Diverter Equipment Systems

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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, S*pecification 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 B36.10M, *Welded and Seamless Wrought Steel Pipe*

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*

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 176371:2011

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
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 preventer
Device that can seal around any object in the wellbore or upon itself.

NOTE Compression of a reinforced rubber/elastomer packing element by hydraulic pressure effects the seal.

3.1.4
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.

3.1.5
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.

3.1.6
bell nipple
Piece of pipe, with inside diameter equal to or greater than the BOP bore, connected to the top of the BOP or marine riser with a side outlet to direct the drilling fluid returns to mud processing equipment.

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

3.1.7
blowout preventer (BOP) stack
Assembly of well control equipment including preventers, spools, valves, and nipples connected to the top of the casing head that allows the well to be sealed to confine well fluids to the wellbore.

3.1.8
body
Any portion of equipment between end connections, with or without internal parts, which contains wellbore pressure.

3.1.9
bolting
All threaded fasteners including studs, tap end studs, double ended studs, headed bolts, cap screws, screws, and nuts.

— primary bolting

Bolting in load path or bolting that joins flow-direction–controlling members.

— closure bolting

Threaded fasteners used to assemble wellbore pressure-containing parts or that join end or outlet connections.

— utility bolting

Bolting required 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.

3.1.10
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, bumper subs, heavy weight drill pipe, etc.

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
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.

3.1.15
diverter control system
Assemblage of pumps, accumulators, manifolds, control panels, valves, lines, etc., used to operate the diverter system.

3.1.16
diverter housing
If part of the diverter design, the interface between the diverter assembly and the required piping.

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

3.1.17
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.

3.1.18
diverter system
Assemblage of an annular sealing device, flow control means, and overboard system components which facilitates closure of the upward flow path of the well fluid and 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.

3.1.19
end connection
Integral male or female thread; clamp hub end connector or flange, studded or through-bolted, or any other means used to join together equipment that contains or controls pressure.

3.1.20
equivalent round

Standard 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.

3.1.21
fill-up line
Line connected into the bell nipple or diverter housing allowing drilling fluid to be added to the hole.

3.1.22
flange
Protruding rim, with holes to accept bolts and having a sealing mechanism, used to join pressure-containing equipment.

3.1.23
flow-direction-controlling member
System component that contains and directs wellbore fluid flow.

3.1.24
flow selector
Three-way valve with switchable target designed to divert wellbore fluids while keeping a diverter overboard line always open.

3.1.25
flow line
Piping that exits the bell nipple or diverter housing, and conducts drilling fluid and cuttings to the mud processing equipment.

3.1.26
flow line seal
Elastomeric element that creates a seal between the diverter housing and diverter assembly.

3.1.27
flow line valve
Valve that controls the flow of drilling fluid through the flow line.

3.1.28
fluid cushion
Cavity in a piping system used to absorb impact of flow direction change to mitigate erosion.

3.1.29
function test
Closing and opening (cycling) equipment to verify operability.

3.1.30
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.

3.1.31
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.

3.1.32
hot-work [*verb*]
Deform metal plastically at a temperature above the recrystallization temperature.

3.1.33
indication
Visual sign of cracks, pits or other abnormalities found during liquid penetrant and magnetic particle examinations.

3.1.34
leakage
Visible passage of pressurized fluid from the inside to the outside of the pressure-containment area of the equipment being tested.

3.1.35
linear indication
Liquid penetrant or magnetic particle examination indication whose length is equal to or greater than three times its width.

3.1.36
load-bearing weldments
Weldments subjected to external loads.

3.1.37
maintenance
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: inspections, cleaning, polishing, function testing, pressure testing, non-destructive 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.

3.1.38
major repair weld
Weld whose depth is greater than 25 % of the original wall thickness or 25 mm, whichever is less.

3.1.39
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.

3.1.40
overshot packer system
Adjustable spacer spool consisting of an overshot spool with sealing packer and a lower overshot mandrel that is designed and manufactured in accordance with API 16A.

3.1.41
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 effect a seal.

— annular packing element

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

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.

3.1.42
post-weld heat treatment
PWHT
Any heat treatment subsequent to welding, including stress relief.

3.1.43
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.

3.1.44
prod
Pointed rod used to induce a magnetic field onto a surface for inspection purposes.

3.1.45
product history file
PHF
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.

3.1.46
rated load
Nominal applied loading conditions used during design, analysis, and testing based on maximum anticipated service load.

3.1.47
rated working pressure
Maximum internal pressure that the equipment is designed to contain or control or a combination thereof.

3.1.48
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).

3.1.49
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.

3.1.50
remanufacture
Activity involving disassembly, reassembly and testing of equipment, with or without the replacement of parts, in which machining, welding, heat treating or other manufacturing operations are employed.

3.1.51
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.

3.1.52
rounded indication
For liquid penetrant or magnetic particle examination—any indication that is approximately circular or elliptical and whose length is less than three times its width.

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

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

3.1.53
serialization
Assignment of a unique code to individual parts or pieces, or a combination thereof, of equipment to maintain records.

3.1.54
stabilized
For pressure testing—state in which the initial pressure-decline rate has decreased to within a specified rate.

NOTE 1 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.

For temperature testing—state in which the initial temperature fluctuations have decreased to within a specified range.

NOTE 2 Temperature fluctuation can be caused by such things as mixing of different-temperature fluids, convection or conduction.

3.1.55
stress relief
Controlled heating of material to a predetermined temperature for the purpose of reducing any residual stresses.

3.1.56
studded connection
Connection in which thread-anchored studs are screwed into tapped holes.

3.1.57
subsea diverter
Diverter system installed above marine drilling riser.

3.1.58
surface diverter
Diverter system not installed above marine drilling riser.

3.1.59
target flange
Bull plug or blind flange to prevent erosion at a point where change in flow direction occurs.

3.1.60
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.

3.1.61
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.

3.1.62
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.

3.1.63
overboard line
vent line
Conduit that directs the flow of diverted wellbore fluids away from the drill floor to the environment.

