Choke and Kill Equipment

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Choke and Kill Equipment

1 Scope

This specification establishes the minimum requirements for the design and manufacture of the following types of new equipment:

a) articulated choke and kill lines;

b) choke and kill manifold buffer chamber;

c) choke and kill manifold assembly;

d) drilling choke actuators;

e) drilling choke controls;

f) drilling chokes;

g) flexible choke and kill lines;

h) union connections used in choke and kill assemblies;

i) rigid choke and kill lines;

j) swivel unions used in choke and kill equipment.

These requirements were formulated to provide for safe and functionally interchangeable surface and subsea choke and kill system equipment utilized for drilling oil and gas wells.

Technical content provides the minimum requirements for performance, design, materials, welding, testing, inspection, storing, and shipping.

See 4.2 for requirements on additional components that may be included in choke and kill system equipment.

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

2 Normative References

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

API Specification 5B, *Specification for Threading, Gauging and Thread Inspection of Casing, Tubing, and Line Pipe Threads*

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

API Specification 5L, *Specification for Line Pipe*

API Specification 6A, *Specification for Wellhead and Christmas Tree Equipment*

API Specification 16A, *Specification for Drill Through Equipment*

API Standard 6X, *Design Calculations for Pressure-containing Equipment*

API Standard 53, *Blowout Prevention Equipment Systems for Drilling Wells*

API Recommended Practice 500, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class 1, Division 1 and Division 2*

API Recommended Practice 505, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class 1, Zone 0, Zone 2*

ASME *Boiler and Pressure Vessel Code (BPVC)* [1], *Section V, Non-Destructive Examination*

ASME *Boiler and Pressure Vessel Code (BPVC), Section VIII, Pressure Vessels–Division 1*

ASME *Boiler and Pressure Vessel Code (BPVC), Section VIII, Division 2, Alternate Rules*

ASME *Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications*

ASME B1.1, *Unified Inch Screw Threads, UN and UNR Thread Form*

ASME B1.2, *Gages and Gaging for Unified Inch Screw Threads*

ASME B31.3, *Process Piping*

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

ASTM A370 [3], *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A388, *Standard Practice for Ultrasonic Examination of Heavy Steel Forgings*

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

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

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

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

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

ASTM E94, *Standard Guide for Radiographic Testing*

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

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

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

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

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

ASTM E384, *Standard Test Method for Knoop and Vickers Hardness of Materials*

ASTM E428, *Standard Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Inspection*

ASTM E709, *Standard Guide for Magnetic Particle Testing*

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

AWS A.5.1 [4], *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*

CSWIP-WI-6-92 [5], *Requirements for the Certification of Visual Welding Inspectors (Level 1), Welding Inspectors (Level 2) and Senior Welding Inspectors (Level 3) (fusion welding) in accordance with the requirements of BS EN ISO 176371:2011*

ISO 6506-1 [6], *Metallic materials—Brinell hardness test—Part 1: Test method*

ISO 6507-1, *Metallic materials—Vickers hardness test—Part 1: Test method*

ISO 6508-1, *Metallic materials—Rockwell hardness test—Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N,T)*

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

NACE Standard MR0175/ISO 15156 [7], *Petroleum and natural gas industries—Materials for use in H_2S-containing environments in oil and gas production*

NFPA 496 [8], *Standard for Purged and Pressurized Enclosures for Electrical Equipment*

SAE J 517 [9], *Hydraulic Hose*

3 Terms, Definitions, and Abbreviations

3.1 Terms and Definitions

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

3.1.1
acceptance criteria
Defined limits placed on characteristics of materials, products, testing, or services.

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

4 American Welding Society, 8669 NW 36 Street, #130, Miami, Florida 33166-6672, www.aws.org.
5 CSWIP Regulations. TWI Certification Ltd, Granta Park, Great Abington, Cambridge, CB21 6AL, United Kingdom, www.cswip.com.
6 International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, www.iso.org.
7 NACE International (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, Houston, Texas 77084-4906, www.nace.org.
8 National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, www.nfpa.org.
9 SAE International (formerly the Society of Automotive Engineers), 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001, www.sae.org.

3.1.3
acceptable quality level
AQL
A statistically based acceptance-sampling plan.

NOTE See ASQ Z1.4 or ISO 2859-1 for examples.

3.1.4
articulated choke and kill line
A choke and kill line assembled as a unit, with rigid pipe, swivel joints and end connections, designed to accommodate specified relative movement between end terminations.

NOTE Articulated lines used for purposes other than choke and kill lines are outside the scope of this document.

3.1.5
blind flange
A flange with no center bore, used to close off completely a flanged end or outlet connection.

3.1.6
body
Any portion of API equipment between end connections, with or without internal parts, that contains well bore pressure.

3.1.7
bonnet
A pressure-containing closure for a body, other than an end or outlet connection.

3.1.8
buffer chamber
A chamber installed downstream of the chokes to allow manifolding of the bleed lines together.

3.1.9
calibration
Comparison and adjustment to a standard of known accuracy.

3.1.10
casting (noun)
An object at or near finished shape obtained by solidification of a substance in a mold.

3.1.11
casting (verb)
Pouring molten metal into a mold to produce an object of desired shape.

3.1.12
check valve
A valve that permits fluid to flow freely in one direction and contains a mechanism to automatically prevent flow in the other direction.

3.1.13
chemical analysis
Determination of the chemical composition of material.

3.1.14
choke
Equipment used to restrict and control the flow of fluids.

3.1.15
choke/kill line
A high-pressure line that allows fluids to be pumped into or removed from the well with the BOPs closed.

3.1.16
choke/kill manifold
An assembly of valves, chokes, gauges, and lines used to control the rate of flow and pressure from the well when the BOPs are closed.

3.1.17
closure bolting
Threaded fasteners (studs, nuts, bolts, and cap screws) used to assemble pressure-containing parts or join end or outlet connections.

3.1.18
flow bean
The replaceable orifice part used in positive chokes to control flow rates.

3.1.19
conformance
Compliance with specified requirements.

3.1.20
carbon steel
An alloy of carbon and iron containing a maximum of 2 % carbon, 1.65 % manganese, and residual quantities of other elements, except those intentionally added in specific quantities for deoxidation (usually silicon and/or aluminum).

3.1.21
corrosion resistant alloys
CRA
Nonferrous-based alloys where any one or the sum of the specified amount of the elements titanium, nickel, cobalt, chromium, and molybdenum exceeds 50 % mass fraction.

NOTE This definition is different from that in NACE MR0175/ISO 15156.

3.1.22
corrosion resistant ring groove
Ring grooves lined with corrosion resistant alloy or an austenitic stainless steel to resist metal loss corrosion.

3.1.23
date of manufacture
The date of the manufacturer’s final acceptance of finished equipment.

3.1.24
end fitting
End assembly containing a flexible termination and end connection used on choke and kill lines.

3.1.25
end and outlet connection
Integral threads and flanges, hubs, unions, or other end connectors used to join together equipment that contains or controls pressure.

3.1.26
end termination
Part of the end fitting that forms the transition between the flexible line construction and the end connector.

3.1.27
equipment
Any single completed unit that can be used for its intended purpose without further processing or assembly (e.g. a valve, choke, cross, tee, spool, etc.).

3.1.28
equivalent design and construction (flexible lines)
Design and construction is regarded as equivalent if it is based on the same design methodology and stress criteria, same number of reinforcing layers, same nonmetallic materials, but physical size of reinforcement (e.g. size of tendon, pressure armor, or reinforcing cable) may be different for different flexible line sizes and pressure ratings.

3.1.29
fabrication weld
A weld joining two or more parts.

3.1.30
fit (noun)
The geometric relationship between parts. This would include the tolerance criteria used during the design of a part and its mating parts.

3.1.31
flange
A protruding rim with holes to accept bolts and having a sealing mechanism used to join pressure-containing equipment.

3.1.32
flexible line
An assembly of a pipe body and end-fittings.

NOTE 1 The pipe body comprises a combination of materials that form a pressure–containing conduit.

NOTE 2 The pipe structure allows large deflections without a significant increase in bending stresses.

NOTE 3 Normally, the pipe body is built up of one of the two construction types shown in Figure 8 as non-bonded and bonded flexible lines.

3.1.33
form (noun)
The essential shape of a product including its component parts.

3.1.34
function
The operation of a product during service.

3.1.35
heat (cast lot)
Material originating from a final melt.

3.1.36
heat (remelted alloys)
The raw material originating from a single remelted ingot.

3.1.37
test, vent, pipe plug, and gauge connections
Holes drilled and tapped into equipment through which internal pressure can be measured or through which pressure can be applied to test the sealing mechanisms.

3.1.38
heat affected zone
HAZ
That portion of the base metal that has not been melted, but whose mechanical properties or microstructure has been altered by the heat of welding or cutting.

3.1.39
heat treatment
heat treating
Alternate steps of controlled heating and cooling of materials for the purpose of changing physical or mechanical properties.

3.1.40
hold period
The period of time that the product is subjected to pressure and isolated from the pressure source.

3.1.41
hot work
Deforming metal plastically at a temperature above the re-crystallization temperature.

3.1.42
job lot traceability
The ability for parts to be identified as originating from a job lot that identified the included heat(s).

3.1.43
low alloy steel
Steel containing less than 5 % total alloying elements, but more than specified for carbon steel.

3.1.44
material performance
Capabilities demonstrated by a material to satisfy the criteria of this standard.

3.1.45
non-pressure-containing weld
A weld, the absence of which will not reduce the pressure-containing integrity of the part.

3.1.46
other end connector
OEC
A Connector used for joining pressure-containing or pressure-controlling equipment whose dimensions are not specified in this standard.

NOTE See API 6A.

3.1.47
post-weld heat treatment
Any heat treatment subsequent to welding, including stress relief.

3.1.48
pressure-containing part
A part whose failure to function as intended would result in a release of retained fluid to the atmosphere.

EXAMPLE Bodies, bonnets, and stems.

3.1.49
pressure-containing weld
A weld, the absence of which will reduce the pressure-containing integrity of the part.

3.1.50
pressure-controlling part
Part intended to control or regulate the movement of pressurized fluids.

EXAMPLE Valve-bore sealing mechanisms, choke trim.

3.1.51
pressure integrity
The structural and leak resistant capability of a product to contain applied pressure.

3.1.52
qualified personnel
Individuals with characteristics or abilities gained through training, experience, or both, as measured against the manufacturer's, user's, and API established requirements.

3.1.53
rated working pressure
The maximum internal pressure equipment is designed to contain and/or control.

NOTE Working pressure is not to be confused with test pressure.

3.1.54
records
Retrievable information.

3.1.55
retained fluid
The actual fluid produced by a well.

3.1.56
rigid choke and kill line
Rigid piping, straight or with bends, with end connectors, for use in choke and kill equipment.

3.1.57
rigid piping
A tubular piece, of any length, made from a section(s) of fabricated, random length pipe, exclusive of any couplings, flanges, or other end connections.

3.1.58
room temperature
Any temperature between 40 °F and 120 °F (4.4 °C and 48.9 °C).

3.1.59
serialization
Assignment of a unique code to individual parts and/or pieces of equipment to maintain records.

3.1.60
stabilized (pressure testing)
In a state in which the initial pressure-decline rate has decreased to within a specified rate.

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

3.1.61
stabilized (temperature testing)
In a state in which the initial temperature fluctuations have decreased to within a specified range.

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

3.1.62
stainless steel
Steel containing chromium, more than 11 %, to render the steel corrosion resistant.

NOTE Other elements can be added to secure special properties.

3.1.63
stress relief
Controlled heating of material to a predetermined temperature for the purpose of reducing any residual stresses after welding.

3.1.64
threaded flange
A flange having a sealing face on one side and female thread on the other for the purpose of joining flanged connections to threaded connections.

3.1.65
visual examination
Examination of parts and equipment for visible defects in material and workmanship.

3.1.66
volumetric nondestructive examination
Examination for internal material defects by methods such as radiography and/or ultrasonic testing.

3.1.67
weld groove
An area between two metals to be joined that has been prepared to receive weld filler metal.

3.1.68
welding
The fusion of materials, with or without the addition of filler materials.

3.1.69
wetted surface
Any surface that will be in contact with pressurized well fluid either by design or because of internal seal leakage.

3.1.70
yield strength
The stress level measured at room temperature at which material plastically deforms and will not return to its original dimensions when the load is released.

NOTE Yield strengths specified in this standard are considered as being the 0.2 % yield offset strength in accordance with ASTM A370.

3.2 Abbreviations

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

ASME	ASME International (formerly the American Society of Mechanical Engineers)
ASTM	ASTM International (formerly the American Society for Testing and Materials)
AWS	American Welding Society
ER	equivalent round
FSL	flexible specification level
ID	internal diameter
LMRP	lower marine riser package
NACE	NACE International (formerly the National Association of Corrosion Engineers)
NDE	nondestructive examination
OD	outside diameter
OEC	other end connector
PQR	welding procedure qualification record
PSL	product specification level
QTC	qualification test coupon
RWP	rated working pressure
SAE	Society of Automotive Engineers
WPS	welding procedure specifications

4 Design Requirements

4.1 Service Conditions

4.1.1 Temperature Ratings

Minimum temperature is the lowest ambient temperature to which the equipment can be subjected, while in service. Maximum temperature is the highest fluid temperature that can flow through the equipment while in service. Equipment shall be designed to operate within one or more of the temperature ranges shown in Table 1. If the operating temperature of flexible choke and kill lines specified and validated by the manufacturer is broader than temperature rating specified in Table 1, the manufacturer may mark the actual temperature range on the line.

For maximum temperature ratings above 250 °F (121 °C), refer to API 6A for material property derating.

4.1.2 Rated Working Pressure

Equipment within the scope of this specification shall be rated in accordance with the working pressures specified in Table 2, Table 3, and Table 4.

Table 1—Temperature Rating for Metallic and Nonmetallic Materials and Flexible Lines

Rating	Operating Range °F (°C)
A	–4 to 180 (–20 to 82)
B	–4 to 212 (–20 to 100)
K	–75 to 180 (–60 to 82)
L	–50 to 180 (–46 to 82)
N	–50 to 140 (–46 to 60)
P	–20 to 180 (–29 to 82)
S	0 to 140 (–18 to 60)
T	0 to 180 (–18 to 82)
U	0 to 250 (–18 to 121)
V	35 to 250 (2 to 121)
X	0 to 350 (–18 to 177)
NOTE The use of combined or multiple ratings is permitted.	

4.1.3 Fluid Service Conditions

Choke and kill systems are generally mobile and can be used in areas where sour service conditions could be encountered. Metallic materials that are exposed to the well fluid shall meet the requirements of NACE MR0175/ISO 15156, including partial pressure rating for H_2S of 1.5 psia (10.34 kPa) or higher.

4.2 Product Specification

The following products shall meet the requirements of API 6A and shall have a minimum product specification level of PSL 3, material Class DD, EE, FF, or HH, with an H_2S partial pressure rating of 1.5 psia (10.34 KPa) or higher, and a temperature rating from Table 1 as appropriate for choke and kill system applications:

a) check valves;

b) chokes;

c) crosses and tees;

d) flanged or studded end and outlet connections;

e) full-bore valves;

f) choke actuator components exposed to well bore fluids;

g) threaded end connections;

h) valve actuator components exposed to well bore fluids.

Hubbed end and outlet connections shall meet the requirements of API 16A. Valve and choke actuators shall meet the requirements of API 6A.

Table 2—Equipment Bore Sizes and Rated Working Pressures

Size (minimum through bore) in. (mm)	**Rated Working Pressure** psi (MPa)
2 1/16 (52)	2000 (13.8)
2 9/16 (65)	
3 1/8 (78)	
4 1/16 (103)	
2 1/16 (52)	3000 (20.7)
2 9/16 (65)	
3 1/8 (78)	
4 1/16 (103)	
2 1/16 (52)	5000 (34.5)
2 9/16 (65)	
3 1/8 (78)	
4 1/16 (103)	
5 1/8 (130)	
1 13/16 (46)	10,000 (69.0)
2 1/16 (52)	
2 9/16 (65)	
3 1/16 (78)	
4 1/16 (103)	
5 1/8 (130)	
1 13/16 (46)	15,000 (103.5)
2 1/16 (52)	
2 9/16 (65)	
3 1/16 (78)	
4 1/16 (103)	
5 1/8 (130)	
1 13/16 (46)	20,000 (138)
2 1/16 (52)	
2 9/16 (65)	
3 1/16 (78)	
4 1/16 (103)	

NOTE Specific size and pressure rating combinations are not necessarily available for each type of end or outlet connection (e.g. threaded flange and hub).

Table 3—Union, Swivel Joint, and Articulated Line Sizes and Rated Working Pressures

Nominal Size in. (mm)	**Rated Working Pressure** psi (MPa)
1 (25.4)	3000 (20.7) 6000 (41.4)
1 1/2 (38.1)	
2 (50.8)	
2 1/2 (63.5)	
3 (76.2)	
4 (101.6)	
1 (25.4)	5000 (34.5) 7500 (51.8)
1 1/2 (38.1)	
2 (50.8)	
2 1/2 (63.5)	
3 (76.2)	
4 (101.6)	
1 (25.4)	10,000 (69.0)
2 (50.8)	
3 (76.2)	
4 (101.6)	
4 1/2 (114.3)	
2 (50.8)	15,000 (103.5)
2 1/2 (63.5)	
3 (76.2)	
4 (101.6)	
4 1/2 (114.3)	
2 (50.8)	20,000 (138.0)
2 1/2 (63.5)	
3 (76.2)	

Table 4—Flexible Line Sizes and Rated Working Pressures

Inner Diameter in. (mm)	Rated Working Pressure psi (MPa)
2 (50.8)	5000 (34.5)
3 (76.2)	
3 1/2 (88.9)	
4 (101.6)	
2 (50.8)	10,000 (69.0)
2 1/2 (63.5)	
3 (76.2)	
4 (101.6)	
2 (50.8)	15,000 (103.5)
2 1/2 (63.5)	
3 (76.2)	
4 (101.6)	
2 (50.8)	20,000 (138.0)
2 1/2 (63.5)	
3 (76.2)	
4 (101.6)	

4.3 Design Method

4.3.1 General

Design method shall be in accordance with one or more of the methods described in 4.3.2, 4.3.3, 4.3.4, and 4.3.5.

4.3.2 API 6X Method

The design methodology shall be in accordance with API 6X. The use of von Mises equivalent stress is permitted.

4.3.3 Distortion Energy Theory Method

The Distortion Energy Method, also known as the Von Mises Law, may be used for design calculations for pressure-containing equipment. Rules for the consideration of discontinuities and stress concentrations are beyond the scope of this method. However, the basic pressure-vessel wall thickness may be sized by combining triaxial stresses based on hydrostatic proof test pressure and limited by the following criterion:

$$S_E = S_Y$$

where

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

S_Y is the material's specified minimum yield strength.

4.3.4 Experimental Stress Analysis

Experimental stress analysis shall be performed in accordance with ASME BPVC, Section VIII, Division 2, Appendix 6, 2004 Edition.

4.3.5 Flanged, Studded, and Hub End and Outlet Connections

4.3.5.1 Design of flanged, studded, and hub end outlet connections shall be in accordance with API 6A and API 16A. Design of other end connectors (OECs) used on API 16C equipment shall meet all the applicable design requirements of API 6A.

4.3.5.2 End and outlet connections shall be manufactured in accordance with the applicable requirements of API 6A and API 16A.

4.4 Performance Requirements

4.4.1 General

Performance requirements are specific and unique to the product in the as shipped condition. Products shall be designed to perform according to the requirements of this section and in the pressure, temperature ranges, test fluids, and in accordance with Section 5.

4.4.2 Pressure Integrity

Products shall be capable of withstanding rated working pressure at rated temperature without deformation to the extent that any other performance requirement is not met.

4.4.3 Thermal Integrity

Products and/or systems shall be capable of functioning throughout the temperature range for which they are rated.

4.4.4 Leakage

No visible leakage is allowed.

4.4.5 Load Capability

Products shall be capable of sustaining rated loads without deformation to the extent that any other performance requirement is not met.

4.4.6 Cycles

Products shall be capable of performing and operating as intended for the number of operating cycles specified in Section 10 for applicable products.

4.4.7 Operating Force or Torque

The force or torque required to operate products shall be within the manufacturer's written specification, which includes acceptance criteria.

4.5 Design Validation

4.5.1 General

Design validation shall be performed in accordance with Annex B. The validation testing specified in this section is intended to be performed on prototypes or samples representative of production models.

4.5.2 Product Changes

A design change that affects the performance of the product in the intended service condition requires design validation. This may include changes in fit, form, function, or material.

4.6 Bore Size and Rated Working Pressure

The bore size and rated working pressure designation of a choke and kill system and the components shall consist of the values provided in Table 2, Table 3, and Table 4.

4.7 Closure Bolting

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

— initial make-up torque;

— operating conditions including pressure loads, external mechanical loads, and thermal stress; and

— hydrostatic proof test pressure conditions.

Bolt stresses, based on the minimum cross-sectional area of the bolt, shall not exceed the following limits:

$$S_a = 0.83\ S_y \text{ and } S_b = 1.0\ S_y$$

where

S_a is the maximum allowable tensile stress;

S_y is the bolting material specified minimum yield strength;

S_b is the maximum allowable tensile membrane plus bending stress.

4.8 Clamps

Clamps for API 16BX hubs shall conform to API 16A. Other hubs and clamps shall conform to the manufacturer's written specifications.

4.9 Test, Vent, Pipe Plugs, and Gauge Connections

Test, vent, pipe plugs and gauge connections for use on 2000 psi (13.8 MPa), 3000 psi (20.7 MPa), 5000 psi (34.5 MPa), 10,000 psi (69.0 MPa), 15,000 psi (103.5 MPa), and 20,000 psi (138.0 MPa) equipment shall be in accordance with API 6A, as applicable. Vent connections shall be in accordance with the manufacturer's written specification.

4.10 Design Documentation

4.10.1 General

Documentation of designs shall include methods, assumptions, calculations, and design requirements. Design documentation media shall be clear, legible, reproducible, and retrievable.

4.10.2 Design Review

Design documentation shall be reviewed and verified by qualified personnel other than those who created the original design. Design changes shall be reviewed in the same manner as the original design.

4.10.3 Design Validation

Manufacturers shall document their validation procedures and the results of validation of designs. Design validation is not required on API flanges, hubs and ring gaskets.

4.10.4 Documentation Retention

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

5 Material Requirements

5.1 General

This section describes the material performance, processing, and compositional requirements for pressure-containing parts. Other parts shall be made of materials that satisfy the design requirements in Section 4 when assembled into equipment designed in accordance with this specification. Metallic materials in direct contact with well fluids shall also meet the requirements for sour service of NACE MR0175/ISO 15156.

5.2 Written Specifications

5.2.1 General

Metallic and non-metallic pressure-containing parts shall have a manufacturer's written material specification.

5.2.2 Metallic Parts

The manufacturer’s written specifications for pressure-containing parts shall include the following:

a) acceptance and/or rejection criteria;

b) allowable melting practice(s);

c) forming practice(s);

d) heat treatment procedure including cycle time and temperature with tolerances, heat treating equipment, and cooling media;

e) material composition requirements, with tolerances;

f) material qualification;

g) mechanical property requirements;

h) NDE requirements.

5.2.3 Non-metallic Parts

The manufacturer’s written specifications for pressure-containing or pressure-controlling seals shall include the following:

a) generic base polymer (see ASTM D1418);

b) physical properties requirements;

c) material qualifications and physical property changes after testing;

d) storage and age control requirements;

e) NDE requirements;

f) acceptance and/or rejection criteria.

5.2.4 Special Materials

Special corrosion and abrasion resistant materials, coatings, or facings shall conform to the manufacturer's written specifications, and shall include acceptance and/or rejection criteria.

5.3 Drilling Chokes

Materials for bodies, bonnets, plugs, caps, and end connections shall conform to Table 5 and Table 6.

5.4 Closure Bolting

Closure bolting material shall conform to manufacturer's written specification, which includes acceptance criteria.

5.5 Flexible Lines

Flexible lines shall meet the requirements of 10.8.

5.6 Pressure-containing Parts, Bodies, Bonnets, Stems, and End Connections

5.6.1 General

Pressure-containing parts including bodies, bonnets, and end connections shall be fabricated from materials as specified by the manufacturer that meet the requirements of Table 5, Table 6, Table 7, and Table 8.

5.6.2 Impact Requirements

Charpy V-Notch impacts shall meet the values of Table 9.

Table 5—Pressure-containing Parts Material Property Requirements[a]

API Material Designation	Yield Strength Minimum[b] psi (MPa)	Tensile Strength Minimum psi (MPa)	Elongation Minimum %	Reduction in Area Minimum %
36K	36,000 (248)	70,000 (483)	21	None specified
45K	45,000 (310)	70,000 (483)	19	32
60K	60,000 (414)	85,000 (586)	18	35
75K	75,000 (517)	95,000 (655)	18	35
Nonstandard	As specified	As specified	15	25

[a] See ASTM A370.

[b] See ASTM A370, Offset Method.

Table 6—Pressure-containing Parts Material Designation

API Material Designation						
Part	**Rated Working Pressure** psi (MPa)					
	2000 (13.8)	**3000 (20.7)**	**5000 (34.5)**	**10,000 (69.0)**	**15,000 (103.5)**	**20,000 (138.0)**
Body, bonnet and rigid piping	36K (248)	36K (248)	36K (248)	36K (248)	45K (248)	60K (413)
	45K (310)	45K (310)	45K (310)	45K (310)	60K (413)	75K (517)
	60K (413)	60K (413)	60K (413)	60K (413)	75K (517)	
	75K (517)	75K (517)	75K (517)	75K (517)		
End and outlet connection	60K (413)	60K (413)	60K (413)	60K (413)	75K (517)	75K (517)
blind flange						
NOTE Non-standard materials are acceptable if their design stress intensity Sm, is greater than or equal to that of the lowest strength grade shown for the component and pressure rating above.						

Table 7—Pressure-containing Parts Material Steel Composition Maximum Limits

Values in WT %

Alloying Element	Carbon and Low Alloy Steels	Martensitic Stainless Steels
Carbon	0.45	0.15
Chromium	2.75	11.0 to 14.0
Manganese	1.80	1.00
Molybdenum	1.50	1.00
Nickel	1.00	4.50
Phosphorous	0.025	0.025
Silicon	1.00	1.50
Sulfur	0.025	0.025
Vanadium	0.30	N/A

Table 8 — Alloying Element Maximum Tolerance Range Requirements

Values in WT %

Alloying Elements	Carbon and Low Alloy Steels	Martensitic Stainless Steels
Carbon	0.08	0.08
Chromium	0.50	—
Manganese	0.40	0.40
Molybdenum	0.20	0.20
Nickel	0.50	1.00
Silicon	0.30	0.35
Vanadium	0.10	0.10

Table 9—Acceptance Criteria Charpy V-notch Impact Requirements

Temperature Rating	Test Temperature °F (°C)	Minimum Average Impact Value For Three Specimens ft-lb. (J)
A	– 4 (–20)	15 (20)
B	– 4 (–20)	15 (20)
K	–75 (–60)	15 (20)
L	–50 (–46)	15 (20)
N	–50 (–46)	15 (20)
P	–20 (–29)	15 (20)
S	0 (–18)	15 (20)
T	0 (–18)	15 (20)
U	0 (–18)	15 (20)
X	0 (–18)	15 (20)
Y	0 (–18)	15 (20)

5.6.3 Processing

5.6.3.1 Melting Practices

The manufacturer shall have a written specification for the melting practices for pressure-containing parts and materials.

5.6.3.2 Casting Practices

The manufacturer shall have a written specification that establishes limits for sand control, core making, rigging and melting.

5.6.3.3 Hot Work Practices

The materials manufacturer shall have a written specification for hot work practices. Wrought materials shall be formed using a hot work practice that produces a wrought structure throughout the part.

5.6.4 Metallic Parts Chemical Composition

5.6.4.1 General

The manufacturer's written specification shall specify the chemical range of material used to manufacture pressure-containing parts. Material composition shall be determined on a heat basis (or a remelt ingot basis for remelt grade materials).

5.6.4.2 Composition Limits

Table 7 lists element limits for carbon and low alloy steels and for martensitic stainless steels used to manufacture pressure-containing parts. Non-martensitic alloy systems are not required to conform to Table 7. Although not generally considered a low alloy steel, steels with less than 11 % chromium shall be included in this category.

5.6.4.3 Alloy Element Range

Table 8 lists the range requirements for elements used to form materials.

5.6.5 Material Qualification

5.6.5.1 Tensile Testing Specimens

Tensile test specimens shall be recovered from a qualification test coupon (QTC) as described in 5.8. This QTC shall be used to qualify a heat and the products produced from that heat.

5.6.5.2 Tensile Testing Methods

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

A minimum of one tensile test shall be performed. The results of the tensile test(s) shall satisfy the applicable requirements of 5.6. 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.

5.6.5.3 Impact Test Sampling

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

5.6.5.4 Impact Test Specimens

Impact test specimens shall be removed from a QTC as prescribed in 5.8. This QTC shall be used to qualify a heat and the products produced from that heat.

Standard size specimens, 10 × 10 mm in cross-section, shall be used except where there is insufficient material. In this 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.

5.6.5.5 Impact Test Methods

Impact tests shall be performed in accordance with the procedures specified in ASTM A370 using the Charpy V-notch technique. To qualify material for a temperature rating the impact tests shall be performed at or below the test temperature shown in Table 9.

