

Drill Pipe

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May: As used in a standard, “may” denotes a course of action permissible within the limits of a standard.

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Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, Suite 1100, Washington, DC 20001, standards@api.org.

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Drill Pipe

1 Scope

1.1 Coverage

This standard specifies the technical delivery conditions for steel drill pipe with upset pipe body ends and welded on tool joints for use in drilling and production operations in petroleum and natural gas industries for three product specification levels (PSL-1, PSL-2, PSL-3). The requirements for PSL-1 form the basis of this standard. The requirements that define different levels of standard technical requirements for PSL-2 and PSL-3 are provided.

This standard covers the following grades of drill pipe:

- grade E;
- high-strength (grades G, S, X, and V);
- sour service (grade SS).

This standard can also be used for drill pipe with tool joints not specified by other standards. By agreement between purchaser and manufacturer, this standard can also be applied to other drill pipe body and/or tool joint dimensions. This standard also lists supplementary requirements (SRs) that may be agreed upon between the purchaser and manufacturer for testing, performance verification, and nondestructive examination (NDE). This standard does not consider performance properties.

NOTE 1 In this standard, drill pipe is designated by label 1, label 2, grade of material (E, X, G, S, SS, and V), upset type, and type of rotary shouldered connection (RSC); designations are used for identification in ordering.

NOTE 2 See API 7-2 for the detailed requirements for the threading and gauging of drill pipe tool joints.

NOTE 3 See API 7G for the performance properties of the drill pipe.

1.2 Application of the API Monogram

If the product is manufactured at a facility licensed by API and is intended to be supplied bearing the API Monogram, the requirements of Annex A apply.

2 Normative References

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

API Recommended Practice 7G, *Recommended Practice for Drill Stem Design and Operating Limits*

API Specification 7-2, *Threading and Gauging of Rotary Shouldered Connections*

API Technical Report 5C3, *Calculating Performance Properties of Pipe Used as Casing or Tubing*

ASME Boiler Pressure and Vessel Code (BPVC) ¹, *Section IX: Welding, Brazing, and Fusing Procedures*

¹ ASME International, 2 Park Avenue, New York, New York 10016-5990, www.asme.org.

ASNT Recommended Practice SNT-TC-1A ², *Personnel Qualification and Certification in Nondestructive Testing*

ASTM A370 ³, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A751, *Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products*

ASTM E4, *Standard Practices for Force Verification of Testing Machines*

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

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

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

ASTM E83, *Standard Practice for Verification and Classification of Extensometer Systems*

ASTM E92, *Standard Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials*

ASTM E213, *Standard Practice for Ultrasonic Testing of Metal Pipe and Tubing*

ASTM E309, *Standard Practice for Eddy Current Examination of Steel Tubular Products Using Magnetic Saturation*

ASTM E570, *Standard Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products*

ASTM E709, *Standard Guide for Magnetic Particle Testing*

ISO 6506-1 ⁴, *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*

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

ISO 7500-1, *Metallic materials—Calibration and verification of static uniaxial testing machines—Part 1: Tension/compression testing machines—Calibration and verification of the force-measuring system*

ISO 9513, *Metallic materials—Calibration of extensometer systems used in uniaxial testing*

ISO 9769, *Steel and iron—Review of available methods of analysis*

ISO 10893-2, *Non-destructive testing of steel tubes—Part 2: Automated eddy current testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of imperfections*

ISO 10893-3, *Non-destructive testing of steel tubes—Part 3: Automated full peripheral flux leakage testing of seamless and welded (except submerged arc-welded) ferromagnetic steel tubes for the detection of longitudinal and/or transverse imperfections*

² American Society for Nondestructive Testing, 1711 Arlingate Lane, P.O. Box 28518, Columbus, Ohio 43228, www.asnt.org.

³ ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

⁴ International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland, www.iso.org.

ISO 10893-5, *Non-destructive testing of steel tubes—Part 5: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections*

ISO 10893-10, *Non-destructive testing of steel tubes—Part 10: Automated full peripheral ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of longitudinal and/or transverse imperfections*

ISO 11484, *Steel products—Employer's qualification system for nondestructive testing (NDT) personnel*

NACE TM0177⁵, *Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H₂S Environments*

3 Terms, Definitions, Symbols, and Abbreviations

3.1 Terms and Definitions

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

3.1.1

bevel diameter

Outer diameter of the sealing shoulder of an RSC.

3.1.2

defect

Imperfection of sufficient magnitude to warrant rejection of the product based on criteria defined in this standard.

3.1.3

drill pipe

Drill pipe body with weld-on tool joints.

3.1.4

drill pipe body

Seamless pipe with upset ends.

3.1.5

drill pipe body manufacturer

Firm, company, or corporation that operates facilities for making the drill pipe body and is responsible for compliance with the requirements of this standard.

3.1.6

drill pipe manufacturer

Firm, company, or corporation responsible for compliance with all the applicable requirements of this standard.

3.1.7

drill pipe torsion-strength ratio

Torsion strength of the tool joint connection divided by the drill pipe body torsion strength.

3.1.8

drill pipe weld neck

Machined part of the drill pipe comprising the tool joint weld neck, the weld, and the drill pipe body upset.

⁵ NACE International, 15835 Park Ten Place, Houston, Texas 77084, www.nace.org.

3.1.9**elephant hide**

Wrinkled outside diameter (OD) surfaces of the drill pipe body caused by the upsetting process.

3.1.10**essential variable**

Variable parameter in which a change affects the mechanical properties of the weld joint.

3.1.11**gouge**

Elongated groove or cavity caused by mechanical removal of metal.

3.1.12**hard banding****(hard facing)**

Application of material onto tool joints to reduce external wear of the tool joint.

3.1.13**hardness number**

Result from a single hardness impression.

3.1.14**heat****(heat of steel)**

Metal produced by a single cycle of a batch-melting process.

3.1.15**heat analysis**

Chemical analysis representative of a heat as reported by the metal producer.

3.1.16**imperfection**

Discontinuity in the product wall or on the product surface that can be detected by an NDE method included in this standard.

3.1.17**indication**

Evidence of a discontinuity that requires interpretation to determine its significance.

3.1.18**inspection**

Process of measuring, examining, testing, gauging, or otherwise comparing the product with the applicable requirements.

3.1.19**label 1**

Dimensionless designation for the drill pipe body size that may be used when ordering.

3.1.20**label 2**

Designation for the drill pipe body wall thickness that may be used when ordering.

NOTE This was historically related to the mass per unit length.

3.1.21**linear imperfection**

Imperfection that includes, but is not limited to, seams, laps, cracks, plug scores, cuts, gouges, and elephant hide (see API 5T1).

3.1.22**lot**

Definite quantity of product manufactured under conditions that are considered uniform for the attribute being inspected.

3.1.23**lot size**

Number of units in a lot.

3.1.24**manufacturer**

One or more of the following, depending on the context: the maker of drill pipe, the maker of drill pipe body, or the maker of tool joints.

3.1.25**mean hardness number**

Result of averaging the hardness numbers for the single specimen or location being evaluated.

3.1.26**non-essential variable**

Variable parameter in which a change may be made in the welding procedure specification (WPS) without re-qualification.

3.1.27**non-linear imperfection**

Imperfection that includes, but is not limited to, pits (see API 5T1).

3.1.28**pipe body**

Seamless pipe excluding upset and upset-affected areas.

3.1.29**procedure qualification record****PQR**

Written documentation stating an assessment that a specific WPS produces welds in accordance with the requirements of this standard.

3.1.30**product**

Drill pipe, drill pipe body, or tool joint.

3.1.31**purchaser**

Party responsible for both the definition of requirements for a product order and for payment for that order.

3.1.32**quench crack**

Crack in steel resulting from stresses produced during the transformation from austenite to martensite.

NOTE This transformation is accompanied by an increase in volume.

