

Specification for Marine Drilling Riser Equipment

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Specification for Marine Drilling Riser Equipment

1 Scope

This specification establishes standards of performance and quality for the design, manufacture, and fabrication of marine drilling riser equipment used in conjunction with a subsea blowout preventer (BOP) stack.

This specification provides the requirements for the following major subsystems in the marine drilling riser system:

- riser tensioner equipment;
- flex/ball joints;
- choke, kill, and auxiliary lines;
- drape hoses and jumper lines for flex/ball joints;
- telescopic joint (slip joint) and tensioner ring;
- riser joints;
- buoyancy equipment;
- riser running equipment;
- special riser system components;
- lower riser adapter;
- riser coupling.

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 Technical Report 5C3, *Technical Report on Equations and Calculations for Casing, Tubing, and Line Pipe Used As Casing or Tubing; and Performance Properties Tables for Casing and Tubing*

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

API Specification 5L, *Specification for Line Pipe*

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

API Standard 6ACRA, *Age-hardened Nickel-based Alloys for Oil and Gas Drilling and Production Equipment*

API Specification 7K, *Drilling and Well Servicing Equipment*

API Specification 8C, *Drilling and Production Hoisting Equipment (PSL 1 and PSL 2)*

API Specification 9A, *Specification for Wire Rope*

API Recommended Practice 9B, *Application, Care, and Use of Wire Rope for Oil Field Service*

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

API Specification 16C, *Choke and Kill Equipment*

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

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

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

AISC 360 ¹, *Specification for Structural Steel Buildings—Allowable Stress Design and Plastic Design*, 1989 Edition

ASME B31.3 ², *Process Piping*

ASME Boiler and Pressure Vessel Code (BPVC), *Section V: Nondestructive Examination*, 2010

ASME Boiler and Pressure Vessel Code (BPVC), *Section V, Subsection A, Article 6 and Subsection B*, 2010

ASME Boiler and Pressure Vessel Code (BPVC), *Section V, Subsection A, Article 7 and Subsection B*, 2010

ASME Boiler and Pressure Vessel Code (BPVC), *Section V, Subsection A, Article 9*, 2010

ASME Boiler and Pressure Vessel Code (BPVC), *Section VIII: Rules for Construction of Pressure Vessels; Division 1*

ASME Boiler and Pressure Vessel Code (BPVC), *Section VIII: Rules for Construction of Pressure Vessels; Division 2: Alternative Rules*

ASME Boiler and Pressure Vessel Code (BPVC), *Section IX: Welding, Brazing, and Fusing Qualifications*

ASNT Recommended Practice No. SNT-TC-1A ³, *Personnel Qualification and Certification in Nondestructive Testing*

ASTM A370 ⁴, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A388/A388M, *Standard Practice for Ultrasonic Examination of Steel Forgings*

¹ American Institute of Steel Construction, One East Wacker Drive, Suite 700, Chicago, Illinois 60601, www.aisc.org.

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

³ American Society for Nondestructive Testing, 1711 Arlingate Lane, P.O. Box 28518, Columbus, Ohio 43228, www.asnt.org.

⁴ ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

ASTM A770/A770M, *Standard Specification for Through-Thickness Tension Testing of Steel Plates for Special Applications*

ASTM A923, *Standard Test Methods for Detecting Detrimental Intermetallic Phase in Duplex Austenitic/Ferritic Stainless Steels*

ASTM E562, *Standard Test Method for Determining Volume Fraction by Systematic Manual Point Count*

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

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

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

ASTM E23, *Standard Test Methods for Notched Bar Impact Testing of Metallic Materials*

ASTM E94, *Standard Guide for Radiographic Examination*

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

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

ASTM E384, *Standard Test Method for Microindentation Hardness of Materials*

ASTM E388, *Standard Test Method for Wavelength Accuracy and Spectral Bandwidth of Fluorescence Spectrometers*

ASTM E428, *Standard Practice for Fabrication and Control of Metal, Other than Aluminum, Reference Blocks Used in Ultrasonic Testing*

ASTM E562, *Standard Test Method for Determining Volume Fraction by Systematic Manual Point Count*

ASTM E709, *Standard Guide for Magnetic Particle Testing*

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

AWHEM Technical Report TR1201 ⁵, *Recommendation for Elimination of Lead Filling in Target Flanges*

AWS D1.1 ⁶, *Structural Welding Code, Steel*

IEC 61892 ⁷, *Mobile and fixed offshore units—Electrical installations*

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*

⁵ Association of Well Head Equipment Manufacturers, 1102 Gloucester Lane, Houston, Texas 77073, www.awhem.org.

⁶ American Welding Society, 8669 NW 36 Street, #130, Miami, Florida 33166-6672, www.aws.org.

⁷ International Electrotechnical Commission, 3, rue de Varembé, 1st Floor, PO Box 131, CH-1211, Geneva 20, Switzerland, www.iec.ch.

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

ISO 11120, *Gas cylinders – Refillable seamless steel tubes of water capacity between 150 l and 3000 l – Design, construction and testing*

NACE⁸ MR0175/ISO 15156, *Petroleum, petrochemical, and natural gas industries—Materials for use in H₂S-containing environments in oil and gas production*

NFPA 70⁹, *National Electrical Code*

UL 94¹⁰, *Standard for Safety: Test for Flammability of Plastic Materials for Parts in Devices and Appliances*

SSPC CS 23.00¹¹, *Specification of the Application of Thermal Spray Coatings (Metallizing) of Aluminum, Zinc, and their Alloys and Composites for the Corrosion Protection of Steel*

3 Terms, Definitions, and Abbreviations

3.1 Terms and Definitions

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

3.1.1

accumulator

Pressure vessel charged with gas over liquid and used to store hydraulic fluid under pressure.

3.1.2

actuator

Mechanism for the remote or automatic operation of a valve or choke.

3.1.3

air can buoyancy

Tension applied to the riser string by the net buoyancy of a chamber created by a closed-top, open-bottom cylinder forming an annulus around the outside of the riser pipe that is filled with air or other low-density fluid.

3.1.4

annulus

Space between two pipes, when one pipe is positioned inside the other.

3.1.5

anti-recoil system

Means of limiting the upward acceleration of the riser when a disconnect is made at the riser connector.

3.1.6

auxiliary line

Conduit [excluding choke and kill (C&K) lines] attached to the outside of the riser main tube (e.g. hydraulic supply line, buoyancy control line, mud boost line).

