Specification for Choke and Kill Equipment

API SPECIFICATION
THIRD EDITION, XXXX 2018
DRAFT
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.

k) choke and kill flex loops

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 Specification 20E, Specification for Alloy and Carbon Steel Bolting

API Specification 20F, Specification for Corrosion Resistant Bolting

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), 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 (BPVC) 2004, Section VIII, Division 2, Appendix 6

ASME Boiler and Pressure Vessel Code (BPVC), 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, Personnel Qualification and Certification in Nondestructive Testing

ASQ Z1.4, Sampling Procedures and Tables for Inspection by Attributes

ASTM A370, 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 E18, Standard Test Methods for Rockwell Hardness of Metallic Materials


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


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 A5.1, Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding

CSWIP-WI-6-92, 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, Metallic materials—Brinell hardness test—Part 1: Test method


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


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2 American Society for Nondestructive Testing, 1711 Arlingate Lane, P.O. Box 28518, Columbus, Ohio 43228, www.asnt.org
3 American Society for Quality, P.O. Box 3005, Milwaukee, WI 53201-3005, www.asq.org.
NFPA 496, Standard for Purged and Pressurized Enclosures for Electrical Equipment

SAE J 517, 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 Actuator
Mechanism for the remote or automatic operation of a valve or choke

3.1.2 Acceptable Quality Level
AQL
Statistically based acceptance-sampling plan

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

3.1.3 articulated choke and kill line
Choke and kill line assembled as a unit, with rigid pipe, swivel unions 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.

3.1.4 blind flange
Flange with no center bore, used to close off completely a flanged end or outlet connection

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

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

— Utility Bolting
Bolting required for mounting equipment and accessories not considered exposed, class 2, or class 3.

NOTE 1 Examples include bolting on lifting eye, name plate, or clamps.

— Class 2 Bolting
Pressure containing or primary load path bolting not exposed to subsea environment, splash zone, or well bore fluid.

— Class 3 Bolting
Pressure containing or primary load path bolting exposed to subsea environment or splash zone, but not exposed to well bore fluid.

NOTE 2 Examples include closure bolting
— Exposed Bolting

Bolting in direct contact with well bore fluid

3.1.7

bonnet

Pressure-containing closure for a body, other than an end or outlet connection

3.1.8

buffer chamber

Chamber installed downstream of the chokes to allow manifolding of the bleed lines together

3.1.9

burst (flexible line)

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.

3.1.10

calibration

Comparison and adjustment to a standard of known accuracy

3.1.11

casting (noun)

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

3.1.12

casting (verb)

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

3.1.13

certificate of conformance

Document containing the statement by the manufacturer certifying that the equipment meets the requirements of this specification.

3.1.14

check valve

Valve that permits fluid to flow freely in one direction and contains a mechanism to automatically prevent flow in the other direction

3.1.15

choke

Equipment used to restrict and control the flow of fluids

3.1.16

choke/kill line

High-pressure line that allows fluids to be pumped into or removed from the well with the BOPs closed

3.1.17

choke/kill manifold

Assembly of valves, chokes, gauges, and lines used to control the rate of flow and pressure from the well when the BOPs are closed
3.1.18 closure bolting
Threaded fasteners (studs, nuts, bolts, and cap screws) used to assemble pressure-containing parts or join end or outlet connections

3.1.19 flow bean
Replaceable orifice part used in positive chokes to control flow rates

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

3.1.21 date of manufacture
Date of the manufacturer’s final acceptance of finished equipment

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

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

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

3.1.25 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.)

3.1.26 fabrication weld
Weld joining two or more parts

3.1.27 flange
Protruding rim with holes to accept bolts and having a sealing mechanism used to join pressure-containing equipment

3.1.28 flexible line
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.

3.1.29
flexloop
    Metallic choke and kill piping designed to accommodate relative deflection between the riser and LMRP.

NOTE   a flexloop and a flexible line may be interchangeable in this function.

3.1.30
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

3.1.31
heat treatment heat treating
    Alternate steps of controlled heating and cooling of materials for the purpose of changing physical or mechanical
    properties

3.1.32
job lot traceability
    Ability for parts to be identified as originating from a job lot that identified the included heat(s)

3.1.33
leak
    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

3.1.34
other end connector (OEC)
    Connector used for joining pressure-containing or pressure-controlling equipment whose dimensions are not
    specified in this standard

NOTE   See API 6A.

3.1.35
pressure-containing part
    Part whose failure to function as intended would result in a release of retained fluid to the atmosphere

    EXAMPLE   Bodies, bonnets, and stems.

3.1.36
pressure-containing weld
    Weld, the absence of which will reduce the pressure-containing integrity of the part

3.1.37
pressure-controlling part
    Part intended to control or regulate the movement of pressurized fluids

    EXAMPLE   Valve-bore sealing mechanisms, choke trim.

3.1.38
pressure integrity
    Structural and leak resistant capability of a product to contain applied pressure

3.1.39
rated working pressure
    Maximum internal pressure equipment is designed to contain and/or control

NOTE   Working pressure is not to be confused with test pressure.
3.1.40 rigid choke and kill line
Rigid piping, straight or with bends, with end connectors, for use in choke and kill equipment

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

3.1.42 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.

3.1.43 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.

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

NOTE Other elements can be added to secure special properties.

3.1.45 weld groove
Area between two metals to be joined that has been prepared to receive weld filler metal

3.1.46 weldment
Assembly whose component parts are joined by welding.

NOTE The weldment includes the weld metal and ½ inch of adjacent base metal on each side.

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

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

ASME American Society of Mechanical Engineers (currently identified as ASME International)
ASTM American Society for Testing and Materials (currently identified as ASTM International)
AWS American Welding Society
ER equivalent round
FSL flexible specification level
ID internal diameter
LMRP lower marine riser package
This document is not an API Standard; it is under consideration within an API technical committee but has not received all approvals required to become an API Standard. It shall not be reproduced or circulated or quoted, in whole or in part, outside of API committee activities except with the approval of the Chairman of the committee having jurisdiction and staff of the API Standards Dept. Copyright API. All rights reserved.

MGS  mud gas separator
NACE  National Association of Corrosion Engineers (currently identified as NACE International)
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
TFA  total flow area
WPS  welding procedure specifications

4 Design Requirements
4.1 Service Conditions
4.1.1 Temperature Ratings

NOTE Minimum temperature is the lowest 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), manufacturer shall refer to API 6A for material property derating.

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

<table>
<thead>
<tr>
<th>Rating</th>
<th>Operating Range °F (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>−4 to 180 (−20 to 82)</td>
</tr>
<tr>
<td>B</td>
<td>−4 to 212 (−20 to 100)</td>
</tr>
<tr>
<td>K</td>
<td>−75 to 180 (−60 to 82)</td>
</tr>
<tr>
<td>L</td>
<td>−50 to 180 (−46 to 82)</td>
</tr>
<tr>
<td>N</td>
<td>−50 to 140 (−46 to 60)</td>
</tr>
<tr>
<td>P</td>
<td>−20 to 180 (−29 to 82)</td>
</tr>
<tr>
<td>S</td>
<td>0 to 140 (−18 to 60)</td>
</tr>
<tr>
<td>T</td>
<td>0 to 180 (−18 to 82)</td>
</tr>
<tr>
<td>U</td>
<td>0 to 250 (−18 to 121)</td>
</tr>
<tr>
<td>V</td>
<td>35 to 250 (2 to 121)</td>
</tr>
<tr>
<td>X</td>
<td>0 to 350 (−18 to 177)</td>
</tr>
</tbody>
</table>

NOTE The use of combined or multiple ratings is permitted.
4.1.2 Rated Working Pressure

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

4.1.3 Fluid Service Conditions

Metallic materials that are exposed to the well fluid shall meet the requirements of NACE MR0175/ISO 15156, including partial pressure rating for H$_2$S of 1.5 psia (10.34 kPa) or higher.

<table>
<thead>
<tr>
<th>Table 2—Equipment Bore Sizes and Rated Working Pressures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size (Minimum Through Bore)</strong></td>
</tr>
<tr>
<td>in. (mm)</td>
</tr>
<tr>
<td>2(\frac{1}{16}) (52)</td>
</tr>
<tr>
<td>2(\frac{5}{16}) (65)</td>
</tr>
<tr>
<td>3(\frac{1}{8}) (78)</td>
</tr>
<tr>
<td>4(\frac{1}{16}) (103)</td>
</tr>
<tr>
<td>2(\frac{1}{16}) (52)</td>
</tr>
<tr>
<td>2(\frac{5}{16}) (65)</td>
</tr>
<tr>
<td>3(\frac{1}{8}) (78)</td>
</tr>
<tr>
<td>4(\frac{1}{16}) (103)</td>
</tr>
<tr>
<td>2(\frac{1}{16}) (52)</td>
</tr>
<tr>
<td>2(\frac{5}{16}) (65)</td>
</tr>
<tr>
<td>3(\frac{1}{8}) (78)</td>
</tr>
<tr>
<td>4(\frac{1}{16}) (103)</td>
</tr>
<tr>
<td>5(\frac{1}{8}) (130)</td>
</tr>
<tr>
<td>1(\frac{13}{16}) (46)</td>
</tr>
<tr>
<td>2(\frac{1}{16}) (52)</td>
</tr>
<tr>
<td>2(\frac{5}{16}) (65)</td>
</tr>
<tr>
<td>3(\frac{1}{16}) (78)</td>
</tr>
<tr>
<td>4(\frac{1}{16}) (103)</td>
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<tr>
<td>5(\frac{1}{8}) (130)</td>
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<tr>
<td>1(\frac{5}{16}) (46)</td>
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<tr>
<td>2(\frac{1}{16}) (52)</td>
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<tr>
<td>2(\frac{5}{16}) (65)</td>
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<tr>
<td>3(\frac{1}{16}) (78)</td>
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<tr>
<td>4(\frac{1}{16}) (103)</td>
</tr>
<tr>
<td>5(\frac{1}{8}) (130)</td>
</tr>
<tr>
<td>1(\frac{13}{16}) (46)</td>
</tr>
<tr>
<td>2(\frac{1}{16}) (52)</td>
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<tr>
<td>2(\frac{5}{16}) (65)</td>
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<tr>
<td>3(\frac{1}{16}) (78)</td>
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<tr>
<td>4(\frac{1}{16}) (103)</td>
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<tr>
<td>5(\frac{1}{8}) (130)</td>
</tr>
<tr>
<td>1(\frac{13}{16}) (46)</td>
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<tr>
<td>2(\frac{1}{16}) (52)</td>
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<tr>
<td>2(\frac{5}{16}) (65)</td>
</tr>
<tr>
<td>3(\frac{1}{16}) (78)</td>
</tr>
<tr>
<td>4(\frac{1}{16}) (103)</td>
</tr>
<tr>
<td>5(\frac{1}{8}) (130)</td>
</tr>
<tr>
<td>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).</td>
</tr>
</tbody>
</table>
### Table 3—Union, Swivel Union, and Articulated Line Sizes and Rated Working Pressures

<table>
<thead>
<tr>
<th>Nominal Size in. (mm)</th>
<th>Rated Working Pressure psi (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (25.4)</td>
<td></td>
</tr>
<tr>
<td>1½ (38.1)</td>
<td></td>
</tr>
<tr>
<td>2 (50.8)</td>
<td>3000 (20.7)</td>
</tr>
<tr>
<td>2½ (63.5)</td>
<td>6000 (41.4)</td>
</tr>
<tr>
<td>3 (76.2)</td>
<td></td>
</tr>
<tr>
<td>4 (101.6)</td>
<td></td>
</tr>
<tr>
<td>1 (25.4)</td>
<td></td>
</tr>
<tr>
<td>1½ (38.1)</td>
<td>5000 (34.5)</td>
</tr>
<tr>
<td>2 (50.8)</td>
<td>7500 (51.8)</td>
</tr>
<tr>
<td>2½ (63.5)</td>
<td></td>
</tr>
<tr>
<td>3 (76.2)</td>
<td></td>
</tr>
<tr>
<td>4 (101.6)</td>
<td></td>
</tr>
<tr>
<td>1 (25.4)</td>
<td></td>
</tr>
<tr>
<td>2 (50.8)</td>
<td>10,000 (69.0)</td>
</tr>
<tr>
<td>3 (76.2)</td>
<td></td>
</tr>
<tr>
<td>4 (101.6)</td>
<td></td>
</tr>
<tr>
<td>4½ (114.3)</td>
<td></td>
</tr>
<tr>
<td>2 (50.8)</td>
<td></td>
</tr>
<tr>
<td>2½ (63.5)</td>
<td></td>
</tr>
<tr>
<td>3 (76.2)</td>
<td></td>
</tr>
<tr>
<td>4 (101.6)</td>
<td></td>
</tr>
<tr>
<td>4½ (114.3)</td>
<td></td>
</tr>
<tr>
<td>2 (50.8)</td>
<td></td>
</tr>
<tr>
<td>2½ (63.5)</td>
<td></td>
</tr>
<tr>
<td>3 (76.2)</td>
<td></td>
</tr>
<tr>
<td>4 (101.6)</td>
<td></td>
</tr>
</tbody>
</table>

### Table 4—Flexible Line Sizes and Rated Working Pressures

<table>
<thead>
<tr>
<th>Inner Diameter in. (mm)</th>
<th>Rated Working Pressure psi (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 (50.8)</td>
<td></td>
</tr>
<tr>
<td>3 (76.2)</td>
<td>5000 (34.5)</td>
</tr>
<tr>
<td>3½ (88.9)</td>
<td></td>
</tr>
<tr>
<td>4 (101.6)</td>
<td></td>
</tr>
<tr>
<td>2 (50.8)</td>
<td></td>
</tr>
<tr>
<td>2½ (63.5)</td>
<td>10,000 (69.0)</td>
</tr>
<tr>
<td>3 (76.2)</td>
<td></td>
</tr>
<tr>
<td>4 (101.6)</td>
<td></td>
</tr>
<tr>
<td>2 (50.8)</td>
<td></td>
</tr>
<tr>
<td>2½ (63.5)</td>
<td>15,000 (103.5)</td>
</tr>
<tr>
<td>3 (76.2)</td>
<td></td>
</tr>
<tr>
<td>4 (101.6)</td>
<td></td>
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<tr>
<td>2 (50.8)</td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>3 (76.2)</td>
<td></td>
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<tr>
<td>4 (101.6)</td>
<td></td>
</tr>
<tr>
<td>2 (50.8)</td>
<td></td>
</tr>
<tr>
<td>2½ (63.5)</td>
<td>20,000 (138.0)</td>
</tr>
<tr>
<td>3 (76.2)</td>
<td></td>
</tr>
<tr>
<td>4 (101.6)</td>
<td></td>
</tr>
</tbody>
</table>
4.1.4 Targeted and Fluid Cushion Connections

All ninety-degree ells, crosses, and tees shall have fluid cushions in the direction of flow. Filled target flanges shall not be used. For examples of fluid cushions see Figure 1.

A blind flange or blind end without fluid cushion shall be acceptable, provided that the total bore depth from the intersecting bore (L) is one nominal bore diameter or greater.

NOTE An example is a buffer chamber(s) with flanges fitted to downstream connections. For examples see Figure 2.

Fluid cushions connections that include pressure-boundary penetrations shall conform to API 6A requirements for test gauge connections.

Figure 1A

Fluid Cushion Bi-Directional

Figure 1B

Fluid Cushion Single Direction

Figure 1C

Weld Fitting Connection

Figure 1D

Flanged Tee Connection - Fluid Cushion

Figure 1E

Flanged Tee Connection - Blind Flange

Figure 1F

Fluid Cushion - Single Direction

Figure 1—Example – Pressure line with cushion targets
Fluid cushion cavity depth (D) shall be greater than or equal to the nominal diameter of the bore as shown in figure 3. B shall be equal to the nominal bore ID diameter.

The wall thickness of fluid cushion components that are not excluded from design and development shall be analyzed using the design methods specified in 4.3.

In cases where the incoming flow intersects a header, the flow shall be considered targeted if the diameter of the header is greater than or equal to twice the diameter of the inlet end connections, as in Figure 4.
Short radius pipe bends ($R/d < 10$) shall not be allowed except in cases when the surrounding geometries do not allow the use of fluid cushions, then the equipment owner shall specify a PM program to address the risk of erosion.

$R$ is the radius of pipe bend measured at the centerline in inches (centimeters), and $d$ is the ID of the pipe in inches (centimeters).

Acceptable bending radius of flexible choke and kill lines shall be per 10.8.6. When the surrounding geometries do not allow the use of fluid cushions, then the OEM shall specify a PM program to address the risk of erosion.

### 4.2 Product Specification

The following products shall meet the requirements of API 6A, PSL 3 (or higher), and shall have a 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 wellbore fluids;
- g) threaded end connections;
- h) valve actuator components exposed to wellbore fluids.

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

### 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 Equation 1:

$$SE = SY$$  \hspace{1cm} (Eq.1)

where

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

$SY$ 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

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.

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

### 4.3.6 Mud Gas Separators

Section 4.3.6 shall apply to atmospheric mud gas separators. This document shall not apply to pressurized mud gas separators. Mud gas separators shall be designed and constructed in accordance with a recognized pressure vessel codes such as ASME Boiler and Pressure Vessel Code Section VIII, Division 1, EN 13445, PD 5500 or equivalent.