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 9. In no case shall an individual impact value fall below $^{2}/_{3}$ the minimum average. No more than one of the three test results may be below the required minimum average. If a test fails, then one retest of three additional specimens (recovered from the same location within the same QTC with no additional heat treatment) may be made, each of which shall exhibit an impact value equal to or exceeding the required minimum average.

5.6.5.6 Specimen Orientation

The values listed in Table 9 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 tested in the longitudinal direction instead of the transverse direction shall exhibit 20 ft-lbs (27 J) minimum average impact value.

5.7 Rigid Piping

Rigid piping shall meet the material requirements of 5.6.

5.8 Qualification Test Coupons

5.8.1 General

5.8.1.1 For parts heat treated in batch furnaces only, the qualification test coupon (QTC) may be taken from a separate test coupon of the same heat of material. For parts heat treated in continuous furnaces or batch furnaces, the QTC may be taken from a prolongation or trepanned core taken from a production part or from a sacrificial production part.

5.8.1.2 The properties exhibited by the QTC shall represent the properties of the thermal response of the material comprising the production parts it qualifies. Depending on the hardenability of a given material, the QTC results may not correspond to the properties of the actual components at all locations throughout their cross-section.

5.8.1.3 For batch heat-treatment only, if the QTC is a trepanned core or prolongation removed from a production part, the QTC may qualify only production parts having the same or smaller equivalent round (ER). The QTC shall qualify only material and parts produced from the same heat.

5.8.1.4 For material heat-treated in a continuous furnace, the QTC shall consist of a sacrificial production part or a prolongation removed from a production part. The sacrificial production part or prolongation QTC shall qualify only production parts having an identical size and shape. The QTC shall qualify only material and parts produced from the same heat and heat-treat lot.

5.8.2 Equivalent Round Method

5.8.2.1 The size of a QTC for a part shall be determined using the ER Method. Figure 1 and Figure 2 illustrate 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” conditions.

5.8.2.2 The ER of a studded type part shall be determined by using *T* equal to the thickness of the thickest flange of that part. ER determination for these parts shall be in accordance with the methods for complex shaped parts.

5.8.2.3 The ER of the QTC shall be equal to or greater than the dimensions of the part it qualifies, except the size is not required to exceed 5 in. (125 mm) ER.

5.8.3 Melting, Casting, and Hot Work

5.8.3.1 Melting Practices

The QTC shall not be processed using a melting practice cleaner than that of the material it qualifies (e.g. a QTC made from a remelt grade or vacuum degassed material shall not be used to qualify material from the same primary melt if that material has not experienced the identical melting practice as the QTC). Remelt grade material removed from a single remelt ingot may be used to qualify other remelt grade material that has been processed in a like manner and is from the same melt. No additional alloying shall be performed on these individual remelt ingots.

5.8.3.2 Casting Practices

The manufacturer shall use the same foundry practices for the QTC as those used for the parts it qualifies.

5.8.3.3 Hot Work Practices

The manufacturer shall use hot work ratios on the QTC that 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.

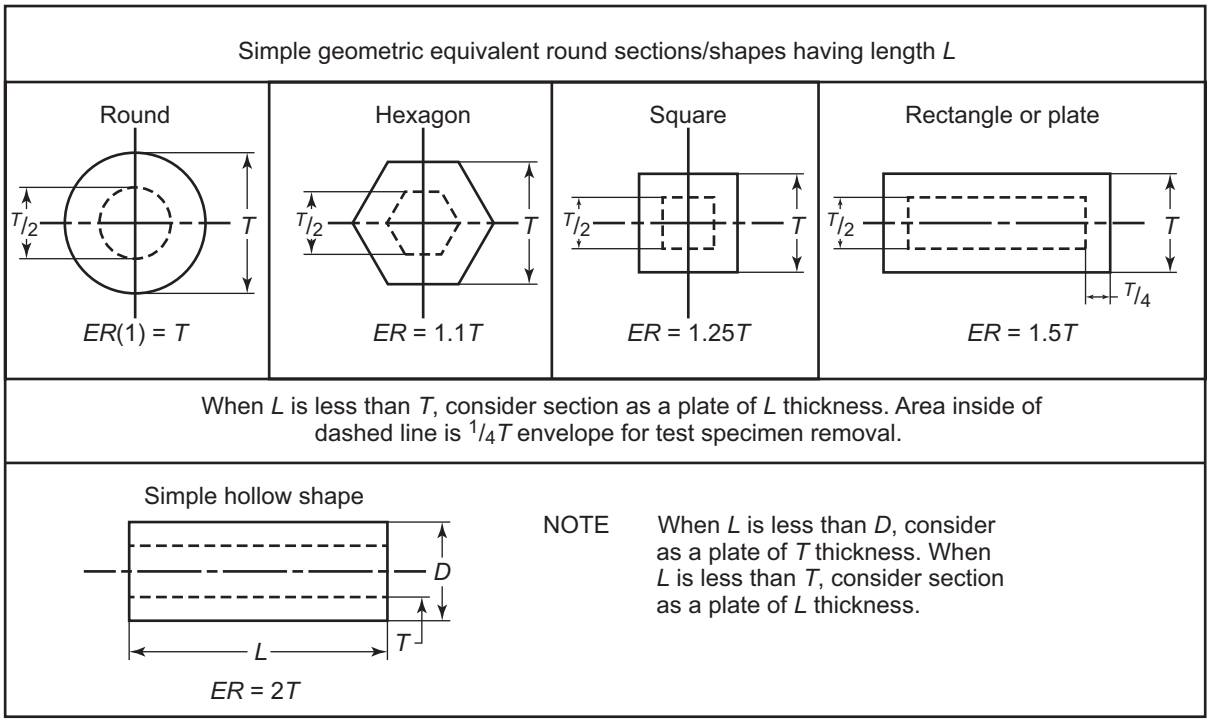
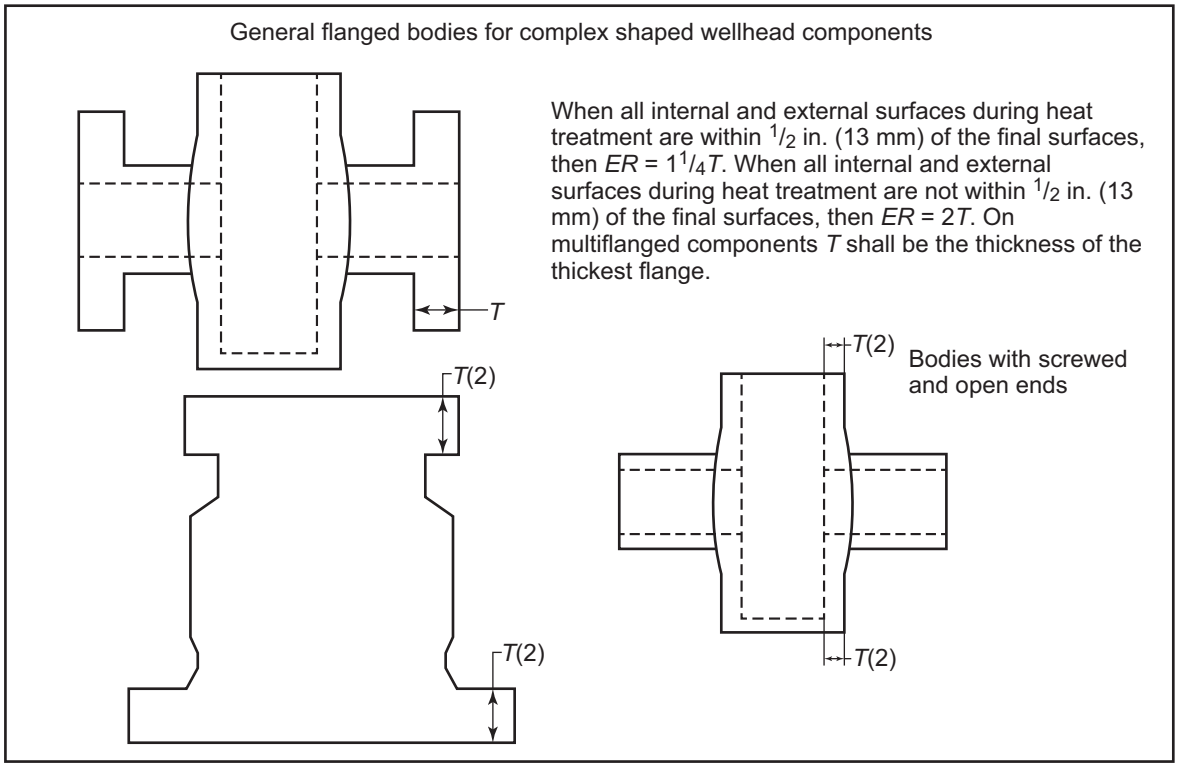


Figure 1—Simple Geometric Shapes



Where *T* is the thickness when the component is heat treated.

(1) ER = Equivalent round

(2) Use the larger dimension

Figure 2—Complex Shaped Components

5.8.3.4 Welding

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

5.8.3.5 Heat Treatment Equipment Qualification

Heat treatment operations shall be performed using “production type” equipment qualified in accordance with API 16A. Production type heat-treating equipment shall be considered equipment that is routinely used to process production parts.

5.8.3.6 Heat Treatment Methods

The QTC shall experience the same specified heat treatment procedure as the parts it qualifies. The QTC shall be heat-treated using the manufacturer’s written specification.

5.8.4 Tensile and Impact Testing

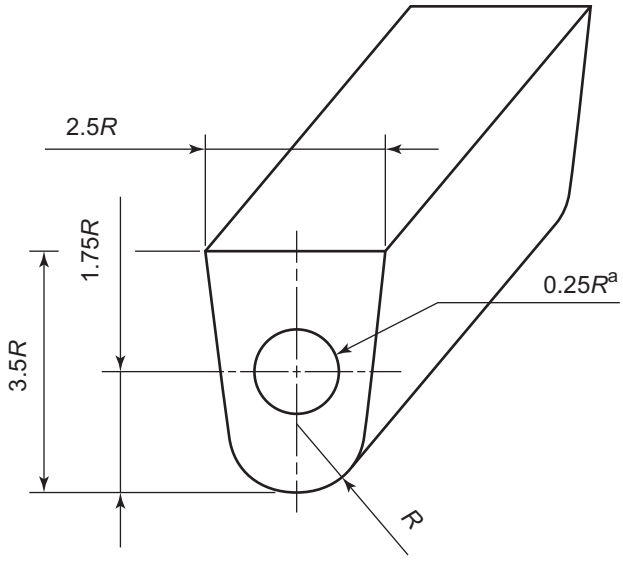
5.8.4.1 Tensile and impact test specimens shall be removed from the same QTC after the final QTC heat treatment cycle.

5.8.4.2 Tensile and impact specimens shall be recovered from the QTC such that their longitudinal center line axis is wholly within the center core $^{1}/_{4}T$ envelope for a solid QTC or within $^{1}/_{8}$ in. (3.2 mm) of the mid-thickness of the thickest section of a hollow QTC, reference Figure 1, Figure 2, and Figure 3.

5.8.4.3 When a sacrificial production part is used as a QTC, the impact and tensile test specimens shall be recovered from the $^{1}/_{4}T$ location of the thickest section in that part.

5.8.5 Hardness Testing

A minimum of two Brinell hardness tests shall be performed on the QTC after the final heat treatment cycle. Hardness testing shall be performed in accordance with procedures specified in Section 7.



NOTE $ER = 2.3R$

[a] Envelope for test specimen removal.

Figure 3—Keel Block Configuration

6 Welding

6.1 General

Welding requirements are established in four groups as follows:

a) non-pressure-containing weldments (except for overlay);

b) pressure-containing fabrication weldments—bodies, bonnets, drilling riser choke, kill, and end and outlet connections;

c) pressure-containing repair weldments—bodies, bonnets, drilling riser choke, kill, and end and outlet connections;

d) weld overlay.

6.2 Non-pressure-containing Weldments

6.2.1 General

This section covers non-pressure-containing weldments other than those used in weld overlay, which are covered in 6.5.

6.2.2 Welding Procedure/Performance

Welding procedures and performance qualifications shall be in accordance with ASME BPVC, Section IX, Article II and Article III.

6.2.3 Application

Welding shall be performed in accordance with qualified procedures by qualified welding personnel. Weld joint types and sizes shall meet the manufacturer's written design requirements.

6.2.4 Quality Control Requirements

Welding and completed welds shall meet the requirements of Section 7.

6.3 Pressure-containing Fabrication Weldments

6.3.1 General

Pressure-containing fabrication weldments for bodies, bonnets, drilling riser choke and kill lines, and end and outlet connections are covered in this section.

6.3.2 Joint Design

Design of groove and fillet welds with tolerances shall be documented in the manufacturer's specifications. Annex C provides information on weld groove designs.

6.3.3 Materials

6.3.3.1 Welding Consumables

Welding consumables shall conform to AWS A.5.1 or the manufacturer's written specifications. The manufacturer shall have a written procedure for storage and control of welding consumables. Materials of low hydrogen type shall be stored and used as specified by consumable manufacturer to retain their original low hydrogen properties.

6.3.3.2 Deposited Weld Metal Properties

6.3.3.2.1 The deposited weld metal's 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.

6.3.3.2.2 For applications involving multiple PWHT, the mechanical properties of the deposited weld metal after all PWHT is complete shall meet or exceed the minimum specified mechanical properties for the base material as documented on the applicable PQR.

6.3.3.2.3 A cross-weld metal tensile test meets these requirements.

6.3.4 Welding Procedure Qualification

6.3.4.1 Written Procedure

Welding shall be performed in accordance with welding procedure specifications (WPS) written and qualified in accordance with ASME BPVC, Section IX, Article II. The WPS shall describe the essential, non-essential, and supplementary essential (when required—see ASME BPVC, Section IX) variables.

The PQR shall record essential and supplementary essential (when required) variables of the weld procedure used for the qualification test(s). Both the WPS and PQR shall be maintained as records in accordance with the requirements in 7.6.

6.3.4.2 Base Metal Groupings

A WPS for each material which is not listed in an ASME BPVC, Section IX, P-number grouping shall be specifically qualified for the manufacturer's specified base material.

6.3.4.3 Heat Treat Condition

Testing shall be done with the test weldment in the post-weld heat-treated condition.

6.3.4.4 Heat Treatment

The post-weld heat treatment of the test weldment shall be in the same temperature range as that specified on the WPS. Allowable range for the post-weld heat treatment on the WPS shall be a nominal temperature range ±25 °F (±13.9 °C). See Annex D for the qualification of heat treating equipment.

6.3.5 Post-weld Heat Treatment, Local Heating

6.3.5.1 General

Local post-weld heat treatment shall consist of heating a circumferential band around the weld at a temperature within the ranges specified in the qualified welding procedure specification. The minimum width of the controlled band at each side of the weld on the face of the greatest weld width shall be the thickness of the weld, or 2 in. (5.1 cm) from the weld edge, whichever is less. Heating by direct flame impingement on the material shall not be permitted.

6.3.5.2 Impact Testing

One set of three test specimens each shall be removed at the 1/4 thickness location of the test weldment for each of the weld metal and base material heat affected zone (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); 100 % weld metal.

b) HAZ specimens (three each); include as much HAZ material as possible. 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. Any retest of impact testing shall be in accordance with ASTM A370.

6.3.5.3 Chemical Analysis

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

6.3.5.4 Hardness Testing

6.3.5.4.1 General

Hardness testing shall be in accordance with 6.3.5.4.2 or 6.3.5.4.3. See 7.4.6.4.2 for acceptance criteria.

6.3.5.4.2 Rockwell Method

The Rockwell Method shall be in accordance with ASTM E18 or ISO 6508-1. Test locations shall be as shown in Figure 4. For a weld cross-section thickness less than $^1/_2$ in. (12.7 mm), four hardness tests each shall be made in the base material(s), the weld, and the HAZ. For a weld cross-section thickness equal to or greater than $^1/_2$ in. (12.7 mm), six hardness tests each shall be made in the base material(s), the weld, and the HAZ.

For all thicknesses, HAZ hardness tests shall be performed in the base material with $^1/_{16}$ in. (1.6 mm) of the weld interface and at least one each within $^1/_8$ in. (3.2 mm) from top and bottom of the weld.

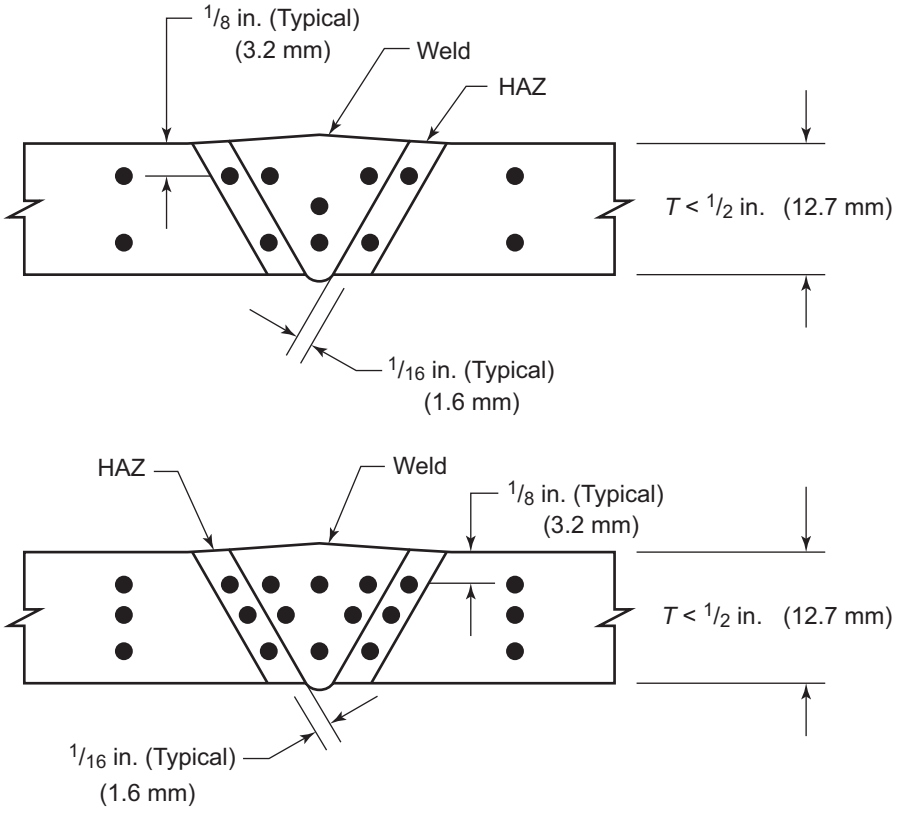


Figure 4—Welding Procedure Qualification Rockwell Hardness Test Locations

6.3.5.4.3 Vickers 10 Kg Method

The Vickers method shall be in accordance with ASTM E384 or ISO 6507-1. Test locations shall be as shown in Figure 5. For a weld cross-section thickness less than 1/2 in. (12.7 mm), four hardness tests each shall be made in the base material(s) and the weld. For a weld cross-section thickness equal to or greater than 1/2 in. (12.7 mm), six hardness tests each shall be made in the base material(s) and the weld.

6.3.5.5 Welding Controls

Instruments, meters, and gauges used to verify welding parameters shall be serviced and calibrated in accordance with 7.2.

6.3.5.6 Application

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

6.3.6 Quality Control Requirements

Quality control requirements for pressure-containing welds are provided in Section 7.

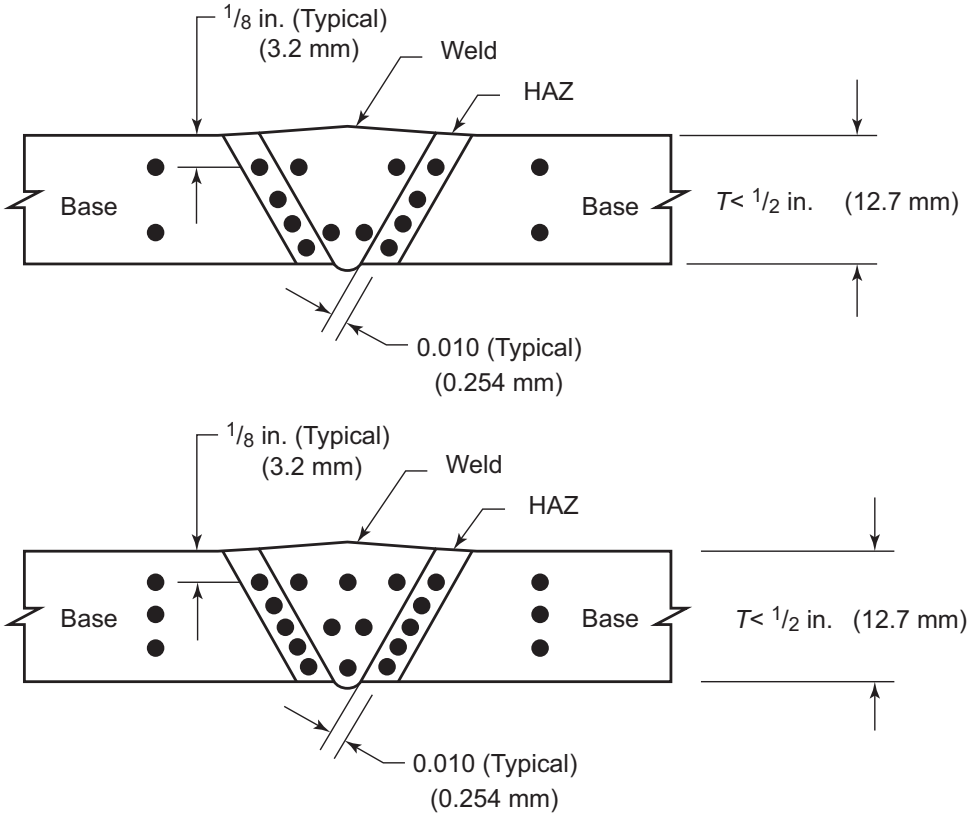


Figure 5—Welding Procedure Qualification Vickers Hardness Test Location

6.4 Pressure-containing Repair Weldments

6.4.1 General

Repair welding procedures for bodies, bonnets, drilling riser choke, kill, end connections, and outlet connections shall define the WPS and NDE requirements. Welding shall be performed in accordance with the specified WPS.

6.4.2 Base Material

The base material requirements for material composition, API material designation, impact toughness, and heat treatment condition shall be known prior to selecting a qualified WPS.

6.4.3 Fusion

The WPS selected for repair shall ensure complete fusion.

6.4.4 PQR

The WPS selected shall be supported by a PQR as described in 6.3.4.

6.4.5 Access

There shall be adequate access to evaluate, remove, repair, and inspect the nonconforming condition.

6.4.6 Welder/Welding Operator Qualification

6.4.6.1 General

The welder/welding operator shall possess a valid qualification for the materials and processes to be used in accordance with Section 7.

6.4.6.2 Hole Repair Performance Qualification

6.4.6.2.1 Bolt hole, tapped hole, and machined blind hole repair performance qualification shall be in accordance with this section. The welder/welding operator shall perform an additional repair welding performance qualification test using a mock-up hole.

6.4.6.2.2 The repair welding qualification test hole shall be qualified by radiography in accordance with Section 7 or shall be cross-sectioned through the centerline of the hole in two places 90 degrees apart and macro etched to verify complete fusion. One surface of each of the four matching pairs shall be macro etched. This evaluation shall include the total depth of the hole.

6.4.6.2.3 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 repairs to holes with the same or smaller depth-to-diameter ratio.

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

6.5 Weld Overlay

6.5.1 General

Weld overlays for corrosion resistance and/or hard facing and other material surface property controls are covered in this section.

6.5.2 Ring Grooves

6.5.2.1 General

This section applies to loose connectors integral end connections, and outlet connections.

6.5.2.2 Chemical Analysis

Chemical analysis shall be performed in the weld metal in accordance with the requirements of ASME BPVC, Section IX, at a location of $^1/_8$ in. (3.2 mm) 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. 300 Series stainless steel chemical composition shall be:

— nickel, 8.0 % minimum;

— chromium, 16.0 % minimum;

— carbon, 0.08 % maximum.

6.5.2.3 Application

6.5.2.3.1 Post-weld Heat Treatment

End and outlet connections with corrosion resistant weld overlaid ring grooves shall be subjected to post-weld heat treatment in accordance with the weld procedure qualification.

6.5.2.3.2 API Grooves

API grooves for welding shall be prepared in accordance with API 6A.

6.5.2.3.3 Other Weld Preparations

Other weld preparations may be used where the mechanical properties of the deposited weld metal equals or exceeds that of the base metal.

6.5.2.4 Hardness Testing for Ring Groove Overlay

Hardness testing shall be performed in the weld metal as part of the procedure qualification testing. Test locations shall be within $^1/_8$ in. (3.2 mm) of the original base material. The average of three or more test results shall be equal to or greater than Rockwell B 83 and recorded as part of the PQR.

6.5.3 Other Corrosion Resistant Overlay

This section applies to use of corrosion resistant weld overlay for bodies, bonnets, drilling riser choke and kill, and end and outlet connectors for purposes other than ring grooves. These requirements do not apply to hard facing or to the weld overlay of valve bore sealing mechanisms of valve stems.

6.5.4 Welding Procedure/Performance Qualification

6.5.4.1 General

Qualification shall be in accordance with ASME BPVC, Section IX, Article II and Article III, for weld overlay, hard facing, or other types of overlay as applicable.

6.5.4.2 Chemical Analysis

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

The chemical analysis of the overlay shall conform to the manufacturer's written specification.

6.5.4.3 Mechanical Properties

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

6.5.4.4 Overlay Mechanical Properties

When the overlay material is not considered as part of the manufacturer's or of the API design criteria, a tensile test and a Charpy test of the material are not required. Overlay materials considered a part of the minimum wall thickness shall have mechanical testing performed. Test results for the overlay material properties shall meet or exceed the specified design requirements.

6.5.4.5 Weld Conformance

Welds shall conform to the requirements of ASME Section IX and NACE MR0175/ISO 15156.

6.5.4.6 Hardness Testing

When the welding procedure is to be qualified for use on bodies, bonnets, drilling riser choke and kill, or flanges, hardness testing shall be in accordance with 6.3.5.4. Hardness tests shall be performed at a minimum of three test locations each: in the base material, in the heat-affected zone, and in each layer of overlay up to a maximum of two layers (see Figure 6).

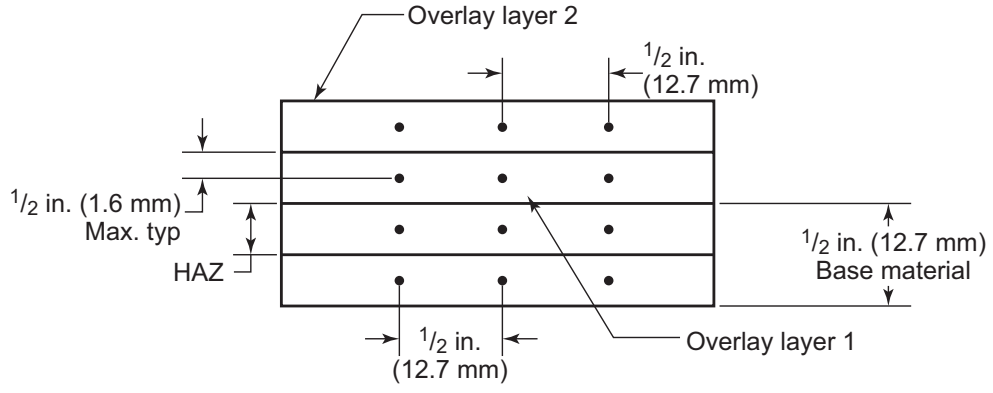


Figure 6—Hardness Test Locations

6.5.4.7 Guided Bend Tests

Guided bend tests and acceptance criteria shall be in accordance with ASME BPVC, Section IX, to verify weld overlay/base material bond integrity.

6.5.4.8 Base Material Conformance

The base material shall conform to NACE MR0175/ISO 15156 after weld overlay and any subsequent heat treatments.

7 Quality Control

7.1 General

This section specifies the quality control and quality control record requirements for choke and kill systems, equipment, and material manufactured to meet this specification.

7.2 Measuring and Testing Equipment

7.2.1 General

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's instructions, and in compliance with referenced industry standards, to maintain the accuracy required by this specification.

7.2.2 Measurement Standards and Measuring Equipment

7.2.2.1 General

Measurement standards and measuring equipment shall be controlled and calibrated to maintain accuracies within the limits specified by the measuring equipment manufacturer or the manufacturer’s written procedure.

7.2.2.2 Measurement Equipment Markings

After receipt and prior to being placed in service, each piece of measuring equipment (gauge) shall be verified to have a permanent unique identification. If no identification exists, the manufacturer shall apply one. The manufacturer may also choose to apply additional unique identification to conform with the manufacturer’s written specifications. The method of application of the identification shall be such that it will not affect the accuracy of the gauge. In the event that the identification cannot be applied directly to the gauge, it may be applied to a tag affixed to the gauge or the gauge container.

7.2.2.3 Measuring Equipment Records

The manufacturer shall maintain individual records of measurement standards and equipment as described in the following:

a) unique identification of measurement standard or equipment;

b) identification of the procedure used in the calibration of the measurement standard or equipment;

c) planned calibration interval;

d) date and results of each calibration including actual readings taken prior to adjustment, corrections, or repairs;

e) due date for next calibration;

f) individual performing calibration and facility performing calibration;

g) assigned location.