3.1.7

back pressure

Pressure resulting from restriction of fluid flow downstream.

⁸ NACE International, 15835 Park Ten Place, Houston, Texas 77084, www.nace.org.

⁹ National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, www.nfpa.org.

¹⁰ Underwriters Laboratories, 333 Pfingsten Road, North Brook, Illinois 60062, www.ul.com.

¹¹ The Society for Protective Coatings, 40 24th Street, 6th Floor, Pittsburgh, Pennsylvania 15222, www.sspc.org.

3.1.8**ball joint**

Ball and socket assembly allowing rotation between the two halves that may be positioned in the riser string to reduce local bending stresses.

3.1.9**blowout**

Uncontrolled flow of well fluids from the wellbore.

3.1.10**blowout preventer****BOP**

Equipment installed at the wellhead or wellhead assemblies to contain wellbore fluids either in the annular space between the casing and the tubulars or in an open hole during drilling, completion, testing, or workover operations.

3.1.11**blowout preventer, annular type**

Remotely controlled device that can form a seal in the annular space around any object in the wellbore or upon itself.

NOTE Compression of reinforced elastomer packing element by hydraulic pressure effects seal.

3.1.12**bolting**

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

3.1.12.1**class 2 bolting**

Bolting in the riser's primary load path not exposed to subsea environment or any subsea pressure-containing bolting not intended for wellbore fluid containment.

NOTE See Table 2.

3.1.12.2**class 3 bolting**

Subsea bolting in the riser's primary load path or bolting whose failure could result in release of wellbore fluid to the environment.

NOTE Examples include riser coupling bolts, see Table 2.

3.1.12.3**utility bolting**

Bolting required for mounting equipment and accessories to the riser equipment not identified as class 2 or class 3 bolting.

NOTE Examples include bolting on lifting eye, wear bushing, nameplate, clamps for tubing, guards, buoyancy supports, lockdown screws, keeper plate screws, hydraulic cylinders (not in the riser primary load path, whose failure would not result in the release of wellbore fluid to the environment), or not in riser running and handling equipment load path.

3.1.13**BOP stack**

Assembly of well control equipment including BOPs, spools, valves, hydraulic connectors, and nipples that connects to the subsea wellhead.

NOTE Common usage of this term sometimes includes the lower marine riser package (LMRP).

3.1.14**box**

Female member of a riser coupling, C&K line stab assembly, or auxiliary line stab assembly.

3.1.15**buoyancy control line**

Auxiliary line dedicated to controlling, charging, or discharging air can buoyancy chambers.

3.1.16**buoyancy equipment**

Devices added to riser joints to reduce their submerged weight, thereby reducing riser top tension requirements.

NOTE The devices normally used for risers take the form of syntactic foam modules or open-bottom air chambers.

3.1.17**choke and kill line****C&K line**

External conduits arranged around the riser pipe and used for circulation of fluids into and out of the wellbore to control well pressure.

3.1.18**collapse pressure**

External pressure at which a structural member's original shape is permanently altered.

3.1.19**control pod**

Assembly of subsea valves and regulators that operates BOP equipment when activated.

3.1.20**coupling**

Mechanical means for joining two sections of riser pipe in end-to-end engagement.

3.1.21**dehydrogenation heat treatment****DHT**

Activity carried out to diffuse hydrogen and minimize the risk of hydrogen cold cracking in completed or partially completed weld joints prior to the weld joint cooling to ambient temperature.

3.1.22**diverter**

Device attached to the wellhead or marine riser to close the vertical flow path and direct well flow away from the drill floor and rig.

3.1.23**drape hose**

Flexible line connecting a choke, kill, auxiliary, or other line on the riser to the appropriate piping on the rig structure.

NOTE 1 A U-shaped bend in this line allows for relative movement between the vessel and the outer barrel of the telescopic joint as the vessel moves.

NOTE 2 This is sometimes referred to as a “moonpool line.”

3.1.24**drilling fluid**

Water- or oil-based fluid with suspension of clays or solids circulated down the drill pipe into the well and back up to the rig for purposes including containment of formation pressure, the removal of cuttings, bit lubrication and cooling, treating the wall of the well, and providing a source for well data.

NOTE This is also known as “mud.”

3.1.25**factory acceptance testing**

Testing by a manufacturer of a particular product to validate its conformance to the specified performance requirements and ratings.

3.1.26**fleet angle**

Angle between the vertical axis and a riser tensioner line (or hydraulic cylinder rod for direct-acting tensioners) at the point where the line (or rod) connects to the tension ring.

3.1.27**flex joint**

Steel and elastomer assembly allowing rotation between the two halves that may be positioned in the riser string to reduce local bending stresses.

3.1.28**full-length riser joint**

Joint of typical length for a particular drilling vessel's riser storage racks and riser handling capabilities or for a particular riser purchase.

3.1.29**handling tool****running tool**

Device that joins to the upper end of a riser joint to permit the lifting and lowering of the joint and the assembled riser string in the derrick by the elevators.

3.1.30**heat treatment (heat treating)**

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

3.1.31**hydraulic connector**

Mechanical connector that is activated hydraulically and connects the BOP stack to the wellhead or the LMRP to the lower BOP stack.

3.1.32**hydraulic line**

Auxiliary line from the vessel to the subsea BOP stack that supplies control system operating fluid to the LMRP and the BOP stack.

3.1.33**instrumented riser joint**

Riser joint equipped with sensors for monitoring parameters such as tension in the riser pipe wall, riser angular offset, annulus fluid temperature and pressure, etc.

3.1.34**jumper line**

Flexible section of choke, kill, or auxiliary line that provides a continuous flow around a flex/ball joint while accommodating the angular motion at the flex/ball joint.

3.1.35**keel joint**

Riser joint designed to withstand contact between the riser and bottom of the moonpool.

3.1.36**landing joint**

Riser joint temporarily attached above the telescopic joint used to land the BOP stack on the wellhead.

3.1.37**load sharing**

Riser joint design where rated load is distributed between the main tube and one or more of the external lines.

3.1.38**local peak stress**

Highest stress in the region or component under consideration

NOTE The basic characteristic of a peak stress is that it causes no significant distortion and is principally objectionable as a possible initiation site for a fatigue crack. These stresses are highly localized and occur at geometric discontinuities.

