Specification for Drill Through Equipment

API SPECIFICATION 16A
SECOND EDITION, DECEMBER 1997

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American Petroleum Institute

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Exploration and Production Department

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Specification for Drill Through Equipment

1 Scope

1.1 PURPOSE

This specification is formulated to provide for the availability of safe and functionally interchangeable drill through equipment utilized for drilling for oil and gas.

Technical content provides requirements for performance, design, materials, tests and inspection, welding, marking, handling, storing, and shipping. This specification does not apply to field use or field testing of drill through equipment.

Critical components are those parts having requirements specified in this document.

1.2 APPLICATIONS

1.2.1 Equipment

Specific equipment covered by this specification is listed as follows:

a. Ram blowout preventers.
b. Ram blocks, packers and top seals.
c. Annular blowout preventers.
d. Annular packing units.
e. Hydraulic connectors.
f. Drilling spools.
g. Adapters.
h. Loose connections.
i. Clamps.

1.2.2 Interchangeability

Dimensional interchangeability is limited to end and outlet connections.

1.2.3 Service Conditions

Service conditions refer to classifications for pressure, temperature and wellbore fluids listed in 4.2 for which the equipment will be designed.

1.3 PRODUCT SPECIFICATION

This specification establishes requirements for products listed in 1.2.1.

1.4 UNITS AND DIMENSIONING

For the purposes of this specification, the decimal/inch system is the standard for the dimensions shown in this specification. API Size Designation will continue to be shown as fractions. Appendix A gives fraction-to-decimal equivalence. For the purposes of this specification, the fractions and their decimal equivalents are equal and interchangeable.

1.5 METRIC CONVERSIONS

Metric conversions are described in Appendix A.

1.6 APPENDICES

Appendices to this specification shall not be considered as requirements. They are included only as guidelines or information.

2 Referenced Standards

2.1 GENERAL

This specification includes by reference, either in total or in part, other API, industry, and government standards listed in this section.

2.2 REQUIREMENTS

Requirements of other standards included by reference in this specification are essential to the safety and functional interchangeability of the equipment produced.

2.3 ALTERNATE STANDARDS

Other nationally or internationally recognized standards shall be submitted to and approved by API for inclusion in this specification prior to their use as equivalent requirements.

3 Abbreviations/Definitions and Reference

3.1 DEFINITIONS

3.1.1 API Monogram: A registered mark of the American Petroleum Institute.

3.1.2 acceptance criteria: Defined limits placed on characteristics of materials, products, or services.

3.1.3 adapter: A pressure-containing piece of equipment having end connections of different API Size Designation and/or pressure ratings, used to connect other pieces of equipment of different API Size Designation and/or pressure ratings.

3.1.4 body: Any portion of equipment between end connections, with or without internal parts, which contains wellbore pressure.

3.1.5 blowout preventer (BOP): The equipment (or valve) installed at the wellhead to contain wellbore pressure either in the annular space between the casing and the tubulars or in an open hole during drilling, completion, testing, or workover operations.

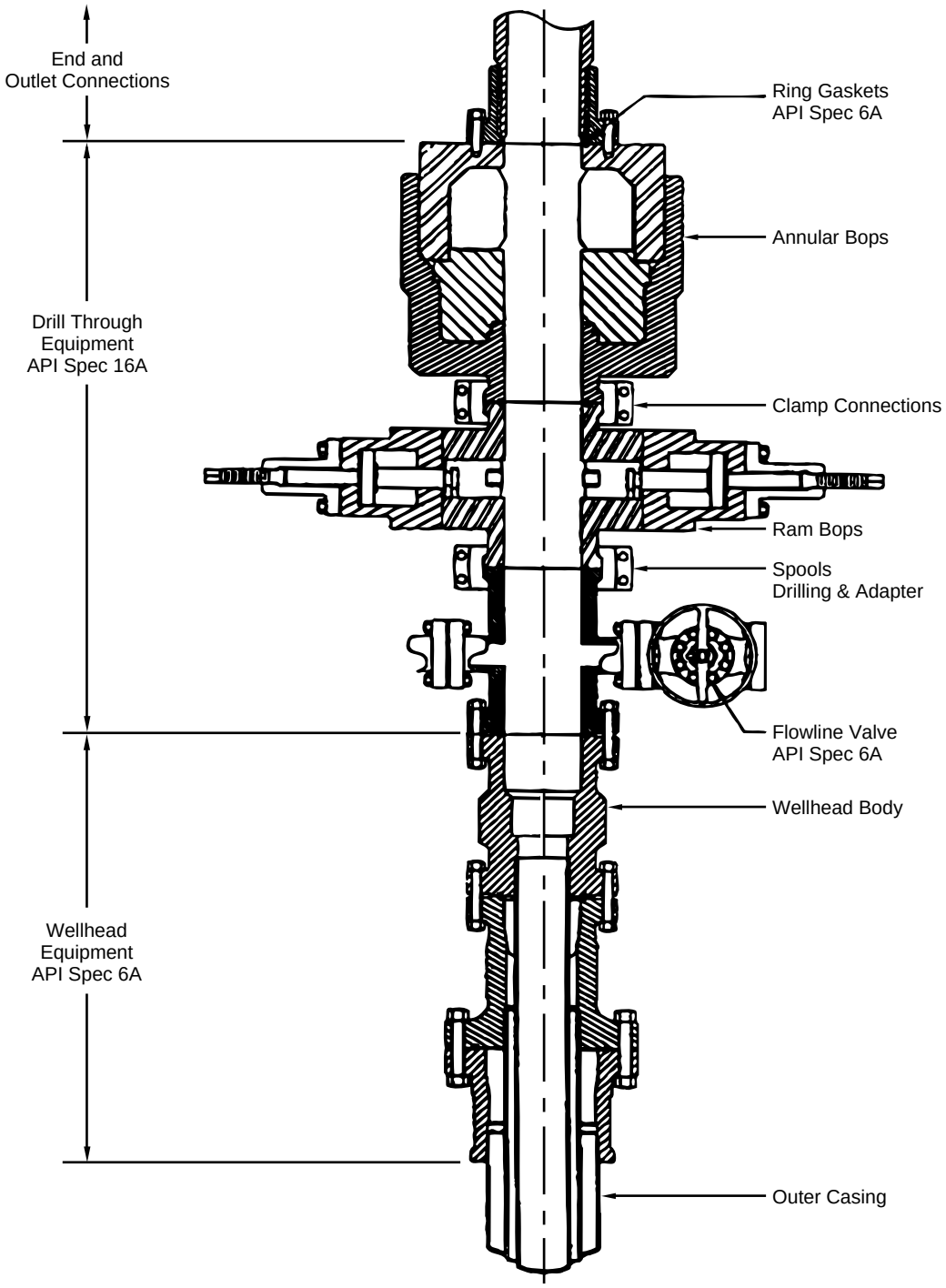


Figure 1—Drill Through Equipment (Typical Surface Equipment)

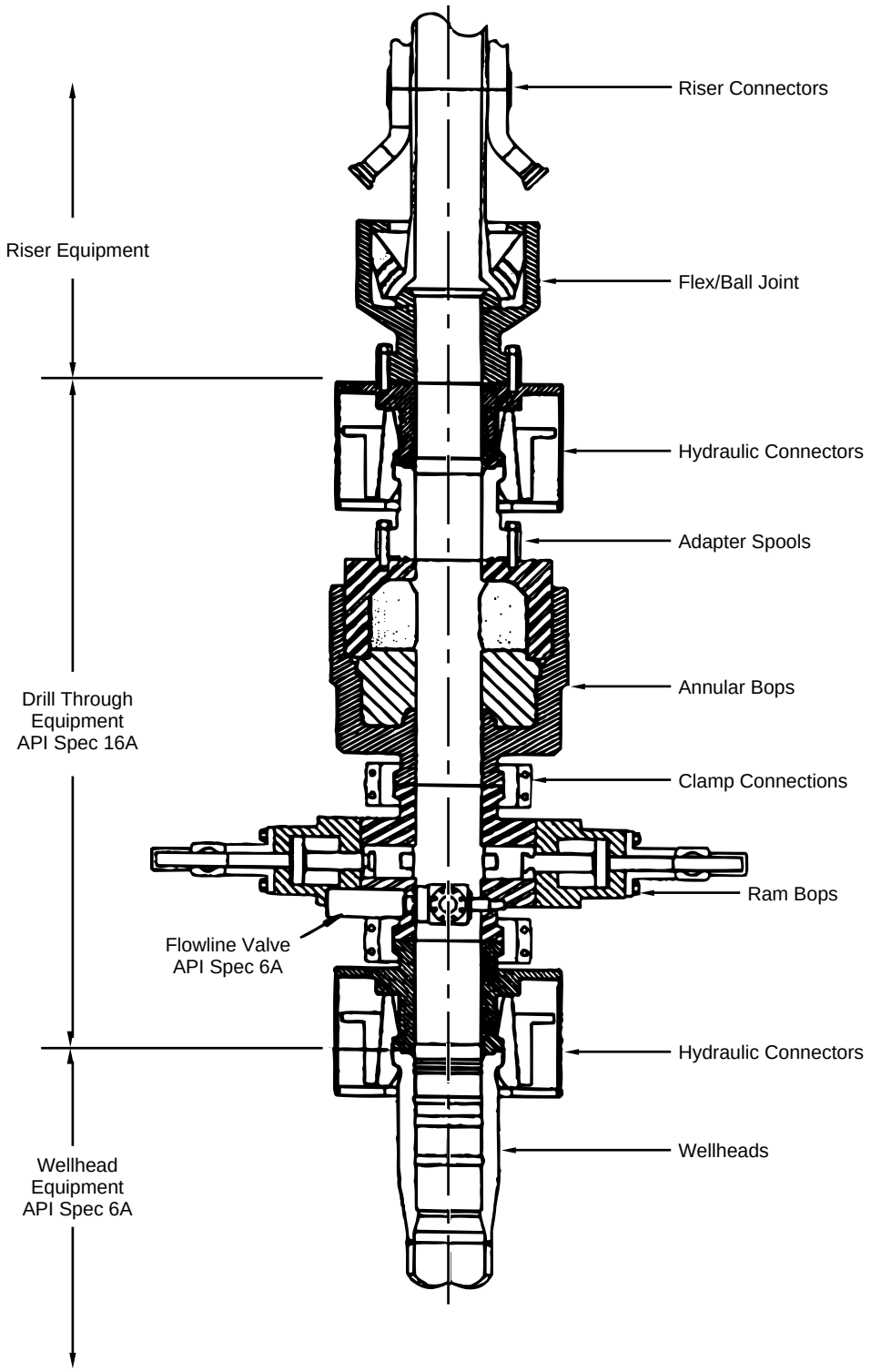


Figure 2—Drill Through Equipment (Typical Subsea Equipment)

3.1.6 blowout preventer, annular: A blowout preventer that uses a shaped elastomeric sealing element to seal the space between the tubular and the wellbore or an open hole.

3.1.7 blowout preventer, ram: A blowout preventer that uses metal blocks with integral elastomer seals to seal off pressure on a wellbore with or without tubulars in the bore.

3.1.8 bolting: Threaded fasteners used to join end or outlet connections.

3.1.9 bolting, closure: Threaded fasteners used to assemble API Specification 16A pressure-containing parts other than end and outlet connections.

3.1.10 calibration: Comparison and adjustment to a standard of known accuracy.

3.1.11 casting: (1) An object at or near finished shape obtained by solidification of a substance in a mold. (2) Pouring molten metal into a mold to produce an object of desired shape.

3.1.12 chemical analysis: Determination of the chemical composition of material.

3.1.13 clamp: A device with internal angled shoulders used to fasten mating hubs.

3.1.14 clamping load: The axial load applied to the clamp hubs by the clamp due to bolt tightening.

3.1.15 conformance (conform): Compliance with specified requirements in every detail.

3.1.16 connection, API: Flanges, hubs, and studded connections manufactured in accordance with API specification including dimensional requirements.

3.1.17 connection, blind: An end or outlet connection with no center bore, used to completely close off a connection.

3.1.18 connection, end: Flanges (studded or open face), hub connections or Other End Connections which are used to join together equipment and are integral to the equipment.

3.1.19 connection, loose: Flanges (studded or open face), hub connections, or Other End Connections which are used to join together equipment but are not integral to the equipment.

3.1.20 connection, other end (O.E.C.): Connections which are not specified in an API dimensional specification, including API flanges and hubs with non-API gasket preparations and manufacturer's proprietary connections.

3.1.21 connections, studded: Connections in which thread-anchored studs are screwed into tapped holes.

3.1.22 data acquisition system: A system for storing and/or providing permanent copies of test information, such as: strip chart recorders, circular chart recorders, or computer systems.

3.1.23 date of manufacture: The date of manufacturer's final acceptance of finished equipment.

3.1.24 equipment: Any single completed unit that can be used for its intended purpose without further processing or assembly.

3.1.25 examination, visual: Examination of parts and equipment for visible defects in material and workmanship.

3.1.26 examination, volumetric nondestructive: Examination for internal material defects by radiography, acoustic emission, or ultrasonic testing.

3.1.27 flange: A protruding rim, with holes to accept bolts and having a sealing mechanism, used to join pressure containing equipment together by bolting one flange to another.

3.1.28 forging: (1) Plastically deforming metal, usually hot, into desired shapes with compressive force, with open or closed dies. (2) A shaped metal part formed by the forging method.

3.1.29 gasket seating load: That portion of the clamping load required to seat the gasket and bring the hub faces into contact.

3.1.30 gasket retaining load: That portion of the clamping load required to offset the separating force the gasket exerts on the hubs when pressurized.

3.1.31 heat affected zone (HAZ): That portion of the base metal which has not been melted, but whose mechanical properties or microstructure has been altered by the heat of welding or cutting.

3.1.32 heat (cast lot): Material originating from a final melt. For remelted alloys, a heat shall be defined as the raw material originating from a single remelted ingot.

3.1.33 heat treatment (heat treating): Alternate steps of controlled heating and cooling of materials for the purpose of changing physical or mechanical properties.

3.1.34 heat treatment load: That material moved as a batch through one heat treatment cycle.

3.1.35 hot working: Deforming metal plastically at a temperature above the recrystallization temperature.

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

3.1.37 hydraulic connector: Hydraulically actuated drill through equipment that locks and seals on end connections.

3.1.38 indications: Visual signs of cracks, pits, or other abnormalities found during liquid penetrant and magnetic particle examination.

3.1.39 indications, linear: An indication in liquid penetrant or magnetic particle examination whose length is equal to or greater than 3 times its width.

3.1.40 indications, relevant: Any indication in liquid penetrant or magnetic particle examination with a major dimension over 0.062 inch.

3.1.41 indications, rounded: Any indication in liquid penetrant or magnetic particle examination that is approximately circular or elliptical with its length less than 3 times its width.

3.1.42 integral: Parts which are joined by the forging, casting, or welding process.

3.1.43 leakage: Visible passage of the pressurized fluid from the inside to the outside of the pressure containment area of the equipment being tested.

3.1.44 part: An individual piece used in the assembly of a single equipment unit.

3.1.45 personnel, qualified: Individuals with characteristics or abilities gained through training, experience, or both, as measured against the manufacturer's established requirements.

3.1.46 post weld heat treatment: Any heat treatment subsequent to welding, including stress relief.

3.1.47 pressure-containing part(s) or member(s): Those parts exposed to wellbore fluids whose failure to function as intended would result in a release of wellbore fluid to the environment, e.g., bodies, bonnets, and connecting rods.

3.1.48 pressure-controlling part(s) or member(s): Those parts intended to control or regulate the movement of wellbore fluids, e.g., packing elements, rams, replaceable seats with a pressure-containing member or part(s).

3.1.49 pressure end load: The axial load resulting from internal pressure applied to the area defined by the maximum seal diameter.

3.1.50 pressure-retaining part(s) or member(s): Those parts not exposed to wellbore fluids whose failure to function as intended would result in a release of wellbore fluid to the environment, e.g., closure bolts and clamps.

3.1.51 pressure vessel quality: Metallic material the integrity of which is such that it can be used to safely contain pressure without risk of leakage or rupture.

3.1.52 product family: A model or type of specific equipment listed in 1.2.1.

3.1.53 ram, blind: The closing and sealing component in a ram blowout preventer that seals the open wellbore.

3.1.54 ram, pipe: The closing and sealing component in a ram blowout preventer that seals around tubulars in the wellbore.

3.1.55 ram, blind-shear: The closing and sealing component in a ram blowout preventer that first shears the tubular in the wellbore and then seals off the bore.

3.1.56 ram, variable bore: The closing and sealing component in a ram blowout preventer that is capable of sealing on a range of tubular sizes.

3.1.57 rated working pressure: The maximum internal pressure that the equipment is designed to contain and/or control.

3.1.58 records: Retrievable information.

3.1.59 relevant: See **indications, relevant.**

3.1.60 ring grooves, corrosion resistant: Ring grooves lined with metal resistant to metal-loss corrosion.

3.1.61 serialization: Assignment of a unique code to individual parts and/or pieces of equipment to maintain records.

3.1.62 shall: In this document the word *shall* is used to indicate requirements which must be satisfied or performed in order to conform with this specification.

3.1.63 special processes: Operations which convert or affect material properties.

3.1.64 spool, drilling: A pressure-containing piece of equipment having end connections, used below or between equipment functioning to space apart, adapt, or provide outlets in an equipment assembly. When outlet connections are provided, they shall be manufactured in accordance with API specifications.

3.1.65 stabilized (pressure testing): When the initial pressure decline rate decreases to within the manufacturer's specified rate. This pressure decline can be caused by such things as changes in temperature, setting of elastomer seals or compression of trapped air in the equipment being tested.

3.1.66 stabilized (temperature testing): When the initial temperature fluctuations decrease to within the manufacturer's specified range. This temperature fluctuation can be caused by such things as mixing of different temperature fluids, convection, or conduction.

3.1.67 stress relief: Controlled heating of material to a predetermined temperature for the purpose of reducing any residual stresses.

3.1.68 structure, wrought: One that contains no cast dendritic structure.

3.1.69 surface finish: The measurement of the average roughness (RMS) of a surface. All of the surface finishes given within this specification are to be considered maximums.

3.1.70 traceability, job lot: The ability for parts to be identified as originating from a job lot which identifies the included heat(s).

3.1.71 trepanned: To 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.

3.1.72 weld, fabrication: A weld joining two or more parts.

3.1.73 weld, full penetration: A weld which extends throughout the complete wall section of the parts joined.

3.1.74 weld, non pressure containing: A weld the failure of which will not reduce the pressure-containing integrity of the component.

3.1.75 weld, pressure containing: A weld, the failure of which will reduce the pressure-containing integrity of the component.

3.1.76 weld groove: An area between two metals to be joined that has been prepared to receive weld filler metal.

3.1.77 weld joint: A description of the way components are fitted together in order to facilitate joining by welding.

3.1.78 weld, major repair: Welds that are greater than 25 percent of the original wall thickness or one inch, whichever is less.

3.1.79 welding: The fusion of materials, with or without the addition of filler materials.

3.1.80 yield strength: The stress level measured at room temperature, expressed in pounds per square inch of loaded area, at which material plastically deforms and will not return to its original dimensions when the load is released. All yield strengths specified in this standard shall be considered as being the 0.2 percent yield offset strength per ASTM A370.

Abbreviations and Descriptions

AE	Acoustic Emissions
ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing and Materials
AWS	American Welding Society
CRA	Corrosion Resistant Alloy
ER	Equivalent Round
HAZ	Heat Affected Zone

Abbreviations and Descriptions (Continued)

AE	Acoustic Emissions
ANSI	American National Standards Institute
I.D.	Inside Diameter
LP	Liquid Penetrant
MP	Magnetic Particle
MIL-STD	Military Standard, USA
NACE	National Association of Corrosion Engineers
NDE	Nondestructive Examination
O.D.	Outside Diameter
O.E.C.	Other End Connection
PDC	Product Description Code
PQR	Procedure Qualification Record
QTC	Qualification Test Coupons
VBR	Variable Bore Ram
WPS	Welding Procedure Specifications

4 Design Requirements

4.1 SIZE DESIGNATION

The size designation of equipment within the scope of this specification shall have a vertical through bore dimension as shown in Table 1.

4.2 SERVICE CONDITIONS

4.2.1 Rated Working Pressure

Equipment within the scope of this specification shall be rated in only the following rated working pressures: 2,000; 3,000; 5,000; 10,000; 15,000; 20,000.

4.2.2 Temperature Ratings

Minimum temperature is the lowest ambient temperature to which the equipment may be subjected. *Maximum temperature* is the highest temperature of the fluid which may flow through the equipment.

Table 1—API 16A Equipment Size and Rated Working Pressure

API Size Designation	Rated Working Pressure (psi)	Drift Diameter (inch)
$7^{1}/_{16}$	2,000 thru 20,000	7.032
9	2,000 thru 15,000	8.970
11	2,000 thru 20,000	10.970
$13^{5}/_{8}$	2,000 thru 15,000	13.595
$16^{3}/_{4}$	2,000 thru 10,000	16.720
$18^{3}/_{4}$	5,000 thru 15,000	18.720
$20^{3}/_{4}$	3,000	20.720
$21^{1}/_{4}$	2,000 thru 10,000	21.220
$26^{3}/_{4}$	2,000 thru 3,000	26.720
30	2,000 thru 3,000	29.970

Note: Specific size and pressure rating combinations are not necessarily available for each type of end or outlet connection, e.g., flange and hub.

4.2.2.1 Metallic Materials

Equipment shall be designed for metallic parts to operate within the temperature ranges shown in Table 2.

Table 2—Temperature Ratings for Metallic Materials

Classification	Operating Range (°F)
T-75	–75° to 250°
T-20	–20° to 250°
T-0	0° to 250°

4.2.2.2 Wellbore Elastomeric Materials

Equipment shall be designed for wellbore elastomeric materials to operate within the temperature classifications of 8.3.4.2.

4.2.2.3 All Other Elastomeric Seals

Seals shall be designed to operate within the temperatures of the manufacturer's written specifications.

4.2.3 Retained Fluid Ratings

All metallic materials which come in contact with well fluids shall meet the requirements of NACE Standard MR0175 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 Specification 6A.

4.3.1.1.1 6B and 6BX flange connections may be used as integral connections.

4.3.1.1.2 6B and 6BX flanges integral to drill through equipment shall not contain test connections.

4.3.1.2 Design

4.3.1.2.1 Pressure Ratings and Size Ranges of Flange Connections

Type 6B and 6BX flange connections shall be designed for use in the combination of API Size Designation and pressure ratings as shown in Table 3.

4.3.1.2.2 Type 6B Flange Connections

4.3.1.2.2.1 General

Type 6B flange connections are of the ring joint type and are not designed for face-to-face make-up.

Table 3—Pressure Ratings and Size Ranges of API Specification 6A Flange Connections

Pressure Rating (psi)	Type 6B	Type 6BX
2,000	$2^{1}/_{16}$ thru $21^{1}/_{4}$	$26^{3}/_{4}$ thru 30
3,000	$2^{1}/_{16}$ thru $20^{3}/_{4}$	$26^{3}/_{4}$ thru 30
5,000	$2^{1}/_{16}$ thru 11	$13^{5}/_{8}$ thru $21^{1}/_{4}$
10,000		$1^{13}/_{16}$ thru $21^{1}/_{4}$
15,000		$1^{13}/_{16}$ thru $18^{3}/_{4}$
20,000		$1^{13}/_{16}$ thru $13^{5}/_{8}$

4.3.1.2.2.2 Standard Dimensions

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

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

4.3.1.2.2.3 Flange Face

The flange face on the ring joint side shall be either flat or raised face and shall be fully machined. The nut bearing surface shall be parallel to the flange face within one degree. The flange back face shall be fully machined or spot faced at the bolt holes. The thickness after facing shall meet the dimensions of API Specification 6A.

4.3.1.2.2.4 Corrosion Resistant Ring Grooves

Type 6B flange connections may be manufactured with corrosion resistant overlays in the ring grooves. Prior to application of the overlay, the preparation of the ring grooves shall conform to API Specification 6A.

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

4.3.1.2.3 Type 6BX Flange Connections

4.3.1.2.3.1 General

Type 6BX flange connections are of the ring joint type and are designed for face-to-face make-up.

4.3.1.2.3.2 Standard Dimensions

Dimensions for Type 6BX integral flange connections shall conform to API Specification 6A.

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

4.3.1.2.3.3 Flange Face

The flange face on the ring joint side shall be raised and shall be fully machined. The nut bearing surface shall be parallel to the flange face within one degree. The back face shall

be fully machined or spot faced at the bolt holes. The thickness after facing shall meet the dimensions of API Specification 6A.

4.3.1.2.3.4 Corrosion Resistant Ring Grooves

Type 6BX flange connections may be manufactured with corrosion resistant overlays in the ring grooves. Prior to application of the overlay, the preparation of the ring grooves shall conform to the dimensions of API Specification 6A.

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) in this specification shall conform to the API Specification 6A.

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

4.3.2.2 Design

Design for studded end and outlet connections is the same specified in 4.3.1.2 except as follows:

4.3.2.2.1 Type 6B Studded Connections

4.3.2.2.1.1 Standard Dimensions

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

4.3.2.2.1.2 Studded Connection Face

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

4.3.2.2.1.3 Stud Bolt Holes

Stud bolt holes shall be sized and located to conform with API Specification 6A. The thread form of the tapped hole shall conform with the requirements of 4.3.3. 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 manufacturer's written specification.

4.3.2.2.2 Type 6BX Studded Connections

4.3.2.2.2.1 Standard Dimensions

Dimensions for Type 6BX studded connections shall conform to API Specification 6A as it relates to bore size, diameter of the bolt circle and flange O.D.

4.3.2.2.2.2 Studded Connection Face

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

4.3.2.2.2.3 Stud Bolt Holes

Stud bolt holes shall be sized and located to conform with API Specification 6A. The thread form of the tapped hole shall conform with the requirements of 4.3.3. 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 specifications.

4.3.3 Studs, Nuts, and Tapped Stud Holes (Bolting)

Bolting for end and outlet connections, both studded and flanged, shall meet the requirements of API Specification 6A, PSL 1.

