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Draft for Ballot # 6071

Diverter Equipment Systems

API STANDARD 64
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Diverter Equipment Systems

1 Scope

This standard is intended to provide information on the design, manufacture, quality control, installation, maintenance and testing of the diverter system, and associated components. The diverter system provides a flow control system to direct controlled or uncontrolled wellbore fluids away from the immediate drilling area for the safety of personnel and equipment.

2 Normative References

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

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

API Technical Report 6AF, *Technical Report on Capabilities of API Flanges under Combinations of Loads*

API Technical Report 6AF2, *Capabilities of API flanges under Combinations of Load*

API Specification 6FA, *Specification for Fire Test for Valves*

API Standard 6D, *Specification for Pipeline and Piping Valves*

API Standard 6DX, *Standard for Actuator Sizing and Mounting Kits for Pipeline Valves*

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

API Specification 16A, *Specification for Drill-through Equipment*

API Specification 16D, *Specification for Control Systems for Drilling Well Control Equipment and Control Systems for Diverter Equipment*

API Specification 16F, *Specification for Marine Drilling Riser Equipment*

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

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

ASME B16.5, *Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard*

ASME B31.3, *Process Piping*

ASME Boiler and Pressure Vessel Code (BPVC), Section V, Article 5, *UT Examination Methods for Materials and Fabrication*

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

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

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

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

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ASTM D412, *Test Methods for Vulcanized Rubber, Thermoplastic Rubbers and Thermoplastic Elastomers*

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

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

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

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

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

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

ASTM E94, *Standard Guide for Radiographic Testing*

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

ASTM E140, *Hardness Conversion Tables for Metals*

ASTM E165, *Standard Test Method for Liquid Penetrant Examination*

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

ASTM E709, *Standard Guide for Magnetic Particle Testing*

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

TWI 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 17637:2011

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

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

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

ISO 6892, *Metallic materials—Tensile testing at ambient temperature*

ISO 9712, *International Standard for Nondestructive Testing Personnel Qualification and Certification*

ISO 18265, *Metallic materials—Conversion of hardness values*

3 Terms, Definitions and Acronyms

3.1 Terms and Definitions

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

3.1.1

acceptance criteria

Defined limits placed on characteristics of materials, products, or service.

3.1.2

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actuator

(valve actuator)

Device used to open or close a valve by means of applied manual, hydraulic, pneumatic, or electrical energy.

3.1.3

annular sealing device

Assembly containing a packing element that facilitates closure of the annulus by constricting to seal on the tubular in the wellbore.

NOTE 1 Some annular sealing devices also facilitate shutoff of the open hole.

NOTE 2 Examples include, but not limited to, diverter assemblies, annular preventer, and overshot packer systems.

3.1.4

annulus

Space between the outer diameter of the drill string and the inside diameter of the hole being drilled, the last string of casing set in the well or the marine riser.

3.1.5

bell nipple

Piece of pipe expanded, or belled, at the top to guide tools into the hole, connected to the top of the annular sealing device with a side outlet to direct the drilling fluid returns to mud processing equipment.

NOTE 1 Usually has a second side outlet for the fill-up line connection.

NOTE 2 The bell nipple is primarily used where no fixed diverter system exists.

3.1.6

blowout preventer stack

BOP stack

An assembly of drill-through and well control equipment connected to the top of the wellhead or wellhead assembly.

3.1.7

body

Portion of equipment between end connections, with or without internal parts, which contains wellbore pressure.

3.1.8

bolting

Threaded fasteners including studs, tap end studs, double ended studs, headed bolts, cap screws, screws, and nuts.

— primary bolting

Bolting in the load path or bolting used to assemble flow-direction-controlling members or that join end or outlet connections.

— utility bolting

Bolting used for mounting equipment and accessories to the diverter equipment not identified as primary bolting.

NOTE Examples include bolting on nameplate, clamps for tubing, guards, etc.

3.1.9

bottom-hole assembly

That part of the drill string located directly above the drill bit.

NOTE The components primarily include drill collars and other specialty tools such as stabilizers, reamers, drilling jars, bumpersubs, heavy weight drill pipe.

3.1.10

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complete shut-off

CSO

Shut-off of wellbore without tubular in wellbore.

3.1.11

corrosion-resistant alloy

CRA

Alloy intended to be resistant to general and localized corrosion when subject to oilfield environments.

3.1.12

corrosion-resistant ring groove

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

3.1.13

date of manufacture

Date of the manufacturer's final acceptance of finished equipment.

3.1.14

divert mode

State in which the diverter system will operate a pre-determined sequence to direct and control flow to designated overboard line(s).

3.1.15

diverter

diverter assembly

Device used to direct flow from the wellbore to the pre-selected side outlet(s).

NOTE 1 Upon activation, the diverter assembly seals the vertical flow path to prevent hydrocarbons from reaching the rig floor and normally diverts flow to the overboard line(s).

NOTE 2 When deactivated, the diverter assembly allows for fluid returns to the flow line for normal drilling operations.

3.1.16

diverter control system

Assemblage of pumps, accumulators, manifolds, control panels, valves, lines, etc., used to operate the diverter system.

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3.1.17

diverter housing

The interface between the diverter assembly and the required piping.

NOTE The diverter housing handles the loads between the rig and the riser system, provides the sealing surface, and the lockdown mechanism for the diverter assembly.

3.1.18

diverter spool

Device to direct an uncontrolled flow which may generate from a shallow zone during well drilling activities.

NOTE A diverter spool is used on a surface application below a diverter prior to the installation of blowout prevention equipment.

3.1.19

diverter system

Assemblage of a sealing device, flow control means, and overboard system components, which facilitates the closure of the upward flow path of the well fluid and the opening of the overboard line to divert the fluid flow to the environment away from the rig floor.

NOTE Components include, but not limited to, diverter, diverter control system, valve(s), side outlets, and flow/overboard lines.

3.1.20

end connection

Integral male or female thread; clamp hub end connector or flange, studded or through-bolted, or any other means used to join equipment that contains or directs fluid flow.

3.1.21

equivalent round

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

3.1.22

fill-up line

Line connected into the bell nipple or diverter housing allowing drilling fluid to be added to the hole.

3.1.23

flange

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

3.1.24

flow-direction-controlling member

System component that contains and directs wellbore fluid flow.

3.1.25

flow selector

Three-way valve with switchable target designed to divert wellbore fluids while keeping a diverter overboard line open.

3.1.26

flow line

Piping that exits the bell nipple or diverter housing, and conducts drilling fluid and cuttings to the mud processing equipment.

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3.1.27

flow line seal

Elastomeric element that creates a seal between the diverter housing and diverter assembly.

3.1.28

fluid cushion

Cavity in a piping system used to absorb impact of flow direction change to mitigate erosion.

3.1.29

full-opening valve

Valve with an unobstructed opening, not smaller than the internal bore of the end connections.

3.1.30

function test

Closing and opening (cycling) equipment to verify operability.

3.1.31

heat-affected zone

HAZ

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

3.1.32

heat treatment

heat treating

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

3.1.33

hot-work [verb]

Deform metal plastically at a temperature above the recrystallization temperature.

3.1.34

indication

Visual sign of cracks, pits or other abnormalities found during liquid penetrant and magnetic particle examinations.

3.1.35

leakage

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

3.1.36

linear indication

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

3.1.37

load-bearing weldments

Weldments subjected to external loads.

3.1.38

load path

Direction in which each consecutive load propagates through connected members.

3.1.39

maintenance

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Upkeep of well control equipment that is performed in accordance with the equipment owner's PM program and the manufacturer's guidelines.

NOTE 1 These procedures may include, but are not limited to: disassembly, inspections, cleaning, polishing, function testing, pressure testing, nondestructive examination, change out of sealing parts, and those parts defined in the PM program to be changed either periodically or on a cycle basis.

NOTE 2 Maintenance does not include machining, welding, heat treating or other manufacturing operations.

3.1.40

major repair weld

Weld whose depth is greater than 25 % of the original wall thickness or 25 mm, whichever is less.

3.1.41

other end connection

OEC

Connection that is not specified in an API Specification or Standard.

NOTE Other end connection includes API flanges and hubs with non-API gasket preparations and manufacturer's proprietary connections that are designed and manufactured in accordance with API 16A.

3.1.42

overboard line

vent line

Conduit that directs the flow of diverted wellbore fluids away from the drill floor to the environment.

3.1.43

overshot spool

Device to direct an uncontrolled flow which may generate from a shallow zone during well drilling activities.

NOTE An Overshot (diverter) spool is used on a surface application below a diverter prior to the installation of blowout prevention equipment.

3.1.44

overshot system

Configurable spacer spool consisting of an overshot packer with sealing element (female slip connection), an overshot mandrel (male slip connection), and overshot spools.

NOTE The overshot system facilitates the space out of the Drilling Equipment.

3.1.45

packing element

Rubber/elastomer element that affects a seal in an annular preventer, diverter, or other annular sealing device.

NOTE A packing element is also an elastomer used in valves or lubricators to affect a seal.

— annular packing element (annular packer)

Torus-shaped rubber/elastomer element that affects a seal in an annular preventer or diverter.

NOTE The annular packing element is displaced toward the bore center by the upward movement of an annular piston.

— insert packing element (insert packer)

Cylindrical shaped rubber/elastomer element that affects a seal in a diverter.

NOTE The insert-type packing element is displaced toward the bore center by an external load, typically actuated by hydraulics.

— diverter packer

Sealing component consisting of a rubber/elastomer element that effects a seal in through bore of a diverter.

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3.1.46

post-weld heat treatment

PWHT

Heat treatment subsequent to welding, including stress relief.

3.1.47

pressure-containing part

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

NOTE Examples include bodies, clamp bolts, bonnets, connecting rods, packing elements, and replaceable seals within a pressure-containing member or part.

3.1.48

product history file

Composite file of records from a traceable API product which includes all records associated with the API product repair and remanufacturing, including certification records required by this Standard.

3.1.49

rated load

Nominal applied loading conditions used during design, analysis, and testing based on maximum anticipated service load.

3.1.50

rated working pressure

Maximum internal pressure that the equipment is designed to contain or control or a combination thereof.

3.1.51

response time

Time elapsed from initiation to completion of the Diverter System closing sequence.

3.1.52

technical authority

Competent and technically qualified person or organization with evidence to demonstrate the expertise, skills, and experience regarding design, quality, and manufacturing processes necessary to perform the required verification(s).

3.1.53

relevant indication

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

NOTE

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

3.1.54

repair

Activity involving disassembly, reassembly, or replacement of components and testing of equipment after the failure of a piece of equipment.

NOTE Repair does not include machining, welding, heat treating or other manufacturing operations.

3.1.55

rounded indication

For liquid penetrant or magnetic particle examination—any indication that is approximately circular or elliptical and whose length is less than three times its width.

For radiographic examination—any indication with a maximum length of three times the width or less on the

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radiograph.

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

3.1.56

serialization

Assignment of a unique code to individual parts or pieces, or a combination thereof, of equipment to maintain records.

3.1.57

Stabilization (pressure testing)

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

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

3.1.58

Stabilization (temperature testing)

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

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

3.1.59

subsea diverter

Diverter system installed above marine drilling riser.

3.1.60

surface diverter

Diverter system not installed above marine drilling riser.

3.1.61

target flange

Bull plug or blind flange to prevent erosion at a point where change in flow direction occurs.

3.1.62

targeted

Refers to a fluid piping system in which flow impinges upon an erosion-resistant end (target flange) when fluid transits a change in direction.

3.1.63

telescopic joint

slip joint

Riser joint having an inner barrel and an outer barrel with sealing means between the two barrels.

NOTE 1 The inner barrel is attached to the flexible joint beneath the diverter and the outer barrel is attached to tensioner lines.

NOTE 2 The inner and outer barrels of the telescoping joint move relative to each other to compensate for the required change in the length of the riser string as the vessel moves.

3.1.64

trepan [verb]

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

3.1.65

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weld groove

Area between two metals to be joined and has been prepared to receive weld filler metal.

3.1.66

wellhead

Component or structure installed to provide an interface between casing and well control equipment.

3.1.67

wrought structure

Structure that contains no cast dendritic structure.

3.1.68

yield strength

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

NOTE 1 Yield strength is expressed in pounds per square inch of loaded area.

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

3.2 Acronyms

For the purposes of this document, the following acronyms apply:

| | |
|-----|--|
| BOP | blow out preventor |
| CE | carbon equivalent |
| CRA | corrosion-resistant alloy |
| CSO | complete shut-off |
| DAC | distance amplitude curve |
| FAT | Factory Acceptance Test |
| FEA | Finite Element Analysis |
| ID | inside diameter |
| IOM | Installation, Operation, and Maintenance |
| LP | liquid penetrant |
| MP | magnetic particle |
| NDE | nondestructive examination |
| OD | outside diameter |
| OEC | other end connection |
| OEM | original equipment manufacturer |

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| | |
|------|---------------------------------|
| PQR | procedure qualification record |
| PWHT | post-weld heat treatment |
| QTC | qualification test coupon |
| RWP | rated working pressure |
| SST | austenitic stainless steel |
| WPS | welding procedure specification |

4 Diverter System Size Designation

Nominal diverter size and corresponding drift diameter(s) shall be agreed upon by manufacturer and purchaser.

NOTE Sizing may be based on nominal rotary table size.

5 Component Design Methodology

5.1 General

NOTE 1 This Section applies to the design and manufacture of new diverter equipment. This Section is not intended to apply to equipment manufactured before the date of publication of this document.

The design methodology shall be in accordance with API 6X and shall be used together with the equipment manufacturer's specifications.

NOTE 2 The use of von Mises equivalent stress is permitted.

5.2 Service Conditions

5.2.1 Rated Working Pressure

Equipment covered in this standard shall be designed and manufactured for a minimum rated working pressure (RWP) of 3.45 MPa (500 psi). Diverter system pressure rating shall be rated by the lowest rated component.

5.2.2 Temperature Ratings

Equipment shall be designed for metallic parts to operate in accordance with the temperature ranges shown in Table 1.

Equipment shall be designed for wellbore elastomeric materials to operate in accordance with the temperature classifications of Table 2.

The low temperature shall be the lowest temperature to which the equipment is subjected.

