Blowout preventers and drilling spools shall be identified by the size designation shown in Table 1.

The end-to-end dimension for blowout preventers, drilling spools, and spacer spools shall be the overall height from the bottom face of the bottom connection to the top face of the top connection. This dimension shall be in accordance with the manufacturer's written specifications.

Blowout preventers, drilling spools, and spacer spools shall have a cylindrical passage (bore) through the body, including end connections. The drill-through diameter shall conform to the size designation and shall allow passage of a drift with a diameter, as shown in Table 1.

**Key**

- 1 Nut
- 2 Outer washer
- 3 Inner washer
- 4 Spherical nut

^a Size designation as specified in Table 16

Maximum height (H) of clamp is $H = 2L - 0.12$ in.

NOTE Dimension L can be found on the appropriate hub table (see Tables 12 through 15)

Figure 7—Clamps for Type 16B and 16BX Hub Connections

Table 17—Ring Gasket Numbers for API 6A/16A Equipment

Ring Number	Designated Size		Rated Working Pressure		Ring Number	Designated Size		Rated Working Pressure	
	mm	(in.)				mm	(in.)		
Type 6B Integral Flange Connections					BX 159	346	(13 ⁵ / ₈)	103.5	(15,000)
R or RX 45	179	(7 ¹ / ₁₆)	13.8 (2000)		BX 164	476	(18 ³ / ₄)	138 (20,000)	
R or RX 49	228	(9)			BX 156	179	(7 ¹ / ₁₆)		
R or RX 53	279	(11)			BX 157	228	(9)		
R or RX 57	346	(13 ⁵ / ₈)			BX 158	279	(11)		
R or RX 65	425	(16 ³ / ₄)			BX 159	346	(13 ⁵ / ₈)		
R or RX 73	540	(21 ¹ / ₄)			Type 16B Integral Hub Connections				
R or RX 45	179	(7 ¹ / ₁₆)	20.7 (3,000)		RX 45	179	(7 ¹ / ₁₆)	13.8 (2000)	
R or RX 49	228	(9)			RX 65	425	(16 ³ / ₄)		
R or RX 53	279	(11)			RX 73	540	(21 ¹ / ₄)		
R or RX 57	346	(13 ⁵ / ₈)			RX 53	279	(11)	20.7 (3000)	
R or RX 66	425	(16 ³ / ₄)			RX 57	346	(13 ⁵ / ₈)		
R or RX 74	527	(20 ³ / ₄)			RX 65	425	(16 ³ / ₄)		
R or RX 46	179	(7 ¹ / ₁₆)	34.5 (5000)		Type 16BX Integral Hub Connections				
R or RX 50	228	(9)			BX-169	130	(5 ¹ / ₈)	34.5 (5000)	
R or RX 54	279	(11)			BX 156	179	(7 ¹ / ₁₆)		
Type 6BX Integral Flange Connections					BX 157	228	(9)		
BX 167	679	(26 ³ / ₄)	13.8 (2000)		BX 158	279	(11)	69 (10,000)	
BX 303	762	(30)			BX 160	346	(13 ⁵ / ₈)		
BX 168	679	(26 ³ / ₄)	20.7 (3000)		BX 162	425	(16 ³ / ₄)		
BX 303	762	(30)			BX 165	540	(21 ¹ / ₄)		
BX 160	346	(13 ⁵ / ₈)	34.5 (5000)		BX-169	130	(5 ¹ / ₈)		
BX 162	425	(16 ³ / ₄)			BX 156	179	(7 ¹ / ₁₆)		
BX 163	476	(18 ³ / ₄)			BX 157	228	(9)		
BX 165	540	(21 ¹ / ₄)			BX 158	279	(11)		
BX 156	179	(7 ¹ / ₁₆)	69 (10,000)		BX 159	346	(13 ⁵ / ₈)	103.5 (15,000)	
BX 157	228	(9)			BX 162	425	(16 ³ / ₄)		
BX 158	279	(11)			BX 164	476	(18 ³ / ₄)		
BX 159	346	(13 ⁵ / ₈)			BX 166	540	(21 ¹ / ₄)		
BX 162	425	(16 ³ / ₄)			BX-169	130	(5 ¹ / ₈)		
BX 164	476	(18 ³ / ₄)			BX 156	179	(7 ¹ / ₁₆)		
BX 166	540	(21 ¹ / ₄)			BX 158	279	(11)		
BX 156	179	(7 ¹ / ₁₆)	103.5 (15,000)		BX 159	346	(13 ⁵ / ₈)	138 (20,000)	
BX 157	228	(9)			BX 164	476	(18 ³ / ₄)		
BX 158	279	(11)			BX 156	179	(7 ¹ / ₁₆)		
					BX 158	279	(11)		

4.3.7.2 Design

Design methods shall conform to 4.4.

