

Petroleum and natural gas industries — Drilling and production equipment — Wellhead and christmas tree equipment

The European Standard EN ISO 10423:2001 has the status of a
British Standard

ICS 75.180.10

National foreword

This British Standard is the official English language version of EN ISO 10423:2001. It is identical with ISO 10423:2001.

The UK participation in its preparation was entrusted to Technical Committee PSE/17, Petroleum and natural gas industries, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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Summary of pages

This document comprises a front cover, an inside front cover, the EN ISO title page, the EN ISO foreword page, the ISO title page, pages ii to vii, a blank page, pages 1 to 401, the Annex ZA page, an inside back cover and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments
14261 Corrigendum No. 1	18 December 2002	Correction to EN ISO foreword page and incorporating the Annex ZA page.

This British Standard, having been prepared under the direction of the Engineering Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 3 September 2001

© BSI 18 December 2002

ISBN 0 580 38419 5

English version

**Petroleum and natural gas industries - Drilling and production
equipment - Wellhead and christmas tree equipment (ISO
10423:2001)**

Indutries du pétrole et du gaz naturel - Equipement de
forage et de production - Equipement pour têtes de puits et
arbre de Noël (ISO 10423:2001)

This European Standard was approved by CEN on 1 August 2001.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

CORRECTED 2002-11-20

Foreword

This document (ISO 10423:2001) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum and natural gas industries" in collaboration with Technical Committee CEN/TC 12 "Materials, equipment and offshore structures for petroleum and natural gas industries", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2002, and conflicting national standards shall be withdrawn at the latest by February 2002.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of ISO 10423:2001 has been approved by CEN as EN ISO 10423:2001 without any modifications.

NOTE Normative references to International Standards are listed in Annex ZA (normative).

INTERNATIONAL STANDARD

EN ISO 10423:2001

ISO
10423

Second edition
2001-08-01

Petroleum and natural gas industries — Drilling and production equipment — Wellhead and christmas tree equipment

*Industries du pétrole et du gaz naturel — Équipement de forage et de
production — Équipement pour têtes de puits et arbre de Noël*



Reference number
ISO 10423:2001(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 10423 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*, Subcommittee SC 4, *Drilling and production equipment*.

This second edition cancels and replaces ISO 10419, ISO 10433 and the first edition of ISO 10423 (ISO 10423:1994).

Annexes H, I, J and L form a normative part of this International Standard. Annexes A, B, C, D, E, F, G, K and M are for information only.

Introduction

This International Standard is based on API Spec 6A, seventeenth edition, February 1996, its errata and supplement, and API Spec 6AV1, first edition, February 1996.

The contents of API Spec 14D (upon which ISO 10433 was based) and API Recommended Practice 14H (upon which ISO 10419 was based) have been incorporated in API Spec 6A, seventeenth edition.

The International System of units (SI) is used in this International Standard. However, nominal sizes are shown as fractions in the inch system.

The fractions and their decimal equivalents are equal and interchangeable. Metric conversions and inch dimensions in this International Standard are based on the original fractional inch designs. Functional dimensions have been converted into the metric system to ensure interchangeability of products manufactured in metric or inch systems (see also annex B).

Tables referenced in the main body of this International Standard which are marked with an asterisk are repeated in annex B in US customary units with the same table number as in the main body but with the prefix B. See also annex M for listings of tables and figures.

Users of this International Standard should be aware that further or differing requirements may be needed for individual applications. This International Standard is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this International Standard and provide details.

Petroleum and natural gas industries — Drilling and production equipment — Wellhead and christmas tree equipment

1 Scope

1.1 Purpose

This International Standard specifies requirements and gives recommendations for the performance, dimensional and functional interchangeability, design, materials, testing, inspection, welding, marking, handling, storing, shipment, purchasing, repair and remanufacture of wellhead and christmas tree equipment for use in the petroleum and natural gas industries.

This International Standard does not apply to field use, field testing or field repair of wellhead and christmas tree equipment.

1.2 Applicability

This International Standard is applicable to the following specific equipment.

- a) Wellhead equipment:
 - casing head housings;
 - casing head spools;
 - tubing head spools;
 - cross-over spools;
 - multi-stage head housings and spools.
- b) Connectors and fittings:
 - cross-over connectors;
 - tubing head adapters;
 - top connectors;
 - tees and crosses;
 - fluid-sampling devices;
 - adapter and spacer spools.
- c) Casing and tubing hangers:
 - mandrel hangers;
 - slip hangers.

d) Valves and chokes:

- single valves;
- multiple valves;
- actuated valves;
- valves prepared for actuators;
- check valves;
- chokes;
- surface and underwater safety valves and actuators;
- back-pressure valves.

e) Loose connectors [flanged, threaded, other end connectors (OEC), and welded]:

- weld neck connectors;
- blind connectors;
- threaded connectors;
- adapter and spacer connectors;
- bullplugs;
- valve-removal plugs.

f) Other equipment:

- actuators;
- hubs;
- pressure boundary penetrations;
- ring gaskets;
- running and testing tools (in annex H);
- wear bushings (in annex H).

The nomenclature used in this International Standard for typical equipment is shown in Figure 1 and Figure 2. All parts whose physical dimensions conform to the metric tables incorporated into the body of this International Standard or to the US customary units tables in annex B are acceptable (see Introduction).

1.3 Service conditions

This International Standard defines service conditions, in terms of pressure, temperature and material class for the well-bore constituents, and operating conditions.

1.4 Product specification levels (PSL)

This International Standard establishes requirements for five product specification levels. These five PSL designations define different levels of technical quality requirements. Annex A provides guidelines (not requirements) for selecting an acceptable PSL.

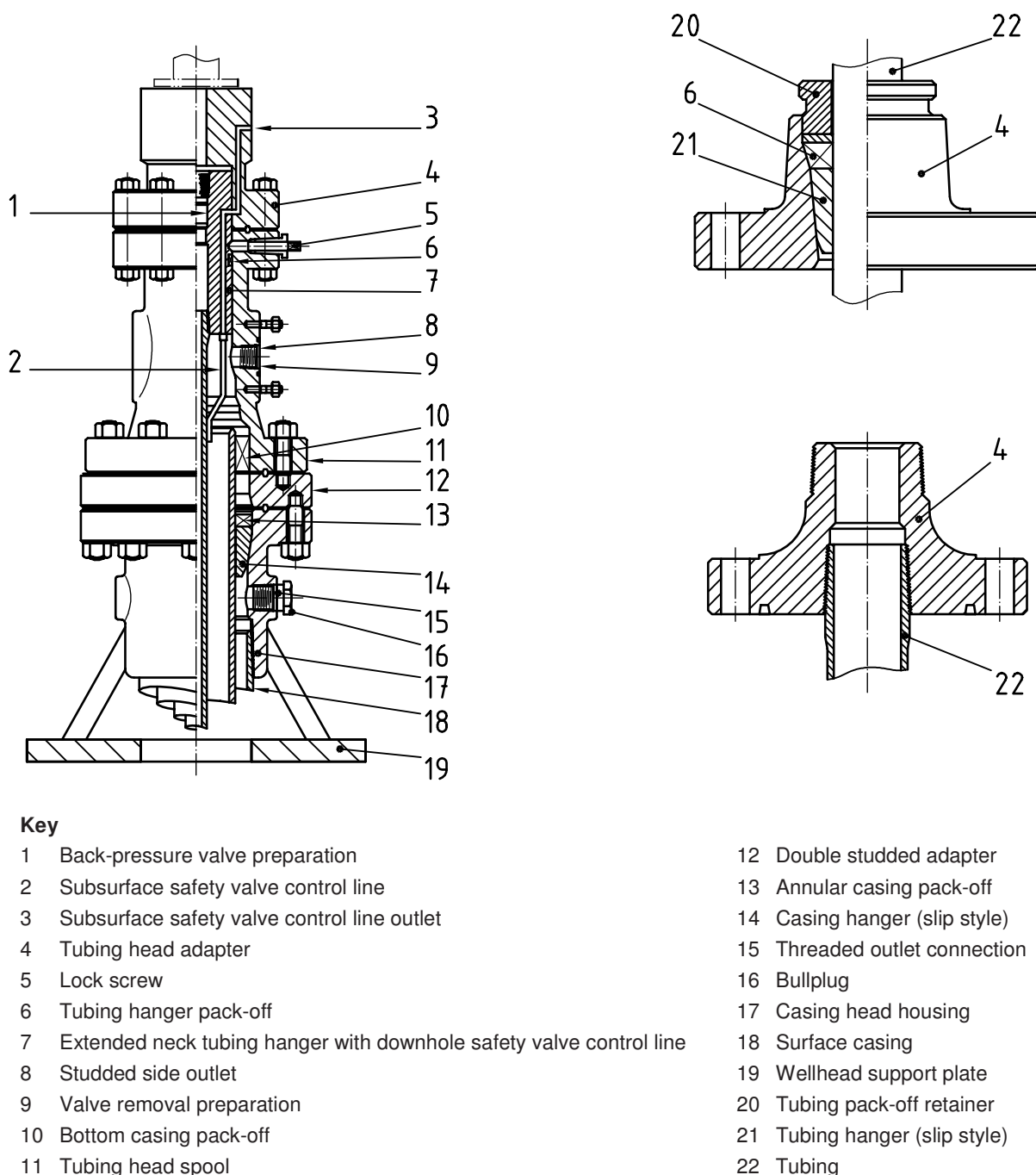
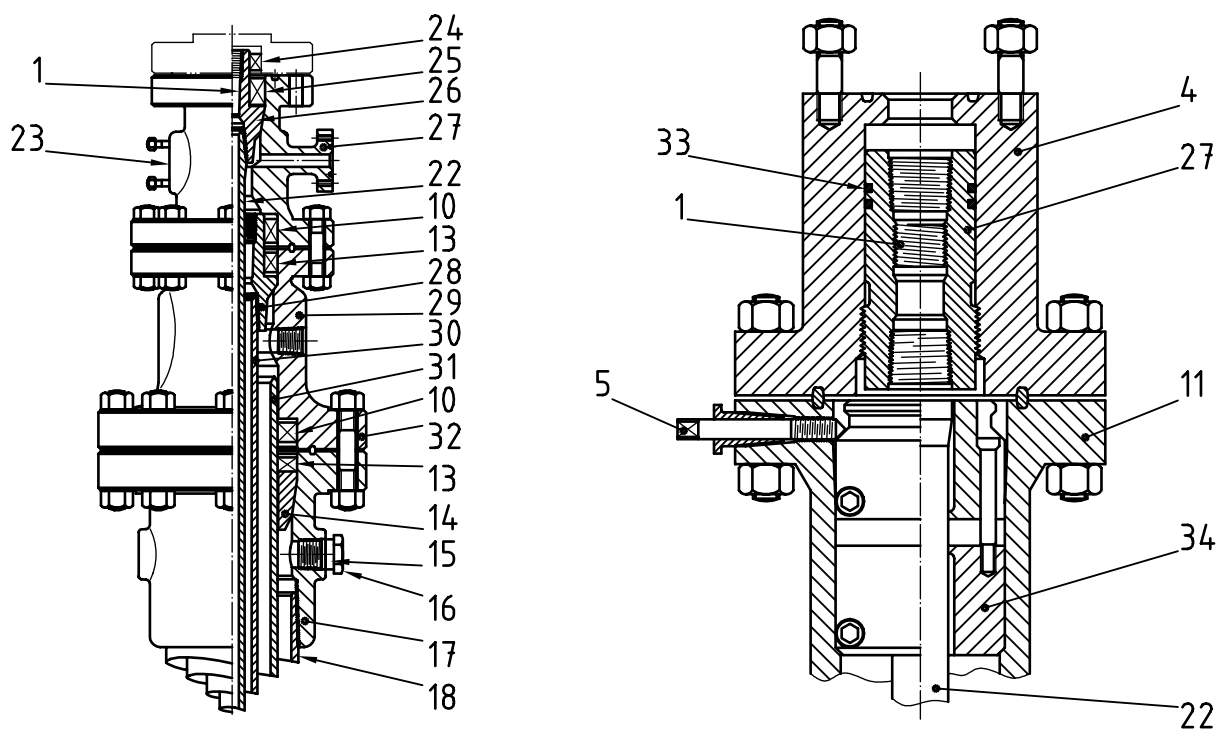