3.1.39**lower marine riser package****LMRP**

Upper section of a two-section subsea BOP stack generally including a hydraulic connector; annular BOP; ball/flex joint; riser adapter; jumper lines for the choke, kill, and auxiliary lines; and subsea control pods.

NOTE This interfaces between the lower subsea BOP stack and the drilling riser.

3.1.40**non-load sharing**

Riser joint design where the rated load is carried by the main tube only.

3.1.41**main tube****riser pipe**

Pipe that forms the principal conduit of the riser joint.

NOTE The riser main tube is the conduit for guiding the drill string and containing the return fluid flow from the well.

3.1.42**major weld repair**

Weld whose depth is greater than 25 % of the original wall thickness or 25.4 mm (1 in.), whichever is less.

3.1.43**makeup tool**

Device used to engage and/or preload coupling members.

3.1.44**marine drilling riser**

Tubular conduit serving as an extension of the wellbore from the equipment on the wellhead at the seafloor to a floating drilling rig.

3.1.45**maximum allowable working pressure****MAWP**

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

3.1.46**maximum compression pressure****MCP**

Maximum pressure that a tensioner achieves when fully retracted for wire line tensioners or when fully extended for direct-acting tensioners.

3.1.47**maximum supply pressure****MSP**

Highest pressure that can be supplied to the tensioners at the stroke corresponding to the rated tension.

NOTE See 7.3.1.1 for rated tension.

3.1.48**module**

Individual, serialized piece of buoyancy.

3.1.49**mud boost line**

Auxiliary line that provides supplementary fluid supply from the surface and injects it into the riser near the LMRP to assist in the circulation of drill cuttings up the marine riser.

3.1.50**other end connection****OEC**

Connection that is not specified in an API specification or standard.

NOTE This includes API flanges and hubs with non-API gasket preparations and manufacturer's proprietary connections.

3.1.51**pin**

Male member of a riser coupling or a choke, kill, or auxiliary line stab assembly.

3.1.52**postweld heat treatment****PWHT**

Any heat treatment subsequent to welding, including stress relief.

3.1.53**preload**

Compressive bearing load developed between connections at their interface.

NOTE This is accomplished by elastic deformation during makeup.

3.1.54**pressure-containing component**

Component whose failure to function as intended would cause a release of pressurized fluid to the environment.

3.1.55**primary-load-carrying component**

Component whose failure would compromise the structural integrity of the marine drilling riser system.

NOTE Examples are components that carry all or a major part of the tension in the riser.

3.1.56**protector, box or pin**

Cap or cover used to protect the box or pin from damage during storage and handling.

3.1.57**pup joint**

Riser joint whose length is shorter than a standard-length riser joint.

3.1.58**rated load**

Maximum applied loading condition used for design, analysis, and operation of the equipment.

3.1.59**rated working pressure**

Maximum internal pressure equipment is designed to contain and/or control.

3.1.60**riser primary load path**

The path through which riser tensioning loads pass from and including the lower flex joint to, but exclusive of, the tensioner foundation.

NOTE All components from the lower flex joint to the tensioner foundation through which riser tension loads pass are in the primary load path. Examples of components in the riser primary load path include: flex joints, riser joints, riser coupling, tension ring, riser tensioner assemblies, both direct connect and wire line type, and idler sheaves. The tensioner foundation is not included in this definition.

3.1.61**reference stress**

Stress at the reference section used for determination of SAF.

3.1.62**relevant indication**

Any surface indication (liquid penetration or magnetic particle examination) with a major dimension greater than 1.6 mm (0.062 in.).

NOTE Inherent indication not associated with surface rupture are considered nonrelevant indications.

3.1.63**riser adapter**

Crossover between riser and flex joint, ball joint, or LMRP.

3.1.64**riser annulus**

Space around the pipe (drill pipe, casing, or tubing) suspended in a riser; its outer boundary is the internal surface of the riser pipe.

3.1.65**riser connector****LMRP connector**

Hydraulically operated connector that joins the LMRP to the top of the BOP stack.

3.1.66**riser disconnect**

Operation of unlatching the riser connector to separate the riser and LMRP from the BOP stack.

3.1.67**riser fill-up valve joint**

Special riser joint having a valve that allows the riser annulus to be opened to the sea.

3.1.68**riser joint**

Section of riser main tube having ends fitted with a box and pin and including choke, kill, and (optional) auxiliary lines and their support brackets.

3.1.69**riser spider**

Device that supports the riser string on the uppermost coupling support shoulder during deployment and retrieval.

3.1.70**riser string**

Deployed assembly of riser joints.

3.1.71**riser tensioner**

Means for providing and maintaining top tension on the deployed riser string to prevent buckling.

3.1.72**riser tensioner ring**

Structural interface between the riser string and the riser tensioners.

3.1.73**stabilized (pressure testing)**

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

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

3.1.74**stress amplification factor****SAF**

Ratio of the incremental change of local peak stress (maximum cyclic principal stress) to the corresponding incremental change of the reference stress used for fatigue analysis.

3.1.75**stress load ratio****SLR**

Ratio of the incremental change of local peak stress (maximum cyclic principal stress) to the corresponding incremental change in the global load (tension/compression or bending) used for fatigue analysis.

3.1.76**support brackets**

Brackets positioned at intervals along the riser joint that provide intermediate radial and lateral support from the riser main tube to the choke, kill, and auxiliary lines.

3.1.77**syntactic foam**

Typically a composite material of hollow spherical fillers in a matrix or binder used to build buoyancy modules.

3.1.78**telescopic joint****slip joint**

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

NOTE The inner barrel moves within the outer barrel to compensate for the change in the length of the riser string as the vessel moves.

3.1.79**telescopic joint packer**

Means of sealing the annular space between the inner and outer barrels of the telescopic joint.

3.1.80**terminal fitting**

Connection between a rigid choke, kill, or auxiliary line on a riser string and its drape hose, affecting a nominal 180° turn in flow direction.

3.1.81**thrust collar**

Device for transmitting the buoyancy force of a buoyancy module to the riser joint.

3.1.82**type certification testing**

Testing by a manufacturer of a representative specimen (or prototype) of a product that qualifies the design and, therefore, validates the integrity of other products of the same design and similar size, dimensions, materials, and manufacture.

3.1.83**submerged weight**

Weight minus the buoyancy effects of water.