### 4.4 Performance Requirements

#### 4.4.1 General

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 shall be allowed.

#### 4.4.5 Load Capability

Products shall be designed to 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.

4.6 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 Equation 2:

\[ Sa = 0.83 \, Sy \quad \text{and} \quad Sb = 1.0 \, Sy \]  

(Eq. 2)

where

- \( Sa \) is the maximum allowable tensile stress;
- \( Sy \) is the bolting material specified minimum yield strength;
- \( Sb \) is the maximum allowable tensile membrane plus bending stress.

4.7 Clamps

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

4.8 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.

4.9 Design Documentation

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

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.

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.

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 shall apply to the material performance, processing, and compositional requirements for all pressure-containing or pressure-controlling 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 Metallic Parts

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

a. material composition with tolerance
b. material qualification
c. allowable melting practice(s)
d. forming practice(s)
e. heat treatment procedure, including cycle time and temperature with tolerances, heat treating equipment and cooling media, heating and cooling requirements
f. NDE requirements
g. mechanical property requirements
h. weld repair requirements
i. material traceability
j. furnace calibrations and certification
k. melting practice

5.3 Non-metallic Parts

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

a. Generic base polymer(s)
b. Hardness in accordance with ASTM D2240 or ASTM D1415
c. Tensile and elongation properties in accordance with ASTM D412 or ASTM D1414
d. Compression set in accordance with ASTM D395 or ASTM D1414
e. Immersion (fluid compatibility) testing in accordance with ASTM D471 or ASTM D1414
f. test liquid, temperature, and the duration of the test shall be defined
g. test shall be performed at or above the extreme temperature rating of the nonmetallic sealing components in which the elastomeric material is used, per Table 1.
h. Material qualifications and physical property changes after testing
i. Storage requirements
j. Visual Inspection Requirements
k. Acceptance and/or rejection criteria.

5.4 Bolting for Choke and Kill Equipment

For equipment covered in 4.2, bolting shall conform to API 6A bolting specifications.

For equipment not covered in 4.2, the Original Equipment Manufacturers (OEMs) shall have a documented procedure for the qualification of bolting manufacturers, which follows the requirements of API 20E and API 20F. Bolting manufactured from low alloy steel or carbon steel (including utility bolting) shall be limited to 34 HRC maximum due to concerns with hydrogen embrittlement. Bolting exposed to wellbore fluids shall meet the requirements of NACE MR0175/ISO 15156. OEMs shall specify the thread form and dimensions of studs, nuts and bolts. When plating or coating is specified refer to API 20E or 20F.

Bolting specification levels shall meet the requirements of Table 5.

<table>
<thead>
<tr>
<th>Material</th>
<th>Minimum Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed Bolting</td>
<td>Alloy Steel and Carbon Steel Stainless Steel and CRA</td>
</tr>
<tr>
<td></td>
<td>API 20E BSL-2</td>
</tr>
<tr>
<td></td>
<td>API 20F BSL-2</td>
</tr>
<tr>
<td>Class 3 Bolting</td>
<td>Alloy Steel and Carbon Steel Stainless Steel and CRA</td>
</tr>
<tr>
<td></td>
<td>API 20E BSL-3</td>
</tr>
<tr>
<td></td>
<td>API 20F BSL 3</td>
</tr>
<tr>
<td>Class 2 Bolting</td>
<td>Alloy Steel and Carbon Steel Stainless Steel and CRA</td>
</tr>
<tr>
<td></td>
<td>API 20E BSL-1</td>
</tr>
<tr>
<td></td>
<td>API 20F BSL-2</td>
</tr>
<tr>
<td>Utility Bolting</td>
<td>Alloy Steel and Carbon Steel Stainless Steel and CRA</td>
</tr>
<tr>
<td></td>
<td>Mfg. Spec.</td>
</tr>
<tr>
<td></td>
<td>Mfg. Spec.</td>
</tr>
</tbody>
</table>

5.5 Flexible Lines

Material requirements for flexible lines shall be per manufacturer’s written specifications.

5.6 Special Materials

Special corrosion and abrasion resistant materials and coatings shall conform to the manufacturer’s written specifications and shall include minimum acceptance criteria.

5.7 Pressure Containing Parts

Material requirements for pressure containing parts shall be as described in this section. Metallic components exposed to well bore fluid shall meet the requirements of NACE MR0175/ISO 15156.

5.8 Casting Practices

The manufacturer shall have either:
- A written specification that establishes limits for sand control, core making, rigging and melting.
- Identify a casting supplier that establishes limits for sand control, core making, rigging and melting.

5.9 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.

Forgings shall have a minimum 3:1 reduction ratio.

5.10 Chemical Composition

Material composition shall be determined on a per heat basis (or a remelt ingot basis for remelt grade materials) and shall meet the requirements of Table 6, Table 7 and Table 8.
Table 6—Pressure-containing Parts Material Designation

<table>
<thead>
<tr>
<th>API Material Designation</th>
<th>Part</th>
<th>Rated Working Pressure psi (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2000 (13.8)</td>
</tr>
<tr>
<td>Body, bonnet and rigid piping</td>
<td>36K (248)</td>
<td>36K (248)</td>
</tr>
<tr>
<td></td>
<td>45K (310)</td>
<td>45K (310)</td>
</tr>
<tr>
<td>End and outlet connection</td>
<td>60K (413)</td>
<td>60K (413)</td>
</tr>
<tr>
<td>Blind flange</td>
<td>75K (517)</td>
<td>75K (517)</td>
</tr>
</tbody>
</table>

NOTE Non-standard materials are acceptable if their design stress intensity $S_m$ 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

<table>
<thead>
<tr>
<th>Alloying Element</th>
<th>Carbon and Low Alloy Steels (WT %)</th>
<th>Martensitic Stainless Steels (WT %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.45</td>
<td>0.15</td>
</tr>
<tr>
<td>Chromium</td>
<td>2.75</td>
<td>11.0 to 14.0</td>
</tr>
<tr>
<td>Manganese</td>
<td>1.80</td>
<td>1.00</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>1.50</td>
<td>1.00</td>
</tr>
<tr>
<td>Nickel</td>
<td>1.00</td>
<td>4.50</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>0.025</td>
<td>0.025</td>
</tr>
<tr>
<td>Silicon</td>
<td>1.00</td>
<td>1.50</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.025</td>
<td>0.025</td>
</tr>
<tr>
<td>Vanadium</td>
<td>0.30</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* Steels containing less than 11% Chromium shall be considered as low alloy steels.
Table 8—Alloying Element Maximum Tolerance Range Requirements (Values in WT %)

<table>
<thead>
<tr>
<th>Alloying Elements</th>
<th>Carbon and Low Alloy Steels</th>
<th>Martensitic Stainless Steels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.50</td>
<td>—</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.30</td>
<td>0.35</td>
</tr>
<tr>
<td>Vanadium</td>
<td>0.10</td>
<td>0.10</td>
</tr>
</tbody>
</table>

NOTE These values are the maximum allowable for any specific element, and not exceed the maximum specified in Table 7

5.11 Qualification Test Coupon

Qualification Test Coupons (QTC) shall be in accordance with all requirements in API 6A.

5.12 Heat Treatment

5.12.1 General

All heat-treatment operations shall be performed utilizing equipment calibrated and surveyed in accordance with Annex D.

5.12.2 Quenching

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

a.) Water quenching - The temperature of the water or water-based quenching medium shall not exceed 38°C (100 °F) at the start of the quench, nor exceed 49 °C (120 °F) at the completion of the quench.

b.) Oil quenching - The temperature of any oil medium shall be greater than 38 °C (100 °F) at the start of the quench.

c.) Polymer quenching - The temperature of polymer shall be as prescribed by the polymer medium manufacturer.

5.13 Mechanical Testing

5.13.1 Tensile Testing

A minimum of one tensile test shall be performed on a qualification test coupon (QTC) per heat and per heat treat lot at a temperature between 40 °F and 120 °F (4.4 °C and 48.9 °C) in accordance with ASTM A370.

The results of the tensile test(s) shall satisfy the applicable requirements of Table 9. If the results of the first tensile test does not satisfy the applicable requirements, an additional test may be performed to qualify the material. The additional test shall consist of a minimum of two tensile tests without any additional heat treatments. The results of both tests shall satisfy the applicable requirements.
Table 9—Pressure-containing Parts Material Property Requirements

<table>
<thead>
<tr>
<th>API Material Designation</th>
<th>Yield Strength Minimum (^{a}) psi (MPa)</th>
<th>Tensile Strength Minimum psi (MPa)</th>
<th>Elongation Minimum %</th>
<th>Reduction in Area Minimum %</th>
</tr>
</thead>
<tbody>
<tr>
<td>36K</td>
<td>36,000 (248)</td>
<td>70,000 (483)</td>
<td>21</td>
<td>32</td>
</tr>
<tr>
<td>45K</td>
<td>45,000 (310)</td>
<td>70,000 (483)</td>
<td>19</td>
<td>32</td>
</tr>
<tr>
<td>60K</td>
<td>60,000 (414)</td>
<td>85,000 (586)</td>
<td>18</td>
<td>35</td>
</tr>
<tr>
<td>75K</td>
<td>75,000 (517)</td>
<td>95,000 (655)</td>
<td>18</td>
<td>35</td>
</tr>
<tr>
<td>Nonstandard</td>
<td>As specified</td>
<td>As specified</td>
<td>15</td>
<td>25</td>
</tr>
</tbody>
</table>

\(^{a}\) By 0.2% Offset. Alternatively, 0.65% EUL Method may be used for pipe.

5.13.2 Impact Testing

A minimum of one set of Charpy V Notch impact tests shall be performed on a qualification test coupon (QTC) per heat and per heat treat lot in accordance with ASTM A370. Test temperature shall be at or below the applicable temperature rating in Table 10.

Table 10—Acceptance Criteria Charpy V-notch Impact Requirements

<table>
<thead>
<tr>
<th>Temperature Rating</th>
<th>Test Temperature °F (°C)</th>
<th>Minimum Average Impact Value for Three Specimens ft-lb. (J)</th>
<th>Minimum Impact Value Permitted for One Specimen Only Per Set ft-lb. (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, B</td>
<td>– 4 (--20)</td>
<td>15 (20) Wrought Transverse or Castings</td>
<td>10 (14) Wrought Transverse or Castings</td>
</tr>
<tr>
<td>K</td>
<td>–75 (--60)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>–20 (--29)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S, T, U, X, Y</td>
<td>0 (--18)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Full size specimens shall be used except where there is insufficient material. In this case, the largest sub-size specimen obtainable shall be used. Sub-size absorbed energy requirements shall be reduced per ASTM A370.

For rigid piping, when the use of full-size (10 mm × 10 mm) transverse test specimens is not possible, the largest possible sub-size transverse test specimen shall be used. When it is not possible to test using transverse test specimens, the largest possible longitudinal test specimen shall be used. Acceptance criteria shall be per Table 9.

5.14 Mud Gas Separators

Materials for mud gas separators shall satisfy the requirements of 4.3.6 and NACE MR0175.

6 Welding
6.1 General

All welding of components exposed to wellbore fluid shall conform to the welding requirements of NACE MR0175/ISO 15156. Verification of conformance shall be established through implementation of the manufacturer’s written welding procedure specification (WPS) and the supporting procedure qualification record (PQR). When material specifications for pressure-containing and pressure-controlling components require impact testing, verification of conformance shall be established through implementation of the manufacturer’s WPS and supporting PQR.

New and repair welds shall be mapped to provide traceability for the weld. Repair welds shall be mapped on a separate weld map. Weld maps shall contain the following traceability information for each weld, at a minimum:

- part sketch denoting new weld/repair area
- part number
- serial number
- welder’s name
- welder’s stamp number
- PT/MT report number of verification of defect removal
- WPS used
- filler material heat/batch/lot
- weld flux heat/batch/lot, if used
- number PWHT hours used
- number PWHT hours remaining

6.2 Welding Procedure and Performance Qualification

Welding procedure and performance qualifications for pressure-containing or controlling parts shall be performed in accordance with ASME BPVC, Section IX, or equivalent national or international standard.

Welding procedure and performance qualifications for structural, non-pressure containing, or non-pressure controlling parts shall be performed in accordance with AWS D1.1, ASME BPVC, Section IX, or equivalent national or international standard.

6.3 Pressure-containing Fabrication Weldments

6.3.1 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.

6.3.2 Materials

6.3.2.1 Welding Consumables

Welding consumables shall conform to ASME BPVC Section II, Part C, 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.

6.3.2.2 Deposited Weld Metal Properties

6.3.2.2.1 General
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.

6.3.2.2.2 Post Weld Heat Treatment

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.

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

6.3.3 Post-weld Heat Treatment

6.3.3.1 General

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.

6.3.3.2 Local PWHT

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.

6.3.4 Impact Testing

When impact testing is required by the base material specification, testing shall be performed per the instructions and diagrams as outlined in Annex I or, alternatively, the following paragraphs shall be followed.

NOTE The preferred method is outlined in Annex I.

When impact testing is required by the base material specification, the testing shall be performed in accordance with ASTM A370 using the Charpy V-notch technique. Results of testing in the weld and base material HAZ shall meet the minimum requirements of the base material. Records of results shall become part of the PQR. When impact testing is required of the base material, 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 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) shall include HAZ material as specified in the manufacturer's written procedure;

c. When weld thickness of the product is equal to or greater than 2 in. (50 mm), impact testing shall be performed on weld metal and HAZ material removed within 1/4 thickness.

6.3.5 Hardness Testing

6.3.5.1 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.
6.3.5.2 Rockwell Method

The Rockwell Method shall be in accordance with ASTM E18 or ISO 6508-1. Test locations shall be as shown in Figure 5. For a weld cross-section thickness less than \( \frac{1}{2} \) 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 \( \frac{1}{2} \) in. (12.7 mm), six hardness tests each shall be made in the base material(s), the weld, and the HAZ.

![Figure 5—Welding Procedure Qualification Rockwell Hardness Test Locations](image)

For all thicknesses, HAZ hardness tests shall be performed in the base material with \( \frac{1}{16} \) in. (1.6 mm) of the weld interface and at least one each within \( \frac{1}{8} \) in. (3.2 mm) from top and bottom of the weld.

6.3.5.3 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 6. For a weld cross-section thickness less than \( \frac{1}{2} \) 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 \( \frac{1}{2} \) in. (12.7 mm), six hardness tests each shall be made in the base material(s) and the weld.
6.3.6 Welding Controls

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

6.3.7 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.

6.3.8 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.

6.3.9 Quality Control Requirements

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

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 Access
There shall be adequate access to evaluate, remove, repair, and inspect a nonconforming condition. If a nonconforming condition does not have adequate access to evaluate, remove, repair, and inspect, the part shall be rejected.

6.4.2 Welder/Welding Operator Qualification

6.4.2.1 General

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

6.4.2.2 Hole Repair Performance Qualification

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.

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.

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:

a. nickel, 8.0 % minimum;
b. chromium, 16.0 % minimum;

c. carbon, 0.08 % maximum.

6.5.2.1 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.

6.5.2.2 API Grooves

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

6.5.2.3 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

For ring groove overlays made of stainless steel filler metal, 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.

NOTE This requirement does not apply to nickel based overlays.

6.5.3 Corrosion Resistant Overlays Other Than Ring Grooves

Corrosion resistant weld overlay for bodies, bonnets, drilling riser choke and kill, and end and outlet connectors for purposes other than ring grooves, shall be per manufacturer’s written specifications.

6.5.4 Welding Procedure/Performance Qualification

6.5.4.1 General

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

6.5.4.2 Mechanical Properties

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.

6.5.4.3 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.
6.5.4.4 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 7).

![Hardness Test Locations](image)

Figure 7—Hardness Test Locations

6.6 Weld NDE

6.6.1 General

Completed weldments 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 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.

6.6.2 Weld NDE—Visual

6.6.2.1 General

Weldments shall be visually examined by the welding inspector for 100% of the length after post-weld heat treatment and machining operations.

6.6.2.2 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.

6.6.3 Weld NDE—Surface

6.6.3.1 General

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.
6.6.3.2 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.

6.6.3.3 Acceptance Criteria for Surfaces Other Than Pressure-contact (Metal-to-metal) Sealing Surfaces

Acceptance criteria are:

a. No relevant indication with a major dimension equal to or greater than 3/16 in. (5 mm);

b. No more than 10 relevant indications in any continuous 6 in.² (40 cm²) 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.

6.6.3.4 Acceptance Criteria for Pressure-contact (Metal-to-metal) Sealing Surfaces

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

6.6.4 Weld NDE—Volumetric

6.6.4.1 General

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 cm²) 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.

6.6.4.2 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.

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 11;
Table 11—Weld Inclusion Length Acceptance Criteria—
Radiographic and Ultrasonic Methods
Dimensions in inches (mm)

<table>
<thead>
<tr>
<th>Thickness $T$</th>
<th>Inclusion Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 0.76 (19.3)</td>
<td>0.25 (6.4)</td>
</tr>
<tr>
<td>0.76 (19.3) to 2.25 (57.2)</td>
<td>0.33$T$</td>
</tr>
<tr>
<td>Greater than 2.25 (57.2)</td>
<td>0.75 (19.1)</td>
</tr>
</tbody>
</table>

a. $T$ is the pressure vessel wall thickness.