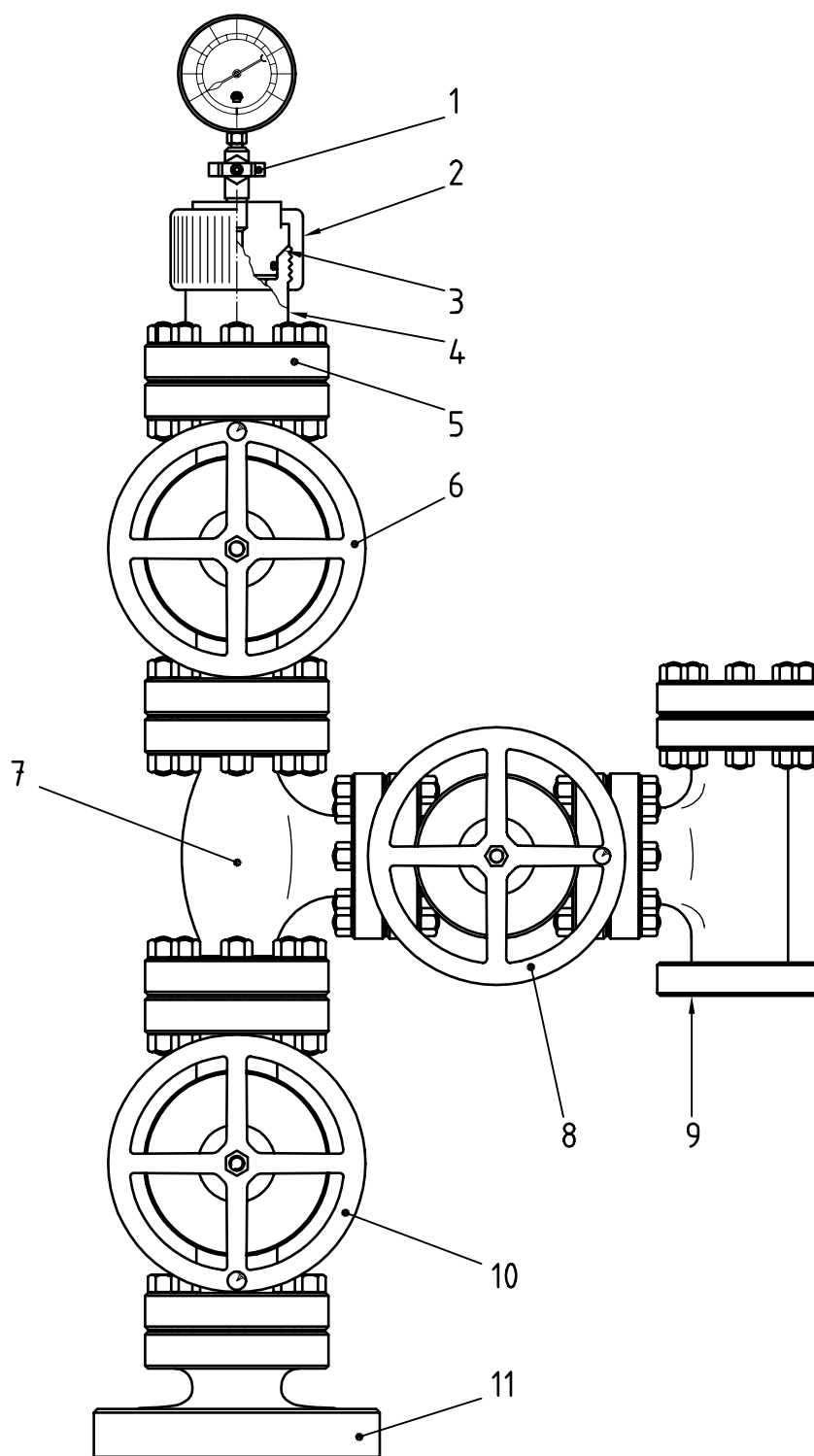
Figure 1 — Typical wellhead assembly nomenclature



Key

- | | |
|-------------------------------------|--------------------------------|
| 23 Studded side outlet connection | 29 Casing head spool |
| 24 Extended neck tubing hanger seal | 30 Inner casing |
| 25 Annular tubing hanger seal | 31 Intermediate casing |
| 26 Tubing hanger mandrel | 32 Flanged end connection |
| 27 Flanged outlet connection | 33 Tubing hanger mandrel seals |
| 28 Casing hanger mandrel | 34 Wrap-around hanger pack-off |

Figure 1 — Typical wellhead assembly nomenclature *(continued)*



Key

- | | |
|-----------------------|------------------------|
| 1 Gauge valve | 7 Tee |
| 2 Bonnet nut | 8 Wing valve |
| 3 Blanking plug | 9 Choke |
| 4 Body | 10 Master valve |
| 5 Top connector | 11 Tubing head adapter |
| 6 Swab or crown valve | |

Figure 2 — Typical christmas tree nomenclature

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 2859-1:1999, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*.

ISO 10414-1, *Petroleum and natural gas industries — Field testing of drilling and completion fluids and well cement — Part 1: Water-based fluids*.

ISO 10422, *Petroleum and natural gas industries — Threading, gauging, and thread inspection of casing, tubing and line pipe threads — Specification*.

ISO 11960, *Petroleum and natural gas industries — Steel pipes for use as casing or tubing for wells*.

ISO 13533, *Petroleum and natural gas industries — Drilling and production equipment — Specification for drill-through equipment*.

ISO 13628-4, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 4: Subsea wellhead and tree equipment*.

ISO 13678, *Petroleum and natural gas industries — Evaluation and testing of thread compounds for use with casing, tubing and line pipe*.

API¹⁾ Spec 7:1997, *Specification for rotary drill stem elements*.

API RP 14F, *Recommended practice for design and installation of electrical systems for offshore fixed and floating production facilities for unclassified and class 1, division 1 and division 2 locations*.

ASME²⁾ B1.1, *Unified inch screw threads*.

ASME B1.2, *Gages and gaging for unified inch screw threads*.

ASME B1.20.1, *Pipe threads, general purpose (inch)*.

ASME Boiler and Pressure Vessel Code:1998, Section V, *Non destructive examination*.

ASME Boiler and Pressure Vessel Code:1998, Section VIII, Division 1, *Rules for construction of pressure vessels*.

ASME Boiler and Pressure Vessel Code:1998, Section VIII, Division 2, *Alternative rules for construction of pressure vessels*.

ASME Boiler and Pressure Vessel Code:1998, Section IX, *Welding and brazing qualifications*.

ASNT³⁾ SNT-TC-1A, *Personnel qualifications and certification in non destructive testing*.