Measurement standards and measuring equipment used for high accuracy measurements require the following additional data:

— the environmental conditions for calibration and the measurement data as measured and as corrected to reference standards;

— details of any maintenance, servicing, adjustment, repair, or modification that can affect the calibration status.

7.2.2.4 Adequacy of Measurement Standards

Measurement standards and procedures used to calibrate measuring equipment shall be evaluated by the manufacturer to assure that any random and systematic errors in calibration do not exceed 25 % of the tolerance of the parameter being measured. Measuring equipment requiring high levels of accuracy, which approach state of the art or natural physical constant limitations, are excluded from this requirement.

7.2.2.5 Calibration Intervals

Measurement standards and measuring equipment shall be calibrated at intervals established by the manufacturer that take into consideration such factors as stability, purpose, and degree of usage. Intervals shall be shortened or lengthened as required to assure continued accuracy and stability as evidenced by the results of previous calibrations.

7.2.2.6 Calibration Labeling

Measurement standards and measuring equipment shall be labeled, coded, or otherwise identified to indicate the calibration status. Any limitation or restriction of use shall be clearly indicated on the equipment. When neither labeling nor coding is practical, other methods as defined by the manufacturer's written procedure shall be used.

7.2.3 Pressure-measuring Devices

7.2.3.1 Type and Accuracy

Test pressure-measuring devices shall be accurate to at least ±2 % of full-scale range. If pressure gauges are used in lieu of pressure transducers, they shall be selected such that the test pressure is indicated within 20 % and 80 % of the full-scale value.

Pressure-recording devices need not meet the requirements of 7.2.2 unless used for both measurement and recording.

7.2.3.2 Calibration Procedure

Pressure-measuring devices shall be recalibrated with a master pressure measuring device or a dead weight tester to at least three equidistant points of full scale (excluding zero and full scale as required points of calibration).

7.2.3.3 Calibration Intervals

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

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

7.3 Quality Control Personnel Qualifications

7.3.1 Nondestructive Examination (NDE) Personnel

NDE Personnel shall be qualified in accordance with ASNT SNT-TC-1A or ISO 9712.

7.3.2 Welding Inspectors

Personnel performing visual inspection of welding operations and completed welds shall be qualified and certified to one of the following:

— AWS certified welding inspector (CWI);

— AWS certified associate welding inspector (CAWI);

— CSWIP-WI-6-92;

— welding inspector certified by the manufacturer's documented training program.

The manufacturer shall have a written procedure that defines the roles and responsibilities of a welding inspector, including essential welding variables and equipment monitoring. In-process welding shall be audited by the welding inspector at least annually.

7.3.3 Other Personnel

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

7.4 Quality Control Requirements

7.4.1 General

Table 10 provides a matrix of quality control requirements for specific parts and equipment.

7.4.2 Materials

Section 5 includes detailed qualification requirements for parts and qualification test coupons.

Quality control testing or examination shall be performed on parts in contact with well fluids to verify that NACE MR0175/ISO 15156 values and requirements have been satisfied. If the other requirements of this section satisfy this requirement, additional testing or examination is not required.

7.4.3 Quality Control Instructions

Quality control activities shall be controlled by manufacturer's documented instructions that shall include appropriate methodology and quantitative or qualitative acceptance criteria.

7.4.4 Nondestructive Examination

Nondestructive examination (NDE) instructions shall be detailed regarding the requirements of this specification and those of applicable referenced standards. All NDE instructions shall be approved by a Level III individual.

Table 10—Quality Control Requirements for Bodies, Bonnets, Choke and Kill Lines, and End and Outlet Connections

Quality Requirement	Section
Tensile testing	7.4.6.2
Impact testing	7.4.6.3
Hardness testing	7.4.6.4
Dimensional verification	7.4.6.5
Traceability	7.4.6.6
Chemical analysis	7.4.6.7
Visual examination	N/A
Surface NDE	7.4.6.9
Volumetric NDE	7.4.6.10
Serialization	7.4.6.13
Weld NDE - general	7.4.6.11.1
Visual examination	7.4.6.11.2
Surface NDE	7.4.6.11.3
Volumetric NDE	7.4.6.11.4
Hardness testing	7.4.6.11.5
Repair welds	7.4.6.12

7.4.5 Acceptance Status

The acceptance status of 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.

7.4.6 Bodies, Bonnets, Choke and Kill Lines, and End and Outlet Connections

7.4.6.1 General

Quality control requirements for bodies, bonnets, choke and kill lines, and end and outlet connections are listed in Table 10.

7.4.6.2 Tensile Testing

Tensile testing requirements shall be in accordance with Section 5.

7.4.6.3 Impact Testing

Impact testing requirements shall be in accordance with Section 5.

7.4.6.4 Hardness Testing

7.4.6.4.1 General

7.4.6.4.1.1 Hardness testing shall be performed with procedures specified in ASTM E10, ASTM E18, ISO 6506-1, or ISO 6508-1.

7.4.6.4.1.2 At least one hardness test shall be performed on each finished part, with additional tests on each end connection face at locations specified in the manufacturer's design documents.

7.4.6.4.1.3 The hardness testing used to qualify each part shall be performed after the last heat treatment cycle (including stress relieving heat treatment cycles) and after exterior machining operations.

7.4.6.4.1.4 When equipment is composed of bodies and flanges having different API material designations, the manufacturer shall perform hardness tests on each part. The results of these hardness tests shall satisfy the hardness value requirements for each respective part.

7.4.6.4.2 Acceptance Criteria

Hardness measurements on parts fabricated from carbon, low alloy and martensitic stainless type steels shall exhibit hardness values equal to or greater than Table 11. See NACE MR0175/ISO 15156 for maximum hardness values. Minimum hardness of non-standard materials shall conform to the manufacturer's documented criteria.

Table 11—Minimum Hardness Values

API Material Designations	Brinell Hardness Number	Rockwell Hardness Number
36 ksi	HB 140	HRB 77.5
45 ksi	HB 140	HRB 77.5
60 ksi	HB 174	HRB 87.8
75 ksi	HB 197	HRB 92.8
80 ksi	HB 207	HRB 94.6

7.4.6.4.3 Alternative Acceptance Criteria

7.4.6.4.3.1 If hardness test results do not meet the required minimum hardness value, the part may be considered acceptable if the calculated tensile strength based on the hardness measurement meets the requirements of 7.4.6.4.3.2.

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

$$HB_c = \frac{UTS \times HB_{QTC}}{UTS_{QTC}}$$

where

HB_c is the minimum acceptable Brinell hardness for a part after the final heat treatment cycle (including stress relieving cycles);

UTS is the minimum acceptable ultimate tensile for the applicable strength level, i.e. 70 ksi (483 MPa), 85 Ksi (587 MPa), or 95 Ksi (656 MPa);

UTS_{QTC} is the average ultimate tensile strength determined from the QTC tensile tests;

HB_{QTC} is the average Brinell hardness values observed among the tests performed on the QTC.

7.4.6.4.3.3 If it is necessary to report the hardness test results in other measurement units, conversions shall be made in accordance with ASTM E140.

7.4.6.5 Dimensional Verification

7.4.6.5.1 General

Dimensional verification requirements shall be as described in 7.4.6.4.2 through 7.4.6.4.5, with verification being performed on all parts.

7.4.6.5.2 Sampling

End and outlet connection threads shall be gauged.

7.4.6.5.3 Methods

Threaded end and outlet connections shall be gauged for standoff at hand-tight assembly by the use of the gauges and gauging of API 6A.

7.4.6.5.4 Acceptance Criteria

Acceptance Criteria shall be in accordance with API 5CT or API 5L or ASME B1.1 or ASME B1.2 as applicable.

7.4.6.5.5 Critical Dimensions

The manufacturer shall specify and verify critical dimensions. Acceptance criteria for critical dimensions shall be as required by the manufacturer's written specification.

7.4.6.6 Traceability

Parts shall be traceable to the individual heat and heat treatment lot. Identification shall be maintained on materials and parts, to facilitate traceability, as required by documented manufacturer specifications.

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

7.4.6.7 Chemical Analysis

7.4.6.7.1 Sampling

Chemical analysis shall be performed on a heat basis.

7.4.6.7.2 Methods

Chemical analysis shall be performed in accordance with a recognized industry standard specified by the manufacturer.

7.4.6.7.3 Acceptance Criteria

The chemical composition shall meet the requirements of Section 5 and the manufacturer's written specification.

7.4.6.8 Visual Examination

No visual examination is required.

7.4.6.9 Surface NDE

7.4.6.9.1 General

Surface NDE requirements shall be as follows:

a) accessible surfaces of each finished part shall be examined after final heat treatment and final machining operations;

b) all magnetic particle examinations shall use the wet fluorescent method;

c) surface NDE shall be performed on all surfaces prepared for weld overlay.

7.4.6.9.2 Surface NDE—Ferromagnetic Materials

7.4.6.9.2.1 General

Ferromagnetic materials shall be examined in accordance with procedures specified in ASTM E709 or ASTM E165. Prods are not permitted on wetted surfaces or sealing surfaces.

7.4.6.9.2.2 Relevant Indication

Only those indications with major dimensions greater than $^{1}/_{16}$ in. (1.6 mm) shall be considered relevant.

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

If indications are believed to be non-relevant, they shall be examined by liquid penetrant surface NDE methods in accordance with ASTM E165, or removed and re-inspected, to prove their non-relevancy.

7.4.6.9.2.3 Linear Indication

Indications where the length is equal to or greater than three times its width.

7.4.6.9.2.4 Rounded Indication

Indications that are circular or elliptical with length less than 3 times the width.

7.4.6.9.2.5 Acceptance Criteria

Acceptance criteria shall be as follows:

a) no relevant indication with a major dimension equal to or greater than $^{3}/_{16}$ in. (4.8 mm);

b) no more than ten relevant indications in any contiguous 6 in. (152.4 mm) square area;

c) four or more relevant indications in a line separated by less than $^{1}/_{16}$ in. (1.6 mm) edge-to-edge are unacceptable;

d) no relevant indications in the pressure contact sealing surfaces.

7.4.6.9.3 Surface NDE—Non-ferromagnetic Materials

All non-ferromagnetic materials shall be examined in accordance with procedures specified in ASTM E165. The definitions of 7.4.6.2.2, 7.4.6.2.3, and 7.4.6.2.4 are applicable.

Acceptance criteria are as follows:

a) no relevant linear indications;

b) no relevant rounded indication with a major dimension equal to or greater than $^{3}/_{16}$ in. (4.8 mm);

c) four or more relevant rounded indications in a line separated by less than $^{1}/_{16}$ in. (1.6 mm) edge-to-edge are unacceptable;

d) no relevant indications in pressure contact sealing surfaces.

7.4.6.10 Volumetric NDE

7.4.6.10.1 Sampling

As far as practical, the entire volume of each part shall be volumetrically inspected (radiography or ultrasonic) after heat treatment for mechanical properties (exclusive of stress relief treatments) and prior to machining operations that limit effective interpretation of the results of the examination.

7.4.6.10.2 Method—Ultrasonic Examination

7.4.6.10.2.1 Hot Worked Parts

Ultrasonic examination of hot worked parts shall be performed in accordance with the flat bottomhole procedures specified in ASTM A388 (except immersion method may be used) and ASTM E428.

7.4.6.10.2.2 Castings

Ultrasonic examinations of castings shall be performed in accordance with the flat bottom hole procedures specified in ASTM A609 (except immersion method may be used) and ASTM E428.

7.4.6.10.2.3 Calibration

The distance amplitude curve (DAC) shall be based on the following:

a) $^{1}/_{16}$ in. (1.6 mm) flat bottom hole for metal thicknesses 1 through $1^{1}/_{2}$ in. (25.4 mm through 38.1 mm);

b) $^{1}/_{8}$ in. (3.2 mm) flat bottom hole for metal thicknesses from $1^{1}/_{2}$ in. through 6 in. (38.1 mm through 152.4 mm);

c) $^{1}/_{4}$ in. (6.4 mm) flat bottom hole for metal thicknesses exceeding 6 in. (152.4 mm).

7.4.6.10.2.4 Acceptance Criteria

No single indications exceeding reference distance amplitude curve.

No multiple indications exceeding 50 % of reference distance amplitude curve. Multiple indications are defined as two or more indications (each exceeding 50 % of the reference distance amplitude curve) within $^{1}/_{2}$ in. (12.7 mm) of each other in any direction.

7.4.6.10.3 Method—Radiographic Examination

Radiographic examinations shall be performed in accordance with procedures specified in ASTM E94, to a minimum equivalent sensitivity of 2 %. 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 %. Wire-type image quality indicators are acceptable for use in accordance with ASTM E747.

See Table 12 for hot worked parts acceptance criteria. Elongated indications with length greater than those listed in Table 12 are not permitted. See Table 13 for castings acceptance criteria.

7.4.6.11 Weld NDE

7.4.6.11.1 General

Completed weldments (a minimum of 1/2 in. (12.7 mm) of surrounding base metal and the entire accessible weld) shall be examined in accordance with the methods and acceptance criteria of this section.

Requirements and acceptance criteria for corrosion resistant weld overlay of bodies, bonnets, and flanges can be different from those for other weld types and shall meet the manufacturer's written specifications. The manufacturer's written specification for corrosion resistant weld overlay shall include a technique for measuring the specified overlay thickness.

Table 12—Hot Worked Parts Acceptance Criteria

Dimensions in inches (mm)

Thickness, *T*[a]	**Inclusion Length**
Less than 0.76 (19.3)	0.25 (6.4)
0.76 to 2.25 (19.3 to 57.2)	0.33*T*
> 2.25 (57.2)	0.75 (19.1)
Cracks, laps, or bursts are not permitted. No group of indications in a line that have an aggregate length greater than *T* in a length of 12*T*.	
[a] *T* is the pressure vessel wall thickness.	

Table 13—Castings Acceptance Criteria

Type Defect	**Maximum Defect Class**
A	2
B	2
C (All Types)	2
D	None acceptable
E	None acceptable
F	None acceptable
G	None acceptable
NOTE See ASTM E186, ASTM E280 and ASTM E446.	

7.4.6.11.2 Weld Examination—Visual

7.4.6.11.2.1 Sampling

Welds shall be visually examined by the welding inspector for 100 % of the length after post-weld heat treatment and machining operations. Examinations shall include a minimum of 1/2 in. (12.7 mm) of adjacent base metal on both sides of the weld.

7.4.6.11.2.2 Acceptance Criteria

Pressure-containing welds shall have complete joint penetration. Undercut shall not reduce the thickness in the area (considering both sides) to below the minimum thickness. Surface porosity and exposed slag are not permitted on or within 1/2 in. (12.7 mm) of sealing surfaces.

7.4.6.11.3 Weld NDE—Surface

7.4.6.11.3.1 Sampling

Each pressure-containing fabrication weld or weld overlay shall be examined by either magnetic particle or liquid penetrant (in the case of non-ferrous materials) methods, after welding, post-weld heat treatment and machining operations. Examinations shall include a minimum of 1/2 in. (12.7 mm) of adjacent base metal on both sides of the weld.

7.4.6.11.3.2 Method

Magnetic particle examination using the Wet Fluorescent Method, shall be performed to procedures specified in ASTM E709. Prods are not permitted on wetted surfaces or sealing surfaces.

Liquid penetrant examination shall be performed on accessible sealing surfaces of each finished part after final heat treatment and after final machining operations. Examination shall be performed as specified in ASTM E165.

7.4.6.11.3.3 Acceptance Criteria

Acceptance criteria for weld surface examination shall be as described in 7.4.6.8 with the following additional requirements:

— no relevant linear indications;

— no rounded indications greater than 1/8 in. (3.2 mm) for welds whose depth is 5/8 in. (15.9 mm) or less; or 3/16 in. (4.8 mm) for welds whose depth is greater than 5/8 in. (15.9 mm).

7.4.6.11.4 Weld NDE—Volumetric

7.4.6.11.4.1 Sampling

Pressure-containing fabrication welds shall be examined by either radiography or ultrasonic methods, after welding, post-weld heat treatment and machining operations.

Repair welds, where the repair is greater than 20 % of the original wall thickness or 1 in. (25.4 mm) (whichever is less) or where the extent of the cavity exceeds 10 $in.^2$ (64.5 cm^2) or where the casting leaks on hydrostatic test, shall be examined by either radiography or ultrasonic methods after welding, post-weld heat treatment, and machining operations.

Examination shall include at least 1/2 in. (12.7 mm) of adjacent base metal on all sides of the weld.

7.4.6.11.4.2 Method

Radiographic Examination. Radiographic examination of welds shall be performed in accordance with methods specified in Section 7.4.6.9.3.

Acceptance criteria are as follows:

a) no type of crack, zone of incomplete fusion or penetration;

b) no elongated inclusion with a length equal to or greater than shown in Table 14;

c) no elongated slag inclusion with a length equal to or greater than the weld thickness (T) in any total length of 12T, except when the distance between successive inclusions exceeds six times the length of the longest inclusion;

d) no rounded indications in excess of that specified in ASME BPVC, Section VIII, Division I, Appendix 4.

Table 14—Weld Inclusion Length Acceptance Criteria—Radiographic Method

Dimensions in inches (mm)

Thickness T[a]	Inclusion Length
Less than 0.76 (19.3)	0.25 (6.4)
0.76 (19.3) to 2.25 (57.2)	0.33T
Greater than 2.25 (57.2)	0.75 (19.1)

[a] T is the pressure vessel wall thickness.

7.4.6.11.4.3 Method—Ultrasonic Examination

Ultrasonic examinations shall be performed in accordance with the procedures specified in ASME BPVC, Section V, Article 5.

Acceptance criteria are as follows:

a) no indications whose signal amplitude exceeds the reference level;

b) no linear indications interpreted as cracks, incomplete joint penetration or incomplete fusion;

c) no slag indications with amplitudes exceeding the reference level whose length exceeds Table 15.

Table 15—Weld Inclusion Length Acceptance Criteria—Ultrasonic Method

Dimensions in inches (mm)

Weld Thickness T	Inclusion Length
Less than 0.76 (19.3)	0.25 (6.4)
0.76 (19.3) to 2.25 (57.2)	0.33T
Greater than 2.25 (57.2)	0.75 (19.1)

7.4.6.11.5 Weld NDE—Hardness Testing

7.4.6.11.5.1 Sampling

Accessible pressure-containing welds, repair welds, and welds to pressure-containing parts shall be hardness tested.

7.4.6.11.5.2 Methods

Hardness testing shall be performed in accordance with those procedures specified in ASTM E10, ASTM E18, ASTM E110, ISO 6506-1, or ISO 6508-1.

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

7.4.6.11.5.3 Acceptance Criteria

Hardness values shall meet the base material requirements of Section 5. The hardness recorded on the PQR shall be the basis for acceptance if the weld is not accessible for hardness testing.

7.4.6.12 Repair Welds

Repair welds shall be examined using the same methods and acceptance criteria as is used in examining the base metal or weld metal in the case of repair to a weld. Examinations shall include $^{1}/_{2}$ in. (12.7 mm) of adjacent base metal on all sides of the weld. Surfaces prepared for welding shall be examined prior to welding to ensure defect removal to acceptable levels.

7.4.6.13 Serialization

All assemblies shall be serialized with a unique number that will allow the assembly and all major components to be traced back through the manufacturing process to the raw material heat certification documents. These records are specified in 7.6.

Marking shall conform to Section 8.

7.4.7 Stems

7.4.7.1 General

Table 16 lists the quality control requirements for stems.

7.4.7.2 Volumetric Examination

7.4.7.2.1 Sampling

Each stem shall be ultrasonically inspected.

7.4.7.2.2 Method

Stems shall be examined in accordance with 7.4.6.9. Additionally, each stem shall be ultrasonically inspected from the outer diameter and by the straight beam technique. Stems that cannot be examined axially using the straight beam technique shall be examined with a beam directed along the axis in both directions using the angle beam technique.

Table 16—Quality Control Requirements for Stems

Quality Requirement	Section
Tensile testing	7.4.6.2
Impact testing	7.4.6.3
Hardness testing	7.4.6.4
Dimensional verification	7.4.6.5
Traceability	7.4.6.6
Chemical analysis	7.4.6.7
Visual examination	N/A
Surface NDE	7.4.6.9
Volumetric NDE	7.4.6.10
Serialization	7.4.6.13
Weld NDE—General	7.4.6.11.1
Visual Examination	7.4.6.11.2
Surface NDE	7.4.6.11.3
Volumetric NDE	7.4.6.11.4
Hardness testing	7.4.6.11.5
Repair welds	7.4.6.12

7.4.7.2.3 Calibration

Calibration shall be by distance amplitude curve based on a $^{1}/_{8}$ in. (3.2 mm) flat bottom hole (straight beam technique) and a $^{1}/_{16}$ in. (1.6 mm) side drilled hole, 1 in. (25.4 mm) deep (angle beam technique).

7.4.7.2.4 Acceptance Criteria

Acceptance criteria in accordance with 7.4.6.9.

7.4.8 Pressure-controlling Parts

NOTE See 7.4.15 for rigid piping.

7.4.8.1 Pressure-controlling Metallic Parts

Table 17 lists the quality control requirements for pressure-controlling metallic parts.

7.4.8.2 Pressure-controlling Non-Metallic Parts

Pressure-controlling non-metallic parts shall meet the requirements of the manufacturer’s written specification.

7.4.9 Drilling Chokes

7.4.9.1 Pressure-containing Parts

Pressure-containing parts of drilling chokes are the body, bonnet, end and outlet connections, and stem.

Table 10 lists the quality control requirements for the pressure-containing parts of a drilling choke.

7.4.9.2 Pressure-controlling Parts

Pressure-controlling parts of drilling chokes are parts such as the disc, plug, gate or needle, and the seat.

Table 17 lists the quality control requirements for the metallic pressure-controlling parts of a drilling choke. Non-metallic pressure-controlling parts shall meet the requirements of 7.4.8.2.

Table 17—Quality Control Requirements for Pressure-controlling Metallic Parts

Quality Requirement	Section
Tensile testing	7.4.6.2
Impact testing	7.4.6.3
Hardness testing	7.4.6.4
Dimensional verification	7.4.6.5
Traceability	7.4.6.6
Chemical analysis	7.4.6.7
Visual examination	N/A
Surface NDE	7.4.6.9
Volumetric NDE	7.4.6.10
Serialization	7.4.6.13
Weld NDE—General	7.4.6.11.1
Visual examination	7.4.6.11.2
Surface NDE	7.4.6.11.3
Volumetric NDE	7.4.6.11.4
Hardness testing	7.4.6.11.5
Repair welds	7.4.6.12

7.4.10 Actuators for Drilling Chokes

7.4.10.1 Pressure-containing Parts

Pressure-containing parts of an actuator include the cylinder, cylinder closure, piston and stem.

7.4.10.2 Quality Control Requirements

Table 18 lists the quality control requirements for actuators.

Table 18—Quality Control Requirements for Pressure-containing Parts of Actuators

Quality Requirement	Section
Tensile testing	7.4.6.2
Impact testing	7.4.6.3
Traceability	7.4.6.6
Chemical analysis	7.4.6.7

7.4.10.3 Material Specifications

Metallic and non-metallic materials used in actuators exposed only to control fluids shall have written material specifications. The manufacturer's written specification shall define the following as a minimum:

a) mechanical property requirements;

b) chemical composition;

c) heat treatment procedure;

d) impact requirements in accordance with Table 9.

7.4.10.4 Job Lot Traceability

Pressure-containing parts of actuators having a minimum working pressure greater than 375 psig (2.59 MPa) require material traceability. Traceability is considered sufficient when the part can be traced to a job lot, which identifies the included heat lot(s). Components in a multi-heat job shall be rejected if any heat lot does not conform with the manufacturer's written specifications. If heat lot traceability is maintained, only non-complying heat lots need be rejected.

7.4.11 Non-metallic Sealing Material

7.4.11.1 Quality Control Requirements

Quality of non-metallic seals shall be controlled in accordance with Table 19.

Table 19—Quality Control Requirements for Non-metallic Sealing Material

Quality Requirement	Section
Dimensional verification	7.4.11.2
Visual examination	7.4.11.3
Hardness testing	7.4.11.4
Documentation	7.4.11.5
Batch traceability	7.4.13.3
Cure date certification	7.4.13.3
Shelf life expiration date certification	7.4.10.3

7.4.11.2 Dimensional Verification

7.4.11.2.1 Sampling

Sampling shall be performed on non-metallic seals in accordance with ASQ Z1.4, Level II, 2.5 acceptance quality level (AQL) for O-rings and 1.5 AQL for other seals.

7.4.11.2.2 Method

Each piece of the sample shall be dimensionally inspected for compliance to specific tolerances.

7.4.11.2.3 Acceptance Criteria

If inspection methods produce rejections less than allowed in sampling, the batch shall be accepted.

7.4.11.3 Visual Examination

7.4.11.3.1 Sampling

Sampling shall be performed in accordance with ASQ Z1.4, Level II, 2.5 AQL for O-rings, and 1.5 AQL for other seals.

7.4.11.3.2 Method

Each piece of the sample shall be visually inspected according to manufacturer's written requirements.

7.4.11.3.3 Acceptance Criteria

If inspection methods produce rejections less than that allowed, the batch shall be accepted.

7.4.11.4 Hardness Testing

7.4.11.4.1 Sampling

Sampling shall be performed in accordance with ASQ Z1.4, Level II, 2.5 AQL for O-rings, and 1.5 AQL for other seals.

7.4.11.4.2 Method

Hardness testing shall be performed in accordance with procedures specified in ASTM D2240 or ASTM D1415.

7.4.11.4.3 Acceptance Criteria

The hardness shall be controlled in accordance with the manufacturer's written specification.

7.4.11.5 Documentation

The supplier and/or manufacturer shall certify that materials and end products meet manufacturer's written specifications. Certification shall include manufacturer's part number, specification number, compound number, batch number, mold date, and shelf life expiration date.

7.4.12 Metallic Sealing Materials Quality Control Requirements

Metallic seals shall be in accordance with the manufacturer's written specifications.

7.4.13 Flexible Choke and Kill Lines

7.4.13.1 Pressure-containing Parts

Pressure-containing parts of flexible choke and kill lines are as follows:

a) metallic wetted end and outlet connections and end terminations;

b) metallic non-wetted reinforcement windings and end terminations;

c) non-metallic non-wetted pressure-containing parts shall be defined by the manufacturer.

7.4.13.2 Quality Control Requirements

Table 20 lists the quality control requirements for the pressure-containing parts of flexible lines.

Table 20—Quality Control Requirements for Pressure-containing Parts of Flexible Lines

Quality Requirement	Metallic Parts (Wetted)	Metallic Parts (Non-wetted)	Non-metallic Parts
Tensile testing	7.4.6.2	7.4.6.1	N/A
Impact testing	7.4.6.3	N/A	N/A
Hardness testing	7.4.6.4	N/A	N/A
Dimensional verification	7.4.6.5	7.4.6.4	N/A
Traceability	7.4.6.6	7.4.6.5	7.4.13.3
Chemical analysis	7.4.6.7	7.4.6.6	7.4.13.3.2
Mechanical testing	N/A	N/A	7.4.13.3
Surface NDE	7.4.6.9	N/A	N/A
Volumetric NDE	7.4.6.10	N/A	N/A
Serialization	7.4.6.13	N/A	N/A
Weld NDE—General	7.4.6.11.1	N/A	N/A
Visual examination	7.4.6.11.2	7.4.6.11.2	N/A
Surface NDE	7.4.6.11.3	N/A	N/A
Volumetric NDE	7.4.6.11.4	N/A	N/A
Hardness testing	7.4.6.11.5	N/A	N/A
Repair welds	7.4.6.12	N/A	N/A

7.4.13.3 Non-metallic Parts Materials

7.4.13.3.1 General

The requirements in 7.4.13.2, 7.4.13.3, 7.4.13.4, and 7.4.13.5 are applicable to thermo-plastic and elastomeric materials.

7.4.13.3.2 Raw Materials

The manufacturer shall document and retain records for critical materials used in the manufacturing of non-metallic materials.

7.4.13.3.3 Processed Materials

The manufacturer shall document and retain records for the processed materials used in pressure-containing parts.

7.4.13.3.4 Testing

Testing of materials shall be in accordance with applicable ASTM procedures. If a suitable ASTM procedure cannot be applied, the manufacturer shall provide a written procedure.

7.4.13.3.5 Acceptance Criteria

Acceptance criteria shall be as identified in the manufacturer's written specification.

7.4.14 Drilling Choke Actuator Control Lines and Fittings Quality Control Requirements

Control lines and fittings for drilling choke actuators shall be in accordance with the manufacturer's written procedures.

7.4.15 Rigid Piping

7.4.15.1 General

Rigid piping is a tubular piece, of any length, made from a section(s) of fabricated, random length pipe, exclusive of any couplings, flanges, or other end connections.

7.4.15.2 Classification

Pipe is classified as a pressure-containing part.

7.4.15.3 Quality Control Requirements

The quality control requirements for rigid piping are specified in Table 21.