3.1.64
overboard line valve
Full-opening valve that facilitates the shut-off of flow or allows passage of diverted wellbore fluids through the overboard line.

3.1.65
overboard outlet
Point at which fluids exit the wellbore below the annular sealing device via the overboard line.

3.1.66
weld groove
Area between two metals to be joined and has been prepared to receive weld filler metal.

3.1.67
wellhead
Component or structure installed to provide an interface between casing and well control equipment.

3.1.68
wrought structure
Structure that contains no cast dendritic structure.

3.1.69
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 in accordance with ASTM A370 or ISO 6892.S.

3.2 Acronyms

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

AE acoustic emission

ANSI American National Standards Institute

AISI American Iron and Steel Institute

AQL acceptance quality level

ASME American Society of Mechanical Engineers

ASTM American Society for Testing and Materials

AWS American Welding Society

BPVC	Boiler and Pressure Vessel Code
CE	carbon equivalent
CRA	corrosion resistant alloy
CSO	complete shut-off
DAC	distance amplitude curve
EP	equivalent P-number
ER	equivalent round
FAT	Factory Acceptance Test
FEA	Finite Element Analysis
HAZ	heat affected zone
IADC	International Association of Drilling Contractors
ID	inside diameter
IOM	Installation, Operation, and Maintenance
ISO	International Organization for Standardization
ITP	inspection test plan
LP	liquid penetrant
MP	magnetic particle
MDB	material data book
NDE	non-destructive examination
OD	outside diameter
OEC	other end connection
OEM	original equipment manufacturer
PHF	product history file
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 shall apply 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 as described in API 6X shall be used together with 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 of 3.45 MPa (500 psi).

5.2.2 Temperature Ratings

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

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
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.		

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

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

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

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

5.2.3 Rated Service Range

The manufacturer shall specify the range of tubulars for each size/type of diverter packer. The minimum and maximum tubular sizes shall define the rated service range.

NOTE Equipment capable of complete shut-off (CSO) may designate “CSO” for the minimum size.

5.3 Diverter Housing

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 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 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 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 complete shut-off, others are designed to seal only 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.

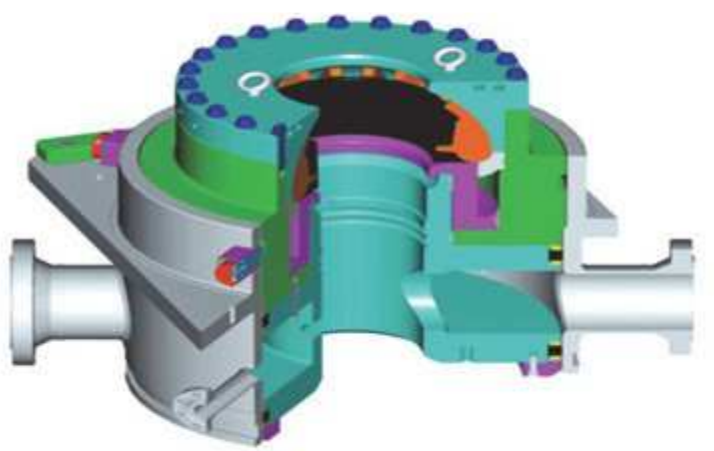


Figure 1—Example Diverter with an Annular Packing Unit

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 be of sufficient internal diameter in the fully open position to pass the drift.

Drift diameter shall be 0.060 in. less than the nominal diverter bore diameter with a tolerance of ±0.030 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.

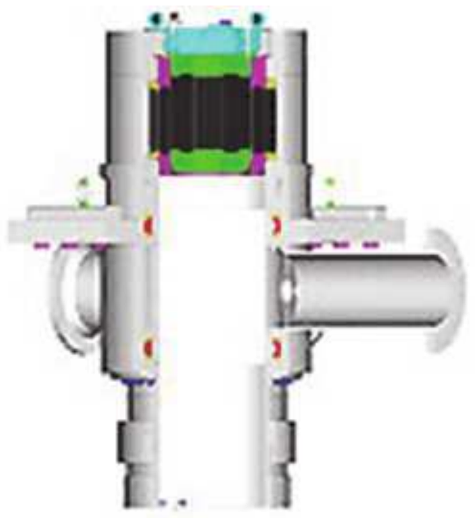


Figure 2—Example Diverter with an Insert Type Packer

5.6 Diverter Spools (Surface Applications)

The diverter spool pressure rating shall be equal to or greater than the annular sealing device 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.

5.7 Diverter Side Outlets

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 diverter side outlets shall be designed to accommodate the flow rate 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.

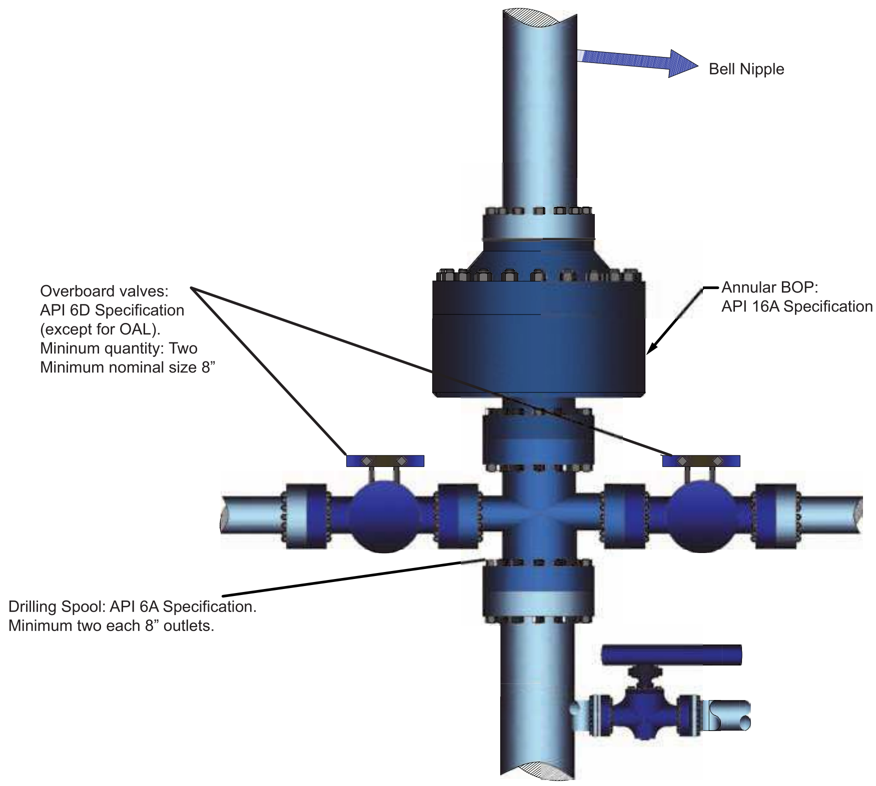


Figure 3—Example Annular BOP Diverter Configuration

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.