1) American Petroleum Institute, 1220 L Street North West, Washington, D.C. 20005, USA.

2) ASME International, 345 East 47th Street New York, NY 10017-2392, USA.

3) American Society for Non destructive Testing, 4153 Arlingate Plaza, Columbus, OH 43228-0518, USA.

ASTM⁴⁾ A 193/A 193 M, *Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.*

ASTM A 194/A 194M, *Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both.*

ASTM A 320/A 320M, *Standard Specification for Alloy/Steel Bolting Materials for Low-Temperature Service.*

ASTM A 370, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products.*

ASTM A 388/A 388M, *Standard Practice for Ultrasonic Examination of Heavy Steel Forgings.*

ASTM A 453/A 453 M, *Standard Specification for High-Temperature Bolting Materials, With Expansion Coefficients Comparable to Austenitic Stainless Steels.*

ASTM A 703/A 703M:1999, *Standard Specification for Steel Castings, General Requirements, for Pressure-Containing Parts.*

ASTM D 395, *Standard Test Methods for Rubber Property — Compression Set.*

ASTM D 412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers — Tension.*

ASTM D 471, *Standard Test Method for Rubber Property — Effect of Liquids.*

ASTM D 1414, *Standard Test Methods for Rubber O-Rings.*

ASTM D 1415, *Standard Test Method for Rubber Property — International Hardness.*

ASTM D 1418, *Standard Practice for Rubber and Rubber Latices — Nomenclature.*

ASTM D 2240, *Standard Test Method for Rubber Property — Durometer Hardness.*

ASTM E 10, *Standard Test Method for Brinell Hardness of Metallic Materials.*

ASTM E 18, *Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials.*

ASTM E 92, *Standard Test Method for Vickers Hardness of Metallic Materials.*

ASTM E 94, *Standard Guide for Radiographic Examination.*

ASTM E 140, *Standard Hardness Conversion Tables for Metals, (Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Rockwell Superficial Hardness, Knoop Hardness and Scleroscope Hardness).*

ASTM E 165, *Standard Test Method for Liquid Penetrant Examination.*

ASTM E 428, *Standard Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Inspection.*

ASTM E 709, *Standard Guide for Magnetic Particle Examination.*

ASTM E 747, *Standard Practice for Design, Manufacture and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiology.*

4) American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-11887, USA.

EN⁵⁾ 473, *Qualification and certification of NDT personnel — General principles.*

MSS⁶⁾ SP-55, *Quality standard for steel castings for valves, flanges and fittings and other piping components, visual method for evaluation of surface irregularities.*

NACE⁷⁾ MR 0175:1999, *Standard material requirements — Sulfide stress cracking resistant metallic materials for oilfield equipment.*

SAE⁸⁾ AS 568A:1974, *Aerospace size standard for O-rings.*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1.1

acceptance criteria

defined limits placed on characteristics of materials, products or services

3.1.2

accessible wetted surface

wetted surface which can be viewed, for purposes of non-destructive examination, by direct line of sight

NOTE This excludes test ports, control line ports, lockdown screw holes and other penetrations of these types.

3.1.3

actuator

mechanism for the remote or automatic operation of a valve or choke

3.1.4

adapter

pressure-containing piece of equipment having end connections of different nominal sizes and/or pressure ratings, used to connect other pieces of equipment of different nominal sizes and/or pressure ratings

3.1.5

annular packoff

mechanism that seals off annular pressure between the outside diameter of a suspended tubular member or hanger and the inside diameter of the head or spool through which the tubular member passes or hanger is suspended

3.1.6

as-shipped condition

condition of the product or equipment when it is ready for shipment

3.1.7

back-pressure valve

unidirectional or bidirectional check valve that is installed through the christmas tree, into the tubing hanger, and prevents well fluids from flowing out of the well

5) European Committee for Standardization, rue de Stassart 36, Brussels B-1050, Belgium.

6) Manufacturers Standardization Society of the Valve & Fittings Industry, 127 Park Street, N.E., Vienna, VA 22180, USA.

7) NACE, P.O. Box 218340, Houston, TX 77218, USA.

8) SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, USA.

3.1.8**body**

any portion of wellhead and christmas tree equipment between end connections, with or without internal parts, which contains well-bore pressure

3.1.9**bolting closure**

threaded fastener used to assemble well-bore pressure-containing parts or join end or outlet connections

EXAMPLES Studs, nuts, bolts and capscrews.

3.1.10**exposed bolting**

bolting that is exposed directly to the sour environment or that is buried, insulated, equipped with flange protectors, or otherwise denied direct atmospheric exposure

3.1.11**non-exposed bolting**

bolting that is not directly exposed to sour environments and is not intended to be buried, insulated, equipped with flange protectors, or otherwise denied direct atmospheric exposure

3.1.12**bonnet**

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

3.1.13**bottom casing packoff**

mechanism that seals off annular pressure between the outside diameter of a suspended tubular member or hanger and the inside diameter of the spool or tubing head adapter placed over the suspended tubular or hanger

3.1.14**bullplug**

pressure-containing closure for a female threaded end or outlet connection, which may have an internal counter bore and/or test port

3.1.15**calibration**

comparison and adjustment to a standard of known accuracy

3.1.16**carbon steel**

alloy of carbon and iron containing a maximum of 2 % carbon (mass fraction), 1,65 % manganese (mass fraction), and residual quantities of other elements, except those intentionally added in specific quantities for deoxidation (usually silicon and/or aluminium)

3.1.17**casing**

pipe run from the surface and intended to line the walls of a drilled hole

3.1.18**casing hanger mandrel**

mechanism used to support a casing string in a casing head by means of a male or female thread attached to the casing

3.1.19**slip-type casing hanger**

mechanism used to support a casing string in a casing head by gripping the pipe with wedge-type members

3.1.20**casing head housing**

equipment attached to the uppermost end of the surface casing which serves to suspend and seal a casing string

3.1.21

casing head spool

equipment attached to another casing head which serves to suspend and seal a secondary casing string

3.1.22

casting, noun

object at or near finished shape obtained by solidification of a fluid substance in a mould

NOTE HIP components are not considered to be a casting.

3.1.23

chemical analysis

determination of the chemical composition of material

3.1.24

choke

equipment used to restrict and control the flow of fluids

3.1.25

choke bean

flow bean

replaceable orifice part used in positive chokes to control flowrate

3.1.26

choke trim

pressure-controlling choke component, including choke beans, used to control or regulate the flow of fluids

NOTE One-piece stems, and that segment of multi-piece stems that passes through the pressure boundary, are pressure-containing components.

3.1.27

christmas tree

assembly of equipment, including tubing head adapters, valves, tees, crosses, top connectors and chokes attached to the uppermost connection of the tubing head, used to control well production

3.1.28

conformance

compliance with specified requirements

3.1.29

loose connector

connector, as-manufactured, not intended to be made integral with another piece of wellhead and christmas tree equipment

EXAMPLE There are blind, threaded, spacer, welding neck, flanged, studded, or other loose connectors.

3.1.30

corrosion-resistant alloy

CRA

nonferrous-based alloy in which any one or the sum of the specified amount of the elements titanium, nickel, cobalt, chromium, and molybdenum exceeds 50 % (mass fraction)

3.1.31

corrosion-resistant ring grooves

ring grooves lined with metal resistant to metal-loss corrosion

NOTE This metal is either a CRA or an austenitic stainless steel.

3.1.32

cross

pressure-containing fitting with a minimum of four openings

3.1.33**cross-over connector**

adapter with a restricted-area sealing means and with a top-connection pressure rating above that of the lower connection

3.1.34**cross-over flange**

double- or single-studded adapter flange with a restricted-area sealing means and with a top-connection pressure rating above that of the lower connection

3.1.35**cross-over spool**

flanged or other connected equipment with a restricted-area sealing means, at or near the face of its lower flange

NOTE Cross-over spools are also provided with suitable means to suspend and seal around an inner string of casing or tubing. A cross-over spool has a top connection with a pressure rating above that of the lower connection.

3.1.36**date of manufacture**

date of manufacturer's final acceptance of finished equipment

3.1.37**date of repair/remanufacture**

date of repairer's/remanufacturer's final acceptance of finished equipment

3.1.38**dynamic seal**

seal in which motion exists relative to the sealing surface after installation

3.1.39**end connection****outlet connection**

integral male or female thread; hub end connector and flange, studded or through-bolted, or any other means used to join together equipment that contains or controls pressure

3.1.40**equipment**

any item or assembled equipment to which this International Standard is applicable

3.1.41**equivalent round****ER**

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

3.1.42**fit**

geometric relationship between parts

NOTE This includes the tolerance criteria used during the design of a part and its mating part.

3.1.43**flange**

protruding rim with holes to accept bolts and having a sealing mechanism used to join pressure-containing equipment, with dimensions specified in this International Standard

3.1.43.1**blind flange**

flange with no centre bore, used to close off completely a flanged end or outlet connection

3.1.43.2

loose flange

flange, as-manufactured, not intended to be made integral with equipment compliant to this International Standard

EXAMPLES Types of flanges include blind, threaded, spacer, welding neck, studded or other connected adapter flanges.

3.1.43.3

threaded flange

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

3.1.43.4

welding neck flange

flange with a neck on the side opposite the sealing face prepared with a bevel to weld to corresponding pipe or transition pieces

3.1.44

forging, noun

shaped metal part formed by the forging method

3.1.45

forge, verb

deform metal plastically into desired shapes with compressive force

NOTE Forging is usually a hot process. Use of dies is optional.