3.1.33**rotary friction welding**

Solid state welding under compressive force contact of work pieces rotating relative to one another along a common axis to increase temperature and plastically displace material from the faying surfaces.

NOTE Either direct drive or inertia friction welding is acceptable.

3.1.34**rotary shouldered connection****RSC**

Connection used on drill string elements that has tapered threads and sealing shoulders.

3.1.35**sample**

One or more units of product selected from a lot to represent that lot.

3.1.36**seamless pipe**

Wrought steel tubular product made without a weld seam.

NOTE It is manufactured by hot working and, if necessary, by subsequently cold working or heat treating, or a combination of these operations, to produce the desired shape, dimensions, and properties.

3.1.37**tool joint**

Forged or rolled steel component for drill pipe designed to be welded to the drill pipe body and having an RSC.

3.1.38**tool joint box**

Threaded connection on tool joints that has internal threads.

3.1.39**tool joint manufacturer**

Firm, company, or corporation that operates facilities for making tool joints and is responsible for compliance with the requirements of this standard applicable to the tool joint.

3.1.40**tool joint pin**

Threaded connection on tool joints that has external threads.

3.1.41**upset ovality**

Difference between the largest and smallest diameter in a plane perpendicular to the axis of the upset.

3.1.42**weld zone**

Zone comprising the weld line and the heat-affected areas on either side of the weld line caused by the friction welding and subsequent heat-treatment processes.

3.1.43**welding machine performance qualification****welding operator performance qualification****WPQ**

Written procedure used to demonstrate that a welding machine and welding operator combination has the capability to use the WPS to produce a weld meeting the requirements of this standard.

NOTE It includes records from the qualification tests.

3.1.44**welding procedure specification****WPS**

Written procedure that provides instructions to the welding operator for making production welds in accordance with the requirements of this standard.

NOTE It includes all essential and nonessential variables for friction welding of tool joints to drill pipe body; a WPS applies to all those welds, of which each element has the same specified dimensions and chemistry, that are grouped according to a documented procedure to ensure a predictable response to weld zone treatment for a particular grade.

3.2 Acronyms, Abbreviations, and Symbols

A	cross-sectional area of the tensile specimen, expressed in square millimeters (square inches)
A	length of reduced section, expressed in millimeters
A_{dp}	cross-sectional area of the drill pipe body based on the specified dimensions of the pipe body
A_w	minimum cross-sectional area of the weld zone
C	standard Charpy impact energy, expressed in foot-pounds
C_m	standard Charpy impact energy, expressed in Joules
CVN	Charpy V-notch
D	tool joint outside diameter (pin and box)
D	diameter of round bar
D_{dp}	pipe body outside diameter
D_f	bevel diameter (pin and box)
D_j	external diameter on the tool joint neck, which becomes D_{te} after welding and final machining
D_{ou}	drill pipe body upset outside diameter
D_{te}	outside diameter of the drill pipe weld after machining
d_{dp}	pipe body inside diameter
d_j	internal diameter of the tool joint neck, which becomes d_{te} after welding and final machining
d_{ou}	drill pipe body upset inside diameter
d_p	tool joint pin inside diameter
d_{te}	inside diameter of the drill pipe weld after machining
EU	external upset
e	minimum extension in a gauge length of 50.8 mm (2.0 in.)

e_m	minimum elongation
e_w	drill pipe body mass gain or loss due to end finishing, for plain end non-upset pipe, e_w equals zero
G	gauge length
ID	inside diameter
IEU	internal-external upset
IU	internal upset
L	length of drill pipe with welded on tool joint (from shoulder to shoulder)
L_b	length of box tool joint outside diameter including connection bevel and hard band
L_{eu}	drill pipe body external upset length
L_{iu}	drill pipe body internal upset length
L_{pb}	length of pin tool joint outside diameter, including connection bevel
L_{pe}	length of drill pipe body (without tool joint)
m_{eu}	drill pipe body external upset taper length
m_{iu}	drill pipe body internal upset taper length
N	fraction or number with a fraction
NDE	nondestructive examination
OD	outside diameter
PQR	procedure qualification record
PSL	product specification level
R	minimum radius of fillet
RSC	rotary shouldered connection
SR	supplementary requirement
T_S	tensile strength
TW	thick-walled (a label 2 designation)
t	pipe body wall thickness
U	upset dimension
U_{dp}	minimum specified tensile strength

W	width
W_L	approximate calculated mass of a piece of drill pipe body of length, L_{pe}
WPQ	welding performance qualification
WPS	welding procedure specification
w_{dp}	approximate linear mass of the drill pipe
w_{pe}	plain end pipe body unit mass (without upsets)
Y_{min}	specified minimum yield strength
Y_w	weld zone yield strength

4 Conformance

4.1 References to Annexes

For additional requirements or information concerning the manufacturing of drill pipe, as referenced, see the following.

- figures in SI (USC) units, see Annex B (normative);
- product tables in USC units, see Annex C (normative);
- product tables in SI units, see Annex D (normative);
- product SRs, see Annex E (informative);
- conversion procedures for USC to SI units, see Annex F (informative);
- product specification levels (PSLs), see Annex G (normative);
- purchaser inspection, see Annex H (normative);
- bevel diameters for tool joints with non-preferred connections, see Annex I (informative).

4.2 Dual Referencing

In the interests of worldwide application of this technical report, the API Subcommittee on Tubular Goods (SC5) has decided, after detailed technical analysis, that certain documents listed in Section 2 and prepared by API SC5 or other technical committees are interchangeable in the context of the relevant requirement with the relevant document prepared by the International Organization for Standardization (ISO) or the American Society for Testing and Materials (ASTM). These latter documents are cited in the running text following the API reference and preceded by “or,” for example “API XXXX or ISO YYYY” or “ISO YYYY or ASTM ZZZZ.” Application of an alternative document cited in this manner may lead to technical results different from the use of the preceding API reference. However, both results are acceptable, and these documents are thus considered interchangeable in practice.

4.3 Units of Measurement

In this standard, data are expressed in both the International System (SI) of units and the U.S. customary (USC) system of units. For a specific order item, it is intended that only one system of units be used without combining data expressed in the other system.

Products manufactured to specifications expressed in either of these unit systems shall be considered equivalent and totally interchangeable. Consequently, compliance with the requirements of this standard as expressed in one system provides compliance with requirements expressed in the other system.

In the text, data in SI units are followed by data in USC units in brackets.

5 Information to Be Supplied by the Purchaser

5.1 When placing orders for drill pipe to be manufactured in accordance with this standard, the purchaser shall specify the following from Table 1 in the purchase agreement.

Table 1—Purchaser-supplied Information for Drill Pipe (Required)

Requirement	Reference
Quantity	
Label 1	Table C.1 or Table D.1
Label 2	Table C.1 or Table D.1
Grade	Table C.1 or Table D.1
Upset type (internal, external, or internal-external upset)	Table C.1 or Table D.1
RSC type or other special connection by agreement between purchaser and manufacturer	6.2.2, or Table C.1 or Table D.1
Range or special length and tolerance by agreement between purchaser and manufacturer	Table C.3 or Table D.3
Delivery date and shipping instructions	
Inspection by purchaser	Annex H
Documentation	6.17

5.2 When placing orders for drill pipe to be manufactured in accordance with this standard, the purchaser may specify any of the following from Table 2 in the purchase agreement.