4.3.4 Hubbed End and Outlet Connections

4.3.4.1 General

End and outlet hubs (16B and 16BX) shall conform to the requirements of this specification.

4.3.4.1.1 16B and 16BX hubs may be used as integral connections.

4.3.4.1.2 16B and 16BX hubs integral to drill through equipment shall not contain test connections.

4.3.4.2 Design

4.3.4.2.1 Pressure Ratings and Size Ranges of Hub Types

API type 16B and 16BX hubs are designed for use in the combination of API designated sizes and pressure ranges shown in Table 4.

Table 4—Pressure Rating and Size Ranges of API Type 16B and 16BX Hubs

Pressure Rating (psi)	Type 16B	Type 16BX
2,000	$7^{1}/_{16}$, $16^{3}/_{4}$, $21^{1}/_{4}$	
3,000	11, $13^{5}/_{8}$, $16^{3}/_{4}$	
5,000		$2^{1}/_{16}$ thru $21^{1}/_{4}$
10,000		$1^{13}/_{16}$ thru $21^{1}/_{4}$
15,000		$1^{13}/_{16}$ thru $18^{3}/_{4}$
20,000		$1^{13}/_{16}$ thru 11

4.3.4.2.2 Type 16B Hubs

4.3.4.2.2.1 General

Type 16B hubs are of the ring joint type and are designed for face-to-face make-up. The type RX ring gasket is used for these connections. In order to accomplish a face-to-face make-up, the special type SR ring grooves shown in Table 5 shall be used.

4.3.4.2.2.2 Dimensions

4.3.4.2.2.2.1 Standard Dimensions

Dimensions for Type 16B integral hubs shall conform to Table 5.

Dimensions for Type 16B blind hubs shall conform to Figure 3.

Dimensions for ring grooves shall conform to Table 5.

4.3.4.2.2.3 Gaskets

Type 16B hubs shall use Type RX gaskets in accordance with 4.3.7.

4.3.4.2.2.4 Corrosion Resistant Ring Grooves

Type 16B hub connections may be manufactured with corrosion resistant overlays in the ring grooves. Prior to overlay, the ring groove shall be prepared as specified in Table 9.

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

4.3.4.2.3 Type 16BX Hubs

4.3.4.2.3.1 General

Type 16BX hubs are of the ring joint type and are designed for face-to-face make-up. The Type BX ring gasket is used for these connections.

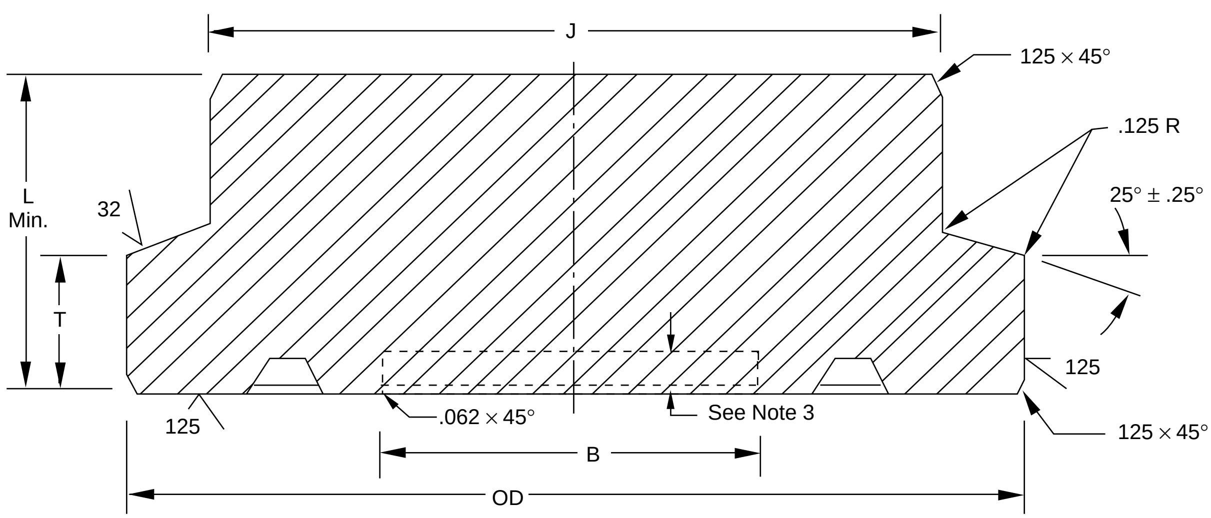
4.3.4.2.3.2 Dimensions

4.3.4.2.3.2.1 Standard Dimensions

Dimensions for Type 16BX integral hubs shall conform to Tables 6, 7, or 8.

Dimensions for Type 16BX blind hubs shall conform to Figure 3.

Dimensions for all ring grooves shall conform to Tables 6, 7, or 8.



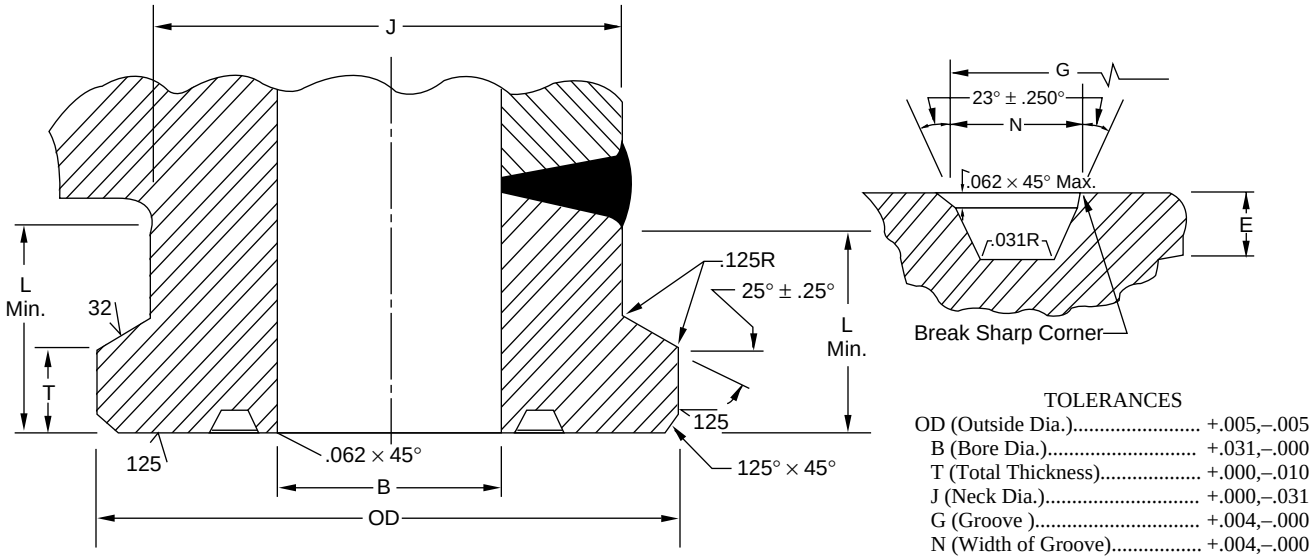
Notes:

1. For API 16B blind hubs (2,000 psi and 3,000 psi rated working pressure):
   a. Refer to Table 5 for hub dimensions and tolerances of OD, J, T, and L.
   b. Refer to Table 5 for ring groove dimensions and tolerances. If corrosion resistant inlay is used in ring groove, refer to Table 9 for rough machining detail.

2. For API 16BX blind hubs (5,000 psi, 10,000 psi, 15,000 psi and 20,000 psi rated working pressure):
   a. Refer to =Table 6, 7, or 8 for hub dimensions and tolerances of OD, J, T, and L.
   b. Refer to Table 5, 7, or 8 for ring groove dimensions and tolerances. If corrosion resistant inlay is used in ring groove, refer to API Spec 6A for rough machining detail.

3. The counterbore in an API Type 16B and 16BX hub is optional. If the counterbore is used, the depth of the counterbore shall not exceed the dimension and tolerance of "E" as shown on the appropriate Ring Groove Dimension Table.

Figure 3—API 16B and 16BX Blind Hubs



TOLERANCES

OD (Outside Dia.)	+.005,–.005
B (Bore Dia.)	+.031,–.000
T (Total Thickness)	+.000,–.010
J (Neck Dia.)	+.000,–.031
G (Groove)	+.004,–.000
N (Width of Groove)	+.004,–.000
E (Depth of Groove)	+.016,–.000
Groove Finish	63 RMS max.

Figure 4—API Type 16B Integral Hub Connections for 2,000 psi and 3,000 psi Rated Working Pressure

Table 5—API Type 16B Integral Hub Connections for 2,000 psi and 3,000 psi Rated Working Pressure

Nominal Size and Bore **B**	Outside Diameter **OD**	Total Thickness **T**	Large Diameter of Neck **J**	Neck Length for Clamp Clearance **L**	Ring Grove Number	Grove O.D. **G**	Width of Grove **N**	Depth of Grove **E**	Ring Gasket Number	Clamp Number
					2,000 psi					
$7\ ^{1}/_{16}$	10.375	1.443	8.875	2.50	SR-45	8.987	.668	.562	RX-45	25
$16^{3}/_{4}$	20.375	1.269	19.000	3.13	SR-65	19.135	.668	.562	RX-65	12
$21^{1}/_{4}$	26.375	1.872	24.500	5.00	SR-73	23.753	.784	.688	RX-73	18
					3,000 psi					
11	15.625	1.399	14.000	3.13	SR-53	13.405	.668	.562	RX-53	9
$13^{5}/_{8}$	18.375	1.336	16.750	3.19	SR-57	15.635	.668	.562	RX-57	11
$16^{3}/_{4}$	21.250	1.459	19.625	3.68	SR-65	19.135	.668	.562	RX-65	14

4.3.4.2.3.3 Gaskets

Type 16BX hubs shall use Type BX gaskets in accordance with 4.3.7.

4.3.4.2.3.4 Corrosion Resistant Ring Grooves

Type 16BX hubs may be manufactured with corrosion resistant overlays in the ring grooves. Prior to overlay, the ring grooves shall conform to API Specification 6A.

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

4.3.5 Clamps

4.3.5.1 General

This section provides the minimum design, material and dimensional requirements for clamps that shall be used in conjunction with API 16B and 16BX hubs (4.3.4).

4.3.5.2 Design

4.3.5.2.1 Pressure Rating and Size Range of Clamps

API clamps shall be designated for use in the combination of API designated size ranges and pressure ratings shown in Table 10. Clamps shall be designated by the clamp number given in column 1 of Table 10.

4.3.5.2.2 Design Methods

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

4.3.5.2.3 Design Requirements

4.3.5.2.3.1 Stresses shall be calculated at make-up, operating, and test conditions.

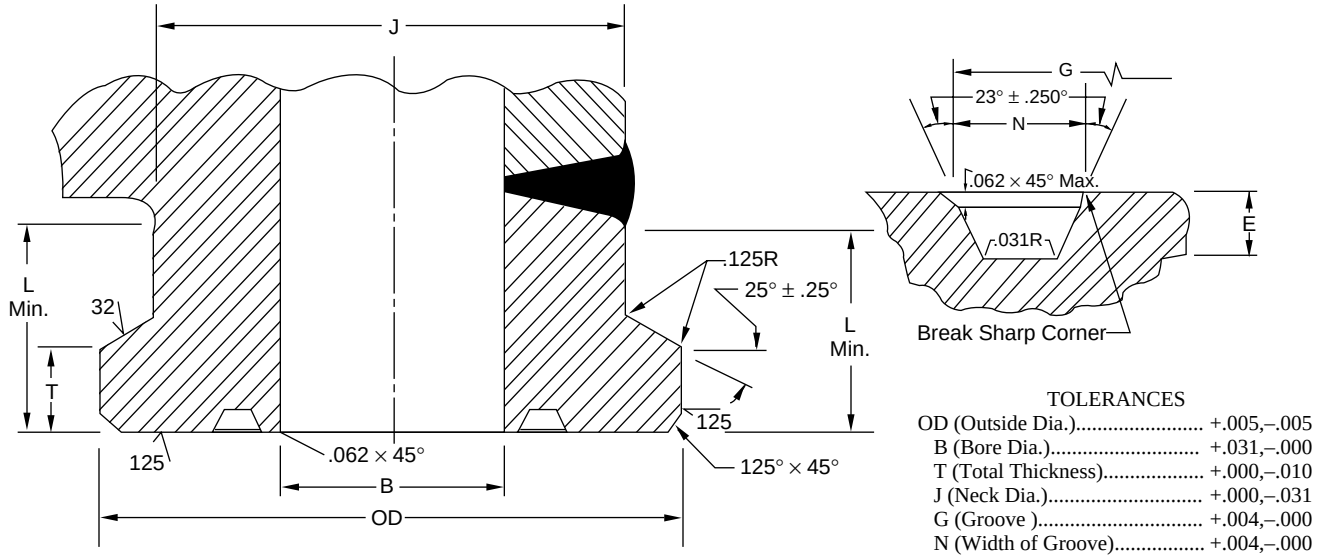


Figure 5—API Type 16BX Integral Hub Connections for 5,000 psi Rated Working Pressure

Table 6—API Type 16BX Integral Hub Connections for 5,000 psi Rated Working Pressure

Nominal Size and Bore **B**	Outside Diameter **OD**	Total Thickness **T**	Large Diameter of Neck **J**	Neck Length for Clamp Clearance **L**	Groove O.D. **G**	Width of Grove **N**	Depth of Groove **E**	Ring Gasket Number	Clamp Number
				5,000 psi					
2 1/16	5.031	1.166	3.656	2.22	3.395	.498	.234	BX-152	1
2 9/16	5.781	1.166	4.406	2.27	4.046	.554	.226	BX-153	2
3 1/8	6.312	1.166	4.938	2.36	4.685	.606	.297	BX-154	4
4 1/16	7.625	1.197	6.250	2.38	5.930	.698	.328	BX-155	5
7 1/16	13.250	1.622	11.625	3.38	9.521	.921	.438	BX-156	6
9	13.250	1.622	11.625	3.38	11.774	1.039	.500	BX-157	8
11	16.250	1.654	14.625	4.13	14.064	1.149	.562	BX-158	10
13 5/8	20.625	1.871	19.000	4.88	16.063	.786	.562	BX-160	13
16 3/4	25.625	1.778	24.000	5.50	18.832	.705	.328	BX-162	19
21 1/4	31.250	3.630	27.875	6.75	24.904	1.071	.750	BX-165	27

4.3.5.2.3.1.1 Make-up stresses are directly proportional to the bolt loads and shall be determined based on the greater of: (1) The bolt load required to seat the gasket and bring the hub faces into contact, or (2) The bolt load required to retain the sum of the rated working pressure end load and the gasket retaining load. Make-up of the clamp shall be sufficient such that the hub faces meet and there shall be no facial separation at the hub O.D. at rated working pressure.

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

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

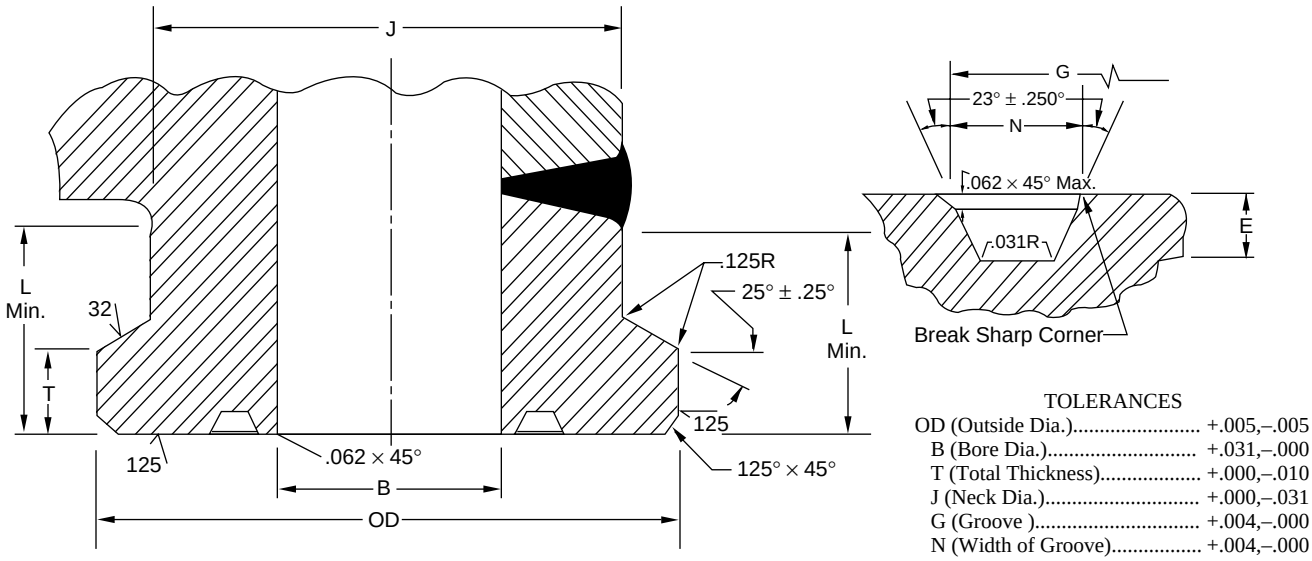
4.3.5.2.3.2 The stresses shall be determined using the outside radius of the gasket as the sealing radius.

4.3.5.2.3.3 All clamps shall have grooves in their bores with 25° ±0.25° angles to fit API 16B and 16BX hubs.

4.3.5.2.3.4 All 25° surfaces in clamp grooves shall have a surface finish of 32 RMS or less.

4.3.5.2.3.5 The coefficient of friction shall be considered and shall be +0.1 at make-up and –0.1 while operating. Friction, therefore, inhibits make-up and assists in holding the connection at operating and test conditions.

Note: The coefficient of friction stated here is that used for clamp and hub design. Materials or coatings which have different coefficients of friction are beyond the scope of this document.



TOLERANCES

OD (Outside Dia.)	+.005,–.005
B (Bore Dia.)	+.031,–.000
T (Total Thickness)	+.000,–.010
J (Neck Dia.)	+.000,–.031
G (Groove)	+.004,–.000
N (Width of Groove)	+.004,–.000
E (Depth of Groove)	+.016,–.000
Groove Finish	32 RMS max.

Figure 6—API Type 16BX Integral Hub Connections for 10,000 psi Rated Working Pressure

Table 7—API Type 16BX Integral Hub Connections for 10,000 psi Rated Working Pressure

Nominal Size and Bore **B**	Outside Diameter **OD**	Total Thickness **T**	Large Diameter of Neck **J**	Neck Length for Clamp Clearance **L**	Groove O.D. **G**	Width of Grove **N**	Depth of Groove **E**	Ring Gasket Number	Clamp Number
10,000 psi									
$1^{13}/_{16}$	5.031	1.166	3.656	2.22	3.062	.466	.219	BX-151	1
$2^{1}/_{16}$	5.781	1.166	4.406	2.27	3.395	.498	.234	BX-152	2
$2^{9}/_{16}$	6.312	1.166	4.938	2.36	4.046	.554	.266	BX-153	4
$3^{1}/_{16}$	7.625	1.197	6.250	2.38	4.685	.606	.297	BX-154	5
$4^{1}/_{16}$	8.437	1.310	6.812	2.82	5.930	.698	.328	BX-155	6
$7^{1}/_{16}$	16.250	1.653	14.625	4.13	9.521	.921	.438	BX-156	10
9	16.250	1.653	14.625	4.13	11.774	1.039	.500	BX-157	10
11	20.625	2.035	18.625	4.75	14.064	1.149	.562	BX-158	22
$13^{5}/_{8}$	22.250	2.309	20.625	5.31	17.033	1.279	.625	BX-159	15
$16^{3}/_{4}$	28.000	3.005	25.000	6.17	18.832	.705	.328	BX-162	28
$18^{3}/_{4}$	31.250	3.630	27.875	6.75	22.752	1.290	.719	BX-164	27
$21^{1}/_{4}$	34.000	4.005	30.500	8.22	25.507	1.373	.750	BX-166	26

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

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

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

4.3.5.2.3.9 Clamp bolting stresses shall conform to 4.4.3. Torques for clamp bolting shall be determined by the manufacturer to suit his design.

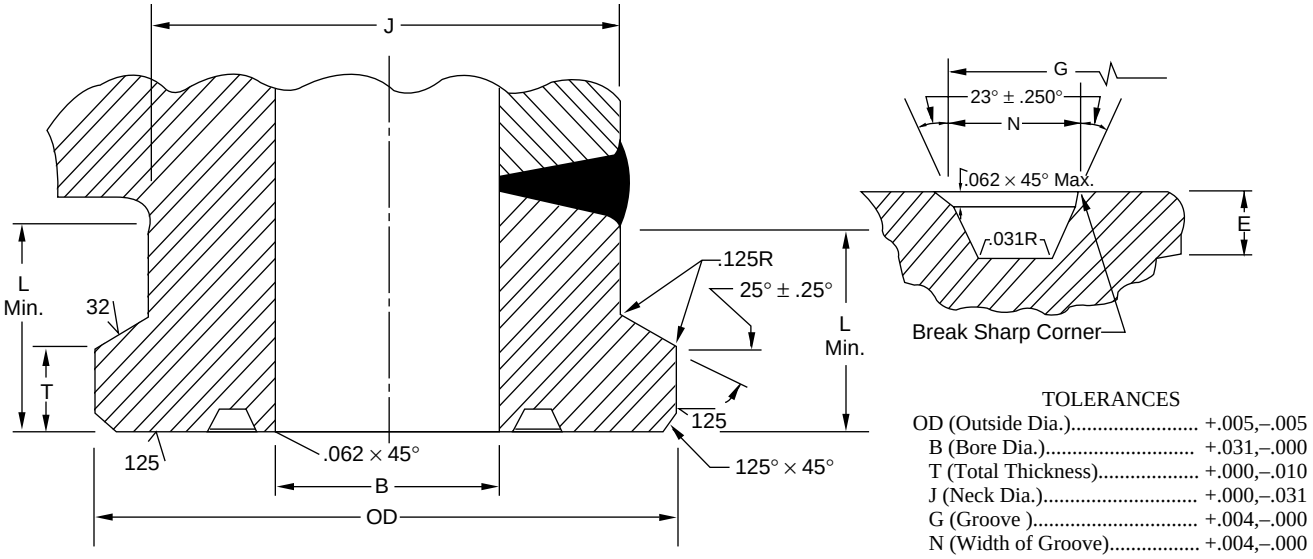
4.3.5.2.4 Material

4.3.5.2.4.1 Clamps

Clamps shall be manufactured from material conforming to Section 5 of this document. Material requirements of NACE MR0175 are not required.

4.3.5.2.4.2 Bolting

Bolting shall comply with the requirements of this document for studs and nuts, 4.3.3.



TOLERANCES

OD (Outside Dia.)	+.005,–.005
B (Bore Dia.)	+.031,–.000
T (Total Thickness)	+.000,–.010
J (Neck Dia.)	+.000,–.031
G (Groove)	+.004,–.000
N (Width of Groove)	+.004,–.000
E (Depth of Groove)	+.016,–.000
Groove Finish	32 RMS max.

Figure 7—API Type 16BX Integral Hub Connections for 15,000 psi and 20,000 psi Rated Working Pressure

Table 8—API Type 16BX Integral Hub Connections for 15,000 psi and 20,000 psi Rated Working Pressure

Nominal Size and Bore **B**	Outside Diameter **OD**	Total Thickness **T**	Large Diameter of Neck **J**	Neck Length for Clamp Clearance **L**	Groove O.D. **G**	Width of Groove **N**	Depth of Groove **E**	Ring Gasket Number	Clamp Number
15,000 psi									
$1^{13}/_{16}$	5.781	1.166	4.406	2.27	3.062	.466	.219	BX-151	2
$2^{1}/_{16}$	6.125	1.622	4.500	3.22	3.395	.498	.234	BX-152	3
$2^{9}/_{16}$	6.125	1.622	4.500	3.22	4.046	.554	.266	BX-153	3
$3^{1}/_{16}$	8.437	1.310	6.812	2.82	4.685	.606	.297	BX-154	6
$4^{1}/_{16}$	13.250	1.622	11.625	3.38	5.930	.698	.328	BX-155	8
$7^{1}/_{16}$	20.626	2.035	18.625	4.75	9.521	.921	.438	BX-156	22
11	22.250	2.309	20.625	5.31	14.064	1.149	.562	BX-158	15
$13^{5}/_{8}$	28.000	3.005	25.000	6.17	17.033	1.279	.625	BX-159	28
$18^{3}/_{4}$	34.000	4.005	30.500	8.22	22.752	1.290	.719	BX-164	26
20,000 psi									
$1^{13}/_{16}$	6.125	1.622	4.500	3.22	3.062	.466	.219	BX-151	3
$2^{1}/_{16}$	6.125	1.622	4.500	3.22	3.395	.498	.234	BX-152	3
$2^{9}/_{16}$	8.437	1.310	6.812	2.82	4.046	.554	.266	BX-153	6
$3^{1}/_{16}$	13.250	1.622	11.625	3.38	4.685	.606	.297	BX-154	8
$4^{1}/_{16}$	16.250	1.653	14.625	4.13	5.930	.698	.328	BX-155	10
$7^{1}/_{16}$	22.250	2.308	20.625	5.31	9.521	.921	.438	BX-156	15
11	27.997	3.005	25.000	6.17	14.064	1.149	.562	BX-158	28

4.3.5.2.5 Washers

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

4.3.6 Blowout Preventers and Drilling Spools

4.3.6.1 Dimensions

4.3.6.1.1 API Designated Size

Blowout preventers and drilling spools shall be identified by the API Size Designation in column 1 of Table 1.

4.3.6.1.2 End-to-End Dimensions

The end-to-end dimensions for BOPs and drilling spools shall be the overall height from the bottom face of the bottom connection to the top face of the top connection. These dimensions shall be in accordance with the manufacturer's written specifications.