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.

6.6.4.3 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 11.

6.6.5 Weld NDE—Hardness Testing

6.6.5.1 General

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

6.6.5.2 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.

6.6.5.3 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.
6.7 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.

6.8 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 Quality Control

7.1 Measuring and Testing Equipment

7.1.1 Equipment Control

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.

7.1.2 Measurement Standards and Measuring Equipment

7.1.2.1 Equipment Standards

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.

7.1.2.2 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.

NOTE 1 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.

NOTE 2 If the identification cannot be applied directly to the gauge, it may be applied to a tag affixed to the gauge or the gauge container.

7.1.2.3 Measuring Equipment Records

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

— unique identification of measurement standard or equipment;
— identification of the procedure used in the calibration of the measurement standard or equipment;
— planned calibration interval;
— date and results of each calibration including actual readings taken prior to adjustment, corrections, or repairs;
— due date for next calibration;
— individual performing calibration and facility performing calibration;
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.

### 7.1.2.4 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.

**NOTE** Measuring equipment requiring high levels of accuracy, which approach state of the art or natural physical constant limitations, are excluded from this requirement.

### 7.1.2.5 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.

### 7.1.2.6 Calibration Labeling

Measurement standards and measuring equipment shall be labeled, coded, or otherwise identified to indicate the calibration status, per manufacturer's written procedure. Any limitation or restriction of use shall be clearly indicated on the equipment.

### 7.1.3 Pressure-measuring Devices

#### 7.1.3.1 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.

#### 7.1.3.2 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).

#### 7.1.3.3 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.

### 7.2 Quality Control Personnel Qualifications

#### 7.2.1 Nondestructive Examination (NDE) Personnel

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

#### 7.2.2 Visual Inspection Personnel

Personnel performing visual examination shall have an annual eye exam in accordance with ASNT SNT-TC-1A or ISO 9712.
7.2.3 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.

7.2.4 Other Personnel

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

7.3 Quality Control Requirements

7.3.1 General

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

7.3.2 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.

7.3.3 Bodies, Bonnets, Rigid Choke and Kill Lines, and End and Outlet Connections

7.3.3.1 General

Quality control requirements for bodies, bonnets, choke and kill lines, and end and outlet connections are listed in Table 12.

<table>
<thead>
<tr>
<th>Quality Requirement</th>
<th>Bodies, Bonnets, and End and Outlet Connections</th>
<th>Rigid Choke and Kill Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness testing</td>
<td>7.4.6.4</td>
<td>Note</td>
</tr>
<tr>
<td>Dimensional verification</td>
<td>7.4.6.5</td>
<td>Note</td>
</tr>
<tr>
<td>Traceability</td>
<td>7.4.6.6</td>
<td>Note</td>
</tr>
<tr>
<td>Chemical analysis</td>
<td>7.4.6.7</td>
<td>Note</td>
</tr>
<tr>
<td>Surface NDE</td>
<td>7.4.6.9</td>
<td>Note</td>
</tr>
<tr>
<td>Volumetric NDE</td>
<td>7.4.6.10</td>
<td>Note</td>
</tr>
<tr>
<td>Serialization</td>
<td>7.4.6.13</td>
<td>Note</td>
</tr>
<tr>
<td>Weld NDE - General</td>
<td>7.4.6.11.1</td>
<td>7.4.6.11.1</td>
</tr>
<tr>
<td>Weld examination - Visual</td>
<td>7.4.6.11.2</td>
<td>7.4.6.11.2</td>
</tr>
</tbody>
</table>
### 7.3.3.2 Hardness Testing

#### 7.3.3.2.1 General

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

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.

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.

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.

#### 7.3.3.2.2 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 13 (see NACE MR0175/ISO 15156 for maximum hardness values). Minimum hardness of non-standard materials shall conform to the manufacturer’s documented criteria.

<table>
<thead>
<tr>
<th>API Material Designations</th>
<th>Brinell Hardness Number</th>
<th>Rockwell Hardness Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>36 ksi</td>
<td>HB 140</td>
<td>HRB 77.5</td>
</tr>
<tr>
<td>45 ksi</td>
<td>HB 140</td>
<td>HRB 77.5</td>
</tr>
<tr>
<td>60 ksi</td>
<td>HB 174</td>
<td>HRB 87.8</td>
</tr>
<tr>
<td>75 ksi</td>
<td>HB 197</td>
<td>HRB 92.8</td>
</tr>
<tr>
<td>80 ksi</td>
<td>HB 207</td>
<td>HRB 94.6</td>
</tr>
</tbody>
</table>

#### 7.3.3.2.3 Alternative Acceptance Criteria

If hardness test results do not meet the required minimum hardness value, the part shall be acceptable if the calculated tensile strength based on the hardness measurement meets the requirements of 7.4 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 Equation 3:
\[ HB_c = \frac{UTS \times HB_{QTC}}{UTS_{QTC}} \]

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.

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

### 7.3.3.3 Dimensional Verification

#### 7.3.3.3.1 Critical Dimensions

The manufacturer shall specify and document the critical dimensions for each product.

The manufacturer shall verify critical dimensions.

#### 7.3.3.3.2 Acceptance Criteria

Acceptance criteria for critical dimensions shall be as required by the manufacturer’s written specification.

#### 7.3.3.3.3 Thread Dimensions

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.

#### 7.3.3.3.4 Thread Acceptance Criteria

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

### 7.3.3.4 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.

### 7.3.3.5 Surface NDE

#### 7.3.3.5.1 General

Surface NDE requirements shall be as follows:

- accessible surfaces of each finished part shall be examined after final heat treatment and final machining operations;
- all magnetic particle examinations shall use the wet fluorescent method;
- surface NDE shall be performed on all surfaces prepared for weld overlay.
7.3.3.5.2 Surface NDE—Ferromagnetic Materials

7.3.3.5.2.1 General

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

7.3.3.5.2.2 Acceptance Criteria

Acceptance criteria shall be as follows:

— no relevant indication with a major dimension equal to or greater than 3/16 in. (4.8 mm);
— no more than ten relevant indications in any contiguous 6 in. (152.4 mm) square area;
— four or more relevant indications in a line separated by less than 1/16 in. (1.6 mm) edge-to-edge are unacceptable;
— no relevant indications in the pressure contact sealing surfaces.

7.3.3.5.3 Surface NDE—Non-ferromagnetic Materials

All non-ferromagnetic materials shall be examined in accordance with procedures specified in ASTM E165.

Acceptance criteria are as follows:

— no relevant linear indications;
— no relevant rounded indication with a major dimension equal to or greater than 3/16 in. (4.8 mm);
— four or more relevant rounded indications in a line separated by less than 1/16 in. (1.6 mm) edge-to-edge are unacceptable;
— no relevant indications in pressure contact sealing surfaces.

7.3.3.5.4 Volumetric NDE

7.3.3.5.4.1 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 or secondary temper treatments) and prior to machining operations that limit effective interpretation of the results of the examination.

7.3.3.5.4.2 Method—Ultrasonic Examination

7.3.3.5.4.2.1 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, to a nationally recognized standard E1001 or E2375 may be used) and ASTM E428.

7.3.3.5.4.2.2 Castings

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

7.3.3.5.4.2.3 Calibration

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

— 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);
— 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);
— 1/4 in. (6.4 mm) flat bottom hole for metal thicknesses exceeding 6 in. (152.4 mm).

7.3.3.5.4.2.4 Acceptance Criteria

The acceptance criteria shall be:

— 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.

7.3.3.5.5 Method—Radiographic Examination for Castings

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.

NOTE 1 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%.

NOTE 2 Wire-type image quality indicators are acceptable for use in accordance with ASTM E747.

NOTE 3 See Table 14 for castings acceptance criteria.

<table>
<thead>
<tr>
<th>Type Defect</th>
<th>Maximum Defect Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
</tr>
<tr>
<td>C (All Types)</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>None acceptable</td>
</tr>
<tr>
<td>E</td>
<td>None acceptable</td>
</tr>
<tr>
<td>F</td>
<td>None acceptable</td>
</tr>
<tr>
<td>G</td>
<td>None acceptable</td>
</tr>
</tbody>
</table>

NOTE See ASTM E186, ASTM E280 and ASTM E446.

7.3.4 Stems

7.3.4.1 General

NOTE Table 15 lists the quality control requirements for stems.

<table>
<thead>
<tr>
<th>Quality Requirement</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness testing</td>
<td>7.4.6.4</td>
</tr>
<tr>
<td>Dimensional verification</td>
<td>7.4.6.5</td>
</tr>
<tr>
<td>Traceability</td>
<td>7.4.6.6</td>
</tr>
<tr>
<td>Chemical analysis</td>
<td>7.4.6.7</td>
</tr>
<tr>
<td>Surface NDE</td>
<td>7.4.6.9</td>
</tr>
<tr>
<td>Volumetric NDE</td>
<td>7.4.6.10</td>
</tr>
<tr>
<td>Serialization</td>
<td>7.4.6.13</td>
</tr>
<tr>
<td>Welds</td>
<td>7.4.6.11.1</td>
</tr>
</tbody>
</table>
7.3.4.2 Volumetric Examination

7.3.4.2.1 Sampling

Each stem shall be ultrasonically inspected.

7.3.4.2.2 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.

7.3.4.2.3 Calibration

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

7.3.4.2.4 Acceptance Criteria

Acceptance criteria shall be in accordance with 7.4.6.9.

7.3.4.2.5 Welds

Weld repairs to stems shall be prohibited.

7.4 Pressure-controlling Parts

7.3.4.3 Pressure-controlling Metallic Parts

Pressure-controlling metallic parts shall follow the quality control requirements from Table 10.

7.3.4.4 Pressure-controlling Non-Metallic Parts

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

7.3.5 Drilling Chokes

Pressure-containing and Pressure-controlling metallic parts shall follow the quality control requirements from Table 10.

Stems shall follow the quality control requirements in section 7.4.4

7.3.6 Actuators for Drilling Chokes

7.3.6.1 Pressure-containing Parts

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

7.3.6.2 Job Lot Traceability

Pressure-containing parts of actuators having a rated 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).

7.3.7 Non-metallic Sealing Material

7.3.7.1 Quality Control Requirements

Quality of non-metallic seals shall be controlled in accordance with Table 16.

Table 16—Quality Control Requirements for Non-metallic Sealing Material
### Quality Requirement

<table>
<thead>
<tr>
<th>Quality Requirement</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensional verification</td>
<td>7.4.11.2</td>
</tr>
<tr>
<td>Visual examination</td>
<td>7.4.11.3</td>
</tr>
<tr>
<td>Hardness testing</td>
<td>7.4.11.4</td>
</tr>
<tr>
<td>Documentation</td>
<td>7.4.11.5</td>
</tr>
<tr>
<td>Batch traceability</td>
<td></td>
</tr>
<tr>
<td>Cure date certification</td>
<td></td>
</tr>
<tr>
<td>Shelf life expiration date</td>
<td></td>
</tr>
<tr>
<td>certification</td>
<td></td>
</tr>
</tbody>
</table>

#### 7.3.7.2 Dimensional Verification

##### 7.3.7.2.1 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.

##### 7.3.7.2.2 Method

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

##### 7.3.7.2.3 Acceptance Criteria

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

#### 7.3.7.3 Visual Examination

##### 7.3.7.3.1 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.

##### 7.3.7.3.2 Method

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

##### 7.3.7.3.3 Acceptance Criteria

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

#### 7.3.7.4 Hardness Testing

##### 7.3.7.4.1 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.

##### 7.3.7.4.2 Method

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

##### 7.3.7.4.3 Acceptance Criteria

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

#### 7.3.7.5 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.

7.3.8 Metallic Sealing Materials Quality Control Requirements

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

7.3.9 Flexible Choke and Kill Lines

7.3.9.1 Pressure-containing Parts

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

— metallic wetted end and outlet connections and end terminations;
— metallic non-wetted reinforcement windings and end terminations;
— non-metallic non-wetted pressure-containing parts shall be defined by the manufacturer.

7.3.9.2 Quality Control Requirements

NOTE Table 17 lists the quality control requirements for the pressure-containing parts of flexible lines.

<table>
<thead>
<tr>
<th>Quality Requirement</th>
<th>Metallic Parts (Wetted)</th>
<th>Metallic Parts (Non-wetted)</th>
<th>Non-metallic Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile testing</td>
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<td>Impact testing</td>
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<td>N/A</td>
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<td>7.4.6.4</td>
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<td>7.4.6.5</td>
<td>7.4.13.3</td>
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<td>7.4.13.3.2</td>
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<td>Mechanical testing</td>
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<td>7.4.6.10</td>
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<td>Weld NDE—General</td>
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<td>N/A</td>
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<td>Hardness testing</td>
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</tr>
<tr>
<td>Repair welds</td>
<td>7.4.6.12</td>
<td>N/A</td>
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</tr>
</tbody>
</table>

7.3.9.3 Non-metallic Parts Materials

7.3.9.3.1 General

The requirements in 7.4.13.2, 7.4.13.3, 7.4.13.3.4, and 7.4.13.3.5 shall be applicable to thermo-plastic and elastomeric
materials.

7.3.9.3.2 Raw Materials

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

7.3.9.3.3 Processed Materials

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

7.3.9.3.4 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.

7.3.9.3.5 Acceptance Criteria

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

7.3.10 Drilling Choke Actuator

7.3.10.1 Hydraulic or Pneumatic 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.

7.3.10.2 Electrical Controls, Components and Accessories

Electrical equipment, connections, cabling, and associated components for electric choke actuators shall be suitable for use in areas classified in accordance with API 500 or API 505 or equivalent or in which they are intended to operate in (see 10.6.3.1).

7.3.11 Rigid Piping

7.3.11.1 Classification

Pipe shall be classified as a pressure-containing part.

7.3.11.2 Quality Control Requirements

The quality control requirements for rigid piping are specified in Table 18.

7.3.11.3 Nondestructive Evaluation of Rigid Piping (NDE)

7.3.11.3.1 Ultrasonic testing — Through-wall

Pipe shall be inspected full-body, full-length from the outside surface using ultrasonic compression wave techniques to detect and identify imperfections. The reference indicator shall be a 6.4 mm (1/4 in) flat bottomed round hole. The minimum coverage shall be 100 % of the inspected surface.

Wall thickness shall be measured and recorded over the full length.

<table>
<thead>
<tr>
<th>Quality Requirement</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness testing</td>
<td>7.4.6.4</td>
</tr>
<tr>
<td>Dimensional verification</td>
<td>7.4.6.5</td>
</tr>
</tbody>
</table>
7.3.11.3.2 Ultrasonic testing—Inside Surface

Pipe shall be inspected for longitudinal and transverse imperfections on the inside surface using ultrasonic shear-wave techniques. UT shall be calibrated to a notch geometry according to section 7.4.15.4.6.

7.3.11.3.3 NDE—Outside Surface

All pipe shall be inspected for the detection of both longitudinal and transverse imperfections on the outside surfaces by one or more of the following methods. UT, flux leakage, and eddy current shall be calibrated to a notch geometry according to section 7.4.15.4.6. Magnetic particle inspection acceptance criteria shall be per section 7.4.6.9.2.

- ultrasonic testing in accordance with ISO 9303 or ASTM E213 (longitudinal) and ISO 9305 or ASTM E213 (transverse);
- flux leakage testing in accordance with ISO 9402 or ASTM E570 (longitudinal) and ISO 9598 or ASTM E570 (transverse);
- eddy current concentric coil testing in accordance with ISO 9304 or ASTM E309.
- for pipe outside surface, magnetic particle inspection in accordance with ISO 10893-5 or ASTM E709.

7.3.11.3.4 NDE Calibration

NDE equipment calibration shall be performed in accordance with ASTM E543.

7.3.11.3.5 NDE Personnel

NDE operations for rigid pipe (except visual inspection) referred to in this Standard shall be conducted by NDE personnel qualified and certified in accordance with ISO 11484 or ASNT SNT-TC-1A.

7.3.11.3.6 Surface NDE Notch Standard

Notch geometry shall be as follows:

- the maximum acceptable notch depth as a percentage of the pipe wall shall not exceed 5 %;
- the maximum acceptable notch length is 1 in. (25.4 mm);
- the maximum acceptable notch width is 0.04 in. (1.0 mm).

7.3.11.3.7 Inspection of Pipe Ends

If automated ultrasonic inspection equipment limitations do not permit the inspection of each pipe end, then this portion of the pipe shall be:
- cropped off by saw cut or mechanical method. Flame cutting is prohibited, or
- subjected to a manual/semi-automatic test which achieves, as a minimum, the same degree of inspection as the automatic NDE for inside and outside surface and through wall.

7.3.11.3.8 Evaluation of Indications (Prove-up)

No weld repair shall be allowed.