Table 21—Quality Control Requirements for Rigid Piping

Quality Requirement	Section
Tensile testing	7.4.6.2
Impact testing	7.4.6.3
Hardness testing	7.4.6.4
Dimensional verification	7.4.6.5
Traceability	7.4.6.6
Chemical analysis	7.4.6.7
Visual examination	N/A
Surface NDE	7.4.15.5
Volumetric NDE	7.4.15.4
Serialization	7.4.6.13

7.4.15.4 Volumetric NDE

7.4.15.4.1 General

Volumetric NDE shall be performed in accordance with any of the methods described in 7.4.15.4.2 and 7.4.15.4.3.

7.4.15.4.2 Ultrasonic Inspection

7.4.15.4.2.1 Ultrasonic inspection shall be performed on 100 % of the pipe body and shall be employed by either manual or automatic methods. Phased array techniques may be used.

7.4.15.4.2.2 All pipe shall be inspected on the inside surface in accordance with ISO 10893-10 or ASTM E213 for longitudinal imperfections, and ISO 10893-10 or ASTM E213 for transverse imperfections.

7.4.15.4.2.3 All pipe shall be inspected for the detection of imperfections on the outside surface by one of the methods specified in 7.4.15.5.

7.4.15.4.2.4 The acceptance criteria shall be in accordance with the following:

a) the maximum acceptable notch depth as a percentage of the pipe wall shall not exceed 5 %;

b) the maximum acceptable notch length is 1 in. (25.4 mm);

c) the maximum acceptable notch width is 0.04 in. (1.0 mm).

7.4.15.4.2.5 If automated ultrasonic inspection equipment limitations do not permit the inspection of the each end of the pipe, then this portion of the pipe shall be manually UT inspected, or discarded.

7.4.15.4.3 Radiographic Examination

Radiographic examination shall be performed in accordance with procedures specified in ASTM E94, to a minimum equivalent sensitivity of 2 %. Both x-ray and gamma ray radiation sources are acceptable within the inherent thickness range limitation of each source. 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 %. Wire-type image quality indicators are acceptable for use in accordance with ASTM E747.

The acceptance criteria are specified as follows:

a) no cracks, laps, or bursts;

b) no elongated indications with length greater than that described in Table 22;

c) no group of indications in a line that have an aggregate length greater than T in a length of $12T$.

Table 22—Acceptance Criteria for Elongated Indications

Dimensions in inches (mm)

Thickness T	Inclusion Length
Less than 0.76 (19.3)	0.25 (6.4)
0.76 to 2.25 $0.33T$ (19.3 to 57.2) $0.33T$	$0.33T$
Where T is the wall thickness.	

7.4.15.5 Surface NDE

7.4.15.5.1 General

Surface NDE shall be performed on the outside diameter of the rigid pipe after heat treatment in accordance with any of the methods described in 7.4.15.5.2 through 7.4.15.5.6.

7.4.15.5.2 Magnetic Particle Examination

7.4.15.5.2.1 Magnetic particle examination shall be performed in accordance with ISO 13665 or ASTM E709. Prods are not permitted on well fluid surfaces or sealing surfaces.

7.4.15.5.2.2 Relevant indications are those indications with major dimensions greater than $^1/_{16}$ in. (1.6 mm).

7.4.15.5.2.3 Linear Indications are those indications where the length is equal to or greater than three times its width.

7.4.15.5.2.4 Rounded indications are those indications that are circular or elliptical with length less than 3 times the width.

7.4.15.5.2.5 Inherent indications not associated with a surface rupture (i.e. magnetic permeability variations, non-metallic stringers) shall be considered non-relevant.

7.4.15.5.2.6 If indications are believed to be non-relevant, they shall be examined by liquid penetrant surface NDE methods in accordance with ASTM E165, or removed and re-inspected, to prove their non-relevancy.

7.4.15.5.2.7 Acceptance criteria shall be in accordance with the following:

a) no relevant indication with a major dimension equal to or greater than $^{3}/_{16}$ (4.8 mm) in.;

b) no more than ten relevant indications in any contiguous 6 in. (152.4 mm) square area;

c) four or more relevant indications in a line separated by less than $^{1}/_{16}$ in. (1.6 mm) edge-to-edge are unacceptable;

d) no relevant indications in the pressure contact sealing surfaces.

7.4.15.5.3 Liquid Penetrant Examination

7.4.15.5.3.1 Liquid penetrant examination shall be performed in accordance with ASTM E165.

7.4.15.5.3.2 Relevant indications are those indications with major dimensions greater than $^{1}/_{16}$ in. (1.6 mm).

7.4.15.5.3.3 Linear Indications are those indications where the length is equal to or greater than three times its width.

7.4.15.5.3.4 Rounded indications are those indications that are circular or elliptical with length less than three times the width.

7.4.15.5.3.5 Acceptance criteria shall be in accordance with 7.4.15.5.2.7.

7.4.15.5.4 Eddy Current Examination

7.4.15.5.4.1 Eddy current examination shall be performed in accordance with ISO 9303 or ASTM E309 on the outside diameter for longitudinal and transverse imperfections.

7.4.15.5.4.2 Acceptance criteria shall be in accordance with 7.4.15.4.2.4.

7.4.15.5.5 Flux Leakage Examination

7.4.15.5.5.1 Flux leakage examination shall be performed on outside diameter in accordance with ISO 9402 or ASTM E570 for longitudinal imperfections and ISO 9598 or ASTM E570 for transverse imperfections.

7.4.15.5.5.2 Acceptance criteria shall be in accordance with 7.4.15.4.2.4.

7.4.15.6 Evaluation of Indications (Prove-up)

7.4.15.6.1 General

7.4.15.6.1.1 For an indication that is greater than or equal to the reject threshold, the manufacturer shall either evaluate it in accordance with this sub-clause or dispose of the indication as a defect in accordance with 7.4.15.6.2 Evaluation of indications shall be performed by NDE Level I certified inspectors under the supervision of NDE Level II

or III certified inspectors, or by NDE Level II or III certified inspectors. Evaluation of indications shall be performed in accordance with documented procedures.

7.4.15.6.1.2 When no imperfection is found in the area of the original indication and there is no explanation for the indication, then the pipe shall be rejected or, at the manufacturer's option, re-inspected full-body, full-length either using the same inspection method or using ultrasonic inspection methods. At the manufacturer's option, the inspection equipment shall be adjusted either to the same sensitivity level as that used to perform the original inspection or to a reduced sensitivity that meets the specified requirements.

7.4.15.6.1.3 All magnetic particle indications that are produced by leakage fields originating from imperfections shall be evaluated in accordance with 7.4.15.6 a).

7.4.15.6.1.4 For the evaluation of an indicated imperfection, the depth shall be measured by one of the following methods.

a) Using a mechanical measuring device (for example, pit gauge, calipers, etc.). Removal of material by grinding or other means to facilitate measurement shall not, for pipe, reduce the remaining wall thickness below the specified minimum wall thickness. Abrupt changes in wall thickness caused by material removal during prove-up shall be removed.

b) Using an ultrasonic technique(s) (time- and/or amplitude-based), or other comparable techniques. Verification of the ultrasonic technique(s) shall be documented, and shall show capability to differentiate imperfection sizes larger and smaller than the appropriate acceptance criteria stated in 7.4.15.4 or 7.4.15.5.

7.4.15.6.1.5 Imperfections that have been evaluated and found to be defects shall be given a disposition in accordance with 7.4.15.6.2.

7.4.15.6.2 Disposition of Pipe Containing Defects

7.4.15.6.2.1 Imperfections that satisfy the material requirements and are less than the defect size stated in 7.4.15.4 or 7.4.15.5 are allowed to remain in the pipe. Repair welding is not permitted.

7.4.15.6.2.2 Pipe containing defects that exceed the stated criteria shall be given one of the following dispositions.

a) Grinding or machining of quench cracks or arc burns is not permitted. Other defects shall be completely removed by grinding or machining, provided the remaining wall thickness is within specified limits. The area affected by grinding or machining shall be blended smoothly into the contour of the tube. After removal of the defect, the affected area shall be re-inspected to verify that the defect was completely removed. The re-inspection shall be either:

   1) by the same inspection unit at the same sensitivity that performed the initial inspection; or

   2) by another NDE method, or combination of methods, that demonstrate equal or greater sensitivity that the original NDE method.

   When Method 2) is used, the NDE method (or combination of methods) shall be documented and shall demonstrate equal of greater sensitivity that the original NDE. In addition, method 2) shall address the possibility that there may be other coincident defects in the affected area.

b) The section of pipe containing the defect shall be cut off within the limits of requirements on length of the intended product.

c) The pipe shall be rejected.

7.4.16 Unions and Swivel Unions

7.4.16.1 Pressure-containing Parts

Pressure-containing parts of unions and swivel unions are the male and female subs.

7.4.16.2 Quality Control Requirements

The quality control requirements for unions and swivel unions are specified in Table 23.

7.4.17 Other Pressure Boundary Penetrations

Other pressure boundary penetrations shall be controlled in accordance with the manufacturer's written specifications.

7.5 Assembled Equipment

7.5.1 General

Table 24 provides a matrix of quality control requirements for assembled equipment.

7.5.2 Serialization

Serialization is required on assembled equipment.

Table 23—Quality Control Requirements for Male and Female Subs

Quality Requirement	Section
Tensile testing	7.4.6.2
Impact testing	7.4.6.3
Hardness testing	7.4.6.4
Dimensional verification	7.4.6.5
Traceability	7.4.6.6
Chemical analysis	7.4.6.7
Visual examination	N/A
Surface NDE	7.4.6.8
Volumetric NDE	7.4.6.10
Serialization	7.4.6.13
Weld NDE—General	7.4.6.11.1
Visual examination	7.4.6.11.2
Surface NDE	7.4.6.11.3
Volumetric NDE	7.4.6.11.4
Hardness testing	7.4.6.11.5
Repair welds	7.4.6.12

Table 24—Quality Control Requirements—Assembled Equipment

Activity	Drilling Choke	Actuator	Drilling Choke and Actuator Assembly	Hydraulic Control System	Articulated Choke and Kill Lines	Flexible Choke and Kill Lines	Unions and Swivel Unions	Rigid Choke and Kill Lines	Buffer Chamber	Manifold Assembly
Hydrostatic test	7.5.5.1	7.5.6	N/A	N/A	7.5.8	7.5.9	7.5.10	7.5.11	7.5.12	7.5.12
Function test	7.5.5.3	7.5.6.2	7.5.7.3	7.5.7.3	N/A	N/A	N/A	N/A	N/A	N/A
Seat to body test	7.5.5.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Torque test	N/A	N/A	7.5.7.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Seal test	N/A	7.5.6.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dimensional verification	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hydraulic operating test	N/A	N/A	N/A	7.5.13	N/A	N/A	N/A	N/A	N/A	N/A

7.5.3 Records

A record shall be maintained in which serialized parts and individual heat traceable parts (except for replaceable parts, such as orifices and wear trim) are listed as traceable to the assembly. Tests shall be continuously recorded. The pressure test record shall identify the actual test pressure, the pressure-holding period, the recording device and shall be dated and signed.

7.5.4 Hydrostatic Testing

7.5.4.1 General

Assembled equipment shall be subjected to a hydrostatic test prior to final acceptance. Water, or water with additives, shall be used as the testing fluid. Hydrostatic test pressure shall not be applied as a differential pressure across internal closure mechanisms of chokes. Tests may be completed prior to or after painting or coating.

7.5.4.2 Hydrostatic Testing Method

Hydrostatic test for complete assemblies shall consist of the following steps:

1) the initial pressure-holding period of not less than three minutes;

2) the reduction of the pressure to zero;

3) the second pressure-holding period of not less than 15 minutes.

The timing of the test shall not start until the test pressure has been stabilized within the manufacturer’s specified test range and the external assembly surfaces are dry.

7.5.4.3 Test Pressures

The hydrostatic test pressure shall be determined by the rated working pressure of the equipment. Hydrostatic test pressures shall be as shown in Table 25.

Table 25—Minimum Hydrostatic Test Pressures

Units in psi (MPa)

Rated Working Pressure	Hydrostatic Test Pressure
2000 (13.80)	3000 (27.60)
3000 (20.70)	4500 (41.40)
5000 (34.50)	7500 (51.75)
6000 (41.40)	9000 (62.10)
7500 (51.75)	11,250 (77.63)
10,000 (69.00)	15,000 (103.5)
15,000 (103.50)	22,500 (155.25)
20,000 (138.00)	30,000 (207.00)

7.5.4.4 Acceptance Criteria

Test results shall be acceptable if there is no visible leakage during the hold periods. Pressure shall remain within 5 % of the testing pressure or 500 psi (3.45 MPa), whichever is less, during the entire hold period and shall not drop below the rated test pressure.

7.5.5 Hydrostatic Testing for Adjustable and Positive Drilling Chokes

7.5.5.1 Body Test

Each choke shall be subjected to a hydrostatic test prior to final acceptance. The hydrostatic body test shall be in accordance with 7.5.4.

7.5.5.2 Hydrostatic Seat-to-body Test

7.5.5.2.1 General

A hydrostatic seat to body test shall be performed by applying rated working pressure and holding for a minimum of five minutes. A blind seat may be used.

7.5.5.2.2 Acceptance Criteria

Test results shall be acceptable if there is no visible leakage during the hold periods. Pressure shall remain within 5 % of the testing pressure or 500 psi (3.45 MPa), whichever is less, during the entire hold period and shall not drop below the rated test pressure.

7.5.6 Actuators for Drilling Chokes

7.5.6.1 Hydrostatic Actuator Shell Test

7.5.6.1.1 General

Each hydraulic or pneumatic actuator shall be subjected to an actuator body shell test to verify structural integrity of the pressure-containing parts prior to final acceptance.

7.5.6.1.2 Method

The test pressure of the actuator/body interface test shall be a minimum of 1.5 times the maximum rated working pressure for actuators with a choke maximum rated working pressure less than or equal to 20,000 psi (138 MPa). The hydraulic portion of the actuator test shall be tested to 1.5 times the maximum rated working pressure of the actuator system. This test may be performed as part of the hydraulic control system test.

Water (with or without additives), gas, hydraulic fluid, or other mixtures of liquids may be used as the testing medium.

7.5.6.1.3 Acceptance Criteria

Test results shall be acceptable if there is no visible leakage during the hold periods. Pressure shall remain within 5 % of the testing pressure or 500 psi (3.45 MPa), whichever is less, during the entire hold period and shall not drop below the rated test pressure.

7.5.6.2 Actuator Function Test

7.5.6.2.1 Method

Each actuator shall be tested for proper operation by cycling the actuator from the minimum stroke position to the maximum stroke position for a minimum of three cycles at its maximum rated working pressure. The actuator may be tested with the equipment for which it is intended or separately. Test media for hydraulic actuators shall be a suitable hydraulic fluid or a gas such as air or nitrogen.

7.5.6.2.2 Acceptance Criteria

The actuator shall operate smoothly in both directions.

7.5.6.3 Actuator Seal Test

7.5.6.3.1 Method

Actuator seals shall be pressure tested in two steps by applying pressure of 20 % and 100 % of the maximum rated working pressure to the actuator. The minimum test duration for each test shall be ten minutes at 20 % and five minutes at 100 % for pneumatic actuators; three minutes at each test pressure for hydraulic actuators.

The test period shall not begin until the test pressure has stabilized and the pressure-monitoring device has been isolated from the pressure source. The test pressure reading and time for each holding period shall be recorded.

7.5.6.3.2 Acceptance Criteria

The seals shall show no visible leakage under the test of each holding period.

7.5.7 Functional Testing for Adjustable Drilling Choke and Choke/Actuator Assemblies

7.5.7.1 General

The adjustable drilling choke or adjustable drilling choke and actuator assembly shall be tested in accordance with this section prior to final acceptance.

7.5.7.2 Manually Actuated Choke Torque Test

7.5.7.2.1 General

The breakaway and running torque for manually actuated chokes shall be measured and documented.

7.5.7.2.2 Method

The measurement method shall be documented by the manufacturer's written specification.

7.5.7.2.3 Acceptance Criteria

The acceptance criterion shall be continued smooth operation, without binding or chattering and the operating force or torque shall be within the manufacturer's specification.

7.5.7.3 Function Test

7.5.7.3.1 Method

Each drilling choke and actuator assembly shall be tested for proper operation by cycling the actuator from the minimum stroke position to the maximum stroke position for a minimum of three cycles at its maximum rated working pressure. The control system shall be function tested in accordance with the manufacturer's written procedures. Test media shall be a suitable fluid or a gas such as air or nitrogen.

NOTE The choke, actuator, and control system can be function tested individually or as a system.

7.5.7.3.2 Acceptance Criteria

The actuator shall operate smoothly in both directions.

7.5.8 Articulated Choke and Kill Lines

Articulated choke and kill line assemblies shall be hydrostatically tested in accordance with 7.5.4 prior to final acceptance.

7.5.9 Flexible Choke and Kill Lines

Each flexible line assembly shall be subjected to a hydrostatic pressure test in accordance with 7.5.4, with the exception that the holding time shall be a minimum of one hour.

7.5.10 Unions and Swivel Unions

Each union and swivel union shall be subjected to a hydrostatic test in accordance with 7.5.4 prior to final acceptance.

7.5.11 Rigid Choke and Kill Line

Each rigid choke and kill line shall be subjected to a hydrostatic proof test in accordance with 7.5.4 prior to final acceptance.

See Annex E for information on the evaluation of pipe thermal expansion.

7.5.12 Manifold Assembly

The manifold assembly shall be subjected to a hydrostatic proof test in accordance with 7.5.4. Manifolds assembled entirely with equipment that has been previously hydrostatically tested shall only be tested to rated working pressure. Loose connectors, as defined in API 6A, do not require hydrostatic proof testing. Testing shall be performed prior to final acceptance. All equipment upstream of the choke seat or downstream gate valve shall be tested in accordance with the choke inlet pressure rating or the manifold inlet pressure rating, whichever is less. Equipment downstream of the choke seat or downstream gate valve shall be tested in accordance with the choke outlet pressure rating, or the lowest pressure rated component downstream of the choke, whichever is less.

A traceability record shall be prepared in which serialized equipment is traceable to the manifold assembly (e.g. assembly part number, serial number).

7.5.13 Hydraulic Control System

7.5.13.1 General

The operating system test shall be conducted on the hydraulic actuating system of remotely controlled equipment.

7.5.13.2 Method

The operating system test shall be in accordance with 7.5.4, with the exception that the test pressure shall be a minimum of 1.5 times the hydraulic system rated working pressure. The test media shall be suitable hydraulic fluid or a gas such as air or nitrogen.

7.5.13.3 Acceptance Criteria

There shall be no visible leakage.

7.6 Quality Control Record Requirements

7.6.1 General

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

7.6.2 NACE Record Requirements

Records substantiating 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 NACE MR0175/ISO 15156 requirements.

7.6.3 Records Control

Records required by this specification shall be legible, identifiable, retrievable, and protected from damage, deterioration, or loss. Records shall be signed and dated. Computer stored records shall contain originator's personal code. Records shall be maintained for five years following the date of manufacture.

7.6.4 Records Maintained by the Manufacturer

The manufacturer shall maintain the following records.

a) Weld procedure qualification record.

b) Welder qualification record.

c) Material test records:

- chemical analysis;
- tensile tests (QTC);
- impact tests (QTC, as required);
- hardness tests (QTC).

d) NDE personnel qualification records.

e) NDE records:

- surface NDE records;
- full penetration fabrication;
- weld volumetric NDE records;
- repair weld NDE records.

f) Hardness test records.

g) Welding process records:

- welder identification;
- weld procedures;
- filler material;
- post-weld heat treatments.

h) Heat treatment records:

- actual temperature;
- actual times at temperature.

i) Volumetric NDE records.

j) Hydrostatic pressure test records.

k) Critical dimensions, as identified by the manufacturer.

NDE personnel qualification records shall be retained by the manufacturer of the component/material and accessible for review by the purchaser of the material if requested.

7.6.5 Records to be furnished to Purchasers

Assembled equipment records shall be provided by the manufacturer to the original purchaser of the equipment. These records, where applicable, shall be identical to or contain the same information as those retained by the manufacturer. The following records shall be provided and each record shall prominently reference the part serial number:

a) certificate of compliance stating that equipment conforms to current edition of this specification and the temperature class;

b) assembly traceability records;

c) pressure test records.

8 Marking

8.1 General

Equipment manufactured in accordance with this specification shall be marked in accordance with the procedures and requirements of this section. Equipment manufactured in accordance with API 6A or API 16A shall be marked in accordance with the procedures and requirements of those specifications. Markings on equipment manufactured under a different specification shall not be removed or otherwise altered on that equipment.

8.2 Low Stress Area Marking

For identification on low stress areas (such as nameplates, outside diameters of flanges, etc.), the use of sharp “V” stamping shall be allowed.

8.3 High Stress Area Marking

Identification on high stress areas shall be dot, vibration, or round “V” stamping.

8.4 Equipment-specific Marking

See Table 26 for equipment-specific marking requirements.

8.5 Hardness Marking for Bodies, Bonnets, and Flanges

When hardness tests are required, the actual value of the hardness test shall be stamped on the part adjacent to the test location.

9 Storing and Shipping

9.1 Storing

9.1.1 Draining after Testing

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 that does not become fluid at below 125 °F (51.7 °C).

9.1.3 Sealing Surface Protection

Flanges, hub faces, sealing surfaces and ring gasket grooves shall be protected.

9.1.4 Ports

Ports shall be plugged.

9.1.5 Hydraulic Operating System

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

Table 26—Metallic Marking Requirements

Marking	Equipment					
	Articulated Lines Swivel Joints Unions	Rigid Piping Buffer Chamber	Flexible Choke and Kill Lines	Drilling Choke	Drilling Choke Actuators	Choke and Kill Manifold Assembly
"API 16C"	OD	OD	Termination OD	Nameplate[a]	Nameplate	Nameplate
Assembly serial number	Nameplate and band	Nameplate or OD	Termination OD	Body and nameplate	Nameplate	Nameplate
Connector size	OD	OD	Connector OD	Connector OD	N/A	N/A
Date of manufacture (month and year)	OD	OD	Termination OD	Body or nameplate	Body or nameplate	Nameplate
Flow direction	N/A	N/A	N/A	Body	N/A	N/A
Mfg. name or mark	OD	OD	Termination OD	Nameplate	Nameplate	Nameplate
Flexible specification level	N/A	N/A	Termination OD	N/A	N/A	N/A
Rated working pressure	Nameplate and band	OD	Termination OD	Nameplate and termination OD	N/A	Nameplate
Ring gasket type and number	OD	OD	Connector OD	Connector OD	N/A	N/A
Schedule/grade	OD	OD	N/A	N/A	N/A	N/A
Safety clamp	N/A	N/A	Termination OD[b]	N/A	N/A	N/A
Size	OD	OD	Termination OD	Nameplate	Nameplate	N/A
Thread size	N/A	N/A	N/A	Adjacent to thread	N/A	N/A
Temperature rating	OD	OD	Termination OD	Body and nameplate	Body and nameplate	Nameplate
Orifice size	N/A	N/A	N/A	Nameplate	N/A	N/A

NOTE See Table 30 for color coding of articulated lines, swivel joints, and unions.

[a] Nameplate marking requirements are satisfied by body marking.

[b] Safety clamp location notation shall be within 3 ft (0.9 m) of the end termination or if applicable of the bend stiffener.

9.1.6 Non-metallic Materials

Age control procedures and protection of non-metallic materials shall be in accordance with the manufacturer's written specification. The manufacturer shall document the age and storage dates.

9.1.7 Ring Gaskets

Loose ring gaskets shall be individually wrapped and/or boxed for storing and shipping.

9.2 Shipping

Equipment shall be shipped in accordance with the manufacturer's written procedures.

10 Equipment-specific Requirements

10.1 General

This section sets forth specific equipment requirements and performance requirements. Performance requirements apply to all products being manufactured and delivered for service. See Annex F for guidelines on purchasing choke and kill systems.

10.2 End and Outlet Connections

10.2.1 General

End and outlet connections used on equipment covered by this specification shall be one or more of the following:

a) 6B and 6BX flanged connectors, as specified in API 6A;

b) 6B and 6BX studded connectors, as specified in API 6A;

c) 16B and 16BX clamp-hub connectors, as specified in API 16A;

d) other end connectors (OECs), as specified in API 6A;

e) pin and box connections for drilling riser choke and kill lines, as specified in API 16F;

f) 17SV and 17SS flanges, as specified in API 17F.

10.2.2 Rated Working Pressure and Sizes for Connections

API 16C connectors shall be used with pressure ratings as shown in Table 1, Table 2, and Table 3. API 16BX connectors shall be used with pressure ratings as shown in API 16A.

10.2.3 Other End Connectors

Other end connectors, including union connectors, shall conform to API 6A.

10.2.4 Corrosion Resistant Ring Grooves

Types 6B and 6BX flange connections may be manufactured with corrosion resistant overlays in the ring grooves in accordance with API 6A.

Types 17SV and 17SS flange connections may be manufactured with corrosion resistant overlays in the ring grooves in accordance with API 17F.

10.2.5 Unions and Swivel Joints

10.2.5.1 General

Unions consist of, a male sub with a special contact face by means of a nut that threads onto the female sub and retains the male against a shoulder.

10.2.5.2 Design Criteria

Design of unions and swivel joints shall be in accordance with Section 4.

10.2.5.3 Materials

Materials for unions and swivel joints shall be in accordance with Section 5.

10.2.5.4 Quality

Unions and swivel joints shall be in accordance with Table 23.

10.2.5.5 End Connection

Unions shall be supplied with butt weld or flanged ends. Line pipe threads shall not be used as an end connection.

10.2.5.6 Rated Working Pressures and Sizes

Unions and swivel joints shall be supplied in rated working pressures and sizes in accordance with Table 2.

10.3 Ring Gaskets

10.3.1 General

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

10.3.2 Ring-joint Gaskets

Type R, RX, and BX ring-joint gaskets shall be used in flanged, studded, and hubbed connections. Type 6B flanged and studded connections with Type R ring grooves shall be assembled with either Types R or RX gaskets. Only Type BX or SBX gaskets shall be used with 6BX ring grooves.

NOTE Type 6B flanged and studded connections do not make up face-to-face. Both Type R and Type RX ring gaskets can be used in Type R ring grooves, but the stand-off between mating flange faces will be larger with RX gaskets.

Type 16B hubbed connections with Type SR ring grooves shall be assembled with Type RX ring gaskets only. Type 6BX flanged and studded connections with Type BX ring grooves shall be assembled with Type BX ring gaskets only. Type 16BX hubbed connections with Type BX ring grooves shall be assembled with Type BX or SBX ring gaskets only.

10.3.3 Reuse of Gaskets

Ring gaskets have a limited amount of positive interference, which assures that the gasket will be joined into a sealing relationship in the flange grooves. These gaskets shall not be reused.

10.4 Studs and Nuts

The requirements for studs and nuts apply only to those used to connect end and outlet flanges. The requirements for studs and nuts are found in API 6A.

10.5 Drilling Chokes

10.5.1 General

This section covers drilling chokes used to control backpressure in a well control situation. Drilling chokes are not intended to be used as shut off valves.

10.5.2 Design Criteria

Design of drilling chokes shall be in accordance with Section 4 and this section.

10.5.3 Adjustable Drilling Chokes

Adjustable drilling chokes have an externally controlled variable area orifice such as a rotary disc, gate and seat, needle and seat, plug and cage, or external sleeve and cage. Adjustable drilling chokes may be controlled manually or remotely. Manually adjustable drilling chokes shall be equipped with a visible orifice area indicating mechanism, showing percent open and/or equivalent orifice diameter. Remotely adjustable drilling chokes shall be equipped with a remote orifice area indicating means.

10.5.4 Positive Drilling Chokes

Positive drilling chokes accommodate replaceable parts having fixed orifice dimensions, which are commonly called flow beans.

10.5.5 Vent Requirement

Adjustable and positive drilling chokes shall be designed to vent trapped pressure prior to disengaging the retention means of the body-to-bonnet or body-to-cap connection.

10.5.6 Size Designation

The nominal size designation of the drilling choke shall be the inlet connection size, in inches, followed by the maximum orifice diameter, in inches, where the orifice size is as follows:

a) for a positive drilling choke, the flow bore diameter of the bean, in inches or in sixty-fourths ($^1/_{64}$) of an inch;

b) for an adjustable drilling choke with a single circular orifice, the flow bore diameter of the seat, in inches;

c) for an adjustable drilling choke with multiple and/or non-circular orifice(s), the equivalent diameter of a circle with the same total area, in inches.

10.5.7 Quality

Drilling chokes shall be in conformance with 7.4.9. Drilling chokes shall be tested as specified in 7.5.5. If assembled with a drilling choke actuator, the choke assembly shall also conform to the test requirements of 7.5.7.

10.5.8 Marking

Drilling chokes shall be marked in conformance with Table 26.

10.5.9 Minimum Orifice Size

Drilling chokes shall be designed to pass a ½ in. (12.7 mm) diameter particle, when fully open.

10.5.10 Flow Design

Drilling chokes shall be designed to direct flow away from the bonnet of adjustable chokes and the cap or blanking plug, of positive chokes. Adjustable chokes shall be designed to limit unintentional position movement during use.

10.5.11 Rated Working Pressure

Drilling chokes shall have inlet and outlet end connections of the same rated working pressure and the choke shall have the rated working pressure of the end connections.

10.5.12 Performance Requirements

Drilling chokes shall meet the general performance requirements of Section 4, Section 10, and Table 27. These requirements include positive chokes, adjustable chokes and chokes designed for actuators.