Table 1—Temperature Rating for Metallic Materials

| Classification | Operation Range | |
|----------------|-----------------|------------|
| | °C | °F |
| T-75/250 | −59 to 121 | −75 to 250 |
| T-75/350 | −59 to 177 | −75 to 350 |
| T-20/250 | −29 to 121 | −20 to 250 |
| T-20/350 | −29 to 177 | −20 to 350 |

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| | | |
|---|------------|----------|
| T-0/250 | –18 to 121 | 0 to 250 |
| T-0/350 | –18 to 171 | 0 to 350 |
| NOTE Information on strength of materials at elevated temperatures is found in API 6A and API 6MET. | | |

Table 2—Temperature Rating for Non-metallic Materials

| Low Temperature Limit (first digit) | | | Continuous Elevated Temperature Limit (second digit) | | | Extreme Temperature Limit (third digit) | | |
|--|-------------|-------|--|-------------|-------|--|-------------|-------|
| Code | Temperature | | Code | Temperature | | Code | Temperature | |
| | °F | °C | | °F | °C | | °F | °C |
| A | –15 | –26 | A | 150 | 66 | A | 180 | 82 |
| B | 0 | –18 | B | 180 | 82 | B | 200 | 93 |
| C | 10 | –12 | C | 210 | 99 | C | 220 | 104 |
| D | 20 | –7 | D | 240 | 116 | D | 250 | 121 |
| E | 30 | –1 | E | 270 | 132 | E | 300 | 149 |
| F | 40 | 4 | F | 300 | 149 | F | 350 | 177 |
| G | Other | Other | G | Other | Other | G | Other | Other |
| NOTE EXAMPLE: Material “FDE” has a low temperature rating of 40 °F (4 °C), a continuous elevated temperature rating of 240 °F (116 °C), and an extreme temperature limit of 300 °F (149 °C). | | | | | | | | |

The continuous elevated temperature limit shall be the maximum average fluid temperature allowed over a ten pressure cycle period.

The extreme temperature limit shall be the maximum fluid temperature to which the equipment is subjected over a one-hour period.

5.2.3 Rated Service Range

The rated service range shall be defined by the manufacturer as the range of tubulars that can be sealed up to the full RWP of the diverter and meet the minimum requirements for the validation testing for that range.

Equipment capable of complete shut-off (CSO) may designate “CSO” for the minimum size. Equipment incapable of CSO shall state the minimum rated tubular size.

Equipment marked as CSO shall be capable of no visible leakage at the RWP of the diverter assembly.

5.2.4 Load Rating

Diverter and attachments shall be evaluated for:

- a) hang-off load capacity;
- b) up-thrust load;
- c) additional loads as defined by purchaser:
 - 1) bending moments;
 - 2) dynamic loading from vessel motion; and,
 - 3) horizontal forces (such as equipment motion).

5.3 Diverter Housing

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5.3.1 General

Diverter housings attached to the rig's substructure shall be designed such that the loads generated by the diverted fluid are directed into the substructure.

Hang-off load capacity shall be defined through calculation, or Finite Element Analysis (FEA), or both. Additional loads acting on the housing such as bending moments, dynamic loading from vessel motion, or horizontal forces (such as equipment motion) shall be defined by the purchaser.

Housing side outlet connections to the wellbore shall not be threaded. Housing side outlet connections shall be specified by the customer or shall conform to the dimensional requirements of API 6A, or ASME B16.5, or a combination thereof.

NOTE Side outlet connections should be designed to reduce erosion.

5.3.2 Weldability of the Attachment Bars to the Substructure

Attachment bar material shall be readily weldable without post-weld heat treatment (PWHT). Welding shall be performed using a weld procedure qualified for the materials to be welded.

The bars shall be welded along a minimum of two sides for the full length, to distribute the bolting load evenly to the beams. Both ends of the attachment bar shall be seal welded.

The weld of the attachment bars to the rig substructure shall be designed to meet the designed load rating of the diverter system.

5.4 Diverter Assembly

Diverter assembly pressure rating shall be rated by the lowest component. Diverter assemblies shall be designed to land and lock within the diverter housing. The assembly shall seal to the housing and provide a flowpath to the diverter outlets.

Diverter assembly shall be capable of transferring loads to housing as defined by the purchaser. The diverter assembly shall actuate the diverter packer to close off on a designated pipe size or open hole if applicable.

5.5 Diverter Packer

5.5.1 General

The diverter packer shall create a wellbore seal and divert the upward flowpath of well fluids.

NOTE 1 Two types of sealing devices or packer elements commonly used in diverters are described in 5.5.2 and 5.5.3.

NOTE 2 Though some diverters and their packer elements are designed for CSO, others are designed to seal on a specified range of pipe diameters.

5.5.2 Annular Type Packing Unit

An annular packing element (see Figure 1) shall seal on the range of tubulars specified by the manufacturer and may seal on an open hole if no pipe is present.

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Figure 1—Example Diverter with an Annular Packing Unit

NOTE The packing element moves radially inward when a hydraulic “close” pressure is applied to the diverter.

The packing element shall relax to the open position when hydraulic “open” pressure moves the operating piston to the open position.

The annular packing element shall pass the drift in the fully open position.

Drift diameter shall be 1.53 mm (0.06 in.) less than the nominal diverter bore diameter with a tolerance of +0.76/-0.00 mm (+0.03 in./-0.000 in).

5.5.3 Insert Packing Element

NOTE 1 An insert packing element (see Figure 2) uses inserts that can close and create a seal on ranges of pipe diameters.

A hydraulic or mechanical lock shall latch the insert packer in place.

NOTE 2 The insert packer may be removed to pull or run the bottom-hole assembly (see Figure 2).

The manufacturer shall define a procedure to verify that the insert packer is properly locked in place each time the packer is inserted.

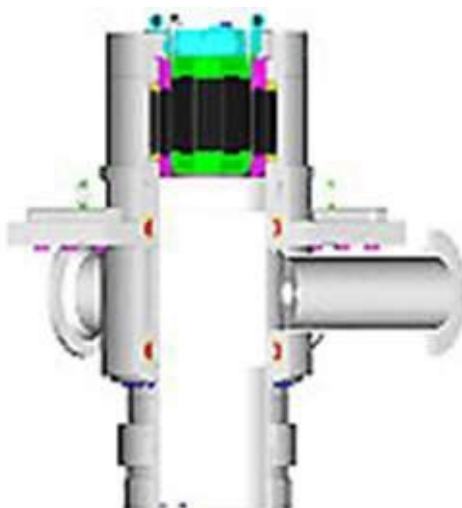


Figure 2—Example Diverter with an Insert Type Packer

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5.6 Overshot System

The overshot system pressure rating shall be equal to or greater than the diverter system pressure rating.

5.6.1 Overshot Mandrel

The overshot mandrel is a piece of plain end pipe or tube with an end connection on the opposite end.

5.6.2 Overshot Packer

The overshot packer is a tubular device or riser with a packer element on one end and an end connection on the opposite end.

The overshot packer shall be capable of creating a wellbore seal against the overshot mandrel to control the upward flow of well fluids.

The overshot packer shall include a minimum of one packer element.

The overshot packer shall allow for replacement of the packer element in the field.

The packer element shall be designed to withstand the overshot system pressure.

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5.6.3 Overshot Spools

Overshot spools shall have a cylindrical passage (bore) through the body, including end connections and may have side outlets.

The body bore diameter shall be equal to or greater than the minimum bore dimension of the end connections.

NOTE Overshot spools usually have the same nominal top and bottom end connections.

5.7 Diverter Spools

The diverter spool pressure rating shall be equal to or greater than the system pressure rating.

A diverter spool shall have at least two side outlets (see Figure 3).

NOTE Drilling diverter spools usually have the same nominal top and bottom end connections. Side outlets may be of same or different size. Top, bottom and side outlet connections can be clamp hub or flanged.

Diverter spools shall have a cylindrical passage (bore) through the body, including end connections.

The body bore diameter shall be equal to or greater than the minimum bore dimension of the end connections.

5.8 Diverter Side Outlets

If the diverter side outlets are incorporated in the housing of the annular sealing device, the housing assembly pressure rating shall be equal to or less than the lowest component's pressure rating.

NOTE 1 Diverter side outlet(s) may be incorporated in the housing of the annular sealing device or be an integral part of a separate spool located below the diverter housing.

The minimum internal cross-sectional area of the overboard/flow line diverter side outlets shall be designed to accommodate the flow rates specified by the purchaser of the equipment and shall not be less than an equivalent 8-in. diameter on a surface diverter and 12-in. diameter on a subsea diverter.

NOTE 2 Other side outlets/inlets may be included when specified by the purchaser to address trip tank, fill-up lines, requirements, etc.

The connection between the diverter side outlet(s) and overboard/flow line and/or valve(s) shall be designed for leak-free construction and to minimize solids accumulation.

All gaskets shall be of fire retardant/fire safe material.

5.9 Bell Nipple

The bell nipple shall have an inside diameter equal to or greater than the annular sealing device bore.

The bell nipple shall have a side outlet to direct drilling fluid returns.

The bell nipple shall be designed for leak-free construction.

The bell nipple shall be designed to minimize solids accumulation.

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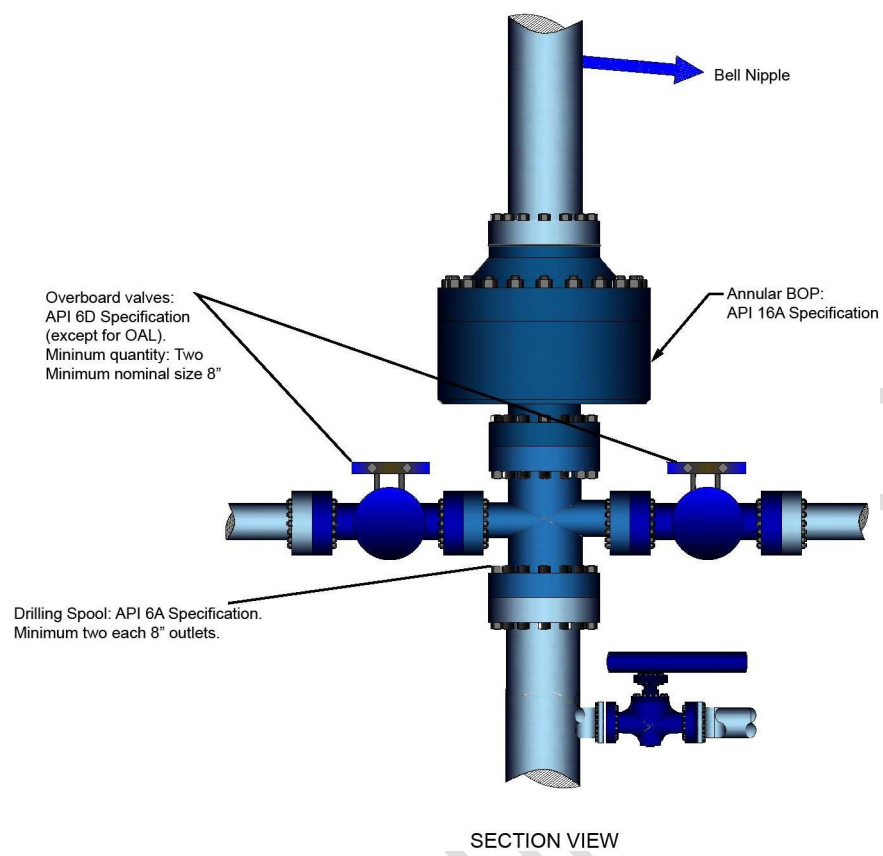


Figure 3—Example Annular BOP Diverter Configuration

5.10 Bolting

5.10.1 General

Primary and utility bolting shall be in accordance with Table 3.

Table 3—Bolting Requirements

| Bolting Type | Material | Requirement Source |
|--------------|--|------------------------------|
| Primary | Alloy Steel and Carbon Steel | API 20E BSL-1 ^{b,c} |
| | Corrosion-Resistant | API 20F BSL-3 ^a |
| Utility | Alloy Steel, Carbon Steel, and Corrosion Resistant | Manufacturer's Specification |

^a ASTM A453 Grade 660 Class D Materials minimum BSL shall be BSL-2
^b For Low Alloy Steel Min Yield >105 ksi ≤120ksi, the minimum BSL shall be BSL-2
^c For Low Alloy Steel Min Yield >120 ksi, the minimum BSL shall be BSL-3

Diverter equipment manufacturers shall have a documented procedure for the qualification of bolting manufacturers, in accordance with API 20E or API 20F.

Manufacturers shall have documented specifications which include both the thread form and the dimensions of studs, nuts and bolts.

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Bolting manufactured from proprietary materials shall conform to both the diverter equipment manufacturer's written specification, and the requirements of API 20E or API 20F, with the exception that the material shall meet manufacturer's specified chemical composition and mechanical properties (see Table 3).

5.10.2 Primary Bolting

The maximum tensile stress for closure bolting shall be determined considering

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

Bolt tensile stress, based on the minimum cross-sectional area of the bolt or stud shall not exceed the following limits calculated in Equation (1).

$$S_a = 0.83 S_y \text{ and } S_b = 1.0 S_y \quad (1)$$

where:

- S_a is the maximum allowable tensile membrane stress;
- S_b is the maximum allowable tensile membrane plus bending stress;
- S_y is the bolting material's specified minimum specified yield strength.

5.11 Diverter Valves

The diverter valves control the flow of drilling fluids both into and out of the diverter housing. Diverter valves shall be full-opening valves and shall conform to API 6D and API 6FA (or equivalent), except for overall length and actual bore size. Diverter valve bolting shall conform to Table 3.

Valves in the diverter system shall have remote position indication based on actual valve position.

All diverter valves shall be fitted with local visual position indicators.

5.12 Flow Selectors

Flow selector shall be a three-way flow control device that is installed in the diverter overboard line to allow the wellbore fluids to exhaust to a preselected direction. The flow selector shall permit discharge flow even during actuation of the flow selector.

Flow selector in the diverter system shall have remote position indication based on actual selector position.

All selectors shall be fitted with local visual position indicators.

The flow selector shall be capable of actuating hydraulically from a remote location (example: Diverter Panel) with an optional manual override.

The flow selector shall be equipped with clean-out lines to provide high velocity water jet during flow diverting to combat solids accumulation or to provide a cooling and lubricating effect on the potentially combustible gas/solids flow. The clean-out lines shall be equipped with isolation valves.

5.13 Actuators for Valves and Flow Selectors

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All actuators shall conform to API 6DX for sizing and instrumentation/regulation.

All electrical components shall conform to API 16D.

5.14 Diverter Control System

Diverter control systems shall conform to API 16D and the original equipment manufacturer (OEM).

5.15 Overboard Piping

5.15.1 General

Piping, valves, equipment, and well monitoring devices exposed to diverted fluids, shall be able to withstand the anticipated backpressure without leaking or failing.