5.8 Bolting

5.8.1 General

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

Table 3—Bolting Requirements

Bolting Type	Material	Requirement Source
Primary	Allow Steel and Carbon Steel Stainless Steel and CRA	API 20E BSL-2 API 20F BSL-2
Closure	Allow Steel and Carbon Steel Stainless Steel and CRA	API 20E BSL-2 API 20F BSL-2
Utility	Allow Steel and Carbon Steel Stainless Steel and CRA	Manufacturer’s Specification Manufacturer’s Specification

Diverter equipment manufacturers shall have a documented procedure for the qualification of bolting manufacturers, which follows the requirements of API 20E or API 20F.

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

Bolting manufactured from proprietary materials shall conform to 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).

5.8.2 Closure Bolting

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

— initial bolt-up;

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

— hydrostatic test pressure conditions.

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

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

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.

5.9 Diverter Valves

The diverter valves control the flow of drilling fluids both into and out of the diverter housing. They shall be full bore, and other than their overall length, shall conform to the requirements of API 6D and API 6FA.

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.

5.10 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 always permit discharge flow even during actuation of the flow selector.

Flow selectors shall be fire tested in accordance with API 6FA.

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.

5.11 Actuators for Valves and Flow Selectors

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

All electrical components shall conform to the requirements of API 16D.

All actuators shall be fire tested in accordance with API 6FA.

5.12 Diverter Control System

Diverter control systems shall conform to the requirements of API 16D and of the OEM.

5.13 Overboard Piping

5.13.1 General

All 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.

5.13.2 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.

5.13.3 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.

5.14 Piping Supports

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

5.15 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 using the format used 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 intended to support the riser and the BOP stack, as well as installing the diverter, shall conform to the requirements of API 16F.

5.17.2 Load

Diverter handling tools shall be designed considering the following loads:

— Maximum rated static load capacity

— Bending loads (during handling)

— 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. All forces that may govern the design shall be taken into account. For each cross section to be considered, the most unfavourable combination, position, and direction of forces shall be used.

5.17.3.2 Design Safety Factor

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

The design safety factor is intended as a design criterion and shall not under any circumstances be construed as allowing loads on the equipment in excess of the load rating.

5.17.3.3 Allowable Stress

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

$$\sigma_{allow,m} = \frac{\sigma_{ys}}{SF_D} \tag{2}$$

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).

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

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).

$$\sigma_{allow,s} = \frac{3.0 \times \sigma_{ys}}{SF_D} \tag{4}$$

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

$$\sigma_{bearing} \leq \sigma_{ys} \tag{5}$$

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 per Section 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:

$$\frac{2.25 \times Rated\ Load}{n \times A_{bolt}} \leq S_y \tag{6}$$

— for calculation based analysis or;

— when FEA results show joint separation (i.e. when the contact pressure between the bolted components ≤ 0);

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

— 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.

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

5.19.2 Acceptance Criteria

The acceptance criterion for all tests that verify pressure integrity shall be no visible leakage.

5.19.3 Diverter Packing Units

5.19.3.1 General

The OEM shall provide a table of maximum allowable closing pressures for the full range of applicable tubular sizes at RWP for each temperature rating.

5.19.3.2 Annular Type

Tests on annular type diverter packing units shall be tested to RWP for the largest and the smallest (CSO if applicable) of applicable pipe sizes.

5.19.3.3 Insert Packer Type

Tests on insert type diverter packing units shall be tested to RWP for the largest and the smallest of applicable pipe sizes for the specified insert packer size.

5.19.3.4 Ambient Temperature Closure Test

Annular packers shall be tested on 5-in. pipe and on open hole (if applicable).

Insert packers shall be tested on the smallest tubular size for the range.

Perform the following design validation testing:

— Perform a pressure test at rated working pressure for 3 minutes.

— Annular packer elements shall be drift tested in accordance with 9.3.1.

NOTE Drift test is not required for insert packer(s).

5.19.3.5 Annular Type Packer Fatigue Test

5.19.3.5.1 Test Procedure

The fatigue test shall be performed on 5-in. pipe.

a) Close and open the diverter six times with the manufacturer's recommended closing pressure.

b) Close the diverter a seventh time with the manufacturer's recommended closing pressure.

c) Apply wellbore pressure to the full rated working pressure of the diverter and hold for 3 minutes.

d) Bleed off wellbore pressure.

e) Repeat Steps A through C until packer leaks or until 364 function cycles (52 pressure cycles) have been completed.

f) Open the diverter.

g) Every twentieth pressure cycle, measure the ID of the packing element when the operating piston reaches the fully open position (this can be detected by a rapid pressure rise on the operating-system pressure gauge).

h) 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 final ID and elapsed time.

5.19.3.5.2 Acceptance Criteria

The packing element shall achieve a minimum of 26 consecutive successful pressure cycles and subsequently pass drift requirements according to 9.3.1.

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

5.19.3.6 Insert Type Packer Fatigue Test

5.19.3.6.1 Ten Inches or Smaller Insert Packer Procedure

The fatigue test shall be performed on the insert packer on 5-in. pipe.

a) Close and open the diverter six times with the manufacturer's recommended closing pressure.

b) Close the diverter a seventh time with the manufacturer's recommended closing pressure.

c) Apply wellbore pressure to the full rated working pressure of the diverter and hold for three minutes.

d) Bleed off wellbore pressure.

e) Repeat Steps A through D until packer leaks or until 364 function cycles (52 pressure cycles) have been completed.

f) Open the diverter.