End connections on all equipment within the scope of this specification shall conform to the requirements of 4.3.1, 4.3.2, 4.3.4, or 4.3.9.

Outlet connections shall conform to the requirements of 4.3.1, 4.3.2, 4.3.4, or 4.3.9. The number of outlets is optional.

4.3.7.3 Material

Material used for pressure-containing parts shall conform to Section 5.

Closure bolting shall conform to 4.3.3, and other parts shall conform to the manufacturer's written specification.

4.3.8 Weld Neck Hubs

This specification is not applicable to weld neck hubs.

4.3.9 Other End Connections (OECs)

4.3.9.1 General

This subsection provides requirements for other end connections that may be used for joining drill-through equipment and that are not specified in an API standard. OECs include flanges and hubs in accordance with this standard, but with proprietary gasket preparations. OECs may also be in accordance with the manufacturer's specifications.

4.3.9.2 Design

OECs shall be designed in accordance with 4.4.

OECs shall be designed with the designated sizes shown in Table 1.

The bore diameter shall conform to the minimum bore dimension, as shown in Table 1.

4.3.9.3 Materials

OEC materials shall meet the requirements of Section 5.

4.3.9.4 Testing

Equipment utilizing OECs shall successfully complete the tests required in Section 7.

4.3.10 Blind Connections

4.3.10.1 Flanges

Type 6B and 6BX blind flanges shall conform to the dimensional requirements of API 6A.

4.3.10.2 Hubs

Dimensions of 16B and 16BX blind hubs shall conform to Figure 4 and Table 8, Table 9, Table 12, Table 13, Table 14, or Table 15, in accordance with applicable size and pressure rating.

4.3.10.3 Other End Connections (OECs)

The design and configuration of blind OECs shall conform to 4.3.9.2, 4.3.9.3, and 4.3.9.4.

4.3.11 Adapters

End connections shall meet the requirements of 4.3.1, 4.3.2, 4.3.4, or 4.3.9.

NOTE Length of adapters is not addressed in this specification.

4.3.12 Hydraulic Connectors

4.3.12.1 Dimensions

Hydraulic connectors shall be identified by the designated size in Table 1.

The end-to-end dimensions for hydraulic connectors shall include both the overall height and the height from the internal face (which connects to the wellhead or blowout-preventer mandrel) to the face of the top end connection. These dimensions are not standardized and shall conform to the manufacturer's written specifications.

The bore diameter shall conform to the minimum bore dimension of the end connections as shown in Table 1.

4.3.12.2 Design

Design methods shall conform to 4.4.

There shall be no hub face separation of the connection face when locked with manufacturer's recommended operating pressure and tested at rated working pressure.

NOTE Maximum recommended latching pressure may be used.

4.3.12.3 Connections

The top connection shall conform to the requirements of 4.3.1, 4.3.2, 4.3.4, or 4.3.9.

The bottom connection shall lock and seal on the adapter or wellhead as specified by the manufacturer.

4.3.12.4 Gasket Retention Mechanism

A gasket retention mechanism shall be provided.

NOTE This mechanism may be hydraulic or mechanical.

4.3.12.5 Position Indicator

A position-indicating device shall be provided to visually show if the connector is locked or unlocked.

4.3.12.6 Material

Material shall conform to the requirements of Section 5.

4.3.12.7 Locks

Hydraulic connectors shall be designed to include primary and secondary unlocking functionality.

4.3.13 Test, Vent, Injection, and Gauge Connections

Sealing and porting of flanges, hubs, and OECs shall conform to the requirements of API 6A.

4.4 Design Methods

4.4.1 End and Outlet Connections

End and outlet connections shall conform to the requirements of this specification.

End and outlet connections to the wellbore shall be integral.