NOTE 1 The aim is to minimize erosion and backpressure, both of which are major considerations in the design of diverter system piping.

NOTE 2 The "ideal" diverter overboard piping is without bends, as large in diameter as practical, internally flush, and as short in length as reasonably practical. Deviations from the "ideal" tend to increase wellbore backpressure and the possibility of erosion during diverting operations.

5.15.2 Pipe Size

Overboard line piping shall be 203.2 mm (8 in.) nominal diameter or larger for surface diverter systems and 304.8 mm (12 in.) nominal diameter or larger for subsea diverter systems.

All diverter overboard line piping shall be a minimum of ANSI B36.10 schedule 80 up to a nominal diameter of 355.6 mm (14 in.). Greater diameters shall have a minimum wall thickness of 19 mm (0.75 in.).

The minimum wall thickness shall consider erosion, corrosion, and wall loss due to bending.

For rigs with more than one overboard line, each line shall be sized to meet these requirements.

5.15.3 Pipe Routing

Unless the rig can be rotated to place the diverter overboard line in a downwind orientation, two or more overboard lines shall be installed. Lines shall be long enough to reach a safe discharge area.

Diverter overboard line(s) shall be routed so that, at all times, one line can vent well fluids away from the rig. Overboard lines should be routed as straight as possible to minimize erosion, flow resistance, fluid/solid settling points, and associated backpressure. Ninety degree or greater bends shall be equipped with a targeted blind flange, targeted plug or a fluid cushion to minimize erosion. Fluid cushion ID shall be equal to the flow pipe and have a minimum depth of one pipe ID. Routing changes should be as gradual as practical.

NOTE Bends less than 90 degrees may require erosion mitigation measures such as thicker wall or reinforced pipe.

The overboard line(s) outside the housing side outlet(s) shall be sloped along its length to avoid low spots that may accumulate fluid and debris.

Design considerations for the connection between the overboard side outlet(s) and line(s) shall include ease of installation, leak-free construction, and freedom from solids accumulation.

5.15.4 Piping Supports

Piping supports for permanently installed piping shall conform to ASME B31.3.

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5.15.5 Other Parts

Flow-direction-controlling parts shall be designed to satisfy the manufacturer's written specifications and the service conditions stipulated in 5.2.

5.16 Other End Connection (OEC) on the Diverter Assembly

The manufacturer shall document the load/capacity for the OEC in accordance with the format for API flanges in API 6AF and API 6AF2.

NOTE This format relates pressure to allowable bending moment for various tensions.

The manufacturer shall state which part of the connection contains the stress limitations that form the basis for the graphs.

NOTE Components or equipment, which are designed, manufactured and validated in accordance with other API or ANSI standards and specifications do not require additional validation.

5.17 Handling Tools

5.17.1 General

Handling tools for the diverter shall be designed for hoisting and lowering the diverter assembly through the rotary table.

NOTE For subsea applications, this typically includes a diverter flex joint and the telescopic joint inner barrel.

Handling tools to support the riser and the BOP stack, as well as for installing the diverter, shall conform to API 16F.

5.17.2 Load

Diverter handling tools design shall include the following loads:

- a) maximum rated static load capacity;
- b) bending loads (during handling);
- c) loads due to pressure.

5.17.3 Strength Analysis

5.17.3.1 General

The equipment design analysis shall address yielding, deflection, and rupture as possible modes of failure.

Finite element analysis, in conjunction with closed form analytical solutions, may be used.

The most unfavourable combination of forces shall be analyzed.

5.17.3.2 Design Safety Factor

The minimum design safety factor, SF_D , for all diverter system handling tools shall be 2.25.

Note: The design safety factor is a design criterion and should not under any circumstances be construed as allowing loads on the equipment more than the load rating.

5.17.3.3 Allowable Stress

Linear elastic theory shall be employed for the determination of stress distributions within components. Equivalent

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stress shall be determined based on the von Mises theory as provided in API 16F.

Linearized primary membrane stresses caused by the rated load shall not exceed the maximum allowable stress, as $\sigma_{allow,m}$, as calculated by Equation (2).

$$\sigma_{allow,m} = \frac{\sigma_{ys}}{SF_D} \quad (2)$$

Linearized primary membrane plus primary bending stresses caused by the rated load shall not exceed the maximum allowable stress, $\sigma_{allow,m+b}$, as calculated by Equation (3).

$$\sigma_{allow,m+b} = \frac{1.5 \times \sigma_{ys}}{SF_D} \quad (3)$$

Linearized membrane plus bending secondary stresses caused by the rated load shall not exceed the maximum allowable stress, $\sigma_{allow,s}$, as calculated by Equation (4).

$$\sigma_{allow,s} = \frac{3.0 \times \sigma_{ys}}{SF_D} \quad (4)$$

Bearing and contact stresses caused by the rated load shall meet the requirement in Equation (5) except for threaded connections.

$$\sigma_{bearing} \leq \sigma_{ys} \quad (5)$$

Where:

σ_{ys} is the material specified minimum yield strength.

5.17.3.4 Shear Strength

For purposes of design calculations involving shear, the maximum ratio of yield strength in shear to yield strength in tension shall be 0.6.

5.17.3.5 Contact Stresses and Geometric Discontinuities (Secondary Stresses)

For areas with contact stresses and geometric discontinuities, the primary membrane stress through the section shall meet the requirements of 5.17.3.3. The rated load capacity with design safety factor shall be analyzed in accordance with API 6X when the primary membrane stresses exceed the limits in 5.17.3.3.

For areas where secondary stresses exceed the allowables of 5.17.3.3, the requirements of API 16F Section "Riser Handling Tools" shall apply.

5.17.4 Bolted Connections

Bolts subject to the primary load shall meet the requirements of Equation (6) or (7) as qualified below:

$$\frac{2.25 \times \text{Rated Load}}{n \times A_{bolt}} \leq S_y \quad (6)$$

- for calculation based analysis or;
- when FEA results show joint separation (i.e. when the contact pressure between the bolted components ≤ 0);

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$$\frac{\text{Preload} + (\text{Joint Stiffness Constant} \times 1.5 \times \text{Rated Load})}{n \times A_{\text{bolt}}} \leq 0.83S_y \quad (7)$$

- when FEA results show that a joint does not separate (i.e. the contact pressure between the bolted components > 0).

Where:

A_{bolt} is the minimum cross sectional area of the bolt being considered;

n is the number of bolts considered.

Note 1 Equation (7) considers the effective joint axial stiffness, i.e. bolt stiffness plus the clamped components stiffness.

Note 2 Both Equations (6) and (7) consider only the membrane stresses through the bolt section in an evenly-distributed load path and do not account for secondary and bending effects.

5.18 Test Tools

Test tools shall be capable of sealing off the bore below the side outlets of the diverter assembly and provide a mandrel to ensure the integrity of the seal.

NOTE For surface installations, the use of wellhead sealing plugs is acceptable.

5.19 Design Validation

5.19.1 General

Design validation shall be performed on equipment specified in Section 5 and shall be described in the manufacturer's written specification.

Elastomers may be replaced between validation tests at the discretion of the OEM. Each validation test per Table 4 shall use an annular packer, insert packer(s), or other non-metallic seals.

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5.19.2 Acceptance Criteria

There shall be no visible leakage for tests that verify pressure integrity.

5.19.3 Diverter Packers and Non-metallic Seals Exposed to Wellbore Fluid

The requirements of this section shall not apply to non-metallic seals within Overshot Systems, Diverter Spools and Bell Nipples.

5.19.3.1 General

The OEM shall provide a table of design validation testing data. If the Diverter is designated CSO by the OEM, the annular packer unit shall satisfy the room temperature closure test requirement on open hole.

At the request of the owner, OEM shall state if packing unit can lower the collapse resistance of the tubular (per API 5C3) at the minimum required closing pressure. End user should consider the mechanical properties of the tubulars (e.g. collapse rating) when using the annular.

Non-metallic seals (e.g. flow line seals) and molded sealing assemblies in diverters shall satisfy the same design temperature validation testing as the packers.

Tests listed in Table 4 shall qualify a packer to the RWP for the specified range of tubulars, when tested against the minimum rated service range tubular.

Tests conducted shall use water or water with additives as the wellbore fluid, except elevated temperature testing may be performed with an oil-based fluid. The manufacturer shall specify and document the test fluid used.

The manufacturer shall maintain documentation that identifies the essential variables related to the manufacture of elastomer components, raw materials, and molded seals. Changes to essential variables shall require revalidation according to this specification. The minimum essential variables evaluated for inclusion in the documentation shall be:

- compound or compound components
- manufacturing process
- compound vendors
- metallic insert design
- bonding agents and application
- mold design.

Table 4—Required Packer Tests by Type

| Test | Annular Type Section | Insert Type Section |
|--|----------------------|---------------------|
| Room Temperature Closure | 5.19.3.2.2 | 5.19.3.3.2 |
| Fatigue | 5.19.3.2.3 | 5.19.3.3.3 |
| Low Temperature | 5.19.3.2.4 | 5.19.3.3.4 |
| Continuous Elevated Temperature | 5.19.3.2.5 | 5.19.3.3.5 |
| High Temperature Extended Duration (Extreme High Temperature) | 5.19.3.2.6 | 5.19.3.3.6 |

NOTE Test results can be used to qualify other diverter packers provided:

- No essential variables have changed as specified in 5.18.3.1.
- The RWP is equal to, or lower than, the equipment tested.

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— The temperature rating is within the qualified temperature range.

5.19.3.2 Annular Type

5.19.3.2.1 General

Annular packers shall be tested on 5-in. pipe and on the minimum rated service range tubular or 5-inch OD, whichever is smaller.

NOTE Annular packers conforming to PR2 per API 16A 4th Edition, Errata 3, Table 27 – Required Test and Performance Criteria for Annular Packers, may be acceptable for use in diverter systems, provided the specified minimum tubular size is no greater than 5 inches.

5.19.3.2.2 Annular Type Room Temperature Closure Test

5.19.3.2.2.1 Purpose

NOTE This test determines the closing pressure required to seal on a specified mandrel to the RWP, at room temperature.

5.19.3.2.2.2 Protocol

The environmental temperature shall be documented and shall not exceed 25°C (77°F).

The room temperature closure test shall be performed on the minimum rated service range tubular or 5-in. OD, whichever is smaller. Annular packers shall be tested on open hole if designated CSO.

The test shall start when the test pressure has stabilized and the external surfaces are dry.

The test shall satisfy the following procedure:

- a) Install the test mandrel in the diverter assembly for the packer test. The test shall be conducted on the specified test mandrel pipe size.
- b) Close diverter with the manufacturer's recommended closing pressure.
- c) For systems rated for greater than 500 psi - apply wellbore pressure of 200 psi to 300 psi and hold for a minimum of 3 minutes after pressure stabilization.
- d) Apply the full RWP of the diverter and hold for a minimum of 10 minutes after pressure stabilization.
- e) Bleed off wellbore pressure and open the diverter.
- f) Perform drift test in accordance with 9.2.4.

5.19.3.2.2.3 Acceptance Criteria

The packing element shall achieve a minimum of 10 minutes hold time. The total time shall be recorded and made available to the purchaser.

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5.19.3.2.3 Annular Type Fatigue Test

5.19.3.2.3.1 Purpose

NOTE This test determines the ability of the packing unit to maintain a seal throughout repeated closings and openings.

5.19.3.2.3.2 Test Protocol

The fatigue test shall be performed on the minimum rated service range tubular or 5-in. OD, whichever is smaller.

The test shall satisfy the following procedure:

- a) Install the test mandrel in diverter assembly for packer test.
- b) Close and open the diverter six times with the manufacturer's recommended closing pressure.
- c) Close the diverter a seventh time with the manufacturer's recommended closing pressure.
- d) For systems rated for greater than 500 psi - Apply wellbore pressure of 200 psi to 300 psi and hold for a minimum of 3 minutes after pressure stabilization.
- e) Apply wellbore pressure to the full RWP of the diverter and hold for a minimum of 3 minutes after pressure stabilization.
- f) Bleed off wellbore pressure and open the diverter.
- g) Every 20th pressure test cycle, measure the ID of the packing element when the operating piston reaches the fully open position. Then, continue to measure the ID of the packer at 5-minute intervals until the packer ID reaches the bore size of the diverter or until 30 minutes have elapsed. Record the ID and elapsed time.
- h) Repeat steps b through f until the packer fails a pressure test or until 364 closings and openings have been completed (52 pressure tests).

5.19.3.2.3.3 Acceptance Criteria

The annular packer shall achieve a minimum of 26 consecutive successful pressure cycles.

The total number of successful consecutive pressure cycles shall be recorded and made available to the purchaser.

5.19.3.2.4 Annular Type Low Temperature Test

5.19.3.2.4.1 Purpose

NOTE This test determines the ability of the non-metallic seals and molded sealing assemblies used as flow direction controlling members to maintain a wellbore pressure seal after repeated closings and openings at the minimum rated temperature and RWP of the non-metallic sealing components and molded sealing assemblies.

5.19.3.2.4.2 Protocol

The test shall be started when the wellbore fluid is at or below the test temperature. The diverter assembly and wellbore fluid temperature shall be maintained at or below the test temperature for the duration of the hold times.

The test shall satisfy the following procedure:

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- a) Install the test mandrel in the diverter assembly for packer test.
- b) Begin the cooling cycle and continue cooling until the diverter assembly and wellbore fluid temperature is reached and has stabilized.
- c) Close and open the diverter seven times with the manufacturer's recommended closing pressure.
- d) Close the diverter an eighth time with the manufacturer's recommended closing pressure.
- e) For systems rated for greater than 500 psi - With the wellbore fluid at or below test temperature, apply wellbore pressure (200 psi to 300 psi) and hold for a minimum of 5 minutes after pressure stabilization.
- f) Apply the full RWP of the diverter and hold for a minimum of 10 minutes after pressure stabilization.
- g) Bleed off wellbore pressure and open the diverter.
- h) Repeat steps b through g for each pressure cycle until the minimum acceptance criteria is met.

5.19.3.2.4.3 Acceptance Criteria

The packing element shall achieve a minimum of 3 consecutive successful pressure cycles.

The total number of successful consecutive pressure cycles shall be recorded and made available to the purchaser.

5.19.3.2.5 Annular Type Continuous Elevated Temperature Test

5.19.3.2.5.1 Purpose

NOTE This test determines the ability of the non-metallic seals and molded sealing assemblies used as flow direction controlling members to maintain a wellbore pressure seal after repeated closings and openings at the continuous elevated rated temperature and RWP of the non-metallic seals and molded sealing assemblies.