5.19.3.6.2 Insert Packers Larger than 10 Inch Procedure

The fatigue test shall be performed on the insert packer on smallest rated pipe size for specified range.

a) Close and open the diverter six times with the manufacturer's recommended closing pressure.

b) Close the diverter a seventh time with the manufacturer's recommended closing pressure.

c) Apply wellbore pressure to the full rated working pressure of the diverter and hold for 3 minutes.

d) Bleed off wellbore pressure.

e) Repeat Steps A through D until packer leaks or until 364 function cycles (52 pressure cycles) have been completed.

f) Open the diverter.

5.19.3.6.3 Acceptance Criteria

For insert packers less than or equal to 10 in., the insert packer shall achieve a minimum of 26 consecutive successful pressure cycles.

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

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

5.19.3.7 Design Temperature Validation Testing

5.19.3.7.1 Packers

Annular packers shall be tested on 5-in. pipe, and on open hole (if applicable).

Insert packers shall be tested on the smallest tubular size for the range.

Perform the following design temperature validation testing:

— low temperature test: perform minimum of three pressure cycles at rated working pressure for 3 minutes per cycle.

— continuous elevated temperature test: perform 10 pressure cycles at rated working pressure with a minimum pressurization hold time of 10 minutes per cycle.

— extreme temperature test: perform minimum of one pressure cycle at rated working pressure for 60 minutes.

NOTE Elastomers may be replaced between qualification tests at the discretion of the OEM.

5.19.3.7.2 Non-metallic Seals

Non-metallic seals and molded sealing assemblies in diverters shall satisfy the same design temperature validation testing as the packers.

5.19.3.7.3 Protocol

The test protocol shall be as follows:

a) Install test mandrel as applicable in diverter for packing unit tests

b) Ensure wellbore fluid temperature is:

— at or below specified temperature for low temperature test

— at or above specified temperature for elevated and extreme temperature tests

c) With wellbore fluid at appropriate test temperature, close the diverter and apply rated working pressure and hold for the time period specified in 5.19.3.7.1.

d) Bleed off test pressure.

e) Repeat Steps B through D as specified in 5.19.3.7.1.

5.20 Documentation

5.20.1 Design Documentation

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

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

5.20.2 Design Review

Design documentation shall be 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 (5.20.1).

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

5.20.3 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

A material specification shall be required for all metallic flow-direction–controlling members or pressure-containing parts.

The 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;

— NDE requirements;

— mechanical property requirements;

— material traceability;

— weld repair requirements;

— furnace calibrations and certification.

6.2.2 Non-metallic Parts

Each manufacturer shall have written specifications for elastomeric materials used in the flow-direction-controlling and pressure-containing components. These specifications shall include the following physical tests and limits for acceptance and control:

— Hardness in accordance with ASTM D2240 or ASTM D1415;

— 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.

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

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

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 4.

Charpy V-notch impact testing shall conform to 6.4.2.

Table 4—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.						

6.3.2 Processing

6.3.2.1 Melting, Casting, and Hot Working

6.3.2.1.1 Melting Practices

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

6.3.2.1.2 Casting Practices

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

6.3.2.1.3 Hot-working Practices

The materials manufacturer 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.

— 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.

— Other quenching media: 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 manufacturer 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 5.

NOTE Limits for non-martensic alloy systems are not required to conform to Table 5 and Table 6.

Table 5—Steel Composition (% mass fraction) for Flow-direction–controlling Members

Alloying Element	Carbon and Low-Alloy Steels Limit % mass fraction	Martensitic Stainless Steels Limit % mass fraction
Carbon	0.45 maximum	0.15 maximum
Manganese	1.80 maximum	1.00 maximum
Silicon	1.00 maximum	1.50 maximum
Phosphorus	0.025 maximum	0.025 maximum
Sulfur	0.025 maximum	0.025 maximum
Nickel	1.00 maximum	4.50 maximum
Chromium	2.75 maximum	11.0 to 14.0 maximum
Molybdenum	1.50 maximum	1.00 maximum
Vanadium	0.30 maximum	N/A

Table 6—Alloying Element Range–Maximum Tolerance Requirements

Alloying Element	Carbon and Low-Alloy Steels Limit % mass fraction	Martensitic Stainless Steels Limit % mass fraction
Carbon	0.08	0.08
Manganese	0.40	0.40
Silicon	0.30	0.35
Nickel	0.50	1.00
Chromium	0.50	—
Molybdenum	0.20	0.20
Vanadium	0.10	0.10
NOTE These values are the maximum allowable tolerance for any specific element and cannot exceed the maximum specified in Table 5.		

6.3.4.3 Tolerance on Composition Limits

The permitted tolerances on alloy element content shall conform to 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 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 the procedures specified in 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 4.

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 × 10 mm (0.39 in. × 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 ASTM A370 using the Charpy V-notch technique.

In order to qualify material for a temperature rating, the impact tests shall be performed at or below the test temperature shown in Table 7.

Table 7—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:

— The average of the impact property value shall be at least the minimum value shown in Table 7.

— In no case shall an individual impact value fall below $^2/_3$ the required minimum average.

— No more than one of the three test results shall be 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 7 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 may be tested in the longitudinal direction instead of the transverse direction, in which case they 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 1 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 2 A QTC may only qualify material and parts produced from the same heat. Remelt heat may be qualified on a master heat 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.