3.1.46

form

essential shape of a product including all its component parts

3.1.47

function

operation of a product during service

3.1.48

gauge and test port connection

hole drilled and tapped into wellhead and christmas tree equipment through which internal pressure may be measured or through which pressure may be applied to test the sealing mechanisms

3.1.49

hanger mandrel

portion of a casing or tubing hanger which is attached by a threaded connection to the tubular string and forms the upper end of that tubular string

3.1.50

heat-affected zone

HAZ

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

3.1.51

heat

cast lot

material originating from a final melt

NOTE For remelted alloys, a heat is the raw material originating from a single remelted ingot.

3.1.52**heat-sensitive lock-open device**

device installed on a surface safety valve (SSV) actuator to maintain the SSV valve in a full open position until exposed to sufficient heat to cause the device to release and allow the SSV valve to close

3.1.53**heat treat lot**

〈batch furnaces〉 material placed on loading or carry devices and moved as a batch through one heat treat cycle

3.1.54**heat treat lot**

〈continuous furnaces〉 group of pieces of material with the same nominal size that is moved sequentially through the heat treatment process using the same process parameters

3.1.55**heat treatment****heat treating**

alternating steps of controlled heating and cooling of materials for the purpose of changing physical or mechanical properties

3.1.56**hold period**

period of time that the product is subjected to pressure and isolated from the pressure source

3.1.57**hot isostatic pressing****HIP**

special forming process used to compact and metallurgically bond metal powder

NOTE This process takes place within a flexible, metal container whose contents are formed into the desired shape by subjecting the container to high temperature and pressure in an autoclave. It produces a fully wrought structure.

3.1.58**hot-work**

deform metal plastically at a temperature above the recrystallization temperature

3.1.59**hub**

protruding rim with an external angled shoulder and a sealing mechanism used to join pressure-containing equipment

3.1.60**job lot traceability**

ability for parts to be traced as originating from a job lot which identifies the included heat(s)

3.1.61**linear indication**

surface NDE indication whose length is equal to or greater than three times its width

3.1.62**lock screw****tie-down screw**

threaded pin extending through the wall of a casing head or tubing head connection used to lock down hangers or energize seals

3.1.63**low-alloy steel**

steel containing less than 5 % (mass fraction) total alloying elements, but more than that specified for carbon steel

NOTE Steels with less than 11 % chromium (mass fraction) are included in this category.

3.1.64

make-and-break, verb

connect and disconnect a connection

3.1.65

manufacturing operation

activity involving, but not limited to the machining, welding, heat treating or other processes utilized to produce a finished product

3.1.66

material performance basis

capabilities which must be demonstrated, as a minimum, for material to satisfy the criteria of this International Standard

3.1.67

multistage cross-over spool

flanged or other connected equipment with more than one restricted-area sealing means to provide suitable capability to suspend and seal around multiple inner strings of casing or tubing at several stages

NOTE A multistage cross-over spool may have a top connector with a pressure rating above that of the lower connector.

3.1.68

objective evidence

documented field experience, test data, publications, finite element analysis or calculations that verify performance characteristics, as applicable

3.1.69

part

individual piece used in the assembly of single equipment units

EXAMPLES Body, bonnet, gate, stud, handwheel, etc., are parts of a valve. A part may also be a piece not in finished form.

3.1.70

post-weld heat treatment

any heat treatment subsequent to welding, including stress relief

3.1.71

pressure-boundary penetration

device which penetrates directly into or communicates with the wellbore and is not defined elsewhere in this International Standard

EXAMPLES Grease or sealant injection fitting; check valve; control, test or gauge port plug and fitting, needle valve on test, gauge or injection port; electric and control line penetration.

3.1.72

pressure-containing part

part whose failure to function as intended would result in a release of retained fluid to the atmosphere

EXAMPLES Bodies, bonnets and stems.

3.1.73

pressure-controlling part

part intended to control or regulate the movement of pressurized fluids

EXAMPLES Valve bore sealing mechanisms, choke trim and hangers.

3.1.74

pressure integrity

structural and leak-resistant capability of a product to contain applied pressure

3.1.75**pressure vessel quality**

metallic material specified for pressure-containing or pressure-controlling parts conforming to the applicable product specification level requirement

3.1.76**primary equipment**

pieces of equipment that cannot normally be isolated from well fluid or well pressure

3.1.77**qualified personnel**

individual with characteristics or abilities gained through training, experience, or both, as measured against the established requirements of the manufacturer/purchaser/this International Standard

3.1.78**rated working pressure**

maximum internal pressure that the equipment is designed to contain and/or control

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

3.1.79**records**

retrievable information

3.1.80**relevant indication**

surface NDE indication with major dimensions greater than 1,6 mm ($\frac{1}{16}$ in)

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

EXAMPLES Magnetic permeability variations, non-metallic stringers.

3.1.81**remanufacture**

activity involving disassembly, reassembly and testing of wellhead and christmas tree equipment, with or without the replacement of parts, where machining, welding, heat treating or other manufacturing operations are employed

NOTE Remanufacture does not include the replacement of bodies.

3.1.82**repair**

activity involving disassembly, reassembly and testing of wellhead and christmas tree equipment with or without the replacement of parts

NOTE Repair does not include machining, welding, heat treating, other manufacturing operations or the replacement of bodies.

3.1.83**repair level**

level to which equipment will be repaired or remanufactured in compliance with this International Standard

3.1.84**repairer/remanufacturer**

principal agent in the repair and remanufacture of wellhead and christmas tree equipment who chooses to be in compliance with this International Standard

3.1.85**replacement part**

part used to repair/remanufacture a piece of equipment that meets the wellhead and christmas tree requirement for the applicable repair/remanufacture level

3.1.86

restricted-area sealing means

restricted-area pack-off

packoff or other device used to isolate an area at higher pressure from one at lower pressure

NOTE This device serves to limit pressure-induced loads on connectors or areas of a lower pressure rating. It may also be a seal which encloses a pressure-containment area smaller than the adjacent ring gasket or connector seal.

3.1.87

retained fluid

actual fluid produced by a well or injected into a well

3.1.88

room temperature

any temperature between 4 °C and 50 °C (40 °F and 120 °F)

3.1.89

rounded indication

surface NDE indication which is circular or elliptical, having a length less than 3 times its width

3.1.90

running tool

tool used to run, retrieve, position or connect wellhead equipment remotely from the drill floor

3.1.91

secondary equipment

piece of equipment that can normally be isolated from the well fluid or well pressure

3.1.92

serialization

assignment of a unique code to individual parts and/or pieces of equipment to maintain records

3.1.93

spacer

pressure-containing piece of equipment used to connect and provide separation between other pieces of equipment

3.1.94

specified material

material meeting a particular performance requirement(s) as specified by a manufacturer or industry standard

3.1.95

stainless steel

steel containing more than 11 % chromium (mass fraction) to render the steel corrosion-resistant

NOTE Other elements may be added to secure special properties.

3.1.96

static seal

seal in which no motion exists relative to sealing surfaces after installation

3.1.97

stress-corrosion cracking

cracking which results from a combination of corrosion and stress

3.1.98

stress relief

controlled heating of material to a predetermined temperature for the purpose of reducing any residual stresses after welding

3.1.99**studded-flange connection**

flanged end or outlet connection in which thread-anchored studs screwed into tapped holes replace the holes for bolt studs

3.1.100**substantive change**

change identified by the manufacturer which affects the performance of the product in the intended service

3.1.101**sulfide-stress cracking**

cracking of metallic materials due to exposure to fluid containing hydrogen sulfide

3.1.102**surface safety valve****SSV**

automatic wellhead valve assembly which closes upon loss of power supply

NOTE Where used in this International Standard, the term is understood to include an SSV valve and SSV actuator.

3.1.103**SSV actuator****underwater safety valve actuator****USV actuator**

device which causes the SSV/USV valve to open when power is supplied and to close automatically when power is lost or released

3.1.104**SSV valve****USV valve**

portion of the SSV/USV which contains the wellstream and shuts off flow when closed

3.1.105**tee**

pressure-containing fitting with three openings

NOTE Two openings opposite one another form the run portion of the tee, and one opening is at 90° to the line of the run. Tees may be equipped with threads, flanges, studs or other end connectors.

3.1.106**test tool**

tool used to run into the wellhead in order to perform a pressure test

3.1.107**top connector****bottom hole test adapter**

uppermost fitting of a christmas tree which allows full-bore access to the christmas tree

3.1.108**thread protector**

cap or insert used to protect threads and seals during handling, transportation and storage

3.1.109**tubing**

pipe placed within a well to conduct fluid from the well's producing formation into the christmas tree or to conduct kill or treatment fluids in a well

NOTE Tubing is distinguished from casing as being retrievable during the life of the well.

3.1.110

tubing hanger mandrel

mechanism used to support a tubing string in a tubing head by means of a male or female thread attached to the tubing

3.1.111

tubing head adapter

equipment which adapts the uppermost connection of a tubing head to the lowermost valve of the christmas tree

3.1.112

tubing head spool

piece of equipment attached to the uppermost casing head or smallest casing string which serves to suspend the tubing and to seal the annular space between the tubing and casing

3.1.113

underwater safety valve

USV

automatic valve assembly (installed at an underwater wellhead location) which will close upon loss of power supply

NOTE Where used in this International Standard, the term is understood to include a USV valve and USV actuator.