5.19.3.2.5.2 Protocol

The test shall be started when the wellbore fluid is at or above the test temperature. The wellbore fluid temperature below the packer shall be maintained at or above the test temperature for the duration of the hold times.

The test shall satisfy the following procedure:

- a) Install the test mandrel in diverter assembly for packer test.
- b) Close and open the diverter three times with the manufacturer's recommended closing pressure.
- c) Close the diverter a fourth time with the manufacturer's recommended closing pressure.
- d) For systems rated for greater than 500 psi - With the wellbore fluid at or above test temperature, apply wellbore pressure (200 psi to 300 psi) and hold for a minimum of 5 minutes after pressure stabilization.
- e) Apply the full RWP of the diverter and hold for a minimum of 10 minutes after pressure stabilization.
- f) Bleed off wellbore pressure and open the diverter.
- g) Repeat steps a through f for each pressure cycle until the minimum acceptance criteria is met.

5.19.3.2.5.3 Acceptance Criteria

The packing element shall achieve a minimum of 10 consecutive successful pressure cycles.

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The total number of successful consecutive pressure cycles shall be recorded and made available to the purchaser.

5.19.3.2.6 Annular Type High Temperature Extended Duration Test (Extreme Temperature Test)

5.19.3.2.6.1 Purpose

NOTE This test determines the ability of the of the non-metallic seals and molded sealing assemblies used as flow direction controlling members to maintain a wellbore pressure seal at the extreme rated temperature and RWP of the non-metallic seals and molded sealing assemblies.

5.19.3.2.6.2 Protocol

The test shall be started when the wellbore fluid is at or above the test temperature. The wellbore fluid temperature below the packer shall be maintained at or above the test temperature for the duration of the hold times.

The test shall satisfy the following procedure:

- a) Install the test mandrel in the diverter assembly for packer test.
- b) Close the diverter with the manufacturer's recommended closing pressure.
- c) Apply the full RWP of the diverter and hold for a minimum of 60 minutes after pressure stabilization.
- d) Bleed off wellbore pressure and open the diverter.

5.19.3.2.6.3 Acceptance Criteria

The packing element shall achieve a minimum of 60 minutes hold time.

The total time achieved shall be recorded and made available to the purchaser.

5.19.3.3 Insert Packer Type

5.19.3.3.1 General

Insert packers shall be tested for each nominal packer size, on the minimum rated service range tubular.

5.19.3.3.2 Insert Packer Type Room Temperature Closure Test

5.19.3.3.2.1 Purpose

NOTE This test determines the closing pressure required to seal on a specified mandrel to the RWP, at room temperature.

5.19.3.3.2.2 Protocol

The environmental temperature shall be documented and shall not exceed 25°C (77°F).

The room temperature closure test shall be performed for each nominal insert packer size and shall be tested against the minimum rated service range tubular.

The test shall start when the test pressure has stabilized and the external surfaces are dry.

The test shall satisfy the following procedure:

- a) Install the test mandrel in the diverter assembly for packer test. The test shall be conducted on the specified test mandrel pipe size.

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- b) Close diverter with the manufacturer's recommended closing pressure.
- c) For systems rated for greater than 500 psi - Apply wellbore pressure of 200 psi to 300 psi and hold for a minimum of 3 minutes after pressure stabilization.
- d) Apply the full RWP of the diverter and hold for a minimum of 10 minutes after pressure stabilization.
- e) Bleed off wellbore pressure and open the diverter.
- f) Perform drift test in accordance with 9.2.4 on the outer most packer only.

5.19.3.3.2.3 Acceptance Criteria

The packer shall achieve a minimum of 10 minutes hold time.

The total time shall be recorded and made available to the purchaser.

5.19.3.3.3 Insert Packer Type Fatigue Test

5.19.3.3.3.1 Purpose

NOTE This test determines the ability of the packing unit to maintain a seal throughout repeated closings and openings.

5.19.3.3.3.2 Protocol

The test shall satisfy the following procedure:

- a) Install the test mandrel in diverter assembly for packer test.
- b) Close and open the diverter six times with the manufacturer's recommended closing pressure.
- c) Close the diverter a seventh time with the manufacturer's recommended closing pressure.
- d) For systems rated for greater than 500 psi - Apply wellbore pressure of 200 psi to 300 psi and hold for a minimum of 3 minutes after pressure stabilization.
- e) Apply wellbore pressure to the full RWP of the diverter and hold for a minimum of three minutes after pressure stabilization.
- f) Bleed off wellbore pressure.
- g) Repeat steps b) through f) until the packer fails a pressure test or until 364 closings and openings have been completed (52 pressure tests).
- h) Open the diverter.

5.19.3.3.3.3 Acceptance Criteria

The Insert Packer shall achieve a minimum of 26 consecutive successful pressure cycles.

The total number of successful consecutive pressure cycles shall be recorded and made available to the purchaser.

For insert packers larger than 10 in. ID, the minimum number of successful consecutive pressure cycles shall be one.

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5.19.3.3.4 Insert Packer Type Low Temperature Test

5.19.3.3.4.1 Purpose

NOTE This test determines the ability of the non-metallic seals and molded sealing assemblies used as flow direction controlling members to maintain a wellbore pressure seal after repeated closings and openings at the minimum rated temperature and RWP of the non-metallic sealing components and molded sealing assemblies.

5.19.3.3.4.2 Protocol

The test shall be started when the wellbore fluid is at or below the test temperature. The diverter assembly and wellbore fluid temperature shall be maintained at or below the test temperature for the duration of the hold times.

The test shall satisfy the following procedure:

- a) Install the test mandrel in the diverter assembly for packer test.
- b) Begin the cooling cycle and continue cooling until the diverter assembly and wellbore fluid temperature is reached and has stabilized.
- c) Close the diverter with the manufacturer's recommended closing pressure.
- d) For systems rated for greater than 500 psi - With the wellbore fluid at or below test temperature, apply wellbore pressure (200 psi to 300 psi) and hold for a minimum of 5 minutes after pressure stabilization.
- e) Apply the full RWP of the diverter and hold for a minimum of 10 minutes after pressure stabilization.
- f) Bleed off wellbore pressure and open the diverter.
- g) Repeat steps a) through g) for each pressure cycle until the minimum acceptance criteria is met.

5.19.3.3.4.3 Acceptance Criteria

The insert packer shall achieve a minimum of 3 consecutive successful pressure cycles.

The total number of successful consecutive pressure cycles shall be recorded and made available to the purchaser.

For insert packers larger than 10 in. ID, the minimum number of successful consecutive pressure cycles shall be one.

5.19.3.3.5 Insert Type Continuous Elevated Temperature Test

5.19.3.3.4.4 Purpose

NOTE This test determines the ability of the non-metallic seals and molded sealing assemblies used as flow direction controlling members to maintain a wellbore pressure seal after repeated closings and openings at the continuous elevated rated temperature and RWP of the non-metallic seals and molded sealing assemblies.

5.19.3.3.4.5 Protocol

The test shall be started when the wellbore fluid is at or above the test temperature. The wellbore fluid temperature below the packer shall be maintained at or above the test temperature for the duration of the hold times.

The test shall satisfy the following procedure:

- a) Install the test mandrel in diverter assembly for packer test.
- b) Close the diverter with the manufacturer's recommended closing pressure.
- c) For systems rated for greater than 500 psi - with the wellbore fluid at or above test temperature, apply wellbore

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pressure (200 psi to 300 psi) and hold for a minimum of 5 minutes after pressure stabilization.

- d) Apply the full RWP of the diverter and hold for a minimum of 10 minutes after pressure stabilization.
- e) Bleed off wellbore pressure and open the diverter.
- f) Repeat steps a) through f) for each pressure cycle until the minimum acceptance criteria is met.

5.19.3.3.4.6 Acceptance Criteria

The packing element shall achieve a minimum of 10 consecutive successful pressure cycles.

The total number of successful consecutive pressure cycles shall be recorded and made available to the purchaser.

For insert packers larger than 10 in. ID, the minimum number of successful consecutive pressure cycles shall be one.

5.19.3.3.6 Insert Type High Temperature Extended Duration Test (Extreme Temperature Test)

5.19.3.3.4.7 Purpose

NOTE This test determines the ability of the of the non-metallic seals and molded sealing assemblies used as flow direction controlling members to maintain a wellbore pressure seal at the extreme rated temperature and RWP of the non-metallic seals and molded sealing assemblies.

5.19.3.3.4.8 Protocol

The test shall be started when the wellbore fluid is at or above the test temperature. The wellbore fluid temperature below the packer shall be maintained at or above the test temperature for the duration of the hold times.

The test shall satisfy the following procedure:

- a) Install the test mandrel in the diverter assembly for packer test.
- b) Close the diverter with the manufacturer's recommended closing pressure.
- c) Apply the full RWP of the diverter and hold for a minimum of 60 minutes after pressure stabilization.
- d) Bleed off wellbore pressure and open the diverter.

5.19.3.3.4.9 Acceptance Criteria

The packing element shall achieve a minimum of 60 minutes hold time.

The total time achieved shall be recorded and made available to the purchaser.

5.18 Documentation

5.19.1 Design Documentation

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

Installation, operation, and maintenance (IOM) manuals, furnished by manufacturers of the various components of the diverter system, shall be readily available for reference and use by maintenance personnel.

5.19.2 Design Review

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Design documentation shall be independently reviewed and verified by a technical authority other than the individual who created the original design. The independent review shall be documented and included in the design documentation (5.19.1).

NOTE Independent review may be performed internally or by third party.

5.19.3 Design Validation Documentation

The following shall be included in the design validation documentation:

- design validation test procedures
- documentation for measuring and testing equipment including calibration verification
- traceability for the equipment subject to design validation
- design validation results.

6 Material Requirements

6.1 General

NOTE This Section describes the material performance, processing, and compositional requirements for flow-direction-controlling members.

Flow-direction-controlling members shall meet the material performance, processing, and compositional requirements of this Section.

Diverter valves and actuators shall be in conformance with the material requirements of API 6D and API 6DX, respectively.

Other parts shall be made of materials that satisfy the design requirements in Section 5 when assembled into equipment specified in this Standard.

6.2 Written Specifications

6.2.1 Metallic Parts

Metallic flow-direction-controlling members or pressure-containing parts shall have a material specification.

The material specification for metallic materials shall define the following:

- material composition with tolerance;
- material qualification;
- allowable melting practice(s);
- forming practice(s);
- heat treatment procedure, including cycle time and temperature with tolerances, heat treating equipment, and cooling media;
- nondestructive examination (NDE) requirements;
- mechanical property requirements;
- material traceability;
- weld repair requirements;
- furnace calibrations and certification.

6.2.2 Non-metallic Parts

Elastomeric materials used in the flow-direction-controlling and pressure-containing components, shall be in accordance with the manufacturer's written specifications. These specifications shall include the following physical tests and limits for acceptance and control:

- hardness in accordance with ASTM D2240 or ASTM D1415;

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- tensile and elongation properties in accordance with ASTM D412 or ASTM D1414;
- compression set in accordance with ASTM D395 or ASTM D1414;
- immersion (fluid compatibility) testing in accordance with ASTM D471 or ASTM D1414.

Test liquid, temperature, and duration of test shall be defined.

Test shall be performed at or above the extreme temperature rating of the non-metallic sealing components in which the elastomeric material is used per Table 2.

6.2.3 Metallic Inserts in Molded Assemblies

Note: Examples include Packer inserts, Packer End Rings, and Flow Line Seal End Rings.

6.2.3.1 Dimensional Verification

Sampling shall be in accordance with the manufacturer's written requirements or ISO 2859-1, Level II 4.0 AQL.

Methods shall be in accordance with the manufacturer's written requirements.

Acceptance shall be in accordance with the manufacturer's written requirements.

6.2.3.2 Hardness Testing

Sampling shall be in accordance with the manufacturer's written requirements or ISO 2859-1, Level II, 4.0 AQL.

A minimum of one hardness test shall be performed in accordance with ASTM E10, ASTM E18, ASTM A370, ASTM E384, ISO 6506-1, ISO 6507-1, or ISO 6508-1, as appropriate.

Acceptance shall be in accordance with the manufacturer's written requirements and NACE MR0175/ISO15156.

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

6.3 Property Requirements

6.3.1 Materials

Flow-direction-controlling members shall be manufactured from materials as specified by the manufacturer that meet the requirements of Table 5.

Charpy V-notch impact testing shall conform to 6.4.2.

Table 5—Material Property Requirements for Flow-direction-controlling Members

| Material Designation | Yield Strength 2 % Offset min. | | Ultimate Tensile Strength min. | | Elongation in 50 mm min. | Reduction of Area min. |
|------------------------|--------------------------------------|--------------|-----------------------------------|--------------|--------------------------------|------------------------------|
| | MPa | (psi) | MPa | (psi) | % | % |
| 36K | 248 | 36,000 | 483 | 70,000 | 21 | none specified |
| 45K | 310 | 45,000 | 483 | 70,000 | 19 | 32 |
| 60K | 414 | 60,000 | 586 | 85,000 | 18 | 35 |
| 75K | 517 | 75,000 | 655 | 95,000 | 18 | 35 |
| Non-standard materials | As specified | As specified | As specified | As specified | 15 | 20 |

NOTE Information on strength of materials at elevated temperatures is found in API 6A and API 6MET.

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6.3.2 Processing

6.3.2.1 Melting, Casting, and Hot Working

6.3.2.1.1 Melting Practices

The OEM shall select and specify the melting practices for all metallic components for flow-direction—controlling members.

6.3.2.1.2 Casting Practices

The manufacturer of the material shall document foundry practices that establish limits for sand control, core-making, rigging, and melting.

6.3.2.1.3 Hot-working Practices

The manufacturer of the material shall document hot-working practices.

All wrought material(s) shall be formed using a hot-working practice(s) that produces a wrought structure throughout.

6.3.3 Heat Treating

All heat-treatment operations shall be performed utilizing equipment qualified in accordance with the requirements specified by the manufacturer.

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

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

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) The temperature range of other quenching media shall meet the manufacturer's written specification.

6.3.4 Chemical Composition

6.3.4.1 Range

The OEM shall specify the range of chemical composition of the material used to manufacture flow-direction—controlling members.

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

6.3.4.2 Composition Limits

The chemical composition limits of flow-direction—controlling members manufactured from carbon and low-alloy steels or martensitic stainless steels shall conform to Table 6.

NOTE Limits for non-martensitic alloy systems are not required to conform to Table 6 and Table 7.