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

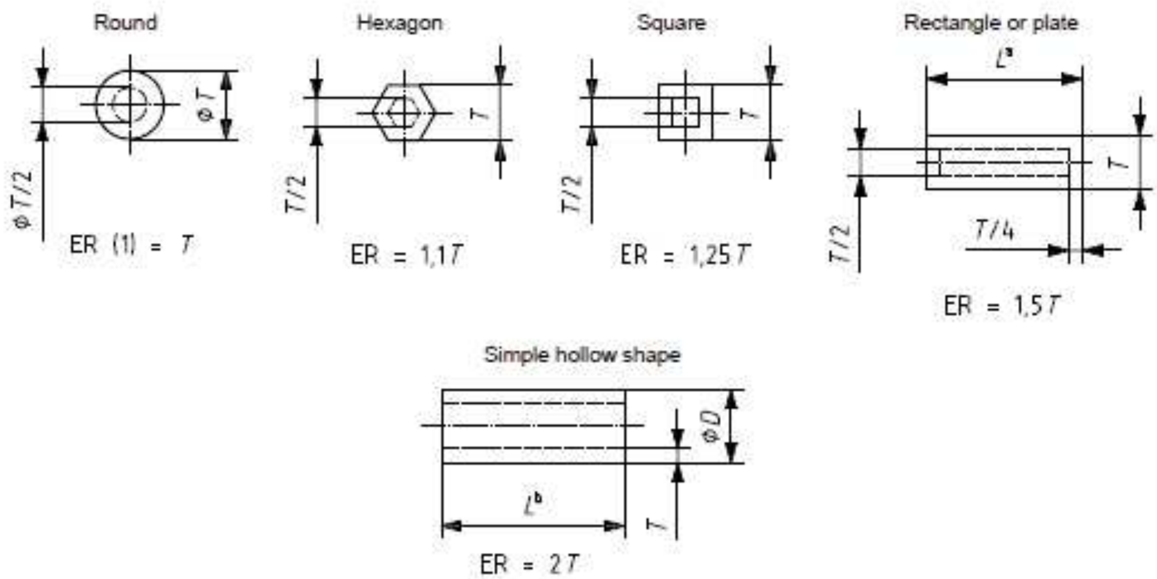
In no case shall the QTC be processed using a melting practice(s) cleaner than that of the material it qualifies [e.g. a QTC made from a remelt grade or vacuum-degassed material may not qualify material from the same primary melt which has not experienced the identical melting practice(s)].

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, in order to ensure accurate representation.

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.



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

6.4.7 Welding

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

6.4.8 Heat Treating

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

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 be no lower than 14 °C (25 °F) below that of the QTC. The upper limit shall be no higher than permitted by the heat-treatment procedure for that material. The cycle time of the QTC at each temperature shall not exceed that 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 It is allowable to remove tensile and impact specimens from multiple QTCs as long as the multiple QTCs have had the same heat-treatment cycle(s).

Tensile and impact specimens shall be removed from the QTC such that their longitudinal centerline axis is 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 procedures specified in ASTM E10, ASTM E18, ASTM A370, ISO 6506-1 or ISO 6508-1, as appropriate.

6.4.10.2 Hardness Examination Acceptance Criteria

Hardness values shall meet the following requirements.

— At least one hardness test (two indentations) shall be performed on each part tested, at a location determined by the manufacturer’s specifications.

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

— The actual value of the hardness test shall be stamped on the part adjacent to the test location. It is permissible for harness marking to be covered by other components after assembly.

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

— Hardness measurements on parts manufactured from carbon low alloy and martensitic stainless type steels shall exhibit maximum values equal to or greater than those specified in Table 8.

Table 8—Minimum Hardness Requirements

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

— In the event that it is necessary to report the hardness test results in other measurement units, conversions shall be made in accordance with ASTM E140 or ISO 18265.

— In the event that a part does not exhibit the required minimum hardness level, the part may be considered to have an acceptable hardness if the measured value satisfies the 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):

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

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 tests;

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 WPS and the supporting 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

6.5.2.1 Flow-direction-controlling Weldments

Flow-direction-controlling weldments that contain wellbore fluid shall have full penetration weldments with the exception of 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 manufacturer shall use a written procedure that provides controls for consistently meeting the manufacturer-specified material surface properties in the final machined condition.

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

Qualification shall be in accordance with Articles II and III of ASME BPVC, Section IX, for corrosion-resistant weld metal 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 manufacturer 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 manufacturer'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

Welding shall be performed by personnel qualified in accordance with the requirements of 8.2.

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.

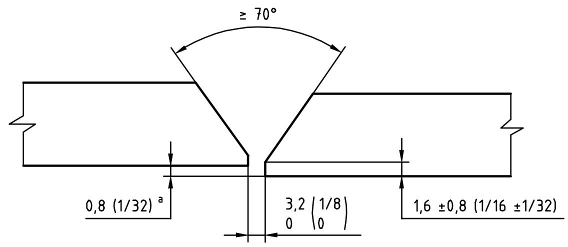
Welders and welding operators shall have access to, and shall comply with, the welding parameters as defined in the WPS.

6.5.5.3 Designed Welds

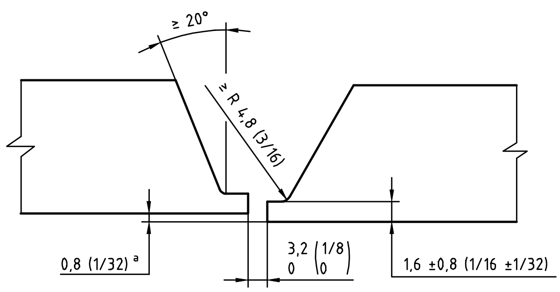
For all welds that are considered part of the design of a production part, the manufacturer shall specify the requirements for the intended weld.