3.1.114

valve-bore sealing mechanism

internal valve parts which close off the flow through the valve bore

EXAMPLES Gates, balls, plugs, poppets, flappers and their respective seats.

3.1.115

check valve

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

3.1.116

full-bore valve

valve whose closure mechanism has the same bore dimension as the valve body

3.1.117

gate valve

valve assembly with a gate operating within the body, 90° to the conduit, to effect a closure

3.1.118

master valve

lowermost valve on the vertical bore of the christmas tree

NOTE It is used to completely shut in the well.

3.1.119

plug valve

valve assembly with a plug permanently mounted across the conduit so that, when rotated 90°, it effects a closure

EXAMPLES Plugs may be straight, tapered, ball, etc.

3.1.120

reduced-opening valve

valve with either a regular or Venturi-type opening, either circular or non-circular, through the closure mechanism

3.1.121

swab valve

crown valve

uppermost valve on the vertical bore of the christmas tree above the flowline outlet

3.1.122**Venturi valve**

valve with a reduced opening, in which the transformation from the full-opening ends to the reduced-closure area is well streamlined to reduce pressure loss

3.1.123**wing valve**

valve located on the christmas tree, but not in the vertical run, which can be used to shut off well flow

3.1.124**valve-removal plug**

threaded plug which can be installed in the wellhead to enable gate valve removal under pressure

3.1.125**visual examination**

examination of parts and equipment for visible defects in material and workmanship

3.1.126**volumetric non-destructive examination****volumetric NDE**

examination for internal material defects by methods such as radiography and/or ultrasonic testing

3.1.127**wear bushing**

retrievable cylindrical device which protects the internal surfaces of wellhead equipment and the top of the last casing suspended

3.1.128**fabrication weld**

weld joining two or more parts

3.1.129**non-pressure-containing weld**

weld whose absence does not reduce the pressure-containing integrity of the part

3.1.130**pressure-containing weld**

weld whose absence reduces the pressure-containing integrity of the part

3.1.131**weld groove**

area between two metals to be joined that has been prepared to receive weld-filler metal

3.1.132**weld joint**

fitting together of components in order to facilitate joining by welding

3.1.133**welding**

fusion of materials, with or without the addition of filler materials

3.1.134**wellhead**

all permanent equipment between the uppermost portion of the surface casing and the tubing head adapter connection

3.1.135**wetted surface**

any surface which has contact with pressurized well fluid, either by design or because of internal seal leakage

3.1.136

wrought products

products shaped by means of forging or hot isostatic pressing

3.1.137

wrought structure

structure that contains no cast dendritic elements

3.1.138

yield strength

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

NOTE All yield strengths specified in this International Standard are the 0,2 % yield offset strength in accordance with ASTM A370.

3.2 Abbreviated terms

For the purposes of this International Standard, the following abbreviated terms apply.

AQL	acceptable quality level
CRA	corrosion-resistant alloy
DAC	distance amplitude curve
ER	equivalent round
FEA	finite element analysis
HAZ	heat-affected zone
HBW	Brinell hardness
HIP	hot isostatic pressing
HRB	Rockwell hardness scale B
HRC	Rockwell hardness scale C
NDE	non-destructive examination
NPT	national pipe thread
OEC	other end connection
OEM	original equipment manufacturer
PQR	procedure qualification record
PR	performance requirement
PSL	product specification level
QTC	qualification test coupon
r.m.s.	root mean square
RL	repair/remanufacture level
R_m	ultimate tensile strength
ROE	radius of exposure
SSV	surface safety valve
TC	test coupon
UNS	unified numbering system
USV	underwater safety valve
WPQ	welder performance qualification
WPS	welding procedure specification

4 Design and performance — General requirements

4.1 Performance requirements — General

Performance requirements are specific and unique to the product in the as-shipped condition. All products shall be designed to perform according to the requirements of this clause and clause 10 while in the pressure and temperature ranges and used with the test fluids consistent with the material class in Table 3 for which they are rated. Other requirements include load capability, cycles, and operating force or torque. There are two performance requirement levels: PR1 and PR2. Valves operating as safety valves shall be of the PR2 performance level and meet the requirements of annex I.

4.2 Service conditions

4.2.1 Pressure ratings

4.2.1.1 General

Equipment shall be designed to operate at only the following maximum rated working pressures:

MPa	psi
13,8	2 000
20,7	3 000
34,5	5 000
69,0	10 000
103,5	15 000
138,0	20 000

4.2.1.2 Threaded equipment limitations

Equipment designed with internal threaded end and outlet connections shall be limited to the thread sizes and rated working pressures in Table 1. Ratings do not include tubing and casing hangers.

4.2.1.3 Design considerations

The design shall take into account the effects of pressure containment and other pressure-induced loads. Special conditions shall also be considered, such as pressure rating changes in cross-over connectors and pressurizing with temporary test plugs. The effects of external loads (i.e. bending moments, tensions, etc.) on the assembly of components are not explicitly addressed by this International Standard (see clause A.2).

Table 1 — Pressure ratings for internal threaded end or outlet connections

Type of thread	Nominal pipe size in	Size OD mm	Rated working pressure	
			MPa	psi
Line-pipe/NPT (nominal sizes)	$\frac{1}{2}$	21,3	69,0	10 000
	$\frac{3}{4}$ to 2	26,7 to 60,3	34,5	5 000
	$2\frac{1}{2}$ to 6	73,0 to 168,3	20,7	3 000
Tubing , non-upset, and external upset round thread	1,050 to $4\frac{1}{2}$	26,7 to 114,3	34,5	5 000
Casing (8 round, buttress, and extreme line)	$4\frac{1}{2}$ to $10\frac{3}{4}$	114,3 to 273,1	34,5	5 000
	$11\frac{3}{4}$ to $13\frac{3}{8}$	298,5 to 339,7	20,7	3 000
	16 to 20	406,4 to 508,0	13,8	2 000

4.2.2 Temperature ratings

4.2.2.1 General

Equipment shall be designed to operate in one or more of the specified temperature ratings with minimum and maximum temperatures as shown in Table 2.

Minimum temperature is the lowest ambient temperature to which the equipment may be subjected. Maximum temperature is the highest temperature of the fluid that may directly contact the equipment.

4.2.2.2 Design considerations

The design shall consider the effects of differential thermal expansion from temperature changes and temperature gradients which the equipment would experience in service. Design for high temperature rating, e.g. X and Y, shall take into consideration the effects of temperature on strength levels, see annex G for guidelines.

4.2.2.3 Temperature rating considerations

Choosing the temperature rating is the ultimate responsibility of the user. In making these selections, the user should consider the temperature the equipment would experience in drilling and/or production services.

Table 2 — Temperature ratings

Temperature classification	Operating range			
	°C		°F	
	min.	max.	min.	max.
K	– 60	82	– 75	180
L	– 46	82	– 50	180
P	– 29	82	– 20	180
R	Room temperature		Room temperature	
S	– 18	66	0	150
T	– 18	82	0	180
U	– 18	121	0	250
V	2	121	35	250

4.2.3 Material class ratings

4.2.3.1 General

Equipment shall be designed with materials, including metallics, which meet requirements set forth in Table 3. Table 3 does not define either the present or the future wellhead environment, but provides material classes for increasing levels of severity of service conditions and relative corrosivity.

Provided the mechanical properties can be met, stainless steels may be used in place of carbon and low-alloy steels and corrosion-resistant alloys may be used in place of stainless steels.

4.2.3.2 Material classes

Choosing material classes is the ultimate responsibility of the user. In making these selections, the user should consider the various environmental factors and production variables listed in annex A.

Table 3 — Material requirements

Material class	Minimum material requirements	
	Body, bonnet, end and outlet connections	Pressure-controlling parts, stems and mandrel hangers
AA — General service	Carbon or low-alloy steel	Carbon or low-alloy steel
BB — General service	Carbon or low-alloy steel	Stainless steel
CC — General service	Stainless steel	Stainless steel
DD — Sour service ^a	Carbon or low-alloy steel ^b	Carbon or low-alloy steel ^b
EE — Sour service ^a	Carbon or low-alloy steel ^b	Stainless steel ^b
FF — Sour service ^a	Stainless steel ^b	Stainless steel ^b
HH — Sour service ^a	CRAs ^b	CRAs ^b
^a As defined by NACE MR 0175. ^b In compliance with NACE MR 0175.		

4.3 Design methods

4.3.1 Connections

4.3.1.1 Flanges

Flanges specified in this International Standard have been designed in accordance with design criteria and methods originally developed by API.

4.3.1.2 Hub and outlet end connections

Design of end and outlet hub connections (16B and 16BX) used on equipment specified in this International Standard shall conform to the material and dimensional requirements of ISO 13533.

4.3.1.3 Clamps

Clamps meeting the requirements of ISO 13533 are acceptable for installation on equipment specified in this International Standard with integral hubs meeting the requirements of ISO 13533.

4.3.2 Casing hangers, tubing hangers, back-pressure valves, lock screws and stems

Casing hangers, tubing hangers, back-pressure valves, lock screws and stems shall be designed to satisfy the manufacturer's documented performance characteristics and service conditions as in 4.2. The manufacturer shall specify methods to be used in design which are consistent with accepted engineering practices.

4.3.3 Other end connectors, bodies and bonnets

4.3.3.1 General

Other end connectors, bodies and bonnets that utilize standard materials (in designs other than those specified in this International Standard) shall be designed in accordance with one or more of the following methods. Standard materials are those materials whose properties meet or exceed the requirements of Table 5.