Table 2—Purchaser-supplied Information for Drill Pipe (Optional)

Requirement	Reference
Tool joint OD	6.2.6
Tool joint inside diameter (ID) of the pin end	6.2.2
Length of pin tool joint OD	6.2.2
Length of box tool joint OD	6.2.6
Under-thickness tolerance if less than 12.5 %	7.1.6
Type of heat treatment for drill pipe body: grade E only	7.3.3
Hard banding: type, location, dimensions, and acceptance criteria NOTE Hard banding reduces the length of the tool joint OD available for tong placement.	8.3.7
Pipe coatings: internal and/or external	6.4.5, 6.4.6, and 7.3.4
Special threads on tool joints	8.1.5
Specific thread or storage compound	6.4.7
Thread protector type	6.4.7 and 8.3.8
Marking requirements	6.15, 7.19, and 8.12
Individual drill pipe traceability	6.5
Supplementary Requirement	Reference
NDE for grades E, X, and G	E.2 (SR 2)
Test certificates	E.3 (SR 15)
Charpy V-notch (CVN) impact toughness testing of grade E pipe body	E.4 (SR 19)
Alternative low-temperature CVN impact testing	E.5 (SR 20)
Weld zone testing frequency	E.6 (SR 23)
CVN: increased weld zone requirements	E.7 (SR 24)
For PSL-2 or PSL-3	Annex G

5.3 When placing orders for drill pipe bodies to be manufactured in accordance with this standard, the purchaser shall specify the following from Table 3 in the purchase agreement.

Table 3—Purchaser-supplied Information for Drill Pipe Body (Required)

Requirement	Reference
Quantity	
Label 1 or specified OD	Table C.1 or Table D.1
Label 2 or specified wall thickness	Table C.1 or Table D.1
Grade	Table C.1 or Table D.1
Upset type (internal, external, or internal-external upset)	Table C.1 or Table D.1
Length and tolerance	
Delivery date and shipping instructions	
Inspection by purchaser	Annex H
Documentation	6.17

5.4 When placing orders for drill pipe bodies to be manufactured in accordance with this standard, the purchaser may specify any of the following from Table 4 in the purchase agreement.

Table 4—Purchaser-supplied Information for Drill Pipe Body (Optional)

Requirement	Reference
Special upset configuration	7.1.2
Under-thickness tolerance if less than 12.5 %	7.1.6
Type of heat treatment for drill pipe body: grade E only	7.3.3
Impact requirements for grade E	E.4 (SR 19)
Alternative requirements for impact test	E.5 (SR 20)
PSL-2 or PSL-3	Annex G

5.5 When placing orders for tool joints to be manufactured in accordance with this standard, the purchaser shall specify the following from Table 5 in the purchase agreement.

Table 5—Purchaser-supplied Information for Tool Joints (Required)

Requirement	Reference
Quantity	
Drawing of the tool joint pin, including any necessary details	Figure B.12
Drawing of the tool joint box, including any necessary details	Figure B.12
Delivery date and shipping instructions	
Inspection by purchaser	Annex H
Documentation	8.14

5.6 When placing orders for tool joints to be manufactured in accordance with this standard, the purchaser may specify any of the following from Table 6 in the purchase agreement.

Table 6—Purchaser-supplied Information for Tool Joints (Optional)

Requirement	Reference
Special surface treatment	8.3.5
Tool joint break-in	8.3.6
Hard banding: type, location, dimensions, and acceptance criteria NOTE Hard banding reduces the length of tool joint OD available for tong placement.	8.3.7
Thread-protector type	8.3.8
Marking requirements	8.12
Alternative requirements for impact testing	E.5 (SR 20)
PSL-2 or PSL-3	Annex G

6 Requirements for Drill Pipe

6.1 General

The drill pipe shall be made from drill pipe body manufactured in accordance with Section 7 and tool joints manufactured in accordance with Section 8. Areas of the drill pipe body and tool joint affected by the welding and finishing processes are addressed in Section 6.

6.2 Dimensions, Masses, and Connections

6.2.1 Standard Configuration

The configuration of drill pipe shall correspond to Figure B.1. Drill pipe shall be furnished with dimensions and tolerances as in Tables C.1 and C.2, or Tables D.1 and D.2, and/or in the purchase agreement. All dimensions shown without tolerances are related to the basis for design and are not subject to measurement to determine acceptance or rejection of product. Drill pipe dimensions that are not in this standard or in the purchase agreement are at the manufacturer's discretion.

RSCs shall conform to the dimensions, together with the tolerances, in API 7-2. Right-hand thread connections shall be considered standard.

When connections not defined in this standard, but described as non-preferred in API 7-2, are used, the bevel diameters should be as described in Annex I, Table I.1.

6.2.2 Alternative Configurations

When specified in the purchase agreement, drill pipe shall be furnished in dimensional configurations not defined in this standard. In this case, dimensions, tolerances, and markings shall be agreed between the purchaser and manufacture. The drill pipe body and tool joint shall be modified in accordance with this agreement, but the drill pipe shall otherwise be manufactured in accordance with the requirements of this standard.

The OD of the box tool joint, D , and ID of the pin tool joint, d_p , dimensions in Table C.1 or Table D.1 result in a drill pipe torsion-strength ratio of 0.8 or greater. Changes in the OD and ID of the tool joints can result in a

lower drill pipe torsion-strength ratio, which should be determined by the purchaser to be suitable for the intended application.

6.2.3 Drill Pipe Weld Neck Diameters

The drill pipe weld diameters, D_{te} and d_{te} , as shown in Figure B.1, apply to the finished product after the tool joint is welded to the drill pipe body and machined and/or ground. The OD, D_{te} , shall meet the requirements of Table C.1 or Table D.1, and 6.3.2. The ID, d_{te} , shall meet the requirements of 6.3.2 and may be different on the pin and box weld zones.

6.2.4 Tool Joint IDs

The tool joint pin ID, d_p , shall meet the requirements in Table C.1 or Table D.1. The tool joint box ID is at the manufacturer's discretion but shall not be less than the tool joint pin ID, d_p .

6.2.5 Length

Drill pipe shall be furnished in length ranges conforming to Table C.3 or Table D.3, or other lengths and tolerances as specified in the purchase agreement.

The drill pipe manufacturer shall specify the lengths and tolerances of the drill pipe body and tool joints such that the required length of each drill pipe is achieved.

6.2.6 Length of Tool Joint OD

The length of pin tool joint OD, L_{pb} , and the length of box tool joint OD, L_b , in Table C.1 or Table D.1, may be increased, or decreased by up to 50.8 mm (2.0 in.), by agreement between purchaser and manufacturer.

6.2.7 End Drift

Each drill pipe shall be end drift tested throughout the length of the tool joints and upsets with a cylindrical mandrel having a minimum diameter of 3.2 mm (0.125 in.) smaller than the specified ID of the pin end, d_p . The drift mandrel shall be at least 100 mm (4 in.) long.

NOTE Drift testing of the full length of the drill pipe is not required.

6.2.8 Tool Joint Alignment

The maximum misalignment between the longitudinal axis of the drill pipe body and the longitudinal axis of the welded-on tool joint shall not exceed the following:

- a) for parallel misalignment: 4 mm (0.157 in.), total indicator reading (TIR);
- b) for angular misalignment: 8 mm/m (0.008 in./in.), TIR for label 1: 4^{1/2} and larger;
10 mm/m (0.010 in./in.), TIR for smaller than label 1: 4^{1/2}.

The axis of the tool joint shall be determined by two locations on the surface of the OD, D , that are unaffected by markings or hard banding. The axis of the drill pipe body shall be determined over a minimum length of 400 mm (15 in.) on the outside surface of the pipe body.

6.2.9 Weld Zone Profile

The weld zone shall have no sharp corners or drastic changes of section. The internal weld zone profile shall not cause a 90° hook-type tool to hang up.

6.3 Material Requirements

6.3.1 General

The material properties of the drill pipe body and the tool joint shall be as in Tables C.4 to C.8, or Tables D.4 to D.8, inclusive. The weld zone is defined for the purposes of this section as the heat-affected zone of the weld and the region that is tempered above the original temperature by the postweld heat treatment.

NOTE This region can extend beyond the gauge length of a standard tensile specimen.