Table 6—Steel Composition (% mass fraction) for Flow-direction—controlling Members

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| Alloying Element | Carbon and Low-Alloy Steels Maximum % mass fraction | Martensitic Stainless Steels Maximum % mass fraction |
|------------------------------------|---|--|
| Carbon | 0.45 | 0.15 |
| Manganese | 1.80 | 1.00 |
| Silicon | 1.00 | 1.50 |
| Phosphorus | 0.025 | 0.025 |
| Sulfur | 0.025 | 0.025 |
| Nickel | 1.00 | 4.50 |
| Chromium | 2.75 | 11.0 to 14.0 ^a |
| Molybdenum | 1.50 | 1.00 |
| Vanadium | 0.30 | N/A |
| ^a This value is a range | | |

6.3.4.3 Tolerance on Composition Limits

The permitted tolerances on alloy element content shall conform to Table 7.

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Table 7—Alloying Element Range—Maximum Tolerance Requirements

| Alloying Element | Carbon and Low-Alloy Steels Limit % mass fraction ^a | Martensitic Stainless Steels Limit % mass fraction ^a |
|---|---|--|
| Carbon | 0.08 | 0.08 |
| Manganese | 0.40 | 0.40 |
| Silicon | 0.30 | 0.35 |
| Nickel | 0.50 | 1.00 |
| Chromium | 0.50 | — |
| Molybdenum | 0.20 | 0.20 |
| Vanadium | 0.10 | 0.10 |
| ^a These values are the maximum allowable tolerance for any specific element and shall not exceed the maximum specified in Table 6. | | |

6.4 Material Qualification

6.4.1 Tensile Testing

Tensile testing shall be performed on each heat of material used for flow-direction-controlling and load bearing members.

Tensile test specimens shall be removed from a qualification test coupon (QTC) as described in 6.4.9 and shall be used to qualify a heat and the products produced from that heat.

Tensile tests shall be performed at room temperature in accordance with ASTM A370 or ISO 6892.

A minimum of one tensile test shall be performed. The results of the tensile test(s) shall satisfy the applicable requirements of Table 5. If the results of the first tensile tests do not satisfy the applicable requirements, two additional tensile tests shall be performed in an effort to qualify the material. The results of each of these additional tests shall satisfy the requirements of Table 5.

6.4.2 Impact Testing

Impact testing shall be performed on each heat of material used for flow-direction-controlling members.

Impact test specimens shall be removed from a QTC in accordance with 6.4.3. This QTC shall be used to qualify a heat and the products produced from that heat.

Standard-size specimens of cross-section 10 mm x 10 mm (0.39 in. x 0.39 in.) shall be used, except where there is insufficient material, in which case the next smaller standard-size specimen obtainable shall be used. When it is necessary to prepare sub-size specimens, the reduced dimension shall be in the direction parallel to the base of the V-notch.

Impact tests shall be performed in accordance with the Charpy V-notch technique in ASTM A370.

In order to qualify material for a temperature rating, the impact tests shall be performed at or below the test temperature shown in Table 8.

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Table 8—Acceptance Criteria for Charpy V-notch Impact Tests

| Temperature Rating | Test Temperature | | Minimum Impact Value Required for Average of Each Set of Three Specimens | | Minimum Impact Value Permitted for One Specimen Only Per Set | |
|--------------------|------------------|------|--|---------|--|---------|
| | °C | (°F) | J | (ft-lb) | J | (ft-lb) |
| T-75/250 | -59 | -75 | 20 | 15 | 14 | 10 |
| T-75/350 | -59 | -75 | 20 | 15 | 14 | 10 |
| T-20/250 | -29 | -20 | 20 | 15 | 14 | 10 |
| T-20/350 | -29 | -20 | 20 | 15 | 14 | 10 |
| T-0/250 | -18 | 0 | 20 | 15 | 14 | 10 |
| T-0/350 | -18 | 0 | 20 | 15 | 14 | 10 |

A minimum of three impact specimens shall be tested to qualify a heat of material and shall meet the following requirements:

- average of the impact property value equal to or greater than the minimum value shown in Table 8;
- individual impact value at or above $\frac{1}{3}$ of the required minimum average;
- no more than one of the three test results below the required minimum average;
- If a test fails, then one retest of three additional specimens (removed from the same location within the same QTC with no additional heat treatment) may be made;
- The retest shall exhibit an average impact value equal to or exceeding the required minimum average.

The values listed in Table 8 shall be the minimum acceptable values for forgings and wrought products tested in the transverse direction and for castings and weld qualifications. Forgings and wrought products tested in the longitudinal direction instead of the transverse direction, shall exhibit 27 J (20 ft-lb) minimum average value.

6.4.3 Qualification Test Coupons (QTC)

The properties exhibited by the QTC shall represent the properties of the material comprising the equipment it qualifies.

NOTE A single QTC may be used to represent the impact or tensile properties, or both, of components produced from the same heat, provided it satisfies the requirements of this Standard.

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

NOTE A QTC may only qualify material and parts produced from the same heat. Remelt heat may be qualified on a masterheat basis.

6.4.4 Equivalent Round (ER)

6.4.4.1 General

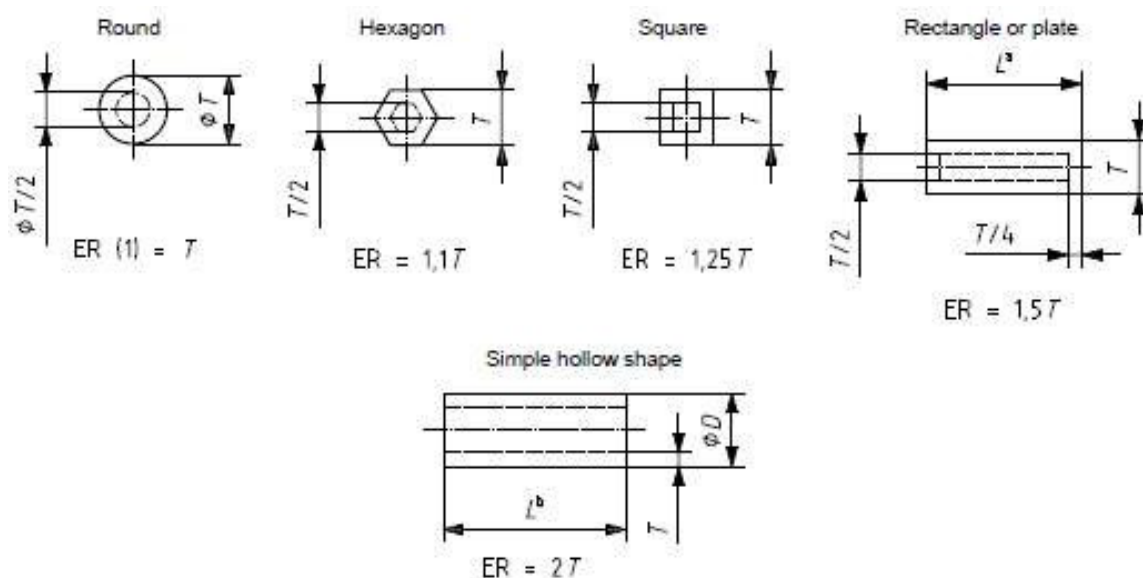
The dimensions of a QTC for a part shall be determined using the ER method.

6.4.4.2 ER Methods

The ER of a part shall be determined using the actual dimensions of the part in the “as-heat-treated” condition.

NOTE Figure 4 illustrates the basic models for determining the ER of simple solid and hollowed parts, and more complicated equipment.

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NOTE 1 When L is less than T , consider section as a plate of L thickness. Area inside dashed lines is $1/4 T$ envelope for test specimen removal.

NOTE 2 When L is less than D , consider as a plate of T thickness.

Figure 4—Simple Geometric Equivalent Rounds

6.4.4.3 Required Dimensions

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

6.4.5 QTC Processing

6.4.5.1 Melting Practices

In no case shall the QTC be processed using a melting practice(s) cleaner than that of the material it qualifies [e.g. a QTC made from a remelt grade or vacuum-degassed material may not qualify material from the same primary melt which has not experienced the identical melting practice(s)].

6.4.5.2 Casting Practices

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

6.4.6 Hot-working Practices

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

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6.4.7 Welding

Welding on the QTC shall be prohibited, except for attachment-type welds.

6.4.8 Heat Treating

Heat-treatment operations shall be performed utilizing equipment that is routinely used to process parts and certified in accordance with the manufacturer's written specification.

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

When the QTC is not heat-treated as part of the same heat treatment load as the parts it qualifies, the austenitizing (or solution heat-treat) temperatures for the QTC shall be within 14 °C (25 °F) of those for the parts. The tempering temperature for the part shall not be lower than 14 °C (25 °F) below that of the QTC. The upper limit shall not be higher than permitted by the heat-treatment procedure for that material. The cycle time of the QTC at each temperature shall not exceed the cycle time for the parts.

6.4.9 Tensile and Impact Testing

When tensile or impact test specimens, or both, are required, they shall be removed from a QTC after the final QTC heat-treatment cycle.

NOTE 1 Tensile and impact specimens may be removed from multiple QTCs if the multiple QTCs have had the same heat-treatment cycle(s).

Tensile and impact specimens shall be removed from the QTC with their longitudinal centerline axis wholly within the center core $1/4T$ envelope for a solid QTC or within 1 mm ($1/4$ in.) of the mid-thickness of the thickest section of a hollow QTC (see Figure 4).

NOTE 2 For QTCs larger than the dimensions specified in 6.4.4.3, the test specimens need not be removed from a location farther from the QTC surface than would be required if the specified QTC dimensions were used.

When a sacrificial production part is used as the QTC, the test specimens shall be removed from a section of the part meeting the dimensional requirements of the QTC for that production part as described in 6.4.4.3.

6.4.10 Hardness Testing

6.4.10.1 General

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

Hardness testing shall be performed in accordance with ASTM E10, ASTM E18, ASTM A370, ASTM E384, ISO 6506-1, ISO 6507-1, or ISO 6508-1, as appropriate.

6.4.10.2 Hardness Examination Acceptance Criteria

Hardness values shall meet the following requirements.

- a) At least one hardness test performed on each part tested, at a location determined by the manufacturer's specifications.
- b) The hardness testing used to qualify each part performed after the last heat-treatment cycle (including all stress-relieving heat-treatment cycles) and after all exterior machining operations.
- c) The actual value of the hardness test stamped on the part adjacent to the test location. It is permissible for harness marking to be covered by other components after assembly.
- d) When equipment is a weldment composed of different material designations, the OEM shall perform

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hardness tests on each component part of the weldment after the final heat treatment (including stress-relieving). The results of these hardness tests shall satisfy the hardness value requirements for each respective part.

- e) Hardness measurements on parts manufactured from carbon low alloy and martensitic stainless type steels exhibit maximum values equal to or greater than those specified in Table 9.

Table 9—Minimum Hardness Requirements

| API Material Designation | Minimum Hardness (Brinell) |
|--------------------------|----------------------------|
| 36K | 140 HBW |
| 45K | 140 HBW |
| 60K | 174 HBW |
| 75K | 197 HBW |

- f) If it is necessary to report the hardness test results in other measurement units, conversions shall be made in accordance with ASTM E140 or ISO 18265.
- g) If a part does not exhibit the required minimum hardness level, the part may be considered to have an acceptable hardness if the measured value satisfies the following requirements:

The 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 parts manufactured from the same heat.

The minimum acceptable hardness value for any part shall be determined by Equation (8):

$$HBW_c = \left[\frac{UTS}{UTS_{QTC}} \right] * HBW_{QTC} \quad (8)$$

where:

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

UTS is the minimum acceptable ultimate tensile strength specified for the applicable strength level, i.e. 483 MPa (70 000 psi), 586 MPa (85 000 psi) or 655 MPa (95 000 psi);

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

HBW_{QTC} is the Brinell hardness value observed on the QTC.

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

6.5 Welding Requirements for Original Manufacture

6.5.1 Requirements

Verification of compliance 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 flow-direction-controlling require impact testing, verification of compliance shall be established through implementation of the manufacturer's WPS and supporting PQR.

6.5.2 Weldment Design and Configuration

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6.5.2.1 Flow-direction-controlling Weldments

Flow-direction-controlling weldments that contain wellbore fluid shall have full penetration weldments except for the housing-to-outlet weldments. Housing-to-outlet welds shall be seal welded as a minimum.

NOTE Figures 5 through 8 are provided for reference.

Welding and completed welds shall meet the quality control requirements of 8.5.

6.5.2.2 Load-bearing Weldments

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

Welding and completed welds shall meet the quality control requirements of 8.5.

6.5.3 Repair Welds

All repair welding shall be performed in accordance with the manufacturer's written specification. All major repair welds to flow-direction-controlling members performed subsequent to original heat treatment shall be mapped.

Repair welding and completed welds shall meet the requirements of 8.5.

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

6.5.4.1 Corrosion-resistant Ring Grooves

Type SR ring grooves for overlays shall meet the requirements of API 16A. Type R and BX ring grooves shall meet the requirements of API 6A.

6.5.4.2 Corrosion-resistant and Wear-resistant Overlays Other than Ring Grooves

The OEM shall use a written procedure that provides controls for consistently meeting the manufacturer-specified material surface properties in the final machined condition.

As a minimum, this shall include inspection methods and acceptance criteria.

Qualification shall be in accordance with Articles II and III of ASME BPVC, Section IX, for corrosion-resistant weldmetal overlay or hard-facing weld metal overlay as applicable.

6.5.4.3 Mechanical Properties

Mechanical properties of the base material shall retain the minimum mechanical property requirements after thermal treatment.

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

6.5.5 Welding Controls

6.5.5.1 Procedures

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

6.5.5.2 Application

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Welding shall be performed by personnel qualified in accordance with the requirements of 8.3.

Welding shall be performed in accordance with written WPS and qualified in accordance with Article II of ASME BPVC, Section IX. The WPS shall describe all the essential, non-essential and supplementary essential (in accordance with ASME BPVC, Section IX) variables.

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

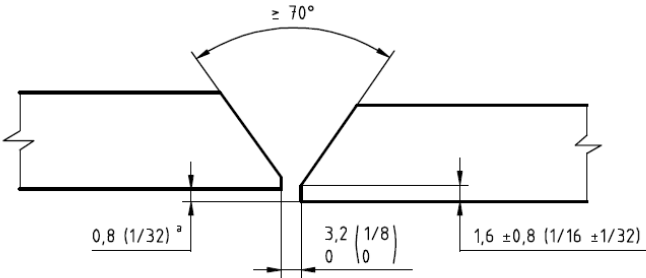
6.5.5.3 Designed Welds

For all welds that are considered part of the design of a production part, the OEM shall specify the requirements for the intended weld.