Other end connectors, bodies and bonnets that utilize non-standard materials shall be designed in accordance with the requirements of 4.3.3.6. Non-standard materials are materials with specified minimum yield strength in excess of 517 MPa (75 000 psi) that do not meet the ductility requirements of Table 5 for standard 75K materials.

In the event stress levels calculated by the methods in 4.3.3.2 to 4.3.3.6 exceed the allowable stresses, other methods identified by the manufacturer shall be used to justify these stresses. Fatigue analysis and localized bearing stress values are beyond the scope of this International Standard.

4.3.3.2 ASME method

The design methodology as described in ASME, Section VIII, Division 2, Appendix 4, may be used for design calculations for pressure-containing equipment. Design-allowable stresses shall be limited by the following criteria:

$$S_T = 0,83 S_Y \text{ and } S_m = 2 \frac{S_Y}{3}$$

where

S_m = design stress intensity at rated working pressure;

S_T = maximum allowable general primary membrane stress intensity at hydrostatic test pressure;

S_Y = material specified minimum yield strength.

4.3.3.3 Theory of constant energy of distortion

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

$$S_E = S_Y$$

where

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

S_Y is the material-specified minimum yield strength.

4.3.3.4 Experimental stress analysis

Experimental stress analysis as described in ASME, Section VIII, Division 2, Appendix 6 may be used as an alternative method to those described in 4.3.3.2 and 4.3.3.3.

4.3.3.5 Design qualification by proof test

4.3.3.5.1 General

As an alternative to the analytical methods above, the pressure rating of equipment may be determined by the use of a hydrostatic test at elevated pressure. A test vessel, or vessel part, is made from the equipment for which the maximum allowable working pressure is to be established. It shall not previously have been subjected to a pressure greater than 1,5 times the desired or anticipated maximum allowable working pressure.

4.3.3.5.2 Determination of yield strength

a) Method

The yield strength of the material in the part tested shall be determined in accordance with the method prescribed in the applicable material specification.

b) Specimen preparation

Yield strength so determined shall be the average from three or four specimens cut from the part tested after the test is completed. The specimens shall be cut from a location where the stress during the test has not exceeded the yield strength. The specimens shall not be flame-cut because this might affect the strength of the material.

c) Alternative specimens

If excess stock from the same piece of material is available and has been given the same heat treatment as the pressure part, the test specimens may be cut from this excess stock. The specimen shall not be removed by flame cutting or any other method involving sufficient heat to affect the properties of the specimen.

d) Exemption

If yield strength is not determined by test specimens, an alternative method is given in 4.3.3.5.3 for evaluation of proof test results to establish the maximum allowable working pressure.

4.3.3.5.3 Test procedure

a) Instrumentation

Measure strains in the direction of the maximum stress as close as practical to the most highly stressed locations by means of strain gauges of any type capable of indicating strains to 50 microstrain (0,005 %) (0,000 05 in/in). The manufacturer shall document the procedure used to determine the location or locations at which strain is to be measured, and the means to compensate for temperature and hydrostatic pressure imposed on the gauges.

b) Application of pressure

Gradually increase the hydrostatic pressure in the vessel or vessel part, until approximately one-half the anticipated working pressure is reached. Thereafter, increase the test pressure in steps of approximately one-tenth or less of the rated working pressure until the pressure required by the test procedure is reached.

c) Observations

After each increment of pressure has been applied, take and record readings of the strain gauges and the hydrostatic pressure. Then release the pressure and determine any permanent strain at each gauge after any pressure increment that indicates an increase in strain for this increment over the previous equal pressure increment. Only one application of each increment of pressure is required.

d) Records

Plot two curves of strain against test pressure for each gauge line as the test progresses, one showing the strain under pressure and one showing the permanent strain when the pressure is removed. The test may be discontinued when the test pressure reaches the value H which will, by the formula, justify the desired working pressure, but shall not exceed the pressure at which the plotted points for the most highly strained gauge line reach 0,2 % strain.

e) Resulting rating

Compute the maximum allowable working pressure p for parts tested under this subclause by one of the following equations.

If the average yield strength is determined in accordance with 4.3.3.5.2:

$$p = 0,5H (S_Y/S_A)$$

If the actual average yield strength is not determined by test specimens:

$$p = 0,4H$$

where

H is the hydrostatic test pressure at which this test was stopped, in accordance with 4.3.3.5.3 b);

S_Y is the material-specified minimum yield strength;

S_A is the actual average yield strength from test specimens.

4.3.3.6 Non-standard materials design requirements

The design methodology as described in ASME, Section VIII, Division 2, Appendix 4, shall be used for design and calculations for pressure-containing equipment utilizing non-standard materials. Design allowable stresses shall be limited by the following criteria:

S_T = the smaller of $\frac{5}{6} S_Y$ or $\frac{2}{3} R_{m, \min.}$

S_m = the smaller of $\frac{2}{3} S_Y$ or $\frac{1}{2} R_{m, \min.}$

S_S = the smaller of $2 S_Y$ or $R_{m, \min.}$

where

S_m is the design stress intensity at rated working pressure;

S_S is the maximum combined primary and secondary stress intensity;

S_T is the maximum allowable general primary membrane stress intensity at hydrostatic test pressure;

$R_{m, \min.}$ is the material-specified minimum ultimate tensile strength;

S_Y is the material-specified minimum yield strength.

4.3.4 Closure bolting

The maximum allowable tensile stress for closure bolting shall be determined considering initial bolt-up, rated working pressure and hydrostatic test pressure conditions. Bolting stresses, based on the root area of the thread, shall not exceed the following limit:

$$S_A = 0,83 S_Y$$

where

S_A is the maximum allowable tensile stress;

S_Y is the bolting material-specified minimum yield strength.

Bolting stresses shall be determined considering all loading on the closure, including pressure acting over the seal area, gasket loads and any additional mechanical and thermal loads.

4.3.5 Other parts

All other pressure-containing parts and all pressure-controlling parts shall be designed to satisfy the manufacturer's documented performance characteristics and the service conditions in 4.2. The manufacturer shall specify methods to be used in design which are consistent with accepted engineering practices.

4.3.6 Specific equipment

Equipment-specific requirements are specified in clause 10.

4.4 Miscellaneous design information

4.4.1 General

End and outlet connections shall be an integral part of the body or attached by welding which meets the requirements of clause 6. PSL 4 equipment design shall not utilize fabrication welding.

4.4.2 Tolerances

Unless otherwise specified in the appropriate table or figure, the following tolerances shall apply:

Metric		Inch	
Dimension	Tolerance mm	Dimension	Tolerance in
x,x	$\pm 0,5$	x,xx	$\pm 0,02$
x,xx	$\pm 0,13$	x,xxx	$\pm 0,005$

4.4.3 Bolting

4.4.3.1 End and outlet bolting

a) Hole alignment

End and outlet bolt holes for flanges shall be equally spaced and shall straddle common centrelines.

b) Stud thread engagement

Stud thread engagement length into the body for studed flanges shall be a minimum of one times the outside diameter of the stud.

4.4.3.2 Other bolting

The stud thread anchoring means shall be designed to sustain a tensile load equivalent to the load which can be transferred to the stud through a fully engaged nut.

4.4.4 Test, vent, injection and gauge connections

4.4.4.1 Sealing

All test, vent, injection and gauge connections shall provide a leaktight seal at the hydrostatic test pressure of the equipment in which they are installed.

4.4.4.2 Test and gauge connection ports

a) 69,0 MPa (10 000 psi) and below

Test and gauge connection ports for 69,0 MPa (10 000 psi) working pressure and below shall be internally threaded in conformance with the methods specified in 10.2 and shall not be less than 12 mm ($1/2$ in) nominal size. High-pressure connections as described in 4.4.4.2 b) may also be used.

- b) 103,5 MPa and 138,0 MPa (15 000 psi and 20 000 psi)

Test and gauge connections for 103,5 MPa and 138,0 MPa (15 000 psi and 20 000 psi) working pressure shall be in accordance with 10.11.

4.4.4.3 Vent and injection ports

Vent and injection ports shall meet the requirements of the manufacturer's specifications.

4.5 Design documentation

Documentation of designs shall include methods, assumptions, calculations and design requirements. Design requirements shall include, but not be limited to, those criteria for size, test and operating pressures, material, environmental and other pertinent requirements upon which the design is to be based. Design documentation media shall be clear, legible, reproducible and retrievable. Design documentation shall be retained for 5 years after the last unit of that model, size and rated working pressure is manufactured.

4.6 Design review

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

4.7 Design verification

Manufacturers shall document their design verification procedures and the results of performance verification of designs. The performance verification procedures including acceptance criteria for SSVs and USVs are given in annex I. Additional verification procedures, including acceptance criteria, are given in annex F to be used if specified by the manufacturer or purchaser.

5 Materials — General requirements

5.1 General

This clause describes the material performance, processing and compositional requirements for bodies, bonnets, end and outlet connections, hub end connectors, hangers, back-pressure valves, bullplugs, valve-removal plugs, wear bushings, pressure-boundary penetrations and ring gaskets. Other pressure-containing and pressure-controlling parts shall be made of materials that satisfy 5.2 and the design requirements of clause 4.

All material requirements in this clause apply to carbon steels, low-alloy steels and martensitic stainless steels (other than precipitation-hardening types). Other alloy systems (including precipitation-hardening stainless steels) may be used provided they satisfy the requirements of this clause and the design requirements of clause 4.

Materials for actuators are specified in 10.16.4.