Table 27—Performance Requirements for Drilling Chokes and Actuators

Performance Attribute	Component	
	Drilling Chokes	Actuators
Operating cycles	200	200
Seat-to-body sealing cycles	3	N/A
NOTE Operating cycles do not apply to positive chokes.		

10.5.13 Materials

10.5.13.1 Metallic Materials

Materials for bodies, bonnets, plugs, caps, end connections, and parts shall be in accordance with Section 5.

10.5.13.2 Non-metallic Seals

Non-metallic seals shall be in accordance with Section 5.

10.6 Actuators for Drilling Chokes

10.6.1 General

This section covers powered actuators for remotely-controlled drilling chokes. This includes single- and double-acting linear- and limited-turn rotary actuators. If the actuator is supplied with the associated parts of the valve or choke (bonnet, stem, seals), these parts shall meet the requirements of 10.5, including pressure testing in conformance with 7.5.5.

10.6.2 Performance Requirements

Actuators shall meet the performance requirements of this section. The maximum required operating temperature for hydraulic actuators is 150 °F (65.5 °C). Actuators shall be capable of performing as specified in Table 27.

10.6.3 Design Criteria

10.6.3.1 Pressure Rating

Hydraulic actuators shall have a hydraulic working pressure rating as specified by the manufacturer’s written specification

Actuator components exposed to well fluid or well pressure shall be designed in accordance with 4.3.

Electric actuators shall be suitable for use in areas classified in accordance with API 500 or API 505.

10.6.3.2 Connections

Fluid connections shall be in accordance with 10.11.12. Hydraulically powered actuators may have connections smaller than 1/2 in. (12.7 mm).

10.6.3.3 Actuation Forces

Actuator output forces shall meet or exceed the operating requirements specified by the choke manufacturer.

10.6.3.4 Pressure Relief

Actuators shall be designed to prevent pressure buildup within the actuator housing or cylinder due to leakage from the choke.

10.6.4 Material

Metallic and non-metallic sealing materials used in actuators shall meet the requirements of Section 5 and shall have written material specifications. The manufacturer's written specification shall define (as a minimum) the following:

a) mechanical properties;

b) chemical composition (metallic materials);

c) heat treat procedures (metallic materials);

d) compound identification (non-metallic materials);

e) acceptance criteria;

f) non-metallic sealing elements;

g) non-metallic seal materials exposed to well fluids shall be in accordance with B.9. Non-metallic seal materials not exposed to well fluids shall meet the manufacturer's written specification.

10.6.5 Quality

Actuator quality requirements shall be in accordance with 7.4.10 and the specific requirements of 10.5, as applicable to drilling choke actuators. Actuators shall be tested as specified in 7.5.6. If assembled with a drilling choke designed for an actuator, the actuator shall also conform to the test requirements of 7.5.7.

10.6.6 Marking

Actuators shall be marked in accordance with Table 26.

10.6.7 Storage and Shipping

Actuators shall be stored and shipped in accordance with Section 9 and the following additional criteria.

a) Actuators shall be drained and lubricated after testing and prior to storage or shipment.

b) Prior to shipment, parts and equipment with exposed metallic surfaces shall be protected with a rust preventative that will not become fluid at a temperature less than 125 °F (51.67 °C). Inherently, corrosion resistant materials do not require protection.

c) Exposed sealing surfaces shall be protected from damage during storage or shipment.

10.7 Rigid Choke and Kill Lines

10.7.1 Design Criteria

The pipe wall thickness for a rated working pressure of 10,000 psi (69.0 MPa) or less shall be in accordance with ASME B31.3, Part 2, or ASME BPVC, Section VIII, Division 2. For rated working pressures above 10,000 psi (69.0 MPa), ASME B31.3 Chapter 9, or ASME BPVC, Section VIII, Division 2 shall be used.

10.7.2 Materials

Materials for rigid piping shall be in accordance with 5.7.

10.7.3 Quality

Quality requirements for rigid piping shall be in accordance with 7.4.15. Rigid choke and kill lines shall meet the quality requirements of 7.5 for assembled equipment, including hydrostatic testing in accordance with Table 24.

10.7.4 End Connections

End connections shall meet the requirements of 10.2 or 10.3. Pipe threads shall not be used as end connections.

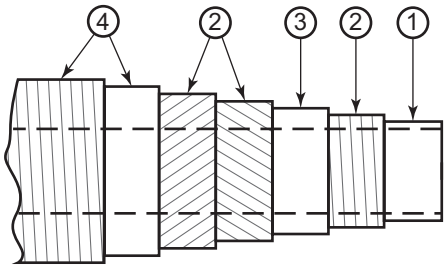
10.7.5 Rigid Choke and Kill Lines

Rigid choke and kill lines shall be marked in accordance with Section 8.

10.8 Flexible Choke and Kill Lines

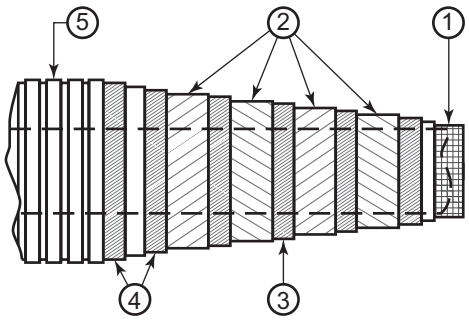
10.8.1 General

Flexible choke and kill lines may be employed when it is necessary to accommodate either relative motion such as that encountered on a jack-up, semi-submersible or barge rig, dimensional variation on sequential rig-ups, and the deflection of the flexible joint on the lower marine riser package (LMRP) of a subsea blowout preventer stack. They may be employed also on land rigs for easier installation. Typical configurations of non-bonded and bonded flexible choke and kill lines and assemblies are shown in Figure 7 and Figure 8 respectively.



Non-bonded Flexible Line

1. fluid containing inner tube
2. reinforcement windings
3. intermediate sheath
4. outer jacket



Bonded Flexible Line

1. fluid containing inner tube
2. reinforcement windings
3. high tensile fabric
4. cushion and cover
5. outer jacket

Figure 7—Typical Flexible Line Construction

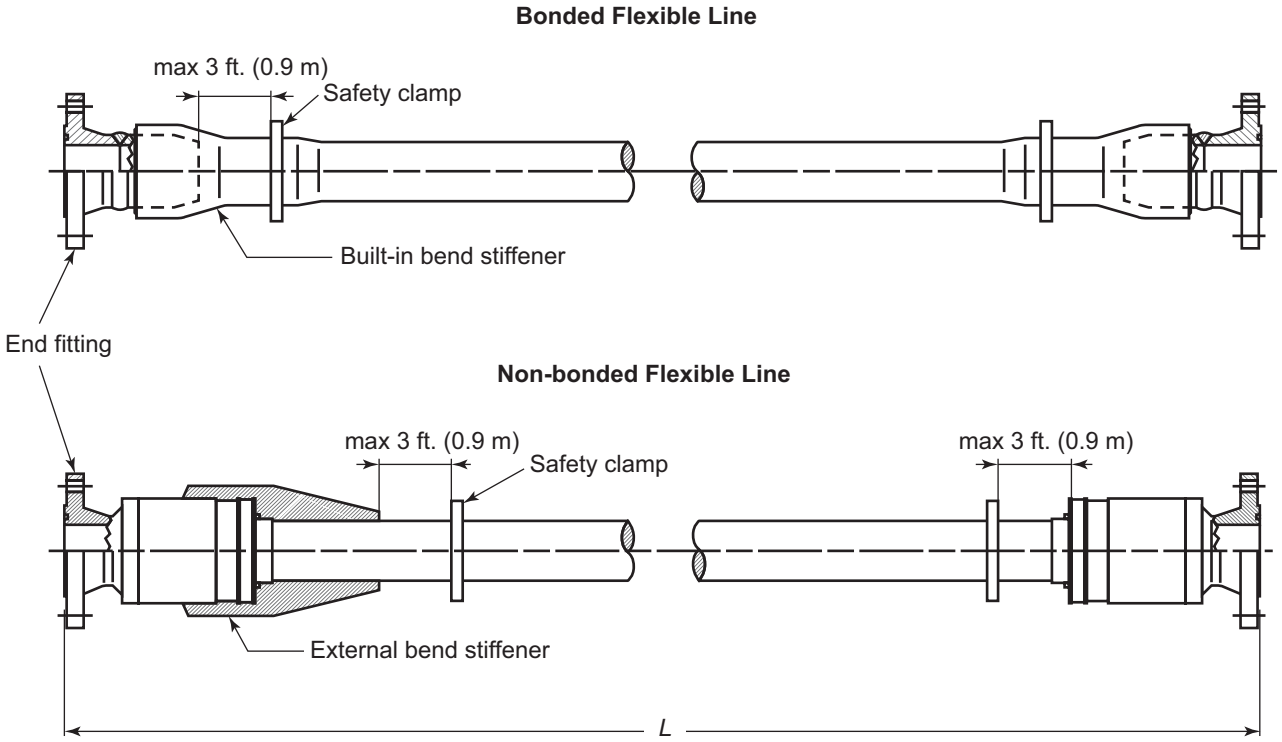


Figure 8—Typical Bonded and Non-bonded Flexible Line Assemblies

10.8.2 Design Criteria

Calculation and design methods shall be in accordance with 10.8.3 through 10.8.10, in addition to the requirements of Section 4.

10.8.3 Pressure-temperature Integrity

Flexible lines shall be capable of withstanding rated working pressures at the rated temperature without deformation to the extent that other performance requirements cannot be met. See Table 3 for rated working pressures and Table 4 for temperature ratings. Working pressures for flexible lines shall be in accordance with Table 28.

10.8.4 End Connectors

Flexible choke and kill line end connectors shall be of welded or one piece pipe design and the pressure rating shall be equivalent and not a higher rating than the pressure rating of the flexible line. End connectors shall meet the requirements of 10.2 or 10.3. Pipe threads are not acceptable end connections. Figure 9 shows a typical end connection for a flexible choke and kill line.

10.8.5 End Termination

The flexible choke and kill line end termination shall be in accordance with the manufacturer's written specification and shall, as a minimum, include the requirements of this specification. Pipe thread connections are not permitted.

10.8.6 Minimum Bend Radius

The minimum bend radii (MBR) at rated working pressure shall be in accordance with manufacturers' written specification.

Table 28—Flexible Line Sizes and Rated Working Pressures

Inside Diameter in. (mm)	**Rated Working Pressure** psi (MPa)	**Test Pressure** psi (MPa)	**Minimum Burst Pressure** psi (MPa)
2 (50.8) 3 (76.2) 3 1/2 (89) 4 (101.6)	5000 (34.5)	7500 (51.7)	11,250 (77.6 kPa)
2 (50.8) 2 1/2 (63.5) 3 (76.2) 4 (101.6)	10,000 (69.0)	15,000 (103.5)	22,500 (155.0)
2 (50.8) 2 1/2 (63.5) 3 (76.2) 4 (101.6)	15,000 (103.5)	22,500 (155.0)	33,750 (233.0)
2 (50.8) 2 1/2 (63.5) 3 (76.2) 4 (101.6)	20,000 (138.0)	30,000 (207.0)	45,000 (310.0)

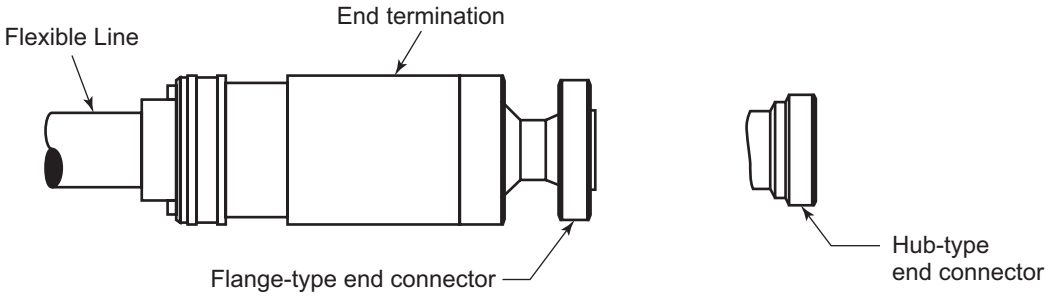


Figure 9—Typical Flexible Line End Fitting

10.8.7 Length Tolerance

The standard overall length tolerances of flexible lines 20 ft (6 m) and under shall be ±2 1/2 in. (65 mm) with the tolerance of longer lines being ±2 %. The standard tolerance for length change from atmospheric to working pressure is a maximum of ±2 % of the overall length.

The length tolerance for LMRP choke and kill lines shall be specified by the manufacturer, after length and orientation modeling are completed.

10.8.8 Collapse Resistance

Flexible lines subjected to subsea service shall be designed to withstand the external hydrostatic pressure for the operational depth without deforming to a point where they can no longer function as the design specifies. Collapse resistance shall be specified by the manufacturer and shall meet the manufacturer's written specifications. The purchaser should provide the maximum water depth of the intended service.

10.8.9 Material

10.8.9.1 General

The following material requirements are in addition to the requirements of Section 5. Metallic and non-metallic materials used in flexible lines require a written material specification.

10.8.9.2 Metallic Materials for Flexible Line Assemblies

The manufacturer's written specification for all pressure-containing (wetted and non-wetted) metallic materials shall be in accordance with 5.2.2.

10.8.9.3 Non-metallic Materials for Flexible Line Assemblies

The manufacturer's written specifications for non-metallic materials shall define the following:

— chemical testing requirements and tolerances;

— mechanical testing requirements and tolerances;

— traceability requirements.

10.8.10 Flexible Specification Levels (FSL)

This specification establishes requirements for four flexible specification levels of flexible choke and kill lines. These four FSL designations that define different levels of technical requirements are shown in Table 29. As a minimum, all FSL levels shall include all of the design, material and design validation test requirements of 10.8 and B.12.1 through B.12.3. The FSL level shall be permanently marked on each flexible choke and kill line.

Table 29—Flexible Choke and Kill Line Flexible Specification Level (FSL)

Flexible Specification Level	Definition
FSL 0	Includes all design, material and design validation test requirements in 10.8, B.12.1, B.12.2, and B.12.3
FSL 1	Includes FSL 0 and the requirements of B.12.4
FSL 2	Includes FSL 0, and the requirements of B.12.5
FSL 3	Includes FSL 0, and the requirements of B.12.4 and B.12.5

10.9 Hydraulic Control System—Drilling Chokes

10.9.1 Design Criteria

The drilling choke hydraulic control system shall be capable of opening or closing the choke at the choke's rated working pressure within 30 seconds. The output pressure of the hydraulic pump shall be limited to the rated working pressure of the control system. The reservoir shall have a visual hydraulic oil level indicator.

10.9.2 Capacity

The pump system shall have a storage reservoir with a volume at least ten times (10x) the capacity of the hydraulic drilling choke control system excluding the reservoir. The reservoir volume need not exceed 10 gal (0.038 m^3), but may at the manufacturer's option.

10.9.3 Hydraulic System Pressure Rating

The hydraulic circuit shall contain a pressure relief valve or a pressure-regulating valve. Hydraulic system components and piping shall be designed with a rated working pressure at least equal to the maximum pressure setting of the pressure-regulating valve. The pressure relief valve shall have a pressure setting not to exceed 10 % above the rated pressure of the regulating valve. The piping and components used as return lines are not covered by this specification.

10.9.4 Temperature Ratings

Components of the choke control system, including power fluids, shall be capable of functioning as a system at temperature of 0 °F to 150 °F (−18 °C to 66 °C), or as agreed upon by the purchaser and manufacturer, if none of the control system components are subjected to well fluids. If a component is subjected to well fluids, that component shall conform to the applicable temperature ratings of 4.1.1 and the additional fluid service conditions provided in 4.1.3.

10.9.5 Accumulators

10.9.5.1 Accumulators, when installed in choke control systems, may serve any or all the following purposes:

a) being used as a surge tank to smooth the operation of the choke actuator;

b) to increase the operating speed of the choke over that provided by the primary hydraulic source;

c) as an emergency power source, to cause the choke to operate when the hydraulic source (i.e. pump) is lost;

d) if condition (c) is desired, then the volumetric capacity shall be adequate to operate the choke at rated working pressure by a specified number of open-close cycles as agreed to by the manufacturer and purchaser;

10.9.5.2 Accumulators shall meet the requirements of ASME BPVC, Section XIII, Division 1.

10.9.5.3 Accumulators shall have a rated working pressure at least equivalent to the hydraulic system rated working pressure.

10.9.5.4 The accumulator system, when used, shall have a volumetric capacity set by an agreement between buyer and seller.

10.9.6 Remote Actuation Backup System

The drilling choke hydraulic control system shall be designed with a backup operating system to open or close the drilling choke after loss of primary power. The backup hydraulic system shall have a rated working pressure equal to or greater than the primary hydraulic pump.

10.9.7 Materials

Materials in the control system that are isolated from well fluids shall be in accordance with the manufacturer’s written specification, including acceptance criteria. Materials in the control system in contact with well fluids shall be suitable to perform adequately in the service.

10.9.8 Control System Rigid Lines Requirements

Drilling choke control system rigid lines shall meet the general requirements of Section 4 and the specific requirements of 10.9.

10.9.9 Control System Flexible Line Requirements

Drilling choke control system flexible lines are a component part of the hydraulic lines connecting the valves and the hydraulic drilling choke control unit. Control system flexible lines shall be in accordance with SAE J 517.

10.9.10 Retained Fluids

The inner bore of the control system flexible line assembly shall be designed to withstand continuous exposure to water, water glycol, emulsified oils, and petroleum based hydraulic fluid. Flexible lines shall meet requirements of SAE J 517 as applicable.

10.9.11 Connections

Control system flexible line assemblies furnished with external threaded connections shall meet API 5B.

10.9.12 Drilling Choke Console

Drilling choke control consoles shall conform to the requirements of Annex G.

10.10 Articulated Choke and Kill Lines

10.10.1 Articulation

10.10.1.1 An articulated choke and/or kill line is an assembly of manifold components used to provide a flow conduit for pumping into a well or accepting flow from a well. Choke lines and kill lines may be differentiated by contained fluids and function. Where appropriate, choke lines and kill lines should be referenced separately. Unless referenced separately, the definition and requirements for choke and kill lines shall refer to both types of lines.

NOTE Flowback equipment for well testing, well clean-up, post fracking, etc. is outside the scope of this document.

10.10.1.2 Articulating line components include swivel joints, pup joints, fittings, and valves. Connections between components are designed to facilitate assembly and disassembly.

10.10.1.3 Articulated lines are distinguished from rigid piping in that they are temporary installations. Articulated lines provide for flexibility in installation and during use. Articulated lines are distinguished from flexible lines in that the individual components are rigid, flexibility being provided by points of rotation designed as a part of swivel components.

10.10.1.4 Articulated choke and kill line shall be used only when fluids and fluid velocities are planned or known. Unless the velocity is specified by the OEM, do not exceed an average fluid velocity of 40 ft/s (12.2 m/s). Maximum average velocity can vary depending on differences in abrasive content or gas content. The OEM should be contacted for recommendations if the fluid contains gas. Articulated lines shall not be used if fluid composition or fluid velocities are unknown. In these cases, use rigid piping.

NOTE 1 Average fluid velocity is the flow rate divided by the actual, not nominal, bore diameter of the component.

NOTE 2 Fluid flow through articulated line components is bidirectional.

NOTE 3 For optimum flexibility, the articulated line requires at least seven points of rotation.

Figure 10 shows a typical articulated line assembly and Figure 11 shows an example of points of rotation.

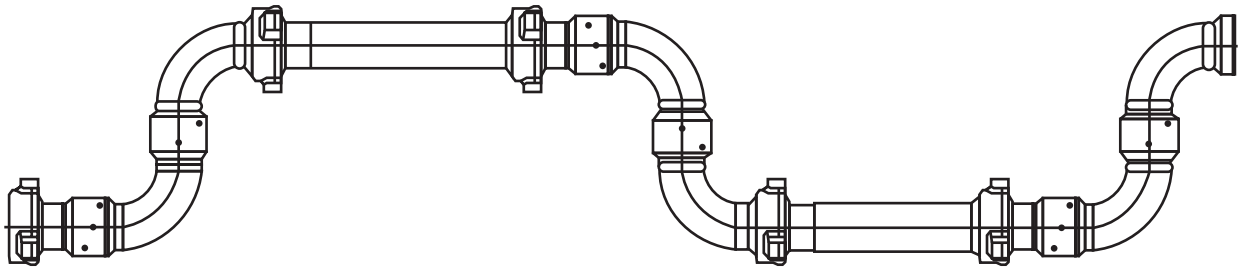


Figure 10—Example of an Articulated Choke or Kill Line

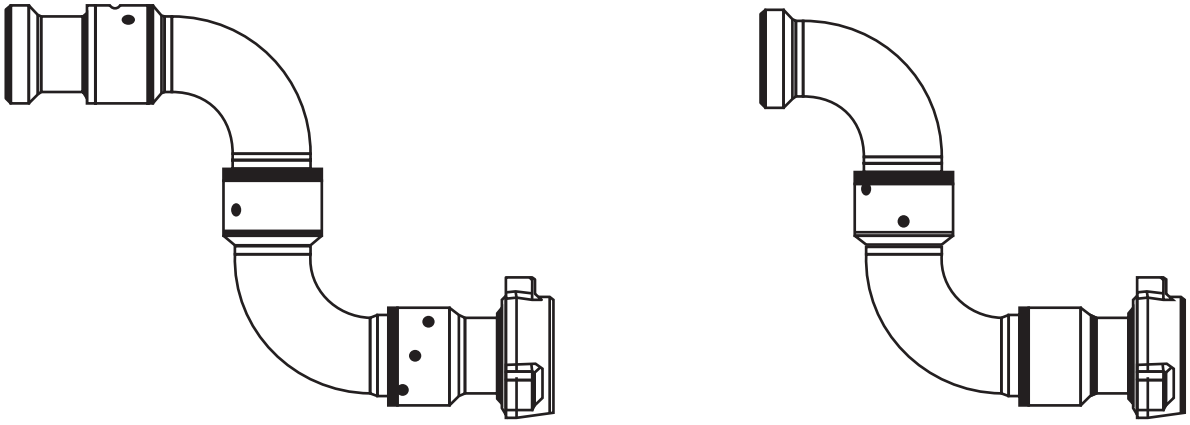


Figure 11—Example Illustrating "Points of Rotation"

10.10.2 Marking

Articulated lines conforming to this specification shall be provided with color coding as detailed Table 30. While components may be painted, a portion of the color coding shall be retained and shall be visible during application.

Each individual pressure-containing part of the articulated line assembly shall be marked with part number and material batch code. Each subassembly in the articulated line shall be identified with stainless steel nameplate or band that includes part number, pressure rating, and serial number and sour service (if applicable). Each union nut shall be marked with size, figure number, manufacturer, and working pressure.

Table 30—Color Coding of Articulated Choke and Kill Line Components

Pressure Rating psi	Service	Color
6000	Standard	Silver
10,000	Standard	Black
15,000	Standard	Red
20,000	Standard	Light Blue
10,000	Sour Gas	Olive Green
15,000	Sour Gas	Olive Green

The serial numbers on each sub assembly shall be traceable to all material test reports, inspection data, and manufacturer's factory pressure tests related to the subassembly. Serial numbers shall also be traceable to inspection documentation. Articulated lines shall be marked with the information at the locations detailed in Table 26.

10.10.3 Installation

The individual application will dictate the flexibility required for the assembly. The manufacturer's recommendations and restrictions shall be followed for each installation.

10.11 Buffer Chamber

10.11.1 Design Criteria

The design thickness for all rated working pressures shall be in accordance with API 6X. The design allowable stresses shall be in accordance with 4.3.

Nozzles and nozzle attachment reinforcement shall be in accordance with API 6X.

10.11.2 Pressure Rating

10.11.2.1 The pressure rating for a buffer chamber shall be established by the system designer consistent with the overall design of the manifold.

10.11.2.2 This pressure rating shall in no case be less than that of the lowest rated connection to the buffer chamber and associated valves as applicable, nor of the downstream equipment.

10.11.2.3 The design pressure rating for the buffer chamber, new and cold, shall be clearly identified on the buffer chamber by means of a nameplate securely affixed to the buffer chamber itself.

10.11.2.4 The corrosion allowance, if any, shall also be marked on the buffer chamber, along with the design pressure in the corroded condition.

10.11.3 Materials

Materials for the buffer chamber shall be in accordance with 5.7.

10.11.4 Quality

Quality requirements for the buffer chamber shall be in accordance with 7.4.15.

10.11.5 Marking

Marking shall be in accordance with Table 26.

10.12 Choke and Kill Manifold Assemblies

10.12.1 General

This section covers choke and kill manifold design. Requirements of this section for choke and kill manifolds are applicable to choke lines, choke manifolds, kill lines, and kill manifold.

10.12.2 Design Configuration

Manifold configuration may depend on a number of operating parameters, such as rig type and size, surface vs. subsea system, pressure rating of the BOP stack and manifold, regulatory requirements, and design standards of the manufacturer and purchaser.

Configuration of the manifold includes the number and location of inlet connections, valves, chokes, pressure gauges and transducers, buffer chamber and outlet connections. Manifold configuration shall conform with the requirements specified in one or more of the following:

a) API 53;

b) purchaser's design specifications;

c) manufacturer's design specifications;

d) rules published by independent certification/classification authorities (if specified by the purchaser).

Typical manifold configurations are shown in Annex H.

10.12.3 Components

10.12.3.1 Choke and kill manifold components listed in 4.2 shall meet the applicable requirements of API 6A. Valves shall be full-bore type. Actuated valves and chokes in the choke and kill manifold shall be a fail-in-place design and shall have hydraulic or electric actuators. Actuated valves in the choke and kill lines mounted to the BOP can have a user-specified fail position.

10.12.3.2 Chokes and choke actuators shall conform with requirements of this specification for drilling chokes.

10.12.3.3 Buffer chambers shall conform with 10.13 and other applicable requirements of this specification.

10.12.3.4 Rigid choke and kill lines shall conform with 10.9 and other applicable requirements of this specification.

10.12.4 Pressure Rating

10.12.4.1 Choke and kill manifolds may have a single pressure rating throughout; or they may have a dual pressure rating, where the lower rating is downstream of the first isolation valve(s) downstream of the choke(s).

NOTE "Downstream" is away from the BOP stack and toward the buffer chamber.

10.12.4.2 Chokes shall have a single pressure rating, with end connections of the same rated working pressure (inlet and outlet). There shall be at least one isolation valve of the same pressure rating as the choke, mounted downstream of each choke.

10.12.4.3 To avoid erosion damage to the isolation valve downstream of the choke, a spacer spool should be installed between the outlet of the choke and the valve unless flow analysis and/or operating experience exists to show that the spacer is not necessary.

10.13 Operating and Maintenance Manual Requirements

10.13.1 10.13.1The manufacturer shall prepare and provide an operating manual for the following choke and kill system equipment manufactured in accordance to this specification:

a) drilling chokes;

b) drilling choke actuators;

c) drilling choke controls;

d) choke and kill manifold assemblies;

e) articulated choke and kill line components.

NOTE A single manual may cover more than one of the equipment types listed in items a) through d).

10.13.2 The operating manual shall contain the following information:

a) instructions for typical installation and normal operation;

b) physical data (size, weight, center of gravity);

c) ordering information for recommended spare parts and seals;

d) maintenance and testing information;

e) disassembly/assembly instructions for user-serviceable repairs;

f) recommended preparation for long-term storage.

Annex A
(informative)

Use of the API Monogram by Licensees

A.1 Scope

The API Monogram® is a registered certification mark owned by the American Petroleum Institute (API) and authorized for licensing by the API Board of Directors. Through the API Monogram Program, API licenses product manufacturers to apply the API Monogram to new products which comply with product specifications and have been manufactured under a quality management system that meets the requirements of API Q1. API maintains a complete, searchable list of all Monogram licensees on the API Composite List website (www.api.org/compositelist).

The application of the API Monogram and license number on products constitutes a representation and warranty by the licensee to API and to purchasers of the products that, as of the date indicated, the products were manufactured under a quality management system conforming to the requirements of API Q1 and that the product conforms in every detail with the applicable standard(s) or product specification(s). API Monogram program licenses are issued only after an on-site audit has verified that an organization has implemented and continually maintained a quality management system that meets the requirements of API Q1 and that the resulting products satisfy the requirements of the applicable API product specification(s) and/or standard(s). Although any manufacturer may claim that its products meet API product requirements without monogramming them, only manufacturers with a license from API can apply the API Monogram to their products.

Together with the requirements of the API Monogram license agreement, this annex establishes the requirements for those organizations who wish to voluntarily obtain an API license to provide API monogrammed products that satisfy the requirements of the applicable API product specification(s) and/or standard(s) and API Monogram Program requirements.

For information on becoming an API Monogram Licensee, please contact API, Certification Programs, 1220 L Street, N. W., Washington, DC 20005 or call 202-682-8145 or by email at certification@api.org.

A.2 Normative References

API Q1, *Specification for Quality Management System Requirements for Product Manufacturing for the Petroleum and Natural Gas Industry*

A.3 Terms and Definitions

For purposes of this annex, the following terms and definitions apply:

A.3.1
API monogrammable product
Product that has been newly manufactured by an API licensee utilizing a fully implemented API Q1 compliant quality management system and that meets all the API specified requirements of the applicable API product specification(s) and/or standard(s)

A.3.2
API specified requirements
Requirements, including performance and licensee-specified requirements, set forth in API Q1 and the applicable API product specification(s) and or standard(s).