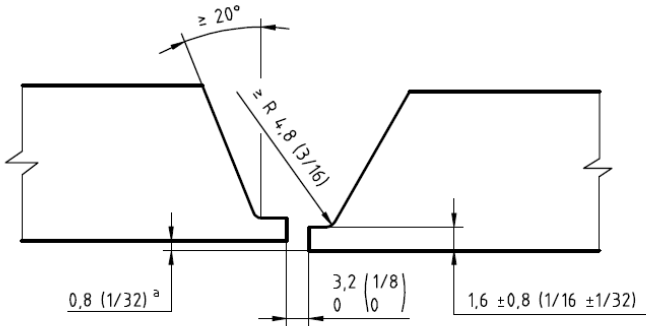
Dimensions of groove and fillet welds with tolerances shall be documented in the manufacturer's specification.

NOTE Figures 5 through 8 depict some typical joint designs.

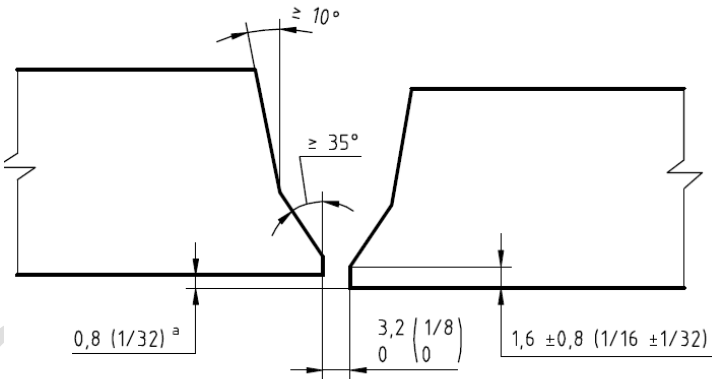
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a) V-groove



b) U-groove

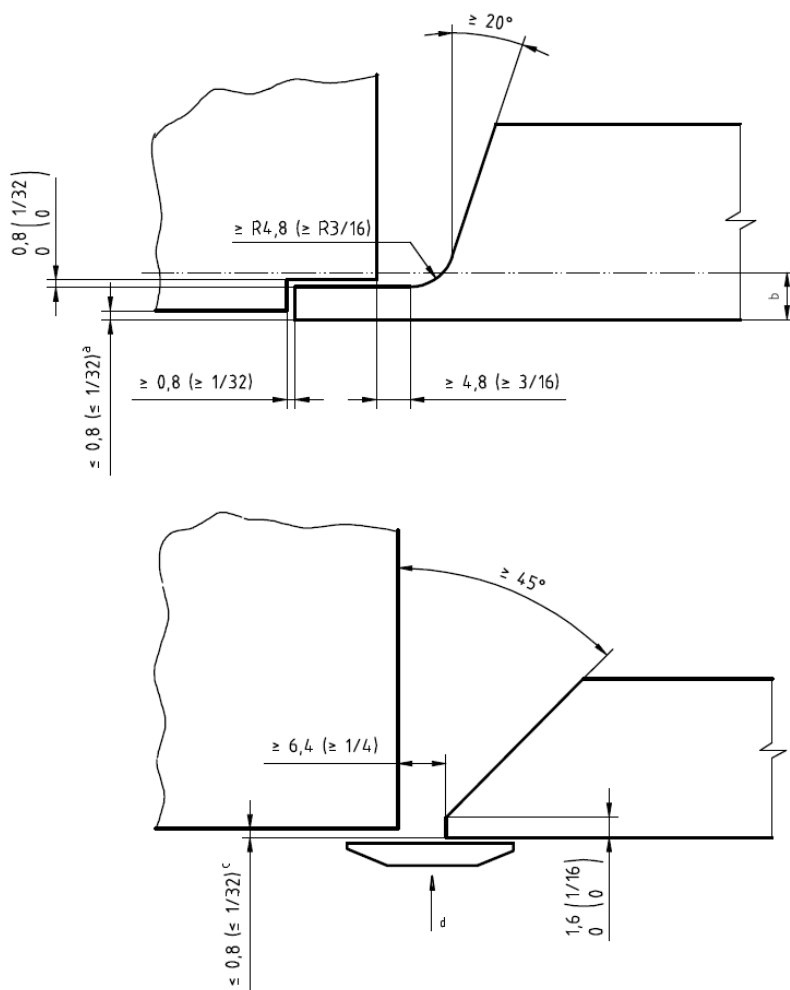


c) Heavy wall V-groove

^a Maximum misalignment

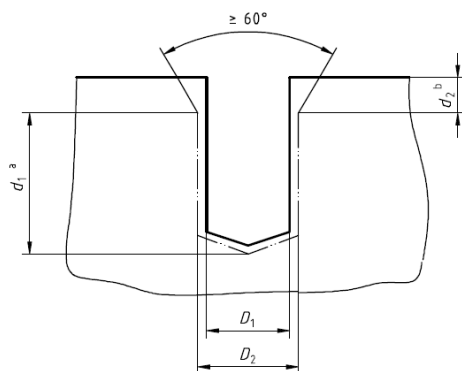
Figure 5—Typical Weld Grooves for Pipe Butt Joints

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- a Mismatch (unless removed by machining)
- b Remove to sound metal by machining
- c Maximum mismatch
- d Backing to be removed. Material to be compatible with base material.

Figure 6—Typical Attachment Welds



- a $d_1 : D_2$ ratio shall not exceed 1.5 : 1
- b d_2 = depth required to maintain a maximum of 1.5 : 1 depth (d_1)-to-diameter (D_2) ratio.

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Figure 7—Typical Repair Welds

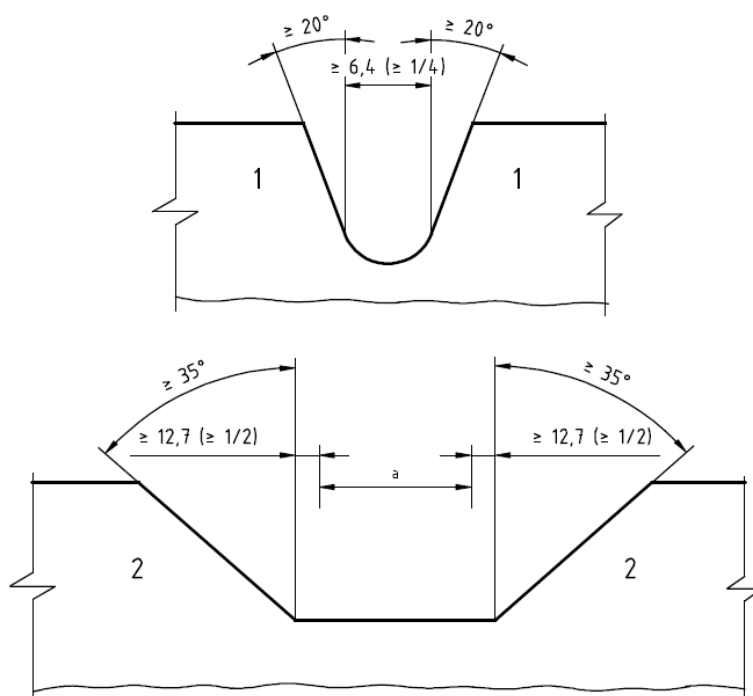


Figure 8—Typical Evacuation for Repair Welds

6.5.5.4 Preheating

Preheating of assemblies or parts, when required, shall be performed in accordance with the manufacturer's written procedures.

6.5.6 Instrument Calibration

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

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6.5.7 Materials

6.5.7.1 Welding Consumables

The manufacturer shall have a written procedure for storage and control of welding consumables. Welding consumables shall conform to AWS or the consumable manufacturer's approved specifications.

Materials of low-hydrogen type shall be stored and used as recommended by the consumable manufacturer to retain their original low-hydrogen properties.

6.5.7.2 Deposited Weld Metal Properties

The deposited weld metal mechanical properties shall meet or exceed the minimum specified mechanical properties of the base material.

Verification of properties shall be established through the implementation of the manufacturer's WPS and supporting PQR.

When materials of differing strength are joined, the weld metal shall meet the minimum requirements of the lesser material.

6.5.7.3 Post-weld Heat Treatment

PWHT of components shall be in accordance with the manufacturer's written procedures.

Furnace PWHT shall be performed in equipment meeting the requirements specified by the manufacturer.

Local PWHT shall consist of heating a band around the weld at a temperature within the range specified in the qualified WPS.

The minimum width of the controlled band adjacent to the weld, on the face of the greatest weld width, shall be the thickness of the weld.

Localized flame-heating shall be permitted provided the flame is baffled to prevent direct impingement on the weld and base material.

6.5.7.4 Welding Procedure and Performance Qualifications

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

6.5.7.5 Base Metals

6.5.7.5.1 General

The OEM shall use ASME BPVC, Section IX P number materials and base metal groupings.

Materials used for qualification that are not listed in ASME BPVC, Section IX shall be qualified separately and meet the requirements of ASME Section IX.

6.5.7.5.2 Equivalent P-Numbers

The OEM shall establish an equivalent P number (EP) grouping for carbon and low-alloy steels not listed in ASME Section IX with a carbon equivalent (CE) less than or equal to 0.43 for <1 in. or less and 0.45 for > 1in. material thickness (see Equation 9).

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$$C.E. = C\% + \frac{(\pi Mn\%)}{6} + \frac{(Cr\% + Mo\% + V\%)}{5} + \frac{(Ni\% + Cu\%)}{15} \quad (9)$$

Additionally, carbon and low-alloy steels not listed in ASME Section IX with an allowable CE as identified above shall have a maximum carbon content less than or equal to 0.23 % (by weight) and shall have a maximum yield strength of 60 ksi (414 MPa).

The manufacturer shall have a written specification that identifies the unassigned base metal by industrial specification, type, and grade or by chemical analysis and mechanical properties.

Qualification of a base material with a similar chemistry and at a specified strength level, shall qualify that base material chemistry at all lower strength levels.

6.5.7.5.3 Base Metals with Modified Chemistries and Mechanical Properties

NOTE 1 Many low-alloy steels with CEs and yield strengths greater than those identified in 6.5.7.5.2 have modified chemistries that differ from the recognized ASME BPVC, Section IX P-Numbers.

Welding procedure qualification of base metals with modified chemical and mechanical properties shall be performed using the similar industrial specification materials, when the following conditions are satisfied:

- a) The modified base metal chemistry is similar to a recognized industrial specification listed in ASME BPVC, Section IX;
- b) The industrial base material used during qualification is heat treated/conditioned to a minimum yield strength that meets or exceeds the minimum yield strength of the modified base material requiring welding qualification; and,
- c) The manufacturer writes a separate material specification identifying the chemistry, chemistry range, material form (cast, forged, plate, shape, etc.), the heat treat cycle(s) for the various thicknesses and corresponding minimum yield strengths, and the mechanical properties (including tensile strength, toughness, and hardness).

Qualification of a base material with a similar chemistry at a specified strength level shall qualify that modified base material chemistry at all lower strength levels.

The CE of the industrial base metal shall be within 10 % of the modified alloy's maximum CE.

NOTE 2 AISI grouping of modified 41XX and modified 86XX are considered different alloys and cannot be used to qualify each other.

NOTE 3 Steels containing 0.30 % carbon (± 0.03 %) cannot be used to qualify alloys with nominal 0.40 % carbon and greater. Additionally, low-alloy steels containing 0.15 % carbon maximum cannot be used to qualify materials with greater than 0.18 % carbon.

6.5.7.6 Heat-treat Condition

All testing shall be performed with the test weldment in the post-weld, heat-treated condition. PWHT of the test weldment shall be according to the manufacturer's written specifications.

6.5.7.7 Procedure Qualification Record

The PQR shall record all essential and supplementary essential (when required by ASME BPVC) variables of the weld procedure used for the qualification test(s). Both the WPS and the PQR shall be maintained as records in accordance with the requirements of Section 8.

6.5.8 Other Requirements

6.5.8.1 General

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ASME BPVC, Section IX, Article I, shall apply with additions as follows.

6.5.8.2 ASME Section IX, Article II—Welding Procedure Qualifications

6.5.8.2.1 General

ASME BPVC, Section IX, Article II, shall apply with additions as shown in this subsection.

6.5.8.2.2 Chemical analysis

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

For corrosion-resistant ring groove overlay, chemical analysis shall be performed in the weld metal in accordance with the requirements of ASME BPVC, Section IX at a location of 3 mm (0.125 in.) or less from the original base metal surface.

The chemical composition shall be in conformance with API 16A or API 16F, as applicable.

For 300 series or austenitic stainless steel (SST), the chemical composition shall be within the following limits:

- nickel 8.0 % mass fraction minimum;
- chromium 16.0 % mass fraction minimum;
- carbon 0.08 % mass fraction maximum.

For the nickel-base alloy N06625, the chemical composition shall meet one of the classes given in Table 10.

Table 10—Chemical Composition of the Nickel-based Alloy N06625

| Class | Element | Composition, % Mass Fraction |
|-------|---------|------------------------------|
| Fe 5 | Iron | 5.0 max |
| Fe 10 | Iron | 10.0 max |

Welds for use in hydrogen sulfide service shall conform to the requirements of NACE MR0175/ISO 15156.

6.5.8.2.3 Heat treatment

The PWHT of the test weldment and the production weldment shall be in the same range as specified on the WPS.

Allowable range for the PWHT on the WPS shall ± 14 °C (± 25 °F) of a nominal temperature.

The stress-relieving heat-treatment(s) time(s) at temperature(s) of production parts shall be equal to or greater than that of the test weldment.

6.5.8.2.4 Hole Repair Procedure Qualification

Procedure Qualification for bolt, tapped, and blind hole repairs shall include the following:

- a) Base material shall be of the same P-number and group number per ASME Section IX. If not listed in ASME Section IX, the base material shall be of the same type and in the highest strength heat-treated condition that the procedure will be qualified for;
- b) The hole repair weld procedure qualification shall demonstrate that the minimum mechanical properties for

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the product can be met.

6.5.8.3 ASME Section IX, Article III—Welding Performance Qualifications

6.5.8.3.1 General

Article III of ASME BPVC, Section IX shall apply with additions as shown in this subsection.