6.3.2 Weld Zone Yield Strength

The yield load of the weld zone in tension shall be greater than the yield load of the drill pipe body as given by Equation (1). If the weld zone is larger than the gauge length, multiple samples may be required to include the transition zones. The lower yield strength shall be reported.

$$(Y_w \times A_w) > (Y_{\min} \times A_{dp}) \quad (1)$$

where

A_{dp} is the cross-sectional area of the drill pipe body based on the specified dimensions of the pipe body;

A_w is the minimum cross-sectional area of the weld zone;

$Y_{\min}$ is the specified minimum yield strength of the drill pipe body;

Y_w is the weld zone minimum yield strength (determined by the manufacturer based on the design).

The method for calculating the minimum cross-sectional area, A_w , of the weld zone shall be as given in Equation (2):

$$A_w = 0.7854 \times D_{te,\min}^2 - d_{te,\max}^2 \quad (2)$$

where

$d_{te,\max}$ is the maximum allowable ID specified by the drill pipe manufacturer;

$D_{te,\min}$ is the minimum allowable OD specified by the drill pipe manufacturer.

6.3.3 Weld Zone Hardness

For surface hardness, no hardness number shall exceed 37 HRC, or equivalent, for grades E, X, G, and S, or 40 HRC for grade V. For SS grades, the surface hardness shall not exceed 30 HRC.

For the through-wall hardness test, the mean hardness number of the weld zone shall not exceed 37 HRC, or equivalent, for grades E, X, G, and S, or 40 HRC for grade V. For SS grades, the mean hardness of the weld zone shall not exceed 30 HRC, with no single value exceeding 32 HRC.

6.3.4 Weld Zone CVN Absorbed Energy Requirements

The minimum absorbed energy requirements shall be as in Table C.8 or Table D.8. In addition, not more than one impact specimen shall exhibit an absorbed energy below the minimum average absorbed energy requirement, and in no case shall an individual impact specimen exhibit an absorbed energy below the minimum specimen absorbed energy requirement.

Additional requirements for PSL-3 are in Annex G.

6.3.5 Weld Zone CVN Absorbed Energy—Alternative Requirements

When specified in the purchase agreement, the absorbed energy shall meet SR 20 (E.5) or SR 24 (E.7) requirements (see also Table C.8 or Table D.8).

6.3.6 Weld Zone Transverse Side-bend Properties

The guided bend specimens shall have no open discontinuity in the weld zone exceeding 3 mm (0.125 in.) measured in any direction on the convex surface of the specimen after bending. Open discontinuities occurring on the corner of the specimen during testing shall not be considered unless there is definite evidence that they result from lack of fusion, inclusions, or other internal discontinuities.

6.3.7 Weld Zone H₂S Resistance for SS Grades

When specified by SR 26 (E.9), the sulfide stress cracking resistance of the weld shall be periodically tested. The frequency shall be once every 3 years or in accordance with a documented procedure.

6.4 Process of Manufacture for Drill Pipe

6.4.1 Processes Requiring Validation

Final operations performed during drill pipe manufacturing that affect compliance as required in this standard (except chemical composition and dimensions) shall have their process validated.

Those processes requiring validation are welding and weld heat treatment.

6.4.2 Welding Qualification

The manufacturer shall develop, qualify, and use a welding procedure, including postweld heat treatment [WPS and procedure qualification record (PQR)], in accordance with ASME *BPVC*, Section IX. The procedure shall identify the essential variables and non-essential variables and address the permissible number of reheat treatments.

The PQR shall include, as a minimum, the data of the specific variables (both essential and non-essential) used to weld a tool joint to a drill pipe body and the results of all mechanical tests to verify the properties in 6.3 carried out on specimens taken from the test weld.

In addition, the manufacturer shall undertake macrostructural examination of the weld to verify that the weld exhibits complete bonding and freedom from cracks.

The manufacturer shall qualify the welding machines and welding operators to a specific welding operator performance qualification (WPQ) for each WPS utilized by the operators.

6.4.3 Welding of Tool Joints to Drill Pipe Body and Postweld Heat Treatment

The welding of the tool joint to the drill pipe body shall be by the rotary friction welding process. A postweld heat treatment shall be performed through the entire thickness and from the weld line to beyond where the flow lines of the tool joint and drill pipe body material change direction because of the welding process. The weld shall be austenitized, cooled below the transformation temperature, and tempered at a minimum temperature of 593 °C (1100 °F).

6.4.4 Weld Machining

The weld area shall be machined and/or ground, both externally and internally, to produce a flush surface (visually free from gouges or abrupt changes in section).

Tool marks from normal machining operations shall be acceptable.

6.4.5 Internal Coating

When specified in the purchase agreement, drill pipe shall be internally coated over the full length, except the thread. The type of coating shall be specified in the purchase agreement, and the application and inspection shall be carried out in accordance with an agreed documented procedure.

6.4.6 External Coating

Unless otherwise specified in the purchase agreement, the drill pipe shall be given an external coating for protection from corrosion during transit. The coating shall be rated to protect the drill pipe for at least 3 months and it should be smooth, hard to the touch, and with minimum sags.

6.4.7 Thread Protection

Threads and shoulders of RSCs shall be equipped with thread protectors to protect them from damage during transportation and storage. Unless otherwise specified in the purchase agreement, the type of thread protector is at the manufacturer's discretion.

A thread compound, suitable for RSCs, shall be applied over the clean threads and shoulders before protectors are installed. Unless otherwise specified in the purchase agreement, the type of thread compound is at the manufacturer's discretion.

When specified in the purchase agreement, a storage compound shall be applied instead of the thread compound.

6.5 Traceability

The drill pipe manufacturer shall establish and follow procedures for maintaining traceability to any applicable SR and/or PSL requirement, as well as to drill pipe body heat and tool joint heat as in Sections 7 and 8, respectively.

Lot identity of all welds shall be maintained until all required tests are performed and conformance with specified requirements has been documented. The procedures shall provide means for tracing the welds to the lot and to mechanical and inspection test results.

When additional traceability is required, the details shall be agreed and be specified in the purchase agreement.

6.6 Inspection and Testing—General

6.6.1 Inspection and Test Equipment Calibration

The manufacturer shall determine and document the appropriate calibration frequency and procedures (including occurrences of out-of-calibration and the consequences on products) to be able to certify that all products conform to the requirements of this standard.

6.6.2 Dimensional Inspection

The drill pipe weld diameter and wall thickness, or diameters, D_{te} and d_{te} , shall be verified, after final machining and/or grinding according to a documented procedure, to meet the requirements of 6.2.3.

6.6.3 Drill Pipe Length

The drill pipe length, L (see Figure B.1), shall be measured from shoulder to shoulder unless otherwise specified in the purchase agreement. This length shall be recorded and reported to the purchaser. The

accuracy of length measuring devices shall be ± 0.03 m (± 0.1 ft). Drill pipe length determination shall be in meters and hundredths of a meter (feet and tenths of a foot).

6.6.4 Straightness

All drill pipe shall be visually examined for straightness. The straightness of questionably bent pipes or crooked extremities shall be measured in accordance with 7.13.

6.6.5 End Drift Test

End drift testing shall be performed with a drift mandrel conforming to the requirements of 6.2.7. It is permissible for the ends of the drift mandrel, extending beyond the specified cylindrical portion, to be shaped to permit easy entry into the drill pipe. The drift mandrel shall pass freely through the length of the drill pipe tool joint and upset using a manual or power drift procedure. In case of dispute, the manual drift procedure shall be used.

6.6.6 Internal Profile

Each end of every drill pipe shall be visually examined for compliance with the requirements of 6.2.9. Questionable ends shall be examined using the following method.