3.2 Abbreviations and Symbols

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

APV	air pressure vessel
BOP	blowout preventer
C&K	choke and kill
CRA	corrosion-resistant alloy

DAC	distance amplitude curve
DHT	dehydrogenation heat treatment
DSS/SDSS	duplex stainless steel/super duplex stainless steel
EA	tension stiffness
EI	bending stiffness
EOS	equation of state
ER	equivalent round
HRC	Rockwell hardness scale C
HVOF	high-velocity oxygenated fuel
ITP	inspection test plan
LMRP	lower marine riser package
LP	liquid penetrant
MAWP	maximum allowable working pressure
MCP	maximum compression pressure
MP	magnetic particle
MPD	managed pressure drilling
MPS	manufacturing procedure specification
MSP	maximum supply pressure
MTL	maximum tension limit
MTO	metal turnover
NDE	nondestructive examination
OEC	other end connection
OEM	original equipment manufacturer
PQR	procedure qualification record
PQT	procedure qualification trial
PWHT	postweld heat treatment
QTC	qualification test coupon
RH	relative humidity
SAF	stress amplification factor

SLR	stress load ratio
TSA	thermal sprayed aluminum
TSC	thermal sprayed coating
t	weld thickness
WPS	welding procedure specification

4 Design

4.1 General

These design standards shall apply to all riser system components that are in the primary load path during operation, running, and retrieval, including but not limited to riser couplings, riser main tube, riser adapters, riser external lines when used for load sharing, riser tensioner rings, telescopic joints, flex/ball joints, and special riser joints. See Annex B for a discussion of the components in a marine drilling riser system.

NOTE Additional component-specific requirements are found in Sections 7 through 18.

4.2 Service Classifications

The riser manufacturer shall provide the following design information for each riser model.

- Main tube description (outside diameter, wall thickness, corrosion allowance, and material).
- C&K and auxiliary line description (outside diameters, wall thickness, corrosion allowance, and material).
- Rated load of riser components, with non-load-sharing or load-sharing designation.
- When applicable, buoyancy depth rating and thrust loads.
- Coupling description (manufacturer, model, coupling rated load).
- Rated working pressures of main tube, C&K, and auxiliary lines (under zero tension).
- Minimum and maximum temperatures for various riser lines/components.

NOTE Procedures for determining design loads are detailed in API 16Q. Guidelines for care and operation are also given in API 16Q.

4.3 Size and Coupling Model

Riser systems shall be described by the size of the main tube and the manufacturer's coupling model designation. Riser pipe outer diameter, wall thickness, corrosion allowance, and material designations for which the riser system is designed shall be documented. The description shall also include the characteristics of C&K and auxiliary lines (diameters, wall thicknesses, corrosion allowances, and material designations for each).

4.4 Rated Load

The purchaser shall specify the minimum rated load or the minimum performance requirements of the riser system components.

The manufacturer shall establish and document the rated load for each riser component based on the minimum rated load or minimum performance requirements specified by the purchaser.

The rated load shall correspond to the total combined load that may be applied to the component. The total combined load includes the axial tension, bending loads, pressure separation loads, and any applicable preloads applied to the component.

NOTE 1 The rated load for non-load-sharing risers can be specified either as an axisymmetric tension of magnitude or it may be considered to be any combination of tension and bending moment as per Equation (1). For load-sharing riser designs, the bending moment relation deviates from Equation (1).

$$T + \frac{McA}{I} = T + \frac{M32t(D-t)^2}{D^4 - (D-2t)^4} = T + T_{EQ} = T_{DES} \quad (1)$$

where

- T is the tension;
- M is the bending moment;
- A is the main tube cross-sectional area;
- c is the mean radius of main tube;
- I is the moment of inertia of main tube;
- D is the outside diameter of main tube;
- t is the wall thickness of main tube.
- T_{DES} is the axisymmetric tensile load;
- T_{EQ} is the equivalent tension.

Internal pressure, external pressure, and temperature shall be included in the component's rated load.

Additional sources of applied load as described below may significantly affect the riser equipment design and shall be included in the design calculations.

- The manufacturer shall document the loads induced by choke, kill, and auxiliary lines for which the riser has been designed.

NOTE 2 Loads can be induced on the joint from pressure in the lines, from deflections imposed on the lines, and also from differential temperatures in the lines.

- If the riser joints provide support for buoyancy, then the manufacturer shall document the buoyancy thrust loads for which the riser has been designed.
- The manufacturer shall document the riser handling loads for which the riser is designed and how these loads are applied.

The riser system shall be designed to support the rated load and any applicable preloads, while keeping the maximum cross-sectional stresses within specified allowable limits. All components shall meet the stress requirements of Annex C unless otherwise specified in Sections 7 through 18. The manufacturer shall document the procedures used and the results.

NOTE 3 If finite element stress analysis is used, see Annex D.

NOTE 4 The load rating of a riser joint may be less than the coupling rating.

Choke, kill, and riser auxiliary lines shall meet the requirements of this specification, Section 9.

NOTE 5 The moment capacity of the assembled component may have limiting factors other than the main tube stresses; for example, a riser joint may be limited by the tensile stress in choke, kill, or auxiliary lines produced by moment in the joint. As a result, the moment/tension relationship above may not accurately apply beyond a specific maximum combination of loads, as moment may have a disproportionate effect on the riser external lines.

4.5 Pressure Ratings

The manufacturer shall document the rated differential pressure for the riser system component and the tension conditions for which they apply.

4.6 Temperature Criteria

The minimum design temperature for the choke, kill, auxiliary lines, and main tube shall be 0 °C (32 °F) unless the purchaser specifies a lower temperature.

The maximum temperature for design varies for the different lines. The maximum design temperature for the main tube and the C&K lines shall be 82 °C (180 °F) unless the purchaser specifies a higher temperature. The maximum design temperature for all auxiliary lines shall be 57 °C (135 °F) unless the purchaser specifies a higher temperature (see Table 1).

Table 1—Design Temperatures for Various Line Types

Type of Line	Minimum Fluid Temperature	Maximum Fluid Temperature
Main tube	0 °C (32 °F)	82 °C (180 °F)
Choke and kill line	0 °C (32 °F)	82 °C (180 °F)
All auxiliary lines	0 °C (32 °F)	57 °C (135 °F)

4.7 Design of Structures and Lifting Attachments

Lifting attachments and structures (e.g. padeyes, lift points, baskets, etc.) shall be designed to meet the requirements of AISC 360 or other nationally or internationally recognized standard. The AISC 360 increase in allowable stresses for short-term loads shall not be used.