4.3.6.1.3 Bores

Blowout preventers and drilling spools shall have a cylindrical passage (bore) through the body, including end connec-

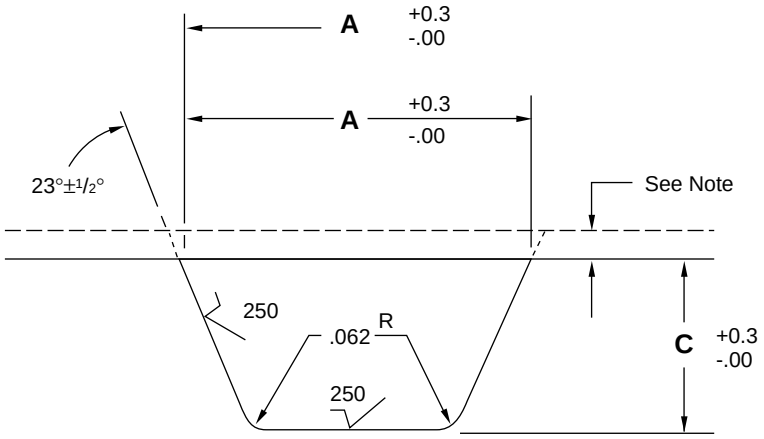


Figure 8—Rough Machining Detail for Corrosion Resistant Overlay of Special Type "SR" Ring Grooves

Table 9—Rough Machining Detail for Corrosion Resistant Overlay of Special Type "SR" Ring Grooves

Ring Groove Number	Outside Diameter of Groove A	Width of Groove B	Depth of Groove C
SR-45	9.316	.944	.699
SR-53	13.743	.944	.699
SR-57	15.964	.944	.699
SR-65	19.464	.944	.699
SR-73	24.082	1.060	.825

Note: Allow 1/2" or greater for final machining of overlay

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

4.3.6.2 Design Methods

Design methods shall conform to 4.4.

4.3.6.3 End Connections

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.

4.3.6.4 Outlet Connections

Outlet connections shall conform to the requirements of Section 4.3.1, 4.3.2, or 4.3.4.

4.3.6.5 Material

4.3.6.5.1 Material used for pressure containing parts or members shall comply with Section 5.

4.3.6.5.2 Closure bolting and other parts shall conform to manufacturer's written specifications.

4.3.7 Ring Gaskets

Gaskets used for equipment manufactured to this specification shall meet all the requirements of API Specification 6A, PSL 1.

4.3.7.1 Use of Gaskets

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 are to be used with SR ring grooves. Only Type BX gaskets are to be used with 6BX ring grooves. Type RX and BX gaskets are not interchangeable. See Table 11 for a summary of groove and gasket usage.

4.3.8 Weld Neck Hubs

Weld neck hubs are not addressed in this edition of Specification 16A.

4.3.9 Other End Connections (O.E.C.s)

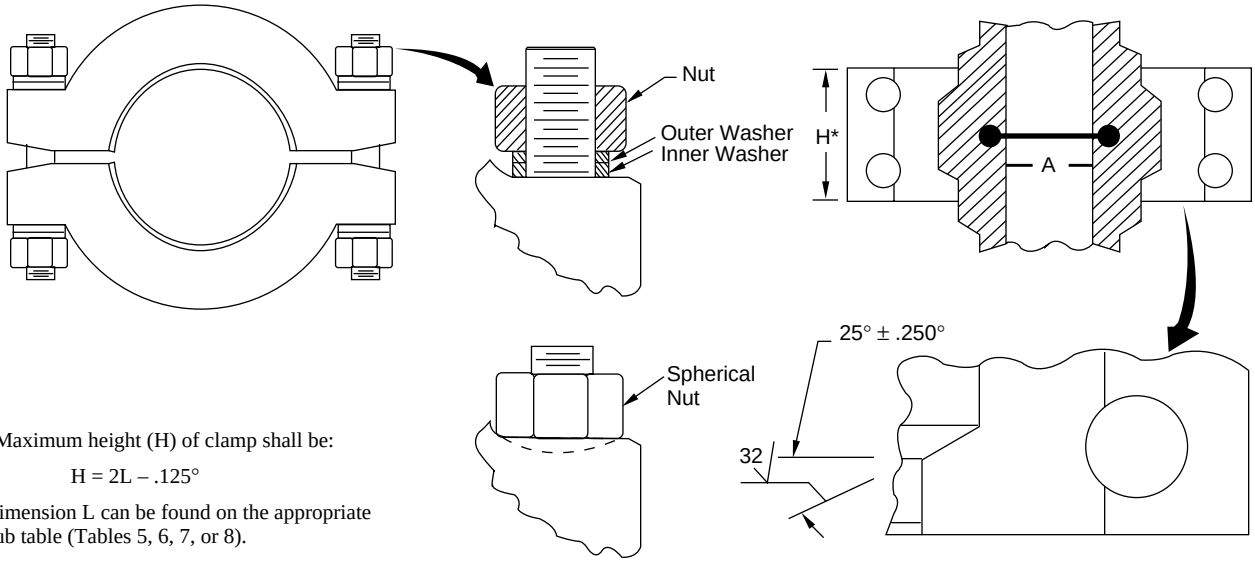
4.3.9.1 General

This section provides requirements for other end connections which may be used for joining drill through equipment and which are not specified in API dimensional specification. O.E.C.s include API flanges and hubs with non-API gasket preparations and manufacturer's proprietary connections.

4.3.9.2 Design

4.3.9.2.1 Design Methods

O.E.C.s shall be designed in accordance with 4.4.



*Maximum height (H) of clamp shall be:

$H = 2L - .125°$

Dimension L can be found on the appropriate hub table (Tables 5, 6, 7, or 8).

Figure 9—Clamps for API Type 16B and 16BX Hub Connections

Table 10—Clamps for API Type 16B and 16BX Hub Connections

HUB		
Clamp No.	API Designated Size (A)	Working Pressure (psi)
1	$1^{13}/_{16}$	10,000
	$2^{1}/_{16}$	5,000
2	$1^{13}/_{16}$	15,000
	$2^{1}/_{16}$	10,000
	$2^{9}/_{16}$	5,000
3	$1^{13}/_{16}$	20,000
	$2^{1}/_{16}$	15,000
	$2^{1}/_{16}$	20,000
	$2^{9}/_{16}$	15,000
4	$2^{9}/_{16}$	10,000
	$3^{1}/_{8}$	5,000
5	$3^{1}/_{16}$	10,000
	$4^{1}/_{16}$	5,000
6	$2^{9}/_{16}$	20,000
	$3^{1}/_{16}$	15,000
	$4^{1}/_{16}$	10,000
8	$3^{1}/_{16}$	20,000
	$4^{1}/_{16}$	15,000
	$7^{1}/_{16}$	5,000
	9	5,000
9	11	3,000
10	$4^{1}/_{16}$	20,000

HUB		
Clamp No.	API Designated Size (A)	Working Pressure (psi)
10	$7^{1}/_{16}$	10,000
	9	10,000
	11	5,000
11	$13^{5}/_{8}$	3,000
12	$16^{3}/_{4}$	2,000
13	$13^{5}/_{8}$	5,000
14	$16^{3}/_{4}$	3,000
15	$7^{1}/_{16}$	20,000
	11	15,000
	$13^{5}/_{8}$	10,000
18	$21^{1}/_{4}$	2,000
19	$16^{3}/_{4}$	5,000
22	$7^{1}/_{16}$	15,000
	11	10,000
25	$7^{1}/_{16}$	2,000
26	$16^{3}/_{4}$	15,000
	$21^{1}/_{4}$	10,000
27	$18^{3}/_{4}$	10,000
	$21^{1}/_{4}$	5,000
28	11	20,000
	$13^{5}/_{8}$	15,000
	$16^{3}/_{4}$	10,000

Table 11—Ring Numbers for API Specification 16A Equipment

Ring Number	API Designated Size	Rated Working Pressure
Type 6B Integral Flange Connections:		
R or RX 45	$7^{1}/_{16}$	2,000
R or RX 49	9	2,000
R or RX 53	11	2,000
R or RX 57	$13^{5}/_{8}$	2,000
R or RX 65	$16^{3}/_{4}$	2,000
R or RX 73	$21^{1}/_{4}$	2,000
R or RX 45	$7^{1}/_{16}$	3,000
R or RX 49	9	3,000
R or RX 53	11	3,000
R or RX 57	$13^{5}/_{8}$	3,000
R or RX 66	$16^{3}/_{4}$	3,000
R or RX 74	$20^{3}/_{4}$	3,000
R or RX 46	$7^{1}/_{16}$	5,000
R or RX 50	9	5,000
R or RX 54	11	5,000
Type 6BX Integral Flange Connections:		
BX 167	$26^{3}/_{4}$	2,000
BX 303	30	2,000
BX 168	$26^{3}/_{4}$	3,000
BX 303	30	3,000
BX 160	$13^{5}/_{8}$	5,000
BX 162	$16^{3}/_{4}$	5,000
BX 163	$18^{3}/_{4}$	5,000
BX 165	$21^{1}/_{4}$	5,000
BX 156	$7^{1}/_{16}$	10,000
BX 157	9	10,000
BX 158	11	10,000
BX 159	$13^{5}/_{8}$	10,000
BX 162	$16^{3}/_{4}$	10,000
BX 164	$18^{3}/_{4}$	10,000
BX 166	$21^{1}/_{4}$	10,000
BX 156	$7\ ^{1}/_{16}$	15,000
BX 157	9	15,000
BX 158	11	15,000
BX 159	$13^{5}/_{8}$	15,000
BX 164	$18^{3}/_{4}$	15,000
BX 156	$7^{1}/_{16}$	20,000
BX 157	9	20,000
BX 158	11	20,000
BX 159	$13^{5}/_{8}$	20,000

Ring Number	API Designated Size	Rated Working Pressure
Type 16B Integral Hub Connections:		
RX 45	$7^{1}/_{16}$	2,000
RX 65	$16^{3}/_{4}$	2,000
RX 73	$21^{1}/_{4}$	2,000
RX 53	11	3,000
RX 57	$13^{5}/_{8}$	3,000
RX 65	$16^{3}/_{4}$	3,000
Type 16BX Integral Hub Connections:		
BX 156	$7^{1}/_{16}$	5,000
BX 157	9	5,000
BX 158	11	5,000
BX 160	$13^{5}/_{8}$	5,000
BX 162	$16^{3}/_{4}$	5,000
BX 165	$21^{1}/_{4}$	5,000
BX 156	$7^{1}/_{16}$	10,000
BX 157	9	10,000
BX 158	11	10,000
BX 159	$13^{5}/_{8}$	10,000
BX 162	$16^{3}/_{4}$	10,000
BX 164	$18^{3}/_{4}$	10,000
BX 166	$21^{1}/_{4}$	10,000
BX 156	$7^{1}/_{16}$	15,000
BX 158	11	15,000
BX 159	$13^{5}/_{8}$	15,000
BX 164	$18^{3}/_{4}$	15,000
BX 156	$7^{1}/_{16}$	20,000
BX 158	11	20,000

4.3.9.2.2 Size

O.E.C.s shall be designed with the same API Size Designation shown in Table 1.

4.3.9.2.3 Bore Dimensions

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

4.3.9.3 Materials

O.E.C. materials shall meet the requirements of Section 5.

4.3.9.4 Testing

API Specification 16A equipment utilizing O.E.C.s shall successfully complete the tests required in Section 7.

4.3.10 Blind Connections

4.3.10.1 Flanges

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

4.3.10.2 Hubs

Dimensions of 16B and 16BX blind hubs shall conform to Figure 3.

4.3.10.3 Other End Connections (O.E.C.s)

The design and configuration of blind O.E.C.s shall conform to 4.3.9.2, 4.3.9.3, and 4.3.9.4.

4.3.11 Adapters

Dimensions of adapters are not addressed in this edition of Specification 16A. End connections shall meet the requirements of 4.3.1, 4.3.2, 4.3.4, or 4.3.9.

4.3.12 Hydraulic Connectors

4.3.12.1 Dimensions

4.3.12.1.1 API Designated Size

Hydraulic connectors shall be identified by the API Size Designated in column 1 of Table 1.

4.3.12.1.2 End-to-End Dimensions

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 of BOP mandrel) to the face of the top end connection. These dimensions are not standardized and shall conform to the manufacturer's written specifications.

4.3.12.1.3 Bore Dimensions

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

4.3.12.2 Design

4.3.12.2.1 Design methods shall conform to 4.4.

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

4.3.12.3 Connections

4.3.12.3.1 Top Connections

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

4.3.12.3.2 Bottom Connections

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. This mechanism can 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 4.3.6.5.

4.3.13 Test, Vent, Injection, and Gage Connections

Sealing and porting of flanges, hubs, and O.E.C.s shall conform to the requirements of API Specification 6A.

4.4 DESIGN METHODS

4.4.1 End and Outlet Connections

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

4.4.2 Members Containing Wellbore Pressure

Pressure-containing parts or members shall be designed in accordance with one or more of the following methods:

Note: Fatigue analysis and localized bearing stress values are beyond the scope of this specification. Design decisions based only on the allowables shown may not be sufficient for all service conditions.

4.4.2.1 ASME

The design methodology shall be described in the ASME Boiler and Pressure Vessel Code Section VIII, Division 2, Appendix 4. Design allowable stresses shall be limited by the following criteria:

$$S_t \leq 0.9\ S_y \quad \text{and} \quad S_m \leq {}^2/_3\ S_y$$

Where:

S_m = design stress intensity at rated working pressure, psi.

S_t = maximum allowable general primary membrane stress intensity at hydrostatic test pressure, psi.

S_y = material specified minimum yield strength, psi.

4.4.2.2 Distortion Energy Theory

This design methodology for the basic pressure vessel wall thickness shall use a combination of the triaxial stresses based on the hydrostatic test pressure and shall be limited by the following criteria:

$$S_e = S_y$$

Where:

S_e = maximum allowable equivalent stress computed by the Distortion Energy Theory method, psi.

S_y = Material specified minimum yield strength, psi.

4.4.2.3 Experimental Stress Analysis

Application of experimental stress analysis shall be as described in the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 2, Appendix 6.

4.4.3 Closure Bolting

Stresses shall be determined considering all loading on the closure including pressure acting over the seal area, gasket loads and any additive mechanical loads. The maximum tensile stress shall be determined considering initial make-up loads, working conditions and hydrostatic test conditions. The stresses, based on the minimum cross sectional area, shall not exceed the following limits:

$$S_a \leq 0.83\ S_y$$

Where:

S_a = maximum allowable tensile stress, psi.

S_y = material specified minimum yield strength, psi.

4.4.4 Other Parts

Pressure retaining parts and pressure-controlling parts shall be designed to satisfy the manufacturer's written specifications and the service conditions defined in 4.2.

4.4.5 Miscellaneous Design Information

4.4.5.1 General

End and outlet connections to the wellbore shall be integral.

4.4.5.2 Hydraulic Connectors

The manufacturer shall document the load/capacity for the hydraulic connector using the same format as used for API flanges in API Bulletin 6AF. This format relates pressure to allowable bending moment for various tensions. The manufacturer shall state whether the limitation is stress level or facial separation. Analytical design methods shall conform to 4.4.

4.4.5.3 Clamps

The manufacturer shall document the load/capacity for the clamp connection using the same format as used for API flanges in API 6AF. This format relates pressure to allowable bending moment for various tensions. The manufacturer shall state whether the limitation is in the stress level of the clamp or the hub. Analytical design methods shall conform to 4.4.

4.4.5.4 O.E.C.s

The manufacturer shall document the load/capacity for the O.E.C. using the same format as used for API flanges in API Bulletin 6AF. This format relates pressure to 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.

4.5 DESIGN VERIFICATION TESTING

4.5.1 Design verification testing shall be performed on equipment specified in 1.2.1 and shall be described in the manufacturer's written specification(s). Design verification testing shall not be required on adapters, drilling spools, clamps, API flanges, API hubs, or API ring gaskets.

4.5.1.1 General

Experimental confirmation of the design shall be documented and verified as required in 4.6.

4.5.1.2 Blowout Preventers

Tests of the operating characteristics for BOPs shall conform to 4.7.

4.5.1.3 Hydraulic Connectors

Tests of the operating characteristics for hydraulic connectors shall conform to 4.7.

4.5.1.4 Annular Packer Units

4.5.1.4.1 Tests on annular packing units shall conform to 4.7.

4.5.1.4.2 Design temperature verification testing on annular packing units shall conform to 4.8.3.

4.5.1.5 Ram Blocks, Packers and Top Seals

4.5.1.5.1 Tests on ram blocks, packers and top seals shall conform to 4.7.

4.5.1.5.2 Design temperature verification testing on ram packers and top seals shall conform to 4.8.2.

4.5.1.6 O.E.C.s

Tests of the operating characteristics for O.E.C.s shall conform to the manufacturer's written specification.

4.6 DOCUMENTATION

4.6.1 Design Documentation

Designs including design requirements, methods, assumptions and calculations shall be documented. Design documentation media shall be clear, legible, reproducible, and retrievable.

4.6.2 Design Review

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

4.6.3 Design Verification

Design verification procedures and results shall be documented.

4.6.4 Documentation Retention

Documentation retention for documents in Section 4 shall be for ten years after the last unit of that model, size, and rated working pressure is manufactured.

4.7 BOP AND HYDRAULIC CONNECTOR OPERATIONAL CHARACTERISTICS TESTS

4.7.1 General

4.7.1.1 Requirements

All testing shall be in accordance with Table 12.

4.7.1.2 Procedure

All operational characteristics tests shall be conducted using water at the same ambient temperature as the wellbore fluid and, unless otherwise noted, the level of piston closing pressure shall be the pressure recommended by the manufacturer and shall not exceed the designed hydraulic operating system working pressure. The manufacturer shall document his procedure and results. Procedures in Appendix B may be used.

4.7.1.3 Acceptance Criterion

With the exception of stripping tests, the acceptance criterion for all tests that verify pressure integrity shall be no leakage.

4.7.1.4 Scaling

If scaling of size and working pressure is utilized, scaling shall conform to Table 12. The manufacturer shall document his technical justifications.

Table 12—Required Operational Characteristics Tests And Acceptable Scaling Practices

Test	Ram-Type BOPs				Annular-Type BOPS	Hydraulic Connectors
	Fixed Bore[a]	Variable Bore	Blind[a]	Shear		
Sealing Characteristics	P1,S2	P3,S3	P1,S2	P1,S2	P1,S2	N/A
Fatigue	P1,S2	P3,S3	P1,S2	P1,S2	P1,S2	
Stripping	P2,S2	P2,S2	N/A	N/A	P2,S2	
Shear	N/A	N/A	N/A	P1,S2	N/A	
Hang-off	P1,S2	P3,S3	N/A	N/A	N/A	
Ram/Packer Access	P2,S2[b]				P2,S2[c]	
Ram Locking Device	P2,S2[d]				N/A	
Locking Mechanism	N/A					P2,S2
Sealing Mechanism						P1,S3
Temperature Verification	P3,S3					N/A

Notes:
[a]One fixed bore test qualifies other fixed bore pipe sizes and blind rams for the same test.
[b]Only one ram access test is required for a product family.
[c]Only closure mechanisms of functionally similar design may be scaled.
[d]Only one ram locking device test (performed with any ram) is required for a product family.

Legend:
P1 =Qualifies all API rated working pressures equal to and below that of the product tested.
P2 =Qualifies all API rated working pressures of the product tested.
P3 =Qualifies only the API rated working pressure of the product tested. Exception: When packers of identical dimensions and material have multiple pressure ratings, they need only be tested at their maximum pressure rating.
S2 =Qualifies all API size designations of the product tested.
S3 =Qualifies only the API size designation of the product tested.

4.7.2 Ram-type BOP

4.7.2.1 Sealing Characteristics Test

This test shall determine the actual opening or closing pressure required to either maintain or break a wellbore pressure seal. The test shall also define the ability of the ram packer to effect a seal when closing against elevated wellbore pressures. For fixed bore pipe rams, a 5-inch test mandrel shall be used for BOPs with wellbores 11-inch and larger and a $3^1/_2$-inch test mandrel shall be used for BOPs with wellbores smaller than 11-inch. Sealing characteristics tests on a variable bore ram (VBR) shall include pipe sizes at the minimum and maximum of the ram's range. Documentation shall include:

a. A record of closing pressure vs. wellbore pressure to effect a seal against elevated wellbore pressures.

b. A record of operator (closing or opening) pressure vs. wellbore pressure to break a wellbore pressure seal.

4.7.2.2 Fatigue Test

This test shall determine the ability of the ram packers and seals to maintain a wellbore pressure seal after repeated closings and openings. This test simulates closing and opening the BOP once per day and wellbore pressure testing at 200–300 psi and full rated working pressure once per week for 1.5 years of service. For fixed bore pipe rams, a 5-inch test mandrel shall be used for BOPs with wellbores 11-inch and larger and a $3^1/_2$-inch test mandrel shall be used for BOPs with wellbores smaller than 11-inch. Tests on VBRs shall be performed at the minimum and maximum sizes for their range. Documentation shall include:

a. Magnetic particle (MP) inspection of ram blocks in accordance with manufacturer's written procedure.

b. Total number of cycles to failure to maintain a seal or 546 close/open cycles and 78 pressure cycles, whichever is attained first.

4.7.2.3 Stripping Life Test

This test shall determine the ability of the ram packers and seals to control wellbore pressure while running drill pipe through the closed rams without exceeding 1gpm leak rate. A 5-inch test mandrel shall be used for BOPs with wellbores 11-inch and larger and a $3^1/_2$-inch test mandrel shall be used for BOPs with wellbores smaller than 11-inch. Documentation shall include:

a. Wellbore pressure used during the test.

b. Record of reciprocating speed.

c. Equivalent length of pipe stripped or 50,000 feet, whichever is attained first.

4.7.2.4 Shear Ram Test

This test shall determine the shearing and sealing capabilities for selected drill pipe samples. As a minimum, the pipe used shall be: $3^1/_2$-inch 13.3 lb/ft Grade E for $7^1/_{16}$-inch BOPs, 5-inch 19.5 lb/ft Grade E for 11-inch BOPs and 5-inch 19.5 lb/ft Grade G for $13^5/_8$-inch and larger BOPs. These tests shall be performed without tension in the pipe and with zero wellbore pressure. Documentation shall include the manufacturer's shear ram and BOP configuration, the actual pressure and force to shear, and actual yield strength, elongation, and weight per foot of the drill pipe samples, as specified in API Specification 5D.

4.7.2.5 Hang-Off Test

This test shall determine the ability of the ram assembly to maintain a 200–300 psi and full rated working pressure seal while supporting drill-pipe loads. This test shall apply to 11-inch and larger blowout preventers. Any hang-off test performed with a variable bore ram shall use drill pipe diameter sizes of the minimum and the maximum diameter designed for that ram. Documentation shall include:

a. Nondestructive Examination (NDE) of ram blocks in accordance with manufacturer's written procedure.

b. Load at which leaks develop or 600,000 lb for 5-inch and larger pipe, or 425,000 lb for pipe smaller than 5-inch, whichever is less.

4.7.2.6 Ram Access Test

This test shall determine the ability of the blowout preventer to undergo repeated ram and/or ram packer changes without affecting operational characteristics. This test shall be accomplished by obtaining access to the rams and performing a wellbore pressure test every 20th ram access. Documentation shall include the number of access cycles to failure or 200 access cycles and 10 wellbore pressure cycles, whichever is less.

4.7.2.7 Ram Locking Device Test

This test shall determine the ability of the BOP's ram locking device to maintain a wellbore pressure seal after removing the closing and/or locking pressure(s). This test may be accomplished as part of the fatigue or hang-off tests. VBRs shall be tested at the minimum and maximum sizes of their range. A 200 to 300 psi and full rated working pressure tests shall be performed.

4.7.3 Annular-Type BOP

4.7.3.1 Sealing Characteristics Test

This test shall determine the piston closing pressure necessary to maintain a seal as a function of wellbore pressures up

to a full rated working pressure of the BOP. The test is conducted on a drill pipe mandrel and on open hole conditions. For 11-inch and larger BOPs a 5-inch mandrel shall be used. For 9-inch and smaller BOPs a $3^1/_2$-inch mandrel shall be used. This test shall consist of three parts:

4.7.3.1.1 Constant Wellbore Pressure Test

This test shall determine the actual closing pressure required to maintain a wellbore pressure seal on the test mandrel. Documentation shall include a record of wellbore pressure vs. closing pressure.

4.7.3.1.2 Constant Closing Pressure Test

This test shall determine the maximum wellbore pressure obtainable for a given closing pressure with the preventer closed on the test mandrel. Documentation shall include a record of wellbore pressure vs. closing pressure.

4.7.3.1.3 Full Closure Pressure Test

This test shall determine the closing pressure required to seal on the open hole at one half rated working pressure. Documentation shall include a record of wellbore pressure vs. closing pressure.

4.7.3.2 Fatigue Test

This test shall determine the ability of an annular packing unit to maintain a 200–300 psi and rated working pressure seal throughout repeated closings and openings. This test simulates closing and opening the BOP once per day and wellbore pressure testing at 200–300 psi and full rated working pressure once per week for one year of service. Documentation shall include:

a. Packing element inside diameter (I.D.) after every twentieth cycle vs. time up to 30 minutes.
b. The number of cycles to failure to maintain a seal or 364 close/open cycles and 52 pressure cycles, whichever is attained first.

4.7.3.3 Packer Access Test

This test shall determine the ability of the blowout preventer to undergo repeated packer changes without affecting operational characteristics. This test shall be accomplished by obtaining access to the packing unit and performing a wellbore pressure test every twentieth packing unit access. Documentation shall include the number of cycles to failure or 200, whichever is attained first.

4.7.3.4 Stripping Life Test

This test shall determine the ability of the annular packing unit to maintain control of wellbore pressure while stripping drill pipe and tool joints through the closed packing unit without exceeding one gallon per minute (gpm) leak rate. Documentation shall include:

a. Wellbore pressure used during the test.
b. Record of reciprocating speed.
c. Equivalent length of pipe and number of tool joints stripped or 5000 tool joints, whichever is attained first.
d. Closing pressure used during the test.