NOTE Licensee-specified requirements include those activities necessary to satisfy API specified requirements.

A.3.3
API product specification
Prescribed set of rules, conditions, or requirements attributed to a specified product which address the definition of terms; classification of components; delineation of procedures; specified dimensions; manufacturing criteria; material requirements, performance testing, design of activities; and the measurement of quality and quantity with respect to materials; products, processes, services, and/or practices

A.3.4
licensee
Organization that has successfully completed the application and audit process and has been issued a license by API

A.3.5
design package
Records and documents required to provide evidence that the applicable product has been designed in accordance with API Q1 and the requirements of the applicable product specification(s) and/or standard(s)

A.4 Quality Management System Requirements

An organization applying the API Monogram to products shall develop, maintain, and operate at all times a quality management system conforming to API Q1.

A.5 Control of the Application and Removal of the API Monogram

Each licensee shall control the application and removal of the API Monogram in accordance with the following:

a) Products that do not conform to API specified requirements shall not bear the API Monogram.

b) Each licensee shall develop and maintain an API Monogram marking procedure that documents the marking/ monogramming requirements specified by this annex and any applicable API product specification(s) and/or standard(s). The marking procedure shall:

   1) define the authority responsible for application and removal of the API Monogram;

   2) define the method(s) used to apply the Monogram;

   3) identify the location on the product where the API Monogram is to be applied;

   4) require the application of the licensee's license number and date of manufacture of the product in conjunction with the use of the API Monogram;

   5) require that the date of manufacture, at a minimum, be two digits representing the month and two digits representing the year (e.g. 05-12 for May 2012) unless otherwise stipulated in the applicable API product specification(s) or standard(s); and

   6) require application of the additional API product specification(s) and/or standard(s) marking requirements.

c) Only an API licensee may apply the API Monogram and its designated license number to API monogrammable products.

d) The API Monogram license, when issued, is site-specific and subsequently the API Monogram shall only be applied at that site specific licensed facility location.

e) The API Monogram may be applied at any time appropriate during the production process but shall be removed in accordance with the licensee's API Monogram marking procedure if the product is subsequently found to be out of conformance with any of the requirements of the applicable API product specification(s) and/or standard(s) and API Monogram Program.

For certain manufacturing processes or types of products, alternative API Monogram marking procedures may be acceptable. Requirements for alternative API Monogram marking are detailed in the API Policy, *API Monogram Program Alternative Marking of Products License Agreement*, available on the API Monogram Program website at http://www.api.org/alternative-marking.

A.6 Design Package Requirements

Each licensee and/or applicant for licensing must maintain a current design package for all of the applicable products that fall under the scope of each Monogram license. The design package information must provide objective evidence that the product design meets the requirements of the applicable and most current API product specification(s). The design package(s) must be made available during API audits of the facility.

In specific instances, the exclusion of design activities is allowed under the Monogram Program, as detailed in *Advisory # 6*, available on API Monogram Program website at http://www.api.org/advisories.

A.7 Manufacturing Capability

The API Monogram Program is designed to identify facilities that have demonstrated the ability to manufacture equipment that conforms to API specifications and/or standards. API may refuse initial licensing or suspend current licensing based on a facility's level of manufacturing capability. If API determines that additional review is warranted, API may perform additional audits (at the organization's expense) of any subcontractors to ensure their compliance with the requirements of the applicable API product specification(s) and/or standard(s).

A.8 API Monogram Program: Nonconformance Reporting

API solicits information on products that are found to be nonconforming with API specified requirements, as well as field failures (or malfunctions), which are judged to be caused by either specification deficiencies or nonconformities with API specified requirements. Customers are requested to report to API all problems with API monogrammed products. A nonconformance may be reported using the API Nonconformance Reporting System available at http://compositelist.api.org/ncr.asp.

Annex B
(normative)

Design Validation Procedures

B.1 General

This annex provides design validation procedures for qualification of equipment manufactured in accordance with this specification.

B.2 Application

This annex addresses the design validation procedures for the products listed in Section 1. The performance requirements apply to all products being manufactured and delivered for service, whereas the design validation procedures are imposed on designs of products and on designs resulting from changes. Validation testing specified in this annex is intended to be performed on prototypes or production models.

B.3 Product Changes

B.3.1 Design Changes

A design that undergoes a substantive change becomes a new design requiring design validation. A substantive change is a change identified by the manufacturer that affects the performance of the product in the intended service condition. This may include changes in fit, form, function or material.

B.3.2 Metallic Materials

A change in metallic materials may not require new design validation if the suitability of the new material can be substantiated by other means. The standard test fluid compatibility shall be documented by testing or reference to established documentation confirming compatibility.

B.3.3 Nonmetallic Seals

A change in nonmetallic materials may not require new design validation if the suitability of the new material can be substantiated by other means. Substantive changes to the original documented design configuration of nonmetallic seals resulting in new design shall undergo design validation in accordance with the testing on nonmetallic seals.

B.4 Compliance

All products evaluated in design validation tests shall conform with the applicable design requirements of this specification.

B.5 Products for Validation Testing

B.5.1 General

Design validation testing, where applicable, shall be performed on prototypes or production models of equipment listed in Section 1 to verify that the performance requirements specified for pressure, temperature, load, mechanical cycles, and standard test fluids are met in the design of the product.

B.5.2 Testing Product

Design validation testing shall be conducted on full size products or fixtures that represent the specified dimensions for the relevant components of the end product being verified, unless otherwise specified in this annex.

B.5.3 Product Dimensions

The actual dimensions of equipment subjected to design validation testing shall be within the allowable tolerance range for dimensions specified for normal production equipment. Worst-case conditions for dimensional tolerances should be addressed by the manufacturer, giving consideration to concerns such as sealing and mechanical functioning.

B.5.4 External Paint or Coatings

The product used in any pressure test shall be free of paint or other coatings that would impede leak detection and/or leak observation.

B.5.5 Maintenance Procedures

The manufacturer's published recommended maintenance procedures may be used on equipment, including lubrication of valves.

B.6 Safety

Due consideration should be given for the safety of personnel and equipment.

B.7 General Acceptance Criteria

B.7.1 General

Validation testing of the product shall include all of the testing requirements of the applicable product specification level in this annex.

B.7.2 Design Validation

B.7.2.1 General

Design validation procedures shall be applied to designs and design changes of products and assemblies. Validation testing shall be performed on prototypes or production models to verify that the performance requirements specified for pressure, temperature, load mechanical cycles and standard test fluids are met in the product design.

B.7.2.2 Scaling

B.7.2.2.1 General

Scaling of size and pressure ratings may be used to verify the members of a product family in accordance with the requirements and limitations of this section.

B.7.2.2.2 Product Family

A product family shall meet the following design requirements.

a) Configuration—The design principles of physical configuration and functional operation are the same.

b) Design Stress Levels—The design stress levels in relation to material mechanical properties are based on the same criteria.

B.7.2.2.3 Limitations of Scaling

B.7.2.2.3.1 General

Validation by scaling is subject to the following limitations.

B.7.2.2.3.2 Validation by Pressure Rating

The test product may be used to qualify products of the same family having equal or less pressure rating.

B.7.2.2.3.3 Validation by Size

Testing of one size of a product family shall verify products one nominal size larger and one nominal size smaller than the tested size, with the exception of flexible choke and kill lines. Testing of two sizes also verifies nominal sizes between the two sizes tested.

B.7.2.2.3.4 Determination of Choke Nominal Size

The choke nominal size shall be defined as the size of the maximum orifice that can be used in that choke (orifice sizes smaller than the nominal size do not require testing). Choke nominal sizes are in one-inch increments.

B.7.2.2.3.5 Determination of Other End Connector Nominal Sizes

The nominal size of other end connectors shall be defined as the nominal end connector size and lowest rated working pressure (see Table 2, Table 3, and Table 4).

B.7.2.2.4 Validation by Temperature Rating

The temperature range validated by the test product shall validate temperature classifications that fall entirely within that range.

B.7.2.2.5 Validation by Standard Test Fluid

Test products validated by the standard test fluid design validation shall validate the same product family and material properties as the test product.

B.7.3 Acceptance Criteria

B.7.3.1 Structural Integrity

The product tested shall not permanently deform to the extent that any other performance requirement is not met.

B.7.3.2 Pressure Integrity

B.7.3.2.1 Hydrostatic Test at Minimum/Room/Maximum Rated Temperature

The hydrostatic tests performed at minimum rated temperature, maximum rated temperature and room temperature shall be acceptable if no visible leakage occurs during the specified pressure hold periods of the test.

B.7.3.2.2 Dynamic Tests at Minimum/Room/Maximum Rated Temperature

The dynamic tests performed at minimum rated temperature, maximum rated temperature, and room temperature shall be acceptable if no visible leakage occurs during the specified dynamic open/close cycles.

B.7.3.3 Standard Test Fluid Compatibility

B.7.3.3.1 Metallic Materials

The standard test fluid compatibility of metallic materials shall be documented by testing or reference to established documentation conforming compatibility.

B.7.3.3.2 Nonmetallic Seals

The acceptance criteria for the standard test fluid compatibility of nonmetallic seals shall be documented in compliance with the requirements of this code and shall be in accordance with the manufacturer's specifications.

B.7.3.4 Post-test Examination

The tested prototype shall be disassembled and inspected. All relevant items should be photographed. The examination shall include a written statement that the product and component design does not contain defects to the extent that any performance requirement is not met.

B.7.4 Hydrostatic Testing

B.7.4.1 Testing Medium

The testing medium shall be a fluid suitable for the testing temperatures. Water with or without additives, gas, hydraulic fluid, or other mixtures of fluids may be used as the testing medium. The testing medium shall be a fluid that remains in the liquid or gaseous state throughout the test.

B.7.4.2 Substitution of Gas

B.7.4.2.1 General

The manufacturer may, at his option, substitute gas for liquid where hydrostatic testing is specified, provided the testing method and acceptance criteria for gas testing are used. If gas is substituted for liquid, the criteria in B.7.4.2.2 and B.7.4.2.3 shall be followed.

B.7.4.2.2 Testing Medium

Air, nitrogen, methane, or other gases or mixture of gases may be used.

B.7.4.2.3 Leak Detection

Gas testing at room temperature shall be conducted with a method for leak detection. The product may be completely submerged in a liquid, or the product may be flooded in the seal areas being verified so all possible leak paths are covered. The product may be assembled with one end of a tube connected to a blind connector enclosing possible leak paths being verified. The other end of the tube shall be immersed in a liquid or attached to a leakage measurement device.

B.7.4.2.4 Acceptance Criteria for Gas Testing

During gas testing at room temperature leakage shall be a maximum of:

— 60 cm^3/h for dynamic seals, or

— 20 cm^3/h for static seals.

During minimum/maximum temperature tests the hydrostatic or gas test at high or low temperature shall be acceptable if the pressure change observed on the pressure-measuring device is less than 5 % of the test pressure or 500 psi (3.45 MPa), whichever is less.

B.7.5 Temperature Testing

B.7.5.1 Location of Temperature Measurement

Temperature shall be measured in contact with the equipment being tested within $^1/_2$ in. (12.7 mm) of the through-bore where applicable and within $^1/_2$ in. (12.7 mm) of the surface wetted by the retained fluid on the other equipment.

B.7.5.2 Application of Heating for Maximum Temperature Testing

The heating for maximum temperature tests may be applied internally in the through-bore or externally. The heating shall be applied such that the entire through-bore or equivalent wetted surface is at or above the maximum temperature.

B.7.5.3 Application of Cooling for Minimum Temperature Testing

The cooling for minimum temperature tests shall be applied to the entire external surface of equipment.

B.7.6 Hold Periods

B.7.6.1 Start of Hold Periods

Hold periods shall start after pressure and temperature stabilization has occurred and the equipment with pressure monitoring device has been isolated from the pressure source. The time specified for hold times shall be a minimum.

B.7.6.2 Pressure Stabilization

The timing of the test shall not start until the test pressure has been stabilized within the manufacturer's specified test range and the external assembly surfaces are dry.

B.7.6.3 Temperature Stabilization

Temperature shall be considered stabilized when the rate of change is less than 1°F/min. The temperature shall remain at or beyond the extreme during the hold period, but shall not exceed the extreme by more than 20 °F (11.1 °C).

B.8 Pressure and Temperature Cycles

Pressure/temperature cycles shall be performed as specified in Section 10. The testing pressure and temperature extremes shall be as specified in 4.1 and 4.6.

B.9 Non-metallic Seals

B.9.1 Design

Design of non-metallic seals shall be in accordance with the requirements of Section 4 and the manufacturer's written specification.

B.9.2 Materials

Materials for non-metallic seals shall be in accordance with the requirements of 5.2.3.

B.9.3 Quality

Non-metallic seals shall meet the quality requirements in accordance with 7.4.11.

B.9.4 Design Validation

B.9.4.1 General

Nonmetallic seals exposed to well fluids, produced or injected, shall undergo the design validation procedures of this section.

B.9.4.2 Intent of Procedure

This procedure is intended to verify seal performance for the standard test fluid as specified in Table B.1, not the performance of products containing the seal. Seals shall be tested in accordance B.9.4.3 and B.9.4.4 to determine temperature and pressure performance.

Table B.1—Standard Test Fluid

Fluid	Percentage by Volume	Remarks
Oil	50	Diesel #2 (ASTM D975)
Brine water	20	Saturated salt at 60 °F (15.5 °C)
Gas composed of — 85 % methane (CH_4), — 5 % carbon dioxide (CO_2), and — 10 % hydrogen sulfide (H_2S)	30	

B.9.4.3 Thermochemical Performance of Seal Materials

B.9.4.3.1 General

The fluid compatibility of the seal materials shall be verified by a test demonstrating the response of the seal exposure to the standard test fluid, at or above the maximum rated temperature (see 4.1.1).

B.9.4.3.2 Test Temperature

The test temperature shall be the specified temperature for the temperature rating being tested (see 4.1.1).

B.9.4.3.3 Test Pressure

The rated working pressure test, at the test temperature, shall be in accordance with 4.4. The low pressure test shall be at 200 psi (1.4 MPa).

B.9.4.3.4 Test Fluid Application

The test fluid shall be the standard test fluid listed in Table B.1. The manufacturer may choose to conduct the testing described in B.9.4.3.6 with water, water with additives, or gas. Seal immersion testing shall be performed on the seals if a test fluid other than the standard test fluid is used.

B.9.4.3.5 Test Cycle

The test cycle shall have five pressure hold periods in accordance with the following listed test steps.

1) At room temperature, apply rated working pressure. After pressure has stabilized, hold for 1 h.
2) Release test pressure.
3) Raise temperature to at least the maximum temperature.
4) Raise pressure to rated working pressure. After stabilizing pressure, hold for 12 h.
5) Release pressure and heating.
6) Raise temperature to at least the maximum temperature.
7) Raise pressure to rated working pressure. After stabilizing, hold for 1 h.
8) Release pressure and heating.
9) Lower temperature to minimum temperature.
10) Raise pressure to rated working pressure; after stabilizing pressure, hold for 1 h.
11) Release pressure and cooling.
12) After stabilization at room temperature, raise pressure to 200 psi (1.4 MPa); after pressure stabilization, hold for 1 h.
13) Raise pressure to rated working pressure; after stabilization, hold for 1 h.

B.9.4.3.6 Testing

A seal may be tested using the procedure described above in fixtures or products that represent the specified nominal clearances and extrusion gaps specified for the manufactured part.

B.9.4.3.7 Acceptance Criteria

There shall be no visible leakage during pressure hold periods

B.9.4.4 Immersion Testing

B.9.4.4.1 General

The acceptance criteria for the standard test fluid compatibility of nonmetallic seals exposed to immersion testing shall be documented by and in accordance with the manufacturer's written specification. The manufacturer's written specification shall include as a minimum the requirements from 5.2.3, test procedure, compound identity and acceptance criteria.

B.9.4.4.2 Test Fluid Application

The standard test fluid is delineated in Table B.1. The product or fixture shall be positioned so that the seal is partially exposed to both the liquid and the gas phases. The hydrocarbon liquid shall be over pressured with the gas mixture.

B.9.4.4.3 Acceptance Criteria

A seal that passes the cycle test described in B.8.4.2.4 and passes the immersion test described in B.9.4.4.1 and B.9.4.4.2 is acceptable without further testing. A seal that passes the fixture testing using the standard fluid test provided in Table B.1 is acceptable even if it fails the immersion testing. A material that fails the fixture testing using the standard fluid described in Table B.1 is not acceptable.

B.10 Design Validation for Drilling Chokes

B.10.1 Force or Torque Measurement

The breakaway and running torque shall be measured. The acceptance criteria shall be in accordance with the manufacturer's specifications.

B.10.2 Static Pressure Testing at Room/Maximum/Minimum Temperature

B.10.2.1 Test Requirements

B.10.2.1.1 Hydrostatic or gas testing shall be performed at minimum temperature, room temperature and at maximum temperature. The static pressure test shall be performed as follows.

B.10.2.1.2 The static body testing pressure shall be the rated working pressure of the choke. The pressure shall be applied to the open body and held as described below. The body test shall be conducted in three steps:

1) a primary hold period of 3 min;

2) pressure shall be released;

3) a secondary hold period of 15 min.

B.10.2.2 Acceptance Criteria

There shall be no visible leakage during pressure hold periods

B.10.3 Hydrostatic Seat-to-body Seal Test at Room Temperature

B.10.3.1 Test Requirements

A hydrostatic seat-to-body seal shall be performed by applying rated working pressure to the closed choke. The hold period shall be one hour. A blind seat may be used at the manufacturer's option.

B.10.3.2 Acceptance Criteria

There shall be no visible leakage during pressure hold periods.

B.10.4 Dynamic Test at Room Temperature

A dynamic test at room temperature shall be performed as follows.

1) With the choke closed, apply rated working pressure at room temperature
2) Open the choke, depressurize the system.
3) Close the choke.
4) Repeat the process a minimum of 160 times fully open to fully closed and back to fully open.

Mating parts shall be free of lubrication not specified in the manufacturing assembly procedures or maintenance procedures. Stem cycle operation shall be smooth and without binding or chattering during operational cycles in accordance with the manufacturer's written specification. Additionally, there shall be no visible leakage during the dynamic testing.

B.10.5 Dynamic Test at Maximum Rated Temperature

A dynamic test at maximum rated temperature shall be performed as follows.

1) With the choke fully closed, apply rated working pressure and maximum rated temperature.
2) Open the choke, depressurize the system.
3) Close the choke.
4) Repeat the process a minimum of 20 times fully open to fully closed and back to fully open.

The test fluid shall be water, water with additives, or gas. Mating parts shall be free of lubrication not specified in the manufacturing assembly procedures or maintenance procedures. Stem cycle operation shall be smooth and without binding or chattering during operational cycles in accordance with the manufacturer's written specification.

B.10.6 Dynamic Test at Minimum Rated Temperature

A dynamic test at minimum rated temperature shall be performed as follows.

1) With the choke fully closed, apply and maintain rated working pressure and minimum rated temperature.
2) Open the choke, depressurize the system.
3) Close the choke.
4) Repeat the process a minimum of 20 times fully open to fully closed and back to fully open.

The test fluid shall be water or water with additives. Mating parts shall be free of lubrication not specified in the manufacturing assembly procedures or maintenance procedures. Stem cycle operation shall be smooth and without binding or chattering during operational cycles in accordance with the manufacturer's written specification.

B.10.7 Pressure-temperature Cycles

The pressure-temperature cycles shall be performed with the choke partially open following these steps.

1) Raise temperature to room temperature.
2) Apply testing pressure at room temperature and maintain while raising temperature to maximum rated temperature.
3) Hold pressure and temperature for 1 h minimum.
4) Reduce to minimum rated temperature while maintaining test pressure.
5) Hold pressure and temperature for 1 h minimum.
6) Raise to room temperature while maintaining test temperature.
7) Release pressure and raise temperature to maximum rated value.
8) Apply testing pressure and hold for 1 h minimum.
9) Release pressure and reduce temperature to minimum rated temperature.
10) Apply test pressure and hold for 1 h minimum.
11) Release pressure and raise to room temperature.
12) Apply testing pressure and hold for 1 h minimum.
13) Release pressure.

The test fluid shall be water or water with additives. The test results shall be acceptable if during this test there is no visible leakage.

B.11 Drilling Choke and Actuator Assembly Function Testing

B.11.1 General

The drilling choke and actuator assembly shall be tested in accordance with this section as part of the validation test process. Water or water with additives shall be used as the test fluid. Any additives shall be documented in the test records.

B.11.2 Test Circuit

The drilling choke with the actuator assembled shall be installed in a fluid flow circuit or manifold having a rated working pressure equal to or greater than, the rated working pressure of the choke.

B.11.3 Flow Capacity

The fluid flow circuit or manifold testing apparatus shall be capable of flowing test fluid through the choke bore up to the rated working pressure of the choke at a minimum rate of 5 gallons per minute for the test duration.

B.11.4 Test Position

The choke/actuator shall be positioned within the fluid flow circuit or manifold such that the entire testing apparatus and the choke cavity upstream of the choke seal elements are full of test fluid prior to initiating the test, and will remain full with no trapped air during the test cycles.

B.11.5 Data Recording

A pressure recording device shall be installed upstream of the choke and the pressure continuously recorded during the function test.

B.11.6 Control Console

The actuator shall be operated by a choke control console in accordance with Annex G. A control system that is representative of the form and functions of a choke control console is acceptable.

B.11.7 Test Sequence

The function test shall consist of three cycles in the following sequence.

1) Using the choke control system, fully open the choke and flow test fluid through the choke at a minimum rate of 5 gal/min.

2) Using the choke control system in a normal operating procedure, close the choke. The choke shall be completely closed in 30 s or less.

3) As the choke closes, choke pressure shall rise until the rated working pressure is reached. If the choke does not provide complete shut-off capability, it shall attain the maximum operating pressure contained in the choke manufacturer's written specification.

4) Rated working pressure shall be established on the upstream side of the choke before the console control device is manipulated in a normal manner to the choke open position.

5) The choke shall operate from fully closed to fully open in 30 s or less.

6) The pressure recording device shall document the pressure increase as the choke closes and the pressure decrease as the choke opens.

B.11.8 Design Validation for Drilling Choke Actuators

B.11.8.1 Design Validation Testing Procedure

Testing media for hydraulic actuators shall be a suitable hydraulic fluid.

B.11.8.2 Actuator Seal Test at Room Temperature

The actuator seals shall be pressure tested in two steps by applying pressure of 20 % and 100 % of the maximum rated working pressure to the actuator. The minimum test duration for each test shall be three minutes at 20 % and 100 % for hydraulic actuators.

The test period shall not begin until the test pressure has stabilized. The test results shall be recorded. The seals shall show no visible leakage under the test of each holding period.

B.11.8.3 Operational Test at Room Temperature

B.11.8.3.1 The actuator shall be tested for proper operation by cycling the actuator from the minimum stroke position to the maximum stroke position.

B.11.8.3.2 The testing shall be performed at ambient temperature for a minimum of 160 cycles. The pressure applied shall be equal to the rated working pressure of the actuator.

B.11.8.3.3 The test results are acceptable if:

— the actuator operation is smooth in both directions during and after the test; and

— there is no visible leakage.

B.11.8.4 Operational Test at Maximum Rated Temperature

The actuator shall be tested for proper operation by cycling the actuator at maximum rated temperature from the normal position to the fully stroked position a minimum of 20 cycles. The pressure applied shall be equal to the rated working pressure of the actuator.

Acceptance criteria shall be in accordance with B.11.8.3.2.

B.11.8.5 Operational Test at Minimum Rated Temperature

The actuator shall be tested for proper operation by cycling the actuator at minimum rated temperature from the normal position to the fully stroked position a minimum of 20 cycles. The actuator shall operate smoothly in both directions. The pressure applied shall be equal to the rated working pressure of the actuator.

B.11.8.6 Pressure-temperature Cycles

B.11.8.6.1 The pressure-temperature cycles shall be performed with the choke partially open following the steps.

1) Raise temperature to room temperature.
2) Apply testing pressure at room temperature and maintain while raising temperature to maximum rated temperature.
3) Hold pressure and temperature for 1 h minimum.
4) Reduce to minimum rated temperature while maintaining test pressure.
5) Hold pressure and temperature for 1 h minimum.
6) Raise to room temperature while maintaining test temperature.
7) Release pressure and raise temperature to maximum rated value.
8) Apply testing pressure and hold for 1 h minimum.
9) Release pressure and reduce temperature to minimum rated temperature.
10) Apply test pressure and hold for 1 h minimum.
11) Release pressure and raise to room temperature.

12) Apply testing pressure and hold for 1 h minimum.

13) Release pressure.

B.11.8.6.2 The test results are acceptable if there is no visible leakage.

B.12 Flexible Choke and Kill Line Design Validation Tests

B.12.1 General

Successful completion of validation testing qualifies the size and pressure rating of the flexible tested, together with smaller sizes and equal or lower pressure ratings and temperature of equivalent design and construction. The tests required are dependent on the FSL for each application and are shown in Table 29. In order to qualify for approval, the minimum tests required for design validation are B.12.2 through B.12.3. Other tests are in accordance with the appropriate FSL. Adding elements or changing the cover outside of the reinforcement (e.g. fire protection, external armoring) does not require new validation testing.

In connection with flexible pipes, a “burst” is defined as the catastrophic failure of the pipe assembly, either by loss of a complete end fitting, or by rupture of the complete assembly such that no flow is possible between the opposing end connectors. A “leak” is defined as a loss of pressure integrity in the flexible pipe assembly, but which allows a significant quantity of flow between the opposing end connectors enough to allow a continued temporary limited use in its intended service.

B.12.2 Hydrostatic Internal Pressure, Bending Flexibility, and Burst Test

B.12.2.1 Hydrostatic Internal Pressure

A minimum length of 10 ft, including the end fittings, shall be used for this test. The flexible line shall be pressurized to test pressure and held for 1 h. The test shall be conducted at room temperature and the temperature shall be recorded. The flexible line shall then be pressure cycled a minimum of 260 pressure cycles, 0 psi (0 MPa) to rated working pressure. The rated working pressure shall be held for five minutes duration per cycle. There shall be no visible leakage.

B.12.2.2 Bending Flexibility Test

Upon completion of the hydrostatic internal pressure test and with no pressure on the line, the line is bent to the manufacturer’s specified working minimum bending radius. The line shall be bent to a minimum 90° to the specified working minimum bend radius. The line shall be subjected to the minimum rated temperature (reference 4.1.1) and bent for a minimum 100 cycles.

The line shall then be brought back to room temperature and bending cycle tests continued for a minimum 260 cycles. The line sample is then pressurized to rated working pressure and is bent to the manufacturer’s specified working minimum bending radius for a minimum 260 cycles. There shall be no visible leakage.

If the bend radius for storage differs from working minimum bend radius, the test shall be repeated for storage minimum bend radius with no pressure applied.

B.12.2.3 Burst Test

Upon completion of the bending flexibility test, the line is pressurized to failure at a rate not exceeding 1500 psi (10.35 MPa)/min. During the pressure application to burst, there shall be no visible leakage. Acceptance criteria shall be burst at or above minimum burst pressure as specified in Table 28.

B.12.3 Exposure Test

B.12.3.1 General

B.12.3.1.1 The tests evaluate the effects of gas permeation, gas decompression, and test fluid exposure at rated temperature. The tests shall be conducted in two series. Series 1 requires three short-term exposures to standard test fluid in Table B.1. Series 2 requires two long-term exposures to the same test fluid.

B.12.3.1.2 All tests shall be conducted on the same flexible line sample with a minimum 10 ft length, including the end fittings. No device shall be introduced to the bore that would support or restrain the bore from reacting to the test medium.

B.12.3.1.3 Successful completion of validation testing as specified in B.12.3 qualifies the size and pressure rating of the flexible tested, together with smaller sizes and equal or lower pressure ratings and temperature of equivalent design and construction.

B.12.3.2 Series 1

The line shall be pressurized three separate times to the rated working pressure (+0, –500 psi [3.45 MPa], or −5 %, whichever is less) and rated temperature (±10 °F, [±5.6 °C]). The first pressurization shall be held for 24 h. The second and third pressure applications shall be held for 12 h. After each cycle the line shall be vented and held for at least one hour at atmospheric pressure between pressure applications. The rate of venting shall be 1000 psi/min (6.9 MPa/min) +100 psi/minute (0.69 MPa/min) from rated working pressure down to 1000 psi (69 MPa).

Following completion of Series 1 testing, the flexible line shall maintain the minimum ID in accordance with manufacturer's written specification.

B.12.3.3 Series 2

The line shall be pressurized to rated working pressure (+0, –500 psi [3.45 MPa], or –5 %, whichever is less) and rated temperature (+10 °F [+5.6 °C]) and held for seven days. After exposure, the line shall be cooled to room temperature. After cooling, the pressure shall be adjusted to the rated working pressure. The pressure shall be held for 30 days at room temperature.

Following the 30-day exposure, the assembly shall be pressurized with water to at least the test pressure specified in Table 28. The test pressure shall be held for 30 min. For acceptance, the assembly shall have no visible leakage nor be damaged in any way affecting normal usage.