Drilling riser equipment that requires lifting with the rig cranes during the normal course of operations shall be fitted with suitable lifting attachments. The design load for the lifting attachments shall be 2.0 times the static sling load in the direction of the sling plus 10 % of the static sling load applied perpendicular to the face of the attachment at the center of the hole for the shackle pin (parallel to the shackle pin).

4.8 Design Documentation

For each riser system size, design, and service classification, the manufacturer shall retain the following documentation for a minimum of 10 years after the manufacture of the last unit of that size, design, and service classification:

- service classification, design bases, and stress amplification factors (SAFs) or stress load ratios (SLRs) used;
- design loads (tensile, bending, and others);

- c) finite element analysis performed; and
- d) results of tests performed.

5 Materials and Welding Requirements

5.1 General

The material requirements in this specification are not intended to overrule material requirements for equipment covered and manufactured in accordance with other API specifications.

Primary-load-carrying components and/or pressure-containing components shall conform to the material and welding requirements specified by this section. In the case of a conflict between this section and specific equipment requirements elsewhere in this specification, the specific equipment requirements shall apply.

Parts other than primary-load-carrying or pressure-containing components shall be made of materials that satisfy the design requirements of the equipment manufacturer.

Material and welding designed for sour conditions shall meet the applicable requirements of NACE MR0175/ISO 15156.

Material and welding of components designed for use in sour service conditions shall meet the requirements of NACE MR0175/ISO 15156 without the use of the permitted exclusion written for drilling riser systems.

NOTE 1 Typically drilling riser main tube, riser coupling, auxiliary lines, ball or flex joints, and telescopic joints (materials and welding) need not conform to NACE MR0175/ISO 15156, because wellbore fluids are diverted through the C&K lines at the seafloor BOP stack.

NOTE 2 Composite materials are outside the scope of this document.

5.2 Materials Selection

Material selection for primary-load-carrying components and pressure-containing components should include consideration for the type of loading, fatigue and fracture mechanics considerations, temperature range, corrosive conditions, strength requirements, and consequences of failure. These considerations shall be included as part of the design review documentation.

The metallic materials that can be exposed to wellbore fluids in the C&K lines shall meet the requirements for sour service defined in NACE MR0175/ISO 15156.

NOTE 1 Care should be exercised in the selection of materials for applications requiring high strength, corrosion resistance, and resistance to hydrogen embrittlement.

NOTE 2 Some materials have demonstrated a susceptibility to hydrogen embrittlement when exposed to cathodic protection in seawater. Materials that have shown this susceptibility include low-alloy steels, martensitic stainless steels, and more highly alloyed steels having actual yield strengths over 135,000 psi (930.8 MPa) or hardness levels above 34 Rockwell C.

Material selection for nonmetallic (e.g. elastomers and thermoplastics) materials shall include consideration for the type of loading, temperature range, explosive decompression resistance (if appropriate), environmental resistance, strength and ductility requirements, and consequences of failure. These considerations shall be included as part of the design review documentation.

5.3 Written Specifications

All materials (including nonmetallic) shall conform to a written specification. The written specification shall be a nationally or internationally recognized standard, or the manufacturer's document.

Specifications for metallic components used for primary-load-carrying components or pressure-containing components shall, at the minimum contain requirements for the following:

- material chemical composition limits and tolerances;
- forming practices—forging, etc.;
- heat treatment procedures including cycle time and temperature with tolerances, heat-treating equipment, and cooling media;
- nondestructive examination (NDE) requirements;
- mechanical property requirements including yield strength, tensile strength, elongation, reduction of area, hardness range, and impact toughness properties.

Specifications for nonmetallic components used for primary-load-carrying components or pressure-containing components shall define the following:

- material type—base material/polymer;
- service temperature range;
- tensile strength, elongation, and elastic modulus;
- acceptable hardness range—shore, in accordance with ASTM D2240;
- density, compression set, and fluid compatibility;
- fiber reinforcement—type, composition, and properties.

5.4 Metallic Materials

5.4.1 Steels

5.4.1.1 General

Non-primary-load-carrying and non-pressure-containing component materials shall be addressed by the manufacturer written specifications.

All primary-load-carrying and pressure-containing materials shall meet the requirements of 5.4, 5.5, and 5.6. Castings shall not be used for primary-load-carrying components unless otherwise allowed by equipment-specific sections.

Primary-load-carrying and pressure-containing materials shall be tested for chemical composition, tensile properties, impact properties, and hardness, unless explicitly excluded in this section or by the equipment-specific sections. The mechanical properties for these components shall be established by testing from a qualification test coupon (QTC) in accordance with 5.6 of this specification, in its final heat treatment condition.

5.4.1.2 Carbon and Low-alloy Steels

5.4.1.2.1 Chemical Composition

Materials shall conform to the chemical composition specified in the written specification. This specification shall include limits and tolerances on the elements carbon, manganese, phosphorous, sulfur, silicon, and any

other elements added intentionally. Residual elements shall meet the requirements of the written specification. Chemical composition shall be determined on a heat basis in accordance with the written specification.

5.4.1.2.2 Mechanical Properties

Materials shall meet the mechanical properties specified in the manufacturer's written specification.

— *Impact Testing.*

Charpy V-notch impact tests shall be conducted in accordance with ASTM A370, ASTM E23, or equivalent industry standard, using one set of three specimens removed from the QTC in a location as specified by API 16A or equivalent industry recognized specification. Standard size (10 mm × 10 mm) Charpy V-notch specimens shall be used whenever practical.

NOTE Impact energy requirements may be reduced by a factor of 0.833 and 0.667 for $\frac{3}{4}$ size and $\frac{1}{2}$ size specimens, respectively.

When full-size impact specimens are not practical due to size constraints, the subsize specimen shall be tested and meet the criteria per methods defined by ASTM A370.

Impact testing shall be conducted at temperature of $-20\text{ }^{\circ}\text{C}$ ($-4\text{ }^{\circ}\text{F}$) or lower, and no higher than minimum design temperature.

Specimens shall be tested in parallel or transverse to the grain orientation. Specimens tested with orientation transverse to the major grain flow shall exhibit 20 J (15 ft-lb) minimum average value and 14 J (10 ft-lb) for single minimum of a set of three specimens (e.g. transverse on a hollow core or solid forging and radial on a rolled ring). Specimens tested with orientation parallel to major grain flow shall exhibit 27 J (20 ft-lb) minimum average value and 20 J (15 ft-lb) for single minimum of a set of three specimens. The location of the specimen in the QTC shall be in accordance with API 16A, with exception of main tube, which shall conform to API 5L.