4.7.4 Hydraulic Connectors

4.7.4.1 Locking Mechanism Test

This test shall verify the operation of both the primary and (if so equipped) secondary locking mechanism at rated working pressure and shall establish the lock/unlock pressure relationship. The test shall be conducted using an assembled connector with a test stump. The functional testing which verifies operation of the locking mechanism to the manufacturer's written design specifications shall be documented.

4.7.4.2 Sealing Mechanism Test

This test shall verify the operation of the sealing mechanics at 200–300 psi and rated working pressure and shall demonstrate the pressure integrity of the seal. This test shall be conducted using an assembled connector with a blind upper connection and a test stump. The functional testing which verifies the sealing mechanics to the manufacturer's written design specifications shall be documented.

4.8 DESIGN TEMPERATURE VERIFICATION TESTING FOR NON-METALLIC SEALING MATERIALS AND MOLDED SEALING ASSEMBLIES

4.8.1 General

4.8.1.1 Safety

Safety procedures shall be in accordance with the manufacturer's written documentation.

4.8.1.2 Intent of Procedure

This procedure shall verify performance of non-metallic seals and molded sealing assemblies used as pressure-controlling and/or pressure-containing members in equipment included in 1.2.1 of this specification. The intent of this procedure is to verify the performance of these components during exposure to low and high temperatures.

4.8.1.3 Procedure

All tests shall be performed at the extreme temperatures for the temperature class of the component being tested. Refer to 8.3.4.2 for the temperature classes. The test fluid used shall be

specified by the manufacturer. Unless otherwise noted, the closing pressure shall be the pressure recommended by the manufacturer and shall not exceed the designed hydraulic operating system rated working pressure. The manufacturer shall document his procedure and results. Procedures in Appendix C may be used.

4.8.1.4 Acceptance Criterion

The acceptance criterion for all pressure tests is that there shall be no leakage.

4.8.1.5 Scaling

If scaling of size and working pressure is utilized, scaling shall conform to Table 12. The manufacturer shall document his technical justifications.

4.8.2 Ram-Type BOP

Non-metallic seals and molded-sealing assemblies in ram BOPs shall be tested to verify their ability to maintain a seal at the extremes of their temperature classification. Variable bore packer tests shall be conducted on the minimum and maximum sizes for their range. Documentation shall include:

a. Elastomer records as detailed in the test procedures.
b. Record of the temperature of the BOP wellbore during the testing.
c. Record of low temperature test performance: A minimum of 3 pressure cycles at rated working pressure shall be required.
d. Record of high temperature test performance: 1 pressure cycle at rated working pressure with a minimum pressurization hold time of 60 minutes shall be required.

4.8.3 Annular-type BOP

Non-metallic seals and molded sealing assemblies in annular BOPs shall be tested to verify their ability to maintain a seal at the extremes of their temperature classification. Documentation shall include:

a. Elastomer records as detailed in the test procedures.
b. Record of the temperature of the BOP wellbore during the testing.
c. Record of low temperature test performance: A minimum of three pressure cycles at rated working pressure shall be required.
d. Record of high temperature test performance: One pressure cycle at rated working pressure with a minimum pressurization hold time of 60 minutes shall be required.

4.9 OPERATING MANUAL REQUIREMENTS

The manufacturer shall prepare and have available an operating manual for each model ram or annular-type BOP or hydraulic connector manufactured in accordance with this specification. The operating manual shall contain the following information as a minimum and as applicable:

a. Operation and installation instructions.
b. Physical data.
c. Packers and seals information.
d. Maintenance and testing information.
e. Disassembly and assembly information.
f. Parts information.
g. Storage information.
h. Hangoff load information.
i. Minimum and maximum operating pressures.
j. Shearing capabilities.

5 Material Requirements

5.1 GENERAL

This section describes the material performance, processing, and compositional requirements for pressure-containing members. Other parts shall be made of materials which satisfy the design requirements in Section 4 when assembled into API Specification 16A equipment. Metallic materials shall meet the requirements for sour service, NACE MR0175.

5.2 WRITTEN SPECIFICATIONS

5.2.1 Metallic Parts

A written material specification shall be required for all metallic pressure-containing or pressure-controlling parts. The manufacturer's written specified requirements for metallic materials shall define the following:

a. Material composition with tolerance.
b. Material qualification.
c. Allowable melting practice(s).
d. Forming practice(s).
e. Heat treatment procedure including cycle time and temperature with tolerances, heat treating equipment, and cooling media.
f. NDE requirements.
g. Mechanical property requirements.

5.2.2 Non-metallic Parts

Each manufacturer shall have written specifications for all elastomeric materials used in the production of drill through equipment. These specifications shall include the following physical tests and limits for acceptance and control:

a. Hardness per ASTM D2240 or D1415.
b. Normal stress-strain properties per ASTM D412 or D1414.
c. Compression per ASTM D395 or D1414.
d. Immersion test per ASTM D471 or D1414.

5.3 PRESSURE-CONTAINING MEMBERS

5.3.1 Property-Requirements

5.3.1.1 Pressure-containing members including API end connections shall be manufactured from materials as specified by the manufacturer that meet the requirements of Tables 13 and 14.

5.3.1.2 Impact Requirements

Charpy V-Notch impact testing shall conform to 5.3.4.2.

5.3.2 Processing

5.3.2.1 Melting, Casting, and Hot Working

5.3.2.1.1 Melting Practices

The manufacturer shall select and specify the melting practices for all pressure-containing member material.

5.3.2.1.2 Casting Practices

The materials manufacturer shall document foundry practices which establish limits for sand control, core making, rigging, and melting. All castings shall be of pressure vessel quality.

5.3.2.1.3 Hot Working Practices

The materials manufacturer shall document hot working practices. All wrought material(s) shall be of pressure vessel quality and shall be formed using a hot working practice(s) which produces a wrought structure throughout.

5.3.2.2 Heat Treating

5.3.2.2.1 Equipment Qualification

All heat treatment operations shall be performed utilizing equipment qualified in accordance with the requirements specified by the manufacturer. (See Appendix D for a recommended practice.)

5.3.2.2.2 Furnace Loading

Care should be taken in loading of material within furnaces such that the presence of one part does not adversely affect the heat treating response of any other part.

5.3.2.2.3 Temperatures

Temperature and times for heat treatment shall be determined in accordance with the manufacturer's written specification.

5.3.2.2.4 Quenching

Quenching shall be performed in accordance with the manufacturer's written specifications.

5.3.2.2.4.1 Water Quenching

The temperature of the water or water-based quenching medium shall not exceed 100°F at the start of the quench, nor exceed 120°F at the completion of the quench.

5.3.2.2.4.2 Oil Quenching

The temperature of any oil quenching medium shall be greater than 100°F at the start of the quench.

Table 13—Pressure Containing Member Material Property Requirements

API Material Designation	Yield Strength 2% offset, minimum (psi)	Tensile Strength minimum (psi)	Elongation in 2 in., minimum (%)	Reduction in Area, minimum (%)
36K	36,000	70,000	21	None specified
45K	45,000	70,000	19	32
60K	60,000	85,000	18	35
75K	75,000	95,000	18	35

Table 14—API Material Applications for Pressure Containing Members

	Pressure Rating (psi)					
PART	2,000	3,000	5,000	10,000	15,000	20,000
Body	36K,45K, 60K, 75K	36K,45K, 60K, 75K	36K,45K, 60K, 75K	36K,45K, 60K, 75K	45K,60K, 75K	60K,75K
End Connections	60K	60K	60K	60K	75K	75K
Blind Flanges	60K	60K	60K	60K	75K	75K
Blind Hubs	60K	60K	60K	60K	75K	75K

5.3.3 Chemical Compositions

5.3.3.1 General

5.3.3.1.1 The manufacturer shall specify the chemical range of material used to manufacture pressure containing members.

5.3.3.1.2 Material composition shall be determined on a heat basis (or a remelt ingot basis for remelt grade materials) in accordance with the manufacturer's written specification.

5.3.3.2 Composition Limits

Pressure containing members manufactured from carbon and low alloy steels or martensitic stainless steels shall have chemical composition limits complying with Table 15. Non-martensitic alloy systems are not required to conform to Tables 15 and 16.

Table 15—Steel Composition Limits (Wt%) for Pressure-Containing Members

Alloying Element	Carbon and Low Alloy Steels Limit (Wt%)	Martensitic Stainless Steels Limit (Wt%)
Carbon	0.45 Max	0.15 Max
Manganese	1.80 Max	1.00 Max
Silicon	1.00 Max	1.50 Max
Phosphorus	0.04 Max	0.04 Max
Sulfur	0.04 Max	0.04 Max
Nickel	1.00 Max	4.50 Max
Chromium	2.75 Max	11.0-14.0
Molybdenum	1.50 Max	1.00 Max
Vanadium	0.30 Max	N/A

Table 16—Alloying Element Maximum Tolerance Range Requirements (Wt%)

Alloying Element	Carbon and Low Alloy Steels Limit (Wt%)	Martensitic Stainless Steels Limit (Wt%)
Carbon	0.08	0.08
Manganese	0.40	0.40
Silicon	0.30	0.35
Nickel	0.50	1.00
Chromium	0.50	—
Molybdenum	0.20	0.20
Vanadium	0.10	0.10

Note: These values are the maximum allowable range in any specific element and shall not exceed the maximum specified in Table 15.

5.3.3.3 Alloy Element Range

The alloy element range shall conform to Table 16.

5.3.4 Material Qualification

5.3.4.1 Tensile Testing

5.3.4.1.1 Test Specimens

Tensile test specimens shall be removed from a Qualification Test Coupon (QTC) as described in 5.3.5. This QTC shall be used to qualify a heat and the products produced from that heat.

5.3.4.1.2 Methods

5.3.4.1.2.1 Tensile tests shall be performed at room temperature in accordance with the procedures specified in ASTM A370.

5.3.4.1.2.2 A minimum of one tensile test shall be performed. The results of the tensile test(s) shall satisfy the applicable requirements of Table 13. If the results of the first tensile tests do not satisfy the applicable requirements, two additional tensile tests may be performed in an effort to qualify the material. The results of each of these additional tests shall satisfy the requirements of Table 13.

5.3.4.2 Impact Testing

5.3.4.2.1 Sampling

Impact testing shall be performed on each heat of material used for pressure-containing members.

5.3.4.2.2 Test Specimens

Impact test specimens shall be removed from a QTC as prescribed in 5.3.5. This QTC shall be used to qualify a heat and the products produced from that heat.

5.3.4.2.3 Size

Standard size specimens, 10 mm x 10 mm in cross section, shall be used except where there is insufficient material, in which case the next smaller standard size specimen obtainable shall be used. When it is necessary to prepare sub-size specimens, the reduced dimension shall be in the direction parallel to the base of the V-Notch.

5.3.4.2.4 Methods

5.3.4.2.4.1 Impact tests shall be performed in accordance with the procedures specified in ASTM A370 using the Charpy V-Notch technique.

5.3.4.2.4.2 In order to qualify material for an API temperature rating T-0, T-20, or T-75, the impact tests shall be performed at or below the test temperature shown in Table 17.

Table 17—Acceptance Criteria Charpy V-Notch Impact Requirements

Temperature Rating	Test Temperature (°F)	Minimum Impact Value Required for Average of Each Set of Three Specimens (ft-lb)	Minimum Impact Value Permitted for One Specimen Only Per Set (ft-lb)
T-0	0°	15	10
T-20	-20°	15	10
T-75	-75°	15	10

5.3.4.2.5 A minimum of three impact specimens shall be tested to qualify a heat of material. Impact property average shall be the minimum shown in Table 17. In no case shall an individual impact value fall below $^2/_3$ the minimum average. No more than 1 of the 3 test results may be below the required minimum average. If a test fails, then 1 retest of 3 additional specimens (removed from the same location within the same QTC with no additional heat treatment) may be made. The retest shall exhibit an impact value equal to or exceeding the required minimum average.

5.3.4.2.6 Specimen Orientation

The values listed in Table 17 are the minimum acceptable values for forgings and wrought products tested in the transverse direction and for castings and weld qualifications. Forgings and wrought products may be tested in the longitudinal direction instead of the transverse direction and then shall exhibit 20 ft-lb minimum average value.

5.3.5 Qualification Test Coupons (QTC)

5.3.5.1 General

5.3.5.1.1 The properties exhibited by the QTC shall represent the properties of the material comprising the equipment it qualifies. A single QTC may be used to represent the impact and/or tensile properties of components produced from the same heat provided it satisfies the requirements of this specification.

5.3.5.1.2 When the QTC is a trepanned core or a prolongation removed from a production part, the QTC may only qualify parts having the same or smaller equivalent round (ER).

5.3.5.1.3 A QTC may only qualify material and parts produced from the same heat. (Remelt heat may be qualified on a master heat basis.)

5.3.5.2 Equivalent Round

5.3.5.2.1 General

The size of a QTC for a part shall be determined using the ER methods in the following sections.

5.3.5.2.2 ER Methods

Figure 10 illustrates the basic models for determining the ER of simple solid and hollowed parts and more complicated equipment. The ER of a part shall be determined using the actual dimensions of the part in the "as heat treated" condition.

5.3.5.2.3 Size Requirements

The ER of the QTC shall be equal to or greater than the dimensions of the part it qualifies, except the size of the QTC is not required to exceed 5 inches ER.

5.3.5.3 Processing

5.3.5.3.1 Melting, Casting, and Hot Working

5.3.5.3.1.1 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 may not qualify material from the same primary melt which 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 which has been processed in like manner and is from the same primary melt. No additional alloying shall be performed on these individual remelt ingots.

5.3.5.3.1.2 Casting Practices

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

5.3.5.3.1.3 Hot Working Practices

The manufacturer shall use hot working ratios on the QTC which are equal to or less than those used in processing the part it qualifies. The total hot work ratio for the QTC shall not exceed the total hot work ratio of the parts it qualifies.

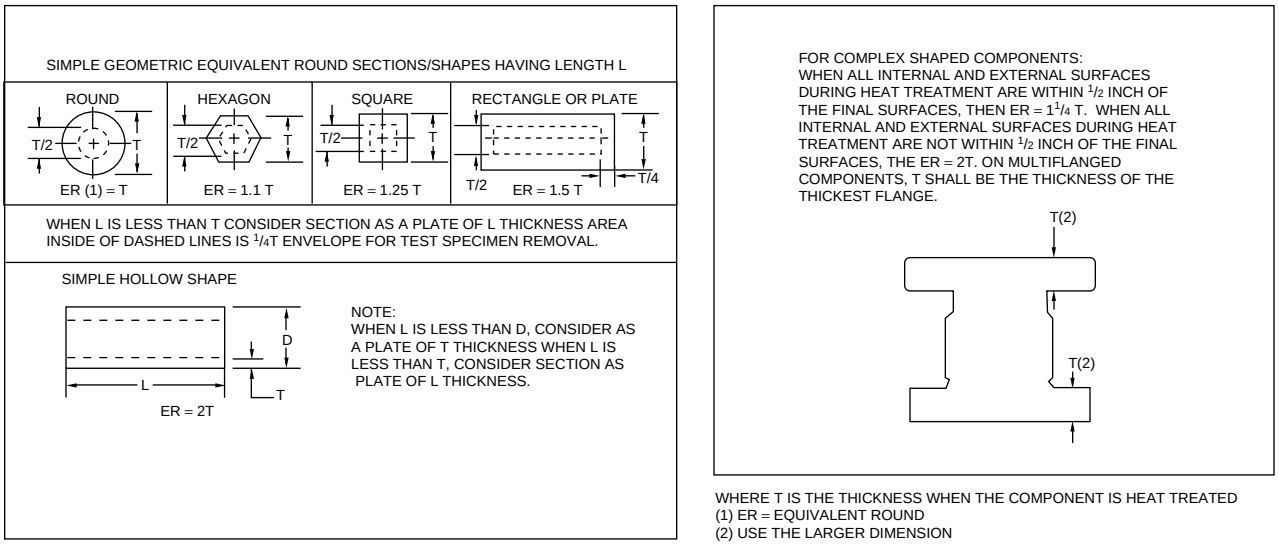
5.3.5.3.2 Welding

Welding on the QTC is prohibited except for attachment type welds.

5.3.5.3.3 Heat Treating

5.3.5.3.3.1 Equipment Qualification

All heat treatment operations shall be performed utilizing "production type" equipment certified in accordance with the manufacturer's written specification. "Production Type" heat treating equipment shall be considered equipment that is routinely used to process parts.



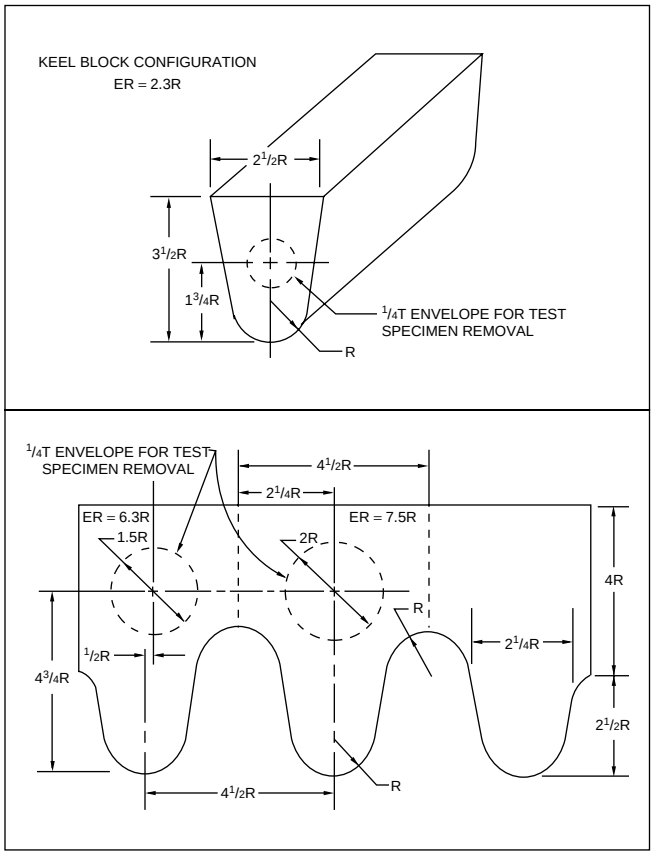


Figure 10—Equivalent Round Models

5.3.5.3.3.2 Methods

5.3.5.3.3.2.1 The QTC shall experience the same specified heat treatment processing as the parts it qualifies. The QTC shall be heat treated using the manufacturer's specified heat treating procedures.

5.3.5.3.3.2.2 When the QTC is not heat treated as part of the same heat treatment load as the parts it qualifies, the austenitizing (or solution heat treat) temperatures for the QTC shall be within 25°F of those for the parts. The tempering temperature for the part shall be no lower than 25°F below that of the QTC. The upper limit shall be no higher than permitted by the heat treat procedure for that material. The cycle time of the QTC at each temperature shall not exceed that for the parts.

5.3.5.4 Tensile and Impact Testing—Test Specimens

5.3.5.4.1 When tensile and/or impact test specimens are required, they shall be removed from a QTC after the final QTC heat treatment cycle. It is allowable to remove tensile and impact specimens from multiple QTCs as long as the multiple QTCs had the same heat treatment cycle(s).

5.3.5.4.2 Tensile and impact specimens shall be removed from the QTC such that their longitudinal centerline axis is wholly within the center core $^1/_4$T envelope for a solid QTC or within $^1/_4$-inch of the mid-thickness of the thickest section of a hollow QTC (refer to Figure 10).

For QTCs larger than the size specified in 5.3.5.2.3, the test specimens need not be removed from a location farther from the QTC surface than would be required if the specified QTC size were used.

5.3.5.4.3 When a sacrificial production part is used as the QTC, the test specimens shall be removed from a section of the part meeting the size requirements of the QTC for that production part as described in 5.3.5.2.

5.3.5.5 Hardness Testing

5.3.5.5.1 General

A hardness test shall be performed on the QTC after the final heat treatment cycle.

5.3.5.5.2 Methods

Hardness testing shall be performed in accordance with procedures specified in ASTM A370 or ASTM E10 as appropriate.

6 Welding Requirements

6.1 GENERAL

6.1.1 All welding of components exposed to wellbore fluid shall comply with the welding requirements of NACE MR0175. Verification of compliance shall be established through the implementation of the manufacturer's written Welding Procedure Specification (WPS) and the supporting Procedure Qualification Record (PQR).

6.1.2 When material specifications for pressure-containing and pressure-retaining components require impact testing, verification of compliance shall be established through the implementation of the manufacturer's WPS and supporting PQR.

6.2 WELDMENT DESIGN AND CONFIGURATION

6.2.1 Pressure Containing Fabrication Weldments

Pressure-containing fabrication weldments contain and are wetted by wellbore fluid.

6.2.1.1 Only full penetration welds fabricated in accordance with the manufacturer's written specification shall be used. Appendix E is provided for reference.

6.2.1.2 Welding and completed welds shall meet the quality control requirements of Section 7 of this specification.

6.2.2 Load Bearing Weldment

Load bearing weldments are those subject to external loads and not exposed to wellbore fluids.

6.2.2.1 Joint design shall be in accordance with the manufacturer's written procedures.

6.2.2.2 Welding and completed welds shall meet the quality control requirements of Section 7 of this specification.

6.2.3 Weld Repairs

Weld repairs to pressure-containing members.

6.2.3.1 All repair welding shall be done in accordance with the manufacturer's written specification. All major repair welds performed subsequent to original heat treatment shall be mapped.

6.2.3.2 Welding and completed welds shall meet the requirement of Section 7 of this specification.

6.2.4 Weld Surfacing (Overlay) for Corrosion Resistance and Wear Resistance for Material Surface Property Controls

6.2.4.1 Corrosion-Resistant API Ring Grooves

Standard dimensions for the preparation of API Type SR ring grooves for overlay are specified in 4.3. Standard dimensions for API Type R and BX ring grooves are specified in API Specification 6A.

6.2.4.2 Corrosion-Resistant and Wear-Resistant Overlays Other Than Ring Grooves

6.2.4.2.1 The manufacturer shall use a written procedure that provides controls for consistently meeting the manufacturer specified material surface properties in the final machined condition. As a minimum this shall include inspection methods and acceptance criteria.

6.2.4.2.2 Qualification shall be in accordance with Article II and III of ASME *Boiler & Pressure Vessel Code* Section IX for corrosion-resistant weld metal overlay or hardfacing weld metal overlay as applicable.

6.2.4.2.3 Mechanical Properties

Mechanical properties of the base material shall retain the minimum mechanical property requirements after thermal treatment. The manufacturer shall specify the methods to assure these mechanical properties and record the results as a part of the PQR.

6.3 WELDING CONTROLS

6.3.1 Procedures

The manufacturer's system for controlling welding shall include procedures for monitoring, updating, and controlling the qualification of welders and welding operators and the use of welding procedure specifications.

6.3.2 Application

6.3.2.1 Welding shall be performed by personnel qualified in accordance with the requirements of 6.4.1.

6.3.2.2 Welding shall be performed in accordance with written WPS and qualified in accordance with Article II of ASME Section IX. The WPS shall describe all the essential, non-essential and supplementary essential (when required—see ASME Section IX) variables. Welders and welding operators shall have access to, and shall comply with, the welding parameters as defined in the WPS.

6.3.3 Designed Welds

6.3.3.1 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.

6.3.3.2 Dimensions of groove and fillet welds with tolerances shall be documented in the manufacturer's specification. Appendix E of this specification depicts some typical joint designs.

6.3.4 Preheating

Preheating of assemblies or parts, when required, shall be performed to manufacturer's written procedures.

6.3.5 Instrument Calibration

Instruments to verify temperature, voltage, and amperage shall be serviced and calibrated in accordance with the written specification of the manufacturer performing the welding.

6.3.6 Materials

6.3.6.1 Welding Consumables

6.3.6.1.1 Welding consumables shall conform to the American Welding Society's (AWS) or consumable manufacturer's approved specifications.

6.3.6.1.2 The manufacturer shall have a written procedure for storage and control of weld consumables. Materials of low hydrogen type shall be stored and used as recommended by the consumable manufacturer to retain their original low hydrogen properties.

6.3.6.1.3 Deposited Weld Metal Properties

The deposited weld metal mechanical properties shall meet or exceed the minimum specified mechanical properties of the base material. Verification of properties shall be established through the implementation of the manufacturer's WPS and supporting PQR. When materials of differing strength are joined, the weld metal shall meet the minimum requirements of the lesser material.

6.3.7 Post-Weld Heat Treatment

6.3.7.1 Post-weld heat treatment of components shall be in accordance with the manufacturer's written procedures.

6.3.7.2 Furnace post-weld heat treatment shall be performed in equipment meeting the requirements specified by the manufacturer.

6.3.7.3 Local post-weld heat treatment shall consist of heating a band around a weld at a temperature within the range specified in the qualified WPS. The minimum width of the controlled band adjacent to the weld, on the face of the

greatest weld width, shall be the thickness of the weld. Localized flame heating is permitted provided the flame is baffled to prevent direct impingement on the weld and base material.

6.4 WELDING PROCEDURE AND PERFORMANCE QUALIFICATIONS

6.4.1 General

All weld procedures, welders, and welding operators shall be qualified in accordance with the qualification and test methods of Section IX, ASME *Boiler and Pressure Vessel Code*, as amended below.

6.4.1.1 Base Metals

6.4.1.1.1 The manufacturer may use ASME Section IX P number materials.

6.4.1.1.2 The manufacturer may establish an equivalent P number (EP) grouping for low alloy steels not listed in ASME Section IX with nominal carbon content equal to or less than 0.35 percent.

6.4.1.1.3 Low alloy steels not listed in ASME Section IX with a nominal carbon content greater than 0.35 percent shall be specifically qualified for the manufacturer's specified base material.

6.4.1.1.4 Qualification of a base material as a specified strength level also qualifies that base material at all lower strength levels.

6.4.1.2 Heat Treat Condition

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 be according to the manufacturer's written specifications.

6.4.2 Procedure Qualification Record

The PQR shall record all essential and supplementary essential (when required by ASME) variables of the weld procedure used for the qualification test(s). Both the WPS and the PQR shall be maintained as records in accordance with the requirements of Section 7 of this specification.