B.12.4 Flexible Line Fire Test

B.12.4.1 Test Criteria

B.12.4.1.1 Flexible choke and kill lines shall withstand a 30 min fire test as described in B.12.4.2.2 through B.12.4.2.6. The lines shall not have visible leakage at rated working pressure as a result of the fire test during the test period.

B.12.4.1.2 The Fire Test shall consist of a direct exposure to flame or to radiation within a furnace. The temperature indicated by the thermocouples during the 30 min test shall be equal to or higher than 1300 °F (704 °C).

B.12.4.1.3 Thermocouples shall be positioned around the flexible line within 1 in. (25.4 mm) of the outer surface of the line or end fittings. At least one thermocouple near the flexible line, and one thermocouple near the surface of the end fitting shall reach a minimum of 1300 °F (704 °C).

B.12.4.1.4 The flexible line shall be pressurized full of water. The line may be tested horizontally or vertically, according to the choice of the manufacturer.

B.12.4.1.5 The test sample shall be a minimum of 10 ft (3.0 m) long. At least 5 ft (1.5 m) of the flexible line and one end fitting shall be exposed to the fire or radiation.

B.12.4.1.6 After exposure to the fire, the line shall remain pressurized until cool down to ambient temperature: the line shall not burst during this period, although a leak may occur.

B.12.5 Flexible Line High Temperature Exposure Test

B.12.5.1 This test is intended to determine the maximum temperature that a flexible choke and kill line will withstand for a short duration when exposed to the rated working pressure. This test represents severe, survival conditions and should not be used to define the temperature rating of the line. It is imperative that both the line structure and the end terminations be exposed to the temperature excursions during the tests.

B.12.5.2 Upon reaching the manufacturer's rated working pressure and maximum temperature, the temperature is raised at a rate not to exceed 5 °F (2.8 °C) per hour to 350 °F, +10 °F, (177 °C +5.5 °C) and held for 1 h. The temperature shall be measured, either at the fluid inside the line or at the inside wall of the line. At the end of one hour, the temperature is raised at a rate not exceeding 5 °F/h (2.8 °C/h) until failure. Failure is defined as a visible fluid leak in the end connection, the body of the line or burst of the line. The total time of exposure to 350 °F (177 °C) and above should be recorded together with the temperature and the failure mode of the pipe leak and its location, or burst and its location. Acceptance criteria shall be sustaining the 350 °F (177 °C) hold period, at rated working pressure, for 1 h with no visible leakage.

B.12.5.3 The pressurization fluid can be water, or heat transfer oil. The fluid may be static or flowing. Because the objective of the testing is to simulate, as closely as possible, service conditions, line heating should be from the inside.

B.12.6 Design Validation of Articulated Choke and Kill Line Assembly

B.12.6.1 General

This section concerns validation of the design of swiveling components used in articulated choke and kill lines. These are tests performed to validate the design. It is not intended that these tests be performed on every component manufactured. The dynamic ability and pressure integrity of the articulated choke and kill line assembly shall be proven by testing. Tests shall use the test fluid of Table B.1 and the temperatures in 4.5.

The dynamic ability and pressure integrity of the articulated choke and kill line assembly shall be proven by testing. Tests shall use the test fluid specified in Table B.1 and the temperatures in Table 1.

B.12.6.2 Dynamic Range Test

The tests shall be at rated working pressure on an articulated line component containing only one point of rotation. The test shall rotate the assembly through a minimum 45° angle, in two planes, for at least 620 cycles.

B.12.6.3 Rapid Decompression Test

The assembly shall be pressurized three separate times to the rated working pressure (+0, –500 psi, [3.4 MPa], or –5 %, whichever is less) and rated temperature (+10 °F, +5.6 °C). The first pressurization shall be held for 24 h. The second and third pressure applications shall be held for 12 hours each. After each pressurization, the assembly shall be vented at 1000 psi (6.9 MPa)/min (+100 psi [0.69 MPa]/min) and held for at least one hour at atmospheric pressure between pressure applications. For acceptance, the assembly shall have no visible leakage nor be damaged in any way affecting normal usage.

B.12.6.4 Pressure Endurance Test

The assembly shall be pressurized to rated working pressure (+0, –500 psi, [3.4 MPa], or –5 %, whichever is less) and rated temperature (+10 °F, +5.6 °C) and held for seven days. After exposure, the assembly shall be cooled to room temperature. The assembly shall be pressurized with water to at least the test pressure specified in Table 3. The test pressure shall be held for 30 min. For acceptance, the assembly shall have no visible leakage nor be damaged in any way affecting normal usage.

B.13 Documentation

The manufacturer shall maintain a file on each design validation. Validation files shall contain or reference the following information, if applicable:

a) test number and revision level, or test procedure;

b) complete identification of the product being tested;

c) date of test completion;

d) test results and post-test examination conclusions;

e) model numbers and other pertinent identifying data on all other sizes, rated pressures, temperature ranges and standard test fluid ratings of products of the same product family that are qualified by the validation of this particular product;

f) class of seal designs (static, dynamic);

g) all detailed dimensional drawings and material specifications applicable to the tested product, including seals and non-extrusion devices;

h) sketch of test fixture, product and seal or sample; temperature and pressure measurement locations should be shown;

i) actual sealing-surface dimensions;

j) all test data specified in this annex, including actual test conditions (pressure, temperature, etc.) and observed leakages or other acceptance parameters;

k) identification of testing media used;

l) test equipment identification and calibration status;

m) certification of manufacturer report, including the supplier of test seals, molding dates, compound identifications and batch numbers for non-metallic materials;

n) letter of compliance stating that the tested equipment is in accordance with the design requirements of this standard.

Annex C
(informative)

Weld Preparation Designs

Figures C.1 through C.7 provide information on various weld preparation designs.

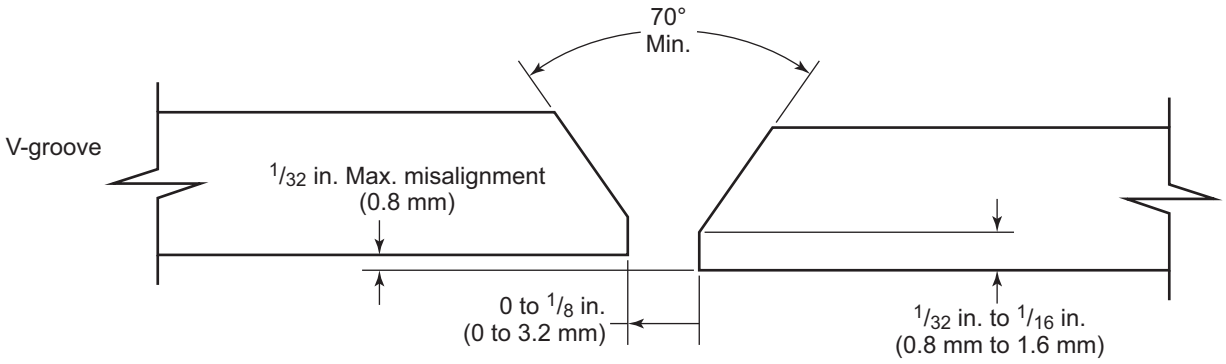


Figure C.1 — Pipe Butt Joints

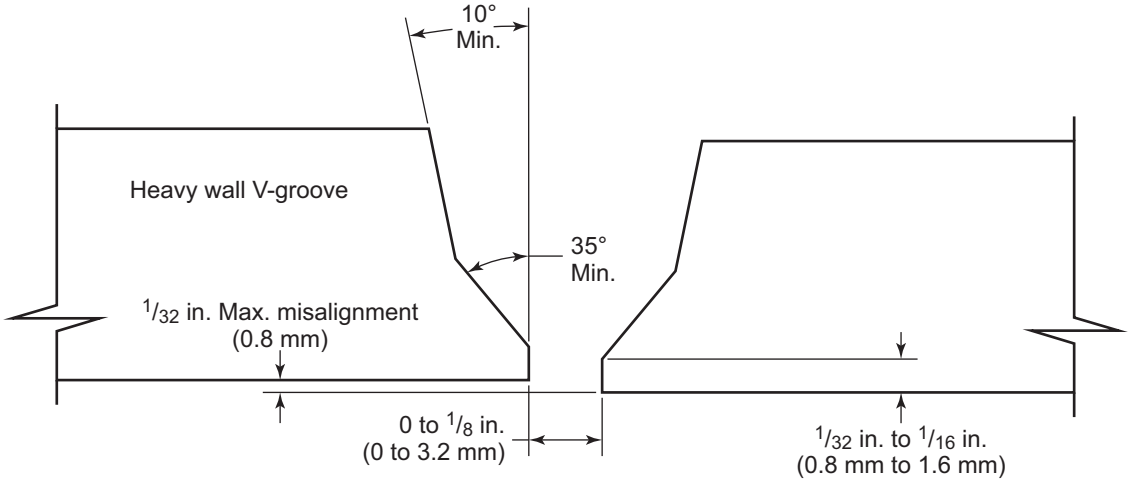


Figure C.2 — U-Groove

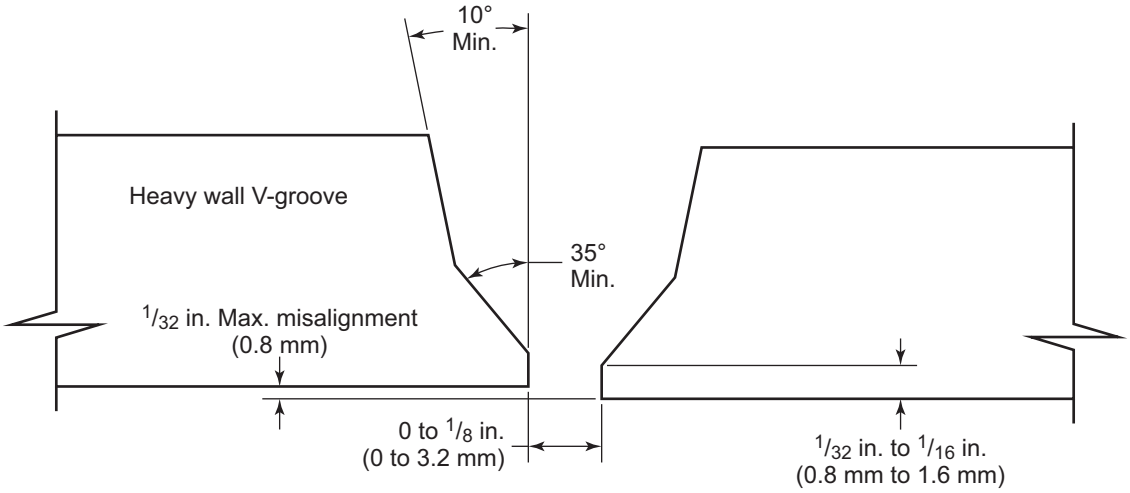


Figure C.3—Heavy Wall V-groove

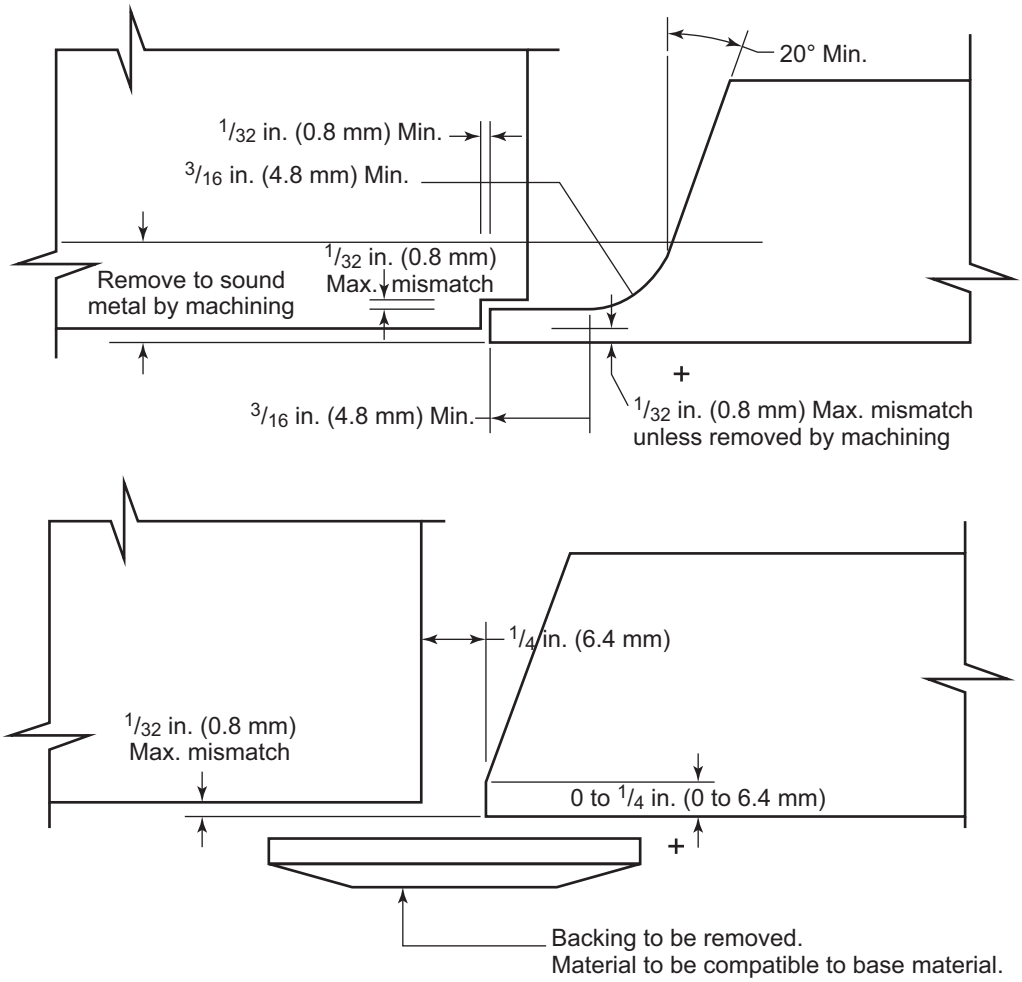
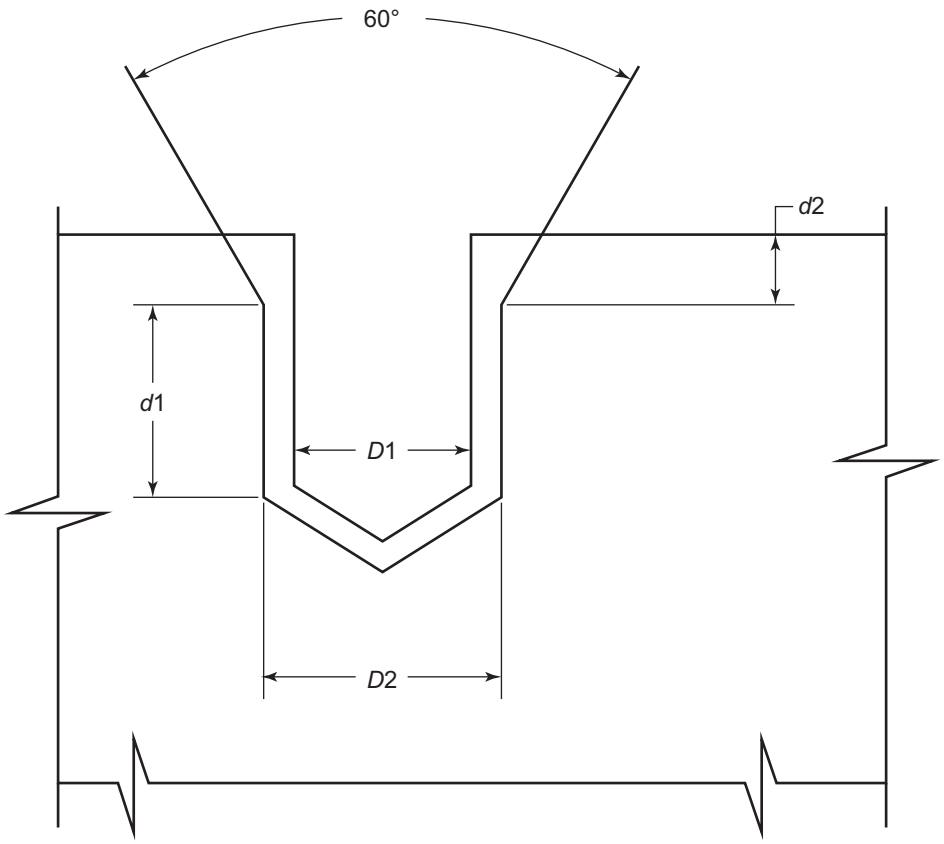


Figure C.4—Attachment Welds



NOTE 1 $d1$ to D does not exceed $1^1/_2$ t.
NOTE 2 $d2$ = depth required to maintain a maximum of $1^1/_2$ I depth (d) to diameter ($D1$) ratio.

Figure C.5—Hole Repair

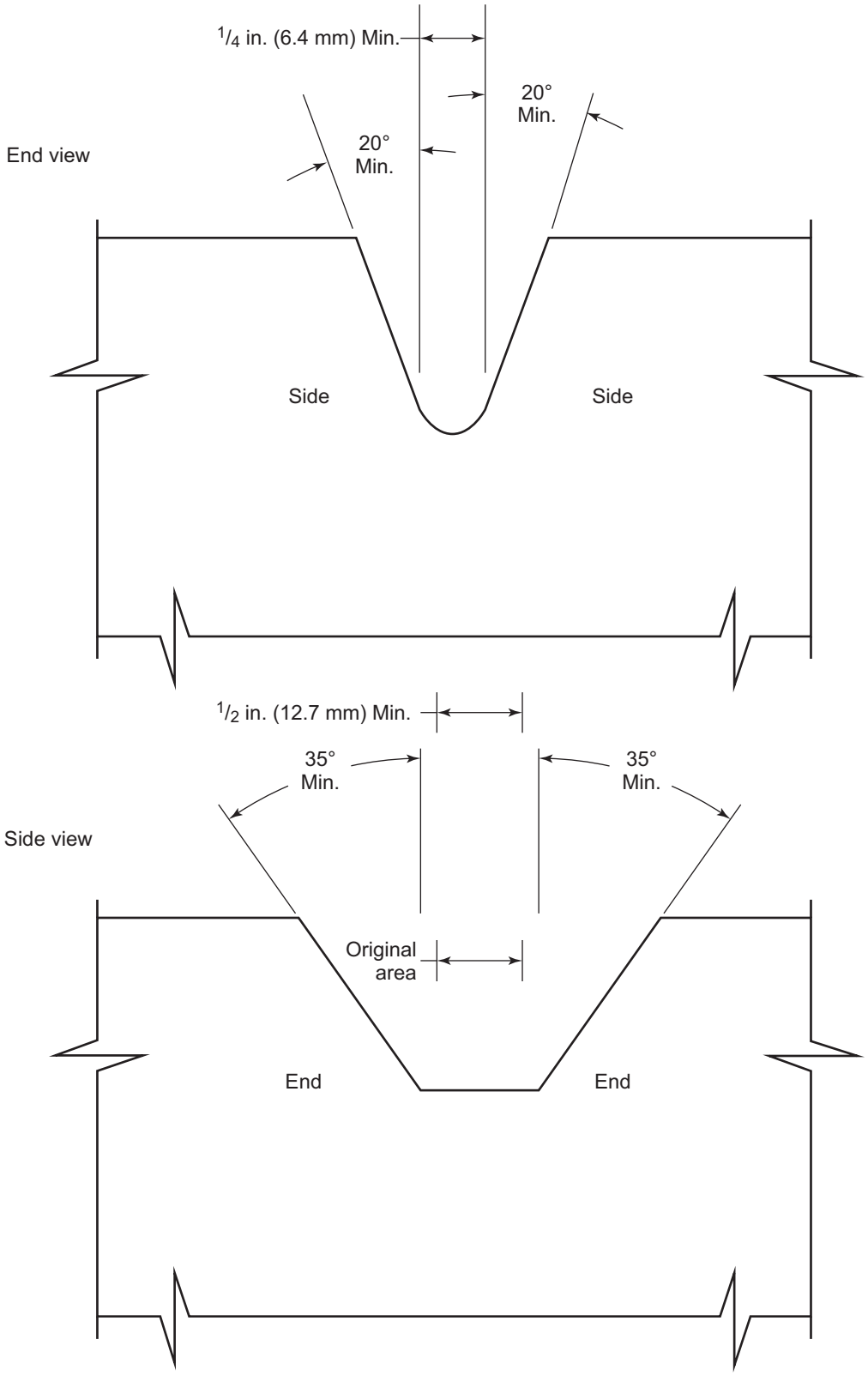


Figure C.6—Excavation for Repair–Removal of Sample Discontinuities in Weld Metal and Base Metal

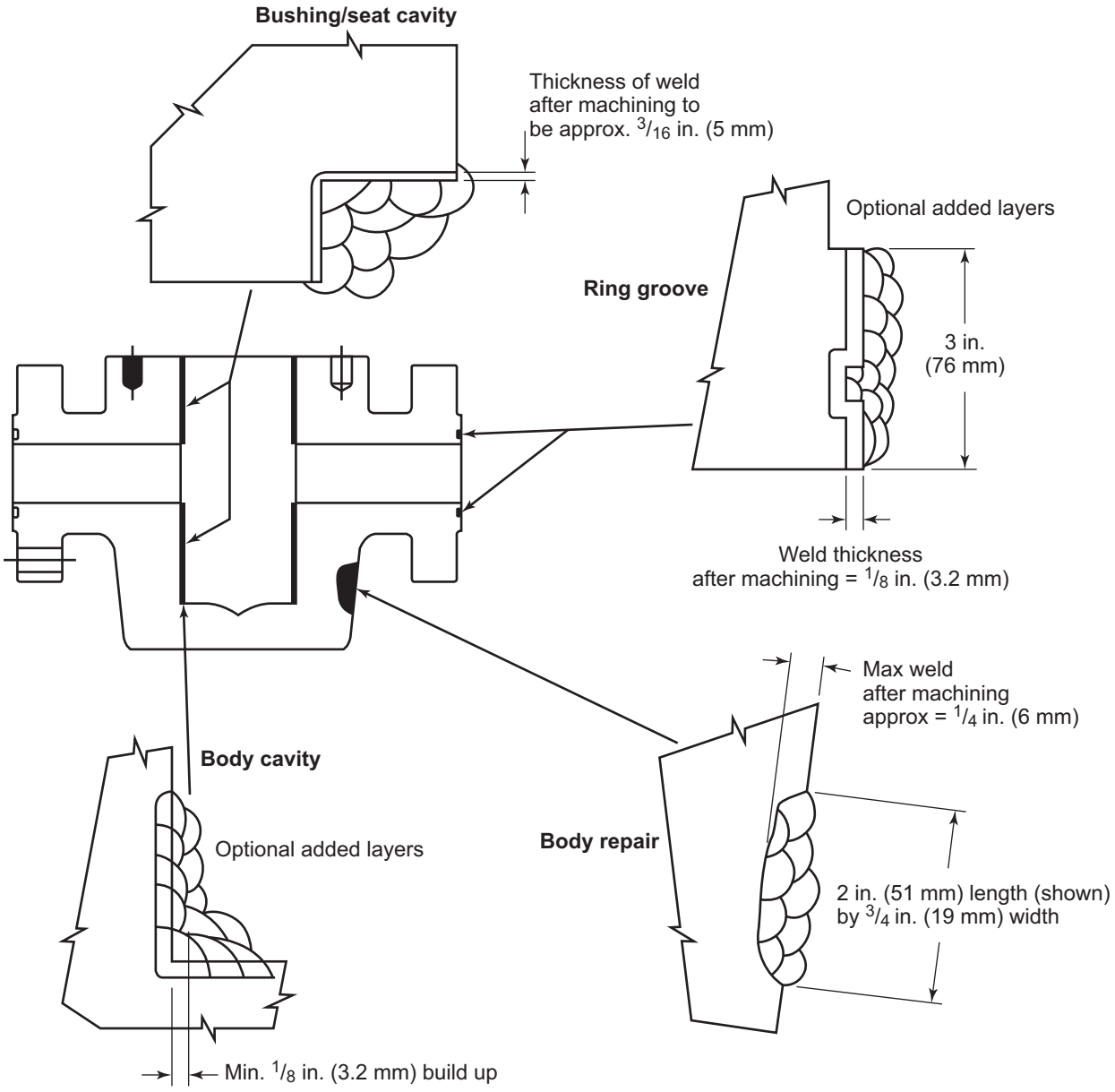


Figure C.7—Bushing/Seat Cavity

Annex D
(informative)

Heat Treating Equipment Qualification

D.1 Temperature Tolerance

The temperate at any point in the working zone should not vary more than +25 °F (+13.9 °C) from the furnace set point temperature, after the furnace working zone has been brought up to temperature. Furnaces used for tempering, aging, and/or stress relieving should not vary more than +15 °F (+8.3 °C) from the furnace set point temperature, after the furnace working zone has been brought up to temperature.

D.2 Furnace Calibration

D.2.1 General

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

D.2.2 Records

Records of furnace calibration and surveys should be maintained for at least two years.

D.2.3 Batch Type Furnace Methods

D.2.3.1 A temperature survey within the furnace working zone(s) should be performed on each furnace at the maximum and minimum temperatures for which the furnace will be used.

D.2.3.2 A minimum of 9 thermocouple test locations should be used for furnaces having a working zone greater than 10 ft^3.

D.2.3.3 For each 125 ft^3 of furnace working zone surveyed, at least one thermocouple test location should be used, up to a maximum of 60 thermocouples. See Figure D.1 for recommended locations of thermocouples.

D.2.3.4 For furnaces having a working zone less than 10 ft^3, the temperature survey may be made with a minimum of three thermocouples front, center, and rear or at the top, center, and bottom of the furnace working zone.

D.2.3.5 After insertion of the thermocouples, readings should be taken at least once every 3 minutes to determine when the temperatures of the furnace working zone approaches the bottom of the temperature range being surveyed.

D.2.3.6 Once the furnace temperature has reached the set point, the temperature of test locations should be recorded at 2-minute intervals for at least 10 min. Then, readings should be taken at 5 minute intervals, for sufficient time to determine the recurrent furnace temperature pattern—at least 30 min.

D.2.3.7 Before the set point temperature is reached, none of the temperature readings should exceed the set point by +25 °F (+13.9 °C).

D.2.3.8 After the furnace control set point temperature is reached, the temperature shall not exceed the manufacturer's written specification. Each furnace shall be calibrated within one year prior to completion of the last heat-treating operation.

D.2.3.9 When a furnace is repaired or rebuilt, it shall be calibrated before heat-treating.

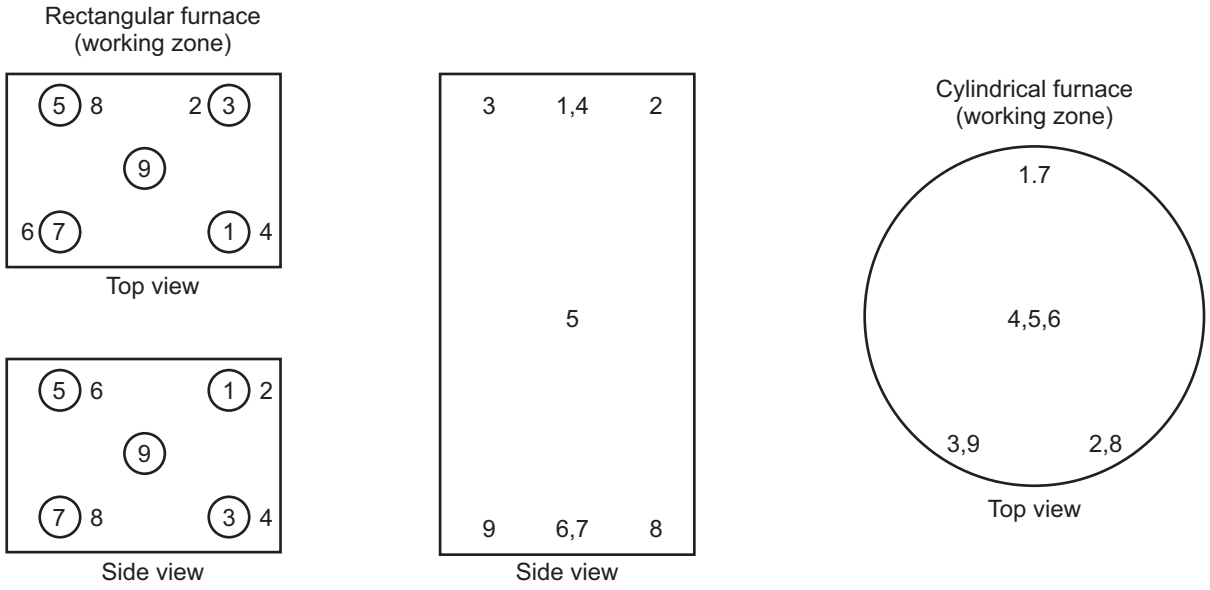


Figure D.1—Thermocouple Locations

D.2.4 Continuous-type Furnace Method

Continuous heat-treating furnaces should be calibrated in accordance with procedures specified in SAE-AMS-H-6875.

D.3 Instruments

D.3.1 General

Automatic controlling and recording instruments should be used.

Thermocouples should be located in the furnace working zone(s) and protected from furnace atmospheres by suitable protecting devices.

D.3.2 Controller Accuracy

The controlling and recording instruments used for the heat treatment process should provide an accuracy of +1 % of the full-scale range.