Outside surface indication may be ground out, however minimum wall thickness shall not be violated. Removal of indication shall be verified by inspection using any of the outside surface methods allowed in section 7.4.15.4.3.
7.3.12 Unions and Swivel Unions

7.3.12.1 Pressure-containing Parts

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

7.3.12.2 Quality Control Requirements for Pressure-containing Parts

The quality control requirements for unions and swivel unions are specified in Table 12.

7.3.13 Other Pressure Boundary Penetrations

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

7.3.14 Mud Gas Separators

Mud gas separator quality requirements shall be in accordance with the selected pressure vessel code as listed in 4.3.6 and as specified in Table 19. In case of variance between the selected design code and Table 19, a Table 20 shall be followed.

Table 19—Quality Control Requirements for Mud Gas Separators

<table>
<thead>
<tr>
<th>Quality Requirement</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensional verification</td>
<td>7.4.6.5</td>
</tr>
<tr>
<td>Traceability</td>
<td>7.4.6.6</td>
</tr>
<tr>
<td>Serialization</td>
<td>7.4.6.13</td>
</tr>
<tr>
<td>Weld Examination – Visual</td>
<td>7.4.6.11.2</td>
</tr>
<tr>
<td>Weld Surface NDE</td>
<td>7.4.6.11.3</td>
</tr>
<tr>
<td>Weld Volumetric NDE</td>
<td>7.4.6.11.4</td>
</tr>
<tr>
<td>Hydrostatic Test</td>
<td>7.5.14</td>
</tr>
<tr>
<td>Functional Test – MGS Monitoring Systems</td>
<td>7.5.15</td>
</tr>
</tbody>
</table>

7.4 Assembled Equipment

7.4.1 General: Quality Control Requirements

Quality control requirements for assembled equipment shall be performed as identified in Table 20.

7.4.2 Serialization

Assembled equipment shall be serialized.

Table 20—Quality Control Requirements—Assembled Equipment

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hydrostatic Body Test</td>
</tr>
<tr>
<td>Positive Drilling Choke</td>
<td>7.5.5.2</td>
</tr>
<tr>
<td>Manually Actuated Drilling Choke</td>
<td>7.5.5.2</td>
</tr>
<tr>
<td>Drilling Choke Actuator</td>
<td>7.5.6.1a</td>
</tr>
<tr>
<td>Drilling Choke and Actuator Assembly</td>
<td>7.5.5.2</td>
</tr>
</tbody>
</table>
7.5.1 Records

7.5.1.1 Traceability Record

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.

7.5.1.2 Pressure Test Records

Tests shall be continuously recorded. The pressure test record shall identify the actual test pressure, the pressure-holding period, the recording device, and the assembly serial number and shall be dated and signed.

7.5.4 Hydrostatic Body Testing

7.5.4.1 General

Assembled equipment shall be subjected to a hydrostatic body test prior to final acceptance. Water, or water with additives, shall be used as the testing fluid. The test fluid shall not include any solids. The contents of the testing fluid shall be documented in the test records. Hydrostatic test pressure shall not be applied as a differential pressure across internal closure mechanisms of chokes.

NOTE Tests may be completed prior to or after painting or coating.

7.5.4.2 Hydrostatic Body Test Method

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

— the initial pressure-holding period of not less than three minutes;
— the reduction of the pressure to zero;
— the second pressure-holding period of not less than 15 minutes.

The pressure-holding period 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 Pressure

The hydrostatic body test pressure shall be determined by the rated working pressure of the equipment. Hydrostatic body test pressures shall be as shown in Table 21.
Table 21—Minimum Hydrostatic Test Pressures Units in psi (MPa)

<table>
<thead>
<tr>
<th>Rated Working Pressure</th>
<th>Hydrostatic Body Test Pressure (minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000 (13.8)</td>
<td>3000 (20.7)</td>
</tr>
<tr>
<td>3000 (20.7)</td>
<td>4500 (31.0)</td>
</tr>
<tr>
<td>5000 (34.5)</td>
<td>7500 (51.7)</td>
</tr>
<tr>
<td>6000 (41.4)</td>
<td>9000 (62.1)</td>
</tr>
<tr>
<td>7500 (51.7)</td>
<td>11,250 (77.6)</td>
</tr>
<tr>
<td>10,000 (69.0)</td>
<td>15,000 (103.5)</td>
</tr>
<tr>
<td>15,000 (103.5)</td>
<td>22,500 (155.0)</td>
</tr>
<tr>
<td>20,000 (138.0)</td>
<td>30,000 (207.0)</td>
</tr>
</tbody>
</table>

7.5.4.4 Acceptance Criteria

Test results shall be acceptable if the following criteria are satisfied during each entire hold period:

— There shall be no visible leakage.

— Pressure shall remain within 5 % of the actual test pressure at the start of the hold period or 500 psi (3.45 MPa), whichever is less.

— Pressure shall not drop below the minimum test pressure specified in Table 21.

7.5.5 Hydrostatic Testing for Adjustable and Positive Drilling Chokes

7.5.5.1 General

Each choke shall be subjected to a hydrostatic body 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

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

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

7.5.5.2.2 Acceptance Criteria

Test results shall be acceptable if the following criteria are satisfied during each entire hold period:

— There shall be no visible leakage.

— Pressure shall remain within 5 % of the actual test pressure at the start of the hold period or 500 psi (3.45 MPa), whichever is less.

— Pressure shall not drop below the rated working pressure.

7.5.5.3 Hydrostatic Seat-to-body Seal Test

7.5.5.3.1 General
A hydrostatic seat-to-body seal test shall be performed by applying rated working pressure and holding for a minimum of five minutes.

NOTE A blind seat may be used.

7.5.5.3.2 Acceptance Criteria

Test results shall be acceptable if there is no visible leakage during the hold period. Pressure shall not vary from the test pressure at the start of the test by more than 5% or 500 psi (3.45 MPa), whichever is less, during the entire hold period, and shall not drop below the test pressure.

7.5.5.4 Body-to-actuator Connection Test

If the wellbore pressure-containing parts of an actuated drilling choke and of the drilling choke actuator have been previously and separately subjected to body testing in accordance with 7.5.5.1 and 7.5.6.1.1, the body-to-actuator connection shall be tested after final assembly and prior to final acceptance. The test method shall conform to 7.5.4.2, the minimum test pressure shall be rated working pressure, and the acceptance criteria shall be as specified in 7.5.4.4.

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.

This test shall be conducted with the actuator installed on the choke or with the actuator installed on a representative test fixture (dummy body). In the latter case, the body-to-actuator connection test of 7.5.5.4 shall also be performed when the actuator is installed on the choke.

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. Manufacturer shall document test fluid used in the test records.

7.5.6.1.3 Acceptance Criteria

Test results shall be acceptable if the following criteria are satisfied during each entire hold period:

— There shall be no visible leakage.

— Pressure shall remain within 5% of the actual test pressure at the start of the hold period or 500 psi (3.45 MPa), whichever is less.

— Pressure shall not drop below the minimum test pressure specified in 7.5.6.1.2

7.5.6.2 Actuator Hydrostatic Body Test—Control Fluid Pressure-containing Parts

7.5.6.2.1 General

Prior to final acceptance, each hydraulic or pneumatic actuator shall be subjected to an actuator hydrostatic body test to
verify structural integrity of the parts that contain hydraulic or pneumatic control fluid.

7.5.6.2.2 Method

The test pressure of the actuator shall be a minimum of 1.5 times the maximum rated working pressure for hydraulic or pneumatic control fluid supplied to the actuator.

NOTE The actuator hydrostatic body test may be performed concurrently with the drilling choke control system test of 7.5.14. For hydraulic actuators, water (with or without additives) or other appropriate hydraulic fluid shall be the test medium.

For pneumatic actuators, water (with or without additives), nitrogen gas, air, or other appropriate gas or hydraulic fluid shall be used as the test medium. Manufacturer shall document test fluid used in the test records.

Double-acting actuators shall be tested in both open and closed directions.

7.5.6.2.3 Acceptance Criteria

Test results shall be acceptable if the following criteria are satisfied during each entire hold period:

— There shall be no visible leakage.

— Pressure shall remain within 5% of the actual test pressure at the start of the hold period or 500 psi (3.45 MPa), whichever is less.

— Pressure shall not drop below the minimum test pressure.

Where gas is to be used as the test medium (nitrogen, air, or other appropriate gas), the acceptance criteria shall be as defined in B.7.4.2.

7.5.6 Actuator Functional Test

7.5.6.3.1 Method

Each hydraulic or pneumatic 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.

NOTE The actuator may be tested with the equipment for which it is intended or tested separately.

The test medium shall be suitable hydraulic fluid (for a hydraulic system) or a gas such as nitrogen, air, or other appropriate gas (for a pneumatic system).

7.5.6.3.2 Acceptance Criteria

The actuator shall operate in both directions.

7.5.6.4 Electric Actuator Functional Test

7.5.6.4.1 General

Each electric actuator shall be operated by a suitable control system that can supply the rated voltage and current to the actuator. Each actuator shall be tested for proper operation by cycling the actuator from the minimum stroke position to the maximum stroke position a minimum of three times.

7.5.6.4.2 Method

Actuators shall be tested to verify functionality per the manufacturer's specifications. Electromechanical brakes (if equipped) shall be tested to ensure proper release upon return of power. Secondary means of operation shall be tested to ensure conformance to 10.12.3.1.

7.5.6.5 Actuator Seal Test
7.5.6.5.1 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 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 and time for each hold period shall be recorded.

7.5.6.5.2 Acceptance Criteria

The actuator shall show no visible leakage during each hold period.

Where gas is to be used as the test medium (nitrogen, air, or other appropriate gas), the acceptance criteria shall be as defined in B.7.4.2.

7.5.7 Functional Testing for Adjustable Drilling Choke Assemblies

7.5.7.1 General

The adjustable manual 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 criteria shall be as follows:

— continued smooth operation, without binding or chattering,

— the operating force or torque shall be within the manufacturer’s specification.

7.5.7.3 Remotely Actuated Choke Functional Test

7.5.7.3.1 Method (Hydraulic/Pneumatic)

Each remotely actuated drilling choke and hydraulic or pneumatic 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, with the choke at its maximum rated working pressure. Test media shall be a suitable fluid or a gas such as air or nitrogen.

NOTE When a liquid is used to pressurize the choke, the choke pressure may be adjusted to allow for fluid displacement due to stem movement.

7.5.7.3.2 Method (Electric)

Electric Actuators and chokes shall be tested to verify full mechanical travel for three cycles. The combination of a choke and actuator shall be tested and verified as per 7.5.6.4.

7.5.7.3.3 Acceptance Criteria
The choke and actuator shall operate in both directions.

7.5.8 Articulated Choke and Kill Lines

Each articulated choke and kill line assembly shall be subjected to a hydrostatic body test 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 body test in accordance with 7.5.4, with the exception that there shall be a single hold period with minimum hold time of one hour.

7.5.10 Unions and Swivel Unions

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

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

7.5.12 Buffer Chamber

Each buffer chamber assembly shall be subjected to a hydrostatic body test in accordance with 7.5.4. The body test pressure shall be as specified in Table 25; however, for buffer chambers having connectors of more than one pressure rating, the test pressure shall be determined by the lowest rated working pressure.

7.5.13 Choke and Kill Manifold Assembly

7.5.13.1 Hydrostatic Test

The manifold assembly shall be subjected to a hydrostatic body test in accordance with 7.5.4. For manifolds assembled entirely with equipment that has been previously subjected to a hydrostatic body test, the test pressure shall be rated working pressure. For manifolds with untested components, other than loose connectors, the test pressure shall be as specified in Table 25.

NOTE Loose connectors, as defined in API 6A, do not require hydrostatic testing.

Testing shall be performed prior to final acceptance. All equipment upstream of the choke isolation valve (downstream) shall be tested in accordance with the manifold inlet pressure rating. Equipment downstream of the choke isolation valve (downstream) shall be tested in accordance with the lowest pressure rated component.

7.5.13.2 Low Pressure Seat Testing for 6A Valves

Full bore valves and check valves installed in assemblies that are within the scope of this specification shall be subjected to a low-pressure seat test prior to final acceptance of the assembly. Testing shall be performed after completion of hydrostatic body testing, but otherwise may be performed on individual valves in any sequence with respect to testing requirements per API 6A, or may be performed on the fully assembled product.

Test pressure for all low-pressure testing shall be 250 PSI to 350 PSI. Testing shall begin by functioning the valve to the open position without pressure and closed for the test. There shall be a minimum hold period of 5 minutes for each direction required, with no visible leakage. Bidirectional valves shall be tested from both sides. Unidirectional valves shall be tested in the direction indicated on the body. Check valves shall be tested from the downstream side. Test medium shall be water or water with additives.

7.5.14 Drilling Choke Controls
7.5.14.1 Pressure Test

7.5.14.1.1 General

The test shall be conducted on the control system of remotely controlled equipment. All components from the power unit outlet to the control line connectors shall be tested.

7.5.14.1.2 Method

The 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 medium shall be suitable hydraulic fluid (for a hydraulic system) or a gas such as nitrogen, air, or other appropriate gas (for a pneumatic system).

7.5.14.1.3 Acceptance Criteria

Test results shall be acceptable if the following criteria are satisfied during each entire hold period:

— There shall be no visible leakage.
— Pressure shall remain within 5% of the actual test pressure at the start of the hold period or 500 psi (3.45 MPa), whichever is less.
— Pressure shall not drop below the minimum test pressure

NOTE Where gas is to be used as the test medium (nitrogen, air, or other appropriate gas), the acceptance criteria shall be in accordance with B.7.4.2.

7.5.14.2 Functional Test

7.5.14.2.1 Method

The control system shall be function tested in accordance with the manufacturer’s written procedures.

NOTE The test may be performed in conjunction with the functional test of the drilling choke and actuator assembly, at the manufacturer’s option.

7.5.14.2.2 Acceptance Criteria

Acceptance criteria shall be as specified in the manufacturer’s written procedures.

7.5.15 Mud Gas Separators

7.5.15.1 General

Assembled mud gas separators shall be subjected to a hydrostatic test prior to final acceptance. Water, or water with additives, shall be used as the testing fluid.

7.5.15.2 Hydrostatic Test Method

The hydrostatic test pressure shall be 1.5 times the rated working pressure. The hydrostatic test pressure-holding period shall not be less than 15 minutes;

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

7.5.15.3 Acceptance Criteria

Test results shall be acceptable if the following criteria are satisfied during each entire hold period:
— There shall be no visible leakage.

— Pressure shall remain within 5% of the actual test pressure at the start of the hold period or 500 psi (3.45 MPa), whichever is less.

— Pressure shall not drop below the minimum test pressure

7.5.16 Functional Testing – MGS Monitoring System

After complete installation of MGS with associated piping and instrumentation, the equipment shall be tested to verify functionality of all instrumentation.

7.5.17 Flexloops

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

Quality control requirements of section 7.4.15 for rigid piping shall apply to flexloops.

7.6 Quality Control Record Requirements

7.6.1 General

Quality control records shall be those documents and records necessary to substantiate that materials and products conform to the requirements of this specification.

7.6.2 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.

7.6.3 Records Maintained by the Manufacturer

The manufacturer shall maintain the following records.

— Weld procedure qualification record.

— Welder qualification record.

— Material test records:
  — chemical analysis;
  — tensile tests (QTC);
  — impact tests (QTC, as required);
  — hardness tests (QTC).

— NDE personnel qualification records.

— NDE records:
  — surface NDE records;
  — full penetration fabrication;
  — weld volumetric NDE records;
— repair weld NDE records.
— Hardness test records.
— Welding process records:
  — welder identification;
  — weld procedures;
  — filler material;
  — post-weld heat treatments.
— Heat treatment records:
  — actual temperature;
  — actual times at temperature.
— Volumetric NDE records.
— Hydrostatic pressure test records.
— 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.

7.6.4 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:

— certificate of compliance stating that equipment conforms to current edition of this specification and the temperature class;
— assembly traceability records;
— 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

Equipment-specific marking requirements shall apply as per Table 22

<table>
<thead>
<tr>
<th>Table 22—Metallic Marking Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Marking</strong></td>
</tr>
<tr>
<td>--------------------------------------</td>
</tr>
<tr>
<td>“API 16C”</td>
</tr>
<tr>
<td>Assembly serial number</td>
</tr>
<tr>
<td>Connector size</td>
</tr>
<tr>
<td>Date of manufacture (month and year)</td>
</tr>
<tr>
<td>Flow direction</td>
</tr>
<tr>
<td>Mfg. name or mark</td>
</tr>
<tr>
<td>Flexible specification level</td>
</tr>
<tr>
<td>Rated working pressure</td>
</tr>
<tr>
<td>Ring gasket type and number</td>
</tr>
<tr>
<td>Schedule/grade</td>
</tr>
<tr>
<td>Safety clamp</td>
</tr>
<tr>
<td>Size</td>
</tr>
<tr>
<td>Thread size</td>
</tr>
<tr>
<td>Temperature rating</td>
</tr>
<tr>
<td>Orifice size</td>
</tr>
</tbody>
</table>

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

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 General

Equipment shall be stored in accordance with the manufacturer’s written procedures.

9.1.2 Draining after Testing

Equipment shall be drained after testing and prior to storage or shipment.