6.5 OTHER REQUIREMENTS

6.5.1 ASME Section IX, Article I—Welding General Requirements

Article I of ASME Section IX shall apply with additions as shown in this section.

6.5.1.1 Hardness Testing

Hardness testing shall be conducted across the weld and base material Heat Affected Zone (HAZ) cross section and shall be recorded as part of the PQR. Results shall be in conformance with NACE MR0175 requirements. The manufacturer shall specify the hardness testing method to be used. Testing shall be performed on the weld and base material HAZ cross section in accordance with ASTM E18, Rockwell; or ASTM E92, Vickers 10kg. Minimum results shall be converted to Rockwell C as applicable per ASTM E140.

6.5.1.1.1 Rockwell Method (ASTM E18)

If the Rockwell method is selected by the manufacturer, the following procedure shall be used (see Figure 11):

a. For a weld cross section thickness less than $^1/_2$-inch, four (4) hardness tests each shall be made in the base material(s), the weld, and the HAZ.

b. For a weld cross section thickness equal to or greater than $^1/_2$-inch, six (6) hardness tests each shall be made in the base material(s), the weld, and the HAZ.

c. HAZ hardness tests shall be performed in the base material within $^1/_{16}$-inch of the weld interface and at least one each within $^1/_8$-inch from top and bottom of the weld.

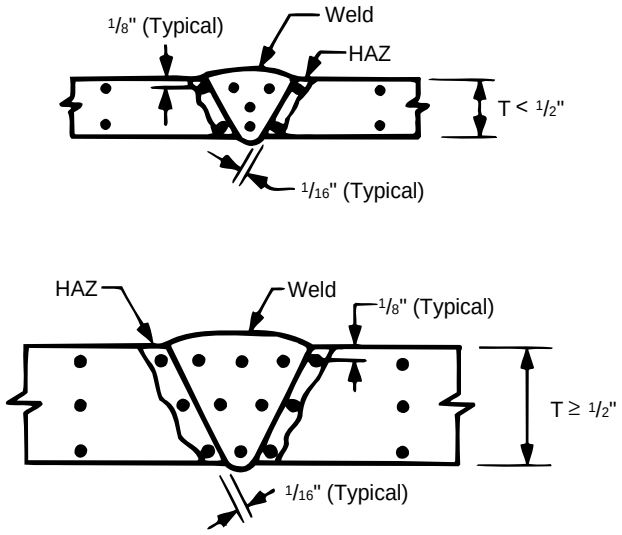


Figure 11—Welding Procedure Qualification Rockwell Hardness Test Locations

6.5.1.1.2 Vickers Method (ASTM E92)

If the Vickers method is selected by the manufacturer, the following procedure shall be used (see Figure 12):

a. For a weld cross section thickness less than $^1/_2$-inch, four (4) hardness tests each shall be made in the base materials and the weld.

b. For a weld cross section thickness equal to or greater than $^1/_2$-inch, six (6) hardness tests each shall be made in the base material(s) and the weld.

c. Multiple HAZ hardness tests equally spaced $^1/_8$-inch apart shall be performed in each of the base materials within 0.010-inch of the weld interface and at least one within $^1/_{16}$-inch from the top and the bottom of the weld.

6.5.1.1.3 Hardness Testing (Optional)

Minimum mechanical properties: For the purpose of hardness inspection and qualifying production weldments, a minimum of three hardness tests in the weld metal shall be made and recorded as part of the PQR. These tests shall be made by the same methods used to inspect production weldments. These tests may be used to qualify weld metal with hardness less than shown in 7.5.1.3 by the method shown in the same section.

6.5.1.2 Impact Testing

6.5.1.2.1 When impact testing is required by the base material specification, the testing shall be performed in accordance with ASTM A370 using the Charpy V-Notch technique. Results of testing in the weld and base material HAZ shall meet the minimum requirements of the base material. Records of results shall become part of the PQR.

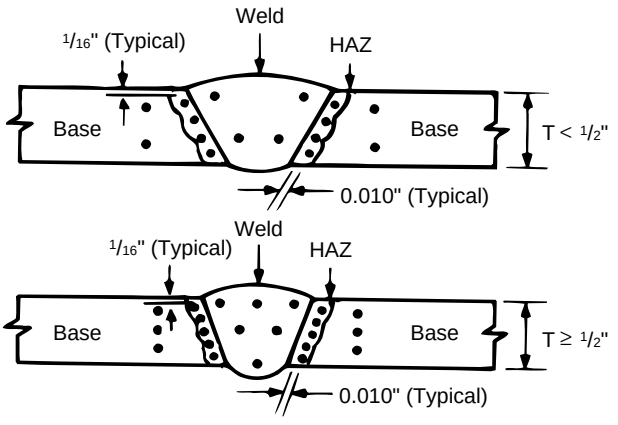


Figure 12—Welding Procedure Qualification Vickers Hardness Test Locations

6.5.1.2.2 When impact testing is required of the base material, one set of three test specimens shall be removed at the $^1/_4$ thickness location of the test weldment for each of the weld metal and base material HAZ. The root of the notch shall be oriented normal to the surface of the test weldment and located as follows:

a. Weld metal specimens (three each) shall be 100 percent weld metal.

b. HAZ specimens (three each) shall include HAZ material as specified in the manufacturer's written procedure.

c. When weld thickness of the product is equal to or greater than 2 inches, impact testing as defined in 6.5.1.2.2 shall be performed on weld metal and HAZ material removed within $^1/_4$ thickness.

6.5.2 ASME Section IX, Article II—Welding Procedure Qualifications

Article II of ASME Section IX shall apply with additions as shown in this section.

6.5.2.1 Heat Treatment

The post-weld heat treatment of the test weldment and the production weldment shall be in the same range as that specified on the WPS. Allowable range for the post-weld heat treatment on the WPS shall be a nominal temperature ±25°F. The stress relieving heat treatment(s) time(s) at temperature(s) of production parts shall be equal to or greater than that of the test weldment.

6.5.2.2 Chemical Analysis

Chemical analysis of the base materials for the test weldment shall be obtained from the supplier or by testing and shall be part of the PQR.

6.5.2.3 Chemical Analysis Ring Groove Overlay

For corrosion-resistant ring groove overlay, chemical analysis shall be performed in the weld metal in accordance with the requirements of ASME Section IX at a location of 0.125 inch or less from the original base metal surface. The chemical composition of the deposited weld metal at that location shall be as specified by the manufacturer. For 300 Series stainless steel, the chemical composition shall be within the following limits:

Nickel	8.0% Minimum
Chromium	16.0% Minimum
Carbon	0.08% Maximum

6.5.3 ASME Section IX, Article III—Welding Performance Qualifications

Article III of ASME Section IX shall apply with additions as shown in this section.

6.5.3.1 Bolt, Tapped, and Blind Hold Repair Performance Qualification

The welder or welding operator shall perform an additional repair welding performance qualification test using a mock-up hole. (Refer to Appendix E.) The repair welding qualification test hole shall be qualified by radiography according to Section 7 of this specification or shall be cross sectioned through the center line of the hole and both faces shall be examined by NDE in accordance with Section 7 of this specification. This evaluation shall include the total depth of the hole.

6.5.3.1.1 The repair weld qualification shall be restricted by the following essential variables for performance controls:

a. The hole diameter used for the performance qualification test is the minimum diameter qualified. Any hole with a greater diameter than the diameter used for the test shall be considered qualified.
b. The depth-to-diameter ratio of the test hole shall qualify all repairs to holes with the same or smaller depth-to-diameter ratio.
c. The performance qualification test shall have straight parallel walls. If any taper, counter bore, or other aid is used to enhance the hole configuration of the performance test, that configuration shall be considered an essential variable.

6.5.3.2 For welder performance qualification, ASME Section IX P-1 base metals may be used for the test coupon in place of the low alloy steels covered by Table 15.

6.5.4 ASME Section IX, Article IV—Welding Data

Article IV of ASME Section IX shall apply as written.

7 Quality Control Requirements

7.1 GENERAL

This section specifies the requirements relative to Quality Control to assure that the equipment, materials, and services meet this specification. The following subjects are covered:

a. Measuring and Test Equipment: 7.2.
b. Quality Control Personnel Qualifications: 7.3.
c. Quality Control Requirements For Equipment and Parts: 7.4.
d. Quality Control Requirements For Specific Equipment and Parts: 7.5.
   1. Pressure Containing and Pressure Controlling Parts: 7.5.1.
   2. Studs and Nuts: 7.5.2.
   3. Closure Bolting: 7.5.3.
   4. Ring Gaskets: 7.5.4.
   5. Non Metallic Sealing Materials and Molded Sealing Assemblies: 7.5.5.
   6. Annular Packers Shipped Separately: 7.5.6.
   7. All Other Drill Through Equipment Parts: 7.5.7.
   8. Assembled Drill Through Equipment: 7.5.8.
e. Quality Control Records: 7.6.

7.2 MEASURING AND TESTING EQUIPMENT

7.2.1 General

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

7.2.2 Dimensional Measuring Equipment

Dimensional measuring equipment shall be controlled and calibrated by the methods specified in MIL-STD-120 to maintain the accuracies specified by API and the manufacturer's specification. Dimensional measuring equipment not covered by MIL-STD-120 shall be controlled and calibrated in accordance with the manufacturer's written specification.

7.2.3 Pressure Measuring Devices

7.2.3.1 Type and Accuracy

Test pressure-measuring devices shall be either pressure gages or pressure transducers and shall be accurate to at least ±0.5 percent of full scale range.

7.2.3.2 Size and Range

Pressure gages shall have a minimum face diameter of 4.5 inches. Pressure measurements shall be made at not less than 25 percent nor more than 75 percent of the full pressure span of the gauge.

7.2.3.3 Calibration Procedure

Pressure-measuring devices shall be periodically recalibrated with a master pressure-measuring device or a dead weight tester at 25 percent, 50 percent, and 75 percent of full scale.

7.2.3.4 Calibration Intervals

7.2.3.4.1 Intervals shall be established for calibrations based on repeatability and degree of usage of the pressure-measuring devices.

7.2.3.4.2 Calibration intervals shall be a maximum of three months until recorded calibration history can be determined by the manufacturer and new intervals established.

7.3 QUALITY CONTROL PERSONNEL QUALIFICATIONS

7.3.1 NDE Personnel

NDE personnel shall be qualified in accordance with requirements specified in ANST Recommended Practice SNT-TC-1A.

7.3.2 Visual Examination Personnel

Personnel performing visual examinations shall have an annual eye examination in accordance with SNT-TC-1A.

7.3.3 Welding Inspectors

Personnel performing visual inspection of welding operations and completed welds shall be qualified and certified as follows:

a. AWS-certified welding inspector, or

b. AWS-certified associate welding inspector, or

c. Welding inspector certified by the manufacturer's documented training program.

7.3.4 Other Personnel

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

7.4 QUALITY CONTROL REQUIREMENTS FOR EQUIPMENT AND PARTS

7.4.1 General

All equipment exposed to wellbore fluid shall comply with the requirements of NACE MR0175 in addition to specific requirements of this specification.

7.4.1.1 Materials

Section 7.5.1 of this specification includes detailed qualification requirements for parts and qualification test coupons. It also includes heat treating equipment qualification requirements.

7.4.1.2 Quality Control Instructions

All quality control work shall be controlled by documented manufacturer's instructions which include appropriate methodology and acceptance criteria.

7.4.1.3 Nondestructive Examination (NDE)

The manufacturer shall provide written instructions for NDE activities regarding the requirements of this specification and those of all applicable referenced specifications. All NDE instructions shall be approved by the manufacturer's qualified Level III NDE personnel.

7.4.1.4 Acceptance Status

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

7.5 QUALITY CONTROL REQUIREMENTS FOR SPECIFIC EQUIPMENT AND PARTS

7.5.1 Pressure-Containing and Pressure-Controlling Parts

Pressure-containing and pressure-controlling parts exposed to wellbore fluid except for studs and nuts, closure bolting, ring gaskets, non-metallic sealing materials, molded sealing assemblies, and metallic inserts in molded assemblies. (See 7.5.2, 7.5.3, 7.5.4, and 7.5.5.)

7.5.1.1 Tensile Testing

7.5.1.1.1 Pressure Containing Parts

Methods and acceptance criteria shall be in accordance with 5.3.4.

7.5.1.1.2 Pressure-Controlling Parts Exposed to Wellbore Fluid

Methods shall be in accordance with 5.3.4. Acceptance criteria shall be in accordance with the manufacturer's written specifications.

7.5.1.2 Impact Testing

7.5.1.2.1 Pressure-Containing Parts

Methods and acceptance criteria shall be in accordance with 5.3.4.

7.5.1.2.2 Pressure Controlling Parts Exposed to Wellbore Fluid

Methods shall be in accordance with 5.3.4. Acceptance criteria shall be in accordance with the manufacturer's written specifications.

7.5.1.3 Hardness Testing

Hardness testing methods shall be in accordance with the procedures of ASTM A370, E10, E18, or E92, as appropriate.

7.5.1.3.1 At least one hardness test shall be performed on each part tested at a location determined by the manufacturer's specifications. The hardness testing used to qualify each part shall be performed after the last heat treatment cycle (including all stress-relieving heat treatment cycles) and after all exterior machining operations.

7.5.1.3.2 When equipment is a weldment composed of different API material designations, the manufacturer shall perform hardness tests on each component part of the weldment after the final heat treatment (including stress relieving). The results of these hardness tests shall satisfy the hardness value requirements for each respective part.

7.5.1.3.3 Acceptance criteria: Hardness measurements on parts manufactured from carbon low alloy and martensitic stainless type steels shall exhibit maximum values in accordance with NACE MR0175 and minimum values equal to or greater than:

API Material Designations	Brinell Hardness
36K	HB140
45K	HB140
60K	HB174
75K	HB197

7.5.1.3.4 In the event that a part does not exhibit the required minimum hardness level, the part may be considered to have an acceptable hardness if the measured value satisfies the requirements of 7.5.1.3.4.1.

7.5.1.3.4.1 The average tensile strength, as determined from the tensile test results, shall be used with the hardness measurements in order to determine the minimum acceptable hardness value for parts manufactured from the same heat. The minimum acceptable hardness value for any part shall be determined by:

$$HB_C = \frac{(UTS)}{(UTS_{QTC})} \cdot HB_{QTC}$$

Where:

HB_C = minimum acceptable Brinell hardness for part after the final heat treatment cycle (including stress relieving cycles).

UTS = minimum acceptable ultimate tensile strength specified for the applicable strength level, i.e., 70,000, 85,000 or 95,000 psi.

UTS_{QTC} = average ultimate tensile strength determined from the QTC tensile tests.

HB_{QTC} = average of the Brinell hardness values observed among all tests performed on the QTC.

7.5.1.3.4.2 In the event that it is necessary to report the hardness test results in other measurement units, conversions shall be made in accordance with ASTM E140: *Standard Hardness Conversion Tables for Metals*.

7.5.1.4 Dimensional Verification

Critical dimensions as defined by the manufacturer shall be documented for each part and such documentation shall be retained by the manufacturer in accordance with 7.6. The manufacturer shall define and document the extent to which dimensions shall be verified.

7.5.1.5 Traceability

Parts and material shall be traceable to the individual heat and heat treatment lot.

7.5.1.5.1 Identification shall be maintained on materials and parts, to facilitate traceability, as required by documented manufacturer requirements.

7.5.1.5.2 Manufacturer documented traceability requirements shall include provisions for maintenance or replacement of identification marks and identification control records.

7.5.1.6 Chemical Analysis

7.5.1.6.1 Sampling

Chemical analysis shall be performed on a heat basis.

7.5.1.6.2 Methods

Chemical analysis shall be performed in accordance with the manufacturer's written procedure.

7.5.1.6.3 Acceptance Criteria

The chemical composition shall meet the requirements of 5.3.3.

7.5.1.7 Visual Examination

7.5.1.7.1 Sampling

Each part shall be visually examined.

7.5.1.7.2 Methods

Visual examinations of castings and forgings shall be performed in accordance with the manufacturer's written specification.

7.5.1.7.3 Acceptance Criteria

Acceptance criteria shall be in accordance with manufacturer's written specifications.

7.5.1.7.4 Non-Well Fluid Wetted and Non-Sealing Surfaces

Such surfaces shall be examined in accordance with visual examination methods described in this section.

7.5.1.8 Surface NDE

7.5.1.8.1 General

All accessible surfaces of each finished part shall be inspected in accordance with this section.

7.5.1.8.1.1 Surface NDE of Ferromagnetic Materials

All accessible well fluid wetted surfaces and all accessible sealing surfaces of each finished part shall be inspected after final heat treatment and after final machining operations by either magnetic particle (MP) or liquid penetrant (LP) methods.

7.5.1.8.1.2 Surface NDE of Non-Ferromagnetic Materials

All accessible well fluid wetted surfaces of each finished part shall be inspected after final heat treatment and after final machining operations by LP method.

7.5.1.8.2 Methods

7.5.1.8.2.1 MP examination shall be in accordance with procedures specified in ASTM E709. Prods are not permitted on well fluid wetted surfaces or sealing surfaces.

7.5.1.8.2.2 LP examination shall be in accordance with procedures specified in ASTM E-165.

7.5.1.8.3 Acceptance Criteria for MP and LP

Note: Inherent indications not associated with a surface rupture (e.g. magnetic permeability variations, non-metallic stringers) are not considered relevant indications.

7.5.1.8.3.1 Acceptance criteria for surfaces other than pressure contact (metal-to-metal) sealing surfaces:

a. No relevant indication with a major dimension equal to or greater than $^{3}/_{16}$-inch.

b. No more than ten relevant indications in any continuous 6-square-inch area.

c. Four or more relevant indications in a line separated by less than $^{1}/_{16}$-inch (edge to edge) are unacceptable.

7.5.1.8.3.2 Acceptance Criteria for pressure-contact (metal-to-metal) sealing surfaces:

There shall be no relevant indications in the pressure contact (metal-to-metal) sealing surfaces.

7.5.1.9 Weld NDE—General

When examination is required herein, essential welding variables and equipment shall be monitored, and completed weldments (a minimum of $^{1}/_{2}$-inch of surrounding base metal) and the entire accessible weld shall be examined in accordance with the methods and acceptance criteria of this section.

7.5.1.10 Weld Prep NDE—Visual

7.5.1.10.1 Weld Prep NDE—Surface Preparation Examination

7.5.1.10.1.1 One hundred percent of all surfaces prepared for welding shall be visually examined prior to initiating welding.

7.5.1.10.1.2 Examinations shall include a minimum of $^{1}/_{2}$-inch of adjacent base metal on both sides of the weld.

7.5.1.10.2 Weld NDE surface preparation acceptance shall be in accordance with the manufacturer's written specification.

7.5.1.11 Post-Weld Visual Examination

7.5.1.11.1 All welds shall be examined according to manufacturer's written specification.

7.5.1.11.2 Any undercut detected by visual examination shall be evaluated in accordance with the manufacturer's written specification.

7.5.1.11.3 Surface porosity and exposed slag are not permitted on or within $^{1}/_{8}$-inch of sealing surfaces.

7.5.1.12 Weld NDE—Surface (Other Than Visual)

7.5.1.12.1 General

One hundred percent of all pressure-containing welds, repair, and weld metal overlay welds and repaired fabrication welds shall be examined by either MP or LP methods after all welding, post-weld heat treatment, and machining operations are completed. The examination shall include $^{1}/_{2}$-inch of adjacent base material on both sides of the weld.

7.5.1.12.2 Methods

Methods and acceptance criteria for MP and LP examinations shall be the same as in 7.5.1.8.2 except:

a. Magnetic Particle
   1. No relevant linear indications.
   2. No rounded indications greater than $^{1}/_{8}$-inch for welds whose depth is $^{5}/_{8}$-inch or less or $^{3}/_{16}$-inch for welds whose depth is greater than $^{5}/_{8}$-inch.

b. Liquid Penetrant: No rounded indications greater than $^{1}/_{8}$-inch for welds whose depth is $^{5}/_{8}$-inch or less or $^{3}/_{16}$-inch for welds whose depth is greater than $^{5}/_{8}$-inch.

7.5.1.12.3 Manufacturers shall not be restricted to these criteria provided they have the means to and determine the acceptable defect size and configuration based on their stress analysis of the product. Results of the analysis shall be documented.

7.5.1.13 Repair Welds

7.5.1.13.1 All repair welds shall be examined using the same methods and acceptance criteria used in examining the base metal (7.5.1.8).

7.5.1.13.2 Examination shall include $^1/_2$-inch of adjacent base metal on all sides of the weld.

7.5.1.13.3 Surfaces of ground out areas for repair welds shall be examined prior to welding to ensure defect removal using the acceptance criteria for fabrication welds (7.5.1.10).

7.5.1.14 Weld NDE—Volumetric for Fabrication Weld

7.5.1.14.1 General

One hundred percent of all pressure-containing welds shall be examined by either radiography, ultrasonic, or acoustic emission methods after all welding and post-weld heat treatment. All repair welds where the repair is greater than 25 percent of the original wall thickness or 1 inch (whichever is less) shall be examined by either radiography, ultrasonic, or acoustic emission methods after all welding and post-weld heat treatment. Examinations shall include at least $^1/_2$-inch of adjacent base metal on all sides of the weld.

7.5.1.14.2 Radiography

7.5.1.14.2.1 Method

Radiographic examinations shall be performed in accordance with procedures specified in ASTM E94, to a minimum equivalent sensitivity of 2 percent. Both X-ray and gamma ray radiation sources are acceptable within the inherent thickness range limitation of each. Real-time imaging and recording/enhancement methods may be used when the manufacturer has documented proof that the methods will result in a minimum equivalent sensitivity of 2 percent. Wire type image quality indicators are acceptable for use in accordance with ASTM E747.

7.5.1.14.2.2 Acceptance Criteria

The following shall be unacceptable: any type of crack, zone of incomplete fusion or penetration, on any elongated slag inclusion which has a length equal to greater than:

Weld thickness (T) (inches)	Inclusion length (inches)
Less than 0.76	0.25
0.76 to 2.25	0.33 T
greater than 2.25	0.75

In addition, the following shall be unacceptable: Any group of slag inclusions in a line having an aggregate length greater than the weld thickness (T) in any total weld length 12T, except when the distance between successive inclusions exceeds six times the length of the longest inclusion, any rounded indications in excess of that specified in ASME *Boiler and Pressure Vessel Code*, Section VIII, Division I, Appendix 4.

7.5.1.14.3 Ultrasonic

7.5.1.14.3.1 Method

Ultrasonic examinations shall be performed in accordance with procedures specified in ASME *Boiler and Pressure Vessel Code*, Section V, Article 5.

7.5.1.14.3.2 Acceptance Criteria

The following shall be unacceptable: Any indications whose signal amplitude exceeds the reference level, any linear indications interpreted as cracks, incomplete joint penetration or incomplete fusion, and any slag indications with amplitudes exceeding the reference level whose length exceeds:

Weld thickness (T) (inches)	Inclusion length (inches)
Less than 0.76	0.25
0.76 to 2.25	0.33T
greater than 2.25	0.75

Note: If a weld joins two members having different thicknesses at the weld, T is the thinner of the two thicknesses.

7.5.1.14.4 Method—Acoustic Emission

7.5.1.14.4.1 Examination

Acoustic emission (AE) examinations shall be performed in accordance with procedures specified in ASTM E569. The acoustic emission examination shall be conducted throughout the duration of the hydrostatic “in-plant” test.

7.5.1.14.4.2 Acceptance Criteria

Evaluation and acceptance criteria shall be as follows:

a. During the first pressurization cycle, any rapid increase in AE events or any rapid increase in AE count rate shall require a pressure hold. If either of these conditions continues during the pressure hold, the pressure shall be immediately reduced to atmospheric pressure and the cause determined. There shall be no leakage at any time during the test.

b. During the second pressurization cycle, the requirements of item a above shall apply and, in addition, the following AE indications shall be unacceptable:

1. Any AE event during any pressure hold.
2. Any single AE event that produces more than 500 counts, or that produces a single attribute equivalent to 500 counts.
3. Three or more AE events from any circular area whose diameter is equal to the weld thickness or 1 inch, whichever is greater.
4. Two or more AE events from any circular area (having a diameter equal to the weld thickness or 1 inch, whichever is greater) that emitted multiple AE events during the first pressurization.
5. Welds that produce questionable acoustic emission response signals (i.e., AE signals that cannot be interpreted by the AE examiner) shall be evaluated by radiography in accordance with 7.5.1.14.2. If the construction of the pressure vessel does not permit interpretable radiographs to be taken, ultrasonic examination may be substituted for radiography in accordance with 7.5.1.14.3. Final acceptance (or rejection) of such welds shall be based on the radiographic or ultrasonic results, as applicable.

7.5.1.15 Weld NDE—Hardness Testing

7.5.1.15.1 Sampling

All accessible pressure-containing, nonpressure-containing, and major repair welds shall be hardness tested.

7.5.1.15.2 Methods

7.5.1.15.2.1 Hardness testing shall be performed in accordance with one of the following:

a. Those procedures specified in ASTM E10, *Standard Test Methods for Brinell Hardness of Metallic Materials*.
b. Those procedures specified in ASTM E18: *Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials*.

7.5.1.15.2.2 At least one hardness test shall be performed in both the weld and the adjacent unaffected base metal after all heat treatment and machining operations.

7.5.1.15.3 Acceptance Criteria

7.5.1.15.3.1 Hardness values shall meet the requirements of Section 7.5.1.3.

7.5.1.15.3.2 The hardness recorded in the PQR shall be the basis for acceptance if the weld is not accessible for hardness testing.

7.5.2 Studs and Nuts (Other Than Closure Bolting)

Studs and nuts shall conform to the requirements of API Specification 6A, PSL 1.

7.5.3 Closure Bolting

Closure bolting shall conform to the requirements of API Specification 6A, PSL 1, plus:

a. Material in closure bolts shall be traceable to the heat or identified in accordance with ASTM A193, A320 or A453.
b. The thread form and dimensions of closure bolts shall conform to the manufacturer's written specification.