6.5.8.3.2 Bolt, Tapped, and Blind Hole Repair Performance Qualification

The welder or welding operator shall perform an additional repair welding performance qualification test using a mock-up hole (refer to Figure 7). The repair welding qualification test hole shall be qualified by radiography according to 8.5.2.3.2 or shall be cross-sectioned through the centerline of the hole, and both faces shall be examined by NDE in accordance with 8.5.2.3.2. 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 shall be the minimum diameter qualified. Any hole with a diameter greater than that used for the test shall be considered qualified.
- b) The depth-to-diameter ratio of the test hole shall qualify all repairs to holes with the same or smaller depth-to-diameter ratio.
- c) The performance qualification test shall have straight parallel walls. If any taper, counter-bore or other aid is used to enhance the hole configuration of the performance test, that configuration shall be considered an essential variable.

NOTE For welder performance qualification, ASME BPVC, Section IX, P-1 base metals may be used for the test coupon in place of the low-alloy steels covered by this Standard (see Table 6).

6.5.8.3.3 ASME Section IX, Article IV—Welding Data

Article IV of ASME BPVC, Section IX shall apply as written.

7 Marking Requirements

7.1 General

The following equipment shall be marked in accordance with Section 7 and Table 11:

- a) diverter housing
- b) diverter assembly
- c) diverter spool
- d) diverter packers
- e) diverter running tool
- f) flow selector

“API S64” shall be stamped on the product.

7.2 Types of Identification Stamping

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7.2.1 Metallic Components

7.2.1.1 Low-stress Area Marking

For identification on low-stress areas (i.e. nameplates), the use of sharp “V” stamping shall be acceptable.

7.2.1.2 High-stress Area Marking

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

Table 11—Marking Requirements and Location

| Marking (as applicable) | Equipment | Diverter Packers |
|---|----------------------------|-------------------|
| OEMs name or mark | Nameplate and body | OEM specification |
| Manufacturer's part number | | |
| Serial number | | OEM specification |
| Size designation | Nameplate or body, or both | |
| Rated working pressure | | |
| Temperature rating | | |
| Load rating | | |
| Model or type designation | | OEM specification |
| Date of manufacture | | OEM specification |
| Hydraulic operating system rated working pressure | | |
| Hydraulic open and close ports | OEM specification | |

7.2.1.3 Weld Metal Overlays

When equipment has weld metal-overlaid ring grooves, the ring gasket type and number shall be followed by “CRA” to designate a corrosion-resistant alloy or “SST” to designate an austenitic stainless steel. Marking locational shall be the OD of the flange.

7.2.2 Non-metallic Components

7.2.2.1 Wellbore Non-metallic Components

For identification of wellbore non-metallic components, such as packers and seals, the manufacturer shall have a written procedure for affixing the required codification to the product or its package. Codification shall be in accordance with API 16A.

7.2.2.2 Non-wellbore Non-metallic Components

Identification of non-wellbore nonmetallic components, such as elastomeric seals used in diverter equipment, shall be in accordance with the manufacturer's written specification.

8 Quality Control Requirements

8.1 General

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The manufacturer shall have a quality management system that, at minimum, meets the requirements of API Q1 or an equivalent national standard.

This Section specifies the quality control requirements for equipment manufactured to this Standard.

8.2 Measuring and Testing Equipment

8.2.1 General

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

8.2.2 Test Pressure-measuring Devices

Test pressure-measuring devices shall be pressure gauges or pressure transducers and shall be accurate to at least ± 1.0 % of full-scale range.

If pressure gauges are used in lieu of pressure transducers, they shall be selected such that the test pressure is indicated within 20 % and 80 % of the full-scale value.

Pressure tests shall be displayed as a chart in the Material Data Book (MDB).

The record shall identify the recording device calibration due date and shall be dated and signed.

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

Intervals shall be established for calibrations based on repeatability and degree of usage. Calibration intervals shall be a maximum of three months until recorded calibration history can be established by the OEM. The increased calibration interval shall not exceed 12 months.

NOTE Once documented, new longer intervals may be established in three month (maximum) increments.

8.3 Quality Control Personnel Qualifications

8.3.1 NDE Personnel

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

8.3.2 Visual Examination Personnel

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

8.3.3 Welding Inspectors

8.3.3.1 Qualifications

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

- AWS Senior Certified Welding Inspector (SCWI) per AWS QC1;
- AWS Certified Welding Inspector (CWI) per AWS QC1;

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- AWS Certified Associate Welding Inspector (CAWI) per AWS QC1;
- CSWIP Certified Visual Welding Inspectors (Level 1), per TWI CSWIP-WI-6-92;
- CSWIP Certified Welding Inspectors (Level 2), per TWI CSWIP-WI-6-92;
- CSWIP Certified Senior Welding Inspectors (Level 3), per TWI CSWIP-WI-6-92;
- welding inspector certified by the manufacturer's documented training program.

8.3.3.2 Procedures

The manufacturer shall have written procedures defining the following:

- a) in-house welding inspector certification program including training syllabus, instructor qualification requirements, length of certification and renewal requirements;
- b) roles, responsibilities, authority and accountability of a welding inspector;
- c) essential welding variables and equipment monitoring;
- d) welding, weld NDE and PWHT audits as follows:
 - 1) Internal audits shall be performed at least annually, covering all on-site areas and shifts.
 - 2) Supplier audits shall be performed in accordance with the manufacturer's written procedure for validation of supplier processes.

8.3.4 Equipment Certification

Equipment certification shall be approved by a technical authority if required by purchase order.

8.3.5 Other Personnel

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

8.4 Quality Control Requirements for Equipment and Parts

8.4.1 Quality Control Instructions

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

8.4.2 Nondestructive Examination (NDE)

NDE instructions shall be detailed regarding the requirements of this Standard and those of all applicable nationally or internationally recognized standards specified by the manufacturer. All NDE instructions shall be approved by an NDE Level III examiner.

NOTE This requirement is not applicable to hardness testing.

8.4.3 Acceptance Status

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

8.4.4 Visual Examination

8.4.4.1 Sampling

Each part shall be visually examined.

8.4.4.2 Procedure

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

8.4.4.3 Acceptance Criteria

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

8.4.5 Surface NDE

8.4.5.1 General

Accessible surfaces of each finished part shall be inspected in accordance with this Section.

8.4.5.2 Surface NDE of Ferromagnetic Materials

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

8.4.5.3 Surface NDE of Non-ferromagnetic Materials

Accessible surfaces of each finished part shall be inspected after final heat treatment and after final machining operations by the LP method.

8.4.5.4 Surface NDE of Overlay Cladding

Accessible surfaces of each finished part shall be inspected after final heat treatment and after final machining. If the cladding is not machined and is to remain as welded after final heat treatment, no additional surface inspection shall be required.

8.4.5.5 Procedures

8.4.5.5.1 General

MP examination shall be in accordance with ASTM E709. Prods are not permitted on surfaces or sealing surfaces.

LP examination shall be in accordance with ASTM E165.

8.4.5.5.2 Acceptance Criteria for MP and LP

Inherent indications not associated with a surface rupture (i.e. magnetic permeability variations, non-metallic stringer, etc.) shall not be deemed as relevant indications.

8.4.5.5.3 Acceptance Criteria for Surfaces Other than Pressure-contact (Metal-to-Metal) Sealing Surfaces

Acceptance criteria shall be:

- No relevant indication with a major dimension equal to or greater than 5 mm ($3/16$ in.);
- No more than ten relevant indications in any continuous 40 cm² (6-in.²) area;
- Four or more relevant indications in a line separated by less than 1.6 mm ($1/16$ in.) (edge-to-edge) are unacceptable.

8.4.5.5.4 Acceptance Criteria for Pressure Contact (Metal-to-Metal) Sealing Surfaces

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

8.4.6 Volumetric NDE

For Volumetric NDE, the following requirements shall apply:

a) Sampling

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

For quench-and-tempered products, the volumetric inspection shall be performed after heat treatment for mechanical properties exclusive of stress-relief treatments or re-tempering to reduce hardness.

b) Ultrasonic examination

1) Test method

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

Calibration: Distance amplitude curve (DAC) shall be based on 1.6 mm ($1/16$ in.) flat-bottom hole for metal thicknesses through 38 mm ($1\frac{1}{2}$ in.); on 3.2 mm ($1/8$ in.) flat-bottom hole for metal thicknesses from 38 mm ($1\frac{1}{2}$ in.) through 150 mm (6 in.); and on 6.4 mm ($1/4$ in.) flat-bottom hole for metal thicknesses exceeding 150 mm (6 in.).

2) Acceptance criteria

The following acceptance criteria apply:

- i) no single indications exceeding reference DAC;
- ii) no multiple indications exceeding 50 % of reference DAC.

Multiple indications shall be defined as two or more indications (each exceeding 50 % of the reference DAC) within 13 mm ($1/2$ in.) of each other in any direction.

c) Radiographic examination

1) Test method

Radiographic examination of hot-worked parts shall be performed in accordance with methods specified in 8.5.2.3.2.

2) Acceptance criteria

The following acceptance criteria apply to hot-worked parts:

- i) no cracks, laps, or bursts;
- ii) no elongated indications with length greater than the measurements and values stated in Table 12.

Table 12—Maximum Length of Elongated Slag Inclusion for Radiography

| Weld Thickness (<i>T</i>) (inches) | Inclusion Length (inches) |
|--------------------------------------|---------------------------|
| Less Than 0.76 | 0.25 |

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| | |
|-------------------|--------|
| 0.76 to 2.25 | 0.33 T |
| Greater than 2.25 | 0.75 |

8.5 NDE of Weldments

8.5.1 General

If examination is required, essential welding variables and equipment shall be monitored during welding. The entire accessible weld, plus at least 13 mm ($1/2$ in.) or surrounding base metal shall be examined.

NDE shall be performed after final heat treatment.

8.5.2 NDE of Welding

8.5.2.1 Visual Examination

Welds shall be visually examined in accordance with ASME BPVC 2010, Section V, Subsection A, Article 9. Undercuts shall not reduce the thickness in the affected area to below the design thickness and shall be ground to blend smoothly with the surrounding material.

Surface porosity or exposed slag shall be more than 13 mm ($1/2$ in.) away from sealing surfaces.

8.5.2.2 Surface NDE

8.5.2.2.1 General

Primary-load-carrying and pressure-containing welds and attachment welds to main load bearing and pressure-containing components shall be examined.

8.5.2.2.2 Method

Ferromagnetic materials shall be examined by the MP method in accordance with ASME BPVC 2010, Section V, Subsection A, Article 7, and Subsection B, Article 25 or ASTM E709. Machined surfaces shall be examined by the wet fluorescent method; other surfaces shall be examined by a wet method or dry method.

Non-ferromagnetic materials shall be examined by the LP method in accordance with ASME BPVC 2010, Section V, Subsection A, Article 6, and Subsection B, Article 24 or ASTM E165.

If the use of prods cannot be avoided, all prod burn-marks shall be removed by grinding, and the affected areas shall be re-examined by the LP method.

8.5.2.2.3 Surface Acceptance Criteria

The surface acceptance criteria shall be:

- no relevant linear indications with a major dimension equal to or greater than 5 mm ($3/16$ in.);
- no rounded indications with a major dimension greater than 3 mm ($1/8$ in.), for welds whose depth is 17 mm ($5/8$ in.) or less;
- no rounded indications with a major dimension greater than 5 mm ($3/16$ in.) for welds whose depth is greater than 17 mm ($5/8$ in.);
- no more than three relevant indications in a line separated by less than 1.6 mm ($1/16$ in.) edge-to-edge.

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8.5.2.3 Volumetric NDE

8.5.2.3.1 General

Full penetration pressure-containing welds and full penetration welds in the primary load path shall be examined by either radiography or ultrasonic methods after all welding, PWHT, and machining operations.

8.5.2.3.2 Radiography

Radiographic examinations shall be performed in accordance with ASTM E94 to a minimum equivalent sensitivity of 2 %.

NOTE 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 result in a minimum equivalent sensitivity of 2 %. Wire type image quality indicators are acceptable for use per ASTM E747.

Acceptance criteria specify that no type of crack, zone of incomplete fusion or penetration shall be allowed. No elongated slag inclusion shall be allowed which has a length equal to or greater than shown in Table 12.

In addition, there shall be no group of slag inclusions in a line having an aggregate length greater than the weld thickness (T) in any total weld length $12T$, except when the distance between successive inclusions exceeds six times the length of the longest inclusion.

No rounded indications in excess of those specified in ASME *Boiler and Pressure Vessel Code*, Section VIII, Division I, Mandatory Appendix 4 shall be permitted.

8.5.2.3.3 Ultrasonic

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

No indications whose signal amplitude exceeds the reference level shall be allowed. No linear indications interpreted as cracks, incomplete joint penetration or incomplete fusion shall be allowed. No slag indications shall be allowed with amplitudes exceeding the reference level whose length exceeds the values shown in Table 13.

Table 13—Maximum Amplitude of Slag Indication for Ultrasonic Examinations

| Weld Thickness (T) (in.) | Inclusion Length (in.) |
|---------------------------------|-------------------------------|
| Less Than 0.76 | 0.25 |
| 0.76 to 2.25 | 0.33 T |
| Greater than 2.25 | 0.75 |

8.5.2.4 Weld Hardness Testing

Welds of flow-direction-controlling and load-bearing components shall be hardness tested. Hardness testing shall be performed in accordance with one of the following:

- a) Vickers Method (ASTM E384);
- b) Brinell Method (ASTM E10 or E110); or
- c) Rockwell Method (ASTM E18).

At least one hardness test shall be performed in both the weld and in the adjacent unaffected base metal after all heat treatment and machining operations. Hardness values shall meet the requirements of the manufacturer's written specification.

Locations deemed inaccessible by the manufacturer for hardness testing shall be identified and recorded on the

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inspection report.

8.6 Chemical Analysis

Chemical analysis shall be performed on a heat basis. Chemical analysis shall be performed in accordance with the manufacturer's written procedure.

8.7 Diverter Packers and Seals

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

Mechanical property data shall include the following:

- a) hardness data in accordance with ASTM D1415 or ASTM D2240;
- b) tensile, elongation, and modulus data in accordance with ASTM D1414 or ASTM D412;

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

8.8 Assembled Equipment

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

Serialization shall be recorded on all assembled equipment and shall be performed in accordance with the OEM written specification.

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

The hydrostatic proof or shell test pressure shall be determined by the RWP for the equipment and be in conformance with this Standard.

The hydraulic operating system shall be tested on each assembled diverter.

9 Factory Acceptance Testing

9.1 General

9.1.1 Pressure Test Procedures

Water or water with additives shall be used as the test fluid; any additives shall be documented in the test records.

After test and prior to shipment, operator fluid should be drained and replaced with a corrosion inhibiting fluid.