— *Hardness.*

Materials shall meet the hardness requirements specified in the manufacturer's written specification

The hardness of components and the QTC shall be determined in accordance with ASTM E10 or ASTM E18 or equivalent recognized standard. A minimum of one hardness test shall be performed on the QTC after the heat treatment cycle [exclusive of postweld heat treatments (PWHTs)]. Conversion of hardness values between test methods shall be in accordance with ASTM E140. The hardness of the QTC and the parts shall conform with the range given by the written specification.

— *Tensile Properties.*

The tensile properties of the materials for all primary-load-carrying and pressure-containing equipment shall be in conformance with the requirements of the written specification chosen for the parts by the manufacturer/purchaser as provided for by 5.3. The material shall meet the requirements for yield strength, ultimate strength, elongation, and when appropriate the reduction of area as required by the design.

Wrought carbon and low-alloy steel such as forgings and bar used for pressure-containing applications shall exhibit a minimum of 35 % reduction of area (excluding plate) and a minimum of 18 % elongation.

The main tube shall meet the requirements of API 5L for PSL 2. Test specimens and test methods shall be in accordance with ASTM A370 or equivalent. Specimen orientation and location shall be in accordance with API 16A or equivalent industry standard. As-heat-treated dimensions shall be used for determining the component thickness.

5.4.1.3 Stainless Steels

5.4.1.3.1 Chemical Composition

All stainless steel materials shall conform to the chemical composition specified in the written specification. This specification shall include limits and tolerances on the elements relevant to the particular grade of stainless steel, and any other elements added intentionally. Residual elements shall meet the requirements of the written specification. Chemical composition shall be determined on a heat basis in accordance with the written specification.

Ferritic-austenitic stainless steel grades shall meet the minimum requirements for pitting-resistance equivalent number (PREN) as specified by NACE MR0175.

5.4.1.3.2 Mechanical Properties

All materials shall meet the minimum mechanical properties specified in the manufacturer's written specification.

The manufacturer shall ensure stainless steels are not adversely affected by deleterious phases that may hinder toughness and corrosion resistance.

— *Impact Testing.*

When required, Charpy V-notch impact tests shall be conducted in accordance with ASTM A370, ASTM E23, or equivalent using specimens removed from the QTC. Standard size (10 mm × 10 mm) Charpy V-notch specimens shall be used whenever practical. One set of three test specimens shall be removed from the QTC at an orientation and location as specified in 5.4.1.2.2.

NOTE Impact energy requirements may be reduced by a factor of 0.833 and 0.667 for $\frac{3}{4}$ size and $\frac{1}{2}$ size specimens, respectively.

Ferritic-austenitic grades shall be impact tested and meet the requirements specified by ASTM A923 Method B for deleterious phases.

Impact testing of austenitic stainless steels is not required.

— *Hardness.*

The hardness of components and the QTC shall be determined in accordance with ASTM E10 or ASTM E18 or equivalent recognized standard. A minimum of one hardness test shall be performed on the QTC after the final heat treatment cycle.

All precipitation hardening and martensitic materials shall meet the hardness requirements specified in the manufacturer's written specification. Hardness testing is not required for ferritic-austenitic or austenitic materials.

Materials intended for sour service environment shall follow applicable limits specified by NACE MR0175.

5.4.1.3.3 Tensile Properties

The tensile properties of the materials for all primary-load-carrying and pressure-containing equipment shall be in conformance with the requirements of the written specification chosen for the parts by the manufacturer/purchaser as provided for by 5.3. The material shall meet the requirements for yield strength, ultimate strength, elongation, and when appropriate the reduction of area as required by the design.

5.4.1.3.4 Microstructural Requirements for Ferritic-austenitic Stainless Steel

Ferritic-austenitic stainless steels shall be inspected for ferrite content by ASTM E562 point count method. The microstructure of the material shall exhibit a ferrite content of 35 % to 65 %, inclusive, after heat treatment.

The microstructure of weld heat-affected zones and ferritic-austenitic weld metal (when ferritic-austenitic weld metal is used) shall have between 30 % and 70 % ferrite.

5.4.2 Nickel-based Alloys

Nickel-based alloys in raw material form (excluding welding consumables) shall conform to API 6ACRA and the equipment manufacturer's written specifications.

Nickel-based alloys not covered in API 6ACRA shall conform to manufacturer's written specifications and NACE MR0175.

Any nickel-based alloy intended for use in sour service shall conform to the requirements of NACE MR0175.

5.5 Material Applications

5.5.1 Main Tube

Riser main tube shall be manufactured per API 5L (PSL 2) requirements and may be longitudinally seam welded or seamless. Spiral-welded pipe and electric-welded pipe shall not be used.

5.5.2 Auxiliary Piping

Only seamless pipe shall be used for hydraulic applications.

5.5.3 Bolting for Marine Drilling Riser Equipment

5.5.3.1 Class 3 and Class 2 Bolting

For class 3 and class 2 bolting, the following requirements shall apply.

- Manufacturers shall have a documented procedure for the qualification of bolting manufacturers, which follows the requirements of API 20E and API 20F.
- Bolting manufactured from low alloy steel or carbon steel shall not exceed 34 HRC due to concerns with hydrogen induced stress cracking.
- Bolting exposed to wellbore fluids shall meet the requirements of NACE MR0175/ISO 15156.
- Manufacturers shall have documented specifications that include the thread form and dimensions of studs, nuts, and bolts.
- When headed, bolting shall be created through the hot upset, closed die forging process.
- Bolting manufactured from proprietary materials shall conform to the 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 (per Table 2).

Riser coupling bolting shall be considered class 3 bolting regardless of location in the riser string.

Bolting above the tension ring excluding riser coupling bolts in the primary load path shall be considered class 2.

Bolting below the tension ring in the primary load path shall be considered class 3.

Primary-load-path bolting on the tension ring and primary-load-path riser tensioner attachments to it shall be class 3.

Bolting in the risers's load path during running/handling operations for Riser Running & Handling Equipment as defined by Section 14 shall be class 2 or class 3.

Bolting for riser tensioner equipment shall meet the requirements of Section 7

5.5.3.2 Utility Bolting

Utility bolting shall conform to the manufacture's written specification (per Table 2).

NOTE 1 The control of hardness levels, cathode protection, coating type and manufacturing process can be considered together in to avoid hydrogen-induced stress cracking.