5.2 Written specifications

5.2.1 General

All metallic and non-metallic pressure-containing or pressure-controlling parts shall require a written material specification.

5.2.2 Metallic requirements

The manufacturer's written specified requirements for metallic materials for bodies, bonnets, end and outlet connections, stems, valve bore sealing mechanisms, back-pressure valves, bullplugs and valve-removal plugs and mandrel hangers shall define the following along with accept/reject criteria:

a) For PSL 1:

- mechanical property requirements;
- material qualification;
- heat-treatment procedure including cycle time, quenching practice and temperatures with tolerances and cooling media;
- material composition with tolerances;
- NDE requirements.

b) For PSL 2 to PSL 4:

The requirements for PSL 2 to PSL 4 are identical to the requirements for PSL 1. In addition:

- allowable melting practice(s);
- forming practice(s), including hot-working and cold-working practices;
- heat-treating equipment calibration.

5.2.3 Non-metallic requirements

Non-metallic pressure-containing or pressure-controlling seals shall have written material specifications. The manufacturer's written specified requirement for non-metallic materials shall define the following:

- generic base polymer(s) — ASTM D 1418;
- physical property requirements;
- material qualification (shall meet the equipment class requirement);
- storage and age-control requirements.

5.3 Mandrel tubing and casing hangers

5.3.1 Material

All mandrel tubing and casing hangers shall be fabricated from materials which meet the applicable property requirements specified by the manufacturer.

a) PSL 1 requirements:

- tensile testing;
- hardness testing.

b) PSL 2 to PSL 4 requirements:

The requirements for PSL 2 to PSL 4 are identical to the requirements for PSL 1. In addition:

- impact requirements.

5.3.2 Processing

5.3.2.1 Casting practices

a) PSL 1 requirements

All castings used for hanger mandrels shall meet applicable requirements of clause 5 and clause 7.

b) PSL 2 requirements

The requirements for PSL 2 are identical to the requirements for PSL 1. In addition the manufacturer shall document foundry practices which establish limits for sand control, core making, rigging, melting, heat treatment and NDE to ensure repeatability in providing castings which meet the requirements of this International Standard.

c) PSL 3 and 4

Wrought products shall be used.

5.3.2.2 Hot-working practices

a) PSL 1 requirements

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

b) PSL 2 to PSL 4 requirements

The requirements for PSL 2 to PSL 4 are identical to the requirements for PSL 1. In addition the manufacturer shall document hot-working practices.

5.3.2.3 Melting practices

a) PSL 1 to PSL 3 requirements

The manufacturer shall specify the melting practices for all hanger mandrel materials.

b) PSL 4 requirements

The requirements for PSL 4 are identical to the requirements for PSL 1 to PSL 3. In addition the manufacturer shall document the melting practice utilized for PSL 4 material.

5.3.3 Heat-treating

5.3.3.1 Equipment qualification

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

5.3.3.2 Temperatures

a) PSL 1 to PSL 3 requirements

Time at temperature and thermal cycles shall comply with the manufacturer's heat-treatment specifications.

b) PSL 4 requirements

The requirements for PSL 4 are identical to the requirements for PSL 1 to PSL 3. In addition the temperature levels for PSL 4 parts shall be determined by using a heat sink.

The heat sink shall be made of the same class of material when the components are made of an alloy of the following classes: carbon steel, alloy steel, stainless steel, titanium-base alloys, nickel-copper alloys and nickel-base alloys. For components which do not meet one of the preceding classes, the heat sink shall be made from the same alloy as the component. The equivalent round (ER) section of all heat sinks shall be determined in accordance with the methods of 5.7.2. The ER of the heat sink shall be greater than or equal to the largest ER of any part in a heat treatment load.

As an alternative, a production part may serve as the heat sink provided all the requirements of this subclause are satisfied. The temperature-sensing tip of the thermocouple shall be within the part or heat sink, and be no closer than 25 mm (1 in) from any external or internal surface.

5.3.3.3 Quenching — PSL 2 to PSL 4 requirements (for materials that are quenched and tempered)

a) Water quenching

The temperature of the water or quench media used to approximate the cooling rate of water shall not exceed 40 °C (100 °F) at the start of the quench. For bath-type quenching, the temperature of the water or quench media shall not exceed 50 °C (120 °F) at the completion of the quench.

b) Other quenching media

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

5.3.4 PSL 2 to PSL 4 chemical composition

Hanger mandrel materials shall conform to the manufacturer's written specification.

The manufacturer shall specify the nominal chemical composition, including the composition tolerances, of the material.

Material composition shall be determined on a heat basis (or a remelt ingot basis for remelt grade materials) in accordance with a nationally or internationally recognized standard specified by the manufacturer.

5.3.5 Material qualification testing — PSL 2 to PSL 4 requirements

5.3.5.1 General

If minimum tensile and/or impact properties are required in order for material to be qualified for service, the tests shall be performed as described in 5.3.5.2 and 5.3.5.3:

A qualification test coupon (QTC) as described in 5.7 shall be used.

5.3.5.2 Tensile testing

a) Test specimens

Tensile test specimens shall be removed from a QTC as described in 5.7.4.1.

b) Test method

Perform tensile tests at room temperature in accordance with the procedures specified in ASTM A 370.

Perform a minimum of one tensile test. The results of the tensile test(s) shall satisfy the manufacturer's specified requirements.

c) Retesting

If the results of the tensile test(s) do not satisfy the applicable requirements, two additional tests on two additional test specimens (removed from the same QTC with no additional heat treatment) may be performed in an effort to qualify the material. The results of each of these tests shall satisfy the applicable requirements.

5.3.5.3 Impact testing

a) Test specimens

Impact test specimens shall be removed from a QTC as described in 5.7.4.1.

b) Test method

Perform impact tests in accordance with the procedures specified in ASTM A370 using the Charpy V-notch technique.

In order to qualify a material for temperature rating, perform the impact tests at or below the lowest temperature of that classification range.

Test a minimum of three impact specimens to qualify a heat of material. Impact properties as determined from these tests shall satisfy the manufacturer's specified requirements.

c) Retesting

If a test fails, then a retest of three additional specimens (removed from typically the same location within the same QTC with no additional heat treatment) may be made, each of which shall exhibit an impact value equal to or exceeding the required minimum average value.

5.4 Bodies, bonnets, end and outlet connections

5.4.1 Material

a) Tensile property requirements

All bodies, bonnets, end and outlet connections shall be fabricated from standard or non-standard materials as specified in Table 4. Standard materials shall meet the applicable properties shown in Table 5. Non-standard material shall conform to the manufacturer's written specification. The specification shall include minimum requirements for tensile strength, yield strength, elongation, reduction of area, toughness and hardness applicable for the specific alloy. All non-standard materials shall exceed a 75K minimum yield strength and meet a minimum of 15 % elongation and 20 % reduction of area.

b) Impact toughness requirements

Impact toughness shall conform to the requirements of Table 6.

If sub-size specimens are used, the Charpy V-notch impact requirements shall be equal to that of the 10 mm × 10 mm specimens multiplied by the adjustment factor listed in Table 7. Sub-size specimens shall not be used for PSL 4.

Table 4 — Standard material applications for bodies, bonnets and end and outlet connections

Part	Pressure ratings					
	MPa (psi)					
	13,8 (2 000)	20,7 (3 000)	34,5 (5 000)	69,0 (10 000)	103,5 (15 000)	138,0 (20 000)
	Material designation					
Body,^a bonnet	36K, 45K 60K, 75K NS ^b	36K, 45K 60K, 75K NS	36K, 45K 60K, 75K NS	36K, 45K 60K, 75K NS	45K, 60K 75K, NS	60K, 75K NS
Integral end connection						
Flanged	60K, 75K NS	60K, 75K NS	60K, 75K NS	60K, 75K NS	75K, NS	75K, NS
Threaded	60K, 75K NS	60K, 75K NS	60K, 75K NS	NA	NA	NA
Other ^c	c	c	c	c	c	c
Loose connectors						
Welding neck	45K	45K	45K	60K, 75K NS	75K, NS	75K, NS
Blind	60K, 75K NS	60K, 75K NS	60K, 75K NS	60K, 75K NS	75K, NS	75K, NS
Threaded	60K, 75K NS	60K, 75K NS	60K, 75K NS	NA	NA	NA
Other	c	c	c	c	c	c

^a If end connections are of the material designation indicated, welding is in accordance with clause 6 and design is in accordance with clause 4.

^b NS indicates non-standard materials as defined in 4.3.3 and 5.4.1.a.

^c As specified by manufacturer.

Table 5 — Standard material property requirements for bodies, bonnets and end and outlet connections

Material designation	0,2 % Yield strength min. MPa (psi)	Tensile strength min. MPa (psi)	Elongation in 50 mm (2 in) min. %	Reduction in area min. %
36K	248 (36 000)	483 (70 000)	21	No requirement
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)	17	35

Table 6 — Charpy V-notch impact requirements (10 mm × 10 mm)

Temperature		Minimum average impact value Transverse direction J (ft-lbf)		
Temperature classification	Test temperature °C (°F)	PSL 1	PSL 2	PSL 3 and PSL 4
K	− 60 (− 75)	20 (15)	20 (15)	20 (15)
L	− 46 (− 50)	20 (15)	20 (15)	20 (15)
P	− 29 (− 20)	—	20 (15)	20 (15)
R	− 18 (0)	—	—	20 (15)
S	− 18 (0)	—	—	20 (15)
T	− 18 (0)	—	—	20 (15)
U	− 18 (0)	—	—	20 (15)
V	− 18 (0)	—	—	20 (15)

Table 7 — Adjustment factors for sub-size impact specimens (PSL 1-3)

Specimen dimension	Adjustment factor
10 mm × 7,5 mm	0,833
10 mm × 5,0 mm	0,667
10 mm × 2,5 mm	0,333

5.4.2 Material qualification testing

5.4.2.1 General

If minimum tensile and/or impact properties are required in order for material to be qualified for service, the required tests shall be performed on specimens from a TC or QTC as applicable.

a) PSL 1 requirements:

An acceptable TC as described in 5.6 or a QTC as described in 5.7 shall be used to qualify material.

b) PSL 2 to PSL 4 requirements:

A QTC as described in 5.7 shall be used.