9.1.3 Rust Prevention

Prior to storage or shipment, parts and equipment shall have exposed metallic surfaces protected with a rust preventative that does not become fluid and run at a temperature of less than 50 °C (125 °F).

9.1.4 Sealing Surface Protection

Exposed sealing surfaces shall be protected from mechanical damage for storage or shipment.

9.1.5 End and Outlet Connection Protection

Exposed end and outlet connections shall be protected from mechanical damage for storage or shipment.

9.1.6 Ports

Ports shall be plugged prior to storage or shipment.

9.1.7 Hydraulic Operating System

The hydraulic operating system shall be flushed with a non-freezing, corrosion-inhibiting fluid in accordance with the manufacturer’s written procedures.

9.1.8 Non-metallic Materials

Storage shall be in accordance with API 16A and API 6A as applicable. The manufacturer's written specified requirements for non-metallic seals shall include the following minimum provisions:

— indoor storage;
— maximum temperature not to exceed 50 °C (125 °F);
— protected from direct natural light;
— stored unstressed;
— stored away from contact with liquids;
— protected from ozone and radiographic damage.

The manufacturer shall define the provisions and requirements.

9.1.9 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 Choke and Kill System Requirements

A choke and kill system shall consist of a choke manifold, choke and kill lines constructed with high-pressure pipe, fittings, flanges, gauges, instrumentation, full bore valves, and adjustable chokes. The choke and a kill lines shall enable well
control operations as follows:
— circulating down the drill pipe and route returns to the choke manifold;
— pump/bullhead through the kill line or both lines;
— allow well pressure monitoring.
— allow well bore pressure to be bled off at a controlled rate
— leak free containment of the well bore fluid or gas
— circulating down one line and up the other line (for subsea only)

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 17D.

10.2.2 Rated Working Pressure and Sizes for Connections
API 16C connectors shall be used with pressure ratings as shown in Table 2, Table 3, and Table 4. 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 Unions and Swivel Unions

10.2.4.1 General
Unions shall 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.

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

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

10.2.4.4 Quality
Quality requirements for unions and swivel unions shall be in accordance with Table 23.

### Table 23—Quality Control Requirements for Male and Female Subs

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

10.2.4.5 End Connection

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

10.2.4.6 Rated Working Pressures and Sizes

Unions and swivel unions shall be supplied in rated working pressures and sizes in accordance with Table 3.

10.3 Ring Gaskets

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

Ring gaskets shall not be reused.

10.4 Drilling Chokes

10.4.1 Design Criteria

**NOTE** Drilling chokes are not intended to be used as shut off valves.

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

10.4.2 Adjustable Drilling Chokes

Adjustable drilling chokes shall 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.

**NOTE** 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.

10.4.3 Positive Drilling Chokes

Positive drilling chokes accommodate replaceable parts having fixed orifice dimensions.

10.4.4 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.

10.4.5 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.

10.4.6 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.

10.4.7 Marking

Drilling chokes shall be marked in conformance with Table 26.

10.4.8 Minimum Orifice Size

Drilling chokes shall be designed to pass a $\frac{1}{2}$ in. (12.7 mm) diameter particle, when fully open.

10.4.9 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.

10.4.10 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.

10.4.11 Performance Requirements

Drilling chokes shall meet the general performance requirements of Section 4, Section 10, and Table 24. These requirements include positive chokes, adjustable chokes and chokes designed for actuators.

<table>
<thead>
<tr>
<th>Performance Attribute</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling Chokes</td>
<td>Actuators</td>
</tr>
</tbody>
</table>
10.4.12 Materials

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

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

10.5 Actuators for Drilling Chokes

10.5.1 General

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. Actuator fail action shall fail in place.

10.5.2 Performance Requirements

Actuators shall be capable of performing as specified in Table 24. The maximum required operating temperature of an actuator shall be 150°F (65.5°C).

Electric actuator bodies or enclosures for actuators shall meet or exceed either a NEMA 4 or IP65 protection standards. Electric actuators shall be suitable for use in areas classified in accordance with API 500 or API 505. Maximum surface temperature of the actuator shall not exceed 200°F (93.3°C). Effective operating temperature range shall be labeled on all electric actuators.

10.5.3 Design Criteria

10.5.3.1 Pressure Rating

Hydraulic actuators shall have a hydraulic rated working pressure specified by the manufacturer

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

10.5.3.2 Actuation Forces

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

10.5.3.3 Pressure Relief

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

10.5.4 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.

10.5.5 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.

10.5.6 Marking

Actuators shall be marked in accordance with Table 22.

10.5.7 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 (52 °C). Inherently corrosion resistant materials do not require protection.

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

10.6 Rigid Choke and Kill Lines

10.6.1 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.

10.6.2 Materials

Materials for rigid piping shall be in accordance with 5.7.

10.6.3 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.

10.6.4 End Connections

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

10.6.5 Marking

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

10.7 Flexible Choke and Kill Lines

10.7.1 General
Typical construction unbonded and bonded flexible choke and kill lines 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
10.7.2 Design Methodology

Flexible pipe manufacturers employ different design methodologies, materials, construction and have different levels of field proven experience. Therefore, design methodology and its domain of validity shall be approved by an independent third party engineering firm.

Calculation and design methods shall be in accordance with 10.8.3 through 10.8.8, in addition to the requirements of Section 4.

10.7.3 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 4 for rated working pressures and Table 1 for temperature ratings. Rated working pressure for flexible lines shall be in accordance with Table 25.

Table 25—Flexible Line Sizes and Rated Working Pressures

<table>
<thead>
<tr>
<th>Inside Diameter in. (mm)</th>
<th>Rated Working Pressure psi (MPa)</th>
<th>Test Pressure psi (MPa)</th>
<th>Minimum Burst Pressure psi (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 (50.8)</td>
<td>5000 (34.5)</td>
<td>7500 (51.7)</td>
<td>11,250 (77.6 kPa)</td>
</tr>
<tr>
<td>3 (76.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3(\frac{1}{2}) (89)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 (101.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 (50.8)</td>
<td>10,000 (69.0)</td>
<td>15,000 (103.5)</td>
<td>22,500 (155.0)</td>
</tr>
<tr>
<td>2(\frac{1}{2}) (63.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 (76.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 (101.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 (50.8)</td>
<td>15,000 (103.5)</td>
<td>22,500 (155.0)</td>
<td>33,750 (233.0)</td>
</tr>
<tr>
<td>2(\frac{1}{2}) (63.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 (76.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 (101.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 (50.8)</td>
<td>20,000 (138.0)</td>
<td>30,000 (207.0)</td>
<td>45,000 (310.0)</td>
</tr>
<tr>
<td>2(\frac{1}{2}) (63.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 (76.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 (101.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10.7.4 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. Pipe threads are not acceptable end connections. Figure 10 shows a typical end connection for a flexible choke and kill line.

Figure 10—Typical Flexible Line End Fitting
10.7.5 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.

10.7.6 Minimum Bend Radius

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

10.7.7 Tolerances

The standard overall length tolerances of flexible lines 20 ft (6 m) and under shall be ±2 1/2 in. (64 mm) with the tolerance of longer lines being ±2 %. The standard tolerance for length change from atmospheric to rated 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 is completed.

Flexible choke and kill lines shall be full bore, with actual inside diameter not lower than 95 % of their nominal inside diameter at their narrowest point, including end termination and end connector.

10.7.8 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.

10.7.9 Material

10.7.9.1 General

The following material requirements shall apply in addition to the requirements of Section 5.

10.7.9.2 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.

10.7.9.3 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.
10.7.10 Flexible Specification Levels (FSL)

These four flexible specification levels (FSL) designations of flexible choke and kill lines shall define different levels of technical requirements as shown in Table 26. 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.12.4. The FSL level shall be permanently marked on each flexible choke and kill line.

<table>
<thead>
<tr>
<th>Flexible Specification Level</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSL 1</td>
<td>Includes all design, material and design validation test requirements in 10.8 and B.12.1, B.12.3 and B.12.4</td>
</tr>
<tr>
<td>FSL 2</td>
<td>FSL 1 plus B.12.5 (Flexible Line Fire Test)</td>
</tr>
<tr>
<td>FSL 3</td>
<td>FSL 1 plus B.12.6 (Flexible Line High Temperature Exposure Test)</td>
</tr>
<tr>
<td>FSL 4</td>
<td>Includes FSL 1 and the requirements of B.12.5 and B.12.6</td>
</tr>
</tbody>
</table>

NOTE Changes to API 16C, 3rd edition FSL levels are purely editorial and no technical change has been made. As the numeral zero denotes nothing, the TG determined that all FSL levels have requirements and the FSL levels will begin at FSL 1.

10.8 Hydraulic Control System—Drilling Chokes

10.8.1 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.

10.8.2 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 m³), but may at the manufacturer’s option.

10.8.3 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.

10.8.4 Temperature Ratings

Fluid handling components of the choke control system, including power fluids, shall be capable of functioning as a system within a temperature range 0 °F to 150 °F (−18 °C to 66 °C), as a minimum 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.

10.8.5 Accumulators

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;

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

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

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

### 10.8.6 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.

### 10.8.7 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.

### 10.8.8 Control System Rigid Lines Requirements

Drilling choke control system rigid lines shall meet the general requirements of Section 4 and the specific requirements of 10.7.

### 10.8.9 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.

### 10.8.10 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.

### 10.8.11 Connections

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

### 10.8.12 Drilling Choke Console

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

### 10.9 Articulated Choke and Kill Lines

#### 10.9.1 Articulation

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.

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

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.

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 11 shows a typical articulated line assembly and Figure 12 shows an example of points of rotation.

![Figure 11](image1)

**Figure 11—Example of an Articulated Choke or Kill Line**

![Figure 12](image2)

**Figure 12—Example Illustrating “Points of Rotation”**

10.9.2 Marking

Articulated lines shall be provided with color coding as detailed Table 27. 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 rated working pressure.
Table 27—Color Coding of Articulated Choke and Kill Line Components

<table>
<thead>
<tr>
<th>Pressure Rating psi</th>
<th>Service</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>6000</td>
<td>Standard</td>
<td>Silver</td>
</tr>
<tr>
<td>10,000</td>
<td>Standard</td>
<td>Black</td>
</tr>
<tr>
<td>15,000</td>
<td>Standard</td>
<td>Red</td>
</tr>
<tr>
<td>20,000</td>
<td>Standard</td>
<td>Light Blue</td>
</tr>
<tr>
<td>10,000</td>
<td>Sour Gas</td>
<td>Olive Green</td>
</tr>
<tr>
<td>15,000</td>
<td>Sour Gas</td>
<td>Olive Green</td>
</tr>
</tbody>
</table>

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 22.

10.9.3 Installation

The manufacturer’s recommendations and restrictions shall be followed for each installation.

10.10 Choke and Kill Line Valves

10.10.1 General

Surface and subsea choke and kill line valves are intended to be installed on the side outlets of BOPs. They shall conform to API 6A requirements specified in clause 4.2 of this specification, and shall meet the requirements of this clause. If requirements of this specification conflict with requirements of API 6A, this specification shall apply.

Hydraulic actuators for surface and subsea choke and kill line valves shall conform to API 6A requirements for non-retained-fluid powered actuators. For hydraulically-actuated valves, the bonnet, valve stem and stem seals shall be considered part of the valve, not the actuator.

NOTE: API 6A hydraulic valve actuators do not have a PSL, Material Class, or Temperature Class.

10.10.2 Surface Choke and Kill Line Valves

Choke and kill line valves for surface BOP stacks shall be either manually-actuated or equipped with a double-acting hydraulic actuator. Hydraulically-actuated valves shall be “fail-in-place” and shall have visual position indication, using a lower balance stem or other means.

10.10.3 Subsea Choke and Kill Line Valves

a) Choke and kill line valves for subsea BOP stacks shall be equipped with a spring-return hydraulic actuator and shall be of fail-close configuration and function. Closing force shall be capable of closing the valve completely in 30 seconds or less, under full flow potential across the valve at rated working pressure, with the actuator open function vented to ambient pressure, and the valve at the maximum rated sea depth. Force for closure shall be supplied by one of the following means:

- Spring force alone;
- Spring force plus valve retained fluid pressure (e.g., acting on an unbalanced stem area);
- Spring force plus hydraulic pressure assist.
b) The manufacturer shall specify the hydraulic control pressure required (in psig, above ambient) and the swept volume required to fully open the valve. If pressure assist is required for closure, the manufacturer shall also specify the pressure required (in psig, above ambient) and the swept volume required to close.

c) The manufacturer shall specify a maximum depth rating for the subsea choke and kill line valve assembly.

d) Two subsea choke and kill line valves may be manufactured as a multiple valve, in a single body for compact installation on the subsea BOP. For multiple valves, there are no requirements for valve length dimensions, and the nominal size of end or outlet connections may be larger than the nominal bore size of the valve.

EXAMPLE: A 3-1/16 inch 15,000-psi dual-valve block may have a 4-1/16 inch 15,000-psi inlet flange with 3-1/16 inch bore for increased bending capacity.

e) Subsea choke and kill line valves are not required to have a stem back seat or other means of repacking the stuffing box while the valve is in service, as required by API 6A.

f) All pressure closure bolting in subsea use shall conform to API 20E or API 20F, BSL 2, and with the additional requirements that:
   — Carbon or low alloy steel bolting shall not exceed a hardness of 34 HRC.
   — ASTM A453/A453M Grade 660 stainless steel bolting shall not be used.

This paragraph applies to bolting used in end and outlet connections, targeted flanges, bonnet closure, and actuator pressure closure as a minimum.

g) The actuator spring(s) shall be designed to provide a minimum mean spring life of 5000 cycles. The spring(s) shall utilize materials and/or coatings that will protect against failure from pitting corrosion.

h) Subsea choke and kill line valves shall have a corrosion resistance rating of CR1, CR2, or CR3, with CRA weld overlays of seal surfaces in the body and bonnet(s) as specified in Table 28.

<table>
<thead>
<tr>
<th>Table 28: Corrosion Resistance Level Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Component</strong></td>
</tr>
<tr>
<td>Body</td>
</tr>
<tr>
<td>Body</td>
</tr>
<tr>
<td>Body &amp; Bonnet(s)¹</td>
</tr>
<tr>
<td>Bonnet(s)¹</td>
</tr>
</tbody>
</table>

¹ upper and lower bonnets, as applicable

10.10.4 Design Validation

For surface and subsea choke and kill line valves, the valve design and the actuator design shall be subjected to design validation testing in conformance with API 6A Annex F PR2 requirements for valves and for actuators, respectively.

Subsea valve and actuator assemblies shall be hyperbarically tested for validation of the maximum depth rating as specified in Annex B.

10.11 Choke and Kill Manifold Assemblies

10.11.1 Design Configuration

10.11.1.1 General

Choke and Kill manifolds and their components shall be designed in accordance with applicable requirements of section 4, applicable equipment specific requirements in section 10, and in accordance with the following equipment specific requirements.
10.11.1.2 Performance Requirements

Performance requirements shall be in accordance with 4.4.

10.11.1.3 Pressure Rating

NOTE 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).

The upstream choke manifold pressure rating shall be specified by the purchaser and equal to or greater than the pressure rating of the BOP.

Chokes shall have a single pressure rating, with end connection of the same rated working pressure (inlet and outlet).

Spools and adapters with different end connections shall be rated to the lowest rated end connection.

10.11.1.4 Temperature Rating

Temperature ratings shall be in accordance with section 4.1.1. The rating for a choke and kill manifold shall be the lowest rating of any component in the manifold.

NOTE For choke and kill systems used with subsea BOPs, temperature ratings may be different between equipment installed and operated above water and equipment operated below water.

10.11.1.5 Sizing

Sizing shall, at a minimum, be in accordance with Table 29. Additional requirements for sizing may be necessary as described in section 10.12.2.5.6.

Table 29—Minimum Choke & Kill Manifold Size and Configuration

<table>
<thead>
<tr>
<th>Choke and Kill System Rating</th>
<th>Choke and Kill System Minimums</th>
<th>Min # of Adjustable Chokes (Total)</th>
<th>Min # of Remote Chokes</th>
<th>Min # of Wing Valves Total</th>
<th>Min # of Remotely Operated Wing Valves</th>
</tr>
</thead>
<tbody>
<tr>
<td>3k or Less</td>
<td></td>
<td>2&quot; (5.08cm)</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5k</td>
<td></td>
<td>2&quot; (5.08cm)</td>
<td>2</td>
<td>1</td>
<td>1 choke line</td>
</tr>
<tr>
<td>10k</td>
<td></td>
<td>3&quot; (7.62 cm)</td>
<td>2</td>
<td>2</td>
<td>1 choke line</td>
</tr>
<tr>
<td>15k</td>
<td></td>
<td>3&quot; (7.62 cm)</td>
<td>2</td>
<td>2</td>
<td>1 choke line</td>
</tr>
<tr>
<td>Riser Choke and Kill Lines</td>
<td></td>
<td>3&quot; (7.62 cm)</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

\( ^{a} \) excluding the choke orifices  
\( ^{b} \) excluding chokes
10.11.1.6 Configuration and Component Selection

Manifold configuration depends on many 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 selection of components and the number and location of inlet connections, valves, chokes, pressure gauges and transducers, buffer chamber and outlet connections.