NOTE 2 Section 5.8.2 discusses coating applied by plating.

NOTE 3 Section 3.1.12 defines bolting class.

Table 2—Bolting Requirements

Bolting Type	Material	Requirement Source
Class 3	Alloy steel and carbon steel Stainless steel and corrosion-resistant alloy (CRA)	API 20E BSL-3 API 20F BSL-3
Class 2	Alloy steel and carbon steel Stainless steel and CRA	API 20E BSL-2 API 20F BSL-2
Utility	Alloy steel and carbon steel Stainless steel and CRA	Manufacturer's specification Manufacturer's specification

5.5.4 Cathodically Protected Steels

Bolting in direct electrical contact with cathodically protected equipment (including components coated with thermally sprayed aluminum) shall be of materials that have shown to have low susceptibility to hydrogen embrittlement.

NOTE Bolting may be coated with various materials for lubricity, corrosion protection, and/or environment isolation.

Regardless of application, coatings shall not alter the bolting design and/or material selection unless agreed to by the purchaser. All coatings applied by electrochemical or autocatalytic means shall have a quality assurance procedure that includes adequate thermal bake-out to increase resistance to cracking caused by hydrogen embrittlement (e.g. see ASTM B850).

5.6 Qualification Test Coupons (QTCs)

5.6.1 General

Mechanical testing to determine the material properties shall be performed on specimens from an acceptable QTC as defined below.

5.6.2 Main Tube (API 5L)

For the main tube, multiple QTCs shall be taken per the requirements of API 5L.

NOTE Additional QTCs may be required per the manufacturer's written specification.

5.6.3 Forgings and Wrought Products

For forgings, extrusions, and wrought products, the QTC shall consist of prolongations, sacrificial forgings, or separately forged test coupons. The separately forged QTC shall be from the same heat as the production parts it represents and shall exhibit hot working ratios that are equal to or less than that used on the production parts. The size of the QTC shall be based on the equivalent round (ER) method as outlined in API 16A. The ER of the QTC shall be equal to or greater than the dimensions of the part it qualifies, but need not exceed 127 mm (5 in.).

The QTC should be heat treated with the production parts it represents whenever practical and shall accompany the parts throughout all heat treat cycles. The QTC shall be furnished in the same heat treat condition as the parts it represents. When the QTC is not heat treated with the parts, the austenitizing and/or tempering temperature of the QTC shall be within 14 °C (25 °F) of those used for the parts. For parts that are quenched and tempered, the QTC shall be quenched in the same media used to quench the production parts. "Production-type" furnaces shall be used. Cycle time for the QTC at the qualifying temperature shall not exceed that for the part.

5.6.4 Castings

QTCs for castings shall conform to API 16A.

5.7 Welding

5.7.1 Primary-load-carrying Weldments and Pressure-containing Weldments

All weld procedures and welders or welding operators shall be qualified in accordance with API 16A, except NACE MR0175 requirements are only applicable to weldments and weld procedure qualification intended for sour service environment. Other recognized industry standards may be used for weld procedure qualification when approved by the purchaser. All welding procedures shall be qualified to meet the same minimum mechanical property requirements as the base material used for the design. Additional essential welding variables shall be by agreement between the purchaser and manufacturer.

Weld procedure qualification and welding practices should be supplemented with requirements necessary for the prevention of hydrogen delayed cracking of welds between alloys with high hardenability.

For corrosion-resistant or hard-facing overlays, the API 16A requirements shall apply.

Butter welds, as defined in ASME *BPVC*, Section IX, shall be approved by the purchaser. Butter weld joints and joining welds shall require procedure qualification records (PQRs) for the buttering weld process and for the joining weld process. A welding procedure specification (WPS) shall be required for the entire completed weldment joint.

Transition welds shall be approved by the purchaser. Each of the two weldments at either extremity of a transition joint shall require a separate WPS and PQR to complete the entire weldment transition joint.

All fabrication welding procedure qualifications, where the base metal requires impact testing, shall measure the notch toughness of the weld metal and heat-affected zone. For procedure qualification tests joining dissimilar materials, both heat-affected zones shall be tested.

Preheating of assemblies or parts, when required, shall be performed to manufacturer's written procedures. If required, these procedures shall address postweld temperature maintenance [dehydrogenation heat treatment (DHT)] to prevent delayed cracking.

NOTE The controlled cooling rate of the weldment after welding, the maintenance of the preheat, and the interpass temperature prior to the PWHT may be shown in the WPS or manufacturing written procedure.

The storage, care, and control of welding consumables shall be defined in the quality assurance procedures that control the manufacturer's welding operations.

5.7.2 Structural Welding Procedure and Welder Performance

Structural weld procedures and welder/operator performance shall be qualified in accordance with the requirements of AWS D1.1, ASME *BPVC*, Section IX, or other recognized industry structural welding specification.

All welding procedures shall be qualified to meet the same minimum mechanical property requirements as the base material used for the design. When impact and/or hardness testing is required by design, the specimens shall be taken from the welded coupon in accordance with the requirements of API 16A.

NOTE Tensile strength may be allowed to be lower as prescribed in ASME *BPVC*, Section IX.

5.7.3 Lifting Devices

Except as amended or superseded by other requirements in the equipment-specific Sections 7 through 18, weld procedure qualifications, welder and welder operator qualifications, and welding processes for lifting devices shall be in accordance with the requirements in ASME *BPVC*, Section IX, AWS D1.1, or other equivalent industry standards.

5.7.4 Noncritical Welding

Welding of noncritical components shall be in accordance with manufacturer's written procedures/specifications or manufacturer-approved written procedures/specifications.

Noncritical welding shall not be allowed on the following: sour service applications, pressure-containing, hoisting equipment, primary-load-carrying members, and/or lifting devices.

5.7.5 Repair of Welds

Welding shall be considered as a repair if performed after PWHT; or if no PWHT is required, after final NDE of the weldment.

NOTE In-process weld repair prior to PWHT (if applicable) is not addressed by this paragraph.

NDE of weld defect repairs shall be identical to that of the original weld.

All major repair of welds to pressure-containing members, where failure would result in release of wellbore fluid to the environment, and to primary-load-carrying members performed subsequent to original PWHT shall be mapped.

Surface examination shall be performed on all excavations for weld repairs, with the method and acceptance criteria as specified in 6.5.2.2.