The weld zone configuration inspection shall be made with a 90° hook-type tool (see Figure B.2 for an example). The contact pin shall be visually determined to be attached perpendicular to the handle. The contact point radius shall not exceed the inside radius of the weld zone being inspected. Sharp edges on the contact point shall be removed (see contact point on Figure B.2). The 90° hook-type tool contact point should be maintained perpendicular to the longitudinal axis of the weld zone while the contact point is passed axially throughout the weld zone length. Pressure on the contact point shall be no greater than the pressure created by the weight of the 90° hook-type tool.

6.6.7 Tool Joint Alignment

Tool joint alignment shall conform to the requirements in 6.2.8 and shall be verified according to a documented procedure. A general tool for measurement is illustrated in Figure B.15.

6.7 Testing of Welds

6.7.1 Lot Size

A lot shall consist of all those welds that are produced in a single production run (either continuous or interrupted) on the same welding machine (without any modification of the set-up parameters) using the same qualified procedures (WPS and WPQ).

6.7.2 Test Specimens

Where size allows, all initial test specimens for the weld zone shall be taken from the same sample.

6.8 Tensile Test

6.8.1 Procedures

The tensile test shall be performed at room temperature in accordance with ISO 6892 or ASTM A370.

Tests may be carried out on semi-finished products before final machining operations but after final heat treatment.

The fracture shall not occur at the weld line.

6.8.2 Test Equipment Calibration

Tensile test machines shall have been calibrated within a period of 15 months preceding any test, in accordance with the procedures in ISO 7500-1 or ASTM E4. Extensometers shall have been calibrated within a period of 15 months preceding any test, in accordance with the procedures in ISO 9513 or ASTM E83. Retention of records shall be in accordance with 6.17.4 and Table C.9 or Table D.9.

6.8.3 Specimens

A longitudinal section of sufficient length to include the entire weld zone shall be suitably prepared and etched to determine the location of the weld zone relative to the weld line and transverse grain flow. This etched section shall be used to ensure that the tensile specimen or specimens include the full weld zone within the reduced section as shown in Figure B.3.

The largest possible round bar tensile specimens, in accordance with the requirements of the 0.2 % offset method in ISO 6892 or ASTM A370, shall be taken from the longitudinal section location as shown in Figure B.3. Specimens with a diameter of 12.7 mm (0.500 in.) are preferred. Specimens with a diameter of 8.9 mm (0.350 in.) or 6.4 mm (0.250 in.) are suitable alternatives for thin sections.

6.8.4 Frequency

The tensile test frequency for the weld shall be as in Table C.10 or Table D.10.

Additional requirements for PSL-2 and PSL-3 are in Annex G.

For an alternative test frequency, see E.6 (SR 23).

6.8.5 Defective Specimen

Specimens showing material imperfections or defective preparation, whether observed before or after testing, may be discarded and replacements shall be considered as original specimens.

6.8.6 Retests

If the initial tensile test fails to conform to the specified requirements, the manufacturer may elect to test two additional specimens from the same weld. If both additional specimens pass, the lot shall be accepted.

If one or more of the additional specimens fail to conform to the requirements, the lot shall be rejected. Rejected lots may be reheat treated and tested as new lots.

If insufficient material remains for the retest specimens to be obtained from the original sample, then it is permitted to obtain specimens from another weld within the same lot.

6.9 Hardness Test

6.9.1 Procedures

Hardness tests shall be made in accordance with the appropriate standards as follows:

- a) ISO 6506-1 or ASTM E10;
- b) ISO 6507-1 or ASTM E92;
- c) ISO 6508-1 or ASTM E18.

Hardness indentations shall not be closer than three indentation diameters from other indentations measured center-to-center.

6.9.2 Surface Hardness Test

Each weld zone shall be hardness tested on the outside surface at three places, $120^\circ \pm 15^\circ$ apart. Selection of the hardness testing method is at the manufacturer's option, including the use of an alternative test method. In such a case, the manufacturer shall demonstrate the equivalence of the test result to those of one of the standards mentioned in 6.9.1.

6.9.3 Surface Hardness—Retest

All welds with a hardness number that exceeds the value specified in 6.3.3 shall be retested or rejected. For any hardness number that exceeds the specified value, one more hardness test shall be made in the immediate area. If the new hardness number does not exceed the specified value, the weld shall be accepted. If the new hardness number exceeds the specified value, the weld shall be rejected. The manufacturer may elect to reheat treat the weld in accordance with the same qualified procedure and perform the surface hardness test again.

6.9.4 Through-wall Hardness Test

The through-wall hardness test frequency of the weld zone shall be as in Table C.10 or Table D.10.

A Rockwell mean hardness number is the average of three Rockwell C-scale numbers taken at 2.5 mm to 6.4 mm (0.10 in. to 0.25 in.) from the outside surface and from the inside surface on the pipe and tool joint sides of the weld line (that is 12 hardness numbers and 4 Rockwell mean hardness numbers on each weld, as shown in Figure B.3).

6.9.5 Through-wall Hardness—Retests

All weld test pieces with a mean hardness number that exceeds the value specified in 6.3.3 shall be retested, or the lot represented by the test shall be rejected. Before retesting, the test surface may be reground. If the retest mean hardness numbers do not exceed the specified value, the lot shall be accepted. If any retest mean hardness number exceeds the specified value, the lot of welds represented by the test piece shall be rejected. Rejected lots may be reheat treated and tested as new lots.

6.10 Charpy V-notch Impact Test

6.10.1 Procedures

A test shall consist of a set of three longitudinal specimens taken from one weld. CVN impact tests as in ASTM A370 and ASTM E23 shall be conducted at a temperature of $21^\circ\text{C} \pm 3^\circ\text{C}$ ($70^\circ\text{F} \pm 5^\circ\text{F}$).

For alternative standardized test temperatures, see E.5 (SR 20) and PSL-3 in Table C.8 or Table D.8.

Tests conducted at any temperature lower than the specified temperature are acceptable provided the absorbed energy requirements at the specified temperature are achieved.

Additional requirements for PSL-2 and PSL-3 are in Annex G.

6.10.2 Specimen Size and Orientation

The impact test specimen shall not be smaller than the largest size shown in Table C.11 or Table D.11 based on the specified drill pipe weld neck diameter (and rounded to the next smaller specified OD if required) and the calculated weld neck thickness (based on specified dimensions).

Specimens shall be removed from the weld longitudinally with respect to the axis of the pipe with the notch oriented in a radial direction as shown in Figure B.3. The center of the notch in the specimen shall be located on the weld line.

6.10.3 Test Frequency

The impact test frequency for the weld shall be as in Table C.10 or Table D.10.

Additional requirements for PSL-2 and PSL-3 are in Annex G.

For an alternative test frequency, see E.6 (SR 23).

6.10.4 Retests

If the requirements of 6.3.4 are not met and not more than one specimen is below the minimum specimen absorbed energy requirement, the manufacturer may elect either to reject the lot or to retest a set of three additional specimens from the same weld test piece. For all three of these specimens, the absorbed energy shall be equal to or greater than the minimum average absorbed energy in Table C.8 or Table D.8, or the lot shall be rejected. If insufficient material remains for the retest specimens to be obtained from the original sample, then it is permitted to obtain specimens from another weld from the same lot.

If more than one specimen in the initial test is below the minimum specimen absorbed energy requirement, then the manufacturer may elect either to reject the lot or to retest an additional set of three specimens from each of three additional welds from the same lot. If these additional sets of specimens do not meet the initial test requirements, then the lot shall be rejected.

Rejected lots may be reheat treated and tested as new lots.