Components selected for choke and kill manifolds shall meet the applicable requirements of 4.2, 10.11, 10.7 and the following:

— Actuated valves and chokes in a surface manifold shall be a fail-in-place design.
— Actuated valves shall be actuated by hydraulic, pneumatic, or electric actuators.
— The chokes and all choke manifold components upstream of the chokes shall have a RWP equal to or greater than the BOPs in use.
— The isolation valve downstream of the choke(s) and any spools between the choke and the isolation valve shall have a RWP equal to or greater than the BOPs in use.
— Lines that bypass the choke shall have an equal or larger internal diameter than the choke line.
— Instrumentation shall be designed to work in the purchaser specified environment and adhere to recommendations in API RP 500.

NOTE Typical manifold configurations are shown in Annex H

Manifold configuration shall conform with the functional requirements of section 10.1 and shall be designed to:

— Enable influx removal while monitoring the annulus pressure
— Have at least one isolation valve of the same pressure rating as the choke, mounted downstream of each choke.
— Mitigate erosion in the manifold downstream of the chokes.
— Have instrumentation necessary to monitor standpipe pressure, casing pressure, and pump strokes while removing the influx.
— Work such that no part of the manifold will be exposed to pressure above its rated working pressure as a result of the failure of another component such as a choke, check, or gate valve assuming there is always a line open to atmosphere downstream of the choke.
— In the event of eroded, plugged, or malfunctioning parts, allow for rerouting of flow through a different choke, without interrupting flow control.
— Provide the ability to isolate a failure downstream of the chokes and reroute flow through the manifold
— Provide a minimum of at least one inlet, upstream of the chokes, in addition to the choke inlet, e.g. to enable the interface of a glycol system for hydrate mitigation, temperature monitoring or redundant pressure monitoring.
— Direct well flow while imparting minimal back pressure on the well. Note: this can be accomplished by having a line that is equal in diameter to the choke line or larger that by-passes the chokes or assuring that when the installed chokes are full open the TFA across the choke trim exceeds the TFA in the choke line. This is a contingency scenario when casing pressure is approaching MASP or MAWHP.
— The manufacturer shall provide a minimum of two outlets downstream of the chokes to enable flow routing to:
— the MGS
— the stripping or trip tank

Additional configuration and sizing requirements may be specified by one or more of the following:
— The purchaser’s design specifications
— The manufacturer’s design specifications;
— Flow and erosion analysis

10.11.2 Materials

Materials shall be in accordance with applicable requirements of section 5.

10.11.3 Quality

Quality Control requirements for assembled equipment shall be performed per Table 24.

The manifold assembly shall be subjected to a hydrostatic body test in accordance with 7.5.4. For manifolds assembled entirely with equipment that has been previously subjected to a hydrostatic body test, the test pressure shall be rated working pressure. For manifolds with untested components, other than loose connectors, the test pressure shall be as specified in Table 25.

NOTE Loose connectors, as defined in API Specification 6A, do not require hydrostatic testing.

Testing shall be performed prior to final acceptance. All equipment upstream of the choke isolation valve (1st valve downstream of the choke) shall be tested in accordance with the manifold inlet pressure rating. Equipment downstream of the choke isolation valve (1st valve downstream of the choke) shall be tested in accordance with the lowest pressure rated component

10.11.4 Marking

Marking shall be in accordance with section 8 of this document.

10.11.5 Shipping and Storing

Shipping and storing shall be in accordance with section 9 of this document.

10.11.6 Documentation

Documentation shall be in accordance with 10.13.

10.11.7 OEM Provided Installation Items

10.11.7.1 Bracing

If included in the scope of supply, OEM provided supports and fasteners shall be designed to address the risk of deflection to mitigate the equipment exceeding its design loads.

10.11.7.2 Access Platforms

If included in the scope of supply, OEM provided platforms shall be designed in a such a way that they do not obstruct performing planned valve servicing.
10.11.7.3 Maintenance Rigging

If included in the scope of supply, OEM provided maintenance aids should aid in valve maintenance or replacement activities. These rigging devices should serve to minimize the necessary disassembly or removal of components adjacent to that being repaired.

10.12 Buffer Chamber

10.12.1 Design Criteria

The design shall be in accordance with 4.3.

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

10.12.2 Pressure Rating

The rated working pressure of the buffer chamber shall be that of the lowest-rated end or outlet connector on the buffer chamber.

The rated working pressure shall be clearly identified by means of a nameplate securely affixed to the main body portion of the buffer chamber.

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

10.12.3 Materials

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

10.12.4 Quality

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

10.12.5 Marking

Marking shall be in accordance with Table 26.

10.12.6 Operating and Maintenance Manual Requirements

The manufacturer shall prepare and provide an operating manual for the following choke and kill system equipment manufactured in accordance with 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).

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.

10.13 Mud Gas Separators

10.13.1 General

This section covers the specific requirements for the design of the atmospheric mud gas separator.

10.13.2 Sizing

The mud and gas capacity of the separator system shall be determined and communicated to the purchaser. Design capacity input requirements shall include expected mud and gas flow rates and densities, reservoir characteristics (if known), mud and gas outlet piping configurations, separator efficiency, and acceptable amounts of mist carry-over in the gas outlet.

Calculations shall be performed on the MGS system to determine the gas and liquid flow rates through the vent and mud return lines for the different load cases defined by the purchaser. The load cases should include reasonable ranges for the liquid fluid properties (density, viscosity), gas properties including mixtures, pressures, and ambient/internal temperatures. The MGS vent line gas flow rate shall account for compressibility and frictional heating. Calculation methods intended for long distance pipeline transmission of gas shall not be applicable for an MGS vent. The resulting pressure and flow rate shall be compared against the rated working pressure, as established by the liquid seal or other pressure containment device utilized in the system design.

10.13.3 Pressure Integrity and Design

The MGS shall be designed for a rated working pressure that is not less than the lowest of the following:

a) The hydrostatic pressure resulting from the vent line being filled with mud at 2.2 SG, or

b) The hydrostatic pressure resulting from the vent line being filled with mud of the maximum density specified by the purchaser, or

c) 200 psi.

A corrosion allowance shall be determined and agreed upon between the manufacturer and end user, accounting for the expected service life and operating conditions. The design package should state a required minimum acceptable metal thickness for the Rated Working Pressure.

10.13.4 Temperature Rating

The MGS vessel low temperature rating shall be equal to or less than subjected conditions such as ambient conditions and the potential for auto-refrigeration due to the decompression of gasses and should be less than or equal to 0°F. The MGS vessel high temperature rating shall be equal to or greater than subjected conditions such as ambient temperature and fluid temperatures, and should be no less than 150°F.

10.13.5 Pressure Relief

If there is a restriction in vent line, pressure relief shall be installed to protect MGS. Relief device capacity shall meet sizing requirement as stated in 10.14.2.

NOTE 1 As the MGS is vented to atmosphere, pressure relief is not considered necessary, in cases where the vent line is provided
without any restriction to the flow of vented gas.

NOTE 2 The pressure relief device may be installed directly on the vessel or in the system piping, in accordance with selected design code.

Installation, discharge routing and maintenance of the device shall be the responsibility of the end user.

10.13.6 Mud Inlet

The mud inlet into the separator shall have a means to reduce the rate of erosion.

NOTE 1 Fluid flowing into the mud gas separator at high velocities can erode the interior of the vessel.

NOTE 2 This can be accomplished by reducing velocity, deflecting the flow, or using wear-resistant materials. Other methods may be used as agreed upon by the end user and manufacturer.

The inlet piping may also be subject to erosion, and the piping should be configured to reduce the rate of erosion as much as practical (piping diameter, number and radius of bends, etc.)

The piping between the choke manifold and mud gas separator shall have a nominal diameter that is equal to or larger than the choke outlet end connection or the downstream choke manifold flange, whichever is larger. The inlet piping shall have a minimum pressure rating equal to the choke manifold buffer chamber and shall meet the requirements of NACE MR0175.

10.13.7 Mud Outlet

NOTE 1 Fluid flowing out of the mud gas separator at low velocities can deposit sediment in the piping and result in restrictions or blockages. High fluid velocities can cause erosion.

The mud outlet line should be sized to balance these conditions.

Where the mud gas separator is installed at a position physically higher than the downstream equipment a siphon breaker shall be installed after the mud leg. The siphon breaker vent shall be minimum 4" nominal diameter and extend minimum of 33 feet (10.1 meters) above MGS. Siphon breaker vent line shall not be connected to any other lines.

NOTE 2 Float mechanism separators and separators with active discharge control systems are exempt from this provision.

The outlet piping shall have a rated working pressure equal to or higher than the pressure rating of the mud gas separator. Where a mud leg is used, the hydrostatic pressure of the column of mud will increase the working pressure at the bottom of the mud leg. If the mud has a high density, this pressure difference can be significant. The pressure rating of the mud outlet piping shall account for this added pressure.

10.13.8 Vent (Gas) Outlet

NOTE High mist carry-over rates can cause fluid to pool in low spots in the gas outlet piping.

The piping shall be configured to avoid low spots and to be self-draining.

The vent line piping shall have an allowable pressure rating equal to or higher than the pressure rating of the mud gas separator.

Vent line shall be minimum nominal diameter of 10”. Vent line shall be as straight as possible and free of restrictions. The MGS vent line shall be independent of other vents.

For offshore applications, the vent line shall extend minimum of 13 feet (4 meters) above crown block.

For land applications vent line shall be directed to safe location for discharge.

10.13.9 Maintenance and Inspection Ports

The separator shall have provisions for internal maintenance and inspection in accordance with the selected design code.

10.13.10 Structural Attachments
Structural attachments and lifting apparatus shall be designed using the criteria and allowable stresses in accordance with selected design code and API RP-2A WSD.

10.13.11 Other Loads

Nozzle loads, seismic, ship motion, and wind loads shall be considered and agreed upon by the manufacturer and purchaser.

10.13.12 MGS Monitoring and Control Systems

Mud-gas separator shall be equipped with a high-level sensor (LSH) and low-level sensor (LSL) or equivalent for monitoring of re-routing flow from choke to overboard or alternate route.

Mud-gas separator shall be equipped with provisions to prevent gas blow-by to the mud conditioning equipment (e.g. possum belly, shale shakers).

Provisions are to be provided for monitoring of liquid seals by:

— Measuring the differential pressure at the liquid seal, or
— Monitoring the mud-gas separator with a low-level sensor (LSL) or equivalent for notifications to rig personnel to take corrective action to prevent gas blow-by.

Any attached electronic devices (such as temperature or pressure sensors, alarm systems, fluid level monitors, etc.) shall be rated in accordance with the appropriate hazardous area requirements. In addition, the temperature service rating of the devices and instrumentation shall be agreed upon by the end user and manufacturer.

10.13.13 Fasteners

Fasteners shall be designated as “exposed” or “non-exposed” as per API 6A.

NOTE Non-exposed fasteners are those directly open to atmosphere. Exposed fasteners are those buried, covered by insulation or flange protectors, or otherwise not open to atmosphere.

Exposed fasteners shall meet the requirements of NACE MR0175.

10.13.14 Insulation

Insulation applied to the exterior of the separator shall be installed in such a way that pressure cannot be trapped. Installations shall follow the guidelines in API 583 and NACE SP0198.

10.14 Flexloops

10.14.1 Design

10.14.1.1 General

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

NOTE For non-metallic flexible lines, follow the requirements of section 10.8

10.14.1.2 Load cases

Load cases for flexloops shall be considered as follows:

a) Pressurized (Drilling) case, azimuth flexible joint deflection in 45° increments, 4 degree deflection

b) Unpressurized (Non-Drilling) case, azimuth flexible joint deflection in 45° increments, full deflection of lower Flexjoint.

c) Hydrostatic pressure test – in neutral position
Note See SPI 16F and API 16Q

10.14.1.3 Fatigue

A fatigue assessment shall be performed utilizing the S-N method from an industry recognized standard such as ASME BPVC section VIII Div 2 or 3, DNV-RP-C203, or BS7608. The material properties used in the analysis shall consider an environmental condition of salt water with cathodic protection. The calculated number of design cycles for each type of operating cycle shall be reported. Optionally, fracture mechanics fatigue assessment may be utilized.

10.14.1.4 Pressure

Pressure rating of the flexloops shall not be less than the RWP of the RAM BOPs. Refer to API standard 53 section 7.2.2

10.14.1.5 Temperature

Temperature rating of the flexloops should equal that of the RAM BOPs. Refer to API Standard 53 section 7.2.2.

10.14.1.6 Fabrication tolerances

Fabrication tolerances are to be considered in design and analysis, to include:

a) Material variance

b) Wall thinning from fabrication of curved components

c) Ovalization of cross-section from fabrication of curved components

10.14.2 Materials

Materials for flexloops shall be in accordance with 5.6.

10.14.3 Quality

Quality requirements for flexloops shall be in accordance with 7.4.15. Flexloops shall meet the quality requirements of 7.5 for assembled equipment, including hydrostatic testing in accordance with Table 24. Dimensional verification of design parameters from section 10.14.1.6 shall be documented.

10.14.4 Intermediate and end connections

Connections shall meet the requirements of 10.2. Connections shall be evaluated against the expected reaction loads. Pipe threads shall not be used as end connections.

10.14.5 Shipping

Flexloops are to be stored and shipped in accordance with section 9. Flexloops are to be adequately braced for shipping. Shape and deflection shall be considered. Documentation of Center of Gravity and intended lifting points shall be provided to the customer.

10.14.6 Marking

Flexloops shall be marked in accordance with Section 8.
Annex A
(informative)

[Reserved for use by the Monogram Program]
Annex B  
(normative)  

Design Validation Procedures

B.1 Application

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

Reference to room temperature shall be a temperature between 40 °F and 120 °F (4.4 °C and 48.9 °C).

B.2 Product Changes

B.2.1 Design Changes

A design that undergoes a substantive change shall require design validation. A substantive change shall be a change identified by the manufacturer that affects the performance of the product in the intended service condition.

NOTE A substantive change includes changes in fit, form, function or material.

Prototype equipment (or first article) and fixtures used to qualify designs using these validation procedures shall be representative of production models in terms of design, production dimensions/tolerances, intended manufacturing processes, deflections and materials. If a product design undergoes any changes in fit-form-function or material, the manufacturer shall document the impact of such changes on the performance of the product. A design that undergoes a substantive change becomes a new design requiring retesting. A substantive change is a change that affects the performance of the product in the intended service condition. A substantive change is considered as any change from the previously qualified configuration or material selection that can affect performance of the product or intended service. This shall be recorded, and the manufacturer shall justify whether re-qualification is required. This may include changes in fit-form-function or material. A change in material might not require retesting if the suitability of the new material can be substantiated by other means.

NOTE Fit, when defined as the geometric relationship between parts, includes the tolerance criteria used during the design of a part and mating parts. Fit, when defined as a state of being adjusted to, or shaped for, includes the tolerance criteria used during the design of a seal and its mating parts.

For items with primary and secondary independent seal mechanisms, the seal mechanisms shall be independently verified. Equipment should be qualified with the minimal lubricants required for assembly unless the lubricants can be replenished when the equipment is in service or is provided for service in a sealed chamber.

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

B.2.2 Metallic Materials

NOTE 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.2.3 Nonmetallic Seals
NOTE 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

B.3 Conformance
All products evaluated in design validation tests shall conform with the applicable design requirements of this specification.

B.4 Product Validation Testing
B.4.1 General
Design validation testing 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.4.2 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.4.3 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.4.4 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.4.5 Maintenance Procedures during validation
The manufacturer’s published maintenance procedures may be included in the validation procedures. Greasing or lubricating valves shall not be performed following a failed pressure test in order to continue testing. The replacement of parts shall not be allowed during validation procedures.

B.5 General Acceptance Criteria
B.5.1 General
Validation testing of the applicable product shall include all of the testing requirements of this annex.

B.5.2 Design Validation
B.5.2.1 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.5.2.2 Scaling
B.5.2.2.1 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.

When scaling is used to verify the members of a product family, the requirements and limitations of this section shall apply.

B.5.2.2.2 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.5.2.2.3 Limitations of Scaling

B.5.2.2.3.1 General

Validation by scaling shall be subject to the following limitations.

B.5.2.2.3.2 Validation by Pressure Rating

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

B.5.2.2.3.3 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 shall also verify nominal sizes between the two sizes tested.

B.5.2.2.3.4 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).

NOTE Choke nominal sizes are in one-inch increments.

B.5.2.2.3.5 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.5.2.2.4 Validation by Temperature Rating

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

B.5.2.2.5 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.5.3 Acceptance Criteria

B.5.3.1 Structural Integrity
The product tested shall not permanently deform to the extent that any other performance requirement is not met.

B.5.3.2 Pressure Integrity

B.5.3.2.1 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.5.3.2.2 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.5.3.3 Standard Test Fluid Compatibility

B.5.3.3.1 Metallic Materials

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

B.5.3.3.2 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.5.3.4 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.5.4 Hydrostatic Testing

B.5.4.1 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.5.4.2 Substitution of Gas

B.5.4.2.1 General

The manufacturer may, 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 applicable requirements in B.7.4.2.3 shall be satisfied.