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

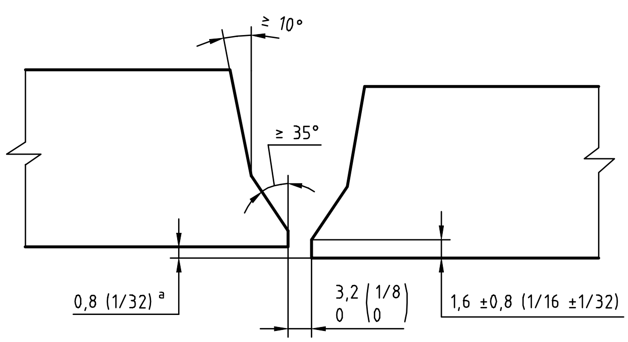
NOTE Figures 5 through 8 depict some typical joint designs.



a) V-groove



b) U-groove



c) Heavy wall V-groove

[a] Maximum misalignment

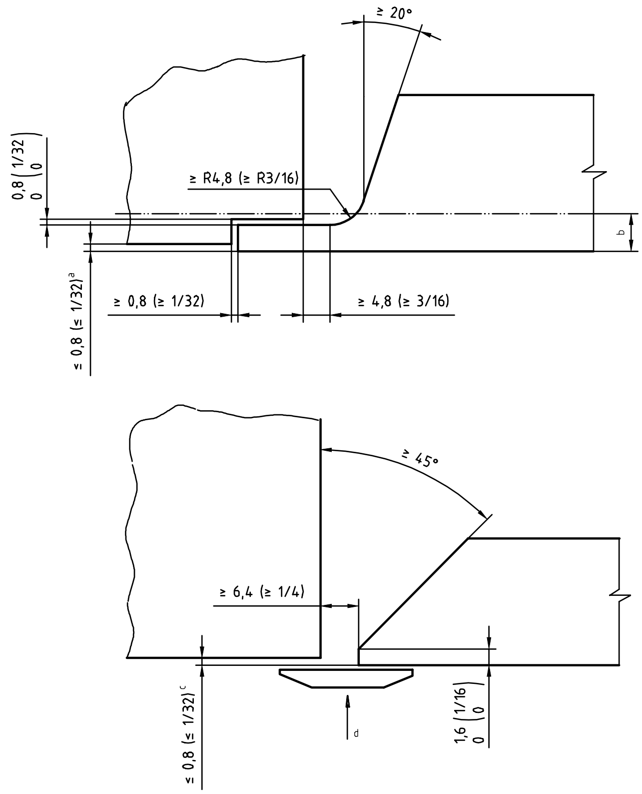
Figure 5—Typical Weld Grooves for Pipe Butt Joints

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.



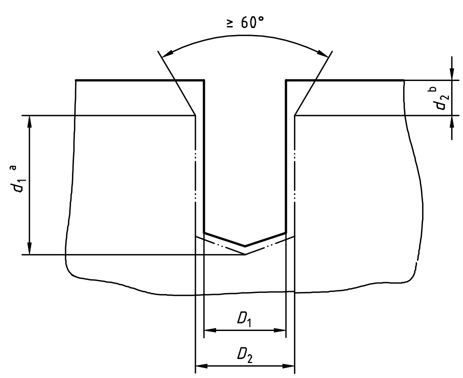
a Mismatch (unless removed by machining)

b Remove to sound metal by machining

c Maximum mismatch

d Backing to be removed. Material to be compatible with base material.

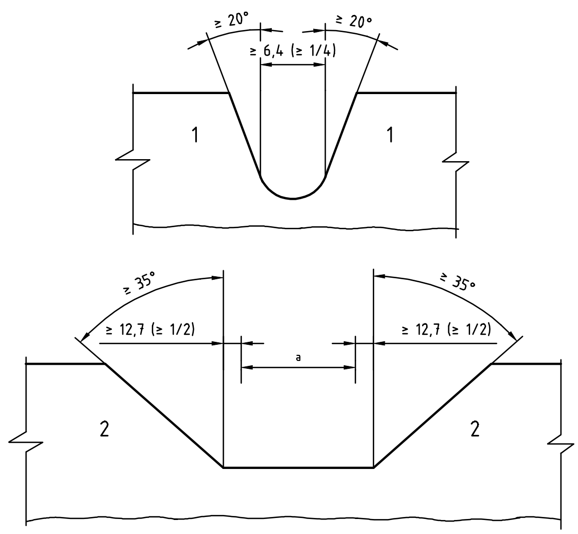
Figure 6—Typical Attachment Welds



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.

Figure 7—Typical Repair Welds



Key

1 Side

2 End

a Original area.

Figure 8—Typical Evacuation for Repair Welds

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

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

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

Local post-weld heat treatment 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 manufacturer 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 manufacturer shall establish an equivalent P number (EP) grouping for carbon and low-alloy steels not listed in ASME Section IX with a carbon equivalent less than or equal to 0.43 for <1 in. or less and 0.45 for > 1-in. material thickness (see Equation 8).

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

Additionally, carbon and low-alloy steels not listed in ASME Section IX with an allowable carbon equivalent 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 carbon equivalents 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. Post-weld heat treatment 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

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 the requirements of API 16A or API 16F, as applicable.

For 300 series or austenitic stainless steel, 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 9.

Table 9—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 post-weld heat treatment of the test weldment and the production weldment shall be in the same range as that specified on the WPS.

Allowable range for the post-weld heat treatment on the WPS shall be a nominal temperature of ±14 °C (±25 °F).

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

6.5.8.2.4 Hole Repair Procedure Qualification

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

— 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;

— The hole repair weld procedure qualification shall demonstrate that the minimum mechanical properties for 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.

— 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.

— The depth-to-diameter ratio of the test hole shall qualify all repairs to holes with the same or smaller depth-to-diameter ratio.

— 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 5).

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 10:

a) diverter housing

b) diverter assembly

c) diverter spool

d) diverter packers

e) diverter running tool

f) flow selector

Equipment shall be stamped on the product with “API S64”.

NOTE API 16A packers can be used in API 64 diverters.

7.2 Types of Identification Stamping

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 10—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.

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.

7.2.2.2 Non-wellbore Non-metallic Components

For the identification of non-wellbore non-metallic components, such as elastomeric seals used in diverter equipment, the manufacturer shall have a written procedure for affixing the required codification to the product or its package.

Actuation systems shall be in accordance with the manufacturer's written specification.

8 Quality Control Requirements

8.1 General

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 internals 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 either 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 MDB.

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

Pressure-measuring devices shall be periodically 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 the requirements specified in 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);
- AWS Certified Welding Inspector (CWI);
- AWS Certified Associate Welding Inspector (CAWI);
- CSWIP Certified Visual Welding Inspectors (Level 1);
- CSWIP Certified Welding Inspectors (Level 2);
- CSWIP Certified Senior Welding Inspectors (Level 3);
- Welding inspector certified by the manufacturer's documented training program.