6.10.5 Defective Specimens

Specimens showing material imperfections or defective preparation, whether observed before or after testing, may be discarded, and replacements shall be considered as original specimens. Specimens shall not be judged defective simply because they fail to exhibit the minimum absorbed energy requirements,

6.11 Transverse Side-bend Test

6.11.1 Procedure

The guided bend test shall be carried out in accordance with ASME *BPVC*, Section IX, paragraphs QW-161.1 and QW-162.1. The specimen shall be bent until the two branches of the specimen form an angle of not greater than 40° under load as shown in Figure B.3. The weld zone shall be completely within the bend portion of the specimen after bending. A test shall consist of one specimen bent in the clockwise direction and another specimen bent in the counter-clockwise direction relative to the pipe axis.

6.11.2 Specimens

One set of two specimens shall be removed from the weld zone of the test piece. The weld zone shall be in the center of longitudinal specimens. The test specimens shall be of full wall thickness, approximately 9.5 mm ($\frac{3}{8}$ in.) wide, and the length shall be 150 mm (6 in.) minimum.

6.11.3 Test Frequency

The transverse side-bend test frequency shall be as in Table C.10 or Table D.10.

For an alternative test frequency, see E.6 (SR 23).

6.11.4 Retests

If only one of the guided bend specimens fail to conform to the specified requirements, the manufacturer may elect to reject the lot or to test an additional set of two specimens from the same weld test piece. If both retest specimens meet the specified requirements, the lot shall be accepted. If one or both retest specimens fail to meet the specified requirements, the lot shall be rejected.

It is preferred that retest specimens be obtained from the same sample as the original test specimen(s). However, if the retest specimens cannot be obtained from the original sample, it is permissible to obtain specimens from another weld within the same lot.

Rejected lots may be reheat treated and tested as a new lot.

6.12 Imperfections and Defects in Drill Pipe

6.12.1 General

Drill pipe shall be free from defects as defined in this standard.

6.12.2 Weld Zone Defects

Any weld zone imperfection detected by visual inspection, as in 6.13, or wet fluorescent magnetic particle inspection, as in 6.14.2, shall be considered a defect.

Any imperfection detected by ultrasonic inspection that produces a signal equal to or greater than the signal produced by the reference standard described in 6.14.4 shall be considered a defect.

Quench cracks shall be considered defects and shall be cause for rejection of the product.

6.12.3 Process Control Plan

The manufacturer, based on knowledge of the production process and the requirements of 6.13 and 6.14, shall apply a process control plan that ensures compliance with the requirements of 6.12.2.

6.13 Visual Inspection of the Drill Pipe Weld Zone

6.13.1 General

Each weld zone shall be visually inspected over the entire outside surface for the detection of defects.

This inspection shall be carried out by trained personnel. Visual acuity requirements shall be documented by the manufacturer. Personnel compliance with these requirements shall be documented.

NOTE Examples of visual acuity requirements are in ISO 11484 or ASNT SNT-TC-1A.

Documented lighting standards for visual inspection shall be established by the manufacturer. The minimum illumination level at the inspection surface shall be 500 lux (50 foot-candles).

The visual inspection for defects may be at any appropriate point in the manufacturing process after machining.

6.13.2 Disposition of Defects

Defects shall be completely removed by grinding or machining. All grinding shall be blended smooth. The dimensions after grinding shall comply with the requirements of 6.2.

6.14 Nondestructive Examination of the Weld Zone

6.14.1 General

All NDE operations (except visual inspection) referred to in this standard shall be conducted by NDE personnel qualified in accordance with ISO 11484 or ASNT SNT-TC-1A.

The manufacturer or inspection company shall have a process for training to qualify or certify NDE personnel for the method, technique, and equipment used for the inspection(s) specified in this standard.

Surfaces to be inspected shall be machined and, if necessary, ground before inspection.

When specified in the purchase agreement, the provisions for purchaser inspection of the weld zone and/or witnessing of NDE operations shall be in accordance with Annex H.

The inspections performed in accordance with 6.14, with the equipment standardized to the specified reference indicators, should not be construed as assuring that the material requirements in 6.12 have been met. The manufacturer shall determine the appropriate NDE equipment verification frequency to certify that all products conform to the requirements of this standard.

6.14.2 Wet Fluorescent Magnetic Particle Inspection

The entire outside surface of the weld zone shall be wet fluorescent magnetic particle inspected for the detection of transverse imperfections in accordance with ISO 10893-5 or ASTM E709. Wet particle concentration shall be checked every 8 hr or each shift change. The minimum black-light intensity at the examination surface shall not be less than 1000 $\mu\text{W}/\text{cm}^2$ (6.345 Mft c or 6.830 Mlx) at 365-370 nm (821-810 THz).

6.14.3 Ultrasonic Inspection—Procedure

Each weld zone shall be ultrasonically inspected from the pipe side around the circumference with the beam directed toward the weld. Shear wave/angle beam ultrasonic equipment capable of inspection of the entire weld zone shall be used. The inspection shall be applied in accordance with the manufacturer's documented procedure. The instrument gain setting during inspection shall not be set lower than the gain setting when checked against the reference standard. In case of dispute, the transducer shall generate a square 2.25 MHz frequency with a $45^\circ \pm 5^\circ$ induced angle.

6.14.4 Ultrasonic Inspection—Reference Standard

A reference standard shall be used to demonstrate the effectiveness of the inspection equipment and procedures at least once every working shift. The equipment shall be adjusted to produce a well-defined indication when the reference standard is scanned in a manner simulating the inspection of the product. The reference standard shall have the same specified diameter, ± 1.60 mm (± 0.063 in.), and similar acoustic properties and surface finish as the weld zone being inspected and may be of any convenient length as determined by the manufacturer.

The manufacturer shall use a documented procedure to establish the reject threshold for ultrasonic inspection. The through-drilled hole described in Figure B.4 shall be detected under normal operating conditions.

6.14.5 Ultrasonic Inspection—System Capability Records

The manufacturer shall maintain NDE system records verifying the capabilities of the system(s) in detecting the reference indicators used to establish the equipment test sensitivity.

6.14.5.1 The verification shall cover, as a minimum, the following criteria:

- a) coverage calculation (i.e. scan plan),
- b) capability for the intended wall thickness,
- c) repeatability,
- d) transducer orientation that detects defects typical of the manufacturing process (see 6.14.3),
- e) documentation demonstrating that defects typical of the manufacturing process are detected, and
- f) threshold-setting parameters.

6.14.5.2 The manufacturer shall maintain documentation relating to:

- a) NDE system operating procedures,
- b) NDE equipment description,
- c) NDE personnel qualification information, and
- d) dynamic test data showing the NDE system/operation capabilities under production test conditions (not applicable to manual operations).

6.14.6 Disposition of Defects

Defects detected by either wet fluorescent magnetic particle inspection or ultrasonic inspection shall be completely removed by grinding or machining, or the weld shall be rejected. All grinding shall be blended smooth. The dimensions after grinding shall comply with the requirements of 6.2. The weld zone shall be reinspected after grinding using the same inspection method originally used to detect the defect to verify complete removal of the defect.

6.15 Marking of Drill Pipe

6.15.1 General

Drill pipe manufactured in conformance with this standard shall be marked by the drill pipe manufacturer as in 6.15. Additional markings may be applied, including those for applicable compatible standards, at the option of the manufacturer or as specified in the purchase agreement. Markings shall not overlap and shall be applied in such a manner as to not damage the drill pipe.

The drill pipe final marking shall be the responsibility of the drill pipe manufacturer and shall include traceability (see 6.5).

6.15.2 Drill Pipe Marking

The final marking of the drill pipe shall consist of:

- a) the traceability marking according to 6.15.3,
- b) marking on the drill pipe body according to 6.15.4, and
- c) marking on the tool joint according to 6.15.5.

6.15.3 Traceability Marking

This marking shall be die stamped on the pin taper as shown in Figure B.1, unless otherwise specified in the purchase agreement. See 6.5 for traceability requirements.