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

B.5.4.2.2 Leak Detection

Gas testing at room temperature shall be conducted with a method for leak detection.

NOTE 1 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.

NOTE 2 The product may be assembled with one end of a tube connected to a blind connector enclosing
possible leak paths being verified.

The end of the tube not connected to the blind connector shall be immersed in a liquid or attached to a leakage measurement device.

B.5.4.2.3 Acceptance Criteria for Gas Testing

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

- 60 cm³/h for dynamic seals, or
- 20 cm³/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.5.5 Temperature Testing

B.5.5.1 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.5.5.2 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.5.5.3 Application of Cooling for Minimum Temperature Testing

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

B.5.6 Hold Periods

B.5.6.1 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.5.6.2 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.5.6.3 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.6 Pressure and Temperature Cycles

Pressure/temperature cycles shall conform to the equipment-specific performance requirements specified in Section 10. The maximum test pressure shall be rated working pressure as specified in 4.6. The minimum and
maximum test temperatures shall be as specified in conformance with 4.1.

B.7 Non-metallic Seals

B.7.1 Design

Design of non-metallic seals shall conform to Section 4 and the manufacturer’s written specifications.

B.7.2 Materials

Materials for non-metallic seals shall conform to the requirements of 5.3.

B.7.3 Quality

Non-metallic seals shall conform to 7.4.11.

B.7.4 Design Validation

B.7.4.1 General

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

B.7.4.2 Procedure

NOTE This procedure validates the seal performance in test fluids specified in Table B.1, and not the performance of products containing the seal.

This procedure is intended to validate the seal performance in exposure to well fluids in accordance with Table B.1. It supports but does not replace the validation of products containing the seal. Seals shall be tested in accordance with B.9.4.3 to validate their performance within the ratings for temperature, pressure, and fluid compatibility.

Table B.1—Standard Test Fluid

<table>
<thead>
<tr>
<th>Test Fluid Option A</th>
<th>Fluid</th>
<th>Percentage by Volume</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oil</td>
<td>50</td>
<td>Diesel #2 (ASTM D975)</td>
</tr>
<tr>
<td></td>
<td>Brine water</td>
<td>20</td>
<td>Saturated salt at 60 °F</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(15.5 °C)</td>
</tr>
<tr>
<td></td>
<td>Gas composed of</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>— 85 % methane (CH4),</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>— 5 % carbon dioxide (CO2),</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>— 10 % hydrogen sulfide (H2S)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test Fluid Option B</td>
<td>Hydrocarbon liquid</td>
<td>60</td>
<td>Jet fuel, diesel, kerosene, etc</td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gas composed of</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>— 85 % methane (CH4),</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>— 5 % carbon dioxide (CO2),</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>— 10 % hydrogen sulfide (H2S)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test Fluid Option C</td>
<td>Hydrocarbon liquid</td>
<td>60</td>
<td>Jet fuel, diesel, kerosene, etc</td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gas composed of</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>— 10 % methane (CH4),</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>— 80 % carbon dioxide (CO2),</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>— 10 % hydrogen sulfide (H2S)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
B.7.4.3 Functional Performance Test of Seals (Pressure / Temperature Testing)

B.7.4.3.1 General

The functional performance of the seal material shall be verified by a test demonstrating the response of the seal to a sequence of steps: rated pressure, rated temperature, and hold time periods.

B.7.4.3.2 Test Temperature

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

B.7.4.3.3 Test Pressure

The rated working pressure test, at the test temperature, shall conform to 4.4. The low-pressure test shall be at 200 psi (1.4 MPa), +10%, -0.

B.7.4.3.4 Test Fluid Application

The manufacturer may choose to conduct the testing described in B.9.4.3.6 with the standard test fluid described in table B.1 or with a fluid of choice (e.g. water, water with additives, or gas). If the functional performance test of the seals is conducted with the standard test fluid, successful completion of the test shall be acceptable to validate their performance within the ratings for temperature, pressure, and fluid compatibility. However, if the test is conducted with a fluid other than the standard test fluid, the manufacturer shall:

— Document the test fluid used
— Confirm seal compatibility as per the seal immersion testing specified in 9.4.4.

B.7.4.3.5 Test Sequence

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

a) At room temperature, apply rated working pressure, +10%, -0. After pressure has stabilized, hold for 1 h.

b) Release test pressure to zero psi.

c) Raise temperature to the maximum rated temperature +10%, -0.

d) Raise pressure to rated working pressure, +10%, -0. After stabilizing pressure, hold for 12 h.

e) Release pressure to zero psi and allow fixture to cool to room temperature.

f) Raise temperature to the maximum rated temperature +10%, -0.

g) Raise pressure to rated working pressure, +10%, -0. After stabilizing, hold for 1 h.

h) Release pressure to zero psi and allow fixture to cool to room temperature.

i) Lower temperature to minimum rated temperature +0, -10%.

j) Raise pressure to rated working pressure, +10%, -0. After stabilizing pressure, hold for 1 h.

k) Release pressure to zero psi and allow fixture to warm to room temperature.

l) After stabilization at room temperature, raise pressure to 200 psi (1.4 MPa), +10%, -0. After pressure stabilization, hold for 1 h.
m) Raise pressure to rated working pressure, +10%, -0%. After stabilization, hold for 1 h.

**B.7.4.3.6 Testing Apparatus**

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.7.4.3.7 Acceptance Criteria, Functional Test**

Test results shall be acceptable if the following criteria are satisfied during each entire hold period:

- There shall be no visible leakage.
- Pressure shall remain within 5% of the actual test pressure at the start of the hold period or 500 psi (3.45 MPa), whichever is less.
- Pressure shall not drop below the minimum test pressure

**B.7.4.4 Immersion Testing**

**B.7.4.4.1 General**

The fluid compatibility of the seal material shall be verified by a test demonstrating the response of the material to the test fluid listed in Table B.1 for Immersion Testing. The temperature shall be at or above the maximum rated temperature.

**B.7.4.4.2 Test Fluid Application**

The standard test fluid is defined in Table B.1. The seal material shall be positioned such that it is partially exposed to both the liquid and gas phases. The hydrocarbon liquid shall be over pressured with the gas mixture.

**B.7.4.4.3 Acceptance Criteria, Immersion Test**

Test results for thermoplastics shall be acceptable if the condition of the seal material satisfies the following:

- The sample volume changes equal to or less than +5% to -1%
- The tensile change +/- 50%
- No visible dissolution, cracking, blistering or physical deformation

Test results for elastomers shall be acceptable if the condition of the seal material satisfies the following:

- Hardness: +/-10/-20 units (+5/-20 units when initial hardness is 90 Shore A)
- Swelling: +25%/-5%
- Tensile strength, elongation and 50% E-modulus +/-50%

**B.8 Design Validation for Drilling Chokes**

**B.8.1 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.8.2 Static Pressure Testing at Room/Maximum/Minimum Temperature**
B.8.2.1 Test Requirements

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.

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.8.2.2 Acceptance Criteria

There shall be no visible leakage during pressure hold periods.

B.8.3 Hydrostatic Seat-to-body Seal Test at Room Temperature

B.8.3.1 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.8.3.2 Acceptance Criteria

There shall be no visible leakage during pressure hold periods.

B.8.4 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, while maintaining the pressure.
3) Close the choke.
4) Repeat steps 1–3 a minimum of 160 times.

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, i.e. 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.8.5 Dynamic Test at Maximum Rated Temperature

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

5) With the choke closed, apply rated working pressure and maximum rated temperature.
6) Open the choke, while maintaining the pressure.
7) Close the choke.
8) Repeat steps 1–3 a minimum of 20 times.
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, i.e. without binding or chattering, during operational cycles, in accordance with the manufacturer's written specification.

**B.8.6 Dynamic Test at Minimum Rated Temperature**

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

9) With the choke closed, apply and maintain rated working pressure and minimum rated temperature.

10) Open the choke, while maintaining the pressure.

11) Close the choke.

12) Repeat steps 1–3 a minimum of 20 times.

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, i.e. without binding or chattering, during operational cycles, in accordance with the manufacturer's written

**B.8.7 Pressure-temperature Cycles**

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

a) Raise temperature to room temperature.

b) Apply test pressure at room temperature and maintain within 50 % and 100 % of the test pressure while raising temperature to maximum rated temperature.

c) Hold test pressure (100 %) and temperature for one hour minimum.

d) Reduce to minimum rated temperature while maintaining pressure within 50 % to 100 % of the test pressure.

e) Hold test pressure (100 %) and temperature for one hour minimum.

f) Raise to room temperature while maintaining pressure within 50 % to 100 % of the test pressure.

h) Apply test pressure (100 %) while maintaining temperature and hold for one hour minimum.

i) Release pressure and reduce temperature to minimum rated temperature.

j) Apply test pressure (100 %) while maintaining temperature and hold for one hour minimum.

k) Release pressure and raise to room temperature.

l) Apply test pressure (100 %) while maintaining temperature and hold for one hour minimum.

m) Release pressure.

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

**B.9 Drilling Choke and Actuator Assembly Function Testing**

**B.9.1 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.9.2 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.9.3 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.9.4 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.9.5 Data Recording**

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

**B.9.6 Control Console**

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

**B.9.7 Test Sequence**

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

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

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

c) 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.

d) 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.

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

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

**B.9.8 Design Validation for Drilling Choke Actuators**

**B.9.8.1 Design Validation Testing Procedure**

Testing media for hydraulic actuators shall be a suitable hydraulic fluid.
B.9.8.2 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.9.8.3 Operational Test at Room Temperature

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

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.

The test results shall be acceptable if:

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

— there is no visible leakage.

B.9.8.4 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.9.8.5 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.9.8.6 Pressure-temperature Cycles

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

a) Raise temperature to room temperature.
b) Apply testing pressure at room temperature and maintain while raising temperature to maximum rated temperature.
c) Hold pressure and temperature for 1 h minimum.
d) Reduce to minimum rated temperature while maintaining test pressure.
e) Hold pressure and temperature for 1 h minimum.
f) Raise to room temperature while maintaining test temperature.
g) Release pressure and raise temperature to maximum rated value.
h) Apply testing pressure and hold for 1 h minimum.
i) Release pressure and reduce temperature to minimum rated temperature.
j) Apply test pressure and hold for 1 h minimum.
k) Release pressure and raise to room temperature.
I) Apply testing pressure and hold for 1 h minimum.

m) Release pressure.

The test results shall be acceptable if there is no visible leakage.

**B.10 Flexible Choke and Kill Line Design Validation Tests**

**B.10.1 General**

The validation tests shall be as identified per the applicable Flexible Specification Level (FSL) presented in Table 26. The minimum validation tests shall conform to B.12.2 and B.12.3. Additional tests shall be performed in accordance with the applicable FSL.

Design validation tests that conform to B.12.2, B.12.3 and B.12.5 shall qualify the flexible pipe tested, together with smaller sizes of equal pressure ratings, provided the flexibles conform to the following:

1. The design principles of physical configuration and functional operation shall be the same.
2. The design stress levels in relation to material mechanical properties shall be based on the same criteria and shall remain below the stress levels of the tested flexible pipe.
3. The inner liner material shall be the same and with at least same thickness as the tested flexible line.
4. End termination type, including sealing and anchoring, shall remain the same.

**NOTE** The connector may be exchanged if the change does not affect the method of sealing and/or anchoring of the coupling to the hose body.

Design changes that cannot be validated by calculation or do not fulfill the items 1 through 4 shall require full design validation as per B.12.2, B.12.3 and B.12.5.

The addition of components or changing the cover outside of the outermost reinforcement layer shall not require new validation testing per B.12.2, B.12.3 and B.12.5.

**B.10.2 Hydrostatic Internal Pressure**

A minimum length of 10 feet (3.1 meters), 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.10.3 Bending Flexibility Test**

Upon completion of the hydrostatic internal pressure test and with no pressure on the line, the line shall be 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 (see 4.1.1) and bent for a minimum 100 cycles.

The line shall be brought back to room temperature and bending cycle tests continued for a minimum 260 cycles. The line sample shall be pressurized to rated working pressure and shall be 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.10.4 Burst Test**

**B.10.4.1 General**
Upon completion of the bending flexibility test, the line is pressurized to failure at a rate not exceeding 1500 psi/minute (10.35 MPa)/minute. 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.

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.

All tests shall be conducted on the same flexible line sample with a minimum 10 feet, (3.1 meters) 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.

Successful completion of validation testing as specified in B.12.3 shall qualify 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.10.4.2 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 hours. The second and third pressurization applications shall be held for 12 hours.

At the end of each pressure cycle, the line shall be vented in a single operation down to atmospheric pressure and the line shall remain for at least one hour at atmospheric pressure between pressure applications.

The venting rate shall be a minimum of 1000 psi/min (6.9 MPa/minute) +100 psi/minute (0.69 MPa/minute) from rated working pressure down to 1000 psi (69 MPa). Below 1000 psi, venting shall be free of constraints to prevent retaining part of internal pressure into the flexible pipe.

Following completion of Series 1 testing, the flexible line shall maintain ID with a maximum of 10 % bore reduction compared with nominal flexible pipe ID.

B.10.4.3 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.10.4.4 Supplemental Information

Flexible hose specified shall be capable of containing the hose rated working pressure while exposed to an external temperature of 704°C (1300°F) for a 30-minute period.

The fire test shall consist of direct exposure of an assembled flexible hose sample to flame or to radiation within a furnace. The length of the tested flexible hose shall be at least 10 ft (3.05 m). At least 5 ft (1.5 m) of the assembly, including one coupling and end connector should be exposed to temperature, horizontally or vertically.

Test sample shall be pressurized with water before the start of the test to the design working pressure and maintained above design working pressure during the fire test without any addition of water.

Temperatures are to be measured at the middle and both ends of the exposed area by three pairs of thermocouples located diametrically opposite to each other at a distance of one inch (25.4 mm) from the surface of the tested sample.
The fire exposure duration starts at the time of test at which average temperature reading of the six thermocouples rise above 1300°F (704°C) and finish once the 30 minute test period is elapsed or alternatively once a leak occurs beyond test period.

B.10.4.5 Acceptance Criteria

The acceptance criterion shall be no leakage at design working pressure during the 30-minute exposure to simulated fire conditions.

Leak of the sample shall be allowed beyond the 30-minute duration or during cool-down of sample to ambient temperature, however burst of the sample either passed the 30 minute fire exposure duration or during cool down time to ambient temperature will disqualify the tested prototype.

B.10.4.6 Scaling for Fire Rating

For fire rating, successful completion of verification test on the smaller internal diameter size hose as per B.10.4 shall qualify the same and larger sizes of the flexible of equivalent design and construction. The tested sample shall however fulfill the following conditions:

a) the same or a smaller thickness of fire protection is applied,

b) the same or a smaller mass of reinforcement metal is used in the hose body (per unit length).

c) the exposed outer surface is the smallest.

NOTE 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. The line structure and the end terminations shall be exposed to the temperature excursions during the tests.

Upon reaching the manufacturer’s rated working pressure and maximum temperature, the temperature shall be 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 hour. 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 shall be raised at a rate not exceeding 5 °F/hour (2.8 °C/hour) until failure. Failure shall be 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 hour with no visible leakage.

NOTE 2 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.11 Design Validation of Articulated Choke and Kill Line Assembly

B.11.1 General

NOTE This section identifies validation of the design of swiveling components used in articulated choke and kill lines.

These shall not be required for 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.11.2 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.11.3 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)/minute (+100 psi [0.7 MPa]/minute) 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.11.4 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 minute. For acceptance, the assembly shall have no visible leakage nor be damaged in any way affecting normal usage.

**B.12 Design Validation of Buffer Chamber**

Design validation requirements for the choke and kill manifold buffer chamber shall be satisfied by the hydrostatic test specified in 7.5.12.

**B.13 Design Validation of Choke and Kill Manifold Assembly**

Design validation requirements for the choke and kill manifold assembly shall be satisfied by the hydrostatic test specified in 7.5.13.

**B.14 Design Validation of Subsea Choke and Kill Line Valves**

**B.14.1 General**

For subsea choke and kill line valves, the valve design and the actuator design shall be subjected to design validation testing in conformance with API 6A, PR2F requirements for chokes, valves and for actuators, respectively; and additional requirements as listed below.

**B.14.2 Hyperbaric Testing**

Valves and Valve actuators shall be subjected to hyperbaric (external) pressure testing to validate performance under installed (water-depth) conditions. The hyperbaric test pressure should be based on the maximum rated water depth specified by the manufacturer for the equipment. The hyperbaric test medium shall be maintained at 40 °F ± 10 °F (4 °C ± 5 °C) throughout the test.

For static components the functional cycles specified in Table 1 should be internal pressure cycles from rated working pressure to fully depressurized (atmospheric pressure), while continuously subjected to external hyperbaric pressure.

For equipment with moving parts, the functional cycles specified in Table B.2 should be dynamic operation cycles, such that full operating motion of the equipment is achieved. E.g., a cycle should consist of starting from the fully closed position, applying a differential bore pressure of RWP, then actuating open under differential pressure and stroking to the full open position with bore pressure vented to atmospheric. The specified number of cycles should be completed with the equipment continuously subjected to external hyperbaric pressure.