D.3.3 Calibration Frequency

Temperature controlling and recording instruments should be calibrated at least every three months.

D.3.4 Calibration Accuracy

Equipment used to calibrate the production equipment should be regularly recalibrated and have an accuracy of +0.25 % of full-scale range.

Annex E
(informative)

Pipe Thermal Expansion Calculations

E.1 Stress Analysis—Thermal Expansion

A stress analysis should be made for a two-anchor system and should meet the following criterion. The calculated stress should only be generated when the two anchor points are immovable (fixed).

$$S_{tm} = \frac{L}{A} \times \Delta T \times B \times E \geq S_m$$

where

S_{tm} is the thermal stress, in psi (Mpa);

L is the length between fixed anchors, in inches (mm);

ΔT is the temperature difference;

B is the coefficient of thermal expansion;

E is the Young's Modulus;

S_m is the membrane design stress, in psi (Mpa);

A is the area, in inches^2 (cm^2).

E.2 Screening Guidelines

The following guidelines and ASME B31.3, Chapter 2, provide guidance on screening pipe or systems that generally will not require thermal stress analysis:

a) systems where the maximum temperature changes will not exceed 50 °F;

b) piping where the maximum temperature change will not exceed 75 °F, provided that the distance between turns in the piping exceeds 12 nominal pipe diameters;

c) systems that satisfy this equation.

$$\frac{D\Delta_1}{(L-U)^2} = 0.03$$

where

D is the nominal pipe size, in inches;

Δ_1 is the expansion to be absorbed by pipe, in inches;

L is the actual length of pipe, in ft;

U is the anchor distance, straight line distance in ft;

Δ_1 may be calculated by the following equation from ASME B31.3;

Δ_1 is $12LB\,\Delta T$;

where

Δ_1 is the expansion to be absorbed by pipe, in inches;

L is the actual length of pipe, in ft;

B is the meant coefficient of thermal expansion at normal operating temperature;

ΔT is the temperature change, in °F.

E.3 Expansion Levels

Pipe movement can be handled by expansion bends (including loops – “U”, “L”, and “Z” shaped piping), and swivel joints. Expansion bends are preferred when practical. If expansion bends are not practical, swivel joints should be used.

Annex F
(informative)

Purchasing Guidelines

F.1 General

This annex provides recommended guidelines for inquiry and purchase of API choke and kill systems equipment. The purchaser should provide rated working pressure, temperature ratings, and size designation, when placing an order or making an inquiry. Water depth should also be specified for subsea equipment.

F.2 Size Designation

The size designation consists of the nominal through bore dimension. A list of standard sizes is found in Table 1.

F.3 Rated Working Pressure

The rated working pressure is determined by the lowest rated working pressure of the component or assembly, including integral end or outlet connections. Standard rated working pressures are listed in 4.6.

F.4 Temperature Rating

F.4.1 General

The minimum temperature rating is based on the lowest ambient temperature to which the equipment can be subjected during operation. The maximum temperature rating is the highest temperature of the fluid that can flow through the equipment.

F.4.2 Metallic Materials

Metallic equipment should be designed to operate in one of the temperature ratings listed in Table 4.

F.4.3 Non-metallic Materials

Non-metallic equipment and components, including seals, should be designed to operate in one of the temperature ranges listed in Table 4.

F.5 Specification Level

For flexible lines, the appropriate FSL (flexible specification level) shall be specified.

Annex G
(normative)

Drilling Choke Control Console System

G.1 General

The function of the remote hydraulic choke control system is to provide reliable control of the drilling choke from one or more remote locations with the sensitivity and resolution required to perform all well control procedures that the choke valve is designed to provide, including the following:

— well flow shut-in procedures;

— throttling of mud, gas, liquid hydrocarbons, and formation debris at any rate of flow up to the physical capacity of the internal flow conduit.

G.2 Functional Requirements

G.2.1 General

The control system shall provide the following.

a) An actuator capable of setting the orifice in the choke at any size from fully open to fully closed at any pressure up to the rated working pressure of the choke.

b) Power to the choke actuator sufficient to completely close the choke from the fully open position in 30 seconds or less.

c) Operating controls enabling the operator to set orifice openings of any size up to fully open that will result in any annulus pressure desired +10 psi (69 KPa) from 0 psi (0 MPa) to the choke rated working pressure. The control device should be suitably marked for direction of control.

d) A choke position indicator that shows at the control console the relative position of the choke trim or relative orifice size as a percent of fully open.

e) A gauge on the control panel for rig air or gas pressure available to power the pump. This is required only for air or gas-over-hydraulic actuation systems.

f) A gauge on the control panel to display system power (hydraulic, air, electric), from the hydraulic pump, accumulator system, or other power source.

g) Pressure gauges shall be scaled 0 psi (0 MPa) to fully rated working pressure of the manifold that the gauge is monitoring. These gauges are to be clearly marked as to function and shall be independent from other gauge systems. These pressure gauges shall also meet the following requirements.

   1) An accuracy of ±0.5 % of full scale. Bourdon tube type gauges are acceptable as are other established types such as electronic transducers and display systems. Also, gauges of any type may be provided with full-scale pressure lower than choke system rated pressure for better resolution at lower pressures; in which case, manual or automatic isolation valves shall be provided to prevent over-ranging these gauge systems.

   2) Minimum dial scale diameter of 6 in. (152.4 mm). Digital readouts shall be 0.5 in. (12.7 mm) high and visible from 10 ft (3 m) in any ambient light with 10 psi (69 KPa) resolution.

3) Dial scale divisions of 25 psi (172.5 KPa) or less and gauge pointer width or configuration shall be complementary to 25 psi (172.5 KPa) or less visual resolution.

4) At the standard pipe manifold and choke manifold pressure-sensing locations, a pressure transmitter shall be employed to keep process fluid separated from gauge system hydraulic or pneumatic fluids.

5) The transmitter shall have a rated working pressure and rated temperature range equal to or greater than the manifold on which it is installed.

G.2.2 Piston Isolator Transmitter

G.2.2.1 A piston isolator transmitter shall have a hydraulic oil displacement capacity equal to 1.5 times the combined volume requirement of the total hose volume and gauge tube volume, considering expansion, when at full-scale pressure on the gauge. A permanent metal tag on the body should warn the user against addition hoses or gauges being driven by the transducer.

G.2.2.2 For rated working pressures up to 10,000 psi (69 MPa), one-to-one piston ratio may be employed. At rated pressures of 10,000 psi (69 MPa) to 20,000 psi (138 MPa), four-to-one (4:1) ratio of process pressure to gauge hydraulic oil pressure shall be required.

G.2.2.3 The 1:1 isolator shall have a sensitivity of 10 psi (69 KPa). The 4:1 isolator shall have a sensitivity of 25 psi (172.5 KPa) at a pressure equal to mid-scale of the receiver gauge.

G.2.2.4 The piston shall be designed such that in the event of a leak in the hydraulic system and hydraulic oil loss, the piston will bump the upper limit of travel, the seal rings (or auxiliary seal) will continue to isolate the process fluid from the hydraulic system, and process fluids will be prevented from entering the hydraulic pressure sensing system.

G.2.2.5 The hydraulic oil shall be operational from –20 °F (–28.9 °C) to 200 °F (93.3 °C), and shall be in accordance with manufacturer's specification regarding compatibility to elastomers and metallic specifications of the transmitter.

G.2.2.6 Gauge system hoses shall have pressure rating compatible with the maximum system operating pressure.

G.2.2.7 The pressure transmitter shall have materials specified for well bore retained fluids.

G.2.2.8 The connection into the rig piping shall be made using API 6A or API 16C connections. No pipe threads or welded pipe thread connections are permitted. Any welding on the transmitter or adapter should conform to welding specifications of this document.

G.2.2.9 Unions forming a part of the transmitter shall conform to specifications for other end connectors in accordance with API 6A.

G.2.2.10 Pump stroke counter/rate meter for monitoring each rig pump used during choke operations shall be incorporated into the control panel.

G.2.2.11 The pump stroke counter display shall show accumulated pump strokes and shall have capability to be reset to zero by the operator, but shall automatically reset to zero and continue counting when reaching its maximum count capacity.

G.2.2.12 A switch on the panel or counter face shall permit selection of "strokes per minute" display if both SPM and total strokes are not available simultaneously.

G.2.2.13 This SPM display, if digital, shall show one stroke/minute minimum resolution.

G.2.2.14 All counter/rate meter wiring (power, pump micro switches, etc.) shall be in conformance with NFPA 496, A.P.S. (all applicable agencies).

G.2.2.15 If digital displays are employed, the digits shall be minimum 1/2 in. (12.7 mm) height and visible from 10 ft in any ambient light.

G.2.3 Emergency Operation Provisions

G.2.3.1 In the event of failure of rig power, the console control system shall provide connections and fittings for accepting alternative power such as nitrogen bottles and the recommendations for amount of motive power necessary to provide 12 hours of choke operation.

G.2.3.2 A hydraulically operated console control system shall have a hand pump, valving, and other components necessary to permit manually applying hydraulic pressure to the choke control system, in the event of failure of the main hydraulic pump.

G.2.4 Instructions

The choke control console shall contain instructions for choke operation in a normal mode and in emergency (power failure) modes. Those instructions should also show procedure steps to verify system readiness.

G.2.5 Hydraulic Hoses (for Operation of Choke)

G.2.5.1 The hoses shall have connections that permit installation in only the correct manner, and shall be prevented from installation into the pressure gauge systems.

G.2.5.2 The pressure gauge hoses shall likewise have connections that assure installation in only the correct manner and shall not be capable of installation in the choke operational hydraulic circuit.

G.2.5.3 All hose connections should be marked on the panel and the choke.

G.2.5.4 Systems designed for multiple choke/control panel installation shall conform to all the preceding requirements except that in multiple control console installations, simultaneous connection of multiple drill pipe and multiple casing pressure gauges is permitted to each console respectively.

G.3 Operation/Maintenance Manual

The manufacturer shall prepare and have available an operating manual for each model and size of choke system manufactured in accordance with this specification. The manual shall contain the following information as a minimum:

a) installation Instructions;

b) operating instructions covering all normal functions of the choke, plus complete instruction for emergency operation in the event of failure of external power or equipment, and failure of any internal components;

c) dimensions and physical data of major components;

d) repair, maintenance, and testing information and procedures, including disassembly and assembly information;

e) parts information;

f) storage information.

Annex H
(informative)

Example Choke and Kill System Configurations

Figure H.1 through Figure H.7 depict typical configurations of kill line, choke line, and manifold arrangements for surface and subsea applications. These configurations are taken from API 53 with the exception of the 20,000 psi (138 MPa) rated working pressure configurations.

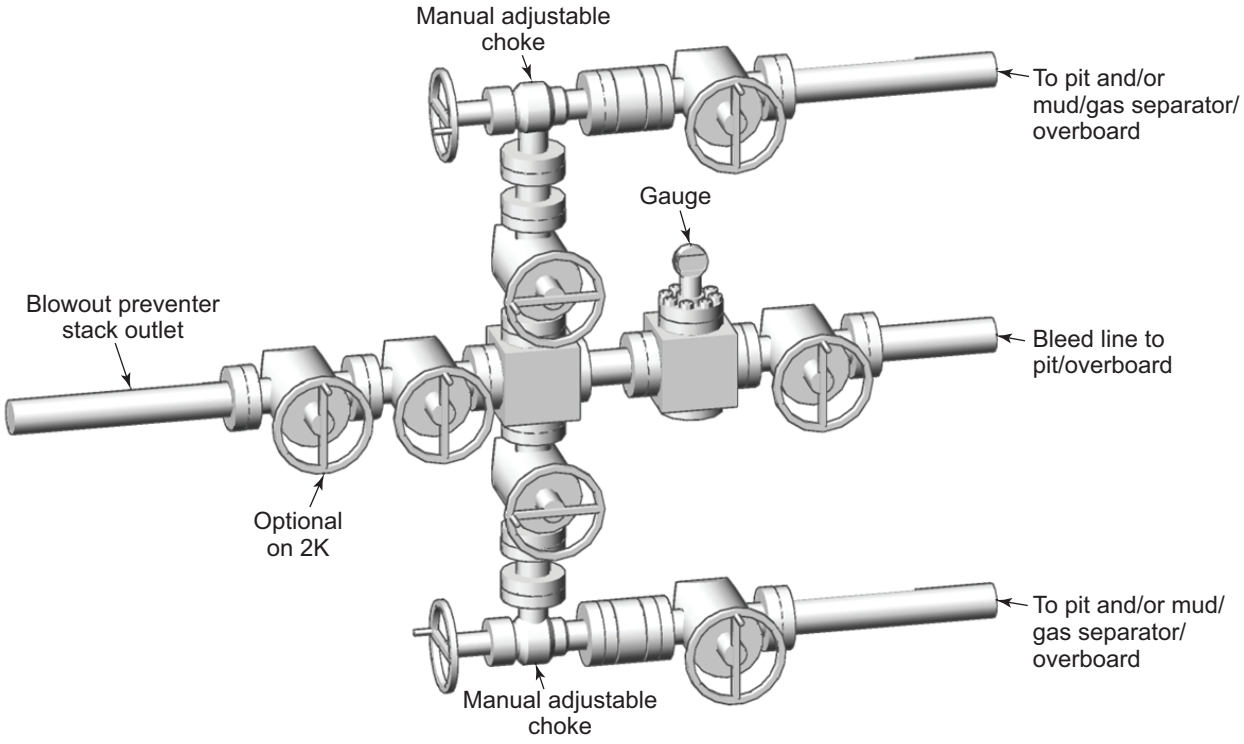


Figure H.1—Example Choke Manifold Assembly for 2K and 3K Rated Working Pressure Service—Surface BOP Installations

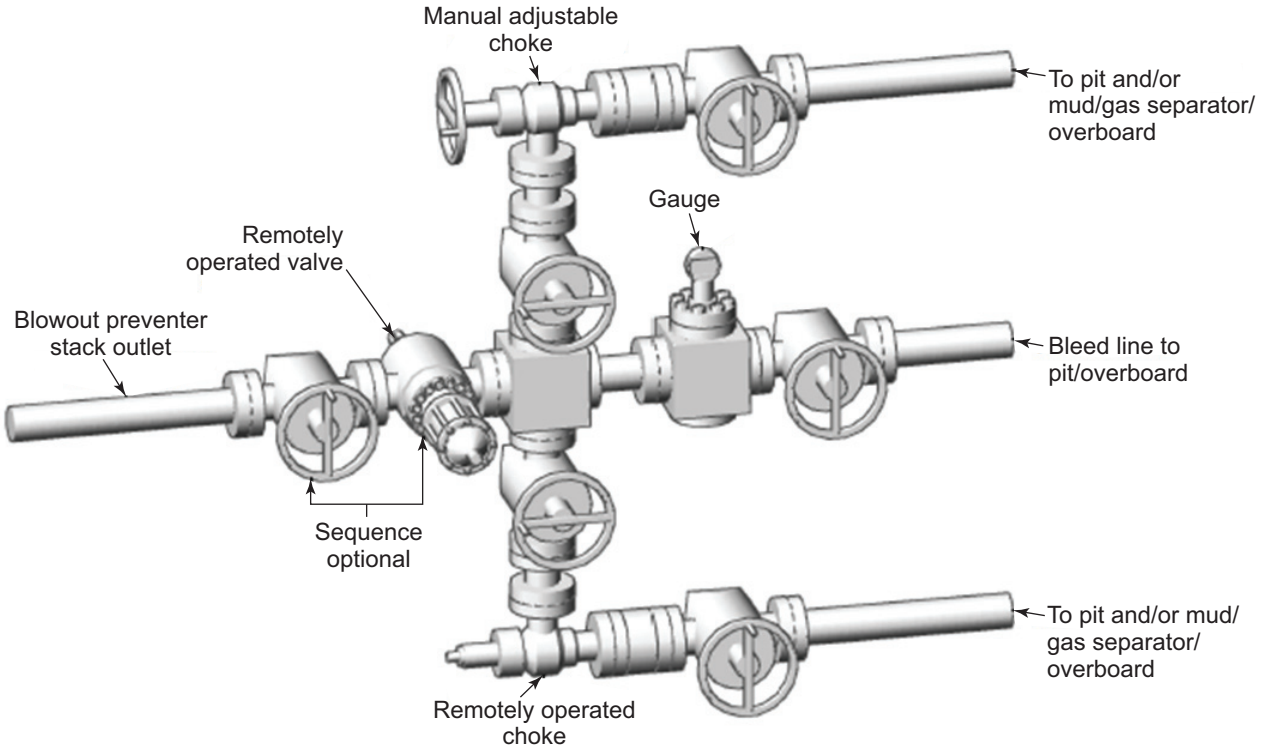


Figure H.2—Example Choke Manifold Assembly for 5K Rated Working Pressure Service—Surface BOP Installations

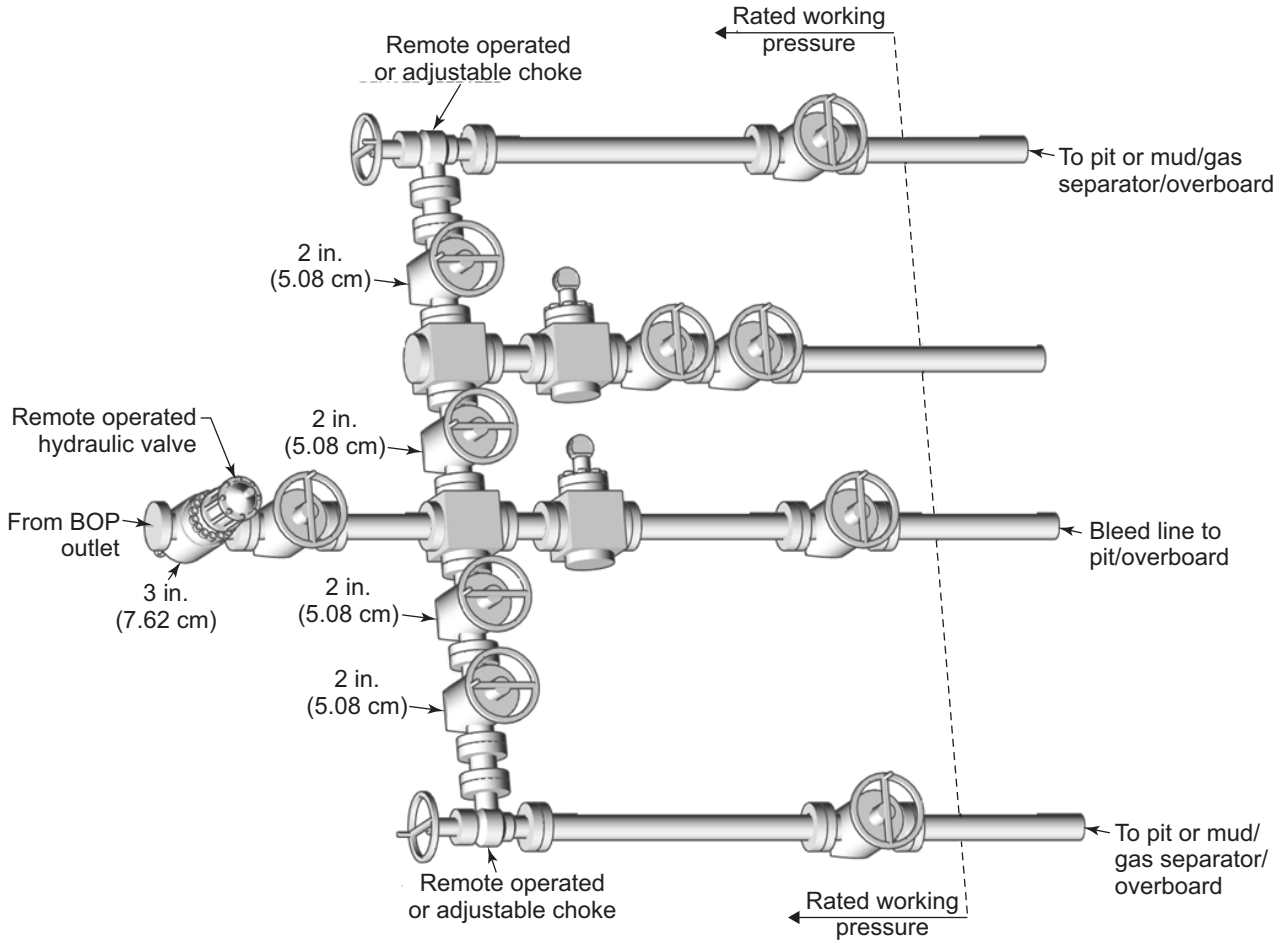


Figure H.3—Example Choke Manifold Assembly for 10K or Greater Rated Working Pressure Service—Surface BOP Installations

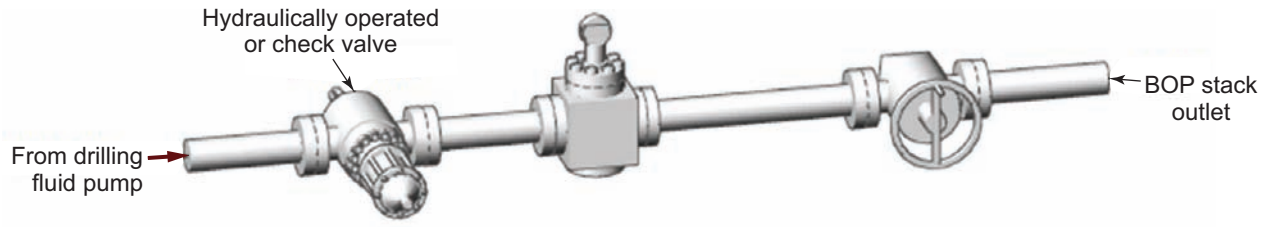


Figure H.4—Example Kill Line Assembly for 2K and 3K Rated Working Pressure Service—Surface BOP Installations

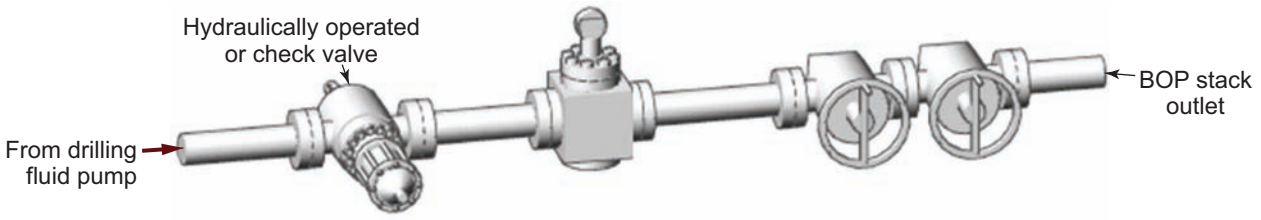


Figure H.5—Example Kill Line Assembly for 5K Rated Working Pressure Service—Surface BOP Installations

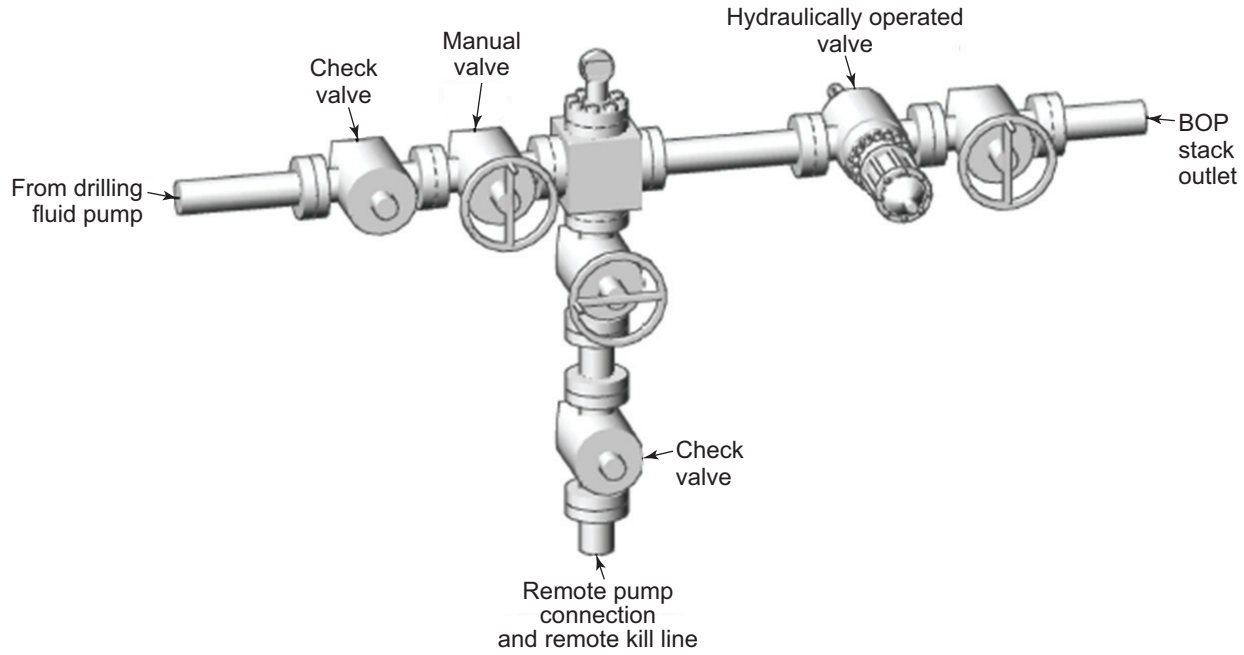


Figure H.6—Example Kill Line Assembly for 10K and Greater Rated Working Pressure Service—Surface BOP Installations

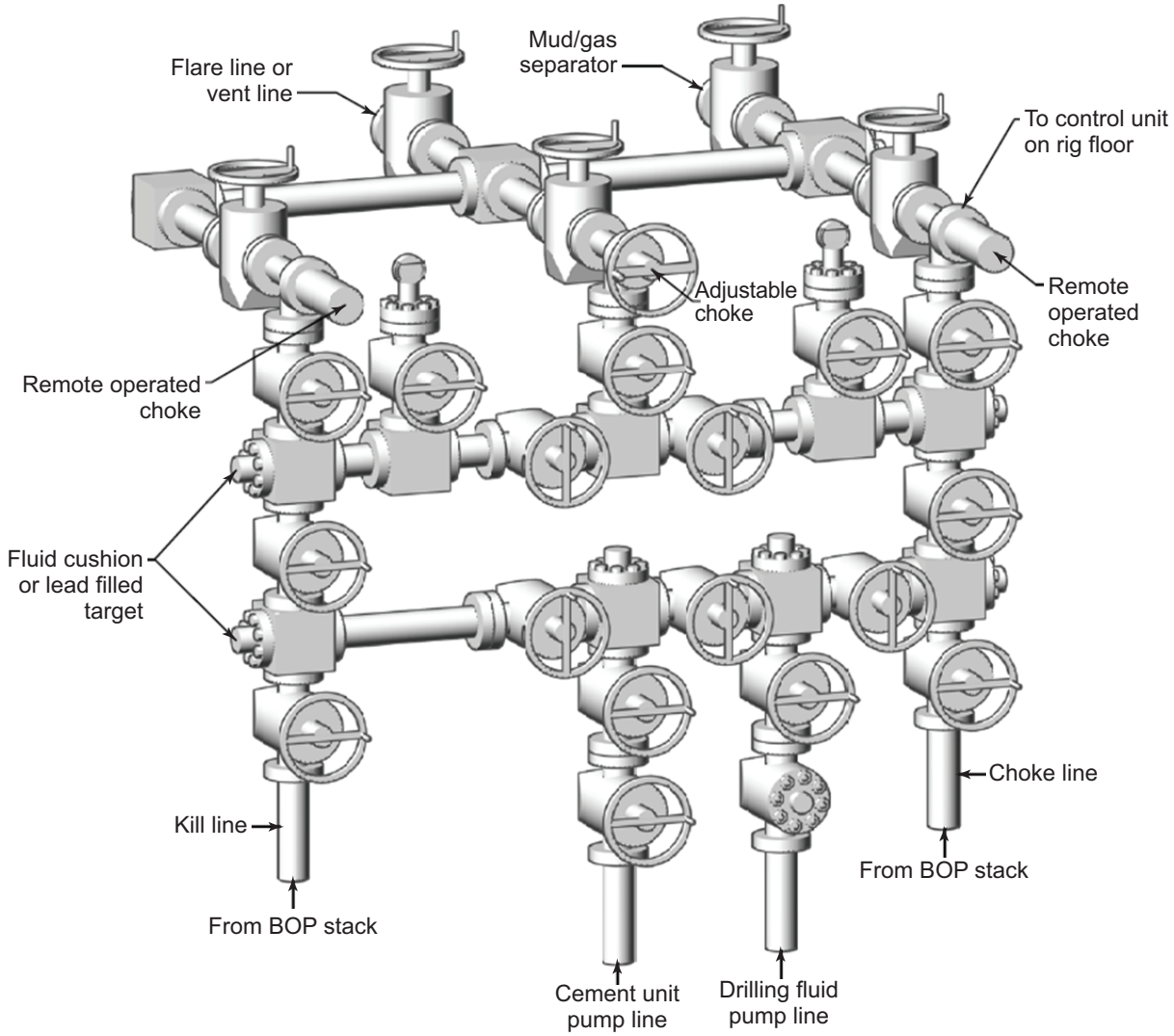


Figure H.7—Example Choke and Kill Manifold for Subsea Systems

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