8.3.3.2 Procedures

The manufacturer shall have written procedures defining the following.

- In-house welding inspector certification program including training syllabus, instructor qualification requirements, length of certification and renewal requirements.
- Roles, responsibilities, authority and accountability of a welding inspector.
- Essential welding variables and equipment monitoring.
- Welding, weld NDE and PWHT audits as follows:
  - internal audits shall be performed at least annually, covering all on-site areas and shifts;
  - supplier audits shall be performed in accordance with the manufacturers 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

All 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

All 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 all equipment, parts and materials, shall be indicated either on the equipment, parts or materials, or in the records traceable to the equipment, parts or materials.

8.4.4 Visual Examination

8.4.4.1 Sampling

Each part shall be visually examined.

8.4.4.2 Procedure

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

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

8.4.5.2 Surface NDE of Ferromagnetic Materials

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

8.4.5.3 Surface NDE of Non-ferromagnetic Materials

All 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

All 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 procedures specified in ASTM E709. Prods are not permitted on surfaces or sealing surfaces.

LP examination shall be in accordance with procedures specified in 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 cm^2 (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

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

8.4.6 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 ($1^1/_2$ in.); on 3.2 mm ($^1/_8$ in.) flat-bottom hole for metal thicknesses from 38 mm ($1^1/_2$ 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:

— no single indications exceeding reference distance amplitude curve;

— no multiple indications exceeding 50 % of reference distance amplitude curve.

Multiple indications shall be defined as two or more indications (each exceeding 50 % of the reference distance amplitude curve) 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:

— no cracks, laps or bursts;

— no elongated indications with length greater than the measurements/values stated in Table 11.

Table 11—Maximum Length of Elongated Slag Inclusion for Radiography

Weld Thickness (*T*) (inches)	Inclusion Length (inches)
Less Than 0.76	0.25
0.76 to 2.2.5	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

All 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 not be permitted on or within 3 mm ($^1/_2$ in.) of sealing surfaces.

8.5.2.2 Surface NDE

8.5.2.2.1 General

All 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 magnetic particle 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 liquid penetrant 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 liquid penetrant 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 2 mm ($^1/_{16}$ in.) edge-to-edge.

8.5.2.3 Volumetric NDE

8.5.2.3.1 General

One hundred percent of 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, post weld heat treatment, and machining operations.

8.5.2.3.2 Radiography

Radiographic examinations shall be performed in accordance with procedures specified in 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 11.

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 procedures specified in 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 12.

Table 12—Maximum Amplitude of Slag Indication for Ultrasonic Examinations

Weld Thickness (*T*) (in.)	Inclusion Length (in.)
Less Than 0.76	0.25
0.76 to 2.2.5	0.33 T
Greater than 2.25	0.75

8.5.2.4 Weld Hardness Testing

All 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:

— Vickers Method (ASTM E384)

— Brinell Method (ASTM E10 or E110)

— 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 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:

— hardness data in accordance with ASTM D1415 or ASTM D2240;

— 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 rated working pressure 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 testing fluid; any additives shall be documented in the test records.

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

9.1.2 Wellbore-wetted Sealing Area Test

Pressure testing shall consist of three steps.

1) An initial rated working pressure-holding period of not less than 3 minutes.

2) Reduction of the pressure to zero.

3) A second rated working pressure-holding period of not less than 15 minutes.

Pressure testing shall meet the following criteria:

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

— The acceptance criterion shall be no visible leakage.

9.1.3 Operating Chamber Test

Pressure testing shall consist of three steps.

1) An initial rated working pressure-holding period of not less than 3 minutes.

2) Reduction of the pressure to zero.

3) A second rated working pressure-holding period of not less than 15 minutes.

Pressure testing shall meet the following criteria:

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

— The acceptance criterion shall be no visible leakage.

9.2 Diverter Housing—Proof Testing in the Shop

All diverter assemblies shall be subjected to an FAT prior to shipment from the manufacturer's facility unless agreement with the purchaser has been reached to test the assembly on-site.

The diverter housing shall undergo an FAT to RWP to prove the wellbore-wetted sealing areas, in accordance with 9.1.2.

9.3 Diverter Assembly

9.3.1 FAT Diverter Drift Test

The diverter assembly shall be drifted after FAT per the manufacturer's written specification.

A drift mandrel shall pass through the bore within 30 minutes of the closing pressure being removed from a rated working pressure 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.).

9.3.2 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 8.1.2.

The record shall identify the recording device, and shall be dated and signed.

9.3.3 FAT Hydrostatic Proof Testing Seal Test

9.3.3.1 In-plant Hydrostatic Body Test

The diverter assembly test pressure shall be the rated working pressure for the equipment.

9.3.3.2 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 a minimum test pressure equal to 1.5 times the operating chamber's rated working pressure.

NOTE If housing is unavailable, a dummy housing may be used to complete the test.

9.4 Diverter Valves and Actuators

Diverter valves shall be Factory Acceptance Tested per API 6D requirements.

Diverter valve actuators shall be Factory Acceptance Tested per API 6DX requirements.

9.5 Diverter Handling and Test Tools

Handling and test tools not intended to support the riser and the BOP stack shall be subject to FAT per the manufacturer's written specifications.

Handling tools intended to support the riser and the BOP stack, as well as installing the diverter, shall conform to "Production Testing" of API 16F.

9.6 Other Equipment

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

10 Maintenance

10.1 General

All replacement parts for equipment designed in accordance with this standard shall be in full 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 installation, operation, and maintenance (IOM) of diverter systems.

10.3 Maintenance Records

Electronic or hard copy records or both, for maintenance, repairs, and remanufacturing performed for the diverter 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 well or in accordance with documented equipment owner's reliability data, whichever is greater.

Diverter system and components shall be inspected at least every 5 years in accordance with the equipment owner's PM program 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 pressure-containing components shall be pressure tested.