7.5.4 Ring Gaskets

Ring gaskets shall conform to the requirements of API Specification 6A, PSL 1.

7.5.5 Non-Metallic Sealing Materials and Molded Sealing Assemblies

7.5.5.1 Ram and Annular BOP Packers and Seals

7.5.5.1.1 Testing of Material

Testing of each batch shall be in accordance with ASTM procedures. If a suitable ASTM procedure cannot be applied, the manufacturer shall provide a written procedure for testing. Characteristics shall be defined by measurements of physical properties.

Mechanical property data shall include the following:

a. Hardness data in accordance with ASTM D1415 or D2240.
b. Tensile data in accordance with ASTM D1414 or D412.
c. Elongation data in accordance with ASTM D1414 or D412.
d. Modulus data in accordance with ASTM D1414 or D412.

7.5.5.1.2 Acceptance Criteria

Acceptance shall be in accordance with manufacturer's written specifications.

7.5.5.2 Metallic Inserts in Molded Assemblies

7.5.5.2.1 Dimensional Verification

7.5.5.2.1.1 Sampling

Sampling shall be in accordance with manufacturer's written requirements or MIL STD 105D, Level II, 4.0 AQL.

7.5.5.2.1.2 Methods

All methods shall be in accordance with manufacturer's written requirements.

7.5.5.2.1.3 Acceptance Criteria

Acceptance shall be in accordance with manufacturer's written specifications.

7.5.5.2.2 Hardness Testing

7.5.5.2.2.1 Sampling

Sampling shall be in accordance with manufacturer's written requirements or MIL STD-105D, Level II, 4.0 AQL.

7.5.5.2.2.2 Methods

A minimum of one hardness test shall be performed in accordance with procedures specified in ASTM E18 or E10.

7.5.5.2.2.3 Acceptance Criteria

Acceptance shall be in accordance with manufacturer's written requirements and NACE MR0175.

7.5.5.2.3 Welding NDE

Welding NDE shall be in accordance with manufacturer's written specifications.

7.5.6 Annular Packers When Shipped Separately From a BOP

7.5.6.1 When shipped separately (not part of an assembled BOP), annular packers shall be drift tested following the pressure testing. Drift tests shall comply with Section 7.5.8.4.

7.5.7 All Other Drill Through Equipment Not Covered in 7.5.1 Through 7.5.6

All quality control requirements shall be documented in the manufacturer's written specifications.

7.5.8 Assembled Equipment

7.5.8.1 General

The quality control requirements for assembled equipment shall include drift tests, pressure tests and hydraulic operating system tests.

7.5.8.2 Serialization

Serialization is required on all assembled equipment and shall be done in accordance with the manufacturer's written specification.

7.5.8.3 Traceability Record Report

A report shall be prepared in which all serialized and individual heat traceable parts are listed as traceable to the assembly (e.g., assembly part number, serial number).

7.5.8.4 Drift Test

A drift test is required on Ram BOP, Annular BOP, hydraulic connectors, drilling spools, and adapters.

7.5.8.4.1 Method

Pass a drift mandrel through the bore of the assembly after all pressure testing.

7.5.8.4.1.1 Drift mandrel diameter shall be in accordance with the drift diameter in Table 1 with a tolerance of plus 0.010 inch and minus 0.000 inch.

7.5.8.4.1.2 Drift mandrel gage length shall be at least 2 inches longer than any cavity that intersects the bore, but not less than 12 inches.

7.5.8.4.2 Acceptance

The drift mandrel shall pass through within 30 minutes without being forced.

7.5.8.5 Pressure Test Equipment

A data acquisition system shall be used on all hydrostatic tests and on hydraulic control system tests. Pressure gauges used shall be as described in 7.2.3. The record shall identify the recording device and shall be dated and signed.

7.5.8.6 Hydrostatic Proof Testing

7.5.8.6.1 General

All drill through equipment shall be subjected to a hydrostatic proof test prior to shipment from the manufacturer's facility. Water or water with additives shall be used as the testing fluid. Any additives shall be documented in the test records.

7.5.8.6.2 In-Plant Hydrostatic body or Shell Test

7.5.8.6.2.1 General

Drill through equipment shall be tested with its sealing mechanisms in the open position, if applicable.

7.5.8.6.2.2 Test Pressure

The hydrostatic proof or shell test pressure shall be determined by the rated working pressure for the equipment. Hydrostatic proof test pressures shall be as shown in Table 18. For equipment with end or outlet connections having different working pressures, the lowest rated working pressure shall be used to determine the shell test pressure.

7.5.8.6.3 Hydraulic Operating Chamber Test

7.5.8.6.3.1 General

The hydraulic operating system test shall be tested on each assembled blowout preventer and hydraulic connector.

Table 18—Hydrostatic Test Pressure[a]

Rated Working Pressure (psi)	Test Pressure (psi) API Size Designation $13\frac{5}{8}$ and Smaller	API Size Designation $16\frac{3}{4}$ and Larger
2,000	4,000	3,000
3,000	6,000	4,500
5,000	10,000	10,000
10,000	15,000	15,000
15,000	22,500	22,500
20,000	30,000	—

[a]Minimum pressure gage reading. Maximum test pressures are determined by the manufacturer.

7.5.8.6.3.2 Test Pressure

The hydraulic operating chamber shall be tested at a minimum test pressure equal to 1.5 times the operating chamber's rated working pressure.

7.5.8.6.4 Procedure

The hydrostatic proof test shall consist of three steps:

a. The initial pressure-holding period of not less than 3 minutes.

b. The reduction of the pressure to zero.

c. The second pressure-holding period of not less than 15 minutes.

7.5.8.6.4.1 The timing of the test shall not start until the test pressure has been stabilized within the manufacturer's specified range and the external surfaces have been thoroughly dried.

7.5.8.6.5 Acceptance Criterion

The acceptance criterion is that there shall be no leakage.

7.5.8.7 Closed Preventer Test

7.5.8.7.1 General

7.5.8.7.1.1 Each ram and annular blowout preventer shall be subjected to a closed preventer test after the hydrostatic proof test. The hydraulic operating system pressure used shall be equal to or less than the manufacturer's specified operating pressure. The test fluids used for all closed preventer tests shall meet the requirements of 7.5.8.6.1.

7.5.8.7.1.2 The timing of all closed preventer tests shall not start until the test pressure has stabilized.

7.5.8.7.1.3 Closed preventer tests shall be performed at low and high pressure with the low pressure tests always preceding the high pressure test.

7.5.8.7.1.3.1 Low Pressure Test

A pressure of 200 to 300 psi shall be applied and held below the closed ram or annular packing unit for a time period of not less than 10 minutes after stabilization.

7.5.8.7.1.3.2 High Pressure Test

A pressure at least equal to the rated working pressure of the preventer shall be applied and held below the closed ram or annular packing unit for a time period of not less than 10 minutes after stabilization. (see exception for annular packing units in 7.5.8.7.2.2.

7.5.8.7.1.3.3 Acceptance Criterion

The acceptance criterion is that there shall be no leakage.

7.5.8.7.2 Annular Packing Unit Test Requirements

Annular packing units shall be tested in two stages.

7.5.8.7.2.1 Stage One

This test shall require closing on the appropriate size drill pipe as follows:

$7\frac{1}{16}$-inch and 9-inch bore	$3\frac{1}{2}$-inch diameter
11-inch and larger bore	5-inch diameter

7.5.8.7.2.2 Stage Two

This test shall require closing without drill pipe in the preventer, i.e., on the open hole. The high pressure test shall be as specified in 7.5.8.7.1.3.2 except as a minimum it shall be performed at 50 percent of the rated working pressure of the preventer.

7.5.8.7.3 Pipe, Blind, and Variable Bore Ram Test Requirements

These tests shall be performed with the appropriate sized drill pipe for the rams being tested. VBRs shall be tested on the minimum and maximum sizes for their range.

7.5.8.7.4 Shear-Blind Ram Test Procedure

Each preventer equipped with shear-blind rams shall be subjected to a shearing test. As a minimum, this test requires shearing of drill pipe as follows: $3\frac{1}{2}$-inch 13.3 lb/ft Grade E for $7\frac{1}{16}$-inch BOPs, 5-inch 19.5 lb/ft Grade E for 11-inch BOPs and 5-inch 19.5 lb/ft Grade G for $13\frac{5}{8}$-inch and larger BOPs. These tests shall be performed without tension in the pipe and with zero wellbore pressure. Shearing and sealing shall be achieved in a single operation. The piston closing pressure shall not exceed the manufacturer's rated working pressure for the operating system.

7.5.8.7.5 Hydraulic Ram Locking System Test Procedure

Each blowout preventer equipped with a hydraulic ram locking system shall be pressure tested with the locking system engaged. The preventer shall be tested in accordance with 7.5.8.7.1.3.1 and 7.5.8.7.1.3.2 after the rams are closed, the locks engaged and then all operating pressure(s) released.

7.5.8.8 Hydraulic Connector Tests

7.5.8.8.1 General

Note: Since there is no closure unit (such as a ram or packer) a rated working pressure test is not required. The hydrostatic proof test shall take the place of any rated working pressure tests.

7.5.8.8.1.1 Each hydraulic connector shall be subjected to a low pressure test and a hydrostatic proof test. The hydraulic operating chamber pressure used shall be equal to or less than the manufacturer's specified operating pressure. The test fluids used shall meet the requirements of 7.5.8.6.1.

7.5.8.8.1.2 The timing of all pressure tests shall not start until the test pressure has stabilized.

7.5.8.8.1.3 The tests shall conform to 7.5.8.8.1.3.1 and 7.5.8.8.1.3.2 with the low pressure tests always preceding the high pressure test.

7.5.8.8.1.3.1 Low Pressure Test

A pressure of 200 to 300 psi shall be applied and held on the connector for a time period of not less than 10 minutes after stabilization.

7.5.8.8.1.3.2 High Pressure Test

A pressure at least equal to the hydrostatic proof test pressure shall be applied and held on the connector for a time period of not less than 10 minutes after stabilization.

7.5.8.8.1.3.3 Acceptance Criterion

The acceptance criterion is that there shall be no leakage.

7.5.8.8.2 Procedure

The connector pressure test shall be in two stages.

7.5.8.8.2.1 Stage One

The connector shall be locked on the appropriate test stump using the manufacturer's recommended operating pressure and then the operating pressure shall be removed prior to pressure testing.

7.5.8.8.2.2 Stage Two

The connector shall be locked on the appropriate test stump using the manufacturer's recommended operating pressure and then pressure tested.

7.6 QUALITY CONTROL RECORDS REQUIREMENTS

7.6.1 General

The quality control records required by this specification are those documents and records necessary to substantiate that all materials and equipment made to this specification do conform to the specified requirements.

7.6.1.1 NACE Records Requirements

Records required to substantiate conformance of equipment to NACE requirements shall be in addition to those described in other sections of this document unless the records required by this specification also satisfy the MR0175 requirements.

7.6.1.2 Records Control

7.6.1.2.1 Records required by this specification shall be legible, identifiable, retrievable and protected from damage, deterioration, or loss.

7.6.1.2.2 Records required by this specification shall be retained by the manufacturer for a minimum of ten years following the date of manufacture as marked on the equipment associated with the records.

7.6.1.2.3 The manufacturer shall document and retain all records for each batch of raw material used in the manufacture of ram and annular BOP packers and seals. Records shall be retained for a minimum period of five years.

7.6.1.2.4 All records required by this specification shall be signed and dated. Computer-stored records shall contain originator's personal code.

7.6.2 Records to Be Maintained by Manufacturer

7.6.2.1 The manufacturer shall retain all documents and records as required in Sections 4, 5, 6, and 7.

7.6.2.2 For those parts or components covered in Section 7.5.1:

a. Weld procedure qualification record.
b. Welder qualification record.
c. Material test records:
    1. Chemical analysis.
    2. Tensile tests (QTC).
    3. Impact tests (QTC, as required).
    4. Hardness tests (QTC).
d. NDE personnel qualification records.
e. NDE records:
    1. Surface NDE records.
    2. Full penetration fabrication.
    3. Weld volumetric NDE records.
    4. Repair weld NDE records.

f. Hardness test records.
g. Welding process records:
   1. Welder identification.
   2. Weld procedures.
   3. Filler materials.
   4. Post-Weld heat treatments.
h. Heat treatment records:
   1. Actual temperature.
   2. Actual times at temperature.
i. Volumetric NDE records.
j. Hydrostatic pressure test records.
k. Critical dimensions as defined by the manufacturer.

7.6.2.3 Closure Bolting

The manufacturer shall retain individual heat traceability records for closure bolting, as required.

7.6.2.4 Non-Metallic Sealing Materials and Molded Sealing Assemblies

The manufacturer shall retain a certification of compliance for non-metallic sealing materials and molded sealing assemblies to manufacturer's written requirements.

7.6.2.5 Annular Packers Shipped Separately

The manufacturer shall retain pressure test records (7.5.8.7.2) and a drift test record (7.5.6.1) for separately-shipped annular packers.

7.6.2.6 Assembled Drill Through Equipment

The manufacturer shall retain pressure test records (7.5.8) and a drift test record for separately-shipped annular packers (7.5.6.2).

7.6.3 Records to Be Furnished to Original Purchaser upon Product Delivery

A manufacturer's certificate of compliance stating that equipment conforms to the current edition of API Specification 16A shall be furnished to the original purchaser upon product delivery.

8 Marking Requirements

8.1 GENERAL

All equipment, as listed in Section 1.2.1, manufactured in accordance with this specification shall be marked in accordance with the procedure and requirements of this section and Table 24.

8.2 TYPES OF IDENTIFICATION STAMPING

8.2.1 Metallic components

8.2.1.1 Low Stress Area Marking

For identification on low stress areas (such as nameplates, outside diameters of flanges, etc.), the use of sharp "V" stamping is acceptable.

8.2.1.2 High Stress Area Marking

For identification on high stress areas, dot, vibration, or round "V" stamping is acceptable. Sharp "V" stamping is allowed in high stress areas only if subsequent stress relieving is performed to the component.

8.2.1.3 Weld Metal Overlays

When equipment has weld metal overlaid ring grooves, the ring gasket type and number shall be followed by "CRA" to designate Corrosion Resistant Alloy.

8.2.1.4 Monogram

For API monogrammed equipment, the API Monogram shall be stamped on the product after the product description code (PDC) or alphanumeric code, followed by "16A", the edition of Specification 16A to which the equipment was manufactured, and the manufacturer's license number. For information on API Licensing, contact the API Exploration and Production Department.

8.2.2 Non-Metallic Components

8.2.2.1 Wellbore Non-Metallic Components

For identification of wellbore non-metallic components, such as ram and annular-type BOP packers and seals, the manufacturer shall have a written procedure for affixing the required codification to the product or its package.

8.2.2.2 Non-Wellbore Non-Metallic Components

Identification of non-wellbore non-metallic components, such as elastomeric seals used in ram and annular type BOP actuation systems shall be in accordance with the manufacturer's written specification.

8.3 SPECIFIC CODIFICATION REQUIREMENTS OF EQUIPMENT

8.3.1 Gaskets

Ring gaskets shall be marked in accordance with API Specification 6A.

8.3.2 Studs and Nuts

Studs and nuts shall be marked in accordance with API Specification 6A.

8.3.3 Closure Bolting

Closure bolting shall be marked in accordance with the manufacturer's written specification.

8.3.4 Packers and Seals

8.3.4.1 Wellbore Non-Metallic Components

Wellbore non-metallic components, as described in Section 8.2.2.1, shall be marked with an alpha-numeric codification system in the sequence denoted below. The meaning of the digits that make up this alpha-numeric number is described below. In addition, the manufacturer's part number shall be marked on the component.

AA BBBB CCCC DDDD EE

Compound Hardness (durometer)	AA
Compound (see Table 19)	BBBB
Date of manufacture (see 8.4.2.5)	CCCC
Lot/Serial Number (per manufacturer's specs.)	DDDD
Temperature Class (see 8.3.4.2)	EE

Table 19—Elastomer Compound Marking Code

Common Name	Chemical Name	ASTM Code D1418
Butyl	Isobutylene-isoprene	IIR
	Epichlorohydrin	CO
	Epichlorohydrin-ethylene oxide	ECO
Kel-F	Chloro fluoro elastomer	CFM
Hypalon	Chlorosulfonated polyethylene	CSM
EPR	Ethylene-propylene copolymer	EPM
EPT	Ethylene-propylene terpolymer	EPDM
Viton	Fluorocarbon	FKM
Natural	Polyisoprene	NR
Isoprene		
Natural or synthetic	Polisoprene	IR
Nitrile	Butadiene-acrylonitrile	NBR
Acrylic	Polyacrylic	ACM
Diene	Polybutadiene	BR
Neoprene	Polychloroprene	CR
Vistanex	Polyisobutylene	IM
Thiokol	Polysulfide	—
Silicone	Polysiloxanes	Si
SBR(GR-S)	Styrene-butadiene	SBR
Urethane	Diisocyanates	—

Note: Compounds which are not listed above shall be marked "N/A."

8.3.4.2 Temperature Class

The temperature class shall be as follows:

Lower Limit (first digit)		Upper Limit (second digit)	
A	–15°F	A	180°F
B	0°F	B	200°F
C	10°F	C	220°F
D	20°F	D	250°F
E	30°F	E	300°F
F	40°F	F	350°F
G	other	G	other
X	(see note)	X	(see note)

Note: These components may carry a temperature class of 40° to 180°F without performing temperature verification testing provided they are marked as temperature class "XX" in accordance with this section.

(Example: "EB" has a temperature class of 30° to 200°F.)

8.4 API PRODUCT DESCRIPTION CODE (PDC)

8.4.1 General

The API product description code (PDC) is used as an aid in describing API equipment. The PDC is a twelve-digit number that can be used to fully describe the equipment to which it is applied. The location and meaning of the digits that make up the PDC are described below.

AA BB CC DD EEEE

Equipment Type (8.4.2.1)	AA
API Size Designation (8.4.2.2)	BB
Rated Working Pressure (8.4.2.3)	CC
Temperature Rating (8.4.2.4)	DD
Date of Manufacture (8.4.2.5)	EEEE

8.4.2 Code Designations

8.4.2.1 Equipment Type

The equipment type code provides a basic description of the equipment. See Table 20 for codification.

Table 20—Equipment Type

Generic Description of Equipment	Code AA
Single ram-type BOP	01
Double ram-type BOP	02
Single annular-type BOP	03
Double annular-type BOP	04
Drilling spool	05
Adapter	06
Triple ram-type BOP	07
Hydraulic connector	08
Clamp	09
Other	99

8.4.2.2 API Size Designation

The API size designation provides the API bore size of the equipment. See Table 21 for codification.

Table 21—API Size Designation

API Size Designation	Code BB
$7^{1}/_{16}$	07
9	09
11	11
$13^{5}/_{8}$	13
$16^{3}/_{4}$	16
$18^{3}/_{4}$	18
$20^{3}/_{4}$	20
$21^{1}/_{4}$	21
$26^{3}/_{4}$	26
30	30

8.4.2.3 Rated Working Pressure

The rated working pressure is the maximum pressure at which the equipment is designed to operate. See Table 22 for codification.

Table 22—Rated Working Pressure

Rated Working Pressure (psi)	Code CC
2,000	02
3,000	03
5,000	05
10,000	10
15,000	15
20,000	20

8.4.2.4 Temperature Rating (Metallic Materials)

The temperature rating is of the metallic materials only. See Table 23 for codification.

Table 23—Temperature Ratings (Metallic Materials)

Operating Range (Degrees Fahrenheit)	Code DD
–75° to 250°	75
–20° to 250°	20
0° to 250°	00

8.4.2.5 Date of Manufacture

The date of manufacture shall consist of the month, in numerical form, and the last two digits of the year (e.g., October 1996 would be coded to 1096 for Code EEEE).

9 Storing and Shipping

9.1 STORING FOR PERIODS OF GREATER THAN 30 DAYS

9.1.1 Draining after Testing

All equipment shall be drained after testing and prior to storage.

9.1.2 Rust Prevention

Prior to storage, parts and equipment shall have exposed metallic surfaces protected with a rust preventative which will not become fluid a temperatures below 125°F.

9.1.3 Connection Surface Protection

All connection faces and ring gasket grooves shall be protected with durable covers.

9.1.4 Hydraulic Operating System

The hydraulic operating system shall be flushed with a non-freezing, corrosion-inhibiting fluid in accordance with the manufacturer's written procedures. Ports shall be plugged prior to storing.

9.1.5 Elastomeric Seals

Elastomeric seals shall be stored in accordance with the manufacturer's written procedures.

9.1.6 Ring Gaskets

Loose ring gaskets shall be wrapped or boxed for storage and shipping.

9.2 SHIPPING

All equipment is to be shipped in accordance with the manufacturer's written procedures.

Table 24—Marking Requirements and Locations

Marking	Ram Blowout Preventer	Annular Blowout Preventer	Hydraulic Connectors	Drilling Spools and Adapters	Loose Connectors	O.E.C.s[d] (Integral and Loose)	Clamps	Ram Blocks	Annular & Ram Packers and Top Seals
API Specification 16A (8.2.1.4)	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body	Connection O.D.	Manufacturer's Specification	Nameplate and/or Body	Manufacturer's Specification	Manufacturer's Specification
Manufacturer's name or mark	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body	Connection O.D. [a,b,c]	Manufacturer's Specification	Nameplate and/or Body	Manufacturer's Specification	Manufacturer's Specification
Model or Type Designation (if applicable) (Table 20)	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body				Nameplate and/or Body		
Serial number (if applicable)	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body			Nameplate and/or Body	Manufacturer's Specification	
API Size Designation (Table 21)	Nameplate and/or Body &Connection O.D. a	Nameplate and/or Body &Connection O.D. a	Nameplate and/or Body &Connection O.D. a	Nameplate and/or Body &Connection O.D. a	Connection O.D.[a,b,c]	Manufacturer's Specification	see note[e]		
Related working Pressure (Table 22)	Nameplate and/or Body &Connection O.D. a	Nameplate and/or Body &Connection O.D. a	Nameplate and/or Body &Connection O.D. a	Nameplate and/or Body &Connection O.D. a	Connection O.D.[a,b,c]	Manufacturer's Specification	see note[e]		
Temperature Rating (Table 23)	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body	Connection O.D.[a,b,c]	Manufacturer's Specification	Nameplate and/or Body		
Manufacturer's Part Number	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body	Connection O.D.[a,b,c]	Manufacturer's Specification	Nameplate and/or Body	Manufacturer's Specification	Manufacturer's Specification
Date of Manufacture	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body	Connection O.D.[a,b,c]	Manufacturer's Specification	Nameplate and/or Body	Manufacturer's Specification	Manufacturer's Specification
API Product Description Code (8.4.1)	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body	Connection O.D.[a,b,c]	Manufacturer's Specification	Nameplate and/or Body[e]		
Hydraulic Operating System Rated Working Pressure	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body						
Hydraulic Operating System Recommended Operating Pressure	Nameplate and/or Body	Nameplate and/or Body	Nameplate and/or Body						
Hydraulic Open and Close Ports	Manufacturer's Specification	Manufacturer's Specification	Manufacturer's Specification						
Equipment Orientation	Upper Portion								
Ring Groove Designation	Connection O.D.[a,b,c]	Connection O.D.[a,b,c]	Connection O.D.[a,b,c]	Connection O.D.[a,b,c]	Connection O.D.[a,b,c]	Manufacturer's Specification[c]			
Alpha-Numeric Codification System (8.3.4.1)									Manufacturer's Specification

[a]All API and 16BX hub connections shall be marked on the neck of the connection, one-half inch maximum from the required length of the neck. (See Tables 5, 6, 7, and 8, dimension "L")
[b]All flanges shall be marked in accordance with API specification 6A.
[c]If the ring groove is overlayed with corrosion resistant material, the ring groove number shall be followed with "CRA".
[d]All API Specification 16A O.E.C.s shall be marked in an easily accessible and readable area selected by the manufacturer.
[e]The API size designation in the PDC may be replaced by the two digit clamp number. If the clamp number is used, the rated working pressure code shall be replaced by the letters "CC".

APPENDIX A—METRIC CONVERSIONS AND FRACTION-TO-DECIMAL EQUIVALENTS

English units are in all cases preferential (except for test coupons, which are 10 mm x 10 mm) and shall be the standard in this specification. These factors are taken from API publication 2564.