4.4.2 Pressure-containing, Pressure-controlling, or Pressure-retaining Parts

4.4.2.1 General

Parts or members shall be designed in accordance with one or more of the methods given in 4.4.2.1 to 4.4.2.4

If equipment is being designed to operate where higher-than-normal atmospheric (14.7 psi) differential pressures (psid) exist, the differential pressure of the intended service shall be considered in the design verification analysis and validation of the equipment. Particular care should be given to identifying trapped voids in the equipment and analyzing the effects of those voids on the system in an externally pressurized environment.

NOTE 1 Validation testing may be performed with test fixtures.

NOTE 2 This specification is not applicable to fatigue analysis and localized bearing stress values. Design decisions based only on the allowable methods shown may not be sufficient for all service conditions.

4.4.2.2 Design Methodology

The design methodology described in API 6X shall be used.

NOTE The use of von Mises equivalent stress is permitted.

4.4.2.3 Distortion Energy Theory

NOTE 1 Distortion energy theory, also known as von Mises Law, may be used for design calculations. Rules for the consideration of discontinuities and stress concentrations are beyond the scope of this method.

NOTE 2 This design methodology for the basic pressure vessel wall thickness may be sized by combining triaxial stresses based on hydrostatic test pressure, and is limited by the following criterion:

$$S_e = S_y \quad (1)$$

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's specified minimum yield strength.

4.4.2.4 Experimental Stress Analysis

NOTE Application of experimental stress analysis as described in ASME Boiler and Pressure Vessel Code, Section VIII, Division 2, may be used.

4.4.3 Closure Bolting

The maximum tensile stress for closure bolting shall be determined considering:

- initial bolt-up;
- operating conditions, including pressure loads, external mechanical loads, and thermal stress;
- hydrostatic test pressure conditions.

Bolt tensile stress, based on the minimum cross-sectional area of the bolt or stud, shall not exceed the following limits:

$$S_a \leq 0.83 S_y \text{ and} \quad (2)$$

$$S_b \leq 1.0 S_y \quad (3)$$

Where

S_a is the maximum allowable tensile membrane stress;

S_b is the maximum allowable tensile membrane plus bending stress;

S_y is the bolting material's specified minimum yield strength.

4.4.4 Other Parts

Other parts shall be designed to satisfy the manufacturer's written specifications and the service conditions defined in 4.2.

4.4.5 Hydraulic Connectors

The manufacturer shall document the capacity for the hydraulic connector in a chart format that provides a relationship of the internal pressure versus bending moment at various tension/compression levels. Effects of preload, pressure end load, ability to maintain a seal, and hub separation shall be defined. It is recommended that the capacity chart is generated using 3-D finite element analysis.

Additionally, for PR2 requirements, the capacity chart shall include the rated capacities with a design factor of 1.5, extreme capacity with a design factor of 1.25, and survival capacity with a design factor of 1. The design methodology shall be per section 4.4.

NOTE 1 The number of tension/compression lines and magnitude of external tension/compression applied can vary depending on the application.

NOTE 2 An example of a connector capacity chart is shown in Figure 8.

The capacity chart shall be validated by physical testing as described in the section 4.5.

The capacity chart shall be based on the capabilities of the connector assembly and the test wellhead, mandrel, or test stump; the end connection may be excluded.

4.4.6 Clamps

The manufacturer shall document the load/capacity for the clamp connection using the format for API flanges in API 6AF2.

The documented load capacity shall relate pressure to the allowable bending moment for various tensions.

The manufacturer shall state whether the limitation is in the stress level of the clamp or of the hub. Analytical design methods shall conform to 4.4. The manufacturer shall state which part of the connection contains the stress limitations or leakage limitations that form the basis for the graphs.

4.4.7 Other End Connections and LMRP mandrels

The manufacturer shall document the load/capacity for the OEC and LMRP mandrels using the format used for API flanges in API 6AF2.

The documented load capacity shall relate pressure to the allowable bending moment for various tensions.

The manufacturer shall state which part of the connection contains the stress limitations that form the basis for the graphs. Analytical design methods shall conform to 4.4.

4.4.8 Test Stumps

Test stumps shall be designed in accordance with API 6X and manufacturer's specifications.

4.5 Design Validation

4.5.1 General

All parts of the equipment and the entire assembly shall be fully design validated in accordance with the manufacturer's written specifications and/or other internationally recognized standards.

Design validation shall be documented as required in 4.6.