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

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, protection against environmental damage, corrosion, etc.

10.9 Weld Repairs

All 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 required by this Standard 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

All 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 required by this Standard shall be legible, identifiable, retrievable, and protected from damage, deterioration or loss.

Records required by this Standard 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.

All records required by this Standard 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
- 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

11.2.5 IOM Manuals

Manufacturer shall provide an IOM manual that contains:

- 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.

11.2.6 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.

11.2.7 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).

11.2.8 Closure Bolting

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

11.2.9 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.

11.2.10 Diverter Packers Shipped Separately

- The following records shall be retained:
- pressure test records (9.3.3);
- Drift test record (only for CSO type) (9.3.1).

11.2.11 Assembled Diverters

The following records shall be retained:

— pressure test records (9.3.3);

— drift test record (only for CSO type) (9.3.1).

11.2.12 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.

12 Field Testing

12.1 Pressure Test

Diverter assembly to flow line and overboard valves shall be pressure tested every 90 days or between wells, whichever is greater. Pressure test shall be performed at RWP for no less than 5 minutes with no visible leakage.

12.2 Function Test

The diverter system sequences and interlocks shall be function tested upon installation and at least once every seven days, to verify the component's intended operations, as operations allow.

Function tests shall be alternated weekly from the control stations where all diverter functions are included.

Actuation times shall be documented for evaluating trends.

A function test of the diverter control system shall be performed following the disconnection or repair, limited to the affected component.

12.3 Flow Test

The following shall be performed:

At the beginning of each well, pump water or drilling fluid through the diverter system.

While flow testing, check the overboard line(s) for returns and examine the entire system for leaks, excessive vibrations, and proper tie-down.

12.4 Operating Chamber Test

An operating chamber test is the application of an RWP test to any operating chamber (in both directions). The test shall be performed annually as part of the equipment owner's preventive maintenance program.

12.5 Diverter Drawdown Test

Diverter accumulator capacity shall be verified at initial installation of the diverter by isolating the diverter system accumulators from the charging pumps and functioning the system in diverter mode.

The end pressure shall be the minimum calculated operating pressure required to close and seal the diverter packing element on drill pipe at the maximum rated wellbore pressure of the diverter system.

The remaining volume of the diverter accumulator shall be sufficient to allow for an additional function of the overboard valves.

12.6 Response Times

12.6.1 Packing Element ID 20 in. or Less

The primary diverter closing system shall be capable of operating the overboard line, flow line valves, auxiliary valves, and closing the annular packing element on the pipe within 30 seconds of actuation.

12.6.2 Packing Element ID Greater Than 20 in.

The primary diverter closing system shall be capable of operating the overboard line, flow line valves, auxiliary valves, and closing the annular packing element on the pipe within 45 seconds of actuation.

12.7 Limitations—Manual Override

Manual override should only be used for maintenance and or test routines.

12.8 Testing Schedule

The testing schedule for Subsea Diverters shall be as defined in Table 13. The testing schedule for Surface Diverters shall be as defined in Table 14.

Table 13—Subsea Diverter Testing Schedule

Frequency	Item to be Tested	Type of Test Required	Minimum Test Pressure	Operating Chamber Test
FAT	Diverter, diverter housing, flow selectors, and valves (component level)	Pressure test[a]	RWP	1.5 × Rated working pressure
		Function test[a]	N/A	
Commissioning	Diverter packers, flow line seals, flow line valves, and overboard valves	Pressure test[a]	RWP	Rated working pressure[b]
	Diverter packers, overboard lines, and flow selectors	Flow and function test[a]	N/A	
Floating rig systems at installation	Diverter packers, flow line seals, flow line valves, and overboard valves	Pressure test[a]	RWP	Rated working pressure[b]
	Diverter packers, overboard and flow line valves/lines, and flow selectors	Flow and function test[a]	N/A	
Floating rig systems subsequent testing[c]	Overboard and flow line valves and flow selectors	Pressure test[d]	RWP	Rated working pressure[f]
		Function test sequence[a,e]	N/A	
Post use		Pipe integrity inspection Close packer Function test[e]		

NOTE All pressure tests shall be recorded.

[a] All response times shall be recorded.

[b] A stabilized RWP test pressure shall be maintained for at least 5 minutes with no visible leakage.

[c] The frequency of the operating chamber tests shall be in accordance with the equipment owner's PM program.

[d] Every 90 days or between wells, whichever is greater.

[e] Not to exceed 7 days between tests.

[f] Not to exceed 1 year.

Table 14—Surface Diverter Testing Schedule

Frequency	Item to be Tested	Type of Test Required	Minimum Test Pressure	Operating Chamber Test
FAT	Diverter, diverter housing, flow selectors and valves (component level)	Pressure test[a]	RWP	1.5 × Rated working pressure
		Function test[a]	N/A	
Commissioning	Diverter packers, flow line seals, flow line valves and overboard valves	Pressure test[a]	RWP	Rated working pressure[b]
	Diverter packers, overboard lines and flow selectors	Flow and function test[a]	N/A	
Bottom supported rigs; installation on wellhead[g]	Diverter packers, flow line seals, flow line valves and overboard valves	Pressure test[a]	RWP	Rated working pressure[b]
	Diverter packers, overboard and flow line valves/lines and flow selectors	Flow and function test[a]	N/A	
Bottom supported rigs; subsequent testing[c]	Overboard and flow line valves and flow selectors	Pressure test[d]	RWP	Rated working pressure[f]
		Function test sequence[a,e]	N/A	

NOTE All pressure tests shall be recorded.

[a] All response times shall be recorded.

[b] A stabilized RWP test pressure shall be maintained for at least 5 minutes with no visible leakage.

[c] The frequency of the operating chamber tests shall be in accordance with the equipment owner's PM program.

[d] Every 90 days or between wells, whichever is greater.

[e] Not to exceed 7 days between tests.

[f] Not to exceed 1 year.

[g] Applies to surface or bottom supported type rigs where the diverter is installed directly to the wellhead.

Annex A
(informative)

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

All 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

All 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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