LENGTH

1 inch (in.) = 25.4 millimeters (mm), exactly

PRESSURE

1 pound per square inch (psi) = 0.06894757 Bar

STRENGTH OR STRESS

1 pound per square inch (psi) = 0.006894757 Megapascals (mPa)

IMPACT ENERGY

1 foot-pound (ft-lb) = 1.355818 Joules (J)

TORQUE

1 foot-pound (ft-lb) = 1.355818 newton-meters (N-m)

TEMPERATURE

To convert degrees Fahrenheit (F) to degrees Celsius (C): ($C = {}^{5}/_{9}(°F-32)$)

MASS

1 pound-mass (lbm) = 0.4535924 kilograms (kg)

FORCE

1 pound-force = 4.44823 newton (N)

Table A-1—Fraction to Decimal Conversion Chart

4ths	8ths	16ths	32ths	64ths	To 3 places	To 2 places	4ths	8ths	16ths	32ths	64ths	To 3 places	To 2 places
				$^{1}/_{64}$	0.016	0.02					$^{33}/_{64}$	0.516	0.52
			$^{1}/_{32}$		0.031	0.03				$^{17}/_{32}$		0.531	0.53
				$^{3}/_{64}$	0.047	0.05					$^{35}/_{64}$	0.547	0.55
		$^{1}/_{16}$			0.062	0.06			$^{9}/_{16}$			0.562	0.56
				$^{5}/_{64}$	0.078	0.08					$^{37}/_{64}$	0.578	0.58
			$^{3}/_{32}$		0.094	0.09				$^{19}/_{32}$		0.594	0.59
				$^{7}/_{64}$	0.109	0.11					$^{39}/_{64}$	0.609	0.61
	$^{1}/_{8}$				0.125	0.12		$^{5}/_{8}$				0.625	0.62
				$^{9}/_{64}$	0.141	0.14					$^{41}/_{64}$	0.641	0.64
			$^{5}/_{32}$		0.156	0.16				$^{21}/_{32}$		0.656	0.66
				$^{11}/_{64}$	0.172	0.17					$^{43}/_{64}$	0.672	0.67
		$^{3}/_{16}$			0.188	0.19			$^{11}/_{16}$			0.688	0.69
				$^{13}/_{64}$	0.203	0.20					$^{45}/_{64}$	0.703	0.70
			$^{7}/_{32}$		0.219	0.22				$^{23}/_{32}$		0.719	0.72
				$^{15}/_{64}$	0.234	0.23					$^{47}/_{64}$	0.734	0.73
$^{1}/_{4}$					0.250	0.25	$^{3}/_{4}$					0.750	0.75
				$^{17}/_{64}$	0.266	0.27					$^{49}/_{64}$	0.766	0.77
			$^{9}/_{32}$		0.281	0.28				$^{25}/_{32}$		0.781	0.78
				$^{19}/_{64}$	0.297	0.30					$^{51}/_{64}$	0.797	0.80
		$^{5}/_{16}$			0.312	0.31			$^{13}/_{16}$			0.812	0.81
				$^{21}/_{64}$	0.328	0.33					$^{53}/_{64}$	0.828	0.83
			$^{11}/_{32}$		0.344	0.34				$^{27}/_{32}$		0.844	0.84
				$^{23}/_{64}$	0.359	0.36					$^{55}/_{64}$	0.859	0.86
	$^{3}/_{8}$				0.375	0.38		$^{7}/_{8}$				0.875	0.88
				$^{25}/_{64}$	0.391	0.39					$^{57}/_{64}$	0.891	0.89
			$^{13}/_{32}$		0.406	0.41				$^{29}/_{32}$		0.906	0.91
				$^{27}/_{64}$	0.422	0.42					$^{59}/_{64}$	0.922	0.92
		$^{7}/_{16}$			0.438	0.44			$^{15}/_{16}$			0.938	0.94
				$^{29}/_{64}$	0.453	0.45					$^{61}/_{64}$	0.953	0.95
			$^{15}/_{32}$		0.469	0.47				$^{31}/_{32}$		0.969	0.97
				$^{31}/_{64}$	0.484	0.48					$^{63}/_{64}$	0.984	0.98
$^{1}/_{2}$					0.500	0.50	1					1.000	1.00

APPENDIX B—OPERATIONAL CHARACTERISTICS TEST PROCEDURES USED TO DEFINE THE OPERATING CHARACTERISTICS OF DRILL THROUGH EQUIPMENT

B.1 Pressure Loss Measurement

Pressure testing on drill through equipment requires allowance for the pressure to stabilize before timing of the test begins.

B.2 Calibration

Each gage or pressure transducer used shall be calibrated in accordance with 7.2.

B.3 Pressure Recording Technique

All tests shall be done in conjunction with a data acquisition system. The information shall be identified, dated, and signed/verified by the tester and witnesses as applicable.

B.4 Ram Type BOPs

B.4.1 SEALING CHARACTERISTICS TEST

B.4.1.1 The following procedure is used to test ram closure against zero initial wellbore pressure.

a. Install the preventer on test stump. Connect opening and closing lines to BOP. Connect line from the high pressure test pump to the stump or BOP side outlet.

b. The opening, closing, and wellbore pressure lines shall each be equipped, as a minimum, with a pressure transducer. All transducers shall be connected to a data acquisition system to provide a permanent record.

c. Install a new set of ram rubber goods onto the blocks. Durometer measurements on the ram rubber face seal shall be made and recorded.

d. Disengage any automatic locking system on the ram closing device.

e. Install test mandrel in the BOP for pipe ram tests. No test mandrel is used for blind/shear ram tests.

f. Close the rams using manufacturer's recommended closing pressure.

g. Initially apply 500 psi wellbore pressure and then reduce the closing pressure slowly until a leak develops. If rams do not leak at zero closing pressure, slowly increase opening pressure until a leak occurs or maximum recommended opening pressure is attained. Note the operating pressure at which the leak occurs.

h. Reapply the recommended closing pressure, increase the wellbore pressure, 500 psi above the previous step, and again reduce the closing pressure (or increase opening pressure) until a well leak occurs. Record the operating pressure.

i. Repeat Item h until the wellbore pressure equals the rated working pressure of the preventer. The wellbore pressure increment shall be 500 psi until the wellbore pressure exceeds 5000 psi. Thereafter the wellbore pressure increment shall be 1000 psi.

B.4.1.2 The following procedure is used to test ram closure against elevated wellbore pressure.

a. Install the preventer on the test stump. Connect opening and closing lines to the BOP. Connect line from the high pressure test pump to the stump.

b. The closing line and wellbore pressure line shall each be equipped, as a minimum, with a pressure transducer. All transducers shall be connected to a data acquisition system to provide a permanent record.

c. Install test mandrel in the BOP. Install a test flange to close the top of preventer. The piping out of the top flange shall include a bleed vent, pressure transducer, 20 to 40 gallons of accumulator bottles, and a pressure regulator. Fill the preventer test assembly with water until no more air comes out the bleed vent.

Note: When the wellbore fluid volume difference between closing position and opening position of the BOP is less than 10 gallons, use a 20-gallon accumulator system; when the difference is greater than 10 gallons, use a 40-gallon accumulator system.

d. With the accumulator bottle precharge set at about one half of the wellbore pressure to be applied for this test step, close the vent and then apply the test step wellbore pressure. (Initially the wellbore pressure is 500 psi.)

e. Close preventer with manufacturer's recommended closing pressure (adjust upward if required).

f. Check that the top flange system pressure is equal to the wellbore pressure and adjust if necessary.

g. Increase the wellbore pressure 500 psi above the level in Item d.

h. Confirm a wellbore pressure seal.

i. Lower the closing pressure until a leak develops, as monitored by fluid discharge from the top flange regulator.

j. Bleed off wellbore and top flange pressure and open preventer.

k. Repeat Items d through j, increasing the wellbore pressure until it equals the rated working pressure of the preventer. The wellbore pressure increment shall be 500 psi until the wellbore pressure exceeds 5000 psi. Thereafter the wellbore pressure increment shall be 1000 psi.

B.4.2 FATIGUE TEST

The following procedure is used for conducting fatigue tests on ram BOP's:

a. Install preventer on test stump. Connect opening and closing lines to BOP. Connect line from high-pressure test pump to the stump or BOP side outlet.

b. The closing line and wellbore pressure lines shall each be equipped, as a minimum, with a pressure transducer. All transducers shall be connected to a data acquisition system to provide a permanent record.

c. The ram blocks shall be inspected prior to testing. The inspection shall include: a) MP inspection of ram blocks, and b) Durometer measurements on ram rubber.

d. Install test mandrel in BOP for pipe ram tests. No test mandrel is required in blind/shear ram tests. A 5-inch O.D. test mandrel shall be used in testing 11-inch and larger blowout preventers. A $3^1/_2$ inch O.D. mandrel shall be used in testing blowout preventers smaller than 11-inch.

e. Close and open the rams seven times using manufacturer's recommended operator pressure. On every seventh closure, pressure test the rams at 200 to 300 psi and at the full rated working pressure of the BOP. On every seventh pressure test cycle, close the rams and lock the locks, then relieve all hydraulic pressure prior to performing the test. Test pressures shall each be held for a period of 3 minutes.

f. Repeat Item e until the rams fail the seal check or until 546 openings and closings have been completed (78 pressure tests).

g. Repeat inspection as in Item c above.

h. Document wear following the test.

B.4.3 SHEAR RAM TEST

The following procedure is used for conducting a shear ram test on ram BOP's:

a. Install the preventer on test stump. Connect opening and closing lines to BOP. Connect line from the high pressure test pump to the stump or BOP side outlet.

b. The opening, closing, and wellbore pressure line each shall be equipped with, as a minimum, a pressure transducer. All transducers shall be connected to a data acquisition system to provide a permanent record.

c. Install a new set of ram packers onto the blocks. Durometer measurements on the ram rubber seal shall have been made and recorded.

d. Suspend a section (approximately 4 feet in length) of drill pipe as specified in 4.7.2.4 for the preventer size vertically above the preventer and lower it into the wellbore. It is permitted to loosely guide the portion of the pipe below the ram to prevent excessive bending of the pipe section during shearing.

e. Set closing unit manifold pressure to manufacturer's recommended pressure for shearing. Close the rams and shear the pipe in a single operation. The pressure at which the pipe is sheared will be obvious from the rapid pressure change at the instant of shearing.

f. Raise the wellbore pressure to 200 to 300 psi and hold for 3 minutes examining for leaks.

g. Raise wellbore pressure to maximum rated working pressure of preventer and again examine for leaks for 3 minutes.

h. Reduce wellbore pressure to zero, open rams, inspect, and document any wear on the preventer.

i. Repeat Items d through h for two additional samples of drill pipe. Ram packers may be replaced as necessary.

B.4.4 HANG OFF TEST

The following procedure is used for conducting a hang off test on ram BOP's:

a. Install the preventer on a pull-down test stump. Connect opening and closing lines to the BOP. Connect line from the high-pressure test pump to the stump or BOP side outlet.

b. The closing line and wellbore pressure line shall each be equipped, as a minimum, with a pressure transducer. All transducer shall be connected to a data acquisition system to provide a permanent record.

c. The ram blocks, a simulated 18° API tool joint mandrel, and rubber packer metal inserts shall be inspected and the results recorded prior to testing. The dimensional and hardness specifications of the simulated tool Joint(s) used shall be in agreement with API Specification 7. The inspection shall include:

1. MP inspection of ram blocks.
2. Hardness measurement of the ram packer steel segments.
3. Hardness measurement of ram blocks.
4. Hardness measurement of the simulated tool joint.
5. Durometer measurements on the ram packer.

d. Raise simulated tool joint so that the 18° taper is immediately above the ram blocks. Close ram on the pipe with the manufacturer's recommended closing pressure.

e. Pressure test to 200 to 300 psi and to maximum rated working pressure of preventer.

f. Bleed wellbore pressure to zero psi, increase the load incrementally and repeat Item e for each load increment until either the rams leak or a 600,000 lb load is reached for 5-inch or larger pipe, or a 425,000 lb load for pipe less than 5-inch.

g. Repeat Items e and f using only the locking mechanism provided with the preventer to maintain the closed position.

h. Document any wear or deformation of the ram blocks, simulated tool joint, and the metal inserts of the ram packer.

B.4.5 RAM ACCESS TEST

The following procedure is used for conducting a ram access test on ram BOP's:

a. Assemble the blowout preventer on a test stump with pipe rams and an appropriate size test mandrel or with blind rams. Connect pressure transducers to the closing line and test stump. Connect the transducer output to appropriate data acquisition system.

b. Perform the manufacturer's recommended procedure for opening all closures required for ram and packer access, removing closures or opening them to their full extent, as required for ram removal.

c. Perform the manufacturer's recommended procedure for closing all ram access closures, including manufacturer's recommended maintenance procedures and replacement parts.

d. Repeat Items b and c for a total of 200 times. Every twentieth time, pressure test the BOP to rated working pressure for a minimum of 3 minutes.

B.4.6 STRIPPING LIFE TEST PROCEDURES FOR RAM-TYPE PREVENTERS

The following procedure is used for conducting a stripping life test on ram BOP's:

a. Measure and record the durometer hardness of the packer rubber. Install BOP on reciprocation machine. Connect opening and closing lines to BOP. Connect line from the high pressure test pump to the stump or BOP side outlet.

b. Connect accumulator (5 gallon minimum) to the wellbore (stump) and precharge to 75 percent of the wellbore pressure to be used during the tests. The closing line and wellbore pressure line shall each be equipped with at least a pressure transducer. Connect all pressure transducers to a data acquisition system to provide a permanent record.

c. For 11-inch BOPs and larger, install a 5-inch O.D. (no tool joint) test mandrel; for 9-inch BOPs and smaller, install a $3^1/_2$-inch O.D. test mandrel (no tool joint).

d. Determine the initial closing pressure by adding 100 psi (frictional effects) to the manufacturer's minimum recommended closing pressure for 1000 psi wellbore pressure. After closing on the test mandrel using this pressure and applying 1000 psi wellbore pressure, reduce the closing pressure until the preventer leak rate is less than 1 gpm (to wet the test mandrel wall).

e. Reciprocate the test mandrel at a speed of approximately 2 ft/sec until an equivalent of 30 feet of pipe has been lubricated through the packer elements.

f. Bleed off wellbore pressure, and open the rams.

g. As the severity of the leak increases, raise the closing pressure as needed up to the manufacturer's recommended value and repeat Items e through g.

h. Repeat Items d through f until the leak rate exceeds 1 gpm or an equivalent of 50,000 feet of pipe has passed through the packer elements.

i. Document wear on all ram packers as they are removed during the tests.

j. Repeat Items d through i using wellbore pressures of 2,000 and then 3,000 psi, providing these pressures do not exceed the working pressure of the BOP.

B.4.7 RAM LOCKING DEVICE TEST

The ram locking device test may be accomplished as part of both the Fatigue and Hang Off tests.

B.5 Annular-type BOP

B.5.1 SEALING CHARACTERISTICS TEST

The following procedure is used for conducting sealing characteristic tests on annular BOP's:

a. Install the preventer on the test stump. Connect opening and closing lines to the BOP. Connect line from the high pressure test pump to the stump or the BOP side outlet.

b. The closing line and wellbore pressure line shall each be equipped as a minimum with a pressure transducer. All transducers shall be connected to a data acquisition system to provide a permanent record.

c. Install the test mandrel in the BOP. For blowout preventers of the 11-inch size and larger, use a 5-inch O.D. test mandrel. For blowout preventers smaller than 11-inch, use a $3^1/_2$-inch O.D. or smaller test mandrel. Fill the preventer body to just above the top of the packer element with water.

d. Conduct constant wellbore pressure test as follows:
   1. Close preventer with manufacturer's recommended closing pressure.
   2. Apply 500 psi wellbore pressure.
   3. Lower closing pressure until a leak develops.
   4. Bleed off wellbore pressure and open preventer.
   5. Repeat Items 1 through 4 increasing wellbore pressure in 10 equal pressure increments until wellbore pressure equals the rated working pressure of the preventer.

e. Conduct constant closing pressure test as follows:
   1. Apply 500 psi closing pressure.
   2. Apply increasing wellbore pressure until leak occurs or wellbore pressure equals the rated working pressure of the preventer.
   3. Bleed off wellbore pressure and open preventer.
   4. Repeat Items 1 through 3, increasing closing pressure 100 psi each time until closing pressure reaches the level recommended by the manufacturer.

f. Full Closure Pressure Test
   1. Remove the drill pipe mandrel. Fill the BOP body to just above the top of the packer element with water.
   2. Close preventer with pressure recommended by manufacturer.

3. Apply wellbore pressure of 200 to 300 psi and hold for 3 minutes. If leakage occurs, increase the closing pressure as needed. Do not exceed manufacturer's recommended maximum operator pressure.
4. Following successful low pressure test, raise wellbore pressure to one half ($^1/_2$) rated working pressure of BOP. Hold pressure 3 minutes. If leakage occurs, increase closing pressure as needed. Do not exceed manufacturer's recommended maximum operator pressure.

B.5.2 FATIGUE TEST

The following procedure is used for conducting fatigue tests on annular BOP's:

a. Install preventer on test stump. Connect opening and closing lines to BOP. Connect line from high pressure test pump to the stump.
b. The closing line and wellbore pressure line shall each be equipped, as a minimum, with a pressure transducer. All transducers shall be connected to a data acquisition system to provide a permanent record.
c. Install test mandrel in the BOP. Use a 5-inch O.D. test mandrel for 11-inch and larger blowout preventers. For blowout preventers 9-inch and smaller, use a $3^1/_2$-inch O.D. test mandrel or smaller. Fill the preventer body with water to just above the top of the packer.
d. Close the BOP with the manufacturer's recommended closing pressure.
e. Apply 200 to 300 psi wellbore pressure, hold for 3 minutes, then increase wellbore pressure to the full rated working pressure of the preventer and hold for 3 minutes. Bleed off wellbore pressure.
f. Open the blowout preventer. This constitutes one pressure cycle.
g. Every twentieth pressure cycle, measure the I.D. of the packing element when the operating piston reaches the full open position (this can be determined by rapid pressure rise on the operating system pressure gauge). Then continue to measure the I.D. of the packer at 5 minute intervals until the packer I.D. reaches the bore size of the BOP or until 30 minutes have elapsed. Record I.D.

Repeat Items d through g until packer leaks or until 365 cycles have been completed.

B.5.3 PACKER ACCESS TEST

The following procedure is used for conducting packer access tests on annular BOP's:

a. Install the blowout preventer on a test stump.
b. Perform the manufacturer's recommended procedures for removing closure required for packer access.
c. Perform the manufacturer's recommended procedures, including recommended maintenance and replacement parts, for closing the packer access closure.
d. Repeat b and c 200 times. Every twentieth time, pressure test the BOP closed on the test mandrel to rated working pressure for a 3 minute holding period.

B.5.4 STRIPPING LIFE TEST PROCEDURES FOR ANNULAR TYPE PREVENTERS

The following procedure is used for conducting stripping life tests on annular BOP's:

a. Measure and record the durometer hardness of the packer rubber. Install BOP on stripping machine. Connect opening and closing lines to BOP. Connect line from the high pressure test pump to the stump or BOP side outlet.
b. Connect an accumulator (5 gallon minimum) to the wellbore (stump) and precharge to 75 percent of the wellbore pressure to be used during the tests. The closing line and wellbore line each shall be at least equipped with a pressure transducer. Connect all pressure transducers to a data acquisition system to provide a permanent record.
c. For 11-inch and larger BOPs, install a 5-inch O.D. test mandrel with a standard 18° API $6^3/_8$-inch tool joint profile; for 9-inch and smaller, install a $3^1/_2$-inch O.D. test mandrel with a simulated 18° API 5-inch tool joint profile.
d. Close the preventer with the manufacturer's recommended closing pressure. Apply 1,000 psi wellbore pressure. Reduce the closing pressure until the preventer leak rate is less than 1 gpm (to wet the test mandrel wall).
e. Reciprocate the test mandrel at speed of approximately 2 ft/sec, 5 feet in each direction and at 4 cycles per minute. Wellbore pressure should vary no more than ±10 percent during the stripping operation. Increase the closing pressure, as needed, to maintain only a slight lubricating leak. Continue testing until a leak rate of 1 gpm develops at the manufacturer's recommended closing pressure, or 5,000 cycles have been completed.
f. Document wear on all packer elastomers.

B.6 Hydraulic Connectors

B.6.1 LOCKING MECHANISM TEST

The following procedure is used for conducting locking mechanism tests on hydraulic connectors:

a. Install connector on the appropriate test stump.
b. Lock connector using the manufacturer's maximum lock pressure.
c. Determine the pressure required to unlock the connector with the primary unlock system. Record required pressure.
d. Repeat b and c with 0.67 of manufacturer's lock pressure.
e. Repeat b and c with 0.33 of manufacturer's lock pressure.
f. Repeat b through e twice more.
g. If connector is equipped with a secondary unlock system, repeat b through f using only the secondary unlock system.
h. Document locking and unlocking pressures.
i. Inspect and document any wear of locking mechanism.

B.6.2 SEALING MECHANISM TEST

The following procedure is used for conducting sealing mechanism tests on hydraulic connectors:

a. Install connector on the appropriate test stump.
b. Lock the connector to the stump using the manufacturer's recommended locking pressure, perform a 200 to 300 psi and a full-rated pressure test for a minimum of 5 minutes, reduce the wellbore pressure to zero and unlock the connector. Repeat this for 5 cycles.

c. After the fifth cycle, lift the connector off of the test stump after unlocking it and then return it to the stump.

d. On every sixth cycle, lock the connector and perform the wellbore pressure tests with the locking pressure removed.

e. Continue testing until the connector fails to seal or 24 pressure cycles have been completed.

f. Document the load required to remove the connector from the stump.

APPENDIX C—DESIGN TEMPERATURE VERIFICATION TEST PROCEDURES USED TO VERIFY THE TEMPERATURE RANGE OF NON-METALLIC SEALS AND MOLDED ASSEMBLIES

C.1 Test Parameters

C.1.1 PRESSURES

Low and high pressure tests are required at each temperature. The low pressure test shall be at 200 to 300 psi. The high pressure test shall be at the rated working pressure of the equipment.

C.1.2 HOLD PERIOD

The hold period shall begin when the specified pressure and temperature have been reached and have stabilized. The minimum hold time shall be as specified.

C.1.3 MONITORING TECHNIQUES

All tests shall be done in conjunction with a suitable data acquisition system for both the pressure and the temperature. The data acquisition shall be in accordance with the manufacturer's written specification. The information shall be identified, dated, and signed/verified by the tester and witnesses as applicable.

C.1.3.1 Pressure Measurement

All devices used to measure or monitor pressure shall be in accordance with 7.2.

C.1.3.2 Temperature Measurement

The BOP shall have a minimum of one thermocouple. The thermocouple shall be within 0.5 inches of the through-bore, and shall be located as close as is practical to the component being tested. All devices used to measure or monitor temperature shall be calibrated in accordance with the manufacturer's written specification.

C.1.4 RECORDS

Measurements on the non-metallic seals and/or molded sealing assemblies shall be made and recorded prior to installing them in the BOP.

C.2 Procedure for High Temperature Testing RAM-Type BOPs

The following procedure is used for conducting high temperature tests on ram BOPs:

a. Install the BOP on the test apparatus as follows:
   1. Connect the hydraulic operating lines.
   2. Connect the lines from the high pressure test pump and the high temperature heating device(s) to the test apparatus or to suitable connections on the BOP.

b. The closing pressure and wellbore pressure lines shall each be equipped, as a minimum, with pressure transducers. All transducers shall be connected to a data acquisition system to provide a permanent record.

c. Install the non-metallic seals and/or molded sealing assembly in the BOP and secure them in accordance with the manufacturer's written procedure.

d. Install the required test mandrel in the BOP.
   1. A 5-inch O.D. test mandrel shall be used for testing 11-inch or larger bore size blowout preventers.
   2. A $3^1/_2$-inch O.D. test mandrel shall be used in testing blowout preventers with a bore size smaller than 11-inch.
   3. VBRs shall be tested on the minimum and maximum size mandrels for their range.
   4. No test mandrel is required for testing blind or shear rams.

e. Open the blowout preventer and begin heating the test fluid until the test temperature is reached and has stabilized.

f. After the test temperature has stabilized, close the blowout preventer using the manufacturer's recommended operating pressure.

g. Apply 200 to 300 psi wellbore pressure and hold for a minimum of 3 minutes after pressure stabilization.

h. Decrease the wellbore test pressure to zero.

i. Apply the full rated working pressure of the BOP and hold for a minimum of 60 minutes after pressure stabilization.

j. Decrease the wellbore test pressure to zero.

k. Document the results of the tests.

C.3 Procedure for High Temperature Testing Annular BOPs

The following procedure is used for conducting high temperature tests on annular BOPs:

a. Install the BOP on the test apparatus as follows:
   1. Connect the hydraulic operating lines.
   2. Connect the lines from the high pressure test pump and the high temperature heating device to the test apparatus or to suitable connections on the BOP.

b. The closing pressure and wellbore pressure lines shall each be equipped, as a minimum, with pressure transducers. All transducers shall be connected to a data acquisition system to provide a permanent record.

c. Install the non-metallic seals and/or molded sealing assembly in the BOP and secure them in accordance with the manufacturer's written procedure.

d. Install the required test mandrel in the BOP.

1. A 5-inch O.D. test mandrel shall be used for testing 11-inch or larger bore size blowout preventers.

2. A $3^{1}/_{2}$-inch O.D. test mandrel shall be used in testing blowout preventers with a bore size smaller than 11-inch.

e. Open the blowout preventer and begin heating the test fluid until the test temperature is reached and has stabilized.

f. Close the blowout preventer using the manufacturer's recommended operating pressure.

g. Apply the full rated working pressure of the BOP and hold for a minimum of 60 minutes after pressure stabilization.

h. Decrease the wellbore test pressure to zero.

i. Open the blowout preventer.

j. Document the results of the tests.

C.4 Procedure for Low Temperature Cycle Testing Ram-Type BOPs

The following procedure is used for conducting low temperature tests on ram BOPs:

a. Install the BOP on the test apparatus as follows:

1. Connect the hydraulic operating lines.

2. Connect the lines from the high pressure test pump to the test apparatus or to a suitable connection on the BOP.

b. The closing pressure and wellbore pressure lines shall each be equipped, as a minimum, with pressure transducers. All transducers shall be connected to a data acquisition system to provide a permanent record.

c. Install the non-metallic seals and/or molded sealing assembly in the BOP and secure them in accordance with the manufacturer's written procedure.

d. Install the required test mandrel in the BOP.

1. A 5-inch O.D. test mandrel shall be used for testing 11-inch or larger bore size blowout preventers.

2. A $3^{1}/_{2}$-inch O.D. test mandrel shall be used in testing blowout preventers with a bore size smaller than 11-inch.

3. VBRs shall be tested on the minimum and maximum size mandrels for their range.

4. No test mandrel is required for testing blind or shear rams.

e. Open the blowout preventer and begin the cooling cycle. Continue cooling until the test temperature is reached and has stabilized.

f. Close and open the blowout preventer 7 times using the manufacturer's recommended operating pressure.

g. Close the BOP and apply 200 to 300 psi wellbore pressure and hold for a minimum of 3 minutes after pressure stabilization.

1. Decrease the wellbore test pressure to zero.

2. Apply the full rated working pressure of the BOP and hold for a minimum of 3 minutes after pressure stabilization.

3. Decrease the wellbore test pressure to zero.

4. Open the blowout preventer.

h. Repeat Items f and g twice more for a total of 21 close/open cycles and 3 pressure test cycles. The test mandrel may be changed during the testing of variable bore packers without increasing the number of test cycles in order to accommodate the need to test the variable bore packers on the minimum and maximum sizes of their range. There shall be a minimum of 3 cycles on any size mandrel.

i. Document the results of the tests.