5.4.2.2 PSL 1 tensile testing

a) Test specimens

Tensile-test specimens shall be removed from a TC as described in 5.6 or 5.7 as applicable. This TC shall be used to qualify a heat and the bodies, bonnets, and end and outlet connections produced from that heat.

b) Test method

Perform tensile tests at room temperature in accordance with the procedures specified in ASTM A 370.

Perform a minimum of one tensile test. The results of the tensile test(s) shall satisfy the applicable requirements of Table 5.

c) Retesting

If the results of the tensile test(s) do not satisfy the applicable requirements, two additional tests on two additional test specimens (removed from the same TC or QTC with no additional heat treatment) may be performed in an effort to qualify the material. The results of each of these tests shall satisfy the applicable requirements.

5.4.2.3 PSL 2 to PSL 4 tensile testing

a) Test specimens

Tensile test specimens shall be removed from a QTC as described in 5.7.

b) Test method

Perform tensile tests at room temperature in accordance with the procedures specified in ASTM A 370.

Perform a minimum of one tensile test. The results of the tensile test(s) shall satisfy the applicable requirements of Table 5.

c) Retesting

If the results of the tensile test(s) do not satisfy the applicable requirements, two additional tests on two additional test specimens (removed from the same QTC with no additional heat treatment) may be performed in an effort to qualify the material. The results of each of these tests shall satisfy the applicable requirements.

5.4.2.4 PSL 1 to PSL 4 impact testing

a) Sampling

Impact tests shall be performed on a heat of material if a body, bonnet, or end and outlet connection produced from that heat requires testing.

b) Test specimens

Impact-test specimens shall be removed from a test coupon as described in 5.6 or 5.7 as applicable. This test coupon shall be used to qualify a heat and the bodies, bonnets, and end and outlet connections produced from that heat.

c) Test method

Perform impact tests in accordance with the procedures specified in ASTM A 370 using the Charpy V-notch technique.

In order to qualify material for a temperature rating, perform the impact tests at or below the lowest temperature of that classification range.

Test a minimum of three impact specimens to qualify a heat of material. Impact properties as determined from these tests shall satisfy the applicable requirements of Table 6. In no case shall an individual impact value fall below two-thirds of that required as a minimum average. Similarly, no more than one of the three test results shall be below the required minimum average.

d) PSL 1 to PSL 4 retest

If a test fails, then a retest of three additional specimens removed from the same QTC (or TC for PSL 1 components) with no additional heat treatment may be made, each of which shall exhibit an impact value equal to or exceeding the required minimum average value.

e) Specimen orientation

The values listed in Table 6 are the minimum acceptable values for wrought products tested in the transverse direction and for castings and weld qualifications. Wrought products may be tested in the longitudinal direction instead of the transverse direction and then shall exhibit 27 J (20 ft-lbf) minimum average value.

5.4.3 Processing

5.4.3.1 Casting practices

a) PSL 1 requirements

All castings used for bodies, bonnets end and outlet connections shall meet applicable requirements of clause 5 and clause 7.

b) PSL 2 requirements

The requirements for PSL 2 are identical to the requirements for PSL 1. In addition the manufacturer shall document foundry practices which establish limits for sand control, core-making, rigging, melting and heat treatment and NDE to ensure repeatability in producing castings which meet the requirements of this International Standard.

c) PSL 3 and PSL 4 requirements

Wrought products shall be used.

5.4.3.2 Hot-working practices

a) PSL 1 requirements

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

b) PSL 2 to PSL 4 requirements

The requirements for PSL 2 to PSL 4 are identical to the requirements for PSL 1. In addition the manufacturer shall document hot working practices.

5.4.3.3 Melting practices

a) PSL 1 to PSL 3 requirements

The manufacturer shall specify melting practices.

b) PSL 4 requirements

The requirements for PSL 4 are identical to the requirements for PSL 1 to PSL 3. In addition the manufacturer shall document the melting practice utilized for PSL 4 material.

5.4.4 Heat treating

5.4.4.1 Equipment qualification

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

5.4.4.2 Temperatures

a) PSL 1 to PSL 3 requirements

Time at temperature and thermal cycles shall comply with the manufacturer's heat-treatment specifications.

b) PSL 4 requirements

The requirements of PSL 1 to PSL 3 shall also apply. Temperature levels for PSL 4 parts shall be determined by using a heat sink.

The heat sink shall be made of the same class of material if the components are made of an alloy of the following classes: carbon steel, alloy steel, stainless steel, titanium-base alloy, nickel-copper alloys and nickel-base alloys. For components which do not meet one of the preceding classes, the heat sink shall be made from the same alloy as the component. The ER section of all heat sinks shall be determined in accordance with the methods of 5.7.2. The ER of the heat sink shall be greater than or equal to the largest ER of any single part in a heat treatment load.

As an alternative, a production part may serve as the heat sink provided all the requirements of this subclause are satisfied. The temperature-sensing tip of the thermocouple shall be within the part or heat sink, and be no closer than 25 mm (1 in) to any external or internal surface.

5.4.4.3 Quenching — PSL 2 to PSL 4 requirements (for quenched and tempered materials)

a) Water quenching

The temperature of the water or quench media used to approximate the cooling rate of water shall not exceed 40 °C (100 °F) at the start of the quench. For bath-type quenching, the temperature of the water or quench media shall not exceed 50 °C (120 °F) at the completion of the quench.

b) Other quenching media

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

5.4.5 Chemical composition

5.4.5.1 General

Material shall conform to the manufacturer's written specification.

- a) The manufacturer shall specify the nominal chemical composition, including composition tolerances, of material.
- b) Material composition shall be determined on a heat basis (or a remelt ingot basis for remelt grade materials) in accordance with a nationally or internationally recognized standard.

5.4.5.2 Composition limits

Tables 8 and 9 list element limits (% mass fraction) for carbon, low-alloy and martensitic stainless steels (other than precipitation-hardening types) required to manufacture bodies, bonnets and end outlet connections. If the composition is specified by reference to a recognized industry standard, those elements specified as residual/trace elements need not be reported, provided the residual/trace element limits of the industry standard are within the limits of this International Standard. Table 8 and Table 9 do not apply to other alloy systems. Composition limits of other alloy systems are purposely omitted from these tables in order to provide the manufacturer with freedom to utilize alloy systems for the multiplicity of requirements encountered.

Table 8 — Steel composition limits for bodies, bonnets and end and outlet connections materials (% mass fraction) (PSL 2 to PSL 4)

Alloying element	Carbon and low-alloy steels composition limits	Martensitic stainless steels composition limits	45K material for welding neck flanges composition limits ^a
Carbon	0,45 max.	0,15 max.	0,35 max.
Manganese	1,80 max.	1,00 max.	1,05 max.
Silicon	1,00 max.	1,50 max.	1,35 max.
Phosphorus	(See Table 9)	(See Table 9)	0,05 max.
Sulfur	(See Table 9)	(See Table 9)	0,05 max.
Nickel	1,00 max.	4,50 max.	NA
Chromium	2,75 max.	11,0–14,0	NA
Molybdenum	1,50 max.	1,00 max.	NA
Vanadium	0,30 max.	NA	NA

^a For each reduction of 0,01 % below the specified carbon maximum (0,35 %), an increase of 0,06 % manganese above the specified maximum (1,05 %) is permitted up to a maximum of 1,35 %.

Table 9 — Phosphorus and sulfur concentration limits (% mass fraction) (PSL 2 to PSL 4)

	PSL 2	PSL 3 and PSL 4
Phosphorus	0,040 max.	0,025 max.
Sulfur	0,040 max.	0,025 max.

5.4.5.3 Tolerance ranges

Table 10 lists, for PSL 3 and PSL 4 only, the tolerance range requirements for elements used in the composition of materials as described by the manufacturer's specification. These tolerances only apply to the materials covered by Table 8.

If the manufacturer specifies a material for PSL 3 or 4 with chemical composition requirements by reference to a recognized industry standard, the material shall meet the tolerance ranges of the referenced industry standard. If the manufacturer specifies a material chemistry not covered by a recognized industry standard, the tolerance ranges shall meet Table 10. These tolerances only apply to the materials covered in Table 8.

Table 10 — Alloying element maximum tolerance range requirements (% mass fraction) (PSL 3 and PSL 4)

Elements	Carbon and low-alloy steel	Martensitic stainless steels	45K material for welding neck flanges
Carbon	0,08	0,08	NA
Manganese	0,40	0,40	NA
Silicon	0,30	0,35	NA
Nickel	0,50	1,00	NA
Chromium	0,50	NA	NA
Molybdenum	0,20	0,20	NA
Vanadium	0,10	0,10	NA
These values are the total allowable variation in any one element and shall not exceed the maximum specified in Table 8.			