Pressure testing shall consist of three steps;

- a) an initial pressure-holding period of a minimum of 3 minutes after pressure stabilization;
- b) reduction of the pressure to zero;
- c) a second pressure-holding period of a minimum of 10 minutes after pressure stabilization.

9.1.2 Acceptance Criteria

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Pressure testing shall meet the acceptance criteria of no visible leakage.

9.1.3 Pressure Test Equipment

A data acquisition system shall be used on all hydrostatic tests and on operating chamber tests. Pressure gauges used shall be as described in 8.2.2.

9.2 Diverter Housing and Diverter Assembly Testing

9.2.1 Application

All diverter assemblies and housings shall be subjected to factory acceptance testing (FAT) prior to shipment from the manufacturer's facility unless agreement with the purchaser has been reached to test the assembly on-site.

NOTE Diverter assemblies and diverter housings may be tested independently.

9.2.2 Hydrostatic

9.2.2.1 Hydraulic Operating Chamber Test

The hydraulic operating system test shall be tested on each assembled diverter assembly and housing.

The operating chamber shall be tested at 1.5 times the operating chamber's RWP.

The operating chamber shall be tested at RWP only, where the Packer forms a boundary of the operating chamber.

NOTE Annular-type element may be removed during testing.

9.2.2.2 Hydrostatic Body Test

The diverter assembly and diverter housing shall be pressure tested to the RWP for the equipment.

9.2.3 Diverter Closing/Packer Pressure Test

The diverter shall be pressure tested as follows:

- a) Install a mandrel of the smallest specified pipe size. For annular packer types, the maximum pipe size shall be 5 in..
- b) Close diverter using manufacturer's recommended hydraulic operating pressure.
- c) For systems rated for greater than 500 psi - apply wellbore pressure of 200 psi to 300 psi and hold for a minimum of 3 minutes after pressure stabilization.
- d) Pressurize to RWP and stabilize.
- e) Hold for a period of not less than 10 minutes.
- f) Reduce pressure to zero.
- g) Open the diverter.

9.2.4 Diverter Drift Test

The diverter assembly shall be drifted after all pressure testing according to the manufacturer's written specification.

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A drift mandrel shall pass through the bore within 30 minutes of the closing pressure being removed from a RWP test with no external force being applied to the drift.

Drift mandrel diameter shall be in accordance with the drift diameter in 5.5.2.

Drift mandrel gauge length shall be at least 51 mm (2 in.) longer than any cavity that intersects the bore but not less than 305 mm (12 in.).

9.3 Diverter Valves and Actuators

Diverter valves shall have FAT in accordance with API 6D.

Diverter valve actuators shall have FAT in accordance with API 6DX.

9.4 Diverter Assembly Handling and Test Tools

9.4.1 Proof Load Test

The production unit shall be tested to a minimum load of 1.5 times the rated load capacity of the component.

The equipment shall be mounted in a test fixture capable of loading the equipment in the same manner as in actual service and with the same areas of contact on the load-bearing surfaces.

The test load, equal to 1.5 times the rated load, shall be applied for a period not less than 5 minutes.

All primary-load-carrying components shall be inspected in accordance with Section 8 after the production load test.

9.4.2 Pressure Test

Pressure-containing systems shall be pressure tested to 1.5 times the maximum rated pressure of that system for a period not less than 5 minutes after stabilization with no detectable leaks.

The pressure test shall be performed after the production load test and inspection in accordance with Section 8.

9.4.3 Function Test

Functional test shall be performed to ensure proper operation of the components.

The function test shall be performed after the completion of the production load test and after the completion of the pressure test including inspection in accordance with Section 8.

9.5 Other Equipment

Flow-direction-controlling assemblies shall be subject to FAT per the manufacturer's written specification.

10 Maintenance

10.1 General

Replacement parts for equipment designed in this standard shall be in conformance to this Standard.

10.2 Installation, Operation, and Maintenance Manuals

Rig-specific procedures that consider recommendations from the OEM shall be developed by the equipment owner for the IOM of diverter systems.

10.3 Maintenance Records

Electronic or hard copy records or both, for maintenance, repairs, and remanufacturing performed for the diverter

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equipment (including documentation that shows the components meet or exceed the OEM specifications), shall be readily available on the rig and preserved at an offsite location until the equipment is permanently removed from the rig or service.

10.4 Scheduled Maintenance

A schedule for inspection and maintenance of diverter systems equipment, including considerations for corrosion and erosion, shall be implemented and kept by the rig operating personnel based on a schedule developed by the equipment owner.

Inspections shall be performed every 90 days, or after each completed well, or in accordance with documented equipment owner's reliability data, whichever is greater.

Diverter system and components shall be inspected every 5 years or in accordance with the equipment owner's PM program reliability data and shall be verified against validated acceptance criteria.

10.5 Maintenance History and Problem Reporting

10.5.1 Product History File

A product history file (PHF) shall be retained by serial number or unique identification number for the components described in Section 5.

The PHF shall follow the equipment when it is transferred.

10.5.2 Equipment Failure Reports

Equipment malfunctions or failures shall be reported in accordance with Annex A.

The equipment owner shall maintain a log of diverter and control system failures. The log shall provide a description and history of the item that failed along with the corrective action. The failure log shall be limited to items used for the diverter system and the equipment used to function this equipment.

Details of the diverter equipment, control system, and essential test data shall be maintained from the beginning to the end of the well and considered for use in condition-based analysis.

Electronic or hard copies, or both, of all documentation shall also be retained at an offsite location.

10.6 Connections

After a pressure seal is broken, a bolted connection shall be established by applying the lubrication, torque and assembly procedures to the connection studs, nuts or bolts, or a combination thereof, in accordance with OEM specifications.

Manuals or bulletins containing flange assembly specifications shall be available on the rig.

After the initial pressure test is completed, all bolts for the affected connection shall then be rechecked for proper torque.

10.7 Replacement Components and Assemblies

Replacement components and assemblies shall be designed and manufactured for their intended use in accordance with this standard. After installation, the affected components shall be tested in accordance with Table 14.

If replacement assemblies are acquired from a non-OEM, the assemblies shall meet or exceed the original equipment specifications and be fully tested, design verified, and supported by traceable documentation in accordance with relevant specifications.

10.8 Equipment Storage

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Elastomeric components should be stored in a manner recommended by the equipment manufacturer.

While not in use, diverter components and assemblies shall be stored according to procedures developed by the equipment owner.

NOTE These procedures may include flushing hydraulic chambers, flange and sealing area protection, or protection against environmental damage and corrosion.

10.9 Weld Repairs

Welding of flow-direction-controlling, pressure-containing, or load-bearing components, or both, shall be performed in accordance with the welding requirements of API 16AR, with the exception of requirements pertaining to NACE MR0175.

NOTE This Section is for equipment that has been in service.

11 Documentation

11.1 Requirements for Quality Control Records

The quality control records shall be those documents and records necessary to substantiate that all materials and equipment made to this Standard do conform to the specified requirements.

11.2 Equipment Traceability

11.2.1 General

Diverter 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.

Utility fasteners and pipe fittings shall be exempt from traceability requirements provided they are marked in accordance with recognized industry standards.

11.2.2 Records Control

Records shall be legible, identifiable, retrievable, and protected from damage, deterioration, or loss.

Records shall be retained by the manufacturer for a minimum of 10 years following the date of manufacture as marked on the equipment associated with the records.

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

Records shall be signed and dated. Computer-stored records shall contain the originator's electronic identification.

11.2.3 Critical Dimensions

Critical dimensions, as defined by the manufacturer, shall be documented for each part and such documentation shall be retained in accordance with the quality control requirements of 11.2.2.

Critical dimensions, as defined by the manufacturer, shall be within acceptable tolerances per the manufacturer.

11.2.4 Records Maintained by the Manufacturer

11.2.4.1 General

The manufacturer shall maintain all documents and records as referenced below:

- weld procedure qualification record;

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- 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;
- weld map;

- heat treatment records:
 - actual temperature;
 - actual times at temperature.
- volumetric NDE records;
- hydrostatic pressure test records;
- critical dimensions, as defined by the manufacturer, for each part;
- IOM manuals.

Manufacturer shall provide an IOM manual that contains the following:

- operation and installation instructions
- physical data including weight, center of gravity, and overall dimensions
- packers and seals information
- maintenance, inspection and testing information, including recommended maintenance frequency based on time or cycles and identifying surfaces deemed critical by the OEM
- assembly and disassembly information
- parts information including a recommended spares list
- storage information; operational characteristics summary, as applicable
 - sealing characteristics test
 - fatigue test
 - vertical load capacity of locking mechanisms

11.2.5 Serialization

Serialization is required on all assembled equipment and shall be performed in accordance with the manufacturer's written specification. Serial numbers should be applied in a manner that will ensure legibility for a minimum period of five years in normal service. Serial number location shall be identified in the IOM manual.

11.2.6 Traceability Record Report

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

11.2.7 Closure Bolting

The manufacturer shall retain individual-heat-traceability records for all closure bolting.

11.2.8 Non-metallic Sealing Materials and Molded Sealing Assemblies

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

11.2.9 Diverter Packers Shipped Separately

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The following records shall be retained:

- pressure test records (9.2.3);
- drift test record (only for CSO type) (9.2.4).

11.2.10 Assembled Diverters

The following records shall be retained:

- pressure test records (9.2.3);
- drift test record (only for CSO type) (9.2.4).

11.2.11 Records to be Furnished upon Product Delivery

A manufacturer's Certificate of Conformance stating that equipment conforms to the current edition of this Standard shall be delivered to the purchaser.

11.3 Technical Data Sheet

The manufacturer shall prepare and provide a technical data sheet for diverter system assembly. The technical data sheet shall contain the following applicable information at a minimum:

- part number
- RWP(s)
- operating ranges (pressures, sealing diameters, and CSO, if applicable;
- closing pressure to effect a wellbore seal at RWP of diverter system for available operators;
- temperature ranges
- wellbore-wetted elastomer type (e.g. common name [Nitrile, HNBR] or other elastomer compound marking information)
- summary of qualification test results from 5.19.3
- size and weight of each component found in 7.1
- any additional pertinent information.

12 Field Testing

Diverter system field testing shall be conducted in accordance with Table 14. If a field test cannot be accomplished per Table 14, the equipment owner shall conduct a risk assessment and document with a Management of Change.

12.1 General

Manual override (test mode) should only be used for maintenance, diverter assembly integrity test, or completion of the divert mode should the divert mode sequence be inoperable or incomplete.

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Table 14 – Diverter System Field Testing ^a

| System/Component | Test Description | Test Acceptance Criteria | Frequency |
|---|---|--|---|
| Diverter Control System Function Test ^b | Operation of the system to Divert Mode ^c | <ul style="list-style-type: none"> — No visible leakage — Packer closes, valves operate, and pressures are appropriate per Divert Mode sequencing — Response Time ^d is within <ul style="list-style-type: none"> — 30 s for Packer ID ≤ 20 in. — 45 s for Packer ID > 20 in. | <ul style="list-style-type: none"> — Upon each installation — Not to exceed 7 days ^e — Following disconnection or repair ^f |
| Diverter Accumulator Drawdown Test ^g | Perform this test in sequence a) Isolate Diverter Accumulator charging pumps b) Operate the diverter system to Divert Mode c) Cycle diverter system overboard valves | <ul style="list-style-type: none"> — Diverter accumulator pressure greater than Minimum Operating Pressure (MOP) after completion of test step b) — Overboard valves cycled | <ul style="list-style-type: none"> — Beginning of each well |
| Diverter System Flow Test ^h | Pump fluid through the diverter system to each installed overboard | <ul style="list-style-type: none"> — Flow returns through each overboard — No visible leakage, no excessive vibrations, and proper installation | <ul style="list-style-type: none"> — Beginning of each well — After a divert event |
| Diverter Assembly Integrity Test ⁱ | Apply 250 psig minimum below the diverter packer for a minimum of five minutes | <ul style="list-style-type: none"> — No visible leakage at packer, housing or flowline seals for the duration of the test | <ul style="list-style-type: none"> — Upon each installation ^j — After a divert event |
| Diverter Operating Chamber Pressure Test ^k | Apply RWP to Diverter packer open and close operating chambers ^l | <ul style="list-style-type: none"> — RWP stabilization for a minimum of 5 minutes — No visible leakage | <ul style="list-style-type: none"> — Every 12 months — Following disassembly or repair |

^a The results of all diverter equipment pressure and function tests shall be documented.

Problems with the diverter equipment that results in an unsuccessful function or pressure test and actions to remedy the problems shall be documented.

The equipment owner shall inform the equipment manufacturer of any diverter equipment that fails to perform in the field, in accordance with Annex A.

^b Diverter Packer pressure recovery is considered an indication of the completed closing sequence.

^c Tests to be alternated between the control stations where all diverter functions are included.

^d Diverter Packer pressure recovery is considered an indication of the completed closing sequence.

^e As drilling operations allow.

^f Limited to the affected Diverter System component.

^g Record pre and post accumulator system pressures.

^h This test may be accomplished during the diverter control system function test.

ⁱ This is not a pressure test, the pressure source is not required to be isolated.

^j Installation of the Diverter Assembly; not required for removal or installation of Insert Packers.

^k Operating Chamber Tests shall be documented with a pressure chart recorder or equivalent data acquisition system.

^l A low pressure test is not required.

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Annex A **(normative)**

Failure Reporting

A.1 User Recommendations

The equipment owner of diverter equipment shall provide a written failure report to the equipment manufacturer of any failure that occurs.

The failure report shall include the following:

- a) as much information as possible on the operating conditions that existed at the time of the failure;
- b) an accurate description as best as possible of the failure;
- c) any operating history of the diverter equipment leading up to the failure (e.g. field repair, modifications made to the diverter equipment, etc.).

The manufacturer shall respond to receiving the failure report and provide a timeline to provide failure resolution.

A.2 Manufacturer's Recommendations

A.2.1 Manufacturer's Internal Recommendations

Significant problems experienced with diverter equipment noted during its manufacture, testing or use shall be formally communicated to the individual or group within the manufacturer's organization responsible for the design and specification documents.

The manufacturer shall have a written procedure that describes forms and procedures for making this type of communication, and shall maintain records of progressive design, material changes or other corrective actions taken for each model and size of diverter equipment.

A.2.2 Manufacturer's External Recommendations

Significant problems experienced with diverter equipment shall be reported in writing to each and every equipment owner of the diverter equipment within three weeks after the occurrence.

The manufacturer shall communicate any design changes resulting from a failure history to every equipment owner using the affected equipment. That notice shall be within 14 days after the design change.

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