6.15.4 Drill Pipe Marking on the Pipe Body

Drill pipe body paint-stencil markings shall start approximately 1 m (40 in.) from the box shoulder and shall include, in the following sequence as a minimum:

- a) drill pipe manufacturer's name or mark (see API 7G-2 for a list of manufacturer marking codes);
- b) "API 5DP", or the API Monogram marking requirements (see Annex A) as applicable to API licensees;
- c) date of drill pipe manufacture (month and year of welding):
 - 1) the date of manufacture shall be a three- or four-digit number consisting of a one- or two-digit number indicating the month followed by the last two digits of the year in which the markings of Section 6 are completed;
 - 2) this marking may be waived at the manufacturer's option (it is also marked on the base of the tool joint pin; see Figure B.5);
 - 3) products manufactured in accordance with this standard during the period of overlap of application with the previous edition may be identified by "00" as the overlap period designation rather than the month;
- d) size designation (label 1);
- e) mass designation (label 2);
- f) grade of the drill pipe body;
- g) SR information applicable to the drill pipe;
- h) L2 or L3 (indicating, respectively, PSL-2 or PSL-3) applicable to the drill pipe.

EXAMPLE Paint-stenciled marking for a label 1: 2³/₈, label 2: 6.65, grade E, PSL-2 drill pipe manufactured by company ZZ in July 2007: ZZ API 5DP 707 2-3/8 6.65 E L2.

At the drill pipe manufacturer's option or as specified in the purchase agreement, the drill pipe body manufacturer's marking may remain on the drill pipe body or be obliterated by the drill pipe manufacturer.

The paint-stenciled marking may be adversely affected when the drill pipe is internally coated.

6.15.5 Drill Pipe Marking on the Tool Joint

Unless otherwise specified in the purchase agreement, the tool joint shall be die stamped at the base of the pin as shown in Figure B.5 and include the following:

- a) drill pipe manufacturer's name or mark;
- b) month welded: for example, "6" designates "June";
- c) year welded: for example, "07" designates "2007";
- d) drill pipe body manufacturer's name or mark, at the manufacturer's option;

- e) drill pipe body grade: for example, “E” designates “grade E” pipe body;
- f) product drill pipe body mass code number (see Table C.12 or Table D.12): for example, “2” designates a standard mass product; for designations not in Table C.12 or Table D.12, the mass code shall be by agreement between the purchaser and the manufacturer;
- g) tool joint designation, at the manufacturer’s option: for example, “NC50” designates an NC50 RSC; for connections not in Table C.1 or Table D.1, the designation shall be as specified by the manufacturer.

The size of the die stamping shall be at the manufacturer’s option.

Marking of the tool joint with grooves and flats shall be as specified in the purchase agreement.

Marking made by the tool joint manufacturer on the outside surface of the tool joint may remain.

6.16 Minimum Facility Requirements for Drill Pipe Manufacturers

The drill pipe manufacturer shall operate facilities for welding tool joints to drill pipe body for postweld heat treatment and for machining the weld area.

Either the drill pipe manufacturer shall have facilities for conducting all required tests and inspections or any of these tests or inspections may be provided by a subcontractor and may be located offsite. If a subcontractor performs any of these services, the conduct of such inspections and tests shall be controlled and monitored by the drill pipe manufacturer in accordance with a documented procedure.

6.17 Documentation Requirements of Drill Pipe

6.17.1 Standard Documentation

The drill pipe manufacturer shall provide the purchaser with the following:

- a) a certificate of compliance giving the product description and a statement that the drill pipe has been manufactured, inspected, and tested in accordance with this standard and the purchase agreement;
- b) a product description that shall include, as a minimum: label 1, label 2, grade, range, RSC type, and any other special requirements specified in the purchase agreement; and
- c) a tally list giving the length, L , of each drill pipe (see 6.6.3 and Figure B.1).

6.17.2 Supplementary documents

When specified in the purchase agreement, the requirements of E.3 (SR 15) shall apply.

Additional requirements for PSL-2 and PSL-3 are in Annex G.

6.17.3 Electronic Data Interchange

The standard or supplementary documents (see 6.17.1 and 6.17.2) printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the drill pipe manufacturer’s facility. The content of the EDI transmitted document shall meet the requirements of this standard and conform to any existing EDI agreement between the purchaser and the drill pipe manufacturer.

6.17.4 Retention of Records

Table C.9 or Table D.9 specifies records that shall be retained. Such records shall be retained by the drill pipe manufacturer and shall be available to the purchaser on request for a period of at least 5 years after the date of purchase from the drill pipe manufacturer.

7 Requirements for Drill Pipe Body

7.1 Dimensional and Mass Requirements

7.1.1 General

The dimensions of the drill pipe body shall correspond with the requirements in Tables C.2 and C.13 or C.14, or Tables D.2 and D.13 or D.14, unless otherwise specified in the purchase agreement.

For drill pipe body furnished with upsets not in this standard, but otherwise manufactured in accordance with the requirements of this standard, special marking as in 7.19 is required.

7.1.2 Configuration

The configuration of drill pipe body shall correspond to Figure B.1. Upset configurations shall correspond to Figure B.6, except as allowed in 6.2.2, or when otherwise specified in the purchase agreement.

7.1.3 Internal Upset Area

The internal upset (IU) taper area of the drill pipe body shall have a smooth profile. The IU configuration shall have no sharp corners or drastic changes of section that can cause a 90° hook-type tool to hang up.

7.1.4 OD Tolerance

The OD tolerances of the drill pipe body shall be in accordance with the requirements of Table C.2 or Table D.2. The OD tolerances behind the length, m_{eu} , apply to the OD of the drill pipe body immediately behind the upset for approximately 127 mm (5 in.) for sizes smaller than label 1: 6⁵/₈ and a distance approximately equal to the OD for label 1: 6⁵/₈. Measurements shall be made with calipers or snap gauges.

7.1.5 Inside Diameter

The pipe body ID, d_{dp} , is calculated as given in Equation (3):

$$d_{dp} = D_{dp} - 2t \quad (3)$$

There is no tolerance on d_{dp} .

7.1.6 Pipe Body Wall Thickness and Tolerance

The wall thickness at any place on the pipe body shall not be less than the specified thickness minus 12.5 %.

When specified in the purchase agreement, the wall thickness under-tolerance may be less than 12.5 %.

7.1.7 Length

The drill pipe body shall be supplied in lengths and tolerances as specified in the purchase agreement. The lengths and tolerances should be such that the required final length of drill pipe is achievable.

7.1.8 Mass

The mass shall conform to the calculated mass for the end finish and dimensions specified in the purchase agreement, within the tolerances stipulated below. Calculated mass, W_L , expressed in kilograms (pounds), of a piece of drill pipe body of length, L_{pe} , shall be determined in accordance with Equation (4):

$$W_L = (w_{pe} \times L_{pe}) + e_w \quad (4)$$

where

w_{pe} is the non-upset pipe mass per unit length, expressed in kilograms per meter (pounds per foot);

L_{pe} is the length of drill pipe body, expressed in meters (feet);

e_w is the drill pipe body mass gain due to end finishing (Tables C.13 and C.14, or Tables D.13 and D.14).

For non-upset pipe, e_w equals zero. The method of calculation is defined in API 5C3 and shall be followed.

Mass tolerance is as follows:

- a) single lengths: $\begin{smallmatrix} +6.5\% \\ -3.5\% \end{smallmatrix}$,
- b) order item: $\begin{smallmatrix} 0\% \\ -1.8\% \end{smallmatrix}$.

Order-item tolerance applies only for masses of 18,140 kg (40,000 lb) or more when shipped from a drill pipe body manufacturer.

Where an under-thickness tolerance smaller than 12.5 % is specified in the purchase agreement, the plus tolerance on mass for single lengths shall be increased to 19 % less the specified under-thickness tolerance.

EXAMPLE If an under-thickness tolerance of 10 % is specified in the purchase agreement, the plus tolerance on mass for single lengths is 19 % minus 10 %, or 9 %.