C.5 Procedure for Low Temperature Cycle Testing Annular BOPs

The following procedure is used for conducting low temperature tests on annular BOPs:

a. Install the BOP on the test apparatus as follows:

1. Connect the hydraulic operating lines.

2. Connect the lines from the high pressure test pump to the test apparatus or to a suitable connection on the BOP.

b. The closing pressure and wellbore pressure lines shall each be equipped, as a minimum, with pressure transducers. All transducers shall be connected to a data acquisition system to provide a permanent record.

c. Install the non-metallic seals and/or molded sealing assembly in the BOP and secure them in accordance with the manufacturer's written procedure.

d. Install the required test mandrel in the BOP.

1. A 5-inch O.D. test mandrel shall be used for testing 11-inch or larger bore size blowout preventers.

2. A $3^{1}/_{2}$-inch O.D. test mandrel shall be used in testing blowout preventers with a bore size smaller than 11-inch.

e. Open the blowout preventer and begin the cooling cycle. Continue cooling until the test temperature is reached and has stabilized.

f. Close and open the blowout preventer seven times using the manufacturer's recommended operating pressure.

g. Close the BOP and apply 200 to 300 psi wellbore pressure and hold for a minimum of 3 minutes after pressure stabilization.

1. Decrease the wellbore test pressure to zero.

2. Apply the full-rated working pressure of the BOP and hold for a minimum of 3 minutes after pressure stabilization.

3. Decrease the wellbore test pressure to zero.

4. Open the blowout preventer.

h. Repeat Items f and g twice more for a total of 21 close/open cycles and 3 pressure test cycles.

i. Document the results of the tests.

APPENDIX D—RECOMMENDED PRACTICE FOR HEAT TREATING EQUIPMENT QUALIFICATIONS

D.1 Heat Treating Equipment Qualifications

All heat treating on parts and QTCs shall be performed with equipment meeting the requirements of this section.

D.2 Furnace Equipment

D.2.1 TEMPERATURE TOLERANCE

The temperature at any point in the working zone shall not vary by more than ±25°F from the furnace set point temperature after the furnace working zone has been brought up to temperature. Furnaces which are used for tempering, aging, and/or stress relieving shall not vary by more than ±15°F from the furnace set point temperature after the furnace working zone has been brought up to temperature.

D.2.2 FURNACE CALIBRATION

D.2.2.1 General

Heat treating of production parts shall be performed with heat treating equipment that has been calibrated and surveyed.

D.2.2.2 Records

Records of furnace calibration and surveys shall be maintained for a period not less than two years.

D.2.2.3 Batch Type Furnace Methods

D.2.2.3.1 A temperature survey within the furnace working zone(s) shall be performed on each furnace at the maximum and minimum temperatures for which each furnace is to be used.

D.2.2.3.2 A minimum of 9 thermocouple test locations shall be used for all furnaces having a working zone greater than 10 cubic feet.

D.2.2.3.3 For each 125 cubic feet of furnace working zone surveyed, at least 1 thermocouple test location shall be used up to a maximum of 40 thermocouples. See Figure D-1 for thermocouple locations.

D.2.2.3.4 For furnaces having a working zone less than 10 cubic feet, the temperature survey may be made with a minimum of 3 thermocouples located either at the front, center and rear, or at the top, center and bottom of the furnace working zone.

D.2.2.3.5 After insertion of the temperature sensing devices, readings shall be taken at least once every three min-

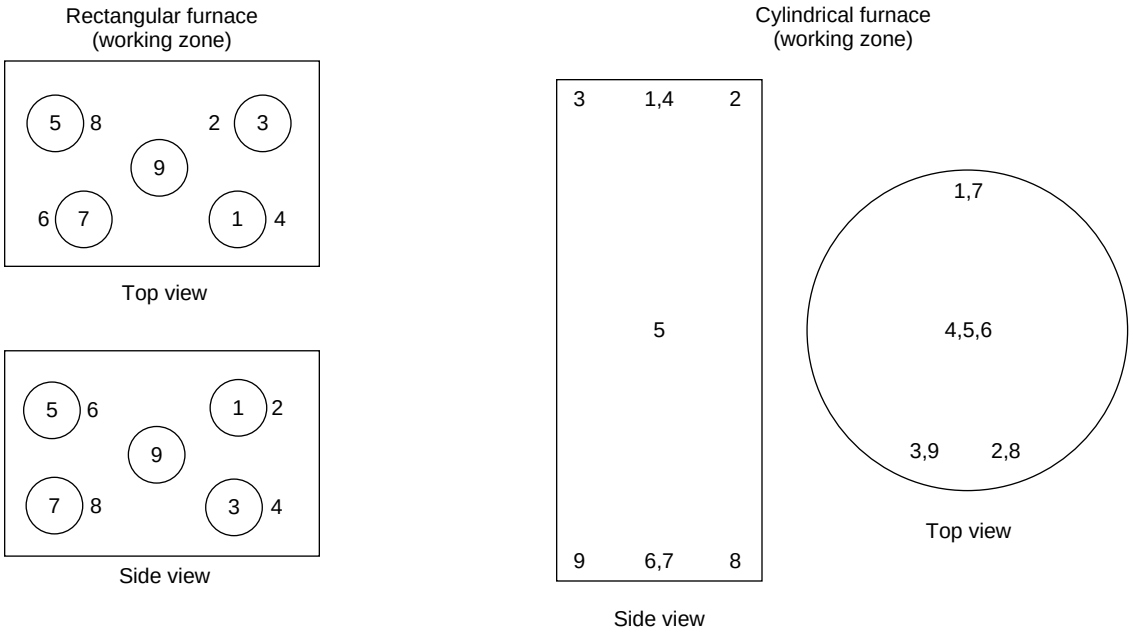


Figure D-1—Thermocouple Locations

utes to determine when the temperature of the furnace working zone approaches the bottom of the temperature range being surveyed.

D.2.2.3.6 Once the furnace temperature has reached the set point temperature, the temperature of all test locations shall be recorded at 2-minute intervals maximum for at least 10 minutes. Then readings shall be taken at 5-minute intervals, maximum, for sufficient time to determine the recurrent temperature pattern of the furnace working zone for at least 30 minutes.

D.2.2.3.7 Before the furnace set point temperature is reached, none of the temperature readings shall exceed the set point temperature by ±25°F.

D.2.2.3.8 After the furnace control set point temperature is reached, no temperature readings shall exceed the limits specified. Each furnace shall be surveyed within 1 year prior to heat treating.

D.2.2.3.9 When a furnace is repaired or rebuilt, a new survey shall be required before heat treating.

D.2.2.4 Continuous Type Furnace Method

Continuous heat treating furnaces shall be calibrated in accordance with procedures specified in Section 3 of MIL-H-6875F, *Heat Treatment of Steels—Aircraft Practice Process*.

D.2.3 INSTRUMENTS

D.2.3.1 General

D.2.3.1.1 Automatic controlling and recording instruments shall be used.

D.2.3.1.2 Thermocouples shall be located in the furnace working zone(s) and protected from furnace atmospheres by means of suitable protecting devices.

D.2.3.2 Accuracy

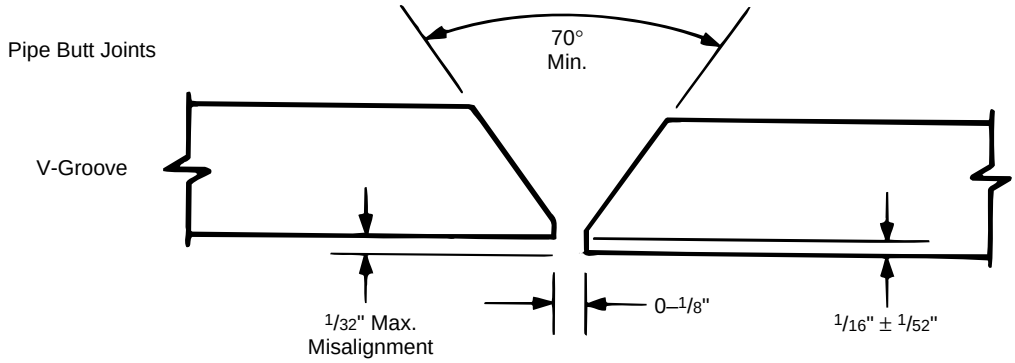
The controlling and recording instruments used for the heat treatment processes shall possess an accuracy of ±1 percent of their full scale range.

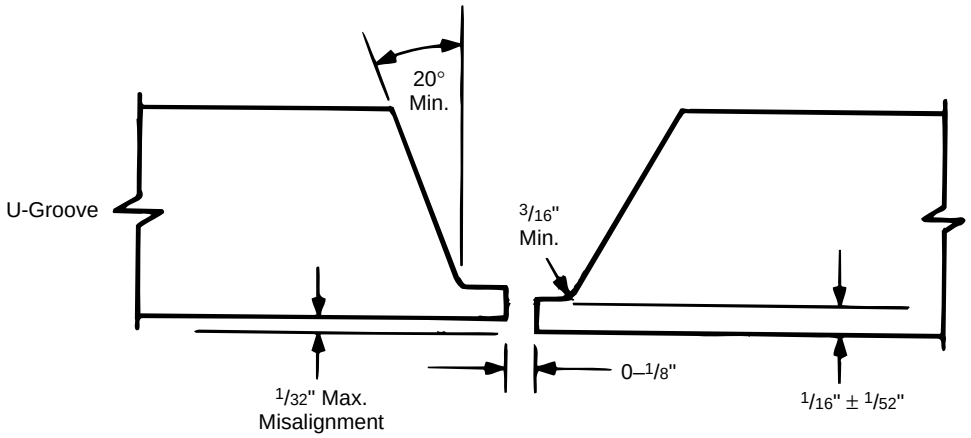
D.2.3.3 Calibration

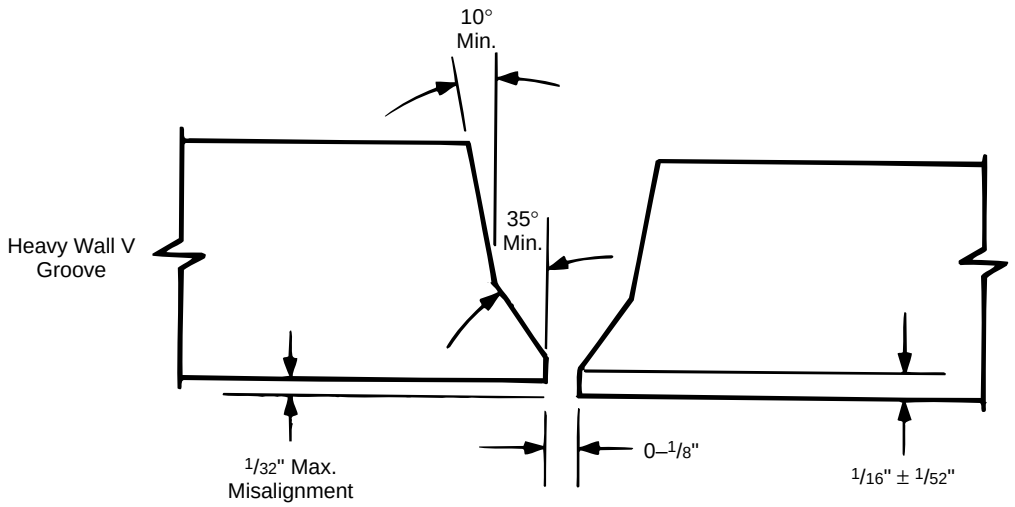
D.2.3.3.1 Temperature controlling and recording instruments shall be calibrated at least once every three months.

D.2.3.3.2 Equipment used to calibrate the production equipment shall possess an accuracy of ±0.25 percent of full scale range.

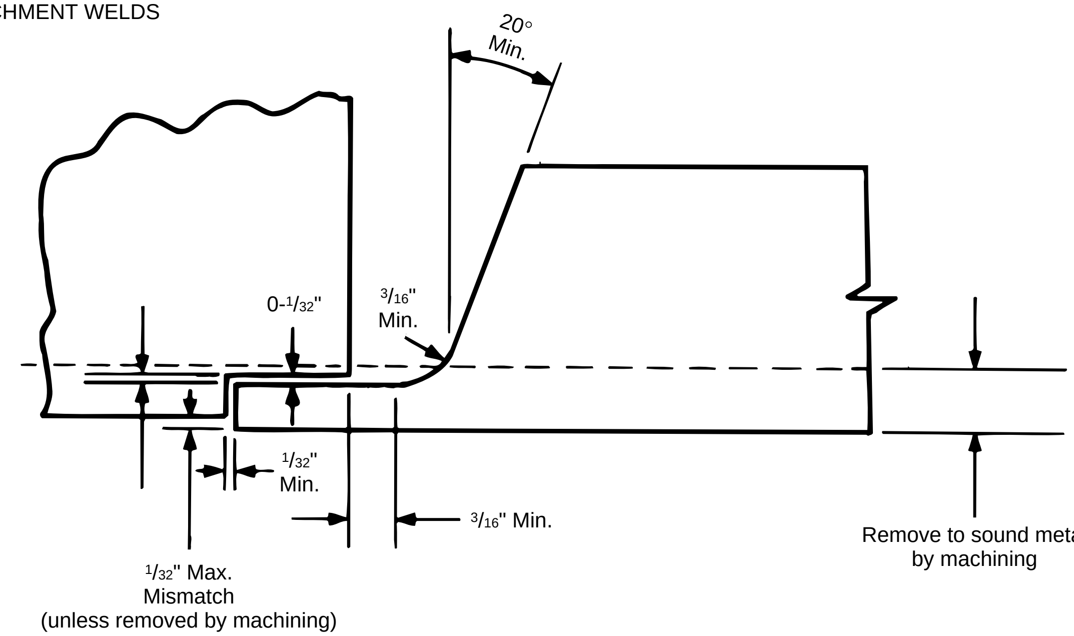
APPENDIX E—TYPICAL WELD GROOVE DESIGNS

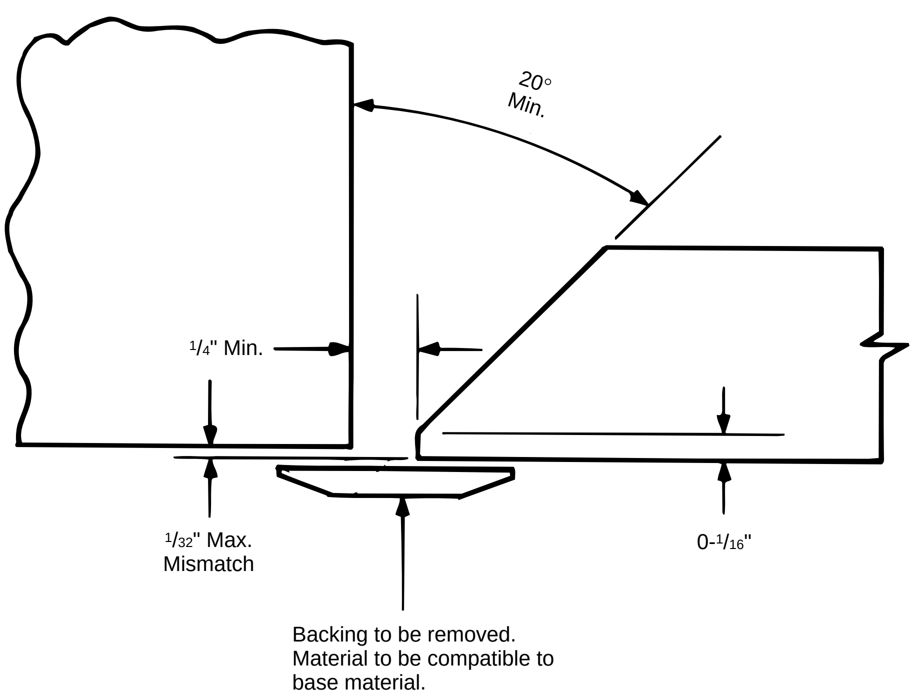




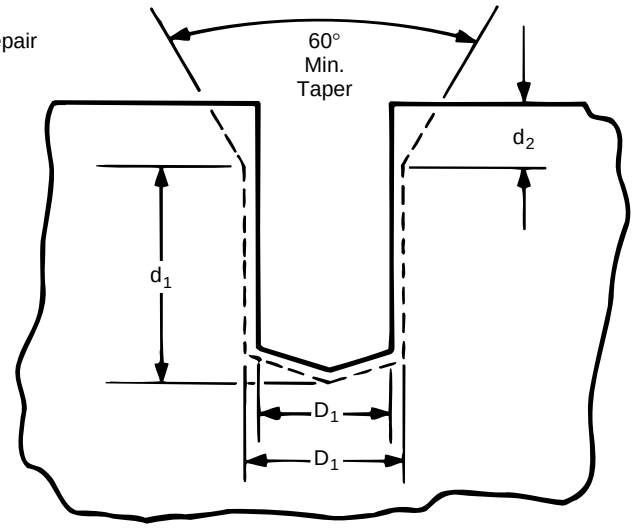


ATTACHMENT WELDS





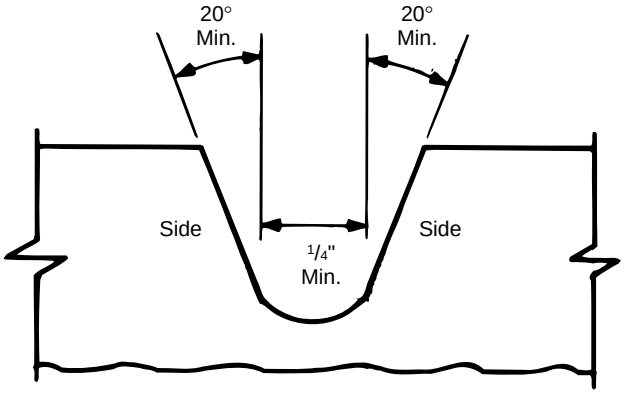
Hole Repair



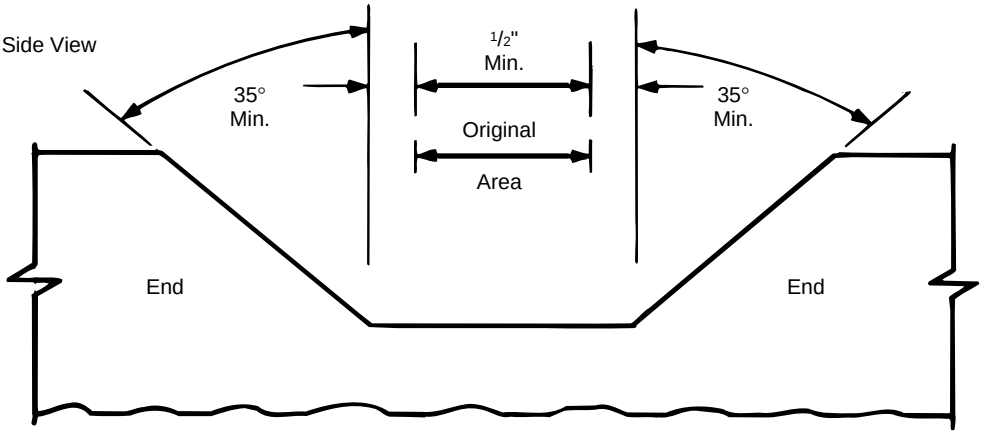
d_1 to D_2 does not exceed $1^1/_2$:1.
d_2 = depth required to maintain a maximum of $1^1/_2$: 1 depth (d_1) to diameter (D_2) ratio.

Excavation for Repair (Removal of rejectable discontinuities in weld metal and base metal).

End View



Side View



APPENDIX F— PURCHASING GUIDELINES

This appendix provides recommended guidelines for inquiry and purchase of API Specification 16A equipment.

F.1 Blowout Preventers and Drilling Spools

F.1.1 SIZE DESIGNATION

The size designation consists of the vertical throughbore dimension. A list of standard sizes is included in Table 1 of this specification.

F.1.2 SERVICE CONDITIONS

F.1.2.1 Rated Working Pressure

The rated working pressure is determined by the lowest pressure rating of all integral end or outlet connections. Rated working pressures for API Specification 16A equipment are given in 4.2.1.

F.1.2.2 Temperature Rating

Minimum temperature is the lowest ambient temperature to which the equipment may be subjected. Maximum temperature is the highest temperature of the fluid which may flow through the equipment.

F.1.2.2.1 Metallic Materials

Metallic parts will be designed to operate in 1 of 3 temperature ratings, which should be designated by the purchaser. These ratings can be found in Table 2.

F.1.2.2.2 Wellbore Elastomeric Materials

The purchaser should provide the temperature range for which wellbore elastomeric materials must operate. These ratings can be found in 8.3.4.2.

F.1.2.2.3 All Other Elastomeric Seals

The purchaser should provide the temperature range for which all other elastomeric materials must operate.

F.1.3 OUTLET CONNECTIONS

The purchaser should determine the number, location, size, pressure, and temperature ratings for all outlet connections. It should be noted that the pressure rating for the BOP or drilling spool is determined by the lowest pressure rating of all end or outlet connections.

F.1.4 EQUIPMENT DETAILS/DATA BOOK

Supply of a data book shall require a request by the purchaser and shall contain the following information:

a. Purchase order number/sales order number.
b. Product identification, type, part number, serial number.
c. Date of completion and inspection.
d. Assembly drawings, actual overall package dimensions, pressure rating, end connection/outlet description, weight, center of gravity, material where used list.
e. Manufacturer's statement of compliance to current edition of API Specification 16A.
f. Material certificates.
g. Welding procedure qualification.
h. NDE reports.
i. Pressure test reports.

APPENDIX G—FAILURE REPORTING

G.1 User Recommendation

The operator of drill through equipment manufactured to this specification shall provide a written report to the equipment manufacturer of any malfunction or failure which occurs. This report shall include as much information as possible as to the operating conditions that existed at the time of the malfunction or failure, and any operating history of the drill through equipment leading up to the malfunction or failure (e.g., field repair, modifications made to the drill through equipment, etc.).

G.2 Manufacturer's Recommendation

G.2.1 MANUFACTURER'S INTERNAL REQUIREMENTS

All significant problems experienced with drill through equipment furnished to this specification noted during its manufacture, testing or use shall be formally communicated to the individual or group within the manufacturer's organization responsible for the design and specification documents. The manufacturer shall have a written procedure that describes forms and procedures for making this type of communication, and the manufacturer shall provide written records of progressive design, material changes or other corrective actions taken for each model and size of drill through equipment.

G.2.2 MANUFACTURER'S EXTERNAL RECOMMENDATIONS

All significant problems experienced with drill through equipment furnished to this specification should be reported in writing to each and every operator of the drill through equipment within six weeks after the occurrence. Design changes resulting from a malfunction or failure history of drill through equipment manufactured to this specification shall be communicated within thirty days after the design change by the manufacturer to each and every operator using the model or size drill through equipment having the malfunctions or failures, and all models of other drill through equipment that could have similar potential problems.

APPENDIX H—REFERENCED STANDARDS

(Current Edition of Publication Date of Second Edition of API Specification 16A)

API

Spec 5CT	*Specification for Casing and Tubing*
Spec 5D	*Specification for Drill Pipe*
Spec 6A	*Specification for Wellhead and Christmas Equipment*

ANSI[1]

ASQC Z1.4	*Sampling Procedures for Tables for Inspection by Attributes*

ASME[2]

Boiler and Pressure Vessel Code, Section V, Nondestructive Testing
Article 5, UT Examination Methods for Materials and Fabrication

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

Boiler and Pressure Vessel Code, Section VIII, Division 2: Pressure Vessel—Alternate Rules
Appendix 4: Design Based on Stress Analysis
Appendix 6: Experimental Stress Analysis

ASNT[3]

SNT-TC-1A	*Personnel Qualification and Certification in Nondestructive Testing*, 1984 or latest Edition

ASTM

A193	*Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature Service*
A320	*Specification for Alloy Steel Bolting Materials for Low Temperature Service*
A370	*Test Methods and Definitions for Mechanical Testing of Steel Products*
A453	*Specification for Bolting Materials, High Temperature, 50 to 120 ksi Yield Strength, with Expansion Coefficients Comparable to Austenitic Steels*
D395	*Standard Test Methods for Rubber Property—Compression Set*
D412	*Test Methods for Vulcanized Rubber, Thermoplastic Rubbers and Thermoplastic Elastomers*
D471	*Standard Test Methods for Rubber Property—Effect of Liquids*
D475	*Specification for Pure Para Red Toner Pigment*
D569	*Method for Measuring the Flow Properties of Thermoplastic Molding Materials*
D575	*Test Methods for Rubber Properties in Compression*
D1414	*Test Methods for Rubber O-Rings*
D1415	*Test Method for Rubber Property—International Hardness*
D1418	*Practice for Rubber and Rubber Latices—Nomenclature*
D2084	*Test Method for Rubber Property—Vulcanization Characteristics Using Oscillating Disk Cure Meter*
D2240	*Test Method for Rubber Property—Durometer Hardness*
E10	*Test Method for Brinell Hardness of Metallic Materials*
E18	*Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials*
E30	*Test Method for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron*
E92	*Test Method for Vickers Hardness of Metallic Materials*
E94	*Guide for Radiographic Testing*
E140	*Hardness Conversion Tables for Metals*
E165	*Practice for Liquid Penetrant Examination*
E709	*Practice for Magnetic Particle Examination*
E747	*Guide for Controlling Quality of Radiographic Examination Using Wire Pentrameters*

MIL-STD[4]

MIL-STD-120	*Gage Inspection*
MIL-STD-105D	*Sampling Procedures and Tables for Inspection Attributes*

NACE[5]

MR0175	*Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment*

[1]American National Standards Institute, 11 West 42nd Street, New York, New York 10036
[2]American Society for Mechanical Engineers, 345 East 47th Street New York, New York 10017
[3]American Society for Nondestructive Testing, Inc., 1711 Arlington Lane, P.O. Box 28518, Columbus, Ohio 43228-0518
[4]U.S. Government Printing Office, Washington, D.C.
[5]National Association of Corrosion Engineers, P.O. Box 218340, Houston, Texas 77218

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