During the hyperbaric functional cycles, leakage should not exceed that specified in API 6A, Annex F, for PR2. A single internal hydrostatic test (7.5) should be performed for acceptance after all hyperbaric functional cycles have
been completed and hyperbaric conditions depressurized to atmospheric pressure. Hold time should be 15 minutes minimum. Acceptance criteria for hold periods shall be as specified in API 6A, Annex F, for PR2.

A valve and actuator assembly shall be subjected to a total of 400 functional cycles, of which 200 are hyperbaric as described in this annex, and 200 are as described in API 6A, Annex F, PR2, including 20 cycles at maximum rated temperature and at minimum rated temperature.

Table B.2—Subsea Valve and Actuator Hyperbaric Testing

<table>
<thead>
<tr>
<th>Component</th>
<th>Operational cycles under Hyperbaric Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valves</td>
<td>200</td>
</tr>
<tr>
<td>Valve actuators</td>
<td>200</td>
</tr>
<tr>
<td>Metal seal (exposed to well bore in production)</td>
<td>200(^a)</td>
</tr>
<tr>
<td>Metal seal (not exposed to well bore in production)</td>
<td>3(^a)</td>
</tr>
<tr>
<td>Non-metallic seal (exposed to well bore in production)</td>
<td>200(^a)</td>
</tr>
<tr>
<td>Non-metallic seal (not exposed to well bore in production)</td>
<td>3(^a)</td>
</tr>
</tbody>
</table>

\(^a\) Applicable if seal is directly exposed to hyperbaric conditions in service.

B.14.3 Valve and Actuator Assembly Testing

Subsea valve and actuator assemblies shall be tested to demonstrate the performance limits of the assembly. Unidirectional valves shall be tested with pressure applied in the intended direction. Bi-directional valves shall be tested with pressure applied in both directions in separate tests.

For a fail-closed (fail-open) valve, with the assembly subjected to external hydrostatic pressure (actual or simulated) of the maximum rated water depth and full rated bore pressure, applied as a differential across the gate, it shall be shown that the valve opens (closes) fully from a previously closed (open) position with a maximum of 90% of the hydraulic RWP above actual or simulated ambient pressure, or the minimum hydraulic pressure as defined in 7.5.6, applied to the actuator.

For a hydraulic fail-closed (fail-open) valve, with the assembly subjected to the external hydrostatic pressure, (actual or simulated) of the maximum rated water depth and atmospheric pressure in the body cavity, the valve shall be shown to move from a previously fully open (closed) position to a fully closed (open) position as the hydraulic pressure in the actuator is lowered to a minimum of 0.69 MPa (100 psi) above ambient pressure.

For a fail-in-place valve, with the assembly subjected to the external hydrostatic pressure (actual or simulated) of the maximum rated water depth, the valve shall be shown to close or open fully from a previously open or closed position with a maximum of 90% of the operating hydraulic fluid pressure above actual or simulated ambient pressure, or the minimum hydraulic pressure as defined in 7.5.6 applied to the actuator. A fail-in-place hydraulic valve shall remain in position as the hydraulic pressure in the actuator is lowered to a minimum of 0.69 MPa (100 psi) above ambient pressure.

B.14.4 Life-cycle/endurance Testing

NOTE 1 Life-cycle/endurance testing, such as operational testing of valves, chokes, and actuators, is intended to evaluate long-term wear characteristics of the equipment being tested. Such tests may be conducted at a temperature specified by the manufacturer and documented as appropriate for that product and rating.

Table B.3 lists equipment that shall be subjected to extended life-cycle/endurance testing to simulate long-term field service. For these life-cycle/endurance tests, the equipment shall be subjected to operational cycles in accordance with the manufacturer's performance specifications (i.e. make-up to full torque/break-out, open/close under full rated working pressure).

NOTE 2 Where it can be demonstrated that pressure and/or temperature testing similarly loads the component or assembly to that condition specified for endurance-cycle testing, those cycles can be accumulated toward the total number of cycles specified for endurance-cycle testing. For example, the 200/3 pressure/temperature cycles used to test a valve can cumulatively qualify as 200 cycles toward the 600 total cycles required for endurance cycling.
Table B.3—Extended Life Cycle and Endurance Testing

<table>
<thead>
<tr>
<th>Component</th>
<th>Pressure/Load Cycling Test</th>
<th>Temperature Cycling Test&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Endurance Cycling Test (Total Cumulative Cycles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valves&lt;sup&gt;b&lt;/sup&gt;</td>
<td>200</td>
<td>3</td>
<td>600</td>
</tr>
<tr>
<td>Valve actuators</td>
<td>200</td>
<td>3</td>
<td>600</td>
</tr>
<tr>
<td>Metal seal (exposed to well bore)</td>
<td>200</td>
<td>3</td>
<td>PMR&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Metal seal (not exposed to well bore in production)</td>
<td>3</td>
<td>3</td>
<td>PMR&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Non-metallic seal (exposed to well bore in production)</td>
<td>200</td>
<td>3</td>
<td>PMR&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Non-metallic seal (not exposed to well bore in production)</td>
<td>3</td>
<td>3</td>
<td>PMR&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> Temperature cycles shall be in accordance with API 6A.
<sup>b</sup> Before and after the pressure cycle test a low-pressure, 2 MPa (300 psi) ± 10%, leak-tightness test shall be performed.
<sup>c</sup> PMR signifies “per manufacturer rating”.

B.14.5 Subsea Choke and Kill Valve and Actuator 5000 Cycle Validation

B.14.5.1 General

In addition to the 16C subsea valve requirements, a 5,000 cycle test shall be performed on side outlet valves and the actuators.

B.14.5.2 Parameters

This test shall be performed at room temperature.

The valve and actuator shall be validated as an assembly and shall have no adjustments, greasing, modifications, or re-assembly, during this test.

The actuator shall be operated at its rated working pressure.

Water with soluble oil that also provides corrosion protection in the vapor phase should be used as the test fluid to avoid corrosion of the equipment. The type of soluble oil and concentration used shall be documented in the test records.

NOTE 1 Water may be used as the test fluid but requires preservation of the equipment afterwards.

NOTE 2 It is not necessary to use the same valve used during the 16C subsea valve validation.

B.14.5.3 Cycles

The follow shall apply:

a) Apply between 250 to 350 psi differential pressure across the valve. If a restriction is installed in the downstream line, it shall be no smaller than 50% the valve bore ID.

b) Open the valve fully.

c) Close the valve fully.

d) Bleed the downstream pressure to 1% or less of test pressure after the valve is fully closed.

e) All subsequent seat tests shall be in the same direction. Repeat until 5,000 cycles have been complete.
f) At a minimum, a low pressure seat hold and a high pressure seat hold on the upstream side of the valve shall be performed every 500 cycles.

g) No visible leakage shall occur during the cycles.

B.14.5.4 Post-cycle Pressure Holds

After 5,000 cycles have been completed the valve shall pass a high-pressure body hold, low pressure body hold, high pressure downstream seat hold, and a low pressure downstream seat hold.

B.14.5.5 Pressure Hold Definitions

B.14.5.5.1 Low Pressure Seat Hold

Valve shall be in the closed position. Apply 250psi to 350psi on the gate and release any pressure on the other side. Hold the pressure for 5 minutes. A pressure drop of 30 psi is acceptable, no visible leakage shall occur.

B.14.5.5.2 Low pressure Body Hold

Valve shall be in the partially open position. Apply 250psi to 350psi to the valve. Hold the pressure for 5 minutes. A pressure drop of 30 psi is acceptable, no visible leakage shall occur.

B.14.5.5.3 High Pressure Seat Hold

Valve shall be in the closed position. Apply the valve’s rated working pressure on the gate and release any pressure on the other side. Hold the pressure for 5 minutes. A pressure drop of 300 psi is acceptable, no visible leakage shall occur.

B.14.5.5.4 High pressure body hold

Valve shall be in the partially open position. Apply the valve’s rated working pressure to the valve. Hold the pressure for 5 minutes. A pressure drop of 300 psi is acceptable, no visible leakage shall occur.

B.14.5.6 Post-test Examination

The tested prototype shall be disassembled and inspected. All relevant items should be photographed. The examination shall include a written statement that neither the product nor component design contains defects to the extent that any performance requirement is not met.

B.15 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
(normative)

Heat Treating Equipment Qualification

C.1 Temperature Tolerance

The temperature at any point in the working zone should not vary more than $+25^\circ F (+13.9 ^\circ C)$ 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 $+15^\circ F (+8.3 ^\circ C)$ from the furnace set point temperature, after the furnace working zone has been brought up to temperature.

C.2 Furnace Calibration

C.2.1 General

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

C.2.2 Records

Records of furnace calibration and surveys should be maintained for at least two years.

C.2.3 Batch Type Furnace Methods

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.

A minimum of 9 thermocouple test locations should be used for furnaces having a working zone greater than 10 ft$^3$.

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 C1 for recommended locations of thermocouples.

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.

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.

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.

Before the set point temperature is reached, none of the temperature readings should exceed the set point by $+25^\circ F (+13.9 ^\circ C)$.

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.

When a furnace is repaired or rebuilt, it shall be calibrated before heat-treating.
C.2.4 Continuous-type Furnace Method

Continuous heat-treating furnaces should be calibrated in accordance with procedures specified in SAE-AMS-H-6875.

C.3 Instruments

C.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.

C.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.

C.3.3 Calibration Frequency

Temperature controlling and recording instruments should be calibrated at least every three months.

C.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 D  
(informative)

Pipe Thermal Expansion Calculations

D.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).

\[ S_{tm} \leq \frac{L \times \Delta T \times B \times E}{A} \]

where

- \( S_{tm} \) is the thermal stress, in psi (Mpa);
- \( L \) is the length between fixed anchors, in inches (mm);
- \( \Delta T \) 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\(^2\)).

D.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;
- \( \Delta_1 \) 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;

$\ominus_1$ may be calculated by the following equation from ASME B31.3;

$\ominus_1 = 12LB \ominus T$;

where

$\ominus_1$ 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;

$\ominus T$ is the temperature change, in °F.

D.3 Expansion Levels

Pipe movement can be handled by expansion bends (including loops – “U”, “L”, and “Z” shaped piping), and swivel unions. Expansion bends are preferred when practical. If expansion bends are not practical, swivel unions should be used.
Annex E
(normative)

Drilling Choke Control Console System

E.1 General
The function of the remote 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 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.

E.2 Functional Requirements
E.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 $\pm 10$ 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 $\pm 0.5\%$ 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.

**E.2.2 Piston Isolator Transmitter**

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.

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.

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.

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.

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.

Gauge system hoses shall have pressure rating compatible with the maximum system operating pressure.

The pressure transmitter shall have materials specified for wellbore retained fluids.

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.

Unions forming a part of the transmitter shall conform to specifications for other end connectors in accordance with API 6A.

Pump stroke counter/rate meter for monitoring each rig pump used during choke operations shall be incorporated into the control panel.

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.

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.

This SPM display, if digital, shall show one stroke/minute minimum resolution.

All counter/rate meter wiring (power, pump micro switches, etc.) shall be in conformance with NFPA 496, A.P.S. (all applicable agencies).

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.

E.2.3 Emergency Operation Provisions

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.

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.

E.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.

E.2.5 Hydraulic Hoses (for Operation of Choke)

The hoses shall have connections that permit installation in only the correct manner, and shall be prevented from installation into the pressure gauge systems.

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.

All hose connections should be marked on the panel and the choke.

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.

E.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 F

(informative)

Example Choke and Kill System Configurations

Figures 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.

(figures to be added on publication)
Annex G
(informative)

Mud Gas Separators

G.1 MGS Vessel Capacity

Bulk or free gas and intermittent slugs of liquid are the normally expected mechanism for gas entering the MGS. However, mud gas separators often incorporate a liquid pool to allow “residence time” for entrained gas to coalesce and separate at near atmospheric conditions. For analysis of this type separation, reference is made to the appendix of API 12J which provides summary of Stokes’s Law separation based on density differences between the gas and liquid. Liquid pools are not a requirement of this spec. Mud gas separators come in two varieties: open-bottom partially submerged vessels and closed-bottom vessels.

For the purposes of this specification, mud gas separator outlets may be classified by one of several configurations: a mud leg or “u-tube”, a float mechanism, an active discharge control system or some combination of any of these three configurations. When a mud leg is used, the height of the mud leg, the density of the fluid and the fluid discharge flow rate determine the hydrostatic pressure that establishes a liquid seal for the MGS fluid discharge. This liquid seal is essential to prevent separated gas from flowing through the fluid discharge and creating a hazardous condition at the shakers and around rig personnel.

The “capacity” of an MGS is functionally determined by the following:

(1) The volume flow rate of gas, when directed through the vent system, which creates a sufficient MGS vessel internal pressure sufficient to overcome the hydrostatic pressure of the mud leg.

(2) The volume flow rate of fluid, or mud, that exceeds the MGS fluid discharge rate over a limited period of time, such that the MGS vessel will overfill and flood the vent system.

(3) MGS vessel diameter, which is a factor in gas/liquid separation of entrained gas.

(4) MGS overall length and baffle inclusion, which influences liquid surface area for gas breakout and overall residence time in the “separation zone” of the MGS.

During MGS use for kick removal the gas and liquid flow rates are dynamic and influence vessel separation capacity.

The gas handling capacity of the MGS can be increased by deploying an active discharge control system, such a float system or actuated discharge control valve. A float mechanism uses a float to open and close a valve and control mud flow in response to the fluid level within the separator. An active discharge control system utilizes a control valve on the mud gas separator discharge to control the discharge flow rate, using a mud gas separator monitoring system for valve position control. Because the float mechanism and the active discharge control system provide active liquid seal integrity, the separation capacity of a mud gas separator using these discharge systems is typically greater than the “passive” mud leg discharge system, alone.

Mud gas separators can be operated at near atmospheric pressure, typically up to 15 psig. For atmospheric installations, the flow of gas through the vent line will impose a slight backpressure on the vessel. When large amounts of gas flow through the separator, this backpressure will increase, and can overcome the hydrostatic pressure of the mud leg. Therefore it is critical to have the mud gas separator sized properly for the expected operating conditions.
The operating pressure of the system is determined by the flow conditions as described above. The Rated Working Pressure of the mud gas separator is determined by its design and construction.

G.2 System Configuration

G.2.1 General

It is important to consider the mud gas separator as part of the choke and kill system. The atmospheric MGS is a component of the choke and kill system and is used to route gas from the choke manifold safely away from the rig work areas. As this equipment prevents the escalation of a well control event, its installation at the well site or on the rig shall assure gas is directed to a safe area through a vent and/or flare system.

G.2.2 MGS Bypass Configuration

In the event the MGS separation capacity is exceeded, provisions should be made to bypass the MGS and direct return flow directly to the flare system, safe location (land installation) or an overboard discharge (offshore installations). The bypass may be a manual bypass or an actuated control system. As an alternative to a bypass, an active discharge control system may be utilized where the discharge control system provides the ability to actively maintain the liquid seal throughout the upset condition.
Annex H
(normative)

Charpy V-notch Impact Test Location for Weld Qualification

When impact testing is required, the testing shall be performed in accordance with ASTM A370 using the Charpy V-notch technique. Results of testing in the weld and HAZ shall meet the minimum requirements of the base material, for both average and minimum toughness requirements.

If any one of the three specimens falls below the minimum allowed toughness requirement, two additional Charpy test specimens will be required from that area, and both shall be at or above the minimum toughness requirement. Records of results shall become part of the PQR.

The number and location of the Charpy V-notch impact test specimen shall be in accordance with Figure F.1, following the sampling requirements in relation with the material thickness, weld type, and weld thickness used for the qualification:

— Less or equal to 19 mm (0.75 in.): Charpy specimens shall be taken from the external surface (within 1.5 mm from the surface), and shall be subject to the requirements for multi-process and double-sided welds.

— Greater than 19 mm (0.75 in.) to less than 38 mm (1.5 in.): Charpy specimens shall be taken from the external and internal surface (within 2 mm from both surfaces), and shall be subject to the requirements for multi-process and double-sided welds.

— Greater or equal to 38 mm (1.5 in.): Charpy specimens shall be taken from the external and internal surfaces within 2 mm (0.1 in.) from both surfaces and from the mid-wall position, and shall be subject to the requirements for multi-process and double-sided welds.

When impact testing is required, sets of three test specimens shall be removed from the weld and heat affected zone.

If multiple welding processes are used to produce the weldment, the weld metal and appropriate HAZ test specimens shall be removed for each welding process.

On double-sided welds, weld metal from the root region containing consumed tack welds made with different weld metal should be Charpy tested.

NOTE The manufacturer can decide to take an impact specimen as near as practical at the midway thickness of the weld for qualification of a single V groove.
Weld thickness $t \leq 19$ mm (0.75 inch)

Weld thickness $t > 19 < 38$ mm (> 0.75 < 1.5 inch)

Weld thickness $t \geq 38$ mm (1.5 inch)

Legend:
- $a =$ On weld center
- $b =$ On fusion line (FL)
- $c =$ In Heat Affected Zone (HAZ), FL + 2 mm (0.08 inch)

Figure J.1 Location of Charpy V-Notch Impact T