7.1.9 Straightness

Deviation from straight or chord height shall not exceed either of the following (see Figure B.7):

- a) 0.2 % of the total length of the drill pipe body measured from one end to the other, or
- b) 3.2 mm ($1/8$ in.) maximum drop in the transverse direction in a length of 1.5 m (5 ft) from each end.

7.1.10 Upset Alignment

The outside and inside surfaces of the upset shall be aligned with the outside surface of the pipe body. The total indicator reading shall not exceed 2.4 mm (0.093 in.) for the outside surface and 3.2 mm (0.125 in.) for the inside surface. See Figure B.1.

7.1.11 Upset Ovality

Maximum ovality, measured with a micrometer on the OD of the upset, shall not exceed 2.4 mm (0.093 in.).

7.2 Material Requirements

7.2.1 Chemical Composition

The chemical composition shall be as provided in Table C.4 or Table D.4.

7.2.2 Tensile Requirements

The pipe body shall conform to the requirements in Table C.5 or Table D.5, which designate strength levels by a letter designation (e.g. E).

NOTE Extensions of this designation (e.g. E-75) may infringe proprietary trademarks and are not recommended.

The upset ends shall conform to the requirements for the pipe body, except that there is no requirement for elongation. Compliance with the requirements for the upset shall be qualified by a documented procedure.

The yield strength shall be the tensile stress required to produce the extension under load in Table C.6 or Table D.6, as determined by an extensometer.

The minimum pipe body elongation, e , in a 50.8 mm (2.0 in.) gauge length, expressed in percent rounded to the nearest 0.5 % for elongations less than 10 % and to the nearest unit percent for elongations of 10 % and greater, shall be that determined by Equation (5):

$$e = k \times \frac{A^{0.2}}{U_{dp}^{0.9}} \quad (5)$$

where

k is a constant equal to 1944 (625,000);

A is the cross-sectional area of the tensile-test specimen, expressed in square millimeters (square inches), based on the specified OD or nominal specimen width and specified wall thickness, rounded to the nearest 10 mm² (0.01 in.²); use 490 mm² (0.75 in.²) if the area is greater than 490 mm² (0.75 in.²);

U_{dp} is the minimum specified tensile strength, in megapascals (pounds per square inch).

Pipe body minimum elongation values in accordance with Equation (5) for various sizes of tensile specimens and pipe grades are shown in Table C.7 or Table D.7. When elongation is recorded or reported, the record or report shall show the nominal width of the test specimen when strip specimens are used, the nominal diameter and gauge length when round bar specimens are used, or shall state when full-section specimens are used.

7.2.3 CVN Absorbed Energy Requirements—Grade E

There is no mandatory CVN absorbed energy requirement for the pipe body or the upset. See E.4 (SR 19) for optional requirements.

Additional requirements for PSL-2 and PSL-3 are in Annex G.

7.2.4 CVN Absorbed Energy Requirements—Grades X, G, S, V, and SS

The minimum absorbed energy requirements of the pipe body shall be as in Table C.8 or Table D.8. In addition, not more than one impact specimen shall exhibit an absorbed energy below the minimum average absorbed energy requirement, and in no case shall an individual impact specimen exhibit an absorbed energy below the minimum specimen absorbed energy requirement.

There is no mandatory CVN absorbed energy requirement for the upset.

Additional requirements for PSL-2 and PSL-3 are in Annex G.

7.2.5 CVN Absorbed Energy Requirements—Alternative Temperature

When specified in the purchase agreement, the absorbed energy of the pipe body shall meet the requirements in E.5 (SR 20) (also see Table C.8 or Table D.8).

7.2.6 H₂S Resistance Testing for SS Grades

SS drill pipe shall have a demonstrated minimum threshold of 85 % of the specified minimum yield strength for 720 hr in accordance with NACE TM0177, Method A using Test Solution A. Testing frequency shall be one specimen per heat, per heat treat lot, or every 200 tubes, whichever is the more frequent. If any heat has a failed specimen, two additional specimens from the same heat/heat-treat lot are required as a retest. If either fail, the heat is unacceptable. Rejected lots may be reheat treated and tested as new lots.

7.3 Process of Manufacture

7.3.1 Processes Requiring Validation

Final operations performed during drill pipe body manufacturing that affect compliance as required in this standard (except chemical composition and dimensions) shall have their process validated.

The only process requiring validation is heat treatment.

7.3.2 General

Steel used for drill pipe body furnished to this standard shall be made according to a fine-grained practice.

NOTE Steel made according to fine-grained practice contains one or more grain-refining elements, such as aluminum, niobium (columbium), vanadium, or titanium in amounts intended to result in the steel having a fine, austenitic grain size.

Drill pipe body shall be made from seamless pipe.

7.3.3 Heat Treatment

Heat treatment shall be performed in accordance with a documented procedure. The procedure shall address the permissible number of reheat treatments. The heat treatment procedure shall be selected by the manufacturer unless specified in the purchase agreement.

The drill pipe body shall be heat treated over the full length after upsetting.

For grade E, the drill pipe body shall be quenched and tempered or normalized and tempered or normalized.

For grades X, G, S, V, and SS, the drill pipe body shall be quenched and tempered.

7.3.4 External Coating

Unless otherwise specified in the purchase agreement, the drill pipe body shall be given an external coating for protection from corrosion during transit. The coating shall be rated to protect the drill pipe body for at least 3 months, and it should be smooth, hard to the touch, and with minimum sags.

7.4 Traceability

The drill pipe body manufacturer shall establish and follow procedures for maintaining the heat identity of all drill pipe body covered by this standard. Lot identity shall be maintained until all required lot tests are performed and conformance with specified requirements has been documented. The procedures shall provide means for tracing the drill pipe body to the relevant heat and to the specified chemical, mechanical, and test results.

Since a heat may be heat treated in more than one lot, there may be more than one set of mechanical test results for a heat.

7.5 Inspection and Testing—General

7.5.1 Inspection and Test Equipment Calibration

The manufacturer shall determine and document the appropriate calibration frequency and procedures (including occurrences of out-of-calibration and the consequences on products) to be able to certify that all products conform to the requirements of this standard.

7.5.2 Heat Treatment Lot

A lot shall consist of those lengths of drill pipe body with the same specified dimensions and grade that are heat treated as part of a continuous operation (or batch), and are of a single heat of steel, or from different heats that are grouped according to a documented procedure that ensures that the appropriate requirements of this standard are met.

7.6 Testing of Chemical Composition

7.6.1 Heat Analysis

Each heat of steel used in the manufacture of drill pipe body shall be analyzed to provide the results of quantitative determinations of phosphorus and sulphur plus any other elements used by the drill pipe body manufacturer to control mechanical properties.

7.6.2 Product Analysis

Two tubular products from each heat used shall be analyzed. These product analyses shall include the results of quantitative determinations of phosphorus and sulphur plus any other elements used by the manufacturer to control mechanical properties.

7.6.3 Test Method

Chemical composition shall be determined by any of the procedures commonly used for determining chemical compositions, such as emission spectroscopy, X-ray emission, atomic absorption, combustion techniques, or wet analytical procedures. The calibration methods used shall be traceable to established standards. In case of conflict, chemical analyses shall be made in accordance with ISO 9769 or ASTM A751.

7.6.4 Retest of Product Analysis

If the product composition of both lengths of tubular product representing the drill pipe body heat fail to conform to the specified requirements, at the manufacturer's option, either the heat shall be rejected or all the remaining lengths in the heat shall be tested individually for conformance to the specified requirements.

If only one of the two samples fail, at the manufacturer's option, either the heat shall be rejected or two recheck analyses shall be made on two additional lengths from the same heat. If both recheck analyses conform to the requirements, the heat shall be accepted, except for the length represented by the initial