Total PWHT time at temperature after the repair(s) shall not exceed the maximum time qualified and recorded on the WPS. If a weld is to be repaired after PWHT, both the original and the repair WPS shall have additional PWHT time to ensure that the total cumulative time at temperature does not exceed the time qualified. All PWHT cycles shall be recorded on a furnace chart or digital file.

5.7.6 Repair Welding of Base Metal

5.7.6.1 General

There shall be adequate access to evaluate, remove, and inspect the nonconforming condition causing the need for the repair. The nonconforming condition causing the need for repair shall be removed and evaluated by NDE prior to the repair.

The WPS and the available access for repair shall be such as to ensure complete fusion of the weld with the base material.

The repair welds on pressure-containing and primary-load-carrying components shall conform to all NDE requirements and acceptance criteria for the components.

Total PWHT time at temperature after the repair(s) shall not exceed the maximum time qualified and recorded on the WPS.

5.7.6.2 Repair Welding Requirements for Wrought Products

All repair welding shall be performed in accordance with the manufacturer's WPSs and inspected to manufacturer's written specifications. WPSs shall be documented and shall be supplied at the purchaser's request.

Prior to any repair, the manufacturer shall document the following criteria for permitted repairs:

- defect type,
- defect size limits,
- definition of major/minor repairs.

All excavations, prior to repair and the subsequent weld repair, shall meet the quality control requirements specified in Section 6.

For major repair welds, the manufacturer shall also produce a weld map of the area to be repaired and the repair sequence. Documentation of repairs shall be maintained in accordance with requirements of Section 6.

5.7.6.3 Riser Main Tube

Wrought tubular products shall not be repair welded.

5.7.7 PWHT

The WPS used for qualifying a repair shall reflect the actual sequence of weld repair and PWHT performed on the repaired item. The WPS shall be qualified to perform the total number of PWHT hours to the base material and to the original weld metal.

5.8 Metallic Coatings

5.8.1 Metallic Coatings Applied by Thermal Spray or Spray and Fused Process

Application of thermal spray and spray and fused processes shall be performed by using vendors and procedures approved by the equipment manufacturer.

The procedures to be approved shall as minimum address the following variables:

- finished thickness of the overlay or hard-facing material;
- type of base metal and qualified thickness range;
- type of filler metal (classification if applicable), particle size, and powder feed rate;
- position;

- preheat, PWHT, and PWHT after fusing (when applicable);
- gas feed rate, plasma/feed gas composition, multiple or single layers, torch to work piece, surface preparation, spray torch, fusing temperature range (when applicable); and
- base metal properties after final PWHT and qualification of final PWHT.

NOTE Variables listed above may be addressed as ranges. Alternatively to the requirements of 5.8.1, if a weld procedure qualification is desired by the equipment manufacturer, more detail can be found in ASME *BPVC*, Section IX under Oxyfuel Gas Welding. For more detail on thermal spray aluminum process, see Annex E.

5.8.2 Metallic Coatings Applied by Plating Process

Application of metallic coatings by plating shall be performed by using vendors and procedures approved by the equipment manufacturer.

The procedures to be approved shall as minimum address the following variables:

- type of plating process and plating material;
- thickness requirements of plated material;
- base metal properties and material's susceptibility to hydrogen embrittlement (relevant to plating process);
- dehydrogenation process (hydrogen bake-out) maximum time allowed between parts being plated and parts being baked, bake-out temperature, minimum bake-out time at temperature; and
- testing and NDE for base metal and plating, as per applicable industry standards.

The procedures to be approved should address the following:

- pre-plating requirements such as visual inspection, surface finish, residual magnetism, suitable cleaning methods;
- plating solution essential variables such as concentration, pH, specific gravity, maximum number of metal turnovers (MTOs);
- health and safety measures.

When hydrogen bake-out is required for the plated material, the bake-out shall occur within 3 hours of the plating process, but preferably within 1 hour.

6 Quality Control Requirements

6.1 General

Section 6 specifies quality control requirements and shall apply to primary-load-carrying components and/or pressure-containing components within the scope of this specification. The main tube shall meet the requirements of API 5L, PSL 2. Other tubular components (i.e. mud boost line) manufactured from carbon and low-alloy steel shall follow API 5CT for eddy current and/or flux leakage testing methodology and acceptance criteria. Tubular components (i.e. hydraulic lines) manufactured from duplex, super duplex, and stainless steel shall be per manufacturer's specification.

Quality control requirements for non-primary-load-carrying components and/or non-pressure-containing components within the scope of this specification shall be performed and documented in accordance with the manufacturer's written specifications.

6.2 Measuring and Testing Equipment

6.2.1 General

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

6.2.2 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-measuring devices shall be periodically recalibrated with a master pressure-measuring device or a deadweight tester at 25 %, 50 %, and 75 % of full scale.

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 equipment manufacturer and new longer intervals (three months maximum increment) established.

6.3 Quality Control Personnel Qualifications

6.3.1 NDE Personnel

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

6.3.2 Visual Examination Personnel

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

6.3.3 Welding Inspectors

Personnel performing visual inspection of welding operations and completed welds shall be qualified and certified to one or more 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.

The manufacturer shall have written procedures:

- defining the roles, responsibilities, authority, and accountability of a welding inspector;
- defining essential welding variables and equipment monitoring;
- defining welding, weld NDE, and PWHT audits;
- defining the in-house welding inspector certification program, if used, including training syllabus, instructor qualification requirements, length of certification, and renewal requirements.

6.3.4 Other Personnel

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

6.4 Quality Control Requirements for Equipment and Parts

6.4.1 Quality Control Instructions

The manufacturer shall provide written instructions for NDE activities regarding the requirements of this standard and those of all applicable referenced specifications. All NDE instructions shall be approved by qualified Level III NDE examiner in the method.

NOTE This requirement is not applicable to hardness testing.

6.4.2 Visual Examination

6.4.2.1 Sampling

Each part shall be visually examined.

6.4.2.2 Procedure

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

6.4.2.3 Acceptance Criteria

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

6.4.3 Surface NDE

6.4.3.1 Surface NDE of Ferromagnetic Materials

All accessible 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.

6.4.3.2 Surface NDE of Nonferromagnetic Materials

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

6.4.3.3 Surface NDE of Overlay Cladding

All accessible surfaces of each finished part shall be inspected after final PWHT. If the cladding is to remain as-welded and not machined, no additional surface inspection shall be required after subsequent heat treat